GENETICS OF LEAF BLIGHT (*Exserohilum turcicum* (Pass.)) RESISTANCE AND ITS INFLUENCE ON YIELD IN SORGHUM (*Sorghum bicolor* (L.) Moench)

By
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CERTIFICATE

Ms K KANAKA DURGA has satisfactorily prosecuted the course of research and that the thesis entitled **GENETICS OF LEAF BLIGHT (*Exserohilum turcicum* (Pass.)) RESISTANCE AND ITS INFLUENCE ON YIELD IN SORGHUM (*Sorghum bicolor* (L.) Moench)** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 3-7-1999

(Dr M Shiva Shanth Reddy)
Major Advisor

CERTIFICATE

This is to certify that the thesis entitled **"GENETICS OF LEAF BLIGHT (*Exserohilum turcicum* (Pass.)) RESISTANCE AND ITS INFLUENCE ON YIELD IN SORGHUM (*Sorghum bicolor* (L.) Moench)"** submitted in partial fulfillment of the requirements for the degree of '**Doctor of Philosophy**' of the Acharya N G Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Ms Kilaru Kanaka Durga** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

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DECLARATION

I, **Ms K KANAKA DURGA** hereby declare that the thesis entitled **GENETICS OF LEAF BLIGHT (*Exserohilum turcicum* (Pass.)) RESISTANCE AND ITS INFLUENCE ON YIELD IN SORGHUM (Sorghum bicolor (L.) Moench)** submitted to Acharya N G Ranga Agricultural University for the Degree of **Doctor of Philosophy in Agriculture** is a result of original research work done by me. I also declare that my material contained in the thesis has not been published earlier.

Date: 09-07-1999

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ABSTRACT

The present investigation was taken up at ICRISAT-Patancheru during rabi 1996 and 1997 to study the mode of inheritance of resistance to leaf blight by using 20 cytoplasmic male-sterile (CMS) lines, 17 male-sterile maintainer (B) lines and six restorer (R) lines crossed in a line x tester design to obtain 120 (A x R) hybrids and 102 (B x R) crosses.

Parental lines exhibiting a range of overall disease damage (score) showed differential response to the disease related characters like length, width and area of the lesion, number of lesions and number of flecks in two years of study. In the first year, none of the individual disease parameters have had profound effect on the expression of the overall disease. On the other hand, in the second year, length, width and area of the lesion, and number of lesions appeared to have played a significant role in contributing to the overall disease damage (score). The hybrid, SPLB 94009A x ICSR 90030 was found stable in yield performance with good agronomic desirability in both the years and it possesses other appreciable traits. The most desirable hybrids based on maximum grain yield plant^{-1} and moderate resistance for overall disease damage (score), minimum length, width and area of the lesion were SPLB 94004A x A 2267-2 (R_{ds} x R_{ds}), SPLB 94011A x ICSR 119 (R_{ds} x LS_{ds}), SPLB 94016A x ICSR 119 (MR_{ds} x R_{ds}), SPLB 94022A x ICSR 119 (MR_{ds} x LS_{ds}) and SPLB 94001A x ICSR 91025 (S_{ds} x LS_{ds}) in the first year, whereas SPLB 94004A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94001A x ICSR 119, SPLB 94019A x ICSR 90030 (LS_{ds} x S_{ds}) and SPLB 94009A x ICSR 90030 (LS_{ds} x S_{ds}) in the second year.

On the basis of overall disease damage score R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, MR_{ds} x MR_{ds} and LS_{ds} x R_{ds} type of crosses in the first year, whereas MR_{ds} x MR_{ds}, LS_{ds} x R_{ds}

and LS_{ds} x MR_{ds} combinations in the second year were found to give resistant hybrids. At least, one of the parents should possess either resistance or moderate resistance to obtain resistant hybrids. The A-lines, SPLB 94016A (MR_{ds}), SPLB 94024A and SPLB 94014A (LS_{ds}); and 296A (S_{ds}), and the R-lines A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}) and ICSR 90030 (S_{ds}) were stable in the expression of disease reaction over the years, while others were unstable.

Out of 26 parental lines studied, SPLB 94009A (R_{ds}), SPLB 94010A (R_{ds}) SPLB 94011A (R_{ds}) and A 2267-2 (R_{ds}) during first year, while A 2267-2 (R_{ds}) in the second year showed resistant reaction for overall disease damage (score) and other disease related characters. The hybrids, SPLB 94012A, SPLB 94015A and SPLB 94006A with ICSR 119, SPLB 94004A, SPLB 94012A, SPLB 94015A, SPLB 94017A, SPLB 94021A and 296A with ICSR 26; and SPLB 94004A, SPLB 94006A, SPLB 94003A, SPLB 94015A, SPLB 94013A, SPLB 94021A and SPLB 94017A with ICSR 90030 were found to be resistant and stable in expression over the two years with less area of the leaf damage and minimum fleck number.

The discrete variation analysis showed that resistance for the overall disease damage (score) was dominant in R_{ds} x R_{ds}, R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, LS_{ds} x R_{ds} and S_{ds} x R_{ds} crosses in the first year, while MR_{ds} x R_{ds} and LS_{ds} x R_{ds} crosses in the second year. On the other hand, R_{ds} x MR_{ds}, MR_{ds} x MR_{ds}, LS_{ds} x MR_{ds} and S_{ds} x MR_{ds} crosses in the first year, while MR_{ds} x MR_{ds} and LS_{ds} x MR_{ds} in the second year showed over dominant reaction for resistance to the overall disease (score). On the other hand, line x tester analysis showed that non-additive gene action played an important role in the inheritance of various disease related characters including disease score and other yield attributes. Ten genotypes in the first year, while six genotypes in the second year with significant GCA / SCA contributions for area of the lesion, number of lesions and number of flecks coupled with low mean performance were considered to be highly desirable, as they contributed to disease resistance.

Male-sterile cytoplasm was found contributing significantly for increasing length and area of the lesion, while its effect on disease score, width of the lesion and number of flecks was not significant. The increase in fleck number in the resistant genotypes in the first year and their decrease in second year indicated the importance of hypersensitive reaction in imparting resistance further restricting the spread of the pathogen. The disease reaction of a genotype could be judged based either on disease score, lesion number and fleck number or taking total leaf area damage or area of the lesion alone into consideration. The parents and the hybrids with delayed disease development and minimum growth rate of the lesion area were found desirable. The latent period for sporulation inheritance (dominance / recessivity) was not found to be consistent which appeared to be dependent on the genotype. Early appearance of the disease symptom (lesion) was found to be most dominant over late appearance of the symptoms.

Introduction

CHAPTER I
INTRODUCTION

Sorghum, *Sorghum bicolor (L.)* Moench is the third most important cereal crop cultivated extensively in India after wheat and rice. The cereal is grown in the tropical and subtropical climates; consequently, it is an unique crop of the semi-arid tropics (SAT). The crop is predominantly cultivated in West Africa, East Africa, South Africa and India. Of the total SAT production, Asia and Africa contribute about 65%, of which 34% is harvested in India alone. Globally, it is cultivated in an area of 44.1 m ha with a production of 61.4 m t and an average yield of 1.4 t ha^{-1} (FAO, 1998).

In India, sorghum is grown in rainfed areas where rainfall ranges from 500 to 1000 mm and temperatures from 26° to 32°c. In India, it is cultivated in an area of 11.2 m ha with a production of 9.0 m t and an average yield of 0.80 t ha^{-1} (FAO, 1998). In some states it is also grown in small pockets in rainy, post-rainy and summer seasons. Generally it is grown in Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Rajasthan, Gujarat, Tamilnadu and Uttar Pradesh and they account for more than 90% of the total production of India (Anahosur, 1992).

Albeit sorghum is potentially a high yielding crop, its productivity continued to be low in India as compared to world's average, owing to the hindrance due to biotic and abiotic stresses. Diseases are one such category of constraints.

Several destructive diseases affect sorghum grain and fodder yield and their quality. Among the diseases, grain mold, charcoal rot, fusarium rot, stalk rot, ergot, downy mildew, foliar diseases and rust are the most predominant. Of these, leaf diseases of sorghum play a pivotal role in influencing the crop growth and performance of sorghum in the subtropics and the tropical lowlands (Odvody and

Hepperly, 1992). Recently, among the foliar diseases, the occurrence of blight is widespread in tropical climates including India (Bandyopadhyay, 1999, personal communication)

Leaf diseases cause significant grain losses due to the reduction of the active photosynthetic leaf area. Leaf blight caused by *Exserohilum turcicum* (Pass.) Leonard and Suggs. is one of the extensively distributed, and at times one of the most damaging foliage pathogens of the sorghum. Leaf blight has been observed in all the major sorghum growing areas of the world (Tarumoto *et al.*, 1977) and severe damages were observed in USA, Argentina, Mexico, and Israel (Frederiksen, 1980). Effect of leaf blight on grain loss is usually low as compared to the damage caused by grain diseases. Nonetheless, it can take a severe toll in susceptible cultivars if the disease occurs prior to or at the booting stage.

Leaf blight disease in India was first reported by Butler (1918) on the leaves of cultivated sorghum and later by Mitra (1923) in Punjab. The disease is prevalent and actively widespread particularly in the states of Andhra Pradesh, Haryana, Maharashtra, Madhya Pradesh, Karnataka, Tamilnadu and Rajasthan (Sundaram *et al.*, 1972). A disease intensity of 32 to 69% (ICRISAT, 1979) has been reported with a loss in grain yield of 45% (Sharma, 1978).

The magnitude of the losses in post rainy season is about the half of the total losses due to the diseases as the area in the post rainy season is almost equal to the *kharif* season in the recent years. Yet, All India Co-ordinated Sorghum Improvement Programme primarily concentrated all its efforts on breeding for high yield potential and very little weightage is given to disease resistance in releasing the cultivars to general cultivation in India.

The safest and the most economical way of combating diseases is through the development of multiple-factor resistant varieties. However, most of the cultivars and hybrids, which are being grown on commercial scale, are found to be susceptible to leaf blight. The reasons for lack of resistance in the material may be attributed to presence of poor variability in the population. No concerted effort is being done in this direction to know the gene action controlling the disease and its influence on yield and yield components since majority of the studies have not taken into consideration the disease related parameters except the disease score. In order to develop the disease resistant and high yielding cultivars, it is imperative to analyse and understand the variability for various disease resistant parameters, the genetics of resistance and the interrelationship of various yield components. An understanding of the nature of the inheritance pattern of the disease greatly helps in formulating a suitable breeding method to develop resistant hybrids in the shortest possible time. Keeping in view the above fact, the present investigation was initiated by selecting elite cytoplasmic male-sterile (CMS) lines and the different restorer (R) lines, mated in a line x tester design and the resulting hybrids will be evaluated for the following specific objectives to work out the suitable selections to combat the leaf blight disease in sorghum.

The specific objectives of the present investigation include *inter-alia* the following:

1. To estimate combining ability for resistance to leaf blight, yield and yield component characters.
2. To explain the pattern of inheritance of resistance to leaf blight in a simple mendelian fashion.

3. To study the influence of cytoplasm (maternal effects) on various blight resistant parameters.
4. To study the extent and magnitude of heterosis for yield and yield attributes and resistance to leaf blight.
5. To find out the relationships between various disease resistant factors and yield contributing characters.
6. To identify superior leaf blight resistant CMS lines, testers (restorers) and hybrids having high yield background.
7. To study the epidemiology of the disease.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The pathogen causing leaf blight disease, *Exserohilum turcicum* (Pass.) is commonly and generally found on sorghum grown in the tropics and tropical lowlands during summer. Occurrence of this pathogen was less consistent in the cooler temperate and tropical highland or tropical environments. The pathogens are easily wind-disseminated, are apparently the most consistent in their occurrence and incidence across the diverse sorghum-growing environments.

2.1 DISEASE

2.1.1 Losses

The most direct effect of foliar pathogens might be from reduced photosynthesis, but foliar infections could increase leaf transpiration, reduce carbohydrate translocation to other plant organs, and / or increase uptake of carbohydrates and other plant nutrients from other plant organs to dysfunctional leaves. Foliar dysfunction at critical stages of plant growth can inhibit roots, stalks, and seed heads. It further reduces or delays plant growth and development and as a consequence reduces yield of both grain and fodder.

2.1.2 Nomenclature of the Pathogen

In 1876, Passerini described the northern leaf blight species as *Helminthosporium turcicum*. In 1858, Luttrell, described the perfect stage of the fungus as *Trichometasphaeria*. In 1974, Leonard and Suggs, redescribed the perfect stage as

Setosphaeria turcica. Regarding the imperfect stage, Dreschler (1954) described the conidial stage as those having the true *Helminthosporium* characters, including *Helminthosporium turcicum*, and the cylindro *Helminthosporium*. However, Shoemaker (1959), proposed a new genus for the graminicola species with *Bipolaris turcica* as the type species. Leonard and Suggs (1974) removed the species having a protuberant conidial hylum from *Bipolaris* and established *Exserohilum turcicum* (Pass.). Because of this, the generic name *Exserohilum turcicum* is probably the preferred name for the pathogen that causes leaf blight of sorghum. The causal organism, *Exserohilum turcicum* belongs to the class Deuteromycetes and the order *Fungi imperfecti*.

2.1.3 Host Range and Pathogen Variability

Exserohilum turcicum is a common pathogen of sorghum, *teosinte*, *Paspalum*, *Zea*, and other related grasses, in many parts of the world, including India, and is prevalent almost everywhere where maize and sorghum are grown. In addition, *Triticum*, *Hordeum*, *Avena*, *Saccharum*, and *Oryza* are susceptible to *Exserohilum turcicum* when artificially inoculated. Though pathogenic on other crops, naturally occurring isolates from host crops are generally genus specific (Frederiksen, 1980).

2.1.4 Stage of the Plant

The leaf blight infection usually appeared 30 to 40 days after sowing, when the crop was at 8 to 9-leaf stage and further development was observed when the crop was completing the vegetative stage. Plants in the immature stages of the plant growth are more susceptible than more mature plants (Tuleen, 1975). Plants of the highly resistant ones developed some lesions when inoculated in the early stages of seedling growth. Most inoculation sites result in the appearance of the hypersensitive flecks. The ability of the host to form flecks decreases not only with susceptibility but also with maturity. A great increase in the percentage of the plants infected was noticed in the flowering and post flowering periods (Shenoi and Ramalingam, 1983).

2.1.5 Sources of Inoculum

The conidia of *Exserohilum turcicum* are easily wind disseminated, with most species released in the morning hours. The primary source of inoculum is mycelia and conidia resting in the soil. Harvested plants with mature spots can also be the potential source of inoculum (Shenoi and Ramalingam, 1983). Increase in temperature, decrease in relative humidity and increasing wind speeds aid in the liberation of conidia and their wind dispersal (Leach, 1975).

2.1.6 Symptoms

Leaf blight like a number of foliar diseases of sorghum, is quite conspicuous. However, leaf blight differs from the symptoms caused by the other foliar pathogens. It causes large, elongated, spindle-shaped spots, measuring several cm in length and up to few cm in width. The straw / grey colored center of the spot is surrounded by a deeply pigmented margin, which darken during sporulation. Several spots may coalesce to kill large patches of the leaf blade. They primarily attack leaf blade but under extended disease conducive environments they may also attack leaf sheaths.

A distinctive feature of the leaf blight is the timing of the appearance of the symptoms. Small flecks appear usually 3 or 4 days after a favourable infection period. These small lesions can be seen with a hand lens, but the large lesions do not appear until two weeks time. The plugging of nearby vessels causes a localized wilt within the leaf tissues. During successive favourable periods, the fungus continues to colonize the leaf, having bands or characteristic zones within the leaf. Total leaf wilting occurs under heavy infestation conditions.

2.1.7 Disease Development and Host Interaction

The conidium of *Exserohilum* is unique, not only in appearance but also in function. The conidia are thick walled, spindle-shaped, olivaceous, brown, 3-8 septate and are formed acrogenously with a prominent hilum. They measure 45-132 x 15-28 μ and germinate by protruding germ tubes from the end cells. The perfect stage of the fungus produces black, ellipsoidal to globose ascocarps containing clavate to cylindrical asci bearing three-septate, hyaline and fusoid, ascospores that are 3-6 in number.

The conidia by thickening their walls become conidiospores as an overwintering or overseasoning spore. Spores or conidia germinate by the formation of a germ tube, which may, or may not form an appresorium on the surface of the leaf. Beneath the appresorium a peg will penetrate through the cuticle and form hyphae within host cells. Most individual penetrations result in the appearance of the hypersensitive fleck (Tuleen and Frederiksen, 1977). Infection hyphae slowly pass through living cells with scant disturbance initially; forming rudimentary appresoria as each wall is encountered. Cells of resistant hosts may form pigments at this stage. Maize with monogenic resistance has a chloronemic halo around the infection site-the typical "Ht" reaction. A similar response has been occasionally observed in some of the more resistant sorghum cultivars. In the absence of resistance, hyphae enter vessels, absorb nutrients, and proliferate and damage results from the mycelial plugging of the vessel.

Leaf blight is described as a local or localized wilt (Jennings and Ullstrup, 1957). Wilting is actually due to the tyloses or complexes with the polysaccharides released by the digestion of the vessel lumen, rather than to the actual physical plugging by the hyphae. Toxins may be partially responsible for the death and the collapse of the host cells (Tuleen and Frederiksen, 1977). Following the development of a major lesion, pathogen fruiting begins.

Hyphae fill the substomatal cavity or epidermal cell and produce a stroma. The conidiophores of *Exserohilum turcicum* develop from the stroma. Conidiophores are olivaceous, slightly bent, measuring 1150-250 x 7-9 μ and produce a conidium at the apex. The conidiophore curves under high humidity conditions. When humidity declines, conidiophore cells dry, bubbles appear inside them, and conidiophore becomes upright, throwing the conidium away and out of the boundary layer. Most conidia are released on days following rainfall. Mycelia within the vessels continue to almost on a daily cycle, as indicated by the borders of the lesion. The mycelium utilizes a crossover vessel to widen the lesion and forms a larger area of colonization. (Jennings and Ullstrup, 1957). The conidiophore is capable of emitting additional conidia on subsequent days.

2.2 MEAN PERFORMANCE

Since the literature available on the genetics of resistance to leaf blight in sorghum is very limited, the information available on the maize crop is also briefly given below. Northern corn leaf blight, caused by *Helminthosporium turcicum* Pass., is a major disease of corn (*Zea mays* L.) in many corn growing areas of the world.

Yield losses in susceptible hosts are considerable when infection occurs before silking and the environment favors disease. In years of unfavourable blight infection, the highest percentage of leaf tissue blighted was only 37% on susceptible plants. On the other hand, in the years of favourable infection, the susceptible, early maturing hybrids recorded 97% of leaf tissue blighted, the moderately, polygenic-resistant, intermediate maturing had 89%, and the chlorotic-lesion-resistant, late maturing had 27% of the blighted leaf area (Raymundo and Hooker, 1981). Grain yield losses in maize due to *turcicum* leaf blight has been reported to be 29-91% (Ullstrup, 1952). The most susceptible hybrids exhibited 30-35% leaf area blighted. While most of the hybrids were less severely infected under favourable weather conditions for the disease. Many inbreds, including the parents of the most susceptible hybrids showed blight infections of 35% or higher (Hooker, 1975).

In sorghum, resistant sources used as males and male-steriles used as females and their F_1 hybrids were evaluated for leaf blight reaction (Hepperly and Rios, 1987). Leaf blight susceptible females (recorded 2.4 lesions leaf $^{-1}$) showed significantly greater leaf blight than male resistant sources (recorded 0.4 lesions leaf $^{-1}$) and F_1 hybrids (recorded 0.9 lesions leaf $^{-1}$). Compared to male-steriles, F_1 hybrids and the resistant male sources showed 62 and 83% less leaf blight respectively. Increased association of seed astringency with resistant sources, decreased resistance and increased variability of F_1 hybrids for leaf blight suggest genetic factors other than a sole dominant resistant allele are influencing leaf blight reaction in sorghum.

In maize, the mean disease ratings for the parental lines ranged from 1.43 to 4.63 and from 1.36 to 4.38 for single crosses. The per cent of heterosis for crosses ranged from -14.35 to 157.34 and from -46.9 to 32.68 over their mid, lower and higher parents, respectively. Hughes and Hooker, 1971 reported that lines possessing intermediate resistance contributed to resistance in crosses.

2.3 GENETICS

Resistance or susceptibility to a disease may be governed either by a single (qualitative) gene or multiple (quantitative) genes. Qualitative genes are governed by one or few genes, less influenced by the environment and exhibit discontinuous variation, while the quantitative genes are governed by large number of genes each with a minor effect. Quantitative genes exhibit continuous variation and are highly influenced by the environment.

2.3.1 Qualitative Genes

Leaf blight resistance of the sorghum hybrids has been characterized by fewer lesions, low incubation period, and lower production of spores per lesion as compared with the susceptible hybrids (Barrera and Frederiksen, 1994).

The utilization of the generalized form of resistance suggests that this disease can be adequately and easily controlled by host resistance (Frederiksen, 1978). Muller (1959) viewed hypersensitivity as the resistant response of the host plant to infection by the pathogen. The rate and the extent of necrosis / hypersensitive reaction in leaf tissue appear to measure quantitatively the resistance to leaf blight (Tuleen and Frederiksen, 1977). Extent and the rate of fleck formation decreases with susceptibility and as each cultivar mature. This phenomenon is suggested as the basis of host plant resistance.

Hypersensitive resistance to *Exserohilum turcicum* in sorghum may be simply inherited and effective over a wide environmental range. Incorporating *Exsreohilum turcicum* resistance into hybrid parents reduces the risk of loss (Frederiksen *et al., 1975).* The hypersensitive reaction was characterized by the formation of the minute necrotic reddish-purple or yellowish-tan flecks within 2-3 days after inoculation. Flecks on resistant plants remained static without sporulation. *Helminthosporium turcicum* isolates from Johnson grass and sorghum produced only flecks on F_1 hybrids of resistant sorghum lines crossed to susceptible cytoplasmic male-sterile A-lines, suggesting a dominant gene(s) conditioning resistance. The F_2, F_3, and backcross populations demonstrated one or two genes conditioning resistance. Different BC_2 plants carrying one dominant gene from each of the Indian sorghum selections had similar hypersensitive reactions (Bergquist and Masias, 1973)

Snyder (1949-50) found susceptibility to be dominant in the F_1 and F_2, and the backcross data suggested that a single factor be involved in the inheritance of leaf blight in sudan grass.

Tarumoto and Isawa (1975) also studied the inheritance of resistance in the F_2 population of sorghum-sudangrass hybrid both under field and greenhouse conditions. They reported that resistance to leaf blight in the field is essentially controlled by a single dominant gene as the F_1 plants had about the same level of resistance as the most resistant parent and the majority of F_2 s are as resistant as F_1. On the other hand, in the greenhouse the F_1 distribution lay between the distribution of both the parents, while the F_2 distribution was closer to that of the resistant parent than that of F_1 indicating that resistance to leaf blight in the greenhouse is partially dominant. Further, the distribution of the F_2 s in the field and greenhouse suggest that a few minor or modifier genes may be involved along with the major gene in controlling resistance to leaf blight.

Tarumoto *et al.*, 1977 conducted an experiment to study the inheritance of leaf blight reaction in popular hybrid combinations and observed that all of the F_1 s, F_2 s, and backcrosses were resistant to *Helminthosporium turcicum*. No segregation was observed in the F_2 s of resistant x resistant parents. In F_2 s of resistant x susceptible parents, the segregation of resistant and susceptible plants fitted the expected ratio of 3:1 assuming a dominant monogenic inheritance. In the BC_2, the segregation of resistant and susceptible plants did not fit the expected ratio of 1:1 indicating the lack of field resistance in most of the BC_2 populations.

2.3.2 Quantitative Genes

The host-specific genes conditioning the hypersensitivity have been described by several workers (Frederiksen *et al.*, 1975 and Tuleen and Frederiksen, 1977) and Frederiksen *et al.* (1978) have provided some evidence to indicate that there are two major genes and some maternal factors conditioning resistance to leaf blight in sorghum. However, in maize, several hybrids when tested in reciprocal combinations showed similar disease reactions to *Helminthosporium turcicum* suggesting the absence of cytoplasmic effects (Hooker, 1975). Neither maternal nor reciprocal effects were significant for mean lesion area, rate of increase in lesion size and shape of lesion size (Sigulas *et al.*, 1988)

Drolsom (1954) observed that the inheritance of the leaf blight reaction in sudan grass is not simple and is governed by several factors. In the crosses between moderately resistant and resistant parents, few factors governed leaf blight reaction as the parental types were recovered in the progeny suggesting that a small number of genes are involved. However, the occurrence of plants more susceptible than either parent implied that different genes controlled resistance in the two parents, or that modifying factors are present. Further, in crosses between susceptible and resistant parents two groups were recovered. In the first group, F_1 plants were susceptible, but F_2 progenies were somewhat intermediate or susceptible. In the second group, all the plants in the F_1, F_2, and F_3 generations were susceptible indicating the presence of major genes for susceptibility in the female parent. They further suggested that changing environmental conditions from season to season and the probable occurrence of strains differing in pathogenicity could be the other variables involved in the inheritance of leaf blight reaction.

Tarumoto and Isawa (1972), reported that leaf blight resistance would be dominant in *Sorghum spp.* and the number of genes inheriting leaf blight resistance (dominant) would be at least three.

Resistant inbred lines in maize behave differently in their crosses with susceptible line; indicating genetic differences exist among them with respect to disease resistance. The F_1 plants and the F_2 s of susceptible x resistant cross are intermediate between the two parents in mean blight ratings. Similarly the differential reactions of three susceptible line with resistant lines indicate that resistance is controlled by large number of genes (Jenkins and Robert, 1952). Jenkins *et al.*, 1952 reported that the resistance to the leaf blight caused by *Helminthosporium turcicum* in maize is controlled by large number of genes. Most of these genes have minor effects and their effects are evident at high levels of disease incidence while, a few of them have major effects that are evident at low levels of disease incidence, and still others show their effect at widely different levels of disease incidence. Five resistant lines differed in their reaction with the highly susceptible line. Two lines showed dominant reaction with the susceptible line while the others have exhibited intermediate (one) and least dominant (two) reaction with the susceptible line.

In maize, both single-gene and multiple-gene resistance exist in host pathogen system. Monogenic resistance is expressed primarily in the form of lesion type and is a qualitative character. While, multiple-gene resistance is expressed primarily in the form of lesion number and is a quantitative character (Hooker, 1963). Chlorotic-lesion resistance, with delayed necrosis and inhibited fungus sporulation, expressed both by seedlings and older plants is simply inherited compared to necrotic lesions characterized by abundant fungus sporulation. Cross between resistant parents and the susceptible inbreds expressed chlorotic resistant-type lesions indicating that a single dominant gene with identical alleles condition resistance to *Helminthosporium turcicum.* The resistance of resistant inbreds (H95 and R177) was found to be dominant in hybrids (Hooker, 1975).

2.3.3 Combining Ability

The general combining ability (GCA) variance and the specific combining ability (SCA) variance are very significant for disease scale and three óther resistant factors (number and area of lesions, and amount of sporogenous per lesion area) indicating the importance of both additive and non-additive gene effects (Weiji *et al.*, 1956). They further reported that combining ability effects varied with the resistant types. For general combining ability, resistant lines showed negative effect, while susceptible lines showed positive effect. On the other hand, the negative effect of SCA usually occurred in crosses involving resistant and susceptible parents indicating that the resistance is partly dominant. Hughes and Hooker, 1971 reported the importance of additive, dominance, and epistatic gene actions in the leaf blight resistance. Additive effects are of major importance while the non-additive gene effects are variable in expression and were of smaller magnitude.

In maize, the GCA and SCA variances were highly significant. However, GCA variance was of higher magnitude than SCA variance. Both additive and dominance components were significant but the additive component was in greater proportion than the dominance component. The direction of positive dominance showed the dominance of susceptibility over resistance. The results from the heterosis studies, combining ability analysis, components of variance analysis and graphic analysis indicated that the gene action for leaf blight in maize was primarily additive, with partial dominance and without any interallelic interaction (Ramamurthy *et al.*, 1980).

Significant mean squares due to GCA and SCA were observed for reaction to leaf blight in maize whereas interaction of the combining abilities with environment showed non significant mean squares indicating the presence of significant variation due to GCA as well as SCA in the inheritance of resistance. The SCA component was found to be of greater importance than the GCA component in the inheritance of the disease.

Significant variation between parents was observed for mean lesion area in maize. The mean of the parents was significantly different from the mean of the hybrids for mean lesion area. GCA effects were also significant for mean lesion area. The greatest lesion area and the greatest increase in lesion area are observed in crosses with parent (R4) having no resistant factors. GCA means were greater than zero, and lesion area increased with time in crosses with the resistant parents. Significant SCA variation was observed for mean lesion size. Significant SCA effects were attributed to the observation that hybrids with R4 were more susceptible and hybrids with resistant and moderately resistant parents are more resistant than expected on the basis of respective parental averages. The SCA mean squares were smaller than their respective GCA mean squares indicating that GCA is the more important source of variation (Sigulas *et al.*, 1988).

2.4 CORRELATIONS

The disease scale, number of lesions or the product of lesion number, lesion area and amount of sporogenous per lesion area and resistance of F_1 hybrid are highly correlative indicating that the resistance of F_1 hybrids can be known by testing of the parental material (Weiji *et al.*, 1956). Lesion length was significantly correlated with %leaf area infected (r-0.78 and 0.95 at initial and final ratings period). The seedling and adult-plant lesion length exhibited non-significant positive correlation (0.24). Hybrids expressed more resistance to the disease as adult plants than as seedlings.

Area under the disease progress curve was highly correlated with the percentage yield loss in years of favourable disease infection. Significant correlation coefficient values of 0.89 and 0.97 were obtained for quintals per hectare and 500-kernel weight bases, respectively. However, in years of unfavourable disease infections, non-significant correlation coefficient values of 0.04 and -0.63 were recorded for quintals per hectare and 500-kernel weight bases, respectively (Raymundo and Hooker, 1981).

2.5 VARIABILITY OF RESISTANCE

In maize, broadsense estimates of heritability for disease score ranged from 40 to 70% indicating that selection would be reliable on individual plant phenotype (Hughes and Hooker, 1971).

Helminthosporium turcicum leaf blight in maize possessed higher PCV and GCV estimates for disease scores during two subsequent years suggesting that the selection based on this trait facilitates a successful isolation of resistant types. However, the differences between the two were narrow for two years indicating the greater role of genetic factors and the minor role of environmental factors further, indicating the expression of disease inheritance and offering greater scope for selection of desirable resistant parents. Higher GCV values coupled with higher heritability and genetic advance are reported for disease score (Satyanarayana, 1995). The higher genotypic variance to the leaf blight is due to the higher additive gene effects (Johnson *et al.*, 1955 and Panse, 1967).

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The present investigation was carried out with an objective of identifying hybrids having high yield potential and high level of resistance to leaf blight. The experiment was conducted under artificial disease epiphytotic conditions and evaluated for various disease resistant parameters along with yield and yield contributing characters for two consecutive seasons i.e., *rabi* 1996 and 1997, at ICRISAT-Patancheru, which is located at 545 m above the mean sea level and a latitude of 17° 32' N and a longitude of 78° 16' E. Weather data for the above two seasons is furnished in the Appendix.

3.1 MATERIALS

3.1.1 Experiment I

In the present study 20 CMS (cytoplasmic male-sterile i.e., A-lines) lines were crossed with six restorer (testers i.e., R-lines) lines in a line x tester fashion during *kharif* 1996 and *kharif* 1997 and the resultant 120 cross combinations (A x R) along with their respective parents and checks were sown in a RCBD replicated thrice during *rabi* 1996 and *rabi* 1997 to evaluate for leaf blight resistance under artificial disease epiphytotic conditions. The pedigree of the parental lines (CMS lines and restorers) included in the experiment is given in Table 1. The material (parental lines, crosses and checks) tested for the study is presented separately in Tables 2 and 3, respectively.

Table 1. Pedigree of different genotypes of sorghum included in the study.

Genotypes	Origin[1]	Pedigree
Lines		
SPLB 94001	SPLB 1008/36625	[(ICSB 26 x PM 1861)ICSB 88001 x ICSB 17)]1-1-2-1
SPLB 94003	SPLB 1006/36619	[(ICSB 26 x PM 1861)ICSB 22 x ICSB 45)(ICSB 52 x ICSB 51)]1-3-7-3
SPLB 94004	SPLB 1007/36623	[(ICSB 26 x PM 1861)ICSB 22 x ICSB 45)(ICSB 52 x ICSB 51)]1-3-12-3
SPLB 94006	SPLB 1026/36687	[(ICSB 26 x PM 1861)ICSB 22 x ICSB 45)(ICSB 52 x ICSB 51)]1-3-7-3
SPLB 94007	SPLB 1032/36705	[(ICSB 26 x PM 1861)ICSB 22 x ICSB 45)(ICSB 52 x ICSB 51)]1-3-12-2
SPLB 94009	SPLB 1021/36663	[(ICSB 26 x PM 1861)PM 2908)]-5
SPLB 94010	SPLB 1046/36747	[(IS 18417 x ICSB 11)ICSB 45)ICSB 30)]4-1-1-1
SPLB 94011	SPLB 1004/36611	[(ICSB 51 x PM 1861)]-2
SPLB 94012	SPLB 1023/36681	[(ICSB 102 x ICSV 7000]5-4-1-1-2-3
SPLB 94013	SPLB 1024/36683	(ICSB 102 x ICSV 700)5-4-1-1-2-4
SPLB 94014	SPLB 1025/36685	[(IS 23493 x SPV 351)MR 940)]8-2
SPLB 94015	SPLB 1041/36731	[(c 85-2 x CSV 11) MR 929]1-3-1-2-4
SPLB 94016	SPLB 1042/36733	[(ICSB 26 x PM 1861)ICSB 22 x ICSB 45)(ICSB 52 x ICSB 51)]1-3-12-3
SPLB 94017	SPLB 1009/36627	[(IS 18417 x ICSB 11)ICSB 45 x ICSB 30)]1-2-1-1
SPLB 94019	SPLB 1016/36647	[(IS 29016 x ICSB 26)]2
SPLB 94021	SPLB 1027/36689	[(ICSB 26 x PM 1861)ICSB 22 x ICSB 45)(ICSB 52 x ICSB 51)]1-3-7-3
SPLB 94022	SPLB 1017/36649	[(IS 29016 x ICSB 26)]1-1
SPLB 94024	SPLB 1008/36625	(IS 29016 x ICSB 26)1-2-2
SPLB 94025	SPLB 1034/36715	[(IS 18417 x ICSB 11)ICSB 45 x ICSB 30)]1-2-1-5
296B		IS 3922 x Karad Local
R-Lines		
A 2267-2		[US/R pop. Sel. X (CSV 4 x GPR 370)}-2-2-2-2
ICSR 26	MR-829	[(SPV 105 x IS 3443)]-1-5-3
ICSR 97	MR-901	[(IS 12645 x CSV 4) x IS 9327 desi]
ICSR 119	MR-924	[(SPV 475 x (IS 12611 x SC 108-3)]-4-8-4-2
ICSR 90030		(IS 33844 x M 35-1)-2
ICSR 91025		ICSV 725

1. Except 296B, all are bred at ICRISAT. 296B was developed at NRCS, Rajendranagar, Hyderabad.

Table 2. Material of sorghum included in the study during rabi season, 1996.

S.No	Genotypes	Disease reaction group[2]	S.No.	Genotypes	Disease reaction group[2]
	LINES		11	SPLB 94011A X ICSR 97	**R X MR**
1	SPLB 94004A	**R**	12	SPLB 94015A X ICSR 97	**R X MR**
2	SPLB 94007A	**R**	13	SPLB 94004A X ICSR 119	**R X LS**
3	SPLB 94009A	**R**	14	SPLB 94007A X ICSR 119	**R X LS**
4	SPLB 94010A	**R**	15	SPLB 94009A X ICSR 119	**R X LS**
5	SPLB 94011A	**R**	16	SPLB 94010A X ICSR 119	**R X LS**
6	SPLB 94015A	**R**	17	SPLB 94011A X ICSR 119	**R X LS**
7	SPLB 94003A	**MR**	18	SPLB 94015A X ICSR 119	**R X LS**
8	SPLB 94006A	**MR**	19	SPLB 94004A X ICSR 91025	**R X LS**
9	SPLB 94016A	**MR**	20	SPLB 94007A X ICSR 91025	**R X LS**
10	SPLB 94019A	**MR**	21	SPLB 94009A X ICSR 91025	**R X LS**
11	SPLB 94021A	**MR**	22	SPLB 94010A X ICSR 91025	**R X LS**
12	SPLB 94022A	**MR**	23	SPLB 94011A X ICSR 91025	**R X LS**
13	SPLB 94012A	**LS**	24	SPLB 94015A X ICSR 91025	**R X LS**
14	SPLB 94014A	**LS**	25	SPLB 94004A X ICSR 26	**R X S**
15	SPLB 94017A	**LS**	26	SPLB 94007A X ICSR 26	**R X S**
16	SPLB 94024A	**LS**	27	SPLB 94009A X ICSR 26	**R X S**
17	SPLB 94025A	**LS**	28	SPLB 94010A X ICSR 26	**R X S**
18	SPLB 94001A	**S**	29	SPLB 94011A X ICSR 26	**R X S**
19	SPLB 94013A	**S**	30	SPLB 94015A X ICSR 26	**R X S**
20	296A	**S**	31	SPLB 94004A X ICSR 90030	**R X S**
	TESTERS		32	SPLB 94007A X ICSR 90030	**R X S**
1	A 2267-2	**R**	33	SPLB 94009A X ICSR 90030	**R X S**
2	ICSR 97	**MR**	34	SPLB 94010A X ICSR 90030	**R X S**
3	ICSR 91025	**LS**	35	SPLB 94011A X ICSR 90030	**R X S**
4	ICSR 119	**LS**	36	SPLB 94015A X ICSR 90030	**R X S**
5	ICSR 26	**S**	37	SPLB 94003A X A 2267-2	**MR X R**
6	ICSR 90030	**S**	38	SPLB 94006A X A 2267-2	**MR X R**
	CROSSES		39	SPLB 94016A X A 2267-2	**MR X R**
1	SPLB 94004A X A 2267-2	**R x R**	40	SPLB 94019A X A 2267-2	**MR X R**
2	SPLB 94007A X A 2267-2	**R x R**	41	SPLB 94022A X A 2267-2	**MR X R**
3	SPLB 94009A X A 2267-2	**R x R**	42	SPLB 94021A X A 2267-2	**MR X R**
4	SPLB 94010A X A 2267-2	**R x R**	43	SPLB 94003A X ICSR 97	**MR X MR**
5	SPLB 94011A X A 2267-2	**R x R**	44	SPLB 94006A X ICSR 97	**MR X MR**
6	SPLB 94015A X A 2267-2	**R x R**	45	SPLB 94016A X ICSR 97	**MR X MR**
7	SPLB 94004A X ICSR 97	**R X MR**	46	SPLB 94019A X ICSR 97	**MR X MR**
8	SPLB 94007A X ICSR 97	**R X MR**	47	SPLB 94021A X ICSR 97	**MR X MR**
9	SPLB 94009A X ICSR 97	**R X MR**	48	SPLB 94022A X ICSR 97	**MR X MR**
10	SPLB 94010A X ICSR 97	**R X MR**	49	SPLB 94003A X ICSR 119	**MR X LS**

Contd..

S.No.	Genotypes	Disease reaction group[2]	S.No	Genotypes	Disease reaction group[2]
50	SPLB 94006A X ICSR 119	**MR X LS**	89	SPLB 94014A X ICSR 91025	**LS x LS**
51	SPLB 94016A X ICSR 119	**MR X LS**	90	SPLB 94017A X ICSR 91025	**LS x LS**
52	SPLB 94019A X ICSR 119	**MR X LS**	91	SPLB 94024A X ICSR 91025	**LS x LS**
53	SPLB 94021A X ICSR 119	**MR X LS**	92	SPLB 94025A X ICSR 91025	**LS x LS**
54	SPLB 94022A X ICSR 119	**MR X LS**	93	SPLB 94012A X ICSR 26	**LS X S**
55	SPLB 94003A X ICSR 91025	**MR X LS**	94	SPLB 94014A X ICSR 26	**LS X S**
56	SPLB 94006A X ICSR 91025	**MR X LS**	95	SPLB 94017A X ICSR 26	**LS X S**
57	SPLB 94016A X ICSR 91025	**MR X LS**	96	SPLB 94024A X ICSR 26	**LS X S**
58	SPLB 94019A X ICSR 91025	**MR X LS**	97	SPLB 94025A X ICSR 26	**LS X S**
59	SPLB 94021A X ICSR 91025	**MR X LS**	98	SPLB 94012A X ICSR 90030	**LS x S**
60	SPLB 94022A X ICSR 91025	**MR X LS**	99	SPLB 94014A X ICSR 90030	**LS X S**
61	SPLB 94003A X ICSR 26	**MR X S**	100	SPLB 94017A X ICSR 90030	**LS x S**
62	SPLB 94006A X ICSR 26	**MR X S**	101	SPLB 94024A X ICSR 90030	**LS x S**
63	SPLB 94016A X ICSR 26	**MR X S**	103	SPLB 94025A X ICSR 90030	**LS x S**
64	SPLB 94019A X ICSR 26	**MR X S**	104	SPLB 94001A X A 2267-2	**S X R**
65	SPLB 94021A X ICSR 26	**MR X S**	105	SPLB 94013A X A 2267-2	**S X R**
66	SPLB 94022A X ICSR 26	**MR X S**	106	296A X A 2267-2	**S X R**
67	SPLB 94003A X ICSR 90030	**MR X S**	107	SPLB 94001A X ICSR 97	**S X MR**
68	SPLB 94006A X ICSR 90030	**MR X S**	140	SPLB 94013A X ICSR 97	**S X MR**
69	SPLB 94016A X ICSR 90030	**MR X S**	108	296A X ICSR 97	**S X MR**
70	SPLB 94019A X ICSR 90030	**MR X S**	109	SPLB 94001A X ICSR 119	**S X LS**
71	SPLB 94021A X ICSR 90030	**MR X S**	110	SPLB 94013A X ICSR 119	**S X LS**
72	SPLB 94022A X ICSR 90030	**MR X S**	111	296A X ICSR119	**S X LS**
73	SPLB 94012A X A 2267-2	**LS X R**	112	SPLB 94001A X ICSR 91025	**S X LS**
74	SPLB 94014A X A 2267-2	**LS X R**	113	SPLB 94013A X ICSR 91025	**S X LS**
75	SPLB 94017A X A 2267-2	**LS X R**	114	296A X ICSR 91025	**S X LS**
76	SPLB 94024A X A 2267-2	**LS X R**	115	SPLB 94001A X ICSR 26	**S X S**
77	SPLB 94025A X A 2267-2	**LS X R**	116	SPLB 94013A X ICSR 26	**S X S**
78	SPLB 94012A X ICSR 97	**LS X MR**	143	296A X ICSR 26	**S X S**
79	SPLB 94014A X ICSR 97	**LS X MR**	118	SPLB 94001A X ICSR 90030	**S X S**
80	SPLB 94017A X ICSR 97	**LS X MR**	119	SPLB 94013A X ICSR 90030	**S X S**
81	SPLB 94024A X ICSR 97	**LS X MR**	120	296A X ICSR 90030	**S X S**
82	SPLB 94025A X ICSR 97	**LS X MR**		**CHECKS**	
83	SPLB 94012A X ICSR 119	**LS x LS**	1	M 35-1	**R**
84	SPLB 94014A X ICSR 119	**LS x LS**	2	ICSB 13	**R**
85	SPLB 94017A X ICSR 119	**LS x LS**	3	PM 1861	**R**
86	SPLB 94024A X ICSR 119	**LS x LS**	4	H 112	**S**
87	SPLB 94025A X ICSR 119	**LS x LS**	5	FSRP Local	**S**
88	SPLB 94012A X ICSR 91025	**LS x LS**	6	Kundi Jowar	**S**

1. The groups are based on the disease score

Table 3. Material of sorghum included in the study during rabi season, 1997.

S.No.	Genotypes	Disease reaction group[1]	S.No.	Genotypes	Disease reaction group[1]
	LINES		11	SPLB 94010A X ICSR 26	MR x MR
1	SPLB 94004A	MR	12	SPLB 94011A X ICSR 26	MR x MR
2	SPLB 94007A	MR	13	SPLB 94013A X ICSR 26	MR x MR
3	SPLB 94010A	MR	14	SPLB 94015A X ICSR 26	MR x MR
4	SPLB 94011A	MR	15	SPLB 94016A X ICSR 26	MR x MR
5	SPLB 94013A	MR	16	SPLB 94025A X ICSR 26	MR x MR
6	SPLB 94015A	MR	17	SPLB 94004A X ICSR 97	MR x MR
7	SPLB 94016A	MR	18	SPLB 94007A X ICSR 97	MR x MR
8	SPLB 94025A	MR	19	SPLB 94010A X ICSR 97	MR x MR
9	SPLB 94001A	LS	20	SPLB 94011A X ICSR 97	MR x MR
10	SPLB 94003A	LS	21	SPLB 94013A X ICSR 97	MR x MR
11	SPLB 94006A	LS	22	SPLB 94015A X ICSR 97	MR x MR
12	SPLB 94009A	LS	23	SPLB 94016A X ICSR 97	MR x MR
13	SPLB 94014A	LS	24	SPLB 94025A X ICSR 97	MR x MR
14	SPLB 94019A	LS	25	SPLB 94004A X ICSR 119	MR x S
15	SPLB 94021A	LS	26	SPLB 94007A X ICSR 119	MR x S
16	SPLB 94022A	LS	27	SPLB 94010A X ICSR 119	MR x S
17	SPLB 94024A	LS	28	SPLB 94011A X ICSR 119	MR x S
18	SPLB 94012A	S	29	SPLB 94013A X ICSR 119	MR x S
19	SPLB 94017A	S	30	SPLB 94015A X ICSR 119	MR x S
20	296A	S	31	SPLB 94016A X ICSR 119	MR x S
	TESTERS		32	SPLB 94025A X ICSR 119	MR x S
1	A 2267-2	R	33	SPLB 94004A X ICSR 90030	MR x S
2	ICSR 26	MR	34	SPLB 94007A X ICSR 90030	MR x S
3	ICSR 97	MR	35	SPLB 94010A X ICSR 90030	MR x S
4	ICSR 119	S	36	SPLB 94011A X ICSR 90030	MR x S
5	ICSR 90030	S	37	SPLB 94013A X ICSR 90030	MR x S
6	ICSR 91025	HS	38	SPLB 94015A X ICSR 90030	MR x S
	CROSSES		39	SPLB 94016A X ICSR 90030	MR x S
1	SPLB 94004A X A 2267-2	MR X R	40	SPLB 94025A X ICSR 90030	MR x S
2	SPLB 94007A X A 2267-2	MR X R	41	SPLB 94004A X ICSR 91025	MR x HS
3	SPLB 94010A X A 2267-2	MR X R	42	SPLB 94007A X ICSR 91025	MR x HS
4	SPLB 94011A X A 2267-2	MR X R	43	SPLB 94010A X ICSR 91025	MR x HS
5	SPLB 94013A X A 2267-2	MR X R	44	SPLB 94011A X ICSR 91025	MR x HS
6	SPLB 94015A X A 2267-2	MR X R	45	SPLB 94013A X ICSR 91025	MR x HS
7	SPLB 94016A X A 2267-2	MR X R	46	SPLB 94015A X ICSR 91025	MR x HS
8	SPLB 94025A X A 2267-2	MR X R	47	SPLB 94016A X ICSR 91025	MR x HS
9	SPLB 94004A X ICSR 26	MR x MR	48	SPLB 94025A X ICSR 91025	MR x HS
10	SPLB 94007A X ICSR 26	MR x MR	49	SPLB 94001A X A 2267-2	LS X R

S.No.	Genotypes	Disease reaction group[1]	S.No	Genotypes	Disease reaction group[1]
50	SPLB 94003A X A 2267-2	LS X R	89	SPLB 94014A X ICSR 90030	LS x S
51	SPLB 94006A X A 2267-2	LS X R	90	SPLB 94019A X ICSR 90030	LS x S
52	SPLB 94009A X A 2267-2	LS X R	91	SPLB 94021A X ICSR 90030	LS x S
53	SPLB 94014A X A 2267-2	LS X R	92	SPLB 94022A X ICSR 90030	LS x S
54	SPLB 94019A X A 2267-2	LS X R	93	SPLB 94024A X ICSR 90030	LS x S
55	SPLB 94021A X A 2267-2	LS X R	94	SPLB 94001A X ICSR 91025	LS x HS
56	SPLB 94022A X A 2267-2	LS X R	95	SPLB 94003A X ICSR 91025	LS x HS
57	SPLB 94024A X A 2267-2	LS X R	96	SPLB 94006A X ICSR 91025	LS x HS
58	SPLB 94001A X ICSR 26	LS x MR	97	SPLB 94009A X ICSR 91025	LS x HS
59	SPLB 94003A X ICSR 26	LS x MR	98	SPLB 94014A X ICSR 91025	LS x HS
60	SPLB 94006A X ICSR 26	LS x MR	99	SPLB 94019A X ICSR 91025	LS x HS
61	SPLB 94009A X ICSR 26	LS x MR	100	SPLB 94021A X ICSR 91025	LS x HS
62	SPLB 94014A X ICSR 26	LS x MR	101	SPLB 94022A X ICSR 91025	LS x HS
63	SPLB 94019A X ICSR 26	LS x MR	103	SPLB 94024A X ICSR 91025	LS x HS
64	SPLB 94021A X ICSR 26	LS x MR	104	SPLB 94012A X A 2267-2	S x R
65	SPLB 94022A X ICSR 26	LS x MR	105	SPLB 94017A X A 2267-2	S x R
66	SPLB 94024A X ICSR 26	LS x MR	106	296A X A 2267-2	S x R
67	SPLB 94001A X ICSR 97	LS x MR	107	SPLB 94012A X ICSR 26	S x MR
68	SPLB 94003A X ICSR 97	LS x MR	140	SPLB 94017A X ICSR 26	S x MR
69	SPLB 94006A X ICSR 97	LS x MR	108	296A X ICSR 26	S x MR
70	SPLB 94009A X ICSR 97	LS x MR	109	SPLB 94012A X ICSR 97	S x MR
71	SPLB 94014A X ICSR 97	LS x MR	110	SPLB 94017A X ICSR 97	S x MR
72	SPLB 94019A X ICSR 97	LS x MR	111	296A X ICSR 97	S x MR
73	SPLB 94021A X ICSR 97	LS x MR	112	SPLB 94012A X ICSR 119	S X S
74	SPLB 94022A X ICSR 97	LS x MR	113	SPLB 94017A X ICSR 119	S X S
75	SPLB 94024A X ICSR 97	LS x MR	114	296A X ICSR119	S X S
76	SPLB 94003A X ICSR 119	LS x S	115	SPLB 94012A X ICSR 90030	S X S
77	SPLB 94006A X ICSR 119	LS x S	116	SPLB 94017A X ICSR 90030	S X S
78	SPLB 94009A X ICSR 119	LS x S	143	296A X ICSR 90030	S X S
79	SPLB 94014A X ICSR 119	LS x S	118	SPLB 94012A X ICSR 91025	S x HS
80	SPLB 94019A X ICSR 119	LS x S	119	SPLB 94017A X ICSR 91025	S x HS
81	SPLB 94021A X ICSR 119	LS x S	120	296A X ICSR 91025	S x HS
82	SPLB 94001A X ICSR 119	LS x S		**CHECKS**	
83	SPLB 94022A X ICSR 119	LS x S	1	M 35-1	R
84	SPLB 94024A X ICSR 119	LS x S	2	ICSB 13	R
85	SPLB 94001A X ICSR 90030	LS x S	3	PM 1861	R
86	SPLB 94003A X ICSR 90030	LS x S	4	H 112	S
87	SPLB 94006A X ICSR 90030	LS x S	5	FSRP Local	S
88	SPLB 94009A X ICSR 90030	LS x S	6	Kundi Jowar	S

1. The groups are based on the disease score

3.1.2 Experiment 2

To study the maternal effects with B-lines, the above crosses were also effected by hand emasculation between cytoplasmic male-sterile maintainer (B) lines and R-lines in a line x tester design excluding three B-lines (SPLB 94012, SPLB 94013 and 296B) and the resultant 102 cross combinations (B x R) along with their respective parents and checks were sown in a split plot design replicated thrice during rabi 1997. In this experiment, genotypes were taken as main plot treatments and cytoplasms as sub plot treatments and evaluated for leaf blight resistance under artificial disease epiphytotic conditions.

For the above two experiments, recommended package of practices was followed to raise a healthy crop. Plot size in both the experiments consists of 2 rows of 4m length each (75 cm between rows and 12 cm within the row). Spraying with fungicides was avoided immediately after the inoculation to prevent its adverse effect on the spread of the inoculum. However, need based plant protection measures were taken up at the initial stages of the crop to safeguard the crop from the incidence of shoot fly. Highly susceptible entries such as Kundi Jowar and H 112 were planted in two rows each as infestor rows all round the field and after every 10 rows and 12 rows of the test material during first and second seasons, respectively.

3.2 METHODS

3.2.1 Inoculum Preparation

For artificial whorl–drop method of inoculation (Frederiksen and Franklin, 1978) in the field, the inoculum was prepared as follows. The leaves affected with leaf blight were collected from the field and cut into small pieces and surface sterilized with 0.1% mercuric chloride for one minute followed by washing with sterile distilled water. Leaf pieces were aseptically transferred to sterilized petri plates containing 20 ml of sterilized potato dextrose agar media (PDA) and incubated at 20°c for encouraging the fungal growth. The fungal growth was aseptically transferred to flasks containing sterilized sorghum grains and incubated at 20°c for 15 days so that the sorghum grains are covered with mycelia and the conidia of fungus colonized grains are removed from the flasks, allowed to airdry and separated as far as possible.

3.2.2 Inoculation

The pathogen, *Exserohilum turcicum* (Pass.), causing leaf blight disease in sorghum was artificially inoculated following whorl–drop method of inoculation (Frederiksen and Franklin, 1978). The first inoculation was carried out 21 and 30 days after emergence of coleoptile during *rabi* 1996 and 1997, respectively. The second inoculation was performed one week after the first inoculation. All the individual plants present in each entry were inoculated by placing two or three grains of seed inoculum in the whorl (Plate 1). After inoculation, high humid conditions were created by providing overhead sprinklers from the day after inoculation until the disease has spread i.e. upto 40 days from the day of inoculation (Plate 1).

3.3 OBSERVATIONS

Observations on following characters were taken for each plot:

3.3.1 Disease Damage Score (1-9)

Disease damage score (DDS) after the full development of the disease prior to the harvest was recorded based on the overall performance of the plants in the plot. Disease score (Plate 2) is given on 1 to 9 scale (Bandyopadhyay, 1997, personal communication).

Observations on disease resistant parameters like length, width and area of the lesion, number of lesions and number of flecks were taken either on flag leaf or one leaf below the flag leaf.

3.3.2 Length of the Lesion (cm)

Length of the lesion for all the lesions actually present on the leaf were measured on five randomly selected plants and averaged.

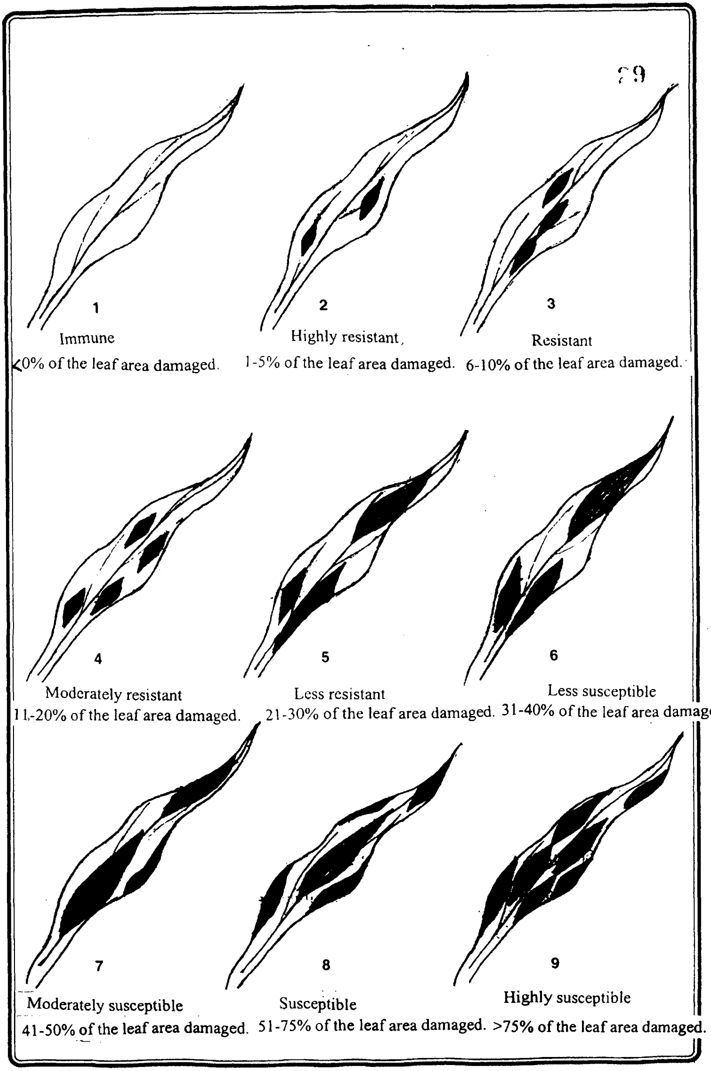
3.3.3 Width of the Lesion (cm)

Width of the lesion, at the broadest point, for all the lesions actually present on the leaf were measured on five randomly selected plants and averaged.

Plate 1. Whorl-drop method of inoculation

2a. Applying inoculum of the pathogen into the whorl of the host plant
2b. Inoculum in the whorl of the host plant after application
2c. Third day after inoculation (no disease symptom in the resistant genotype. A 2267-2)
2d. A week after inoculation (no disease symptom in the resistant genotype. A 2267-2)
2e. Sprinklers to augment the leaf blight pathogen

Plate 2. Disease damage visual score (score is 1 to 9)


1
Immune
<0% of the leaf area damaged.
2
Highly resistant,
1-5% of the leaf area damaged.
3
Resistant
6-10% of the leaf area damaged.
4
Moderately resistant
11-20% of the leaf area damaged.
5
Less resistant
21-30% of the leaf area damaged.
6
Less susceptible
31-40% of the leaf area damaged
7
Moderately susceptible
41-50% of the leaf area damaged.
8
Susceptible
51-75% of the leaf area damaged.
9
Highly susceptible
>75% of the leaf area damaged.

3.3.4 Area of the Lesion (cm^2)

Area of the lesion was calculated by multiplying length of the lesion with the width for all the lesions actually present on the leaf. Observations were recorded on five randomly selected plants and averaged.

3.3.5 Number of Lesions (no)

Total number of lesions actually present on the leaf was counted on five randomly selected plants and averaged. Leaves from five random plants, selected for taking observations on the length, width and area of the lesion, were used for recording observations on the lesion number.

3.3.5 Number of Flecks (no)

Total number of flecks, exhibiting hypersensitive reaction (Plate 3), present on the leaf was counted on five randomly selected plants and averaged. Leaves from five random plants, selected for taking observations on the length, width and area of the lesion, were used for recording observations on the fleck number.

3.3.6 Lodging(%)

Number of plants lodged due to disease and the percentage was calculated plotwise.

3.3.7 Days to 50% Flowering (days)

Number of days taken from sowing to 50% flowering.

Plate 3. Hypersensitive reaction of the disease (indicated by fleck without lesion development around it)

3.3.8 Plant Height (cm)

Height from the base of the plant to the tip of the panicle at maturity was measured.

3.3.9 Agronomic Score (1-5)

Line 296B parent was taken as standard since it possesses an earhead with good shape and size and the score was given accordingly to all the entries. Score is given on 1 (excellent) to 5 (poor) scale.

3.3.10 Grain Yield Plant^{-1} (g)

Earheads were harvested from five random plants and average grain yield plant^{-1} was calculated. The grain yield on A-line parents is due to the pollen from the neighbouring plants.

3.3.11 100 Seed Weight (g)

One hundred seeds were counted from each entry using seed counter and their weight was recorded

These observations were recorded for all the entries included in the Experiment I i.e. cytoplasmic male sterile lines (A) x restorer lines (R) during the first year. All the above observations excluding lodging were taken for both (A x R) hybrids and (B x R) crosses during the second year. In order to study epidemiology of the disease, detailed observations on latent period, average growth of the lesion, and sporulation capacity as the spread of the disease were recorded only on selected entries during the second year. The entries included in the experiment were chosen based on differential disease reaction, limiting one entry from each category. The following genotypes and their cross combinations are included for taking these observations:

Lines	**Testers**
SPLB 94007 A	A 2267-2 (resistant)
SPLB 94007 B	ICSR 90030 (susceptible)
SPLB 94011 A	
SPLB 94011 B	
SPLB 94025 A	
SPLB 94025 B	
296 A	

Crosses

SPLB 94007A x A 2267-2	SPLB 94007B x A 2267-2
SPLB 94007A x ICSR 90030	SPLB 94007B x ICSR 90030
SPLB 94011A x A 2267-2	SPLB 94011B x A 2267-2
SPLB 94011A x ICSR 90030	SPLB 94011B x ICSR 90030
SPLB 94025A x A 2267-2	SPLB 94025B x A 2267-2
SPLB 94025A x ICSR 90030	SPLB 94025B x ICSR 90030
296B x A 2267-2	296B x ICSR 90030

The following detailed plot wise observations were taken for all the selected entries during the second year.

3.3.12 Latent Period

Latent period is the time taken for the appearance of the first fleck. Observations were taken on the leaf, present in the whorl at the time of inoculation, from five randomly selected plants from each of the selected entry and the average values were computed.

3.3.14 Average Growth of the Lesion

Five fleck like spots were earmarked on the leaf, present in the whorl at the time of inoculation, on five randomly selected plants from each of the selected entry. Length and width of the lesion was measured on every alternate day and the overall average growth of the lesion was measured in cm^2.

3.3.15 Sporulation Capacity

Five samples of the lesion-affected areas were collected from five different leaves (preferably flag leaf) on five randomly selected plants from each entry. After the symptoms are fully developed on flag leaf or leaf next to flag leaf, affected leaves were selected and washed in sterile distilled water, then placed in a petri dish, and incubated at 22°c for 24h. After incubation, growth of the fungus was seen on the lesion-affected area. Spores suspension solution was prepared in a 100 µl of sterile distilled water. Spores adhering to the brush were removed by washing the brush with 50 µl of sterile distilled water. A drop of spore suspension was placed on a haemocytometer and the number of conidia present in the field was recorded under the microscope. For each sample, observations were recorded from five different fields and the average values were computed. The total number of conidia present in ml^{-3} was calculated.

3.4 STATISTICAL ANALYSIS

The data recorded on various disease resistant parameters, and yield and contributing characters were analysed for the following statistical procedures.

1. Analysis of variance to compare mean performance, determine gene action and estimate variability
2. Combining ability analysis to select superior parents and crosses
3. Estimation of heterosis to identify superior heterotic hybrids.
4. Correlations to study associations between and among various disease resistant parameters and yield contributing characters.
5. Split plot analysis to study the influence of maternal effects.

3.4.1 Analysis of Variance

Analysis of variance for each character was carried out as per the experimental design used. The significance of treatment differences was tested at five and one per cent level of probability.

3.4.2 Combining Ability Analysis

The combining ability analysis was carried out following the line x tester model suggested by Kempthorne (1957). The covariance of full sibs and half sibs was used to obtain estimates of general combining ability (GCA) and specific combining ability (SCA).

3.4.3 Estimation of Heterosis

Heterosis is expressed as per cent increase or decrease of F_1 hybrid over the mid parent, while heterobeltiosis is expressed as per cent increase or decrease of F_1 hybrid over the better parent. It is estimated according to the formula suggested by Hayes *et al.*. (1955). The significance of heterosis was tested by a t-statistic as per the formula suggested by Arunachalam (1980).

3.4.4 Correlation

Simple correlation coefficients between different variables were calculated by using the statistical procedures outlined by Singh and Chaudhary (1977) and their significance was tested by referring to the "r" table values (Fisher and Yates, 1963) at n-2 degrees of freedom.

3.4.5 Estimation of Genetic Parameters

3.4.5.1 Phenotypic and Genotypic Variance. These were estimated according to the method given by Lush (1940).

$$\text{Genotypic variance } (\sigma^2 g) = \frac{Mt-E}{r}$$

$$\text{Phenotypic variance } (\sigma^2 p) = \sigma^2 g + \sigma^2 e$$

Where,

Mt = Mean sum of squares of treatments

E = Mean sum of squares for error

r = Number of replications

3.4.5.2 Phenotypic and Genotypic Coefficient of Variation (PCV and GCV). These were computed according to the formula given by Burton (1952).

$$PCV = \frac{(\text{Phenotypic variance})^{1/2}}{\text{Grand Mean}} \times 100$$

$$GCV = \frac{(\text{Genotypic variance})^{1/2}}{\text{Grand Mean}} \times 100$$

3.4.5.3 Heritability (H). Heritability in broad sense (H), is the ratio of genetic variance to the total variance (phenotypic variance) and was calculated by the formula suggested by Lush (1940) and expressed in percentage.

$$\text{Heritability in broad sense (H)} = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

where,

H = Heritability (%) in broad sense

$\sigma^2 g$ = Genotypic variance

$\sigma^2 p$ = Phenotypic variance

3.4.5.4 Genetic Advance. This was worked out based on the formula given by Johnson *et al.* (1955)

$$\text{Genetic advance (GA)} = \sigma_P \times H \times K$$

where,

σ_P = Phenotypic standard deviation

H = Heritability in broad sense

K = Selection differential at 5% selection intensity (2.06)

$$\text{Genetic advance as per cent of mean} = \frac{GA}{\text{Grand Mean}} \times 100$$

Results

CHAPTER IV

RESULTS

The data collected on 12 characters [disease damage score (1-9 scale), length of the lesion (cm), width of the lesion (cm), area of the lesion (cm^2), number of lesions (no), number of flecks (no), lodging (%), days to 50% flowering (days), plant height (cm), agronomic score for earhead shape and size (1-5 scale), grain yield plant^{-1} (g) and 100 seed weight (g)] during the first year and on 11 characters (all the above characters excluding lodging) in the second year for A x R hybrids were utilized for comparing mean performances, estimating variations, combining ability effects, heterosis and correlation. The data collected on the above eleven characters for both (A x R) hybrids and (B x R) crosses during the second year were utilized to study the influence of maternal effects using split plot analysis. The data on number of plants lodged against total plant stand was presented for the first year only as there was no lodging in the second year. High per cent of lodging observed in the first year may be attributed to disease incidence, large soil heterogeneity, and occurrence of heavy winds at crop maturity which resulted in high coefficient of variation. The results obtained in the present investigation were briefly presented below.

4.1 EFFECTS OF GENOTYPES, VARIANCE DUE TO GENOTYPES (G), YEARS (Y) AND G X Y

The results of analysis of variance showed significant difference among the genotypes at 1% level of significance for all the characters studied during *rabi* 1996 (Table 4) and *rabi* 1997 (Table 5), respectively.

Table 4. Analysis of variance for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1996.

Characteristic	Replication mean squares d.f. = 2	Treatment mean squares d.f. = 151	Error mean squares d.f. = 302
DISEASE PARAMETERS			
Disease score[1]	0.27	5.60**	0.520
Length of the lesion (cm)	3.80	3.35**	0.970
Width of the lesion (cm)	0.02	0.01**	0.001
Area of the lesion (cm^2)	0.23	0.51**	0.020
Number of lesions (no)	11.59	107.30**	1.230
Number of flecks (no)	317.80	23363.70**	381.300
Lodging (%)	2234.60	952.80**	219.300
GRAIN YIELD COMPONENTS			
Days to 50% flowering (days)	27.11	56.72**	4.750
Plant height (cm)	3.26	1752.60**	25.020
Agronomic score[2]	0.74	1.03**	0.320
Grain yield $plant^{-1}$ (g)	15.46	180.25**	15.540
100 seed weight (g)	0.39	0.34**	0.040

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
**** Significant at 1%.**
*** Significant at 5%.**

Table 5. Analysis of variance for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1997.

Characteristic	Replication mean squares d.f. = 2	Treatment mean squares d.f. = 151	Error mean squares d.f. = 302
DISEASE PARAMETERS			
Disease score[1]	10.6300	3.110**	0.440
Length of the lesion (cm)	0.0630	3.151**	0.176
Width of the lesion (cm)	0.0004	0.017**	0.002
Area of the lesion (cm^2)	0.0050	0.861**	0.050
Number of lesions (no)	0.9940	30.474**	0.662
Number of flecks (no)	870.8210	98406.737**	1439.370
GRAIN YIELD COMPONENTS			
Days to 50% flowering (days)	5.8090	57.046**	1.160
Plant height (cm)	142.1700	4528.520**	40.420
Agronomic score[2]	5.7500	1.650**	0.280
Grain yield $plant^{-1}$ (g)	1.8600	308.630**	5.020
100 seed weight (g)	0.0200	0.510**	0.030

1. Scored on a (1-9) scale.

2. Scored on a (1-5) scale.

**** Significant at 1%.**

*** Significant at 5%.**

The results of the pooled analysis of variance for all the entries i.e., A x R hybrids for two consecutive years revealed non-significant difference among the years and significant difference among the genotypes and year x genotype interaction at both levels of significance. Though years were found non-significant, and year x genotype interaction was significant, since the error degrees of freedom was only 4, the grouping of genotypes based on the disease damage score was handled separately for two consecutive years. The genotypes were therefore grouped into various disease reaction (score) groups separately for each year taking standard deviation into consideration and the list of the genotypes grouped on the basis of disease damage score are given separately in Table 2 for *rabi* 1996 and Table 3 for *rabi* 1997, respectively.

Highly resistant (HR)	$= < (\bar{x} - 2\ S.D.)$
Resistant (R)	$= (\bar{x} - 2\ S.D.)$ to $(\bar{x} - S.D.)$
Moderately resistant (MR)	$= (\bar{x} - S.D.)$ to $(\bar{x})$
Less susceptible (LS)	$= (\bar{x})$ to $(\bar{x} + S.D.)$
Susceptible (S)	$= (\bar{x} + S.D.)$ to $(\bar{x} + 2\ S.D.)$
Highly susceptible (HS)	$= > (\bar{x} + 2\ S.D.)$

Where S.D. = Standard Deviation; $\bar{x}$ = Mean of the trial.

4.2 MEAN PERFORMANCE

The mean performance of all the genotypes included in the study for all the characters under consideration including disease reaction groups based on their respective characters are given separately in Table 6 and 8 for *rabi* 1996 and Table 7 and 9 for *rabi* 1997, respectively.

Length and width of the lesion, area of the lesion, number of lesions, number of flecks and lodging are the major components of plant response to disease infection. Disease damage score is considered to embrace or integrate all the components of the plant response. However, it is clear that the grouping based on the disease damage score was different from those formed on the basis of the components. Again among the disease components, the groupings were different.

4.2.1 Disease Damage Score

On the basis of the disease damage score, the parental lines and the hybrids were classified into different disease reaction groups like highly resistant (HR_{ds}), resistant (R_{ds}), moderately resistant (MR_{ds}), less susceptible (LS_{ds}), susceptible (S_{ds}) and highly susceptible (HS_{ds}).

4.2.1.1 Reaction of the Parents

Studies in the first year indicated that among the A-lines SPLB 94004A, SPLB 94007A, SPLB 94009A, SPLB 94010A, SPLB 94011A and SPLB 94015A fall in R_{ds} group. While six genotypes (SPLB 94003A, SPLB 94006A, SPLB 94016A, SPLB 94019A, SPLB 94021A and SPLB 94022A) fall in MR_{ds} group. On the other hand, five genotypes (SPLB 94012A, SPLB 94017A, SPLB 94014A, SPLB 94024A and SPLB 94025A) fall in LS_{ds} group; and SPLB 94001A, SPLB 94013A and 296A were found S_{ds} taking the above criterion into consideration. Similarly among R-lines, A 2267-2 and ICSR 97 fall in R_{ds} and MR_{ds} groups, respectively. While, the other two genotypes fall each in LS_{ds} and S_{ds} group (Table 6).

Table 6. Mean performance of different genotypes of sorghum for various disease resistant parameters, rabi season 1996.

Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
LINES												
Resistant (R[2])												
SPLB 94004A	3.3	R	4.62	S	0.43	HS	2.00	HS	1.3	HR	26.80	HR
SPLB 94007A	3.3	R	1.32	MR	0.25	LS	0.34	MR	3.1	HR	31.53	HR
SPLB 94009A	3.3	R	0.88	MR	0.18	MR	0.16	R	6.8	MR	54.03	HR
SPLB 94010A	3.0	R	1.12	MR	0.14	R	0.11	R	7.3	MR	43.80	HR
SPLB 94011A	2.7	R	0.81	MR	0.15	R	0.12	R	9.2	LS	78.60	R
SPLB 94015A	3.3	R	2.28	LS	0.32	S	0.74	S	1.9	HR	21.47	HR
Moderately Resistant (MR[2])												
SPLB 94003A	5.0	MR	0.39	MR	0.14	R	0.06	R	12.0	S	81.60	R
SPLB 94006A	4.7	MR	8.14	HS	0.18	MR	0.27	MR	7.3	MR	54.87	HR
SPLB 94016A	4.3	MR	4.15	S	0.37	HS	1.54	HS	1.0	HR	48.40	HR
SPLB 94019A	5.0	MR	3.10	LS	0.30	S	0.92	S	7.1	MR	207.53	HS
SPLB 94021A	4.7	MR	1.33	MR	0.18	MR	0.25	MR	4.5	HR	28.13	HR
SPLB 94022A	5.0	MR	1.82	MR	0.25	LS	0.47	LS	3.2	HR	12.20	HR
Less Susceptible (LS[2])												
SPLB 94012A	5.7	LS	1.89	LS	0.23	LS	0.43	MR	7.3	MR	40.43	HR
SPLB 94014A	6.3	LS	3.22	LS	0.30	S	0.96	HS	5.1	R	50.47	HR
SPLB 94017A	6.0	LS	0.92	MR	0.15	R	0.14	R	15.5	HS	35.27	HR
SPLB 94024A	6.0	LS	0.93	MR	0.15	R	0.14	R	21.8	HS	75.33	R
SPLB 94025A	6.0	LS	2.06	LS	0.25	LS	0.52	LS	6.9	MR	70.67	R
Susceptible (S[2])												
SPLB 94001A	6.7	S	1.89	LS	0.22	MR	0.42	MR	12.9	HS	171.37	S
SPLB 94013A	7.3	S	2.09	LS	0.27	LS	0.57	LS	5.1	R	22.93	HR
296A	7.7	S	1.40	MR	0.19	MR	0.27	MR	8.4	MR	53.33	HR

Contd..

Contd..

Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
TESTERS												
Resistant (R[2])												
A 2267-2	3.0	R	1.55	MR	0.23	LS	0.35	MR	4.8	R	45.03	HR
Moderately Resistant (MR[2])												
ICSR 97	4.7	MR	1.69	MR	0.18	MR	0.30	MR	8.5	MR	58.80	HR
Less Susceptible (LS[2])												
ICSR 119	6.3	LS	1.38	MR	0.19	MR	0.26	MR	7.0	MR	42.70	HR
ICSR 91025	6.0	LS	2.59	LS	0.27	LS	0.70	S	6.1	R	49.60	HR
Susceptible (S[2])												
ICSR 26	7.3	S	1.74	MR	0.24	LS	0.42	MR	8.9	LS	129.07	MR
ICSR 90030	8.0	S	3.80	S	0.25	LS	0.98	HS	5.8	R	51.03	HR
CROSSES												
R x R												
SPLB 94004A X A 2267-2	4.0	MR	1.55	MR	0.20	MR	0.30	MR	1.8	HR	22.87	HR
SPLB 94007A X A 2267-2	3.3	R	0.68	MR	0.15	R	0.10	R	5.6	R	121.43	MR
SPLB 94009A X A 2267-2	4.0	MR	1.19	MR	0.17	MR	0.20	R	3.2	HR	23.57	HR
SPLB 94010A X A 2267-2	3.3	R	0.42	MR	0.13	R	0.06	R	25.2	HS	381.53	HS
SPLB 94011A X A 2267-2	3.0	R	0.35	MR	0.11	R	0.04	R	17.5	HS	104.53	MR
SPLB 94015A X A 2267-2	4.7	MR	2.37	LS	0.33	S	0.80	S	4.1	HR	44.20	HR
R x MR												
SPLB 94004A X ICSR 97	3.3	R	1.25	MR	0.22	MR	0.28	MR	3.6	HR	86.17	R
SPLB 94007A X ICSR 97	2.7	R	0.74	MR	0.15	R	0.11	R	3.6	HR	81.40	R
SPLB 94009A X ICSR 97	2.3	HR	1.05	MR	0.18	MR	0.19	R	7.4	MR	105.93	MR
SPLB 94010A X ICSR 97	3.0	R	0.68	MR	0.15	R	0.10	R	19.0	HS	350.07	HS
SPLB 94011A X ICSR 97	2.3	HR	1.14	MR	0.17	MR	0.19	R	6.1	R	74.80	R
SPLB 94015A X ICSR 97	5.7	LS	1.90	LS	0.24	LS	0.45	MR	3.9	HR	80.77	R

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Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
R x LS												
SPLB 94004A X ICSR 91025	6.0	LS	3.67	S	0.51	HS	1.87	HS	5.5	R	177.70	S
SPLB 94007A X ICSR 91025	3.3	R	1.68	MR	0.22	MR	0.37	MR	1.9	HR	54.33	HR
SPLB 94009A X ICSR 91025	2.7	R	1.45	MR	0.18	MR	0.26	MR	4.8	R	142.53	LS
SPLB 94010A X ICSR 91025	5.0	MR	1.58	MR	0.33	LS	0.51	LS	3.8	HR	92.80	R
SPLB 94011A X ICSR 91025	4.7	MR	0.71	MR	0.15	R	0.12	R	14.2	HS	190.27	S
SPLB 94015A X ICSR 91025	5.0	MR	1.90	LS	0.29	LS	0.55	LS	2.4	HR	43.80	HR
SPLB 94004A X ICSR 119	5.0	MR	2.62	LS	0.32	S	0.85	S	3.6	HR	41.57	HR
SPLB 94007A X ICSR 119	4.3	MR	1.61	MR	0.24	LS	0.38	MR	2.7	HR	36.20	HR
SPLB 94009A X ICSR 119	4.7	MR	1.89	LS	0.24	LS	0.45	MR	9.1	LS	234.53	HS
SPLB 94010A X ICSR 119	6.7	S	1.18	MR	0.20	MR	0.23	R	13.3	HS	411.20	HS
SPLB 94011A X ICSR 119	4.3	MR	1.81	MR	0.22	MR	0.41	MR	15.2	HS	340.70	HS
SPLB 94015A X ICSR 119	6.3	LS	3.60	S	0.30	S	1.08	HS	2.3	HR	63.87	HR
R x S												
SPLB 94004A X ICSR 26	4.7	MR	2.30	LS	0.22	MR	0.51	LS	6.9	MR	57.57	HR
SPLB 94007A X ICSR 26	5.0	MR	1.83	MR	0.25	LS	0.45	MR	4.1	HR	119.00	MR
SPLB 94009A X ICSR 26	5.3	LS	1.18	MR	0.20	MR	0.24	MR	9.7	LS	153.77	LS
SPLB 94010A X ICSR 26	5.7	LS	1.34	MR	0.22	MR	0.29	MR	6.4	R	164.83	LS
SPLB 94011A X ICSR 26	4.3	MR	2.27	LS	0.31	S	0.70	S	3.4	HR	80.43	R
SPLB 94015A X ICSR 26	5.3	LS	2.07	LS	0.34	S	0.71	S	3.0	HR	132.13	MR
SPLB 94004A X ICSR 90030	6.3	LS	3.72	S	0.32	S	1.20	HS	3.8	HR	126.00	MR
SPLB 94007A X ICSR 90030	4.7	MR	2.22	LS	0.25	LS	0.57	LS	6.4	R	115.27	MR
SPLB 94009A X ICSR 90030	5.7	LS	2.22	LS	0.23	LS	0.51	LS	12.9	HS	137.67	LS
SPLB 94010A X ICSR 90030	5.0	MR	2.95	LS	0.42	HS	1.25	HS	6.8	MR	210.00	HS
SPLB 94011A X ICSR 90030	5.3	LS	1.30	MR	0.23	LS	0.30	MR	7.6	MR	152.27	LS
SPLB 94015A X ICSR 90030	5.0	MR	0.50	MR	0.21	MR	0.11	R	1.9	HR	14.87	HR
MR x R												
SPLB 94003A X A 2267-2	5.0	MR	1.26	MR	0.23	LS	0.29	MR	30.4	HS	382.47	HS

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Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94006A X A 2267-2	5.3	LS	1.56	MR	0.21	MR	0.34	MR	3.2	HR	41.17	HR
SPLB 94016A X A 2267-2	4.3	MR	1.78	MR	0.22	MR	0.40	MR	4.7	HR	44.20	HR
SPLB 94019A X A 2267-2	4.7	MR	2.36	LS	0.24	LS	0.56	LS	6.7	MR	218.87	HS
SPLB 94021A X A 2267-2	5.7	LS	0.76	MR	0.16	MR	0.12	R	18.5	HS	243.30	HS
SPLB 94022A X A 2267-2	5.0	MR	2.27	LS	0.31	S	0.09	R	4.9	R	132.00	MR
MR x MR												
SPLB 94003A X ICSR 97	4.7	MR	2.44	LS	0.26	LS	0.64	LS	5.3	R	101.93	MR
SPLB 94006A X ICSR 97	4.3	MR	1.31	MR	0.19	MR	0.24	MR	3.5	HR	74.33	R
SPLB 94016A X ICSR 97	2.7	R	1.16	MR	0.17	MR	0.19	R	10.0	LS	185.03	S
SPLB 94019A X ICSR 97	3.0	R	0.79	MR	0.14	R	0.11	R	4.9	R	94.27	R
SPLB 94021A X ICSR 97	3.0	R	1.25	MR	0.18	MR	0.24	MR	9.5	LS	197.33	S
SPLB 94022A X ICSR 97	3.3	R	0.93	MR	0.16	MR	0.15	R	4.9	R	56.07	HR
MR x LS												
SPLB 94003A X ICSR 91025	4.7	MR	1.98	LS	0.24	LS	0.48	LS	5.5	R	260.93	HS
SPLB 94006A X ICSR 91025	4.7	MR	1.69	MR	0.24	LS	0.41	MR	5.2	R	78.00	R
SPLB 94016A X ICSR 91025	4.7	MR	1.85	LS	0.22	MR	0.41	MR	8.5	MR	185.77	S
SPLB 94019A X ICSR 91025	5.3	LS	1.72	MR	0.22	MR	0.40	MR	6.5	R	141.67	LS
SPLB 94021A X ICSR 91025	6.0	LS	1.77	MR	0.22	MR	0.39	MR	5.4	R	33.07	HR
SPLB 94022A X ICSR 91025	5.3	LS	1.43	MR	0.24	LS	0.34	MR	8.4	MR	171.33	S
SPLB 94003A X ICSR 119	7.0	S	0.88	MR	0.20	MR	0.18	R	13.1	HS	217.33	HS
SPLB 94006A X ICSR 119	4.7	MR	1.34	MR	0.22	MR	0.29	MR	2.0	HR	23.20	HR
SPLB 94016A X ICSR 119	4.0	MR	2.82	LS	0.25	LS	0.69	LS	19.0	HS	175.53	S
SPLB 94019A X ICSR 119	4.7	MR	2.62	LS	0.27	LS	0.71	S	8.3	MR	210.53	HS
SPLB 94021A X ICSR 119	6.0	LS	2.05	LS	0.25	LS	0.53	LS	13.0	HS	157.93	LS
SPLB 94022A X ICSR 119	4.3	MR	1.52	MR	0.19	MR	0.28	MR	9.1	LS	66.93	R
MR x S												
SPLB 94003A X ICSR 26	5.7	LS	1.63	MR	0.20	MR	0.33	MR	9.6	LS	166.00	LS
SPLB 94006A X ICSR 26	6.0	LS	1.36	MR	0.18	MR	0.26	MR	12.7	HS	155.00	LS

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Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94016A X ICSR 26	5.0	MR	1.13	MR	0.20	MR	0.22	R	7.4	MR	164.73	LS
SPLB 94019A X ICSR 26	5.7	LS	1.38	MR	0.20	MR	0.29	MR	8.1	MR	157.00	LS
SPLB 94021A X ICSR 26	6.0	LS	1.17	MR	0.22	MR	0.25	MR	8.7	LS	86.70	R
SPLB 94022A X ICSR 26	4.3	MR	2.59	LS	0.26	LS	0.68	LS	11.6	S	171.03	S
SPLB 94003A X ICSR 90030	5.7	LS	0.76	MR	0.23	MR	0.17	R	15.0	HS	133.10	MR
SPLB 94006A X ICSR 90030	6.0	LS	1.58	MR	0.22	MR	0.35	MR	9.2	LS	84.07	R
SPLB 94016A X ICSR 90030	4.7	MR	1.31	MR	0.20	MR	0.27	MR	8.5	MR	276.13	HS
SPLB 94019A X ICSR 90030	5.0	MR	3.13	LS	0.32	LS	1.03	HS	5.4	R	182.20	S
SPLB 94021A X ICSR 90030	7.0	S	1.60	MR	0.26	MR	0.43	MR	4.9	R	72.60	R
SPLB 94022A X ICSR 90030	6.7	S	2.03	LS	0.26	LS	0.53	LS	16.1	HS	151.87	LS
LS x R												
SPLB 94012A X A 2267-2	4.7	MR	1.58	MR	0.14	MR	0.22	R	5.5	R	69.80	R
SPLB 94014A X A 2267-2	4.3	MR	2.20	LS	0.27	LS	0.60	LS	7.4	MR	167.33	S
SPLB 94017A X A 2267-2	3.7	R	0.60	MR	0.15	R	0.09	R	10.5	LS	28.67	HR
SPLB 94024A X A 2267-2	5.3	LS	0.59	MR	0.15	R	0.24	MR	26.1	HS	268.93	HS
SPLB 94025A X A 2267-2	4.7	MR	1.18	MR	0.21	MR	0.15	R	14.0	HS	191.93	S
LS x MR												
SPLB 94012A X ICSR 97	4.7	MR	1.44	MR	0.22	MR	0.32	MR	2.3	HR	145.17	LS
SPLB 94014A X ICSR 97	5.0	MR	2.27	LS	0.31	S	0.71	S	4.9	R	132.00	MR
SPLB 94017A X ICSR 97	3.3	R	1.47	MR	0.18	MR	0.26	MR	18.0	HS	139.40	LS
SPLB 94024A X ICSR 97	4.0	MR	1.38	MR	0.17	MR	0.24	MR	8.5	MR	144.40	LS
SPLB 94025A X ICSR 97	6.3	LS	0.83	MR	0.18	MR	0.15	R	17.4	HS	276.93	HS
LS x LS												
SPLB 94012A X ICSR 91025	5.7	LS	1.85	LS	0.25	LS	0.47	LS	5.8	R	86.20	R
SPLB 94014A X ICSR 91025	6.7	S	2.19	LS	0.25	LS	0.57	LS	4.4	HR	134.00	LS
SPLB 94017A X ICSR 91025	5.7	LS	2.41	LS	0.27	LS	0.66	LS	3.9	HR	42.93	HR
SPLB 94024A X ICSR 91025	4.7	MR	1.40	MR	0.23	LS	0.32	MR	10.3	LS	233.40	HS
SPLB 94025A X ICSR 91025	7.0	S	1.47	MR	0.17	MR	0.25	MR	12.0	S	250.13	HS

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Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94012A X ICSR 119	5.7	LS	1.76	MR	0.25	LS	0.43	MR	8.1	MR	131.40	MR
SPLB 94014A X ICSR 119	6.0	LS	1.82	MR	0.23	LS	0.42	MR	6.9	MR	230.40	HS
SPLB 94017A X ICSR 119	4.3	MR	2.39	LS	0.26	LS	0.63	LS	6.5	R	154.60	LS
SPLB 94024A X ICSR 119	5.3	LS	1.97	LS	0.22	MR	0.44	MR	18.8	HS	218.27	HS
SPLB 94025A X ICSR 119	6.0	LS	3.40	LS	0.31	S	1.05	HS	7.8	MR	165.63	LS
LS x S												
SPLB 94012A X ICSR 26	7.7	HS	2.73	LS	0.29	LS	0.80	S	6.7	MR	119.40	MR
SPLB 94014A X ICSR 26	7.0	S	2.16	LS	0.34	S	0.73	S	6.5	R	157.93	R
SPLB 94017A X ICSR 26	5.3	LS	1.57	MR	0.21	MR	0.34	MR	3.9	HR	80.33	R
SPLB 94024A X ICSR 26	6.0	LS	1.23	MR	0.20	MR	0.24	MR	14.8	HS	150.97	LS
SPLB 94025A X ICSR 26	6.7	S	3.88	S	0.37	HS	1.43	HS	8.0	MR	149.90	LS
SPLB 94012A X ICSR 90030	7.0	S	1.45	MR	0.22	MR	0.32	MR	3.4	HR	203.47	HS
SPLB 94014A X ICSR 90030	6.3	LS	1.85	LS	0.32	S	0.59	LS	8.4	MR	180.77	MR
SPLB 94017A X ICSR 90030	6.0	LS	1.55	MR	0.21	MR	0.33	MR	7.7	MR	141.20	LS
SPLB 94024A X ICSR 90030	7.0	S	1.60	MR	0.19	MR	0.31	MR	5.1	R	240.57	HS
SPLB 94025A X ICSR 90030	7.7	HS	3.50	LS	0.34	S	1.21	HS	7.8	MR	325.90	HS
S x R												
SPLB 94001A X A 2267-2	3.7	R	1.99	LS	0.18	MR	0.36	MR	7.0	MR	47.67	HR
SPLB 94013A X A 2267-2	5.3	LS	0.83	MR	0.18	R	0.15	R	4.6	HR	81.80	R
296A X A 2267-2	6.0	LS	1.03	MR	0.17	R	0.18	R	20.7	HS	258.53	HS
S x MR												
SPLB 94001A X ICSR 97	3.3	R	0.73	MR	0.14	R	0.11	R	13.0	HS	91.73	R
SPLB 94013A X ICSR 97	3.3	R	0.94	MR	0.17	R	0.16	R	3.1	HR	64.13	HR
296A X ICSR 97	6.0	LS	2.78	LS	0.23	LS	0.66	LS	4.3	HR	49.60	MR
S x LS												
SPLB 94001A X ICSR 91025	5.0	MR	1.80	MR	0.17	MR	0.31	MR	5.6	R	87.20	R
SPLB 94013A X ICSR 91025	5.7	LS	2.26	LS	0.25	LS	0.57	LS	1.5	HR	40.60	HR
296A X ICSR 91025	7.0	S	2.16	LS	0.27	LS	0.59	LS	10.1	LS	164.40	LS

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Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94001A X ICSR 119	7.0	S	1.57	MR	0.30	S	0.47	LS	6.7	MR	196.13	S
SPLB 94013A X ICSR 119	6.3	LS	1.39	MR	0.16	MR	0.23	R	7.5	MR	45.77	HR
296A X ICSR 119	6.3	LS	2.04	LS	0.24	LS	0.48	LS	11.0	S	179.40	S
S x S												
SPLB 94001A X ICSR 26	6.0	LS	1.29	MR	0.19	MR	0.25	MR	5.7	R	59.23	R
SPLB 94013A X ICSR 26	5.3	LS	1.24	MR	0.15	R	0.18	R	11.0	S	258.60	S
296A X ICSR 26	6.3	LS	1.58	MR	0.22	MR	0.36	MR	12.0	S	122.60	S
SPLB 94001A X ICSR 90030	5.0	MR	3.59	S	0.32	S	1.15	HS	14.5	HS	356.33	HS
SPLB 94013A X ICSR 90030	6.7	S	1.74	MR	0.27	LS	0.47	LS	5.3	R	136.87	R
296A X ICSR 90030	7.3	S	1.39	MR	0.25	LS	0.35	MR	9.9	LS	176.07	LS
CHECKS												
Resistant												
M 35-1	7.3	S	0.89	MR	0.19	MR	0.17	R	23.9	HS	218.33	HS
ICSB 13	7.0	S	5.81	HS	0.44	HS	2.57	HS	8.3	MR	99.90	MR
PM 1861	4.0	MR	2.83	LS	0.21	MR	0.61	LS	6.1	R	63.33	HR
Susceptible												
H 112	9.0	HS	5.40	HS	0.49	HS	2.63	HS	5.5	R	89.50	R
FSRP Local	9.0	HS	2.08	LS	0.21	MR	0.41	MR	17.7	HS	318.63	HS
Kundi Jowar	6.7	S	0.93	MR	0.18	MR	0.17	R	38.8	HS	331.37	HS
G. Mean	5.20		1.84		0.23		0.47		8.60		133.38	
S. Em.	0.72		0.98		0.04		0.13		1.11		19.53	
C.V. (%)	13.80		53.40		15.30		28.10		12.90		14.60	

1. Scored on a (1-9) scale

2. The groups are based on disease score

During the second year, none of the female parents were found to be resistant$_{ds}$ to the disease. The female lines, SPLB 94004A, SPLB 94007A, SPLB 94010A, SPLB 94011A, SPLB 94013A, SPLB 94015A, SPLB 94016A and SPLB 94025A were moderately resistant$_{ds}$. While nine and three A-lines were found less susceptible$_{ds}$ and susceptible$_{ds}$ to the disease, respectively. Among the R-lines, A 2267-2 was resistant$_{ds}$, ICSR 26 and ICSR 97 were moderately resistant$_{ds}$, ICSR 119 and ICSR 90030 were susceptible$_{ds}$; and ICSR 91025 was highly susceptible$_{ds}$ based on the disease damage score (Table 7).

4.2.1.2 Reaction of the Hybrids

Among the hybrids involving resistant A-lines as the female parent, only two hybrids (SPLB 94009A x ICSR 97 and SPLB 94011A x ICSR 97) involving the MR$_{ds}$ male parent, i.e., ICSR 97 were found to be highly resistant (HR$_{ds}$) for disease damage score. Majority of the hybrids involving MR$_{ds}$ parents were found to be moderately resistant$_{ds}$, while four out of six MR$_{ds}$ x MR$_{ds}$ hybrids were found resistant$_{ds}$. Of all the hybrids involving LS$_{ds}$ lines as the female parent, three hybrids each involving R$_{ds}$ (A 2267-2) and MR$_{ds}$ (ICSR 97) male parents i.e., SPLB 94012A, SPLB 94025A and SPLB 94014A with A 2267-2, SPLB 94012A, SPLB 94024A and SPLB 94014A with ICSR 97, and SPLB 94024A x ICSR 91025 (LS$_{ds}$ x LS$_{ds}$), SPLB 94017A x ICSR 119 (LS$_{ds}$ x S$_{ds}$); and SPLB 94001A x ICSR 91025 (S$_{ds}$ x LS$_{ds}$) were moderately resistant$_{ds}$ for disease damage score, while majority of the other cross combinations was either LS$_{ds}$ or S$_{ds}$ or HS$_{ds}$ to the disease. Similar results were observed in hybrids involving susceptible$_{ds}$ lines as the female parent except S$_{ds}$ x MR$_{ds}$ (two out of three hybrids were resistant$_{ds}$) and S$_{ds}$ x R$_{ds}$ (SPLB 94001A x A 2267-2 i.e., 33% were resistant) group of hybrids.

Plate 4. Resistant female parent

Plate 5. Susceptible female parent


SPLB 94007B

Plate 6. Resistant male parent

Plate 7. Susceptible male parent

Table 7. Mean performance of different genotypes of sorghum for various disease resistant parameters, rabi season 1997.

Genotypes	Disease score[1]	Disease reaction	Length of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	umber of flecks (no)	Disease reaction
LINES												
Moderately Resistant (MR[2])												
SPLB 94004A	4.30	MR	2.33	MR	0.35	LS	0.83	MR	3.20	HR	261.50	MR
SPLB 94007A	4.00	MR	4.23	HS	0.47	HS	2.01	HS	3.20	HR	368.70	S
SPLB 94010A	4.00	MR	1.16	HR	0.24	MR	0.28	R	9.00	HS	312.60	LS
SPLB 94011A	4.00	MR	1.16	HR	0.24	MR	0.29	R	9.00	HS	845.50	HS
SPLB 94013A	4.70	MR	3.44	S	0.43	S	1.48	S	3.40	R	154.70	R
SPLB 94015A	4.30	MR	3.63	S	0.44	S	1.63	S	2.10	HR	139.70	R
SPLB 94016A	4.70	MR	4.50	HS	0.50	HS	2.27	HS	1.30	HR	93.80	HR
SPLB 94025A	4.70	MR	2.48	MR	0.24	MR	0.60	MR	8.90	HS	157.60	R
Less Susceptible (LS[2])												
SPLB 94001A	5.70	LS	2.24	MR	0.33	LS	0.74	MR	4.80	MR	191.90	R
SPLB 94003A	5.00	LS	2.54	MR	0.33	MR	0.85	MR	7.10	LS	189.70	R
SPLB 94006A	5.70	LS	2.95	LS	0.32	S	0.95	LS	6.70	LS	346.30	S
SPLB 94009A	5.30	LS	3.40	S	0.39	MR	1.33	S	2.30	HR	132.10	HR
SPLB 94014A	5.30	LS	2.17	MR	0.30	LS	0.67	MR	2.90	HR	79.50	HR
SPLB 94019A	5.00	LS	1.58	R	0.27	S	0.43	R	6.90	LS	568.20	HS
SPLB 94021A	5.30	LS	2.96	LS	0.35	LS	1.04	LS	5.90	MR	85.40	HR
SPLB 94022A	5.00	LS	3.63	S	0.40	LS	1.44	S	5.10	MR	195.70	R
SPLB 94024A	5.00	LS	3.08	LS	0.36	LS	1.10	LS	3.20	HR	213.90	MR
Susceptible (S[2])												
SPLB 94012A	6.00	S	2.59	MR	0.32	MR	0.83	MR	4.00	R	136.90	R

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm$^{2)}$	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94017A	6.00	S	1.33	R	0.24	LS	0.32	R	3.50	R	281.20	LS
296A	7.00	S	3.63	S	0.36	LS	1.32	S	5.10	MR	147.00	R
TESTERS												
Resistant (R^2)												
A 2267-2	2.70	R	0.79	HR	0.16	HR	0.14	R	4.20	R	374.60	S
Moderately Resistant (MR^2)												
ICSR 26	4.70	MR	4.96	HS	0.37	LS	1.84	HS	2.50	HR	119.70	HR
ICSR 97	4.30	MR	1.86	R	0.24	MR	0.45	R	6.60	LS	927.10	HS
Susceptible (S^2)												
ICSR 119	6.00	S	2.49	MR	0.37	LS	0.92	LS	5.70	MR	259.90	MR
ICSR 90030	7.00	S	3.76	S	0.37	LS	1.40	S	8.50	S	49.50	HR
Highly Susceptible (HS^2)												
ICSR 91025	7.30	HS	4.29	HS	0.39	S	1.68	HS	9.60	HS	135.60	R
CROSSES												
MR x R												
SPLB 94004A X A 2267-2	5.30	LS	3.49	S	0.38	S	1.37	S	4.60	R	361.80	S
SPLB 94007A X A 2267-2	4.00	MR	1.69	R	0.26	MR	0.45	R	6.70	LS	681.40	HS
SPLB 94010A X A 2267-2	3.30	R	0.42	HR	0.15	HR	0.06	HR	15.90	HS	465.10	HS
SPLB 94011A X A 2267-2	4.00	MR	0.48	HR	0.15	HR	0.07	HR	8.40	S	498.10	HS
SPLB 94013A X A 2267-2	4.70	MR	1.97	MR	0.27	MR	0.52	MR	5.60	MR	327.60	LS
SPLB 94015A X A 2267-2	5.00	LS	3.14	LS	0.42	S	1.32	S	6.90	LS	474.70	HS
SPLB 94016A X A 2267-2	3.30	R	0.00	HR	0.00	HR	0.00	HR	0.00	HR	92.80	HR
SPLB 94025A X A 2267-2	3.30	R	1.13	HR	0.19	R	0.21	R	11.10	HS`	237.60	MR

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
MR x MR												
SPLB 94004A X ICSR 26	5.00	LS	2.90	LS	0.32	LS	0.94	LS	4.70	MR	225.70	MR
SPLB 94007A X ICSR 26	6.00	S	2.58	MR	0.28	MR	0.73	MR	4.40	R	209.20	MR
SPLB 94010A X ICSR 26	4.70	MR	1.69	R	0.23	R	0.40	R	7.20	LS	280.30	LS
SPLB 94011A X ICSR 26	4.30	MR	1.50	R	0.22	R	0.35	R	8.30	S	668.30	HS
SPLB 94013A X ICSR 26	5.70	LS	3.77	S	0.41	S	1.54	S	3.80	R	251.80	MR
SPLB 94015A X ICSR 26	5.70	LS	4.31	HS	0.49	HS	2.13	HS	5.10	MR	173.70	R
SPLB 94016A X ICSR 26	5.00	LS	4.45	HS	0.47	HS	2.13	HS	3.50	R	285.10	LS
SPLB 94025A X ICSR 26	4.70	MR	1.23	R	0.24	MR	0.30	R	5.30	MR	269.80	LS
SPLB 94004A X ICSR 97	3.30	R	4.81	HS	0.50	HS	2.43	HS	1.90	HR	192.10	R
SPLB 94007A X ICSR 97	3.00	R	2.46	MR	0.31	LS	0.79	MR	1.70	HR	117.40	HR
SPLB 94010A X ICSR 97	3.70	MR	1.46	R	0.23	R	0.33	R	10.20	HS	442.20	HS
SPLB 94011A X ICSR 97	3.30	R	0.63	HR	0.15	HR	0.10	HR	12.50	HS	477.50	HS
SPLB 94013A X ICSR 97	3.70	MR	3.81	S	0.34	LS	1.31	S	2.70	HR	163.10	R
SPLB 94015A X ICSR 97	4.30	MR	3.35	LS	0.40	S	1.33	S	2.30	HR	145.20	R
SPLB 94016A X ICSR 97	4.00	MR	3.73	S	0.29	MR	1.09	LS	2.60	HR	123.20	HR
SPLB 94025A X ICSR 97	3.30	R	0.99	HR	0.21	R	0.22	R	6.90	LS	171.90	R
MR x S												
SPLB 94004A X ICSR 119	5.30	LS	3.21	LS	0.38	S	1.23	LS	11.20	HS	591.80	HS
SPLB 94007A X ICSR 119	4.70	MR	1.63	R	0.26	MR	0.43	R	11.80	HS	437.20	HS
SPLB 94010A X ICSR 119	5.00	LS	1.45	R	0.25	MR	0.36	R	10.40	HS	557.90	HS
SPLB 94011A X ICSR 119	4.00	MR	1.60	R	0.29	MR	0.47	R	11.30	HS	474.40	HS
SPLB 94013A X ICSR 119	5.30	LS	2.97	LS	0.34	LS	1.04	LS	7.90	S	378.70	S
SPLB 94015A X ICSR 119	5.30	LS	2.63	MR	0.35	LS	0.93	LS	3.40	R	234.30	MR
SPLB 94016A X ICSR 119	6.00	S	3.09	LS	0.38	S	1.17	LS	3.90	R	136.70	R

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94025A X ICSR 119	4.70	MR	1.67	R	0.22	R	0.36	R	7.70	S	237.70	MR
SPLB 94004A X ICSR 90030	4.70	MR	3.01	LS	0.35	LS	1.06	LS	7.50	S	217.40	MR
SPLB 94007A X ICSR 90030	4.00	MR	1.90	R	0.24	MR	0.47	R	3.30	R	127.70	HR
SPLB 94010A X ICSR 90030	4.30	MR	2.15	MR	0.28	MR	0.60	MR	3.30	R	145.90	R
SPLB 94011A X ICSR 90030	5.00	LS	2.40	MR	0.30	MR	0.76	MR	6.10	LS	167.40	R
SPLB 94013A X ICSR 90030	6.00	S	2.93	LS	0.34	LS	1.00	LS	3.80	R	164.00	R
SPLB 94015A X ICSR 90030	4.70	MR	3.26	LS	0.31	LS	1.01	LS	4.50	R	154.70	R
SPLB 94016A X ICSR 90030	4.70	MR	4.53	HS	0.39	S	1.77	HS	3.80	R	286.40	LS
SPLB 94025A X ICSR 90030	4.30	MR	3.27	LS	0.35	LS	1.16	LS	7.30	LS	112.50	HR
MR x HS												
SPLB 94004A X ICSR 91025	6.00	S	3.25	LS	0.31	LS	1.04	LS	6.10	LS	219.90	MR
SPLB 94007A X ICSR 91025	5.30	LS	3.30	LS	0.33	LS	1.10	LS	6.10	LS	312.50	LS
SPLB 94010A X ICSR 91025	4.70	MR	1.54	R	0.19	R	0.29	R	15.30	HS	338.40	S
SPLB 94011A X ICSR 91025	4.30	MR	2.91	LS	0.30	MR	0.89	LS	7.90	S	529.70	HS
SPLB 94013A X ICSR 91025	5.70	LS	3.15	LS	0.28	MR	0.87	MR	4.00	R	39.30	R
SPLB 94015A X ICSR 91025	5.30	LS	3.39	S	0.36	LS	1.22	LS	4.20	R	135.10	R
SPLB 94016A X ICSR 91025	6.70	S	4.03	S	0.44	S	1.80	HS	5.00	MR	187.30	R
SPLB 94025A X ICSR 91025	4.30	MR	3.49	S	0.26	MR	0.93	LS	5.70	MR	47.40	HR
LS x R												
SPLB 94001A X A 2267-2	3.70	MR	1.15	R	0.20	R	0.22	R	5.30	MR	423.90	HS
SPLB 94003A X A 2267-2	4.00	MR	2.32	MR	0.33	LS	0.77	MR	10.60	HS	647.70	HS
SPLB 94006A X A 2267-2	4.70	MR	1.80	R	0.24	MR	0.43	R	2.00	HR	175.90	R
SPLB 94009A X A 2267-2	3.70	MR	1.91	MR	0.30	MR	0.57	MR	3.90	R	305.70	LS
SPLB 94014A X A 2267-2	4.30	MR	1.37	R	0.26	MR	0.36	R	8.10	S	359.40	S
SPLB 94019A X A 2267-2	3.30	R	1.60	R	0.26	MR	0.42	R	1.70	HR	359.00	S

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94021A X A 2267-2	3.70	MR	1.69	R	0.28	MR	0.48	R	8.30	S	218.00	MR
SPLB 94022A X A 2267-2	4.00	MR	1.95	MR	0.27	MR	0.53	MR	5.80	MR	373.70	S
SPLB 94024A X A 2267-2	4.00	MR	0.95	HR	0.20	R	0.20	R	7.30	LS	433.50	HS
LS x MR												
SPLB 94001A X ICSR 26	4.70	MR	1.56	R	0.23	R	0.36	R	8.60	S	237.00	MR
SPLB 94003A X ICSR 26	5.70	LS	3.01	LS	0.30	MR	0.90	LS	2.70	HR	451.40	HS
SPLB 94006A X ICSR 26	6.30	S	2.79	LS	0.30	MR	0.82	MR	4.70	MR	284.10	LS
SPLB 94009A X ICSR 26	3.30	R	3.73	S	0.38	S	1.43	S	2.70	HR	123.10	HR
SPLB 94014A X ICSR 26	6.70	S	3.75	S	0.42	S	1.57	S	2.70	HR	144.20	R
SPLB 94019A X ICSR 26	5.30	LS	1.75	R	0.31	LS	0.53	MR	8.90	HS	456.80	HS
SPLB 94021A X ICSR 26	6.30	S	3.82	S	0.38	S	1.46	S	5.70	MR	143.40	R
SPLB 94022A X ICSR 26	4.00	MR	1.64	R	0.23	R	0.37	R	1.70	HR	188.10	R
SPLB 94024A X ICSR 26	4.70	MR	2.88	LS	0.33	LS	0.97	LS	4.70	MR	169.70	R
SPLB 94001A X ICSR 97	4.00	MR	1.25	R	0.21	R	0.26	R	11.30	HS	598.50	HS
SPLB 94003A X ICSR 97	4.70	MR	3.14	LS	0.36	LS	1.17	LS	9.50	HS	415.00	HS
SPLB 94006A X ICSR 97	3.70	MR	2.21	MR	0.26	MR	0.59	MR	4.10	R	126.60	HR
SPLB 94009A X ICSR 97	3.70	MR	2.46	MR	0.28	MR	0.69	MR	3.10	HR	130.70	HR
SPLB 94014A X ICSR 97	4.70	MR	2.18	MR	0.28	MR	0.61	MR	9.30	HS	323.40	LS
SPLB 94019A X ICSR 97	4.30	MR	1.78	R	0.28	MR	0.51	MR	16.60	HS	870.30	HS
SPLB 94021A X ICSR 97	5.00	LS	3.49	S	0.36	LS	1.27	S	5.30	MR	183.60	R
SPLB 94022A X ICSR 97	5.00	LS	1.78	R	0.30	MR	0.54	MR	3.80	R	343.40	S
SPLB 94024A X ICSR 97	4.00	MR	1.33	R	0.19	R	0.26	R	7.10	LS	377.60	S
LS x S												
SPLB 94001A X ICSR 119	4.30	MR	2.40	MR	0.28	MR	0.68	MR	7.20	LS	261.70	MR
SPLB 94003A X ICSR 119	5.70	LS	2.31	MR	0.27	MR	0.64	MR	5.20	MR	76.40	HR

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
SPLB 94006A X ICSR 119	5.00	LS	2.62	MR	0.33	LS	0.88	MR	8.10	S	347.20	S
SPLB 94009A X ICSR 119	4.00	MR	2.47	MR	0.30	MR	0.75	MR	2.70	HR	120.30	HR
SPLB 94014A X ICSR 119	4.00	MR	2.06	MR	0.28	MR	0.57	MR	4.50	R	166.30	R
SPLB 94019A X ICSR 119	5.30	LS	3.25	LS	0.41	S	1.32	S	12.70	HS	980.80	HS
SPLB 94021A X ICSR 119	5.00	LS	3.57	S	0.28	MR	0.72	MR	6.70	LS	254.70	MR
SPLB 94022A X ICSR 119	5.30	LS	3.44	S	0.37	LS	1.29	S	13.70	HS	544.00	HS
SPLB 94024A X ICSR 119	4.00	MR	1.81	R	0.27	MR	0.49	R	5.20	MR	265.20	MR
SPLB 94001A X ICSR 90030	6.00	S	4.13	HS	0.36	LS	1.50	S	5.40	MR	145.60	R
SPLB 94003A X ICSR 90030	5.70	LS	2.17	MR	0.27	MR	0.59	MR	5.70	MR	208.90	MR
SPLB 94006A X ICSR 90030	6.00	S	3.01	LS	0.32	LS	0.98	LS	4.70	MR	145.00	R
SPLB 94009A X ICSR 90030	3.70	MR	2.42	MR	0.27	MR	0.66	MR	2.80	HR	53.00	HR
SPLB 94014A X ICSR 90030	5.30	LS	2.86	LS	0.36	LS	1.04	LS	3.50	R	74.20	HR
SPLB 94019A X ICSR 90030	4.70	MR	2.02	MR	0.27	MR	0.54	MR	11.10	HS	160.40	R
SPLB 94021A X ICSR 90030	5.00	LS	2.19	MR	0.24	MR	0.54	MR	3.70	R	146.10	R
SPLB 94022A X ICSR 90030	5.00	LS	2.32	MR	0.28	MR	0.65	MR	4.80	MR	85.30	HR
SPLB 94024A X ICSR 90030	4.70	MR	3.29	LS	0.32	LS	1.06	LS	4.90	MR	147.50	R
LS x HS												
SPLB 94001A X ICSR 91025	4.30	MR	2.83	LS	0.29	MR	0.83	MR	5.50	MR	79.50	HR
SPLB 94003A X ICSR 91025	6.30	S	4.20	HS	0.44	S	1.86	HS	13.60	HS	286.20	LS
SPLB 94006A X ICSR 91025	5.70	LS	4.20	HS	0.36	LS	1.52	S	5.70	MR	137.60	R
SPLB 94009A X ICSR 91025	3.70	MR	3.15	LS	0.33	LS	1.04	LS	6.50	LS	106.90	HR
SPLB 94014A X ICSR 91025	5.00	LS	3.16	LS	0.32	LS	1.04	LS	8.10	S	159.80	R
SPLB 94019A X ICSR 91025	6.00	S	1.95	MR	0.25	MR	0.50	R	13.00	HS	619.80	R
SPLB 94021A X ICSR 91025	5.00	LS	2.29	MR	0.29	MR	0.67	MR	3.10	HR	72.60	HR
SPLB 94022A X ICSR 91025	4.70	MR	2.91	LS	0.31	LS	0.91	LS	5.90	MR	228.80	MR
SPLB 94024A X ICSR 91025	5.30	LS	3.42	S	0.30	MR	1.04	LS	8.00	S	177.60	R

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
S x R												
SPLB 94012A X A 2267-2	3.70	MR	1.66	R	0.28	MR	0.47	R	4.20	R	421.30	HS
SPLB 94017A X A 2267-2	4.00	MR	0.68	HR	0.15	HR	0.11	HR	8.50	S	334.00	S
296A X A 2267-2	4.30	MR	1.67	R	0.28	MR	0.47	R	5.00	MR	191.10	R
S x MR												
SPLB 94012A X ICSR 26	5.30	LS	2.72	LS	0.32	LS	0.87	MR	7.90	S	246.00	MR
SPLB 94017A X ICSR 26	5.30	LS	1.90	R	0.23	R	0.44	R	8.90	HS	307.80	HS
296A X ICSR 26	6.70	S	2.59	MR	0.27	MR	0.70	MR	5.50	MR	210.60	MR
SPLB 94012A X ICSR 97	3.70	MR	2.76	LS	0.33	LS	0.90	LS	5.20	MR	492.10	HS
SPLB 94017A X ICSR 97	3.70	MR	1.10	HR	0.19	R	0.21	R	7.40	LS	327.20	LS
296A X ICSR 97	6.70	S	2.63	MR	0.26	MR	0.68	MR	5.70	MR	66.70	HR
S x S												
SPLB 94012A X ICSR 119	4.70	MR	3.12	LS	0.35	LS	1.09	LS	2.90	HR	136.50	R
SPLB 94017A X ICSR 119	4.30	MR	2.53	MR	0.33	LS	0.83	MR	4.70	MR	188.10	R
296A X ICSR 119	5.70	LS	2.71	LS	0.28	MR	0.78	MR	8.60	S	144.40	R
SPLB 94012A X ICSR 90030	5.70	LS	2.62	MR	0.28	MR	0.79	MR	5.90	MR	256.90	MR
SPLB 94017A X ICSR 90030	4.70	MR	3.26	LS	0.35	LS	1.15	LS	3.10	HR	140.50	R
296A X ICSR 90030	5.30	LS	2.73	LS	0.34	LS	0.93	LS	3.10	HR	64.20	HR
S x HS												
SPLB 94012A X ICSR 91025	6.30	S	4.73	HS	0.37	LS	1.74	HS	3.20	HR	112.10	HR
SPLB 94017A X ICSR 91025	4.30	MR	2.79	LS	0.32	LS	0.88	MR	5.30	MR	196.40	R
296A X ICSR 91025	5.30	LS	3.38	S	0.34	LS	1.16	LS	4.10	R	82.30	HR

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Genotypes	Disease score[1]	Disease reaction	ength of the lesion (cm)	Disease reaction	Width of the lesion (cm)	Disease reaction	Area of the lesion (cm^2)	Disease reaction	Number of lesions (no)	Disease reaction	Number of flecks (no)	Disease reaction
CHECKS												
Resistant												
M 35-1	4.30	MR	2.63	MR	0.33	LS	0.89	LS	3.50	R	293.30	LS
ICSB 13	4.70	MR	3.07	LS	0.41	S	1.29	S	4.90	MR	131.10	HR
PM 1861	4.00	MR	2.48	MR	0.31	LS	0.77	MR	2.20	HR	36.30	HR
Susceptible												
H 112	8.70	HS	6.39	HS	0.57	HS	3.63	HS	9.20	HS	249.80	MR
Kundi Jowar	3.30	R	3.38	S	0.30	MR	1.03	LS	3.00	HR	82.00	HR
FSRP Local	8.70	HS	4.13	HS	0.40	S	1.67	HS	13.00	HS	476.50	HS
G. Mean	4.80		2.64		0.31		0.89		6.06		266.10	
S. Em.	0.66		0.42		0.04		0.22		0.81		37.94	
C.V. (%)	13.70		15.90		13.60		25.00		13.40		14.30	

1. Scored on a (1-9) scale.

2. The groups are based on the disease score.

Among the 120 hybrids studied in the second year, only three of the MR_{ds} x R_{ds} hybrids i.e. 38% (SPLB 94010A x A 2267-2, SPLB 94016A x A 2267-2 and SPLB 94025A x A 2267-2) were found resistant$_{ds}$ for disease damage score. Majority (75%) of the cross combinations of MR_{ds} x S_{ds} (ICSR 90030) group were moderately resistant$_{ds}$, while the cross combinations of MR_{ds} x ICSR 97 (MR_{ds}) were resistant$_{ds}$ and moderately resistant$_{ds}$. Majority of the LS_{ds} x R_{ds} hybrids (89%) was moderately resistant$_{ds}$ except SPLB 94019A x A 2267-2, which was R_{ds}. While, only one hybrid from LS_{ds} x MR_{ds} group, i.e., SPLB 94009A x ICSR 26 was found resistant$_{ds}$. Rest of the hybrids was found to be either MR_{ds} or LS_{ds} or S_{ds} to the disease.

C2

4.2.1.3 Gene Action in-groups based on Disease Damage Score

First year studies indicated that 33% of the F_1 s from R_{ds} x MR_{ds} combination were highly resistant$_{ds}$ due to over dominance for resistance. While, 67% of the F_1 s from MR_{ds} x MR_{ds} and S_{ds} x MR_{ds} group, 50% of the F_1 s from R_{ds} x R_{ds} and R_{ds} x MR_{ds} group, 33% of the F_1 s from S_{ds} x R_{ds} group, 20% of the F_1 s from LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} group; and 17% of the F_1 s from R_{ds} x LS_{ds} group were found to give resistant$_{ds}$ hybrids. On the other hand, susceptibility was overdominant over resistance for the character under consideration in 17% of the F_1 s (LS_{ds}) from R_{ds} x MR_{ds} group, 50% of the F_1 s (MR_{ds}) from R_{ds} x R_{ds} group and 8% of the F_1 s (S_{ds}) from R_{ds} x LS_{ds} group. Fifty per cent of the F_1 s from R_{ds} x R_{ds} and R_{ds} x MR_{ds} group; and 17% of the F_1 s from R_{ds} x LS_{ds} group were resistant$_{ds}$, whereas 17% of the F_1 s from R_{ds} x LS_{ds} group were less susceptible$_{ds}$ indicating complete dominance for resistance. On the other hand, 58% of the F_1 s from R_{ds} x LS_{ds} group and 50% of the F_1 s from R_{ds} x S_{ds} group were moderately resistant$_{ds}$, while 50% of the F_1 s from R_{ds} x S_{ds} group were less susceptible$_{ds}$ indicating partial dominance for resistance.

The presence of over dominance for disease resistance in the second year was observed by 25% of the F_1 s from MR_{ds} x MR_{ds} group and 11% of the F_1 s from LS_{ds} x MR_{ds} group where the hybrids were $resistant_{ds}$. On the other hand, 25% of the F_1 s from MR_{ds} x MR_{ds} and MR_{ds} x R_{ds} group were less $susceptible_{ds}$, while 6% of the F_1 s from MR_{ds} x MR_{ds} group were $susceptible_{ds}$ indicating that susceptibility was over dominant over resistance. Complete dominance of resistance over susceptibility was observed by 6% of the F_1 s (R_{ds}) from LS_{ds} x R_{ds} group. In addition, complete dominance for moderate resistance was noticed by 38% of the F_1 s from MR_{ds} x R_{ds} group, 44% of the F_1 s from MR_{ds} x R_{ds} group, 56% of the F_1 s from MR_{ds} x S_{ds} group and 38% of the F_1 s from MR_{ds} x HS_{ds} group where the hybrids were moderately $resistant_{ds}$. While susceptibility was completely dominant over resistance in MR_{ds} x S_{ds} group of hybrids where 13% of the F_1 s were $susceptible_{ds}$. Thirty eight per cent of the F_1 s from MR_{ds} x HS_{ds} group were LS_{ds} and 25% of the F_1 s from MR_{ds} x HS_{ds} group were S_{ds} indicating that susceptibility was partially dominant over resistance in these hybrids.

The data over two years revealed that the hybrids, i.e., SPLB 94011A x ICSR 97 and SPLB 94009A x ICSR 97 which were found to be highly $resistant_{ds}$ during first year were found to be $resistant_{ds}$ and moderately $resistant_{ds}$ in the second year. Among the hybrids which were found to be $resistant_{ds}$ during second year, only three hybrids (SPLB 94010A x A 2267-2, SPLB 94007A x ICSR 97 and SPLB 94004A x ICSR 97) showed similar pattern of disease reaction over the seasons. While, the rest of the hybrids were found to be either HR_{ds}, or MR_{ds} or LS_{ds} to the disease.

4.2.2 Length of the Lesion

C4

The parental lines and the hybrids were classified into different disease reaction groups on the basis of the length of the lesion such as highly resistant (HR_{ll}), resistant (R_{ll}), moderately resistant (MR_{ll}), less susceptible (LS_{ll}), susceptible (S_{ll}) and highly susceptible (HS_{ll}).

4.2.2.1 Reaction of the Parents

Moderate resistance (MR_{ll}) for lesion length during first year was observed by four R_{ds} A-lines (SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94011A), while LS_{ds} and S_{ds} A-lines were either moderately resistant$_{ll}$ or less susceptible$_{ll}$. Similar reaction was observed among MR_{ds} A-lines except SPLB 94016A and SPLB 94006A, which were found to be susceptible$_{ll}$ and highly susceptible$_{ll}$. Among the restorers, R_{ds} and MR_{ds} lines like ICSR 119 (LS_{ds}) and ICSR 26 (S_{ds}) were moderately resistant$_{ll}$, while ICSR 91025 (LS_{ds}) and ICSR 90030 (S_{ds}) were found to be less susceptible$_{ll}$ and susceptible$_{ll}$, respectively (Table 6).

In the second year, SPLB 94010A and SPLB 94011A (MR_{ds}) were highly resistant$_{ll}$, while SPLB 94019A (LS_{ds}) and SPLB 94017A (S_{ds}) were found to be resistant$_{ll}$. Among the R-lines, A 2267-2 (R_{ds}) was highly resistant$_{ll}$, whereas ICSR 97 (MR_{ds}) was resistant$_{ll}$ for lesion length (Table 7).

4.2.2.2 Reaction of Hybrids

The hybrids involving R_{ds} x R_{ds} and R_{ds} x MR_{ds} parents were found to be moderately resistant$_{ll}$ for lesion length except the hybrids involving SPLB 94015A as the female parent. Majority of the hybrids involving MR_{ds} x R_{ds} (67%), MR_{ds} x MR_{ds} (83%), MR_{ds} x LS_{ds}

Plate 8. Resistant and moderately resistant hybrids produced when resistant parents were involved

Plate 9. Moderately resistant hybrids produced by crossing resistant and susceptible parents

Plate 10. Less susceptible and moderately resistant hybrids produced by crossing susceptible and resistant parents

Plate 11. Susceptible and less susceptible hybrids produced when susceptible parents were involved


296A
X
A 2267-2


X

(83%) and MR_{ds} x S_{ds} (75%) parental lines were moderately $resistant_{ll}$. While rest of the hybrids of the above combinations exhibited less $susceptible_{ll}$ reaction. Similarly majority of the hybrids involving LS_{ds} x R_{ds} (80%) and LS_{ds} x MR_{ds} (80%) parents were moderately $resistant_{ll}$. Most of the hybrids involving $susceptible_{ds}$ female parents and all the cross combinations involving S_{ds} x ICSR 26 (S_{ds}) parents were moderately $resistant_{ll}$.

The second year studies indicated that the hybrids, SPLB 94010A, SPLB 94011A, SPLB 94016A and SPLB 94025A crossed with A 2267-2 (MR_{ds} x R_{ds}), SPLB 94011A and SPLB 94025A crossed with ICSR 97 (MR_{ds} x MR_{ds}), SPLB 94024A x A 2267-2 (LS_{ds} x R_{ds}), SPLB 94017A x A 2267-2 (S_{ds} x R_{ds}); and SPLB 94017A x ICSR 97 (S_{ds} x MR_{ds}) were highly $resistant_{ll}$ for the character. Rest of the two hybrids from S_{ds} x R_{ds} group was $resistant_{ll}$ for the lesion length.

4.2.2.3 Per cent Recovery of the Resistant Hybrids

$Resistant_{ll}$ hybrids for the lesion length were observed in the first year by 83% of the F_1 s from R_{ds} x R_{ds}, R_{ds} x MR_{ds}, MR_{ds} x MR_{ds} and S_{ds} x S_{ds} group, whereas 80% of the F_1 s from LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} group, 58% of the F_1 s from R_{ds} x LS_{ds} and MR_{ds} x LS_{ds} group, 67% of the F_1 s from MR_{ds} x R_{ds}, S_{ds} x R_{ds} and S_{ds} x MR_{ds} group, 50% of the F_1 s from LS_{ds} x S_{ds} and S_{ds} x LS_{ds} group, 75% of the F_1 s from MR_{ds} x S_{ds} group, 40% of the F_1 s from LS_{ds} x LS_{ds} group; and 42% of the F_1 s from R_{ds} x S_{ds} group were moderately $resistant_{ll}$.

Maximum probability of the $resistant_{ll}$ hybrids in the second year were seen in S_{ds} x R_{ds} (67%) group followed by LS_{ds} x R_{ds} (56%), LS_{ds} x MR_{ds} (39%), MR_{ds} x S_{ds} (31%), MR_{ds} x MR_{ds} (25%), S_{ds} x MR_{ds} (17%), MR_{ds} x R_{ds} (13%), MR_{ds} x HS_{ds} (13%) and LS_{ds} x S_{ds} (6%) group.

4.2.2.4 Gene Action in-groups based on Disease Damage Score and Reaction

First year studies indicated that 83% of the F_1 s from S_{ds} x S_{ds} group, 50% of the F_1 s from S_{ds} x LS_{ds} and LS_{ds} x S_{ds} group; and 40% of the F_1 s from LS_{ds} x LS_{ds} group were found to give moderately resistant$_{ll}$ hybrids due to overdominance for resistance. However, susceptibility was over dominant over resistance in 17% of the F_1 s (LS_{ll}) from R_{ds} x MR_{ds} group, 83% of the F_1 s (MR_{ll}) from R_{ds} x R_{ds} group, 17% of the F_1 s (LS_{ll}) from R_{ds} x R_{ds} group and 17% of the F_1 s (S_{ll}) from R_{ds} x LS_{ds} group. While, 83% of the F_1 s from R_{ds} x MR_{ds} group were MR_{ll}, 25% of the F_1 s from R_{ds} x LS_{ds} group were LS_{ll} and 8% of the F_1 s from R_{ds} x S_{ds} were S_{ll} indicating that susceptibility was completely dominant over resistance in these group of hybrids. On the other hand, susceptibility was partially dominant over resistance in 58% of the F_1 s (MR_{ll}) from R_{ds} x LS_{ds} group, 42% of the F_1 s (MR_{ll}) from R_{ds} x S_{ds} group and 50% of the F_1 s (LS_{ll}) from R_{ds} x S_{ds} group.

Of the ten MR_{ll} x S_{ll} hybrids, four hybrids (SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94022A crossed with ICSR 90030) showed less susceptibility$_{ll}$, while SPLB 94011A, SPLB 94003A, SPLB 94021A, SPLB 94017A, SPLB 94024A and 296A crossed with ICSR 90030 exhibited moderate resistance$_{ll}$ for lesion length.

In the second year, 50% of the F_1 s (HR_{ll}) from MR_{ds} x R_{ds} group, 25% of the F_1 s (R_{ll}) from MR_{ds} x MR_{ds} group, 13% of the F_1 s (HR_{ll}) from MR_{ds} x MR_{ds} group, 31% of the F_1 s (R_{ll}) from MR_{ds} x S_{ds} group, 13% of the F_1 s (R_{ll}) from MR_{ds} x HS_{ds} group, 11% of the F_1 s (MR_{ll}) from LS_{ds} x R_{ds} group, 33% of the F_1 s (R_{ll}) from S_{ds} x R_{ds} group and 17% of the F_1 s (HR_{ll}) from S_{ds} x MR_{ds} group were superior due to over dominance for resistance. On the other hand, susceptibility was over dominant in 13% of the F_1 s (S_{ll}) from MR_{ds} x R_{ds} group, 13% of the F_1 s (LS_{ll}) from MR_{ds} x R_{ds} group, 19% of the F_1 s (HS_{ll}) from MR_{ds} x MR_{ds} group, 13% of the F_1 s (LS_{ll}) from MR_{ds} x MR_{ds} group, 19% of the F_1 s (S_{ll}) from

MR_{ds} x MR_{ds} group and 6% of the F_1 s (HS_{ll}) from MR_{ds} x S_{ds} group. Complete dominance for resistance was seen in 13% of the F_1 s (R_{ll}) from MR_{ds} x R_{ds} group, while complete dominance for moderate resistance was recorded by 13% of the F_1 s (MR_{ll}) from MR_{ds} x R_{ds} group, 19% of the F_1 s (MR_{ll}) from MR_{ds} x S_{ds} group and 13% of the F_1 s (MR_{ll}) from MR_{ds} x MR_{ds} group. On the other hand, partial dominance was observed by 50% of the F_1 s (LS_{ll}) from MR_{ds} x HS_{ds} group, 38% of the F_1 s (S_{ll}) from MR_{ds} x HS_{ds} group and 44% of the F_1 s (LS_{ll}) from MR_{ds} x S_{ds} group.

Of the four HR_{ll} x HS_{ll} hybrids, three hybrids (SPLB 94010A and SPLB 94011A with ICSR 26; and SPLB 94010A x ICSR 91025) were resistant$_{ll}$, while SPLB 94011A x ICSR 91025 was less susceptible$_{ll}$. Of the two R_{ll} x S_{ll} hybrids, SPLB 94019A x ICSR 90030 was moderately resistant$_{ll}$, whereas SPLB 94017A x ICSR 90030 was less susceptible$_{ll}$.

4.2.2.5 Disease Parameters Pattern

Among the A-lines studied in the first year, SPLB 94003A, SPLB 94021A and SPLB 94022A were consistent in disease reaction when grouped either on the basis of disease damage score (MR_{ds}) or length of the lesion (MR_{ll}). Similar consistency was also observed among $LS_{ds/ll}$ A-lines (SPLB 94012A, SPLB 94025A and SPLB 94014A); and $MR_{ds/ll}$ (ICSR 97), $LS_{ds/ll}$ (ICSR 91025) and $S_{ds/ll}$ (ICSR 90030) restorer lines. Among their respective hybrids, SPLB 94021A, SPLB 94012A, SPLB 94025A and SPLB 94022A ($MR_{ds/ll}$) with ICSR 97 ($MR_{ds/ll}$) were moderately resistant$_{ds}$, while SPLB 94012A and SPLB 94014A ($LS_{ds/ll}$) with ICSR 91025 ($LS_{ds/ll}$), SPLB 94021A, SPLB 94022A and SPLB 94025A with ICSR 91025, SPLB 94003A, SPLB 94012A and SPLB 94021A with ICSR

90030, SPLB 94003A and 94014A with ICSR 97; and SPLB 94022A, SPLB 94025A and SPLB 94014A crossed with ICSR 90030 were less susceptible$_{ds}$ for length of the lesion.

In the second year, similar pattern of disease reaction for disease damage score and length of the lesion was reported by SPLB 94004A and SPLB 94025A (MR$_{ds/ll}$), SPLB 94024A, SPLB 94006A and SPLB 94021A (LS$_{ds/ll}$); and 296A (S$_{ds/ll}$) among A-lines, whereas ICSR 90030 (S$_{ds/ll}$) and ICSR 91025 (HS$_{ds/ll}$) among restorer lines (Table 7).

The parents (three) and the cross combinations (nine) which were found to be highly resistant$_{ll}$ for lesion length in the second year, were moderately resistant$_{ll}$ in the first year. During first year, none of the parents or their respective hybrids exhibited either HR$_{ll}$ or R$_{ll}$. However the parents and the cross combinations which exhibited moderate resistance$_{ll}$ across the seasons were SPLB 94003A among A-lines, ICSR 119 among restorer lines, SPLB 94013A, SPLB 94003A and SPLB 94009A with A 2267-2, SPLB 94007A, SPLB 94006A and SPLB 94009A with ICSR 97, SPLB 94011A, SPLB 94003A, SPLB 94021A and SPLB 94012A with ICSR 90030, SPLB 94007A and 296A with ICSR 26; SPLB 94003A, SPLB 94001A, SPLB 94006A and SPLB 94014A with ICSR 119; and SPLB 94019A and SPLB 94021A crossed with ICSR 91025 among hybrids.

4.2.3 Width of the Lesion

The parental lines and the hybrids classified on the basis of the width of the lesion were categorised into different disease reaction groups like highly resistant (HR$_{wl}$), resistant (R$_{wl}$), moderately resistant (MR$_{wl}$), less susceptible (LS$_{wl}$), susceptible (S$_{wl}$) and highly susceptible (HS$_{wl}$).

4.2.3.1 Reaction of the Parents

The male-sterile lines, SPLB 94010A and SPLB 94011A grouped based on disease damage score as $resistant_{ds}$, SPLB 94003A as moderately $resistant_{ds}$, SPLB 94017A and SPLB 94024A as less $susceptible_{ds}$ were found to be R_{wl} for lesion width. All the other restorer lines were found to be LS_{wl} (Table 6) in the first year except ICSR 97 and ICSR 119 (MR_{ds}).

During second year, the A-lines SPLB 94010A, SPLB 94011A and SPLB 94025A (MR_{ds}), SPLB 94003A and SPLB 94009A (LS_{ds}); and SPLB 94012A (S_{ds}) were moderately $resistant_{wl}$, while others were either less $susceptible_{wl}$ or $susceptible_{wl}$ or highly $susceptible_{wl}$. Among the restorer lines, A 2267-2 (R_{ds}) was highly $resistant_{wl}$, while ICSR 97 (MR_{ds}) was moderately $resistant_{wl}$ and rest of the lines exhibited either $susceptibility_{wl}$ or less $susceptibility_{wl}$ (Table 7).

4.2.3.2 Reaction of the Hybrids

Similar to the length of the lesion, the cross combinations R_{ds} x R_{ds} and R_{ds} x MR_{ds} were found to be either $resistant_{wl}$ or moderately $resistant_{wl}$ for lesion width in the first year except the cross involving SPLB 94015A as the female parent (exhibited S_{wl} with A 2267-2 and LS_{wl} with ICSR 97). All the cross combinations involving MR_{ds} A-line as the female parent exhibited either moderate $resistance_{wl}$ or less $susceptibility_{wl}$ except the hybrids SPLB 94022A x A 2267-2 (MR_{ds} x R_{ds}) and SPLB 94019A x ICSR 97 (MR_{ds} x MR_{ds}) which exhibited $susceptible_{wl}$ and $resistant_{wl}$ reaction. Similarly hybrids involving LS_{ds} and S_{ds} line as the female parent were found to be either moderately $resistant_{wl}$ or less $susceptible_{wl}$ or $susceptible_{wl}$ or highly $susceptible_{wl}$ except the hybrids SPLB 94017A and SPLB 94024A with A 2267-2 (LS_{ds} x R_{ds}), 296A and SPLB 94013A (S_{ds}) with A 2267-2

(R_{ds}), SPLB 94001A and 94013A (S_{ds}) with ICSR 97 (MR_{ds}); and SPLB 94013A x ICSR 26 (S_{ds}) which expressed $resistant_{wl}$ reaction.

The hybrids involving MR_{ds} A-lines *viz.*, SPLB 94010A, SPLB 94011A and SPLB 94016A with A 2267-2 (R_{ds}); and SPLB 94011A x ICSR 97 (MR_{ds}) were highly $resistant_{wl}$ for lesion width in the second year, while SPLB 94025A x A 2267-2 (MR_{ds} x R_{ds}), SPLB 94010A and SPLB 94011A with ICSR 26 (MR_{ds} x MR_{ds}); SPLB 94010A and SPLB 94025A with ICSR 97 (MR_{ds} x MR_{ds}); SPLB 94025A x ICSR 119 (MR_{ds} x S_{ds}); and SPLB 94010A x ICSR 91025 (MR_{ds} x HS_{ds}) were $resistant_{wl}$. The rest of the hybrids were either moderately $resistant_{wl}$ or less $susceptible_{wl}$ or $susceptible_{wl}$ or highly $susceptible_{wl}$. Majority of the LS_{ds} x R_{ds}, LS_{ds} x MR_{ds} and LS_{ds} x S_{ds} hybrids were moderately $resistant_{wl}$ except the hybrids SPLB 94024A and SPLB 94001A with A 2267-2 (LS_{ds} x R_{ds}); SPLB 94022A and SPLB 94001A with ICSR 26; and SPLB 94024A and SPLB 94001A with ICSR 97 (LS_{ds} x MR_{ds}) which were found to be $resistant_{wl}$. All other hybrids of the above combinations were either less $susceptible_{wl}$ or $susceptible_{wl}$. On the other hand, SPLB 94017A x A 2267-2 (S_{ds} x R_{ds}) was highly $resistant_{wl}$, while SPLB 94017A x ICSR 26 and SPLB 94017A x ICSR 97 (S_{ds} x MR_{ds}) were $resistant_{wl}$. The S_{ds} x HS_{ds} group of hybrids was less $susceptible_{wl}$, while four hybrids from S_{ds} x S_{ds} group were less $susceptible_{wl}$ and two were moderately $resistant_{wl}$.

4.2.3.3 Per cent Recovery of the Resistant Hybrids

Maximum per cent of $resistant_{wl}$ hybrids in the first year were noticed by 60% of the S_{ds} x R_{ds} and S_{ds} x MR_{ds} hybrids followed by 50% of the R_{ds} x R_{ds}, 33% of the R_{ds} x MR_{ds}, 40% of the LS_{ds} x R_{ds}, 17% of the MR_{ds} x MR_{ds} and S_{ds} x S_{ds} hybrids; and 8% of the R_{ds} x LS_{ds} hybrids.

In the second year, 38% of the MR_{ds} x R_{ds}, 6% of the MR_{ds} x MR_{ds} and 33% of the S_{ds} x R_{ds} hybrids were highly resistant$_{wl}$ for width of the lesion. In addition, maximum per cent of the resistant$_{wl}$ hybrids were recorded by 33% of the S_{ds} x MR_{ds} and 25% of the MR_{ds} x MR_{ds} hybrids followed by 22% of the LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} hybrids, 13% of the MR_{ds} x R_{ds} and MR_{ds} x HS_{ds} hybrids; and 6% of the MR_{ds} x S_{ds} hybrids.

4.2.3.4 Gene Action in-groups based on Disease Damage Score and Reaction

First year studies indicated that, 50% of the F_1 s (R_{wl}) from R_{ds} x R_{ds} group, 33% of the F_1 s (R_{wl}) from R_{ds} x MR_{ds} group, 8% of the F_1 s (R_{wl}) from R_{ds} x LS_{ds} group, 50% of the F_1 s (MR_{wl}) from R_{ds} x MR_{ds} group, 33% of the F_1 s (LS_{wl}) from R_{ds} x LS_{ds} group and 25% of the F_1 s (S_{wl}) from R_{ds} x S_{ds} group exhibited complete dominance as the performance of the hybrid was equal to either of their parents. Of these, resistance was completely dominant over susceptibility in the first three F_1 hybrids, while susceptibility was completely dominant over resistance in the rest three hybrids. Partial dominance was seen in 33% of the F_1 s (MR_{wl}) from R_{ds} x LS_{ds} group, 33% of the F_1 s (MR_{wl}) from R_{ds} x S_{ds} group and 33% of the F_1 s (LS_{wl}) from R_{ds} x S_{ds} group, whereas over dominance for susceptibility was noticed by 17% of the F_1 s (LS_{wl}) from R_{ds} x MR_{ds} group, 33% of the F_1 s (MR_{wl}) from R_{ds} x R_{ds} group, 17% of the F_1 s (S_{wl}) from R_{ds} x R_{ds} group, 17% of the F_1 s (S_{wl}) from R_{ds} x LS_{ds} group and 8% of the F_1 s (HS_{wl}) from R_{ds} x LS_{ds} and R_{ds} x S_{ds} group.

Among the R_{wl} x LS_{wl} hybrids, all the hybrids with ICSR 26 as the restorer line were moderately resistant$_{wl}$ except SPLB 94011A x ICSR 26 (the hybrid is susceptible). On the other hand, four A-lines (SPLB 94010A, SPLB 94011A, SPLB 94017A and SPLB 94024A), with A 2267-2 and SPLB 94011A with ICSR 91025 were resistant$_{wl}$. Three A-lines (SPLB 94003A, SPLB 94017A and SPLB 94024A) with ICSR 90030 were moderately resistant$_{wl}$, while SPLB 94010A x ICSR 90030 was highly susceptible$_{wl}$. The rest of the hybrids were less susceptible$_{wl}$.

Among the 120 hybrids studied in the second year, over dominance for resistance was observed by 38% of the F_1 s (HR$_{wl}$) from MR$_{ds}$ x R$_{ds}$ group, 6% of the F_1 s (HR$_{wl}$) from MR$_{ds}$ x MR$_{ds}$ group, 25% of the F_1 s (R$_{wl}$) from MR$_{ds}$ x MR$_{ds}$ group, 6% of the F_1 s (R$_{wl}$) from MR$_{ds}$ x S$_{ds}$ group and 13% of the F_1 s from MR$_{ds}$ x HS$_{ds}$ group, while over dominance for susceptibility was observed by 25% of the F_1 s (S$_{wl}$) from MR$_{ds}$ x R$_{ds}$ group, 19% of the F_1 s (LS$_{wl}$) from MR$_{ds}$ x MR$_{ds}$ group, 13% of the F_1 s (S$_{wl}$) from MR$_{ds}$ x MR$_{ds}$ group and 19% of the F_1 s (HS$_{wl}$) from MR$_{ds}$ x MR$_{ds}$ group. Resistance was completely dominant over susceptibility in 13% of the F_1 s (R$_{wl}$) from MR$_{ds}$ x R$_{ds}$ group, 19% of the hybrids (MR$_{wl}$) from MR$_{ds}$ x MR$_{ds}$ group, 38% of the F_1 s (MR$_{wl}$) from MR$_{ds}$ x S$_{ds}$ group and 38% of the F_1 s (MR$_{wl}$) from MR$_{ds}$ x HS$_{ds}$ group. While susceptibility was completely dominant over resistance in 19% of the F_1 s (S$_{wl}$) from MR$_{ds}$ x S$_{ds}$ group, 25% of the F_1 s (MR$_{wl}$) from MR$_{ds}$ x R$_{ds}$ group. On the other hand, partial dominance was seen in 38% of the F_1 s (LS$_{wl}$) from MR$_{ds}$ x HS$_{ds}$ group, 13% of the F_1 s (S$_{wl}$) from MR$_{ds}$ x HS$_{ds}$ group and 38% of the F_1 s (LS$_{wl}$) from MR$_{ds}$ x S$_{ds}$ group.

Among the MR$_{wl}$ x S$_{wl}$ group of hybrids, SPLB 94010A x ICSR 91025 exhibited resistant$_{wl}$ reaction, while SPLB 94011A and SPLB 94025A with ICSR 91025 were moderately resistant$_{wl}$. The hybrids SPLB 94003A x ICSR 91025; and SPLB 94009A and SPLB 94012A with ICSR 91025 were susceptible$_{wl}$ and less susceptible$_{wl}$, respectively.

4.2.3.5 Disease Parameters Pattern

The parental lines, SPLB 94010A and SPLB 94011A (R$_{ds/wl}$), SPLB 94006A and SPLB 94021A (MR$_{ds/wl}$), SPLB 94012A and SPLB 94025A (LS$_{ds/wl}$) among A-lines; and

ICSR 97 ($MR_{ds/wl}$) and ICSR 91025 ($LS_{ds/wl}$) among restorer lines in the first year (Table 6), whereas SPLB 94010A, SPLB 94011A and SPLB 94025A ($MR_{ds/wl}$), SPLB 94022A, SPLB 94024A, SPLB 94001A, SPLB 94014A and SPLB 94021A ($LS_{ds/wl}$) among A-lines; and ICSR 97 ($MR_{ds/wl}$) among restorer lines in the second year (Table 7) showed similar pattern of disease reaction for disease damage score and width of the lesion.

The A-lines, SPLB 94010A, SPLB 94011A and SPLB 94003A that were found to be resistant$_{wl}$ in the first year were moderately resistant$_{wl}$ in the second year. A 2267-2 a HR_{ds} restorer line during second year, exhibited less susceptibility$_{wl}$ in the first year. However, ICSR 97 (MR_{wl}); and ICSR 26 and ICSR 90030 (LS_{wl}) were consistent for lesion width across the seasons. The hybrids, SPLB 94010A x A 2267-2, SPLB 94011A x A 2267-2 and SPLB 94017A x A 2267-2 which were highly resistant$_{wl}$ during the second year were resistant$_{wl}$ in the first year, while SPLB 94016A x A 2267-2 and SPLB 94011A x ICSR 97 (highly resistant$_{wl}$ during second year) were moderately resistant$_{wl}$ in the first year. The hybrids, SPLB 94010A x ICSR 97, SPLB 94024A x A 2267-2, SPLB 94001A x ICSR 97, SPLB 94010A and SPLB 94011A crossed with ICSR 119, SPLB 94006A and SPLB 94021A with A 2267-2, SPLB 94022A, SPLB 94006A and SPLB 94016A with ICSR 97, SPLB 94019A and SPLB 94001A with ICSR 91025, SPLB 94003A with ICSR 119 and SPLB 94006A and SPLB 94003A with ICSR 26 exhibited similar reaction (resistance$_{wl}$) in both the years, while SPLB 94017A x A 2267-2; and SPLB 94010A and SPLB 94011A with A 2267-2 with resistance in the first year exhibited HR_{wl} in the second year. On the other hand, of the 14 hybrids that exhibited resistance$_{wl}$ in the first year, only three hybrids exhibited HR_{wl}, one showed resistance$_{wl}$, three recorded MR_{wl} in the second year, whereas rest showed LS_{wl} and S_{wl} reaction.

4.2.4 Area of the Lesion

The parental lines and the hybrids classified on the basis of the area of the lesion were categorised into different disease reaction groups as highly resistant (HR_{al}), resistant (R_{al}), moderately resistant (MR_{al}), less susceptible (LS_{al}), susceptible (S_{al}) and highly susceptible (HS_{al}).

4.2.4.1 Reaction of the Parents

In the first year, the male-sterile lines, SPLB 94009A, SPLB 94010A and SPLB 94011A (R_{ds}), 94003A (MR_{ds}); and SPLB 94017A and SPLB 94024A (LS_{ds}) were found to be resistant$_{al}$ for lesion area. Among the restorer lines, A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}), ICSR 119 (LS_{ds}) and ICSR 26 (S_{ds}) were moderately resistant$_{al}$, while ICSR 91025 (LS_{ds}) was susceptible$_{al}$ and ICSR 90030 (S_{ds}) was highly susceptible$_{al}$ (Table 6).

During second year, SPLB 94010A and SPLB 94011A (R_{ds}), SPLB 94019A (LS_{ds}) and SPLB 94017A (S_{ds}) among A-lines, whereas A 2267-2 (R_{ds}) and ICSR 97 (MR_{ds}) among restorer lines were resistant$_{al}$ (Table 7).

4.2.4.2 Reaction of the Hybrids

In the first year, majority of the R_{ds} x R_{ds} group of hybrids (SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94011A with A 2267-2), R_{ds} x MR_{ds} hybrids (SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94011A with ICSR 97), SPLB 94011A x ICSR 91025 and SPLB 94010A x ICSR 119 (R_{ds} x LS_{ds}); and SPLB 94015A x ICSR 90030 (R_{ds} x S_{ds}) were resistant$_{al}$. On the other hand, majority of the MR_{ds} x R_{ds}, MR_{ds} x ICSR 91025 (LS_{ds}), and MR_{ds} x S_{ds} group of hybrids were moderately resistant$_{al}$, while SPLB 94022A and SPLB 94021A with A 2267-2 (MR_{ds} x R_{ds}), SPLB 94016A, SPLB

94019A and SPLB 94022A with ICSR 97 (MR_{ds} x MR_{ds}), SPLB 94003A x ICSR 119 (MR_{ds} x LS_{ds}), SPLB 94016A x ICSR 26; and SPLB 94003A x ICSR 90030 (MR_{ds} x S_{ds}) were $resistant_{al}$ for lesion area. Most of the LS_{ds} x MR_{ds}, LS_{ds} x LS_{ds} and LS_{ds} x S_{ds} group of hybrids were moderately $resistant_{al}$, whereas LS_{ds} x R_{ds} group of hybrids were $resistant_{al}$. The female line, SPLB 94013A (S_{ds}) crossed with majority of the R-lines like A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}), ICSR 119 (LS_{ds}) and ICSR 26 (S_{ds}), SPLB 94001A x ICSR 97 (S_{ds} x MR_{ds}); and 296A x A 2267-2 (S_{ds} x R_{ds}) exhibited $resistance_{al}$, while rest of the hybrids involving S_{ds} female parent were either moderately $resistant_{al}$ or less $susceptible_{al}$ or highly $susceptible_{al}$.

Among the hybrids studied in the second year, the hybrids involving MR_{ds} female parents i.e., SPLB 94010A, SPLB 94011A and SPLB 94016A crossed with A 2267-2 (R_{ds}); and SPLB 94011A x ICSR 97 (MR_{ds}) were highly resistant, while SPLB 94007A and SPLB 94025A with A 2267-2 (R_{ds}), SPLB 94010A, SPLB 94011A and SPLB 94025A with ICSR 26 (MR_{ds}), SPLB 94010A and SPLB 94025A with ICSR 97 (MR_{ds}), SPLB 94007A, SPLB 94010A, SPLB 94025A and SPLB 94011A with ICSR 119 (S_{ds}), SPLB 94007A x ICSR 90030 (S_{ds}); and SPLB 94010A x ICSR 91025 (HS_{ds}) were $resistant_{al}$. The rest of the other hybrids exhibited either MR_{al} or LS_{al} or S_{al} or HS_{al} reaction. Majority of the LS_{ds} x R_{ds} hybrids, SPLB 94022A and SPLB 94001A with ICSR 26 and SPLB 94024A and SPLB 94001A with ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94024A x ICSR 119 (LS_{ds} x S_{ds}); and SPLB 94019A x ICSR 91025 (LS_{ds} x HS_{ds}) were moderately $resistant_{al}$. Majority of the S_{ds} x R_{ds} group of hybrids was $resistant_{al}$ except SPLB 94017A x A 2267-2, which was highly $resistant_{al}$. Most of the S_{ds} x MR_{ds} and S_{ds} x ICSR 119 (S_{ds}) hybrids were moderately $resistant_{al}$. On the other hand, SPLB 94017A with ICSR 26 and ICSR 97 (S_{ds} x MR_{ds}) was resistant$_{al}$, whereas S_{ds} x ICSR 90030 (S_{ds}) was less susceptible$_{al}$. S_{ds} x HS_{ds} group of hybrids exhibited MR_{al}, LS_{al} and HS_{al} reaction.

4.2.4.3 Per cent Recovery of the Resistant Hybrids

First year studies indicated that 67% of the F_1 s from R_{ds} x R_{ds}, R_{ds} x MR_{ds}, S_{ds} x R_{ds} and S_{ds} x MR_{ds} group were reported to give resistant$_{al}$ hybrids followed by 60% from LS_{ds} x R_{ds} group, 50% from MR_{ds} x MR_{ds} group, 33% from MR_{ds} x R_{ds} group, 20% from LS_{ds} x MR_{ds} group, 17% from R_{ds} x LS_{ds}, MR_{ds} x S_{ds}, S_{ds} x LS_{ds} and S_{ds} x S_{ds} group; and 8% from R_{ds} x S_{ds} and MR_{ds} x LS_{ds} group.

In the second year, 38% of the MR_{ds} x R_{ds} hybrids, 6% of the MR_{ds} x MR_{ds} hybrids and 33% of the S_{ds} x MR_{ds} hybrids were highly resistant$_{al}$ for the area of the lesion. In addition, maximum per cent of the resistant$_{al}$ hybrids were observed by 67% of the F_1 s from S_{ds} x R_{ds} and LS_{ds} x R_{ds} group followed by 33% from S_{ds} x MR_{ds} group, 31% from MR_{ds} x MR_{ds} and MR_{ds} x S_{ds} group, 25% from MR_{ds} x R_{ds} group, 22% from LS_{ds} x MR_{ds} group, 13% from MR_{ds} x HS_{ds} group, 11% from LS_{ds} x HS_{ds} group, and 6% from LS_{ds} x S_{ds} group.

4.2.4.4 Gene Action in-groups based on Disease Damage Score and Reaction

Over dominance for susceptibility in the first year was observed by 17% of the F_1 s (MR_{al}) from R_{ds} x R_{ds} group, 17% of the F_1 s (S_{al}) from R_{ds} x R_{ds} group, 8% of the F_1 s (S) from R_{ds} x LS_{ds} group, 17% of the F_1 s (HS_{al}) from R_{ds} x LS_{ds} group; and 17% of the F_1 s (HS_{al}) from R_{ds} x S_{ds} group. Resistance was completely dominant over susceptibility in 67% of the F_1 s (R_{al}) from R_{ds} x R_{ds} and R_{ds} x MR_{ds} group, 17% of the F_1 s (R_{al}) from R_{ds} x LS_{ds} group; and 8% of the F_1 s (R_{al}) from R_{ds} x S_{ds} group, whereas susceptibilty was completely dominant over resistance in 33% of the F_1 s (MR_{al}) from R_{ds} x MR_{ds} group, 17% of the F_1 s (LS_{al}) from R_{ds} x LS_{ds} group and 17% of the F_1 s (S_{al}) from R_{ds} x S_{ds} group. On the other hand, partial dominance was exhibited by 25% of the F_1 s (LS_{al}) from R_{ds} x S_{ds} group, 33% of the F_1 s (MR_{al}) from R_{ds} x S_{ds} group and 42% of the F_1 s (MR_{al}) from R_{ds} x LS_{ds} group.

Among the hybrids involving R_{al} x S_{al} parents, SPLB 94011A x ICSR 91025 exhibited resistance$_{al}$. On the other hand, SPLB 94009A and SPLB 94024A with ICSR 91025 exhibited moderate resistance$_{al}$, while SPLB 94010A, SPLB 94003A and SPLB 94017A with ICSR 91025 showed less susceptibility$_{al}$.

In the second year, 38% of the F_1 s (HR_{al}) from MR_{ds} x R_{ds} group, 6% of the F_1 s (HR_{al}) from MR_{ds} x MR_{ds} group, 31% of the F_1 s (R_{al}) from MR_{ds} x MR_{ds} group, 31% of the F_1 s (R_{al}) from MR_{ds} x S_{ds} group and 13% of the F_1 s (R_{al}) from MR_{ds} x HS_{ds} group showed over dominance for resistance. While, over dominance of susceptibility was observed by 19% of the F_1 s (S_{al}) from MR_{ds} x MR_{ds} group, 13% of the F_1 s (LS_{al}) from MR_{ds} x MR_{ds} group, 19% of the F_1 s (HS_{al}) from MR_{ds} x MR_{ds} group, 25% of the F_1 s (S_{al}) from MR_{ds} x R_{ds} group and 6% of the F_1 s (HS_{al}) from MR_{ds} x S_{ds} group. Complete dominance of resistance over susceptibility was seen in 25% of the F_1 s (R_{al}) from MR_{ds} x R_{ds} group, whereas complete dominance of susceptibility over resistance was observed by 13% of the F_1 s (HS_{al}) from MR_{ds} x HS_{ds} group. Complete dominance for moderate resistance was also observed by 13% of the F_1 s (MR_{al}) from MR_{ds} x MR_{ds}, MR_{ds} x R_{ds}, MR_{ds} x S_{ds} and MR_{ds} x HS_{ds} group. Partial dominance was noticed by 50% of the F_1 s (LS_{al}) from MR_{ds} x S_{ds} group, and 63% of the F_1 s (LS_{al}) from MR_{ds} x HS_{ds} group.

Among the R_{al} x HS_{al} group of hybrids, SPLB 94010A, SPLB 94011A and SPLB 94017A with ICSR 26; and SPLB 94010A and SPLB 94019A with ICSR 91025 exhibited resistance$_{al}$, while, SPLB 94019A x ICSR 26 and SPLB 94017A x ICSR 91025 showed moderate resistance$_{al}$; and SPLB 94011A x ICSR 91025 exhibited less susceptibility$_{al}$.

4.2.4.5 Disease Parameters Pattern

Similar disease reaction for disease damage score and area of the lesion, was recorded by SPLB 94009A, SPLB 94010A, SPLB 94011A ($R_{ds/al}$), SPLB 94006A and SPLB 94021A ($MR_{ds/al}$), SPLB 94025A ($LS_{ds/al}$) among A-lines and ICSR 97 ($MR_{ds/al}$) among restorer lines in the first year, while SPLB 94004A and SPLB 94025A ($MR_{ds/al}$), SPLB 94024A, SPLB 94006A, SPLB 94021A ($LS_{ds/al}$) and 296A ($S_{ds/al}$) among A-lines; and A 2267-2 ($R_{ds/al}$), ICSR 90030 ($S_{ds/al}$) and ICSR 91025 ($HS_{ds/al}$) among restorer lines in the second year.

Among the A-lines, three A-lines i.e., SPLB 94010A and SPLB 94011A (MR_{ds}); and SPLB 94017A (S_{ds}) group were found resistant$_{al}$ for both the years showing their consistency in disease reaction across the seasons. On the other hand, SPLB 94019A that was found resistant$_{al}$ in the second year exhibited susceptibility$_{al}$ in the first year. The restorer lines, i.e., A 2267-2 (R_{ds}) and ICSR 97 (MR_{ds}) with resistance$_{al}$ during first year showed moderate resistance$_{al}$ in the second year. Of the five hybrids which exhibited high resistance$_{al}$ during second year, four hybrids i.e., SPLB 94010A and SPLB 94011A with A 2267-2 (R_{ds} x R_{ds}), SPLB 94011A x ICSR 97 (R_{ds} x MR_{ds}); and SPLB 94017A x A 2267-2 (S_{ds} x R_{ds}) were resistant$_{al}$ during first year, while SPLB 94016A x A 2267-2 (MR_{ds} x R_{ds}) exhibited moderate resistance$_{al}$. Of all the hybrids with resistance$_{al}$ during first year, only few hybrids (SPLB 94012A, SPLB 94007A, SPLB 94025A, SPLB 94021A and 296A with A 2267-2, SPLB 94001A, SPLB 94010A, SPLB 94025A with ICSR 97 and SPLB 94010A with ICSR 119) showed similar disease reaction (resistance) over the years. Of the 28 hybrids which were found $resistant_{al}$ during second year, majority (12) of the hybrids (SPLB 94017A and SPLB 94024A with ICSR 97, SPLB 94019A x 91025, SPLB 94024A, SPLB 94007A and SPLB 94011A with ICSR 119, SPLB 94001A, SPLB 94017A and SPLB 94010A with ICSR 26; and SPLB 94001A, SPLB 94024A and SPLB 94006A with A 2267-2) showed moderate $resistance_{al}$ during first year, while eight hybrids exhibited resistance, five recorded less $susceptibility_{al}$, one showed $susceptibility_{al}$ and two hybrids had highly $susceptible_{al}$ reaction.

4.2.5 Number of Lesions

The parental lines and the hybrids classified on the basis of the number of lesions were categorised based on disease reaction as highly resistant (HR_{nl}), resistant (R_{nl}), moderately resistant (MR_{nl}), less susceptible (LS_{nl}), susceptible (S_{nl}) and highly susceptible (HS_{nl}).

4.2.5.1 Reaction of the Parents

In the first year, the female lines, SPLB 94004A, SPLB 94007A and SPLB 94015A from R_{ds} group; and SPLB 94016A, SPLB 94021A and SPLB 94022A from MR_{ds} group were highly $resistant_{nl}$. While SPLB 94013A (S_{ds}) and SPLB 94014A (LS_{ds}) were $resistant_{nl}$. A 2267-2 (R_{ds}), ICSR 91025 (LS_{ds}) and ICSR 90030 (S_{ds}) among restorer lines were $resistant_{nl}$ for number of lesions (Table 6).

During the second year, the male-sterile lines SPLB 94007A, SPLB 94004A, SPLB 94015A and SPLB 94016A (MR_{ds}); and SPLB 94024A, SPLB 94009A and SPLB 94014A (LS_{ds}) were highly $resistant_{nl}$, while SPLB 94013A (MR_{ds}), SPLB 94012A and SPLB 94017A (S_{ds}) were $resistant_{nl}$. Other male-sterile lines exhibited either MR_{nl} or LS_{nl} or HS_{nl}

reaction. Among the restorers, A 2267-2 (R_{ds}) was resistant$_{nl}$, while ICSR 26 (MR_{ds}) was highly resistant$_{nl}$. On the other hand, ICSR 97 (MR_{ds}) was less susceptible$_{nl}$, while ICSR 119 (S_{ds}) was moderately resistant$_{nl}$ for the lesion number (Table 7).

4.2.5.2 Reaction of the Hybrids

In the first year, majority of the hybrids involving R_{ds} female parents was highly resistant$_{nl}$. While, the hybrids involving MR_{ds} female parents exhibited either HR_{nl} or R_{nl} or MR_{nl} or LS_{nl} or S or HS_{nl} reaction. The hybrids, SPLB 94012A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94017A x ICSR 91025 and SPLB 94014A x ICSR 91025 (LS_{ds} x LS_{ds}), SPLB 94017A x ICSR 26 and SPLB 94012A x ICSR 90030 (LS_{ds} x S_{ds}), SPLB 94013A x A 2267-2 (S_{ds} x R_{ds}), SPLB 94013A and 296A with ICSR 97 (S_{ds} x MR_{ds}); and SPLB 94013A x ICSR 91025 (S_{ds} x LS_{ds}) were highly resistant$_{nl}$. Whereas all other hybrids exhibited either R_{nl} or MR_{nl} or LS_{nl} or S_{nl} or HS_{nl} reaction.

Among the 120 hybrids studied in the second year, the hybrids involving moderately resistant$_{ds}$ female parent, i.e., SPLB 94016A x A 2267-2 (MR_{ds} x R_{ds}) and majority of the MR_{ds} x MR_{ds} hybrids were highly resistant$_{nl}$. The female lines, SPLB 94019A and SPLB 94006A crossed with A 2267-2 (LS_{ds} x R_{ds}), SPLB 94003A, SPLB 94022A, SPLB 94009A and SPLB 94014A crossed with ICSR 26 and SPLB 94009A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94009A and SPLB 94012A with ICSR 119 and SPLB 94009A x ICSR 90030 (LS_{ds} x S_{ds}), SPLB 94021A x 91025 (LS_{ds} x HS_{ds}), SPLB 94017A x ICSR 90030 and 296A x ICSR 90030 (S_{ds} x S_{ds}) and SPLB 94012A x ICSR 91025 (S_{ds} x HS_{ds}) were highly resistant$_{nl}$. While the other hybrids exhibited either R_{nl} or MR_{nl} or LS_{nl} or S_{nl} or HS_{nl} reaction. The hybrids, SPLB 94009A x A 2267-2 (LS_{ds} x R_{ds}), SPLB 94022A and SPLB 94006A with ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94014A x ICSR 119, SPLB 94014A x ICSR 90030 and SPLB 94021A x ICSR 90030 (LS_{ds} x MR_{ds}), SPLB 94012A x A 2267-2 (S_{ds} x R_{ds}); and 296A x ICSR 91025 (S_{ds} x HS_{ds}) were found $resistant_{nl}$ for lesion number.

4.2.5.3 Per cent Recovery of the Resistant Hybrids

Highly $resistant_{nl}$ hybrids in the first year were observed by 50% of the F_1 s from R_{ds} x R_{ds}, R_{ds} x MR_{ds} and R_{ds} x LS_{ds} group, 42% of the F_1 s from R_{ds} x S_{ds} group, 33% of the F_1 s from MR_{ds} x R_{ds} and S_{ds} x R_{ds} group, 17% of the F_1 s from MR_{ds} x MR_{ds} and S_{ds} x LS_{ds} group, 8% of the F_1 s from MR_{ds} x LS_{ds} group, 20% of the F_1 s from LS_{ds} x MR_{ds}, LS_{ds} x LS_{ds} and LS_{ds} x S_{ds} group; and 67% of the F_1 s from S_{ds} x MR_{ds} group. On the other hand, 50% of the F_1 s from MR_{ds} x MR_{ds} group were reported to give hybrids with $resistance_{nl}$ followed by 33% from MR_{ds} x LS_{ds} and S_{ds} x S_{ds} group. Other hybrids with $resistance_{nl}$ were reported from LS_{ds} x R_{ds}, LS_{ds} x MR_{ds}, LS_{ds} x LS_{ds} and LS_{ds} x S_{ds} (20%) group; and R_{ds} x LS_{ds}, R_{ds} x S_{ds}, MR_{ds} x S_{ds}, R_{ds} x R_{ds}, R_{ds} x MR_{ds}, MR_{ds} x R_{ds} and S_{ds} x LS_{ds} group (17%).

In the second year, 13% of the MR_{ds} x R_{ds} hybrids, 31% of the MR_{ds} x MR_{ds} hybrids, 22% of the LS_{ds} x R_{ds} hybrids, 28% of the LS_{ds} x MR_{ds} hybrids, 11% of the LS_{ds} x S_{ds} and LS_{ds} x HS_{ds} hybrids, 50% of the S_{ds} x S_{ds} hybrids, and 33% of the S_{ds} x HS_{ds} hybrids were found to give highly $resistant_{nl}$ hybrids due to overdominance. Whereas, maximum per cent (44%) of the $resistant_{nl}$ hybrids were observed from MR_{ds} x S_{ds} group followed by 33% from S_{ds} x R_{ds} and S_{ds} x HS_{ds} group, 25% from MR_{ds} x HS_{ds} group, 19% from MR_{ds} x MR_{ds} group, 17% from LS_{ds} x S_{ds} group, 13% from MR_{ds} x R_{ds} group; and 11% from LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} group.

4.2.5.4 Gene Action in-groups based on Disease Damage Score and Reaction

Overdominance for resistance in the first year was observed by 50% of the hybrids (HR_{nl}) from R_{ds} x R_{ds}, R_{ds} x MR_{ds}, and R_{ds} x LS_{ds} group; and 42% of the F_1 s (HR_{nl}) from R_{ds} x S_{ds} group. While 33% of the F_1 s (HS_{nl}) from R_{ds} x R_{ds} group, 17% of the F_1 s (HS_{nl}) from R_{ds} x MR_{ds} group, 25% of the F_1 s (HS_{nl}) from R_{ds} x LS_{ds} group and 8% of the F_1 s (HS_{nl}) from R_{ds} x S_{ds} group exhibited over dominance for susceptibility. Resistance was completely dominant over susceptibility in 17% of the F_1 s (R_{nl}) from R_{ds} x S_{ds}, R_{ds} x LS_{ds}, R_{ds} x R_{ds} and R_{ds} x MR_{ds} group. On the other hand, susceptibility was completely dominant over resistance in 17% of the F_1 s (MR_{nl}) from R_{ds} x MR_{ds} group and 8% of the F_1 s (LS_{nl}) from R_{ds} x LS_{ds} group. Twenty five per cent of the F_1 s (MR_{nl}) from R_{ds} x S_{ds} group and 8% of the F_1 s (LS_{nl}) from R_{ds} x S_{ds} group exhibited partial dominance.

Among the two hybrids involving R_{nl} x LS_{nl} parents, the hybrid 94014A x ICSR 26 exhibited resistance$_{nl}$, while the other hybrid (SPLB 94013A x ICSR 26) showed susceptibility$_{nl}$.

Among the 16 cross combinations studied in the second year, 13% of the F_1 s (HR_{nl}) from MR_{ds} x R_{ds} group, 31% of the F_1 s (HR_{nl}) from MR_{ds} x MR_{ds} group, 19% of the F_1 s (R_{nl}) from MR_{ds} x MR_{ds} group, 44% of the F_1 s (R_{nl}) from MR_{ds} x S_{ds} group and 25% of the F_1 s (R_{nl}) from MR_{ds} x HS_{ds} group expressed over dominance for resistance. On the otherhand, over dominance for susceptibility was expressed by 25% of the F_1 s (LS_{nl}) from MR_{ds} x R_{ds} group, 25% of the F_1 s (HS_{nl}) from MR_{ds} x R_{ds} group, 13% of the F_1 s (S_{nl}) from MR_{ds} x R_{ds} group, 13% of the F_1 s (LS_{nl}) from MR_{ds} x MR_{ds} group, 6% of the F_1 s (S_{nl}) from MR_{ds} x MR_{ds} group, 13% of the F_1 s (HS_{nl}) from MR_{ds} x MR_{ds} group, and 25% of the F_1 s (HS_{nl}) from MR_{ds} x S_{ds} group. Complete dominance of resistance over susceptibility was expressed by 13% of the F_1 s (R_{nl}) from MR_{ds} x R_{ds} group, 19% of the F_1 s (MR_{nl}) from

MR_{ds} x MR_{ds} group and 25% of the F_1 s (MR_{nl}) from MR_{ds} x HS_{ds} group. Whereas, susceptibility was completely dominant over resistance in 19% of the F_1 s (S_{nl}) from MR_{ds} x S_{ds} group and 13% of the F_1 s (HS_{nl}) from MR_{ds} x HS_{ds} group. Resistance was completely dominant over moderate resistance in 13% of the F_1 s (MR_{nl}) from MR_{ds} x R_{ds} group. However partial dominance was observed by 13% of the F_1 s (LS_{nl}) from MR_{ds} x S_{ds} group, 25% of the F_1 s (LS_{nl}) from MR_{ds} x HS_{ds} group and 13% of the F_1 s (S_{nl}) from MR_{ds} x HS_{ds} group.

Among the hybrids involving HR_{nl} x S_{nl} parents, only one hybrid (SPLB 94009A x ICSR 90030) exhibited HR_{nl}, while four hybrids (SPLB 94007A, SPLB 94015A, SPLB 94016A and SPLB 94014A with ICSR 90030) were reported to possess $resistance_{nl}$. SPLB 94024A x ICSR 90030 and SPLB 94004A x ICSR 90030 showed moderate $resistance_{nl}$ and $susceptibility_{nl}$ respectively.

4.2.5.5 Disease Parameters Pattern

The parents, SPLB 94006A and SPLB 94019A ($MR_{ds/nl}$) among A-lines, A 2267-2 ($R_{ds/nl}$) and ICSR 97 ($MR_{ds/nl}$) among restorer lines in the first year, while $LS_{ds/nl}$ A-lines (SPLB 94003A, SPLB 94019A and SPLB 94006A); and $R_{ds/nl}$ (A 2267-2), $S_{ds/nl}$ (ICSR 90030) and $HS_{ds/nl}$ (ICSR 91025) restorer lines in the second year showed similar pattern of reaction for disease damage score and number of lesions.

Similarity in disease reaction i.e., high $resistance_{nl}$ for two consecutive years was reported by SPLB 94007A, SPLB 94004A, SPLB 94015A and SPLB 94016A among male-sterile lines; and SPLB 94007A, SPLB 94013A, SPLB 94015A and SPLB 94004A with ICSR 97; and 94016A and 94006A with A 2267-2 among crosses exhibited high $resistance_{nl}$ for both the years, while the restorer line, A 2267-2 exhibited $resistance_{nl}$ in both the years. The hybrids SPLB 94004A and SPLB 94009A with A 2267-2, SPLB 94015A x ICSR 119, SPLB 94007A x ICSR 26, SPLB 94015A and SPLB 94013A with ICSR 91025, SPLB 94006A x ICSR 97 and SPLB 94015A x ICSR 90030 which were found to be highly resistant$_{nl}$ in the first year exhibited resistance$_{nl}$ in the second year, while the hybrids, SPLB 94012A x ICSR 91025 and SPLB 94014A x ICSR 26 with high resistance$_{nl}$ in the second year showed resistance$_{nl}$ in the first year.

4.2.6 Number of Flecks

The parental lines and the hybrids classified on the basis of the number of flecks were represented into different disease reaction groups as highly resistant (HR$_{nf}$), resistant (R$_{nf}$), moderately resistant (MR$_{nf}$), less susceptible (LS$_{nf}$), susceptible (S$_{nf}$) and highly susceptible (HS$_{nf}$).

4.2.6.1 Reaction of the Parents

During first year, all the female parental lines except six lines were highly resistant$_{nf}$. Of the six lines, SPLB 94011A (R$_{ds}$), SPLB 94003A (MR$_{ds}$), SPLB 94024A, and SPLB 94025A (LS$_{ds}$) were resistant$_{nf}$, while SPLB 94001A (S$_{ds}$) was susceptible$_{nf}$ and SPLB 94019A was HS$_{nf}$ for fleck number. All the restorer lines were highly resistant$_{nf}$ except ICSR 26 (S$_{ds}$), which showed moderate resistance$_{nf}$ (Table 6).

In the second year, SPLB 94016A (MR$_{ds}$), SPLB 94009A, SPLB 94014A and SPLB 94021A (LS$_{ds}$) were highly resistant$_{nf}$ for fleck number, while SPLB 94013A, SPLB 94015A and SPLB 94025A (MR$_{ds}$), SPLB 94003A, SPLB 94022A and SPLB 94001A (LS$_{ds}$); and SPLB 94012A and 296A (S$_{ds}$) were resistant$_{nf}$. The R-lines, ICSR 26 (MR$_{ds}$) and ICSR 90030 (S$_{ds}$) exhibited high resistance$_{nf}$ indicating the importance of fleck number in these hybrids. ICSR 91025, a highly susceptible$_{ds}$ R-line was found resistant$_{nf}$. While A 2267-2 (R$_{ds}$) was found to be susceptible$_{nf}$ (Table 7).

4.2.6.2 Reaction of the Hybrids

The hybrids, SPLB 94004A, SPLB 94009A and SPLB 94015A with A 2267-2 (R$_{ds}$ x R$_{ds}$), SPLB 94007A and SPLB 94015A with ICSR 91025 and SPLB 94004A, SPLB 94007A, and SPLB 94015A with ICSR 119 (R$_{ds}$ x LS$_{ds}$), SPLB 94004A x ICSR 26 and SPLB 94015A x 90030 (R$_{ds}$ x S$_{ds}$), SPLB 94006A and SPLB 94016A with A 2267-2 (MR$_{ds}$ x R$_{ds}$), SPLB 94022A x ICSR 97 (MR$_{ds}$ x MR$_{ds}$), and SPLB 94021A x ICSR 91025 and SPLB 94006A x ICSR 119 (MR$_{ds}$ x LS$_{ds}$) were highly resistant$_{nf}$. Majority of the cross combinations involving LS$_{ds}$ female parent, exhibited either LS$_{nf}$ or S$_{nf}$ or HS$_{nf}$ reaction. While SPLB 94012A x A 2267-2 (LS$_{ds}$ x R$_{ds}$), SPLB 94012A x ICSR 91025 (LS$_{ds}$ x LS$_{ds}$), SPLB 94017A x ICSR 26 and SPLB 94014A x ICSR 26 (LS$_{ds}$ x S$_{ds}$) were resistant$_{nf}$; and SPLB 94017A x A 2267-2 (LS$_{ds}$ x R$_{ds}$) and SPLB 94017A x ICSR 91025 (LS$_{ds}$ x LS$_{ds}$) were highly resistant$_{nf}$. The female parent, SPLB 94013A (S$_{ds}$) crossed with ICSR 97 (MR$_{ds}$), ICSR 91025 (LS$_{ds}$) and ICSR 119 (LS$_{ds}$) and SPLB 94001A x A 2267-2 (S$_{ds}$ x R$_{ds}$) exhibited high resistance$_{nf}$. S$_{ds}$ x MR$_{ds}$ group of hybrids expressed either MR$_{nf}$ or R$_{nf}$ or HR$_{nf}$ for fleck number. SPLB 94013A x A 2267-2 (S$_{ds}$ x R$_{ds}$), SPLB 94001A x ICSR 97 (S$_{ds}$ x MR$_{ds}$), SPLB 94001A x ICSR 91025 (S$_{ds}$ x LS$_{ds}$); and SPLB 94001A x ICSR 26 and SPLB 94013A x ICSR 90030 (S$_{ds}$ x S$_{ds}$) exhibited resistance$_{nf}$ for fleck number.

Majority of the MR$_{ds}$ x R$_{ds}$ and MR$_{ds}$ x ICSR 119 hybrids, exhibited susceptibility$_{nf}$ or less susceptibility$_{nf}$ or high susceptibility$_{nf}$. While, MR$_{ds}$ x ICSR 97, MR$_{ds}$ x ICSR 90030 and MR$_{ds}$ x HS$_{ds}$ hybrids showed either MR$_{nf}$ or R$_{nf}$ or HR$_{nf}$. Among the hybrids, involving MR$_{ds}$ A-lines, SPLB 94016A x A 2267-2 (R$_{ds}$), SPLB 94007A and SPLB 94016A with

ICSR 97 (MR_{ds}), SPLB 94007A and SPLB 94025A with ICSR 90030 (S_{ds}); and SPLB 94025A x ICSR 91025 (HS_{ds}) were highly $resistant_{nf}$ to disease with less number of flecks. Almost all the hybrids of LS_{ds} x ICSR 90030 (S_{ds}) and LS_{ds} x HS_{ds} group were $resistant_{nf}$ or highly $resistant_{nf}$ for fleck number. While majority of the hybrids from LS_{ds} x ICSR 26 (MR_{ds}) showed $resistance_{nf}$. On the other hand, most of the hybrids involving LS_{ds} x R_{ds} and LS_{ds} x ICSR 97 parental lines exhibited $susceptibility_{nf}$ or high $susceptibility_{nf}$. Among the hybrids involving S_{ds} A-lines, hybrids with ICSR 119 (S_{ds}) as the male parent showed $resistance_{nf}$. While hybrids with ICSR 90030 (S_{ds}) expressed either MR_{nf} or R_{nf} or HR_{nf} and hybrids with ICSR 91025 (HS_{ds}) showed either R_{nf} or HR_{nf}. Majority of the hybrids from S_{ds} x R_{ds} group, S_{ds} x ICSR 97 (MR_{ds}) showed $susceptibility_{nf}$ for fleck number, while S_{ds} x ICSR 26 (MR_{ds}) group exhibited moderate $resistance_{nf}$. Besides, 296A x ICSR 97 (S_{ds} x MR_{ds}), 296A x ICSR 90030 (S_{ds} x S_{ds}) and SPLB 94012A and 296A with ICSR 91025 (S_{ds} x HS_{ds}) group were also reported to exhibit high $resistance_{nf}$.

4.2.6.3 Per cent Recovery of the Resistant Hybrids

Among the 16 groups of hybrids studied in the first year, 50% of the R_{ds} x R_{ds} hybrids, 42% from R_{ds} x LS_{ds} group, 17% from R_{ds} x S_{ds} group, 33% from MR_{ds} x R_{ds} group, 17% from MR_{ds} x MR_{ds} and MR_{ds} x LS_{ds} group, 20% from LS_{ds} x R_{ds} group, 10% from LS_{ds} x LS_{ds} and 33% from S_{ds} x R_{ds}, S_{ds} x MR_{ds} and S_{ds} x LS_{ds} group were highly $resistant_{nf}$ for fleck number. In addition, maximum per cent (33%) of the $resistant_{nf}$ hybrids were also recorded from MR_{ds} x MR_{ds}, S_{ds} x R_{ds}, S_{ds} x MR_{ds} and S_{ds} x S_{ds} group followed by 25% from MR_{ds} x S_{ds} group, 20% from LS_{ds} x R_{ds} and LS_{ds} x S_{ds} group, 17% from MR_{ds} x LS_{ds} and S_{ds} x LS_{ds} group, 10% from LS_{ds} x LS_{ds}, and 8% from R_{ds} x LS_{ds} and R_{ds} x S_{ds} group.

In the second year, high resistance$_{nf}$ for fleck number was reported by 13% of the F_1 s involving MR_{ds} female parent (MR_{ds} x R_{ds}, MR_{ds} x MR_{ds}, MR_{ds} x S_{ds} and MR_{ds} x HS_{ds} group), 17% of the F_1 s from LS_{ds} x MR_{ds}, S_{ds} x MR_{ds} and S_{ds} x S_{ds} group, 28% of the F_1 s from LS_{ds} x S_{ds} group, 33% of the F_1 s from LS_{ds} x HS_{ds} group and 67% of the F_1 s from S_{ds} x HS_{ds} group. However, maximum per cent (67%) of the resistant$_{nf}$ hybrids were observed from S_{ds} x S_{ds} group followed by 44% from LS_{ds} x HS_{ds} group, 38% from MR_{ds} x HS_{ds} group, 33% from S_{ds} x HS_{ds}, S_{ds} x R_{ds} and LS_{ds} x S_{ds} group, 31% from MR_{ds} x MR_{ds} and MR_{ds} x S_{ds} group, 28% from LS_{ds} x MR_{ds} group and 11% from LS_{ds} x R_{ds} group.

4.2.6.4 Gene Action in groups based on Disease Damage Score and Reaction

In the first year, over dominance for resistance was expressed by 50% of the F_1 s (HR_{nf}) from R_{ds} x R_{ds} group, 42% of the F_1 s (HR_{nf}) from R_{ds} x LS_{ds} group and 17% of the F_1 s (HR_{nf}) from R_{ds} x S_{ds} group, while over dominance for susceptibility was observed by 17% of the F_1 s (HS_{nf}) from R_{ds} x R_{ds} group, 25% of the F_1 s (HS_{nf}) from R_{ds} x LS_{ds} group, 17% of the F_1 s (S_{nf}) from R_{ds} x LS_{ds} group, 33% of the F_1 s (MR_{nf}) from R_{ds} x R_{ds} group, and 8% of the F_1 s (HS_{nf}) from R_{ds} x S_{ds} group. On the other hand, complete dominance of resistance over susceptibility was observed by 8% of the F_1 s (R_{nf}) from R_{ds} x LS_{ds} and R_{ds} x S_{ds} group. While, susceptibility was completely dominant over resistance in 8% of the F_1 s (LS_{nf}) from R_{ds} x LS_{ds} group. Partial dominance was observed by 33% of the F_1 s (MR_{nf}) from R_{ds} x S_{ds} group and 33% of the F_1 s (LS_{nf}) from R_{ds} x S_{ds} group. (Table 6)

Among the 14 hybrids involving HR_{nf} x MR_{nf} parents, one hybrid (SPLB 94004A x ICSR 26) expressed HR_{nf}, three hybrids (SPLB 94014A, SPLB 94017A and SPLB 94021A with ICSR 26) exhibited resistance$_{nf}$, three hybrids (SPLB 94007A, SPLB 94015A and SPLB 94012A with ICSR 26) were reported to possess MR_{nf}, four hybrids (SPLB 4009A, SPLB 94010A, SPLB 94006A and SPLB 94016A with ICSR 26) showed less susciptibility$_{nf}$ and three hybrids (SPLB 94013A, SPLB 94022A and 296A with ICSR 26) exhibited susceptibility$_{nf}$ for fleck number.

The over dominance for resistance was observed in the second year by 13% of the F_1 s (HR_{nf}) from MR_{ds} x R_{ds} group,13% of the F_1 s (HR_{nf}) from MR_{ds} x MR_{ds}, MR_{ds} x S_{ds} and MR_{ds} x HS_{ds} group, 31% of the F_1 s (R_{nf}) from MR_{ds} x MR_{ds} and MR_{ds} x S_{ds} group; and 38% of the F_1 s (R_{nf}) from MR_{ds} x HS_{ds} group (Table 7). While over dominance for susceptibility was reported by 13% of the F_1 s (S_{nf}) from MR_{ds} x R_{ds} group, 13% of the F_1 s (LS_{nf}) from MR_{ds} x R_{ds} group, 50% of the F_1 s (HS_{nf}) from MR_{ds} x R_{ds} group, 19% of the F_1 s (LS_{nf} and HS_{nf}) from MR_{ds} x MR_{ds} group, 6% of the F_1 s (LS_{nf}) from MR_{ds} x S_{ds} group and 25% of the F_1 s (HS_{nf}) from MR_{ds} x S_{ds} group. Moderate resistance was completely dominant over suscepbility in 19% of the F_1 s (MR_{nf}) from MR_{ds} x MR_{ds} and MR_{ds} x S_{ds} group and 13% of the F_1 s (MR_{nf}) from MR_{ds} x R_{ds} and MR_{ds} x S_{ds} group, while susceptibility was completely dominant over resistance in 6% of the F_1 s (S_{nf}) from MR_{ds} x S_{ds} group and 13% of the F_1 s (HS_{nf}) from MR_{ds} x HS_{ds} group. On the other hand, partial dominance was reported by 13% of the F_1 s (S_{nf}) from MR_{ds} x HS_{ds} group and 13% of the F_1 s (LS_{nf}) from MR_{ds} x HS_{ds} group.

Of the four hybrids involving HR_{nf} and HS_{nf} parents, only two hybrids (SPLB 94016A and SPLB 94009A with ICSR 97) exhibited high resistance$_{nf}$ for fleck number, while SPLB 94014A x ICSR 97 was found to be less susceptible$_{nf}$. However, the hybrid, SPLB 94021A x ICSR 97 expressed resistant$_{nf}$ reaction.

4.2.6.5 Disease Parameters Pattern

The A-lines, SPLB 94011A ($R_{ds/nf}$) and SPLB 94001A ($S_{ds/nf}$) in the first year (Table

6); and SPLB 94004A ($MR_{ds/nf}$) in the second year, (Table 7) exhibited similar pattern of disease reaction for disease damage score and number of flecks, respectively.

The female parental lines with high resistance$_{nf}$ for fleck number during first year (Table 8) exhibited either HR_{nf} or R_{nf} or MR_{nf} or S or HS_{nf} or LS_{nf} reaction in the second year (Table 9). The A-lines, SPLB 94016A, SPLB 94009A, SPLB 94014A and SPLB 94021A (LS_{ds}), the restorer line, i.e., ICSR 90030; and the hybrids SPLB 94016A x A 2267-2 and SPLB 94021A x ICSR 91025 were highly resistant$_{nf}$ for fleck number across the years. While, ICSR 26 with moderate resistance$_{nf}$ during first year was highly resistant$_{nf}$ in the second year. Of the remaining hybrids with high resistance$_{nf}$ in the first year, only six hybrids (SPLB 94015A x ICSR 90030, SPLB 94013A and SPLB 94015A with ICSR 91025, SPLB 94006A x A 2267-2, SPLB 94017A x ICSR 91025 and SPLB 94013A x ICSR 97) showed resistance$_{nf}$ in the second year. While the other hybrids exhibited MR_{nf} (two hybrids), LS_{nf} (two hybrids), S_{nf} (five hybrids) and HS_{nf} (four hybrids) reactions, respectively. Of the 18 hybrids with high resistance$_{nf}$ in the second year, three hybrids each showed moderate resistance$_{nf}$ and resistance$_{nf}$, respectively. On the other hand, six hybrids exhibited LS_{nf}, reaction while one and four hybrids were reported to express S_{nf} and HS_{nf}, reactions respectively.

4.2.7 Lodging

The parental lines and the hybrids classified into various disease reaction groups on the basis of the lodging were represented as highly resistant (HR_{lp}), resistant (R_{lp}), moderately resistant (MR_{lp}), less susceptible (LS_{lp}), susceptible (S_{lp}) and highly susceptible (HS_{lp}).

4.2.7.1 Reaction of the Parents

Majority (nine) of the A-lines (SPLB 94003A, SPLB 94016A, SPLB 94019A and SPLB 94022A (MR_{ds}), SPLB 94012A and SPLB 94014A (LS_{ds}); and SPLB 94013A and 296A (S_{ds})) were moderately $resistant_{lp}$, while most of the A-lines from R_{ds} group exhibited less $susceptibility_{lp}$ to lodging. On the other hand, SPLB 94011A from R_{ds} group showed moderate $resistance_{lp}$. Among the restorer lines, A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}) and ICSR 91025 (LS_{ds}) were moderately $resistant_{lp}$. While ICSR 119 (LS_{ds}) and ICSR 26 (S_{ds}) were less $susceptible_{lp}$ (Table 8).

4.2.7.2 Reaction of the Hybrids

Among the hybrids involving R_{ds} A-lines, majority of the cross combinations showed moderate $resistance_{lp}$. While SPLB 94009A x A 2267-2 (R_{ds} x R_{ds}), SPLB 94004A and 94011A with ICSR 119 (R_{ds} x LS_{ds}), SPLB 94009A, SPLB 94010A and SPLB 94015A with ICSR 26 and SPLB 94004A with ICSR 90030 (R_{ds} x S_{ds}) were less $susceptible_{lp}$. All the cross combinations involving MR_{ds} female parents were less $susceptible_{lp}$ except SPLB 94022A x A 2267-2 (MR_{ds} x R_{ds}), SPLB 94016A x ICSR 119 (MR_{ds} x LS_{ds}), SPLB 94016A and SPLB 94019A with ICSR 26 (MR_{ds} x S_{ds}); and SPLB 94016A x ICSR 90030 (MR_{ds} x S_{ds}), while the remaining hybrids exhibited moderate $resistance_{lp}$. The LS_{ds} x MR_{ds} group of hybrids and the remaining group of hybrids with LS_{ds} line as the female parent majorily exhibited moderate $resistance_{lp}$. The S_{ds} x MR_{ds} group of hybrids was moderately $resistant_{lp}$, while S_{ds} x ICSR 119 (LS_{ds}) group was less $susceptible_{lp}$. Rest of the cross combinations exhibited either MR_{lp} or LS_{lp} reaction.

Table 8. Mean performance of different genotypes of sorghum for lodging (%) and various yield contributing characters, rabi season 1996.

Genotypes	Lodging (%)	Disease reaction	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score^2	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
LINES												
Resistant (R^2)												
SPLB 94004A	13.49	LS	71.33	E	122.00	S	4.00	UD	18.60	A	2.43	L
SPLB 94007A	35.12	LS	85.00	Lt	108.33	S	3.00	D	22.80	A	2.40	L
SPLB 94009A	38.92	LS	78.67	M	95.00	S	3.33	UD	20.00	A	2.70	L
SPLB 94010A	18.69	LS	73.33	E	121.67	S	3.00	D	24.53	A	2.97	A
SPLB 94011A	0.00	MR	73.33	E	106.67	S	3.33	UD	21.93	A	2.47	L
SPLB 94015A	32.78	LS	77.00	M	115.00	S	3.33	UD	11.27	L	2.57	L
Moderately Resistant (MR^2)												
SPLB 94003A	6.55	MR	83.33	M	121.67	S	3.33	UD	20.00	A	2.90	A
SPLB 94006A	37.08	LS	85.00	Lt	130.00	S	2.00	D	27.33	A	2.67	L
SPLB 94016A	2.38	MR	74.00	E	118.33	S	4.00	UD	16.40	L	2.90	A
SPLB 94019A	9.76	MR	86.00	Lt	121.67	S	3.67	UD	22.60	A	2.43	L
SPLB 94021A	27.04	LS	79.67	M	128.33	S	3.00	D	20.00	A	3.10	A
SPLB 94022A	2.22	MR	82.00	M	125.00	S	3.33	UD	17.87	L	2.97	A
Less Susceptible (LS^2)												
SPLB 94012A	9.44	MR	84.00	Lt	155.00	M	3.33	UD	17.20	L	3.33	A
SPLB 94014A	4.65	MR	83.67	Lt	140.00	S	3.00	D	23.33	A	3.40	H
SPLB 94017A	92.59	HS	84.00	Lt	145.00	M	3.33	UD	11.80	L	2.27	L
SPLB 94024A	22.94	LS	82.67	M	116.67	S	3.33	UD	15.33	L	2.73	L
SPLB 94025A	48.68	S	79.67	M	148.33	M	3.33	UD	15.60	L	2.70	L
Susceptible (S^2)												
SPLB 94001A	56.88	S	82.00	M	121.67	S	3.00	D	20.00	A	2.00	L
SPLB 94013A	6.53	MR	86.00	Lt	156.67	M	2.67	D	26.13	A	3.43	H
296A	2.08	MR	74.67	E	105.00	S	4.00	UD	14.13	L	2.60	L

Contd..

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Genotypes	Lodging (%)	Disease reaction	Days to 50% flowering (days)	Groups	Plant height (cm)	Groups	Agronomic score[2]	Groups	Grain yield $plant^{-1}$ (g)	Groups	100 seed weight (g)	Groups
TESTERS												
Resistant (R^2)												
A 2267-2	7.41	MR	80.00	M	156.67	M	3.33	UD	21.80	A	2.67	L
Moderately Resistant (MR^2)												
ICSR 97	1.67	MR	84.67	Lt	116.67	S	3.33	UD	13.20	L	3.07	A
Less Susceptible (LS^2)												
ICSR 119	16.93	LS	76.00	M	120.00	S	3.67	UD	21.73	A	2.93	A
ICSR 91025	7.14	MR	83.33	M	135.00	S	2.67	D	29.67	A	2.73	L
Susceptible (S^2)												
ICSR 26	36.06	LS	77.33	M	128.33	S	3.33	UD	15.87	L	3.03	A
ICSR 90030	69.45	HS	85.00	Lt	130.00	S	3.33	UD	18.27	A	2.70	L
CROSSES												
R x R												
SPLB 94004A X A 2267-2	1.45	MR	77.67	M	181.67	T	3.67	UD	32.13	H	3.17	A
SPLB 94007A X A 2267-2	12.05	MR	82.00	M	188.33	T	2.00	D	42.67	H	3.17	A
SPLB 94009A X A 2267-2	36.67	LS	80.33	M	176.67	T	2.67	D	54.13	H	3.13	A
SPLB 94010A X A 2267-2	0.00	MR	83.00	M	180.00	T	3.00	D	24.40	A	3.50	H
SPLB 94011A X A 2267-2	5.56	MR	85.67	M	185.00	T	3.33	UD	16.13	L	3.10	A
SPLB 94015A X A 2267-2	4.17	MR	86.00	Lt	128.33	S	3.00	D	13.20	L	2.90	A
R x MR												
SPLB 94004A X ICSR 97	0.00	MR	79.33	M	128.33	S	3.33	UD	15.80	L	3.30	A
SPLB 94007A X ICSR 97	0.00	MR	83.00	M	125.00	S	4.00	UD	23.67	A	3.40	H
SPLB 94009A X ICSR 97	0.00	MR	80.67	M	135.00	S	3.00	D	17.67	L	3.03	A
SPLB 94010A X ICSR 97	0.00	MR	78.00	M	123.33	S	3.33	UD	28.27	A	3.37	H
SPLB 94011A X ICSR 97	0.00	MR	82.67	M	131.67	S	3.00	D	29.33	A	2.63	L
SPLB 94015A X ICSR 97	4.76	MR	85.00	Lt	121.67	S	3.00	D	25.47	A	3.10	A

Contd..

Contd..

Genotypes	Lodging (%)	Disease reaction	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[2]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
R x LS												
SPLB 94004A X ICSR 91025	0.00	MR	87.00	Lt	146.67	M	3.00	D	19.67	A	3.10	A
SPLB 94007A X ICSR 91025	0.00	MR	86.00	Lt	148.33	M	3.33	UD	20.00	A	3.20	A
SPLB 94009A X ICSR 91025	0.00	MR	79.67	M	202.00	T	2.33	D	26.67	A	3.47	H
SPLB 94010A X ICSR 91025	0.00	MR	86.33	Lt	143.33	M	3.33	UD	28.93	A	3.20	A
SPLB 94011A X ICSR 91025	3.17	MR	83.33	M	142.00	M	2.00	D	20.20	A	3.10	A
SPLB 94015A X ICSR 91025	4.78	MR	84.00	Lt	121.67	S	3.33	UD	15.67	L	2.90	A
SPLB 94004A X ICSR 119	17.78	LS	87.00	Lt	150.00	M	3.33	UD	14.73	L	3.10	A
SPLB 94007A X ICSR 119	0.00	MR	85.67	Lt	135.00	S	4.00	UD	28.33	A	3.17	A
SPLB 94009A X ICSR 119	10.18	MR	80.00	M	150.00	M	2.67	D	36.00	H	3.37	H
SPLB 94010A X ICSR 119	7.52	MR	80.67	M	150.00	M	3.00	D	31.53	A	3.17	A
SPLB 94011A X ICSR 119	36.97	LS	78.67	M	131.67	S	2.67	D	36.00	H	3.33	A
SPLB 94015A X ICSR 119	8.89	MR	83.67	Lt	143.33	M	3.33	UD	24.93	A	3.50	H
R x S												
SPLB 94004A X ICSR 26	6.36	MR	80.33	M	153.00	M	2.33	D	36.40	H	3.03	A
SPLB 94007A X ICSR 26	7.69	MR	79.00	M	143.33	M	2.67	D	26.80	L	3.10	A
SPLB 94009A X ICSR 26	23.98	LS	78.33	M	133.33	S	2.33	D	29.33	A	3.23	A
SPLB 94010A X ICSR 26	36.85	LS	78.00	M	148.33	M	2.33	D	27.07	A	3.27	A
SPLB 94011A X ICSR 26	4.76	MR	86.33	Lt	153.33	M	3.33	UD	25.13	A	3.20	A
SPLB 94015A X ICSR 26	17.99	LS	79.33	M	128.33	S	3.00	D	28.00	A	2.67	LS
SPLB 94004A X ICSR 90030	15.74	LS	85.00	Lt	146.67	M	3.67	UD	23.60	A	3.10	A
SPLB 94007A X ICSR 90030	5.00	MR	81.33	M	140.00	S	3.00	D	23.13	A	3.53	H
SPLB 94009A X ICSR 90030	3.70	MR	82.67	M	143.33	M	2.67	D	33.13	H	3.50	H
SPLB 94010A X ICSR 90030	0.00	MR	88.00	Lt	135.00	S	3.00	D	25.67	A	3.47	H
SPLB 94011A X ICSR 90030	12.04	MR	82.33	M	140.00	S	2.67	D	27.40	A	3.40	H
SPLB 94015A X ICSR 90030	6.67	MR	81.00	M	123.33	S	4.67	UD	17.20	L	2.77	A
MR x R												
SPLB 94003A X A 2267-2	4.52	MR	84.00	Lt	191.67	T	2.67	D	31.20	A	3.43	H

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Genotypes	Lodging (%)	Disease reaction	Days to 50% flowering (days)	Groups	Plant height (cm)	Groups	Agronomic score^2	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
SPLB 94006A X A 2267-2	0.00	MR	85.00	Lt	190.00	T	2.67	D	14.67	L	3.47	H
SPLB 94016A X A 2267-2	33.33	MR	87.00	Lt	185.00	T	2.67	D	47.87	H	2.97	A
SPLB 94019A X A 2267-2	0.00	MR	87.67	Lt	188.33	T	2.33	D	41.67	H	3.10	A
SPLB 94021A X A 2267-2	2.56	MR	84.63	Lt	178.33	T	3.00	D	18.13	A	3.33	A
SPLB 94022A X A 2267-2	0.00	LS	82.00	M	166.67	T	3.33	UD	31.80	H	3.57	H
MR x MR												
SPLB 94003A X ICSR 97	0.00	MR	86.33	Lt	125.00	S	4.00	UD	28.00	A	3.10	A
SPLB 94006A X ICSR 97	0.00	MR	82.00	M	128.33	S	3.33	UD	28.07	A	3.27	A
SPLB 94016A X ICSR 97	2.08	MR	75.67	M	118.33	S	3.67	UD	19.13	A	3.17	A
SPLB 94019A X ICSR 97	1.85	MR	81.00	M	133.33	S	2.33	D	32.33	H	2.90	A
SPLB 94021A X ICSR 97	0.00	MR	77.67	M	133.33	S	3.67	UD	15.20	L	3.27	A
SPLB 94022A X ICSR 97	0.00	MR	73.00	E	130.00	S	2.70	D	25.10	A	3.00	A
MR x LS												
SPLB 94003A X ICSR 91025	0.00	MR	82.33	M	156.67	M	2.00	D	25.07	A	3.07	A
SPLB 94006A X ICSR 91025	3.17	MR	84.33	Lt	175.00	T	3.00	D	20.87	A	3.03	A
SPLB 94016A X ICSR 91025	3.75	MR	87.33	Lt	153.33	M	2.00	D	27.40	A	3.27	A
SPLB 94019A X ICSR 91025	0.00	MR	79.00	M	148.33	M	2.00	D	29.67	A	2.77	A
SPLB 94021A X ICSR 91025	0.00	MR	84.33	Lt	156.67	M	2.67	D	19.27	A	3.13	A
SPLB 94022A X ICSR 91025	0.00	MR	77.33	M	155.00	M	2.67	D	23.73	A	3.17	A
SPLB 94003A X ICSR 119	2.48	MR	80.67	M	155.00	M	3.33	UD	14.93	L	3.00	A
SPLB 94006A X ICSR 119	9.71	MR	88.00	Lt	146.67	M	4.33	UD	17.40	L	3.23	A
SPLB 94016A X ICSR 119	22.67	LS	72.33	E	168.33	T	3.00	D	28.00	A	3.53	H
SPLB 94019A X ICSR 119	3.17	MR	77.00	M	151.67	M	2.00	D	27.20	A	3.13	A
SPLB 94021A X ICSR 119	0.00	MR	76.67	M	151.67	M	2.67	D	20.67	A	3.47	H
SPLB 94022A X ICSR 119	3.70	MR	73.00	E	146.67	M	3.33	UD	31.93	H	3.43	H
MR x S												
SPLB 94003A X ICSR 26	4.77	MR	78.33	M	155.00	M	2.67	D	35.73	H	3.00	A
SPLB 94006A X ICSR 26	10.28	MR	79.33	M	151.67	M	3.00	D	20.40	A	3.07	A

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Genotypes	Lodging (%)	Disease reaction	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[2]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
SPLB 94016A X ICSR 26	22.62	LS	74.00	E	145.00	M	2.67	D	35.27	H	3.33	A
SPLB 94019A X ICSR 26	23.81	LS	76.33	M	156.67	M	2.00	D	38.33	H	3.07	A
SPLB 94021A X ICSR 26	0.00	MR	77.33	M	158.33	M	3.00	D	27.33	A	3.27	A
SPLB 94022A X ICSR 26	10.26	MR	72.33	E	151.67	M	2.33	D	32.20	H	3.33	A
SPLB 94003A X ICSR 90030	0.00	MR	83.67	Lt	142.00	M	3.67	UD	29.73	A	3.13	A
SPLB 94006A X ICSR 90030	4.86	MR	85.00	Lt	135.00	S	3.67	UD	18.93	A	3.30	A
SPLB 94016A X ICSR 90030	21.87	LS	73.00	E	148.33	M	2.67	D	27.00	A	3.10	A
SPLB 94019A X ICSR 90030	9.76	MR	74.00	E	136.67	S	2.33	D	28.13	A	3.17	A
SPLB 94021A X ICSR 90030	1.59	MR	82.67	M	148.33	M	2.67	D	20.67	A	3.03	A
SPLB 94022A X ICSR 90030	7.07	MR	71.33	E	158.33	M	3.00	D	29.93	A	3.47	H
LS x R												
SPLB 94012A X A 2267-2	0.00	MR	81.67	M	201.67	T	2.33	D	33.53	H	3.93	H
SPLB 94014A X A 2267-2	0.00	MR	81.33	M	176.00	T	3.33	UD	22.87	A	3.40	H
SPLB 94017A X A 2267-2	34.49	LS	86.67	Lt	200.00	T	3.33	UD	12.47	L	2.73	L
SPLB 94024A X A 2267-2	32.71	LS	78.67	M	201.00	T	2.00	D	30.07	A	3.40	H
SPLB 94025A X A 2267-2	17.78	LS	78.33	M	180.33	T	2.33	D	36.80	H	3.10	A
LS x MR												
SPLB 94012A X ICSR 97	0.00	MR	85.67	Lt	143.33	M	4.33	UD	12.67	L	3.50	H
SPLB 94014A X ICSR 97	0.00	MR	81.67	M	167.00	T	3.30	UD	31.80	H	3.60	H
SPLB 94017A X ICSR 97	3.70	MR	82.00	M	137.00	S	3.00	D	18.70	A	2.70	L
SPLB 94024A X ICSR 97	0.00	MR	80.00	M	112.00	S	3.70	UD	14.10	L	3.10	A
SPLB 94025A X ICSR 97	1.52	MR	78.00	M	146.67	M	3.33	UD	14.93	L	3.17	A
LS x LS												
SPLB 94012A X ICSR 91025	0.00	MR	83.33	M	180.00	T	2.67	D	25.13	A	3.60	H
SPLB 94014A X ICSR 91025	1.96	MR	84.67	Lt	181.67	T	3.33	UD	17.53	L	3.20	A
SPLB 94017A X ICSR 91025	18.18	LS	84.33	Lt	178.33	T	3.00	D	17.73	L	2.60	L
SPLB 94024A X ICSR 91025	5.03	MR	76.67	M	151.67	M	2.67	D	25.93	A	3.17	A
SPLB 94025A X ICSR 91025	6.05	MR	81.33	M	160.00	T	3.00	D	22.80	A	3.07	A

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Genotypes	Lodging (%)	Disease reaction	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[2]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
SPLB 94012A X ICSR 119	3.03	MR	80.00	M	175.00	T	2.67	D	26.73	A	3.80	H
SPLB 94014A X ICSR 119	0.00	MR	80.00	M	165.00	T	3.67	UD	24.47	A	3.40	H
SPLB 94017A X ICSR 119	16.56	LS	79.33	M	160.00	T	3.00	D	16.33	L	3.10	A
SPLB 94024A X ICSR 119	6.94	MR	76.00	M	133.33	S	2.67	D	27.80	A	3.20	A
SPLB 94025A X ICSR 119	13.46	LS	74.67	E	163.33	T	3.00	D	21.93	A	3.43	H
LS x S												
SPLB 94012A X ICSR 26	23.14	LS	80.33	M	185.00	T	2.67	D	41.07	H	3.37	H
SPLB 94014A X ICSR 26	3.33	MR	81.00	M	176.67	T	3.00	D	22.80	A	3.33	A
SPLB 94017A X ICSR 26	21.78	LS	79.33	M	161.67	T	2.67	D	25.33	A	2.97	A
SPLB 94024A X ICSR 26	16.35	LS	75.00	E	145.00	M	2.67	D	42.47	H	3.37	H
SPLB 94025A X ICSR 26	49.31	S	73.00	E	165.00	T	2.67	D	29.87	A	3.20	A
SPLB 94012A X ICSR 90030	4.76	MR	84.67	Lt	175.00	T	3.00	D	27.80	A	3.63	H
SPLB 94014A X ICSR 90030	2.22	MR	83.33	M	168.33	T	3.33	UD	16.13	L	3.43	H
SPLB 94017A X ICSR 90030	16.78	LS	77.33	M	160.00	T	2.67	D	23.47	A	2.97	A
SPLB 94024A X ICSR 90030	18.08	LS	77.67	M	145.00	M	3.33	UD	21.53	A	2.83	A
SPLB 94025A X ICSR 90030	9.76	MR	77.33	M	161.67	T	2.00	D	25.93	A	3.20	A
S x R												
SPLB 94001A X A 2267-2	3.03	MR	78.00	M	216.67	T	3.00	D	30.33	A	3.03	A
SPLB 94013A X A 2267-2	2.08	MR	86.67	Lt	203.33	T	2.67	D	29.67	A	3.50	H
296A X A 2267-2	27.73	LS	81.67	M	181.67	T	2.00	D	29.40	A	3.17	A
S x MR												
SPLB 94001A X ICSR 97	0.00	MR	84.33	Lt	140.00	S	2.67	D	20.40	A	2.17	L
SPLB 94013A X ICSR 97	0.00	MR	81.00	M	158.00	M	3.67	UD	14.73	L	3.60	H
296A X ICSR 97	8.63	MR	77.33	M	120.00	S	2.67	D	26.20	A	2.90	A
S x LS												
SPLB 94001A X ICSR 91025	33.81	LS	86.00	Lt	160.00	T	2.67	D	32.47	H	2.30	L
SPLB 94013A X ICSR 91025	0.00	MR	87.00	Lt	181.67	T	3.00	D	21.87	A	3.47	H
296A X ICSR 91025	1.28	MR	83.00	M	141.67	M	2.67	D	15.53	L	3.20	A

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Genotypes	Lodging (%)	Disease reaction	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[2]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
SPLB 94001A X ICSR 119	26.16	LS	77.00	M	153.33	M	2.33	D	44.93	H	3.00	A
SPLB 94013A X ICSR 119	15.00	LS	80.67	M	173.33	T	3.00	D	27.73	A	3.23	A
296A X ICSR 119	23.81	LS	74.67	E	135.00	S	2.67	D	24.47	A	3.23	A
S x S												
SPLB 94001A X ICSR 26	3.70	MR	86.00	Lt	165.00	T	2.33	D	26.00	A	2.77	A
SPLB 94013A X ICSR 26	32.73	LS	76.00	M	180.00	T	2.00	D	29.53	A	3.73	H
296A X ICSR 26	13.49	LS	79.00	M	151.67	M	3.33	UD	17.20	L	3.37	H
SPLB 94001A X ICSR 90030	17.36	LS	77.00	M	170.00	T	2.67	D	33.27	H	2.73	L
SPLB 94013A X ICSR 90030	0.00	MR	82.00	M	158.33	M	3.33	UD	17.27	L	3.57	H
296A X ICSR 90030	25.54	LS	77.67	M	148.33	M	3.00	D	24.53	A	2.90	A
CHECKS												
Resistant												
M 35-1	31.11	LS	80.33	M	185.00	T	2.67	D	29.87	A	3.73	H
ICSB 13	53.05	S	71.67	E	110.00	S	3.33	UD	20.67	A	2.67	L
PM 1861	0.00	MR	75.33	E	108.33	S	4.00	UD	17.87	L	2.60	L
Susceptible												
H 112	97.62	HS	72.00	E	157.33	M	4.67	UD	36.00	H	3.10	A
FSRP Local	89.41	HS	75.00	E	153.33	M	4.33	UD	20.80	A	2.80	A
Kundi Jowar	11.62	MR	67.33	E	110.00	S	5.00	UD	16.73	L	2.95	A
G. Mean	12.90		80.00		150.09		3.02		24.75		3.11	
S. Em	14.81		2.18		5.00		0.56		3.94		0.19	
C.V. (%)	114.80		2.70		3.30		18.60		15.90		6.10	

1. Scored on a (1-5) scale
2. The groups are based on disease score

E = Early, M = Medium, Lt = Late
S = Short, T = Tall
D = Agronomically desirable, UD = Agronomically undesirable
L = Low, A = Average, H = High

4.2.7.3 Per cent Recovery of the Resistant Hybrids

Majority of the cross combinations exhibited moderate resistance$_{lp}$ for lodging Four cross combinations involving moderately resistant$_{ds}$ male parents (R_{ds} x MR_{ds}, MR_{ds} x MR_{ds}, LS_{ds} x MR_{ds} and S_{ds} x MR_{ds} groups) were reported to give maximum per cent (100%) of moderately resistant$_{lp}$ hybrids. This is followed by 92% of the F_1 s from MR_{ds} x LS_{ds} group, 83% of the F_1 s from R_{ds} x R_{ds}, R_{ds} x LS_{ds} and MR_{ds} x R_{ds}, group 75% of the F_1 s from MR_{ds} x S_{ds} group, 70% of the F_1 s from LS_{ds} x LS_{ds} group, 67% of the F_1 s from R_{ds} x S_{ds} and S_{ds} x R_{ds} group, 40% of the F_1 s from LS_{ds} x R_{ds} and LS_{ds} x S_{ds} group; and 33% of the F_1 s from S_{ds} x LS_{ds} and S_{ds} x S_{ds} group.

4.2.7.4 Gene Action in groups based on Disease Damage Score and Reaction

Complete dominance of susceptibility over resistance was expressed by 100% of the F_1 s (MR_{lp}) from R_{ds} x MR_{ds} group and 17% of the F_1 s (LS_{lp}) from R_{ds} x LS_{ds} group. Partial dominance was exhibited by 83% of the F_1 s (MR_{lp}) from R_{ds} x LS_{ds} group, 67% of the F_1 s (MR_{lp}) from R_{ds} x S_{ds} group and 33% of the F_1 s (LS_{lp}) from R_{ds} x S_{ds} group. However, 83% of the F_1 s (MR_{lp}) from R_{ds} x R_{ds} group and 17% of the F_1 s (LS_{lp}) from R_{ds} x R_{ds} group may not be useful in the future breeding programmes due to the presence of over dominance for susceptibility.

Among the nine hybrids involving MR_{lp} x HS_{lp} parents, seven hybrids (SPLB 94011A, SPLB 94003A, SPLB 94019A, SPLB 94022A, SPLB 94012A, SPLB 94014A and SPLB 94013A crossed with ICSR 90030) exhibited moderate resistance$_{lp}$, while the remaining two hybrids (SPLB 94016A and 296A with ICSR 90030) showed less susceptibility$_{lp}$ for lodging.

4.2.7.5 Disease Parameters Pattern

Among the parental lines, SPLB 94003A, SPLB 94016A, SPLB 94019A and SPLB 94022A ($MR_{ds/lp}$) SPLB 94024A ($LS_{ds/lp}$) and SPLB 94001A ($S_{ds/lp}$) were found to exhibit similar pattern of disease reaction for disease damage score and lodging (Table 8).

4.2.8. Days to 50% Flowering

The parental lines and the hybrids were classified into three groups ($early_{df}$, $medium_{df}$ and $late_{df}$) on the basis of days to 50% flowering taking standard deviation into consideration.

Early = < ($\bar{x}$)

Medium = ($\bar{x}$) to ($\bar{x}$- S.D.)

Late = > ($\bar{x}$ - S.D.)

Where, S.D. = Standard deviation; $\bar{x}$ = Mean of the trial.

4.2.8.1 Reaction of the Parents

During first year, SPLB 94004A, SPLB 94010A and SPLB 94011A from R_{ds} group, SPLB 94016A from MR_{ds} group and 296A from S_{ds} group of A-lines were $early_{df}$ in flowering, while rest of the female lines were either $medium_{df}$ or $late_{df}$ in flowering. None of the restorer lines exhibited $early_{df}$ flowering, whereas A 2267-2 (R_{ds}), ICSR 91025 (LS_{ds}), ICSR 119 (LS_{ds}) and ICSR 26 (S_{ds}) were $medium_{df}$ in flowering. On the other hand, ICSR 97 (MR_{ds}) and ICSR 90030 (S_{ds}) were $late_{df}$ in flowering (Table 8).

Studies of the second year indicated that the A-lines, SPLB 94024A and SPLB 94009A (LS_{ds}) were $early_{df}$ in flowering, while SPLB 94025A (MR_{ds}) exhibited $medium_{df}$

Table 9. Mean performance of different genotypes of sorghum for various yield contributing characters, rabi season 1997.

Genotypes	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[1]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
LINES										
Moderately Resistant (MR[2])										
SPLB 94004A	71	Lt	150	S	4.0	UD	20.8	L	2.6	A
SPLB 94007A	71	Lt	133	S	5.0	UD	23.5	L	2.8	A
SPLB 94010A	70	Lt	133	S	5.0	UD	25.0	L	3.0	A
SPLB 94011A	72	Lt	110	S	5.0	UD	23.1	L	2.4	L
SPLB 94013A	76	Lt	197	S	5.0	UD	28.8	A	3.6	H
SPLB 94015A	76	Lt	140	S	5.0	UD	13.3	L	2.7	A
SPLB 94016A	71	Lt	150	S	5.0	UD	18.0	L	2.6	A
SPLB 94025A	64	M	197	M	3.7	UD	20.0	L	2.1	L
Less Susceptible (LS[2])										
SPLB 94001A	69	Lt	150	S	4.3	UD	21.5	L	2.2	L
SPLB 94003A	68	Lt	150	S	4.0	UD	20.4	L	3.1	A
SPLB 94006A	70	Lt	160	S	5.0	UD	28.9	L	2.6	A
SPLB 94009A	59	E	137	S	4.7	UD	11.5	A	3.2	H
SPLB 94014A	70	Lt	180	S	5.0	UD	24.1	L	3.5	H
SPLB 94019A	68	Lt	160	S	4.7	UD	23.7	L	2.4	L
SPLB 94021A	68	Lt	160	S	5.0	UD	20.4	L	3.0	A
SPLB 94022A	68	Lt	183	M	4.3	UD	18.0	L	2.8	A
SPLB 94024A	62	E	163	S	3.3	UD	25.3	L	2.6	A
Susceptible (S[2])										
SPLB 94012A	71	Lt	197	M	5.0	UD	17.7	L	3.2	H

Contd..

Contd..

Genotypes	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[1]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
SPLB 94017A	68	Lt	203	T	4.7	UD	15.3	L	2.1	L
296A	70	Lt	113	S	5.0	UD	14.6	L	2.5	L
TESTERS										
Resistant (R^2)										
A 2267-2	69	Lt	220	T	4.7	UD	25.1	L	3.1	A
Moderately Resistant (MR^2)										
ICSR 26	61	E	170	S	3.3	UD	36.3	H	2.6	A
ICSR 97	68	Lt	133	S	3.0	D	29.7	A	3.0	A
Susceptible (S^2)										
ICSR 119	67	M	170	S	3.0	D	35.1	H	3.0	A
ICSR 90030	65	M	173	S	3.3	UD	31.3	A	2.5	L
Highly Susceptible (HS^2)										
ICSR 91025	67	M	223	T	4.0	UD	21.9	L	2.3	L
CROSSES										
MR x R										
SPLB 94004A X A 2267-2	68	Lt	178	S	4.7	UD	13.7	L	2.1	L
SPLB 94007A X A 2267-2	69	Lt	195	M	4.3	UD	17.9	L	2.1	L
SPLB 94010A X A 2267-2	67	M	257	T	3.3	UD	21.9	L	2.7	A
SPLB 94011A X A 2267-2	68	Lt	213	T	2.7	D	42.1	H	3.2	H
SPLB 94013A X A 2267-2	67	M	260	T	3.0	D	24.0	L	3.6	H
SPLB 94015A X A 2267-2	70	Lt	158	S	4.7	UD	16.0	L	2.9	A
SPLB 94016A X A 2267-2	69	Lt	240	T	4.3	UD	51.3	H	3.2	H
SPLB 94025A X A 2267-2	64	M	250	T	3.0	D	43.3	H	3.2	H

Contd..

Contd..

Genotypes	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[1]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
MR x MR										
SPLB 94004A X ICSR 26	67	M	183	M	2.3	D	36.8	H	2.8	A
SPLB 94007A X ICSR 26	67	M	177	S	3.0	D	40.5	H	3.2	H
SPLB 94010A X ICSR 26	63	E	177	S	3.3	UD	36.1	H	2.9	A
SPLB 94011A X ICSR 26	67	M	183	M	3.7	UD	29.2	A	2.2	L
SPLB 94013A X ICSR 26	67	M	227	T	3.0	D	39.3	H	2.9	A
SPLB 94015A X ICSR 26	67	M	173	S	3.7	UD	40.7	H	3.2	H
SPLB 94016A X ICSR 26	68	Lt	170	S	3.7	UD	29.2	A	3.8	H
SPLB 94025A X ICSR 26	58	E	240	T	3.3	UD	50.7	H	3.4	H
SPLB 94004A X ICSR 97	71	Lt	145	S	3.7	UD	43.1	H	3.2	H
SPLB 94007A X ICSR 97	69	Lt	150	S	4.3	UD	31.9	A	2.7	A
SPLB 94010A X ICSR 97	68	Lt	138	S	3.7	UD	30.1	A	3.1	A
SPLB 94011A X ICSR 97	67	M	138	S	3.3	UD	29.1	A	2.9	A
SPLB 94013A X ICSR 97	68	Lt	180	S	4.0	UD	25.9	A	3.2	H
SPLB 94015A X ICSR 97	66	M	132	S	3.3	UD	31.8	A	2.9	A
SPLB 94016A X ICSR 97	69	Lt	133	S	4.7	UD	14.3	L	3.6	H
SPLB 94025A X ICSR 97	61	E	155	S	3.3	UD	25.5	L	3.0	A
MR x S										
SPLB 94004A X ICSR 119	69	Lt	187	M	4.7	UD	17.4	L	3.2	H
SPLB 94007A X ICSR 119	66	M	190	M	3.3	UD	32.9	A	3.3	H
SPLB 94010A X ICSR 119	67	M	193	M	4.3	UD	18.1	L	3.4	H
SPLB 94011A X ICSR 119	66	M	167	S	2.7	D	45.5	H	3.0	A
SPLB 94013A X ICSR 119	70	Lt	213	T	4.7	UD	29.1	A	3.4	H
SPLB 94015A X ICSR 119	70	Lt	145	S	4.7	UD	26.2	A	3.6	H
SPLB 94016A X ICSR 119	69	E	195	M	5.0	UD	35.2	H	3.7	H

Contd..

Contd..

Genotypes	Days to 50% flowering (days)	Groups	Plant height (cm)	Groups	Agronomic score[1]	Groups	Grain yield $plant^{-1}$ (g)	Groups	100 seed weight (g)	Groups
SPLB 94025A X ICSR 119	61	E	203	T	3.3	UD	47.3	H	3.1	A
SPLB 94004A X ICSR 90030	69	Lt	173	S	3.7	UD	22.9	L	2.4	L
SPLB 94007A X ICSR 90030	60	E	157	S	3.3	UD	32.9	A	3.2	H
SPLB 94010A X ICSR 90030	65	M	187	M	3.3	UD	30.9	A	3.6	H
SPLB 94011A X ICSR 90030	67	M	180	S	3.0	D	37.9	H	3.5	H
SPLB 94013A X ICSR 90030	67	M	207	T	3.3	UD	35.1	H	3.2	H
SPLB 94015A X ICSR 90030	67	M	177	S	3.3	UD	29.1	A	3.2	H
SPLB 94016A X ICSR 90030	68	Lt	143	S	5.0	UD	29.3	A	3.1	A
SPLB 94025A X ICSR 90030	59	E	203	T	3.3	UD	28.9	A	2.9	A
MR x HS										
SPLB 94004A X ICSR 91025	68	Lt	253	T	3.0	D	47.7	H	2.4	L
SPLB 94007A X ICSR 91025	67	M	227	T	2.7	D	50.1	H	2.3	L
SPLB 94010A X ICSR 91025	67	M	250	T	2.7	D	27.3	A	2.4	L
SPLB 94011A X ICSR 91025	68	Lt	243	T	3.3	UD	32.3	A	2.4	L
SPLB 94013A X ICSR 91025	66	M	247	T	2.7	D	48.0	H	3.2	H
SPLB 94015A X ICSR 91025	67	M	250	T	3.7	UD	26.0	A	2.2	L
SPLB 94016A X ICSR 91025	68	Lt	263	T	3.3	UD	27.1	A	2.2	L
SPLB 94025A X ICSR 91025	60	E	257	T	3.7	UD	29.0	A	2.6	A
LS x R										
SPLB 94001A X A 2267-2	68	Lt	277	T	3.3	UD	39.0	H	2.5	L
SPLB 94003A X A 2267-2	70	Lt	208	T	4.0	UD	31.9	A	3.4	H
SPLB 94006A X A 2267-2	68	Lt	243	T	3.0	D	34.4	H	2.4	L
SPLB 94009A X A 2267-2	58	E	217	T	3.0	D	30.7	A	3.3	H
SPLB 94014A X A 2267-2	68	Lt	260	T	3.7	UD	18.8	L	2.6	A
SPLB 94019A X A 2267-2	67	M	175	S	3.3	UD	44.5	H	3.2	H

Contd..

Contd..

Genotypes	Days to 50% flowering (days)	Groups	Plant height (cm)	Groups	Agronomic score[1]	Groups	Grain yield $plant^{-1}$ (g)	Groups	100 seed weight (g)	Groups
SPLB 94021A X A 2267-2	67	M	247	T	3.7	UD	29.7	A	3.5	H
SPLB 94022A X A 2267-2	68	Lt	262	T	3.7	UD	41.1	H	3.2	H
SPLB 94024A X A 2267-2	62	E	230	T	3.0	D	50.5	H	3.1	A
LS x MR										
SPLB 94001A X ICSR 26	61	E	197	M	3.0	D	32.5	A	2.4	L
SPLB 94003A X ICSR 26	63	E	177	S	4.0	UD	28.1	A	3.2	H
SPLB 94006A X ICSR 26	63	E	193	M	4.0	UD	27.7	A	2.7	A
SPLB 94009A X ICSR 26	56	E	167	S	3.7	UD	30.8	A	3.3	H
SPLB 94014A X ICSR 26	65	M	230	T	3.0	D	26.1	A	2.9	A
SPLB 94019A X ICSR 26	65	M	203	T	3.3	UD	61.5	H	2.9	A
SPLB 94021A X ICSR 26	62	E	200	M	4.0	UD	25.1	L	3.0	A
SPLB 94022A X ICSR 26	64	M	160	S	3.7	UD	17.9	L	2.3	L
SPLB 94024A X ICSR 26	60	E	207	S	2.7	D	46.5	H	2.9	A
SPLB 94001A X ICSR 97	64	M	180	S	3.0	D	38.7	H	2.8	A
SPLB 94003A X ICSR 97	68	Lt	167	S	4.3	UD	18.7	L	3.3	H
SPLB 94006A X ICSR 97	65	M	157	S	3.7	UD	35.2	H	3.0	A
SPLB 94009A X ICSR 97	58	E	140	S	3.3	UD	28.5	A	3.3	H
SPLB 94014A X ICSR 97	68	Lt	190	M	4.7	UD	15.1	L	2.9	A
SPLB 94019A X ICSR 97	67	M	157	S	2.0	D	38.2	H	3.1	A
SPLB 94021A X ICSR 97	66	M	170	S	3.7	UD	20.1	L	3.1	A
SPLB 94022A X ICSR 97	68	Lt	165	S	4.0	UD	17.8	L	3.2	H
SPLB 94024A X ICSR 97	61	E	160	S	3.7	UD	18.3	L	3.0	A
LS x S										
SPLB 94001A X ICSR 119	62	E	207	T	2.7	D	45.4	H	3.4	H
SPLB 94003A X ICSR 119	67	M	197	M	3.3	UD	19.7	L	3.1	A

Contd..

Contd..

Genotypes	Days to 50% flowering (days)	Groups	Plant height (cm)	Groups	Agronomic score[1]	Groups	Grain yield $plant^{-1}$ (g)	Groups	100 seed weight (g)	Groups
SPLB 94006A X ICSR 119	68	Lt	200	M	4.0	UD	16.7	L	2.8	A
SPLB 94009A X ICSR 119	58	E	173	S	3.7	UD	25.5	L	3.6	H
SPLB 94014A X ICSR 119	67	M	210	T	4.3	UD	18.5	L	2.9	A
SPLB 94019A X ICSR 119	68	Lt	175	S	2.3	D	27.5	A	3.0	A
SPLB 94021A X ICSR 119	67	M	193	M	3.0	D	18.1	L	3.2	H
SPLB 94022A X ICSR 119	66	M	165	S	4.3	UD	24.6	L	3.1	A
SPLB 94024A X ICSR 119	62	E	160	S	4.0	UD	23.7	L	2.9	A
SPLB 94001A X ICSR 90030	60	E	197	M	2.7	D	33.1	A	2.7	A
SPLB 94003A X ICSR 90030	68	Lt	150	S	4.7	UD	30.0	A	2.7	A
SPLB 94006A X ICSR 90030	65	M	180	S	3.0	D	27.0	A	2.5	L
SPLB 94009A X ICSR 90030	58	E	167	S	3.0	D	40.5	H	3.4	H
SPLB 94014A X ICSR 90030	63	E	197	M	3.0	D	34.6	H	3.1	A
SPLB 94019A X ICSR 90030	61	E	160	S	3.3	UD	37.0	H	3.1	A
SPLB 94021A X ICSR 90030	63	E	180	S	3.0	D	33.6	H	3.0	A
SPLB 94022A X ICSR 90030	59	E	183	M	3.0	D	32.9	A	3.1	A
SPLB 94024A X ICSR 90030	56	E	173	S	3.3	UD	21.7	L	3.1	A
LS x HS										
SPLB 94001A X ICSR 91025	62	E	250	T	3.7	UD	23.3	L	2.7	A
SPLB 94003A X ICSR 91025	68	Lt	237	T	5.0	UD	15.3	L	2.0	L
SPLB 94006A X ICSR 91025	67	M	253	T	3.7	UD	26.8	A	2.4	L
SPLB 94009A X ICSR 91025	57	E	193	M	4.0	UD	20.2	L	3.4	H
SPLB 94014A X ICSR 91025	67	M	250	T	3.7	UD	22.1	L	2.7	A
SPLB 94019A X ICSR 91025	68	Lt	240	T	2.7	D	58.7	H	3.0	A
SPLB 94021A X ICSR 91025	67	M	250	T	3.0	D	30.7	A	2.8	A
SPLB 94022A X ICSR 91025	64	M	267	T	2.7	D	46.9	H	3.3	H
SPLB 94024A X ICSR 91025	60	E	233	T	3.0	D	37.9	H	2.6	A

Contd..

Contd..

Genotypes	Days to 50% fl owering (days)	Groups	Plant height (cm)	Groups	Agron omic score[1]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
S x R										
SPLB 94012A X A 2267-2	68	Lt	263	T	3.7	UD	22.3	L	2.6	A
SPLB 94017A X A 2267-2	67	M	270	T	3.3	UD	27.7	A	2.7	A
296A X A 2267-2	66	M	240	T	2.7	D	38.9	H	2.8	A
S x MR										
SPLB 94012A X ICSR 26	69	Lt	190	M	4.0	UD	19.1	L	2.6	A
SPLB 94017A X ICSR 26	62	E	210	T	3.3	UD	36.2	H	2.6	A
296A X ICSR 26	62	E	170	S	4.0	UD	16.8	L	2.7	A
SPLB 94012A X ICSR 97	68	Lt	162	S	4.0	UD	27.1	A	3.2	H
SPLB 94017A X ICSR 97	64	M	177	S	4.0	UD	30.6	A	2.8	A
296A X ICSR 97	77	Lt	130	S	3.3	UD	30.1	A	3.0	A
S x S										
SPLB 94012A X ICSR 119	67	M	223	T	4.3	UD	24.1	L	3.4	H
SPLB 94017A X ICSR 119	65	M	227	T	3.7	UD	26.7	A	3.4	H
296A X ICSR 119	62	E	183	M	3.0	D	34.0	H	3.1	A
SPLB 94012A X ICSR 90030	64	M	213	T	3.0	D	30.1	A	3.3	H
SPLB 94017A X ICSR 90030	61	E	207	T	3.0	D	32.5	A	2.7	A
296A X ICSR 90030	59	E	167	S	3.3	UD	34.6	H	3.0	A
S x HS										
SPLB 94012A X ICSR 91025	66	M	240	T	3.0	D	36.5	H	3.3	H
SPLB 94017A X ICSR 91025	67	M	253	T	3.0	D	53.0	H	2.4	L

Contd..

Contd..

Genotypes	Days to 50% flowering (days)	Groups	Plant height (cm)	Groups	Agronomic score[1]	Groups	Grain yield plant^{-1} (g)	Groups	100 seed weight (g)	Groups
296A X ICSR 91025	62	E	220	T	4.0	UD	24.9	L	1.9	L
CHECKS										
Resistant										
M 35-1	68	Lt	227	T	4.7	UD	20.1	L	2.1	L
ICSB 13	59	E	143	S	5.0	UD	15.3	L	2.0	L
PM 1861	58	E	137	S	4.0	UD	18.5	L	2.4	L
Susceptible										
H 112	60	E	220	T	5.0	UD	38.0	H	3.2	H
Kundi Jowar	46	E	140	S	4.7	UD	11.0	L	2.7	A
FSRP Local	58	E	220	T	5.0	UD	15.3	L	2.4	L
G. Mean	66.00		192.00		3.70		29.25		2.90	
S. Em	1.08		6.36		0.53		2.24		0.17	
C.V. (%)	1.60		3.30		14.40		7.70		5.70	

1. Scored on a (1-5) scale.
2. The groups are based on disease score.
E = Early
M = Medium
Lt = Late

S = Short
T = Tall

D = Agronomically desirable
UD = Agronomically undesirable
L = Low
A = Average
H = High

flowering. All the other A-lines were late$_{df}$ in flowering. The restorer lines A 2267-2 (R_{ds}) and ICSR 97 (MR_{ds}) were late$_{df}$ in flowering, while ICSR 26 (MR_{ds}) was early$_{df}$ in flowering. On the other hand, the other three restorer lines were medium$_{df}$ in flowering (Table 9).

4.2.8.2 Reaction of the Hybrids

First year studies indicated that four hybrids (SPLB 94004A, SPLB 94007A, SPLB 94009A and SPLB 94010A with A 2267-2) from R_{ds} x R_{ds} group were medium$_{df}$ in flowering, while the other two hybrids were late$_{df}$ in flowering. R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, R_{ds} x S_{ds}, MR_{ds} x R_{ds}, MR_{ds} x MR_{ds} and MR_{ds} x ICSR 91025 (LS_{ds}) group of hybrids were medium$_{df}$ to late$_{df}$ in flowering. The hybrids SPLB 94016A and SPLB 94022A with ICSR 119 (MR_{ds} x LS_{ds}), SPLB 94016A and SPLB 94022A with ICSR 26 (MR_{ds} x S_{ds}), SPLB 94016A, SPLB 94019A and SPLB 94022A with ICSR 90030 (MR_{ds} x S_{ds}), SPLB 94025A x ICSR 119 (LS_{ds} x LS_{ds}), SPLB 94024A and SPLB 94025A with ICSR 26 (LS_{ds} x S_{ds}); and 296A x ICSR 119 (S_{ds} x LS_{ds}) were early$_{df}$ in flowering. While rest of the hybrids were medium$_{df}$ to late$_{df}$ in flowering. Majority of the hybrids from S_{ds} x R_{ds} group, S_{ds} x MR_{ds} group, S_{ds} x S_{ds} group and S_{ds} x ICSR 119 group was medium$_{df}$ in flowering.

Among the 120 hybrids studied in the second year, most of the MR_{ds} female parents crossed with ICSR 26 (MR_{ds}), ICSR 90030 (S_{ds}) and ICSR 91025 (HS_{ds}) were medium$_{df}$ in flowering. While SPLB 94025A (MR_{ds}) female parent with most of the male parents like ICSR 26 (MR_{ds}), ICSR 97 (MR_{ds}), ICSR 119 (S_{ds}), ICSR 90030 (S_{ds}) and ICSR 91025 (HS_{ds}), SPLB 94007A x ICSR 90030 (MR_{ds} x S_{ds}), SPLB 94010A x ICSR 26 (MR_{ds} x MR_{ds}); most of the LS_{ds} x ICSR 26 (MR_{ds}) group of hybrids; LS_{ds} x S_{ds} hybrids; SPLB 94024A and SPLB 94009A (LS_{ds}) with majority of the restorer lines like ICSR 26 (MR_{ds}),

ICSR 119 (S_{ds}), ICSR 97 (MR_{ds}), ICSR 91025 (HS_{ds}), A 2267-2 (R_{ds}) and ICSR 90030 (S_{ds}), the females i.e., SPLB 94003A, SPLB 94001A, SPLB 94006A and SPLB 94021A crossed with ICSR 26 (LS_{ds} x MR_{ds}) as the male parent, SPLB 94001A x ICSR 119 (LS_{ds} x S_{ds}), SPLB 94019A, SPLB 94022A, SPLB 94001A, SPLB 94014A and SPLB 94021A with ICSR 90030 (LS_{ds} x S_{ds}); and SPLB 94001A x ICSR 91025 (LS_{ds} x HS_{ds}) were early$_{df}$ in flowering. Among the hybrids involving susceptible$_{ds}$ A-lines, SPLB 94017A and 296A with ICSR 26 (MR_{ds}) and ICSR 90030 (S_{ds}); and 296A with ICSR 119 (S_{ds}) and ICSR 91025 (HS_{ds}) also exhibited early$_{df}$ flowering. On the other hand, 296A x ICSR 97 (MR_{ds}); and SPLB 94012A with A 2267-2 (R_{ds}), ICSR 26 (MR_{ds}) and ICSR 97 (MR_{ds}) were late$_{df}$ in flowering.

4.2.8.3 Per cent Recovery of the early Flowering Hybrids

Maximum per cent (42%) of early$_{df}$ flowering hybrids were reported by MR_{ds} x S_{ds} group followed by 20% of the F_1 s from LS_{ds} x S_{ds} group, 17% of the F_1 s from MR_{ds} x MR_{ds}, MR_{ds} x LS_{ds} and S_{ds} x LS_{ds} group; and 10% of the F_1 s from LS_{ds} x LS_{ds} group. While, maximum per cent (83%) of medium$_{df}$ flowering hybrids were reported from R_{ds} x MR_{ds} and S_{ds} x S_{ds} group. All the hybrids involving R_{ds} female parents exhibited medium$_{df}$ to late$_{df}$ flowering. Seventy five per cent of the F_1 s from R_{ds} x S_{ds} group, 67% of the R_{ds} x R_{ds} hybrids, 42% of the F_1 s from R_{ds} x LS_{ds} group exhibited medium$_{df}$ flowering. On the other hand, 58% of the F_1 s from R_{ds} x LS_{ds} group, 33% of the F_1 s from R_{ds} x R_{ds} group, 25% of the F_1 s from R_{ds} x S_{ds} group and 17% of the F_1 s from R_{ds} x MR_{ds} group were late$_{df}$ to flower.

The hybrids (SPLB 94004A, SPLB 94010A, SPLB 94011A, SPLB 94016A and 296A with ICSR 97; and SPLB 94011A and 296A with ICSR 90030) involving early$_{df}$ x

$late_{df}$ (ICSR 97 and ICSR 90030) male parents exhibited $medium_{df}$ flowering. The hybrids involving $early_{df}$ x $late_{df}$ parents (SPLB 94004A and SPLB 94010A with ICSR 90030) were $late_{df}$ in flowering, while the hybrid, SPLB 94016A x ICSR 90030 was $early_{df}$ to flower.

Over dominance for $earliness_{df}$ in the second year, was reported by 19% of the F_1 s from MR_{ds} x MR_{ds} and MR_{ds} x S_{ds} group, 13% of the F_1 s from MR_{ds} x HS_{ds} group, 22% of the F_1 s from LS_{ds} x R_{ds} group, 44% of the F_1 s from LS_{ds} x MR_{ds} group, 56% of the F_1 s from LS_{ds} x S_{ds} group, 33% of the F_1 s from and S_{ds} x HS_{ds}, S_{ds} x MR_{ds} and LS_{ds} x HS_{ds} group; and 50% of the F_1 s from S_{ds} x S_{ds} group.

The hybrids involving MR_{ds} x R_{ds} parents exhibited $medium_{df}$ to $late_{df}$ flowering, while the hybrids involving MR_{ds} x MR_{ds}, MR_{ds} x S_{ds} and MR_{ds} x HS_{ds} parents exhibited $early_{df}$, $medium_{df}$ and $late_{df}$ flowering. Maximum proportion (56%) of the F_1 s with early flowering were reported from LS_{ds} x S_{ds} group, while with $medium_{df}$ flowering habit from S_{ds} x R_{ds} and S_{ds} x HS_{ds} group (67%). Thirty eight per cent of the F_1 s from MR_{ds} x R_{ds} group, 44% of the F_1 s from MR_{ds} x MR_{ds} and MR_{ds} x S_{ds} group; and 50% of the F_1 s from MR_{ds} x HS_{ds} group were $medium_{df}$ in flowering. On the other hand, 63% of the F_1 s from MR_{ds} x R_{ds} group; and 38% of the F_1 s from MR_{ds} x MR_{ds}, MR_{ds} x S_{ds} and MR_{ds} x HS_{ds} groups were $late_{df}$ in flowering

The female parents with early flowering, (SPLB 94024A and SPLB 94009A) when crossed with either $late_{df}$ (A 2267-2, R_{ds} or ICSR 97, MR_{ds}) or $early_{df}$ (ICSR 26, MR_{ds}) flowering restorer lines produced hybrids with $early_{df}$ flowering. Of the two hybrids involving $medium_{df}$ and $late_{df}$ flowering parents, only one hybrid (SPLB 94024A x A 2267-2, MR_{ds} x R_{ds}) exhibited $medium_{df}$ flowering, while the other hybrid (SPLB 94025A x ICSR 97, MR_{ds} x MR_{ds}) was found to be $early_{df}$ in flowering. On the other hand, SPLB 94025A (MR_{ds}) x ICSR 26 (MR_{ds}) involving $medium_{df}$ x $early_{df}$ parents also exhibited early$_{df}$ flowering habit.

A perusal of the date given in Table 8 and 9 for two years showed that, SPLB 94024A and SPLB 94009A among A-lines; and ICSR 26 among restorers with early$_{df}$ flowering in the second year exhibited medium$_{df}$ flowering in the first year. While SPLB 94010A, SPLB 94011A, SPLB 94004A, SPLB 94016A and 296A with early$_{df}$ flowering in the first year exhibited late$_{df}$ flowering in the second year. Of all the hybrids with early$_{df}$ flowering in the first year, six hybrids i.e., SPLB 94016A and 296A with ICSR 119, SPLB 94025A x ICSR 119, SPLB 94024A and SPLB 94025A with ICSR 26; and SPLB 94019A and SPLB 94022A with ICSR 90030 also showed early$_{df}$ flowering in the second year indicating that these genotypes took same number of days to flower in both the years On the other hand SPLB 94022A with ICSR 119 (LS$_{ds}$) and ICSR 26 (S$_{ds}$) were medium$_{df}$ to flower. While SPLB 94016A with ICSR 26 (S$_{ds}$) and ICSR 90030 (S$_{ds}$); and SPLB 94022A x ICSR 97 exhibited late$_{df}$ flowering. Of the 37 hybrids with early$_{df}$ flowering in the second year, 28 hybrids viz., SPLB 94017A, SPLB 94010A, SPLB 94003A, SPLB 94006A, SPLB 94009A, SPLB 94021A and 296A with ICSR 26, SPLB 94025A, SPLB 94024A, SPLB 94009A crossed with ICSR 97, SPLB 94001A, SPLB 94007A, SPLB 94025A, SPLB 94009A, SPLB 94017A, SPLB 94021A, SPLB 94014A, SPLB 94024A and 296A crossed with ICSR 90030, SPLB 94025A, SPLB 94024A, SPLB 94009A and 296A crossed with ICSR 91025, SPLB 94024A and SPLB 94009A crossed with A 2267-2; and SPLB 94024A, SPLB 94001A, and SPLB 94009A crossed with ICSR 119 exhibited medium$_{df}$ flowering in the first year, while SPLB 94016A, SPLB 94025A and 296A with ICSR 119, SPLB 94019A and SPLB 94022A with ICSR 90030, SPLB 94024A x ICSR 26; and SPLB 94025A x ICSR 26 were early to flower.

4.2.9 Plant Height

The parental lines and the hybrids were classified into three groups ($dwarf_{ph}$, $medium_{ph}$ and $tall_{ph}$) on the basis of plant height taking standard deviation into consideration.

Dwarf = < ($\bar{x}$)

Medium = ($\bar{x}$) to ($\bar{x}$ - S.D.)

Tall = > ($\bar{x}$ - S.D.)

Where, S.D. = Standard deviation; $\bar{x}$ = Mean of the trial.

4.2.9.1 Reaction of the Parents

During the first year, all R_{ds} and MR_{ds} group of A-lines, and SPLB 94024A and SPLB 94014A (LS_{ds}) and SPLB 94001A and 296A (S_{ds}) group were $dwarf_{ph}$. Among the restorer lines, ICSR 97 (MR_{ds}), ICSR 119 (LS_{ds}), ICSR 91025 (LS_{ds}) and ICSR 26 and ICSR 90030 (S_{ds}) were $dwarf_{ph}$. While A 2267-2 (R_{ds}) was $medium_{ph}$ in height (Table 8).

Second season studies indicated that majority of the A-lines from MR_{ds}, LS_{ds} and S_{ds} group were $dwarf_{ph}$ in height except SPLB 94013A and SPLB 94025A from MR_{ds} group, SPLB 94022A from LS_{ds} group, SPLB 94012A and SPLB 94017A from S_{ds} group (which were $medium_{ph}$ to $tall_{ph}$ in height). ICSR 119 and ICSR 90030 from S_{ds} group of R-lines and ICSR 26 and ICSR 97 from MR_{ds} group were $dwarf_{ph}$ in height, while A 2267-2 (R_{ds}) and ICSR 91025 (HS_{ds}) were $tall_{ph}$ (Table 9).

4.2.9.2 Reaction of the Hybrids

In the first year the R_{ds} x R_{ds} group of crosses were $tall_{ph}$ except SPLB 94015A x A

2267-2 (F_1 was short). While R_{ds} x MR_{ds}, SPLB 94015A with ICSR 91025, ICSR 26 and ICSR 90030, SPLB 94007A and SPLB 94011A with ICSR 119 (R_{ds} x LS_{ds}), SPLB 94009A and SPLB 94015A with ICSR 26, SPLB 94007A, SPLB 94010A and SPLB 94011A with ICSR 90030 (R_{ds} x S_{ds}) and SPLB 94006A and SPLB 94019A with ICSR 90030 from MR_{ds} x S_{ds} were $dwarf_{ph}$ in height. All the hybrids from MR_{ds} x R_{ds} group, SPLB 94006A x ICSR 91025 and SPLB 94016A x ICSR 119 (MR_{ds} x LS_{ds}) were $tall_{ph}$. Rest of the hybrids involving MR_{ds} female parent were $medium_{ph}$ in height. On the other hand, all the LS_{ds} x R_{ds} and S_{ds} x R_{ds} group of hybrids were $tall_{ph}$. SPLB 94017A and SPLB 94024A with ICSR 97 (LS_{ds} x MR_{ds}); SPLB 94024A x ICSR 119 (LS_{ds} x LS_{ds}), 296A x ICSR 97 and SPLB 94001A x ICSR 97 (S_{ds} x MR_{ds}); and 296A x ICSR 119 (S_{ds} x LS_{ds}) were $dwarf_{ph}$.

In the second year, the hybrids, SPLB 94015A and SPLB 94004A with A 2267-2 (MR_{ds} x R_{ds}); SPLB 94007A, SPLB 94010A, SPLB 94015A and SPLB 94016A with ICSR 26 (MR_{ds} x MR_{ds}); SPLB 94007A, SPLB 94010A, SPLB 94011A, SPLB 94004A, SPLB 94013A, SPLB 94015A, SPLB 94016A and SPLB 94025A with ICSR 97, SPLB 94011A and SPLB 94015A with ICSR 119 and SPLB 94007A, SPLB 94016A, SPLB 94011A, SPLB 94004A and SPLB 94015A x ICSR 90030 from MR_{ds} x S_{ds} group were $dwarf_{ph}$. Most of the LS_{ds} x ICSR 26 (MR_{ds}) hybrids, the LS_{ds} x ICSR 97 (MR_{ds}) except SPLB 94014A x ICSR 97, SPLB 94019A, SPLB 94009A, SPLB 94022A and SPLB 94024A with ICSR 119, SPLB 94003A, SPLB 94019A, SPLB 94024A, SPLB 94009A, SPLB 94006A and SPLB 94021A with ICSR 90030 from LS_{ds} x S_{ds} group; 296A x ICSR 26; SPLB 94017A, SPLB 94012A and 296A with ICSR 97 (S_{ds} x MR_{ds}) and 296A x ICSR 90030 from S_{ds} x S_{ds} group were $dwarf_{ph}$. While all the MR_{ds} x HS_{ds} and LS_{ds} x R_{ds} hybrids with the exception of SPLB 94019A x A 2267-2 (LS_{ds} x R_{ds}), all the LS_{ds} x HS_{ds} hybrids except

SPLB 94009A x ICSR 91025, S_{ds} x R_{ds} hybrids and S_{ds} x HS_{ds} hybrids and most of the S_{ds} x S_{ds} hybrids were $tall_{ph}$,

4.2.9.3 Per cent Recovery of the Tall Hybrids

All the hybrids (100%) from MR_{ds} x R_{ds}, LS_{ds} x R_{ds} and S_{ds} x R_{ds} group were $tall_{ph}$ in height, while 83% of the F_1 s from R_{ds} x R_{ds} group and 8% of the F_1 s from R_{ds} x LS_{ds} group were $tall_{ph}$ in height. $Dwarf_{ph}$ plants in the first year were reported from R_{ds} x MR_{ds} and MR_{ds} x MR_{ds} groups. These were 67% of the F_1 s from S_{ds} x MR_{ds} group, 50% of the F_1 s from R_{ds} x S_{ds} group, 40% of the F_1 s from LS_{ds} x MR_{ds} group, 25% of the F_1 s from R_{ds} x LS_{ds} group, 17% of the F_1 s from R_{ds} x R_{ds} group, 17% from MR_{ds} x S_{ds} and S_{ds} x LS_{ds} groups; and 10% of the F_1 s from LS_{ds} x LS_{ds} group and

Sixteen A-lines with $dwarf_{ph}$ height when crossed with A 2267-2 ($medium_{ph}$ height) all the fifteen hybrids (SPLB 94004A, SPLB 94007A, SPLB 94009A, SPLB 94010A, SPLB 94011A, SPLB 94003A, SPLB 94006A, SPLB 94016A, SPLB 94019A, SPLB 94021A, SPLB 94022A, SPLB 94024A, SPLB 94014A, SPLB 94001A and 296A with A 2267-2) were tall in $height_{ph}$ except SPLB 94015A x A 2267-2 ($dwarf_{ph}$). On the other hand. crosses involving $medium_{ph}$ and $dwarf_{ph}$ parents viz., SPLB 94012A, SPLB 94017A, SPLB 94025A and SPLB 94013A with ICSR 119, ICSR 91025, ICSR 26 and ICSR 90030, resulted in $tall_{ph}$ hybrids except the cross, SPLB 94013A x ICSR 90030 which exhibited $medium_{ph}$ height. Similarly when the above set of A-lines were crossed with the ICSR 97 ($dwarf_{ph}$), all the hybrids were $medium_{ph}$ in height except the cross, SPLB 94017A x ICSR 97 which recorded $short_{ph}$ plant height.

In the second year, maximum proportion of tall plants (100%) were reported from MR_{ds} x HS_{ds}, S_{ds} x R_{ds} and S_{ds} x HS_{ds} group followed by 89% of the F_1 s from LS_{ds} x R_{ds}

and LS_{ds} x HS_{ds} group, while 63% of the F_1 s from MR_{ds} x R_{ds} group, 13% of the F_1 s from MR_{ds} x MR_{ds} group and 25% of the F_1 s from MR_{ds} x S_{ds} groups were $tall_{ph}$. On the other hand, 25% of the F_1 s from MR_{ds} x R_{ds} group, 11% of the F_1 s from LS_{ds} x R_{ds} group, 67% of the F_1 s from LS_{ds} x MR_{ds} group and S_{ds} x MR_{ds} group, 56% of the F_1 s from LS_{ds} x S_{ds} group and 17% of the F_1 s from S_{ds} x S_{ds} group were also $dwarf_{ph}$ in plant height. Twenty five per cent of the F_1 s from MR_{ds} x R_{ds} group, 75% of the F_1 s from MR_{ds} x MR_{ds} group and 44% of the F_1 s from MR_{ds} x S_{ds} were $dwarf_{ph}$. Similarly plants with $medium_{ph}$ plant height were reported from 13% of the F_1 s from MR_{ds} x R_{ds}, MR_{ds} x MR_{ds} group and 31% of the F_1 s from MR_{ds} x S_{ds} group (Table 9).

All the female lines (except SPLB 940015A) crossed with A 2267-2; and SPLB 94012A, SPLB 94017A, SPLB 94025A and SPLB 94014A with ICSR 26, ICSR 119, ICSR 91025 and ICSR 90030 exhibited tallness in first year. However, in the second year all female lines except SPLB 94004A, SPLB 94007A, SPLB 94019A and SPLB 94015A with A 2267-2 exhibited tall plant height and thus were consistent across the years. The other hybrids with consistent performance were SPLB 94017A, SPLB 94025A, SPLB 94014A and SPLB 94013A with ICSR 26; SPLB 94017A, SPLB 94025A, SPLB 94014A, SPLB 94012A, SPLB 94001A, SPLB 94006A and SPLB 94013A with ICSR 91025; and SPLB 94012A, SPLB 94017A and SPLB 94025A with ICSR 90030.

The crosses involving $dwarf_{ph}$ A-lines (SPLB 94007A, SPLB 94010A, SPLB 94011A, SPLB 94004A, SPLB 94015A, SPLB 94016A, SPLB 94003A, SPLB 94019A, SPLB 94024A, SPLB 94001A, SPLB 94006A, SPLB 94014A, SPLB 94021A and 296A) and $tall_{ph}$ restorer line (ICSR 91025) were $tall_{ph}$ in height, except the cross (SPLB 94009A x ICSR 91025) which exhibited $medium_{ph}$ height. The crosses viz., SPLB 94010A, SPLB 94011A, SPLB 94016A, SPLB 94003A, SPLB 94024A, SPLB 94001A, SPLB 94006A, SPLB 94009A, SPLB 94014A, SPLB 94021A and 296A with A 2267-2, (a $tall_{ph}$ restorer line), were $tall_{ph}$ in height. While, the hybrids, SPLB 94004A, SPLB 94015A and SPLB 94019A with A 2267-2 were $dwarf_{ph}$ in height and the cross i.e. SPLB 94007A x A 2267-2 exhibited $medium_{ph}$ height. A $tall_{ph}$ male-sterile line (SPLB 94017A) crossed with dwarf restorer lines (ICSR 119, ICSR 90030 and ICSR 26 produced $tall_{ph}$ and dwarf hybrids.

The A-lines with medium plant height (SPLB 94013A-MR_{ds}, SPLB 94025A-MR_{ds}, SPLB 94022A-LS_{ds} and SPLB 94012A-S_{ds}) crossed with $dwarf_{ph}$ restorer lines (ICSR 97-MR_{ds}), SPLB 94022A x ICSR 26 and SPLB 94022A x ICSR 119 were dwarf in height. The cross, SPLB 94012A x ICSR 26 (S_{ds} x MR_{ds}) and SPLB 94022A x ICSR 90030 (LS_{ds} x S_{ds}) were medium in height. However, SPLB 94013A and SPLB 94025A with ICSR 26 (MR_{ds}), ICSR 119 (S_{ds}), ICSR 90030 (S_{ds}) and SPLB 94012A with ICSR 119 and ICSR 90030 were tall in height.

All the female lines (except SPLB 94015A) crossed with A 2267-2 and SPLB 94012A, SPLB 94017A, SPLB 94025A and SPLB 94014A with ICSR 91025, ICSR 119, ICSR 26 and ICSR 90030 exhibited tallness in the first year. However, in the second year, all A-lines except SPLB 94019A, 94009A, SPLB 94007A, SPLB 94004A, SPLB 94015A with A2267-2 exhibited tallness over two seasons. The other crosses with consistent performance were SPLB 94017A, SPLB 94025A, SPLB 94014A, SPLB 94013A crossed with ICSR 26, ICSR 119, SPLB 91025, SPLB 94012 x ICSR 119, SPLB 94012, SPLB 94001 and SPLB 94006 x ICSR 91025, SPLB 94012, SPLB 94017 and SPLB 94025 with ICSR 90030.

4.2.10 Agronomic Score

The parental lines and the hybrids were classified into two groups (desirable$_{as}$ and undesirable$_{as}$) on the basis of agronomic score taking mean values into consideration and are represented as follows.

Agronomically desirable = (1-3)

Agronomically undesirable = (4-5)

4.2.10.1 Reaction of the Parents

During first year, SPLB 94007A and SPLB 94010A (R$_{ds}$), SPLB 94021A and 94006A (MR$_{ds}$), SPLB 94014A (LS$_{ds}$) and SPLB 94001A and SPLB 94013A (S$_{ds}$) exhibited agronomic desirability. Among R-lines, ICSR 91025 (LS$_{ds}$) showed good agronomic performance$_{as}$, while all other restorer lines were agronomically undesirable$_{as}$ (Table 8).

Second year studies indicate that, none of the A-lines showed agronomic desirability$_{as}$. The restorer lines which exhibited agronomic desirability were ICSR 97 (MR$_{ds}$) and ICSR 119 (LS$_{ds}$). While rest of the restorer lines were agronomically undesirable$_{as}$ (Table 9).

4.2.10.2 Reaction of the Hybrids

Among the 120 hybrids studied in the first year, SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94015A with A 2267-2 (R$_{ds}$ x R$_{ds}$), SPLB 94009A, SPLB 94011A and SPLB 94015A with ICSR 97 (R$_{ds}$ x MR$_{ds}$), SPLB 94009A, SPLB 94011A and SPLB 94004A with ICSR 91025 and SPLB 94011A, SPLB 94009A and SPLB 94010A with ICSR 119 from R$_{ds}$ x LS$_{ds}$ group, SPLB 94007A, SPLB 94009A, SPLB

94010A, SPLB 94004A and SPLB 94015A with ICSR 26; and SPLB 94007A, SPLB 94009A, SPLB 94010A, SPLB 94011A with ICSR 90030 (R_{ds} x S_{ds}) showed agronomic desirability$_{as}$. Among the hybrids involving MR_{ds} line as the female parent, the hybrids SPLB 94022A x A 2267-2 (R_{ds}); MR_{ds} x MR_{ds} group of crosses except SPLB 94019A and SPLB 94022A with ICSR 97; SPLB 94003A, SPLB 94006A and SPLB 94022A with ICSR 119 (LS_{ds}); and SPLB 94006A and SPLB 94003A with ICSR 90030 (S_{ds}) were agronomically undesirable$_{as}$, while all other hybrids exhibited agronomic desirability$_{as}$. Similarly majority of the cross combinations involving less susceptible$_{ds}$ line as the female parent were agronomically desirable$_{as}$ except SPLB 94017A and SPLB 94014A with A 2267-2 (R_{ds}), SPLB 94012A and SPLB 94024A with ICSR 97 (MR_{ds}), SPLB 94014A x ICSR 91025 (LS_{ds}) and ICSR 119 (LS_{ds}); and SPLB 94024A and SPLB 94014A with ICSR 90030 (S_{ds}). All the hybrids of S_{ds} x R_{ds} and S_{ds} x LS_{ds} group, SPLB 94001A and 296A with ICSR 97 (MR_{ds}), SPLB 94001A and SPLB 94013A with ICSR 26 (S_{ds}); and SPLB 94001A and 296A with ICSR 90030 (S_{ds}) were agronomically desirable$_{as}$.

In the second year, crosses SPLB 94011A, 94013A and 94025A with A 2267-2 from MR_{ds} x R_{ds} group; SPLB 94007A, SPLB 94013A, SPLB 94004A with ICSR 26 from MR_{ds} x MR_{ds} group; SPLB 94011A with ICSR 119 and ICSR 90030 from MR_{ds} x S_{ds} group; and SPLB 94007A, SPLB 94010A, SPLB 94004A, SPLB 94013A with ICSR 91025 from MR_{ds} x HS_{ds} group exhibited good agronomic desirability$_{as}$. The crosses involving LS_{ds} line as the female parent, viz., SPLB 94024A, SPLB 94006A and SPLB 94009A with A 2267-2 (R_{ds}); SPLB 94024A, SPLB 94001A, SPLB 94014A with ICSR 26 (MR_{ds}), SPLB 94019A and SPLB 94001A with ICSR 97 (MR_{ds}), SPLB 94019A with SPLB 94001A and SPLB 94021A with ICSR 119 (S_{ds}), SPLB 94022A, SPLB 94001A, SPLB 94006A, SPLB 94009A, SPLB 94014A and SPLB 94021A with ICSR 90030 (S_{ds}); and SPLB 94019A, SPLB 94022A, SPLB 94024A and SPLB 94021A with ICSR 91025 (HS_{ds}) exhibited agronomic desirability$_{as}$, while all the other hybrids were agronomically undesirable$_{as}$. The other agronomically desirable$_{ds}$ crosses were 296A (S_{ds}) with A 2267-2 (R_{ds}) and ICSR 119 (S_{ds}); SPLB 94012A (S_{ds}) and SPLB 94017A (S_{ds}) with ICSR 90030 (S_{ds}) and ICSR 91025 (HS_{ds}). On the other hand, all the six crosses of S_{ds} x MR_{ds} parental lines and rest of the hybrids involving S_{ds} female parent showed agronomic undesirability$_{as}$.

4.2.10.3 Per cent Recovery of the Agronomically Desirable Hybrids

Agronomic desirability$_{as}$ in the first year was reported by F_1 s from S_{ds} x R_{ds} and S_{ds} x LS_{ds} group (100%), R_{ds} x R_{ds}, S_{ds} x MR_{ds} and S_{ds} x S_{ds} group (67%), R_{ds} x MR_{ds} and R_{ds} x LS_{ds} group (50%), R_{ds} x S_{ds} and MR_{ds} x LS group (75%), MR_{ds} x R_{ds} group (83%), MR_{ds} x S_{ds} group (58%), MR_{ds} x MR_{ds} group (33%), LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} group (60%); and LS_{ds} x LS_{ds} and LS_{ds} x S_{ds} group (80%). Agronomically undesirable hybrids were reported by 33% of the F_1 s from R_{ds} x R_{ds} group, 50% of the F_1 s from R_{ds} x MR_{ds} and R_{ds} x LS_{ds} group and 25% of the F_1 s from R_{ds} x S_{ds} group.

Among the hybrids involving desirable$_{as}$ x undesirable$_{as}$ parents, the female lines (SPLB 94007A, SPLB 94006A, SPLB 94010A, SPLB 94021A, SPLB 94014A, SPLB 94001A and SPLB 94013A) crossed with ICSR 26, SPLB 94007A, SPLB 94010A, SPLB 94021A and SPLB 94001A with ICSR 90030, SPLB 94007A, SPLB 94006A, SPLB 94010A, SPLB 94021A, SPLB 94001A and SPLB 94013A with A 2267-2, SPLB 94014A and SPLB 94001A with ICSR 97; and SPLB 94010A, SPLB 94021A, SPLB 94001A and SPLB 94013A with ICSR 119 produced agronomically desirable$_{as}$, hybrids, while rest of the hybrids were agronomically undesirable$_{as}$.

Among the 16 cross combinations studied in the second year, maximum per cent

(67%) of the agronomically desirable$_{as}$ hybrids were reported from S_{ds} x HS_{ds} group followed by 50% from S_{ds} x S_{ds}, LS_{ds} x S_{ds} and MR_{ds} x HS_{ds} group, 33% from S_{ds} x R_{ds} and LS_{ds} x R_{ds} group, 44% from LS_{ds} x HS_{ds} group, 28% from LS_{ds} x MR_{ds} group, 13% from MR_{ds} x S_{ds} group, 19% from MR_{ds} x MR_{ds} group and 38% from MR_{ds} x R_{ds} group. While 63% of the F_1 s from MR_{ds} x R_{ds}, 81% of the F_1 s from MR_{ds} x MR_{ds}, 88% of the F_1 s from MR_{ds} x S_{ds} and 50% of the F_1 s from MR_{ds} x HS_{ds} groups produced agronomically undesirable$_{as}$ hybrids.

The MR_{ds} female parents (undesirable$_{as}$) crossed with the agronomically desirable$_{as}$ restorer lines, ICSR 97 (MR_{ds}) and ICSR 119 (S_{ds}) produced agronomic undesirable$_{as}$ hybrids except the cross, SPLB 94011A x ICSR 119 (desirable$_{as}$). Similarly LS_{ds} female parents crossed with agronomically desirable$_{as}$ restorer lines i.e., ICSR 97 and ICSR 119 resulted in five agronomically desirable$_{ad}$ hybrids (SPLB 94019A and SPLB 94001A with ICSR 97; and 94019A, SPLB 94001A and SPLB 94021A with ICSR 119). The hybrids involving agronomically undesirable$_{as}$ susceptible$_{ds}$ females and ICSR 97 (MR), and ICSR 119 (S_{ds}) restorer lines produced agronomically undesirable$_{as}$ hybrids except 296A x ICSR 119 (desirable).

Seven A-lines which exhibited agronomic desirability$_{as}$ in the first year showed agronomic undesirability$_{as}$ during second year and none of the A-lines were found desirable in the second year. Agronomically desirabile$_{as}$ restorer line i.e., ICSR 91025 in the first year was found to be undesirable$_{as}$ in the second year. While, agronomically desirable$_{as}$ hybrids like ICSR 97 and ICSR 119 in the second year exhibited agronomic undesirability$_{as}$ in the first year. The hybrids, which were found to possess agronomic desirability in both the years were SPLB 94013A and SPLB 94025A with A 2267-2; SPLB 94007A, SPLB 94004A, and SPLB 94013A with ICSR 26; SPLB 94011A with ICSR 119 and ICSR 90030;

SPLB 94004A and SPLB 94013A with ICSR 91025; SPLB 94024A, SPLB 94006A and SPLB 94009A with A 2267-2; SPLB 94024A, SPLB 94001A and SPLB 94014A with ICSR 26 and SPLB 94019A, SPLB 94001A with ICSR 97; SPLB 94019A, SPLB 94001A, and SPLB 94021A with ICSR 119; SPLB 94022A, SPLB 94001A, SPLB 94009A, and SPLB 94021A with ICSR 90030; SPLB 94019A, SPLB 94022A, SPLB 94024A and SPLB 94021A with ICSR 91025; 296A x A 2267-2; 296A x ICSR 119; SPLB 94012A and SPLB 94017A with ICSR 90030; and SPLB 94012A, SPLB 94017A with ICSR 91025.

4.2.11 Grain Yield Plant^{-1}

The primary focus of the study is disease parameters and disease resistance. A-line parents were included (instead of their maintainer lines) in the experiment suscepting there could be maternal effects. The grain yield on A-lines is due to wind pollination of the pollen received from neighbouring plants and this is considered to be random.

The parental lines and the hybrids were classified into three groups (low_{gy}, $medium_{gy}$ and $high_{gy}$) on the basis of grain yield plant^{-1} taking standard deviation into consideration.

Low = < ($\bar{x}$)

Medium = ($\bar{x}$) to ($\bar{x}$ -S.D.)

High = > ($\bar{x}$)- (S.D.)

Where, S.D. = Standard deviation; $\bar{x}$ = Mean of the trial.

4.2.11.1 Reaction of the Parents

Studies in the first year, indicated that none of the parental lines recorded $high_{gy}$ seed yields. Almost all the A-lines except SPLB 94015A from R_{ds} group, SPLB 94016A and SPLB 94022A from MR_{ds} group, SPLB 94012A, SPLB 94017A, SPLB 94024A and SPLB 94025A from LS_{ds} group; and 296A (S_{ds}) recorded low_{gy} yields, while rest of the A-lines recorded $average_{gy}$ seed yields. Among the restorer lines, ICSR 97 (MR_{ds}) and ICSR 26 (S_{ds}) recorded low_{gy} yields. While A 2267-2 (R_{ds}), ICSR 119 (LS_{ds}), ICSR 91025 (LS_{ds}) and ICSR 90030 (S_{ds}) were found to be $average_{gy}$ seed yielders (Table 8).

In the second year, SPLB 94013A (MR_{ds}) and SPLB 94006A (LS_{ds}) recorded $average_{gy}$ seed yields, while all other A-lines recorded low_{gy} grain yields. ICSR 26 (MR_{ds}) and ICSR 119 (S_{ds}) recorded $high_{gy}$ seed yields. ICSR 97 (MR_{ds}) and ICSR 90030 (S_{ds}) recorded $average_{gy}$ seed yields. While, A 2267-2 (R_{ds}) and ICSR 91025 (HS_{ds}) among restorer lines recorded low_{gy} seed yields (Table 9).

4.2.11.2 Reaction of the Hybrids

In the first year among the hybrids involving $resistant_{ds}$ female lines, SPLB 94004A, SPLB 94007A and SPLB 94009A with A 2267-2 (R_{ds}); SPLB 94009A and SPLB 94011A with ICSR 119 (LS_{ds}); SPLB 94004A x ICSR 26 (S_{ds}); and SPLB 94009A x ICSR 90030 (S_{ds}) were $high_{gy}$ grain yielders. Among the hybrids involving moderately $resistant_{ds}$ female parents, SPLB 94016A, SPLB 94019A and SPLB 94022A with A 2267-2 (R_{ds}); SPLB 94019A x ICSR 26 (S_{ds}); SPLB 94022A with A 2267-2 (R_{ds}), ICSR 119 (LS_{ds}) and ICSR 26 (S_{ds}); SPLB 94019A x ICSR 97 (MR_{ds}); SPLB 94003A x ICSR 26 (S_{ds}); and SPLB 94016A x ICSR 26 (S_{ds}) were $high_{gy}$ seed yielders. SPLB 94012A and SPLB 94025A (LS_{ds}) with A 2267-2 (R_{ds}); SPLB 94014A x ICSR 97 (MR_{ds}); and SPLB 94024A and SPLB 94012A with ICSR 26 (S_{ds}) from hybrids involving less $susceptible_{ds}$ female parents were $high_{gy}$ seed yielders, while most of the hybrids from LS_{ds} x ICSR 119 (LS_{ds}), ICSR 91025 (LS_{ds}), ICSR 90030 (S_{ds}) were $average_{gy}$ to low_{gy} yielders. SPLB 94001A x ICSR

119 (LS_{ds}), ICSR 90030 (S_{ds}) from hybrids involving susceptible$_{ds}$ female parent were high$_{gy}$ yielders. All the hybrids from S_{ds} x R_{ds} (A 2267-2) group were average$_{gy}$ yielders and the hybrids from S_{ds} x MR_{ds} (ICSR 97) group were average$_{gy}$ to low$_{gy}$ seed yielders.

Among the hybrids, studied in the second year SPLB 94011A, SPLB 94016A and SPLB 94025A with A 2267-2 from MR_{ds} x R_{ds} group; SPLB 94013A, SPLB 94007A, SPLB 94010A, SPLB 94004A, SPLB 94015A and SPLB 94025A with ICSR 26 and SPLB 94004A x ICSR 97 from MR_{ds} x MR_{ds} group; SPLB 94011A, SPLB 94016A and SPLB 94025A with ICSR 119, and SPLB 94011A and SPLB 94013A with ICSR 90030 from MR_{ds} x S_{ds} group; SPLB 94007A, SPLB 94004A and SPLB 94013A with ICSR 91025 from MR_{ds} x HS_{ds} group; most of the LS_{ds} x R_{ds} hybrids, viz., SPLB 94019A, SPLB 94022A, SPLB 94024A, SPLB 94001A and SPLB 94006A with A 2267-2; SPLB 94019A and SPLB 94024A with ICSR 26 and SPLB 94019A, SPLB 94001A and SPLB 94006A with ICSR 97 from LS_{ds} x MR_{ds} group; SPLB 94001A with ICSR 119; SPLB 94019A, SPLB 94009A, SPLB 94014A and SPLB 94021A with ICSR 90030 from LS_{ds} x S_{ds} group; and LS_{ds} x HS_{ds} group of hybrids (SPLB 94019A, SPLB 94022A and SPLB 94024A with ICSR 91025) exhibited high$_{gy}$ seed yield. 296A x A 2267-2 (R_{ds}), SPLB 94017A x ICSR 26 (MR_{ds}), 296A x ICSR 119 (S_{ds}), ICSR 90030 (S_{ds}) and SPLB 94012A and 94017A with ICSR 91025 (HS_{ds}) were among the group of hybrids involving susceptible$_{ds}$ female parents with high$_{gy}$ seed yields.

4.2.11.3 Per cent Recovery of the High Yielding Hybrids

High yielding hybrids were reported from R_{ds} x R_{ds} and MR_{ds} x R_{ds} group (50%) followed by 17% of the F_1 s from R_{ds} x LS_{ds}, R_{ds} x S_{ds}, MR_{ds} x MR_{ds} and S_{ds} x S_{ds} group, 8% of the F_1 s from MR_{ds} x LS_{ds}, 33% of the F_1 s from MR_{ds} x S_{ds} and S_{ds} x LS_{ds}, 40% of the F_1 s from LS_{ds} x R_{ds} and 20% of the F_1 s from LS_{ds} x MR_{ds} and LS_{ds} x S_{ds} groups. Seventeen % of the F_1 s from R_{ds} x R_{ds}, group 67% of the F_1 s from R_{ds} x MR_{ds}, R_{ds} x LS_{ds} and R_{ds} x S_{ds} group were $average_{gy}$ yielders, while 33% of the F_1 s from R_{ds} x R_{ds} and R_{ds} x MR_{ds} group and 17% of the F_1 s from R_{ds} x LS_{ds} and R_{ds} x S_{ds} group were low_{gy} grain yielders.

Among the 48 hybrids involving $average_{gy}$ yielding male-sterile lines (SPLB 94004A, SPLB 94007A, SPLB 94009A, SPLB 94010A, SPLB 94011A, SPLB 94003A, SPLB 94006A, SPLB 94019A, SPLB 94021A, SPLB 94014A, SPLB 94001A and SPLB 94013A) and $average_{gy}$ yielding restorer lines (A 2267-2, ICSR 119, ICSR 91025 and ICSR 90030), only ten hybrids (SPLB 94004A, SPLB 94007A, SPLB 94009A, and SPLB 94019A with A 2267-2; SPLB 94009A, SPLB 94011A and SPLB 94001A with ICSR 119; SPLB 94001A x ICSR 91025; SPLB 94009A, and SPLB 94001A with ICSR 90030) were found to be $high_{gy}$ yielders. While majority of the other hybrids exhibited $average_{gy}$ grain yields.

In the second year, high yielding hybrids to a maximum extent (67%) were reported from S_{ds} x HS_{ds} group followed by 38% of the F_1 s from MR_{ds} x R_{ds} group, MR_{ds} x HS_{ds} group, 33% of the F_1 s from S_{ds} x R_{ds}, S_{ds} x S_{ds}, and LS_{ds} x HS_{ds} group, 17% of the F_1 s from S_{ds} x MR_{ds} group, 28% of the F_1 s from LS_{ds} x S_{ds} and LS_{ds} x MR_{ds} group, 56% of the F_1 s from LS_{ds} x R_{ds} group, 31% of the F_1 s from MR_{ds} x S_{ds} group and 44% of the F_1 s from MR_{ds} x MR_{ds} group. $Average_{gy}$ yields were recorded by 44% of the F_1 s from MR_{ds} x MR_{ds}, 50% of the F_1 s from MR_{ds} x S_{ds} and 63% of the F_1 s from MR_{ds} x HS_{ds} group. While 63% of the F_1 s from MR_{ds} x R_{ds} group, 13% of the F_1 s from MR_{ds} x MR_{ds} group and 19% of the F_1 s from MR_{ds} x S_{ds} group recorded low_{gy} yields.

The hybrids involving $average_{gy}$ yielding female parents (SPLB 94013A, MR_{ds} and

SPLB 94006A, LS_{ds}) and low_{gy} yielding restorer lines (A 2267-2, R_{ds} and ICSR 91025, HS_{ds}), recorded high yielding (SPLB 94006A x A 2267-2 and SPLB 94013A x ICSR 91025) low yielding (SPLB 94013A x A 2267-2) and average yielding (SPLB 94006A x ICSR 91025) hybrids.

The A-lines, with $average_{gy}$ grain yields in the first year viz., SPLB 94007A, SPLB 94010A, SPLB 94011A, SPLB 94004A, SPLB 94003A, SPLB 94019A, SPLB 94001A, SPLB 94006A, SPLB 94014A and SPLB 94021A showed low_{gy} yield performance in the second year. However, SPLB 94013A and SPLB 94009A with $average_{gy}$ performance in both the years was found to be consistent across the seasons. ICSR 97 (MR_{ds}) a low_{gy} yielding restorer line in the first year was found to be $average_{gy}$ yielding in the second year. While, ICSR 90030 recorded $average_{gy}$ seed yields in both the years. The hybrids, with $high_{gy}$ yields in both the years were SPLB 94022A, SPLB 94019A, SPLB 94016A and SPLB 94025A with A 2267-2; SPLB 94011A and SPLB 94001A with ICSR 119; SPLB 94024A and SPLB 94004A with ICSR 26; SPLB 94009A x ICSR 90030; and SPLB 94019A with ICSR 97 and ICSR 26.

4.2.12 100 seed Weight

The parental lines and the hybrids were classified into three groups (low_{tw}, $medium_{tw}$ and $high_{tw}$) on the basis of 100 seed weight taking standard deviation into consideration.

Low = $< (\bar{x})$

Medium = $(\bar{x})$ to $(\bar{x}$- S.D.)

High = $> (\bar{x}$ - S.D.)

Where, S.D. = Standard deviation; $\bar{x}$ = Mean of the trial.

4.2.12.1 Reaction of the Parents

First year studies indicated that the A-lines SPLB 94014A (LS_{ds}) and SPLB 94013A (S_{ds}) recorded $high_{tw}$ seed weight, while rest of the A-lines recorded low_{tw} to $average_{tw}$ grain weight. Among the R-lines, A 2267-2 (R_{ds}), ICSR 91025 (LS_{ds}) and ICSR 90030 (S_{ds}) recorded low_{tw} grain weights, while others recorded $average_{tw}$ seed weight (Table 9).

During the second year, SPLB 94013A (MR_{ds}), SPLB 94012A (S_{ds}), SPLB 94009A (LS_{ds}) and SPLB 94014A (LS_{ds}) were the A-lines with $high_{tw}$ grain weight, while rest of the A-lines recorded low_{tw} to $average_{tw}$ seed weights. Among the restorer lines, A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}), ICSR 26 (MR_{ds}) and ICSR 119 (S_{ds}) showed $average_{tw}$ weight of 100 seeds. While ICSR 90030 (S_{ds}) and ICSR 91025 (HS_{ds}) exhibited low_{tw} seed weight (Table 9).

4.2.12.2 Reaction of the Hybrids

Studies in the first year indicated that, majority of the hybrids recorded $average_{tw}$ weight of 100 grains. The crosses SPLB 94010A x A 2267-2 (R_{ds} x R_{ds}); SPLB 94007A and SPLB 94010A with ICSR 97 (R_{ds} x MR_{ds}); SPLB 94009A x ICSR 91025, SPLB 94009A and SPLB 94015A with ICSR 119 (R_{ds} x LS_{ds}); SPLB 94007A x ICSR 90030, SPLB 94009A x ICSR 90030, SPLB 94010A, SPLB 94011A with ICSR 90030 from R_{ds} x S_{ds} group; SPLB 94003A, SPLB 94006A and SPLB 94022A with A 2267-2 (MR_{ds} x R_{ds}); SPLB 94016A, SPLB 94021A and SPLB 94022A with ICSR 119 (MR_{ds} x LS_{ds}); SPLB 94022A x ICSR 90030 (MR_{ds} x S_{ds}); SPLB 94012A and SPLB 94014A with ICSR 90030 (LS_{ds}); SPLB 94012A and SPLB 94014A (LS_{ds}) with ICSR 97 (MR_{ds}); SPLB 94012A (LS_{ds}) x ICSR 91025(LS_{ds}); SPLB 94012A, SPLB 94024A and SPLB 94014A with A 2267-2 (LS_{ds} x R_{ds}); SPLB 94012A, SPLB 94025A and SPLB 94014A with ICSR 119

(LS_{ds} x LS_{ds}); SPLB 94012A and SPLB 94024A with ICSR 26 (LS_{ds} x LS_{ds}) recorded $high_{tw}$ grain weight. The A-line, SPLB 94013A (S_{ds}) with most of the R-lines like A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}), ICSR 91025 (LS_{ds}), ICSR 26 (S_{ds}); and ICSR 90030 (S_{ds}); 296A x ICSR 26 (S_{ds} x S_{ds}) also recorded $bold_{tw}$ seeds. While, all the hybrids from MR_{ds} x MR_{ds} group, MR_{ds} x ICSR 91025 (LS_{ds}) and MR_{ds} x S_{ds} group recorded $average_{tw}$ seed weight except SPLB 94022A x ICSR 90030.

In the second year, majority of the MR_{ds} x R_{ds}, MR_{ds} x ICSR 26 (MR_{ds}) and MR_{ds} x S_{ds} group of hybrids; SPLB 94013A, SPLB 94011A, SPLB 94016A and SPLB 94025A with A 2267-2 from MR_{ds} x R_{ds} group; SPLB 94016A, SPLB 94007A, SPLB 94015A and 94025A with ICSR 26 and SPLB 94004A, SPLB 94013A and SPLB 94016A with ICSR 97 from MR_{ds} x MR_{ds} group; SPLB 94007A, SPLB 94010A, SPLB 94004A, SPLB 94013A, SPLB 94016A and SPLB 94015A with ICSR 119 and SPLB 94007A, 94010A, SPLB 94011A, SPLB 94013A and SPLB 94015A with ICSR 90030 from MR_{ds} x S_{ds} group; 94013A x 91025 (MR_{ds} x HS_{ds}); SPLB 94003A, SPLB 94019A, SPLB 94022A, SPLB 94009A, SPLB 94021A with A 2267-2 (LS_{ds} x R_{ds}); SPLB 94009A and SPLB 94003A with ICSR 26 (LS_{ds} x MR_{ds}); 94003A, SPLB 94022A and SPLB 94009A with ICSR 97 (LS_{ds} x MR_{ds}); SPLB 94001A, SPLB 94009A and SPLB 94021A with ICSR 119 (LS_{ds} x S_{ds}); SPLB 94009A x ICSR 90030 (LS_{ds} x S_{ds}); and SPLB 94022A and SPLB 94009A with ICSR 91025 (LS_{ds} x HS_{ds}) recorded maximum 100 seed weight. Among the hybrids involving $susceptible_{ds}$ A-lines, SPLB 94012A with most of the R-lines (ICSR 97-MR_{ds}, ICSR 119-S_{ds}, ICSR 90030-S_{ds}) and ICSR 91025 (HS_{ds}); and SPLB 94017 A x ICSR 119 also recorded $maximum_{tw}$ seed weight. All the three hybrids of S_{ds} x R_{ds} group and S_{ds} x ICSR 26 (MR_{ds}) group recorded $average_{tw}$ seed weights. While, majority of the MR_{ds} x HS_{ds} hybrids recorded $less_{tw}$ seed weights.

4.2.12.3 Per cent Recovery of the Bold Seeded Hybrids

In the first year, the F_1 s from LS_{ds} x R_{ds} group were found to give maximum per cent (60%) of the hybrids with $bold_{tw}$ seeds followed by R_{ds} x R_{ds} and S_{ds} x LS_{ds} (17%), R_{ds} x MR_{ds}, R_{ds} x S_{ds}, S_{ds} x R_{ds} and S_{ds} x MR_{ds} group (30%), R_{ds} x LS_{ds}, MR_{ds} x LS_{ds} (25%), MR_{ds} x R_{ds} and S_{ds} x S_{ds} (50%), LS_{ds} x MR_{ds}, LS_{ds} x LS_{ds} and LS_{ds} x S_{ds} group (40%); and MR_{ds} x S_{ds} group (8%) Majority of the hybrids involving R_{ds} female lines viz., 83% of the F_1 s from R_{ds} x R_{ds} group, 50% of the F_1 s from R_{ds} x MR_{ds} group, 75% of the F_1 s from R_{ds} x LS_{ds} group and 92% of the F_1 s from R_{ds} x S_{ds} group exhibited $average_{tw}$ seed weight.

The hybrids involving $high_{tw}$ grain weight female lines (SPLB 94014A and SPLB 94013A) and low_{tw} grain weight restorer lines (A 2267-2, ICSR 91025 and ICSR 90030) produced hybrids with $bold_{tw}$ seeds except the hybrid SPLB 94014A x ICSR 91025 ($average_{tw}$ weight)

Studies in the second year indicated that, maximum per cent (69%) of the F_1 s with $bold_{tw}$ seeds were reported from MR_{ds} x S_{ds} group followed by 56% of the F_1 s from LS_{ds} x R_{ds} group, 50% of the F_1 s from MR_{ds} x R_{ds} group, 44% of the F_1 s from MR_{ds} x MR_{ds} group, 13% of the F_1 s from MR_{ds} x HS_{ds} group, 28% of the F_1 s from LS_{ds} x MR_{ds} group, 22% of the F_1 s from LS_{ds} x S_{ds} and LS_{ds} x HS_{ds} group, 50% of the F_1 s from S_{ds} x S_{ds} group, 17% of the F_1 s from S_{ds} x MR_{ds} group and 33% of the F_1 s from S_{ds} x HS_{ds} group. While, 25% of the F_1 s from MR_{ds} x R_{ds} group, 6% of the F_1 s from MR_{ds} x MR_{ds} group, 6% of the F_1 s from MR_{ds} x S_{ds} group and 75% of the F_1 s from MR_{ds} x HS_{ds} group were reported to have $least_{tw}$ seed weight. On the other hand, hybrids with $average_{tw}$ weight of 100 seeds were reported by 25% of the F_1 s from MR_{ds} x R_{ds} and MR_{ds} x S_{ds} group, 50% of the F_1 s from MR_{ds} x MR_{ds} group and 13% of the F_1 s from MR_{ds} x HS_{ds} group.

Among the four female lines with $bold_{tw}$ seeds, three A-lines viz., SPLB 94013A

(MR_{ds}), SPLB 94009A (LS_{ds}) and SPLB 94012A (S_{ds}) crossed with restorer lines with $least_{tw}$ seed weight like ICSR 90030 (S_{ds}) and ICSR 91025 (HS_{ds}) produced $bold_{tw}$ seeded hybrids. While, the remaining A-line (SPLB 94014A, LS_{ds}) crossed either with ICSR 90030 or ICSR 91025 produced hybrids with $average_{tw}$ seed weight.

The restorer lines ICSR 26, ICSR 97 and ICSR 119 recorded $average_{tw}$ seed weights across the years indicating their consistency over the years. The A-lines namely, SPLB 94013A and SPLB 94014A and the hybrids, SPLB 94013A x ICSR 97, A 2267-2, ICSR 90030, ICSR 91025 and SPLB 94009A with ICSR 119, ICSR 90030, ICSR 91025; SPLB 94012A with ICSR 97, ICSR 119, ICSR 90030 and ICSR 91025; SPLB 94021A, SPLB 94016A and SPLB 94015A with ICSR 119; ICSR 94011A and ICSR 94007A and SPLB 94010A with ICSR 90030; and SPLB 94003A and SPLB 94022A with A 2267-2 showed consistent performance across the seasons with $bold_{tw}$ seeds in both the years, while the rest of the hybrids with $bold_{tw}$ seeds in the first year exhibited $average_{tw}$ to low_{tw} 100 seed weight in the second year.

4.3 RESPONSE BASED ON LEAF AREA DAMAGE AND FLECK NUMBER

The set of genotypes included in the study classified into six groups on the basis of total leaf area damage (high and low) and number of flecks (high, medium and low) are presented in two way table for *rabi* 1996 (Table 10) and *rabi* 1997 (Table 11). Accordingly the genotypes were grouped into five severity groups as follows:

S. No.	Combination	Disease Severity	Group
1	Low fleck number and less leaf area damage	1	Resistant
2	Medium fleck number and less leaf area damage	2	Moderately resistant
3	High fleck number and less leaf area damage	3	Less susceptible
4	Low fleck number and high leaf area damage	3	Less susceptible
5	Medium fleck number and high leaf area damage	4	Susceptible
6	High fleck number and high leaf area damage	5	Highly susceptible

The data given in Table 10 shows that in the first year, 18 female lines fall in severity group 1 i.e., resistant group, while two in moderately resistant group. Among the restorer lines, all the six restorers fall in severity group 1 i.e., resistant group. While none of the genotypes fall in moderately resistant, less susceptible, susceptible and highly susceptible groups. Among the hybrids, 65 F_1 s fall in severity group 1 i.e., resistant group, while 43 genotypes fall in moderately resistant group, five genotypes in less susceptible group, five in susceptible group and two in highly susceptible group.

The parental lines and the hybrids falling in disease severity group 1 i.e., resistant group were considered desirable for future breeding works. A perusal of the result showed that of the 18 male-sterile lines falling in resistant group when crossed with six restorer lines also falling in resistant group, only 59 F_1 s fall in disease severity group 1 i.e., resistant group, and were considered desirable for future breeding programmes. Next group of hybrids from the point of desirability in future breeding programme were the hybrids (38) falling in moderately resistant group. However, the crosses falling in disease severity group three, four and five may not be useful in future breeding works.

Table 10. Two-way table showing the response of genotypes based on total leaf area damage and fleck number, rabi season 1996.

		FLECK NUMBER			
		LOW (12.20-145.20)		**MEDIUM (145.21-278.20)**	**HIGH (278.21-411.20)**
		A-lines		**A-lines**	**Hybrids**
		SPLB 94003A	SPLB 94001A x ICSR 97	SPLB 94001A	SPLB 94010A x A 2267-2
		SPLB 94004A	SPLB 94003A x ICSR 97	SPLB 94019A	SPLB 94010A x ICSR 97
		SPLB 94006A	SPLB 94004A x ICSR 97	**Hybrids**	SPLB 94010A x ICSR 119
		SPLB 94007A	SPLB 94006A x ICSR 97	SPLB 94014A x A 2267-2	SPLB 94011A x ICSR 119
		SPLB 94009A	SPLB 94007A x ICSR 97	SPLB 94019A x A 2267-2	SPLB 94025A x ICSR 90030
		SPLB 94010A	SPLB 94009A x ICSR 97	SPLB 94021A x A 2267-2	
		SPLB 94011A	SPLB 94011A x ICSR 97	SPLB 94024A x A 2267-2	
		SPLB 94012A	SPLB 94012A x ICSR 97	SPLB 94025A x A 2267-2	
		SPLB 94013A	SPLB 94013A x ICSR 97	296A x A2267-2	
		SPLB 94014A	SPLB 94014A x ICSR 97	SPLB 94016A x ICSR 97	
TOTAL	**LOW**	SPLB 94015A	SPLB 94015A x ICSR 97	SPLB 94021A x ICSR 97	
LEAF	**(0-12.648**	SPLB 94016A	SPLB 94017A x ICSR 97	SPLB 94025A x ICSR 97	
AREA	**cm^2)**	SPLB 94017A	SPLB 94019A x ICSR 97	SPLB 94003A x ICSR 26	
DAMAGE		SPLB 94021A	SPLB 94022A x ICSR 97	SPLB 94006A x ICSR 26	
		SPLB 94022A	SPLB 94024A x ICSR 97	SPLB 94009A x ICSR 26	
		SPLB 94024A	296A x ICSR 97	SPLB 94010A x ICSR 26	
		SPLB 94025A	SPLB 94003A x ICSR 90030	SPLB 94013A x ICSR 26	
		296A	SPLB 94004A x ICSR 90030	SPLB 94014A x ICSR 26	
		R-lines	SPLB 94006A x ICSR 90030	SPLB 94016A x ICSR 26	
		A 2267-2	SPLB 94007A x ICSR 90030	SPLB 94019A x ICSR 26	
		ICSR 26	SPLB 94009A x ICSR 90030	SPLB 94022A x ICSR 26	
		ICSR 97	SPLB 94013A x ICSR 90030	SPLB 94024A x ICSR 26	
		ICSR 119	SPLB 94015A x ICSR 90030	SPLB 94001A x ICSR 119	
		ICSR 91025	SPLB 94017A x ICSR 90030	SPLB 94003A x ICSR 119	
		ICSR 90030	SPLB 94021A x ICSR 90030	SPLB 94009A x ICSR 119	
		Hybrids	SPLB 94001A x ICSR 26	SPLB 94014A x ICSR 119	
		SPLB 94001A x A 2267-2	SPLB 94004A x ICSR 26	SPLB 94017A x ICSR 119	
		SPLB 94004A x A 2267-2	SPLB 94007A x ICSR 26	SPLB 94019A x ICSR 119	

Contd..

Contd..

		FLECK NUMBER			
		LOW (12.20-145.20)		MEDIUM (145.21-278.20)	HIGH (278.21-411.20)
TOTAL LEAF AREA DAMAGE	LOW (0-12.648 cm^2)	SPLB 94006A x A 2267-2	SPLB 94011A x ICSR 26	SPLB 94021A x ICSR 119	
		SPLB 94007A x A 2267-2	SPLB 94012A x ICSR 26	SPLB 94024A x ICSR 119	
		SPLB 94009A x A 2267-2	SPLB 94015A x ICSR 26	SPLB 94025A x ICSR 119	
		SPLB 94011A x A 2267-2	SPLB 94017A x ICSR 26	296A x ICSR 119	
		SPLB 94012A x A 2267-2	SPLB 94021A x ICSR 26	SPLB 94003A x ICSR 91025	
		SPLB 94013A x A 2267-2	296A x ICSR 26	SPLB 94011A x ICSR 91025	
		SPLB 94015A x A 2267-2	SPLB 94001A x ICSR 91025	SPLB 94016A x ICSR 91025	
		SPLB 94016A x A 2267-2	SPLB 94006A x ICSR 91025	SPLB 94022A x ICSR 91025	
		SPLB 94017A x A 2267-2	SPLB 94007A x ICSR 91025	SPLB 94024A x ICSR 91025	
		SPLB 94022A x A 2267-2	SPLB 94009A x ICSR 91025	SPLB 94025A x ICSR 91025	
		SPLB 94004A x ICSR 119	SPLB 94010A x ICSR 91025	296A x ICSR 91025	
		SPLB 94006A x ICSR 119	SPLB 94012A x ICSR 91025	SPLB 94011A x ICSR 90030	
		SPLB 94007A x ICSR 119	SPLB 94013A x ICSR 91025	SPLB 94012A x ICSR 90030	
		SPLB 94012A x ICSR 119	SPLB 94014A x ICSR 91025	SPLB 94014A x ICSR 90030	
		SPLB 94015A x ICSR 119	SPLB 94015A x ICSR 91025	SPLB 94016A x ICSR 90030	
		SPLB 94022A x ICSR 119	SPLB 94017A x ICSR 91025	SPLB 94019A x ICSR 90030	
		SPLB 94013A x ICSR 119	SPLB 94019A x ICSR 91025	SPLB 94024A x ICSR 90030	
			SPLB 94021A x ICSR 91025	296A x ICSR 90030	
	HIGH (8.4232-16.6405 cm^2)			Hybrids	Hybrids
				SPLB 94016A x ICSR 119	SPLB 94003A x A 2267-2
				SPLB 94025A x ICSR 26	SPLB 94001A x ICSR 90030
				SPLB 94010A x ICSR 90030	
				SPLB 94022A x ICSR 90030	
				SPLB 94004A x ICSR 91025	

Table 11. Two-way table showing the response of genotypes based on total leaf area damage and fleck number, rabi season 1997.

		FLECK NUMBER			
		LOW (39.30-353.13)		MEDIUM (353.14-666.96)	HIGH (666.97-98080)
		A-lines		**A-lines**	**A-lines**
		SPLB 94001A	SPLB 94004A x ICSR 97	SPLB 94007A	SPLB 94011A
		SPLB 94003A	SPLB 94015A x ICSR 97	SPLB 94019A	**R-lines**
		SPLB 94004A	SPLB 94007A x ICSR 97	**R-lines**	ICSR 97
		SPLB 94006A	SPLB 94006A x ICSR 97	A 2267-2	**Hybrids**
		SPLB 94009A	SPLB 94009A x ICSR 97	**Hybrids**	SPLB 94007A x A 2267-2
		SPLB 94010A	SPLB 94013A x ICSR 97	SPLB 94004A x A 2267-2	SPLB 94011A x ICSR 26
		SPLB 94012A	SPLB 94014A x ICSR 97	SPLB 94010A x A 2267-2	SPLB 94019A x ICSR 97
		SPLB 94013A	SPLB 94016A x ICSR 97	SPLB 94015A x A 2267-2	
		SPLB 94014A	SPLB 94017A x ICSR 97	SPLB 94001A x A 2267-2	
		SPLB 94015A	SPLB 94021A x ICSR 97	SPLB 94003A x A 2267-2	
TOTAL	**LOW**	SPLB 94016A	SPLB 94022A x ICSR 97	SPLB 94012A x A 2267-2	
LEAF	**(0-12.648**	SPLB 94017A	SPLB 94025A x ICSR 97	SPLB 94014A x A 2267-2	
AREA	**cm^2)**	SPLB 94021A	296A x ICSR 97	SPLB 94019A x A 2267-2	
DAMAGE		SPLB 94022A	SPLB 94001A x ICSR 90030	SPLB 94022A x A 2267-2	
		SPLB 94024A	SPLB 94003A x ICSR 90030	SPLB 94024A x A 2267-2	
		SPLB 94025A	SPLB 94004A x ICSR 90030	SPLB 94011A x A 2267-2	
		296A	SPLB 94006A x ICSR 90030	SPLB 94019A x ICSR 26	
		R-lines	SPLB 94007A x ICSR 90030	SPLB 94003A x ICSR 26	
		ICSR 119	SPLB 94009A x ICSR 90030	SPLB 94011A x ICSR 97	
		ICSR 26	SPLB 94010A x ICSR 90030	SPLB 94010A x ICSR 97	
		ICSR 90030	SPLB 94011A x ICSR 90030	SPLB 94001A x ICSR 97	
		Hybrids	SPLB 94012A x ICSR 90030	SPLB 94003A x ICSR 97	
		SPLB 94009A x A 2267-2	SPLB 94013A x ICSR 90030	SPLB 94012A x ICSR 97	
		SPLB 94006A x A 2267-2	SPLB 94014A x ICSR 90030	SPLB 94024A x ICSR 97	
		SPLB 94013A x A 2267-2	SPLB 94015A x ICSR 90030	SPLB 94011A x ICSR 119	
		SPLB 94016A x A 2267-2	SPLB 94016A x ICSR 90030	SPLB 94010A x ICSR 119	
		SPLB 94017A x A 2267-2	SPLB 94017A x ICSR 90030	SPLB 94007A x ICSR 119	
		SPLB 94021A x A 2267-2	SPLB 94019A x ICSR 90030	SPLB 94013A x ICSR 119	
		SPLB 94025A x A 2267-2	SPLB 94021A x ICSR 90030	SPLB 94011A x ICSR 91025	
		296A x A 2267-2	SPLB 94022A x ICSR 90030	SPLB 94019A x ICSR 91025	
		SPLB 94003A x ICSR 119	SPLB 94024A x ICSR 90030	SPLB 94009A x ICSR 26	
		SPLB 94015A x ICSR 119	SPLB 94025A x ICSR 90030		
		SPLB 94001A x ICSR 119	296A x ICSR 90030		

Contd...

Contd..

		FLECK NUMBER			
		LOW (39.30-353.13)		MEDIUM (353.14-666.96)	HIGH (666.97-98080)
TOTAL LEAF AREA DAMAGE	**LOW (0-12.648 cm^2)**	SPLB 94006A x ICSR 119 SPLB 94012A x ICSR 119 SPLB 94014A x ICSR 119 SPLB 94016A x ICSR 119 SPLB 94021A x ICSR 119 SPLB 94024A x ICSR 119 SPLB 94025A x ICSR 119 296A x ICSR 119 SPLB 94009A x ICSR 119 SPLB 94017A x ICSR 119 SPLB 94004A x ICSR 91025 SPLB 94010A x ICSR 91025 SPLB 94015A x ICSR 91025 SPLB 94001A x ICSR 91025 SPLB 94007A x ICSR 91025 SPLB 94006A x ICSR 91025 SPLB 94012A x ICSR 91025 SPLB 94013A x ICSR 91025 SPLB 94014A x ICSR 91025 SPLB 94016A x ICSR 91025	SPLB 94009A x ICSR 91025 SPLB 94017A x ICSR 91025 SPLB 94021A x ICSR 91025 SPLB 94022A x ICSR 91025 SPLB 94024A x ICSR 91025 SPLB 94025A x ICSR 91025 296A x ICSR 91025 SPLB 94001A x ICSR 26 SPLB 94004A x ICSR 26 SPLB 94006A x ICSR 26 SPLB 94007A x ICSR 26 SPLB 94010A x ICSR 26 SPLB 94015A x ICSR 26 SPLB 94012A x ICSR 26 SPLB 94013A x ICSR 26 SPLB 94014A x ICSR 26 SPLB 94016A x ICSR 26 SPLB 94017A x ICSR 26 SPLB 94021A x ICSR 26 SPLB 94022A x ICSR 26 SPLB 94024A x ICSR 26 SPLB 94025A x ICSR 26 296A x ICSR 26		
	HIGH (12.649-25.296 cm^2)	**R-line** ICSR 91025 **Hybrids** SPLB 94003A x ICSR 91025		**Hybrids** SPLB 94004A x ICSR 119 SPLB 94022A x ICSR 119	**Hybrids** SPLB 94019A x ICSR 119

During the second year, among the male-sterile lines, 17 A-lines fall in disease severity group 1 i.e., resistant group, while two (SPLB 94007A and SPLB 94019A) in moderately resistant group, and one (SPLB 94011A) in less susceptible group. Among the restorers, three (ICSR 119, ICSR 26 and ICSR 90030) genotypes fall in disease severity group 1 i.e., resistant group, one (A 2267-2) in moderately resistant group and two (ICSR 97, ICSR 91025) in less susceptible group. Among the hybrids, 87 F_1 s fall in disease severity group 1 i.e., resistant group, 26 in moderately resistant group, four in less susceptible group, two in susceptible group and one in highly susceptible group.

The results of the data from the second year showed that all the A-lines and R-lines falling in disease severity group 1 i.e., resistant group were desirable from the point of view of breeding. All their respective cross combinations with six exceptions were superior with less leaf area damage and less number of flecks. However, SPLB 94010A and SPLB 94019A with ICSR 119, and SPLB 94003A and SPLB 94009A x ICSR 26 fall in moderately resistant group as they exhibited medium fleck number with less leaf area damage. On the other hand, SPLB 94004A and SPLB 94022A with ICSR 119 were undesirable as it falls in disease severity group 4 i.e., susceptible group Thus the genotypes i.e. A-lines, R-lines and their cross combinations falling in resistant group could be used in future breeding programmes.

Irrespective of the differential reactions to the diseases for two different years, the data over two years showed that two hybrids SPLB 94012A and SPLB 94015A with ICSR 119 fall in disease severity group 1 i.e., resistant group and were consistent in their disease reaction over both the years.

4.4 COMBINING ABILITY

Analysis of variance for line x tester mating design for all the characters under study for *rabi* 1996 and 1997 seasons are presented in Tables 12 and 13, respectively. The classification of the genotypes on the basis of disease damage score was taken into consideration for interpreting the data.

The data revealed significant differences among A-lines, restorer lines, and their F_1 s in both the seasons indicating genetic differences among A-lines as well as restorer lines for all the characters under study. The significance of line x tester mean squares indicated that the A-lines do not appear to behave consistently over different restorer lines and *vice versa*. The results of general combining ability (GCA) effects and specific combining ability (SCA) effects for all the genotypes under study for various disease resistant parameters and yield contributing characters for 1996 and 1997 are presented in Tables 14, 15, 16 and 17, respectively and were briefly discussed below.

4.4.1 Disease Damage Score

SCA variance (0.360, 0.425) during both the years was more than GCA variance (0.045, 0.010) indicating the predominance of non-additive gene action. The degree of dominance was estimated as 2.00 and 4.61 during the first and second years, respectively (Table 18).

Seven A-lines during the first year and 6 A-lines during the second year contributed significantly to the GCA variance for disease resistance. The A-lines that contributed to the resistance significantly were SPLB 94007A (R, -1.22), SPLB

Table 12. Anova for combining ability analysis for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1996.

Characteristic	Replication mean squares d.f. = 2	Line mean squares d.f. = 19	Tester mean squares d.f. = 5	Line x Tester mean squares d.f. = 95	Error mean squares d.f. = 238
DISEASE PARAMETERS					
Disease score[1]	0.210	9.69**	39.83**	1.60**	0.520
Length of the lesion (cm)	1.090	2.14**	6.66**	1.33**	0.100
Width of the lesion (cm)	0.010	0.02**	0.06**	0.01**	0.001
Area of the lesion (cm^2)	0.230	0.41**	1.00**	0.22**	0.020
Number of lesions (no)	9.930	189.79**	214.34**	64.46**	1.230
Number of flecks (no)	313.000	52619.20**	20701.70**	16181.10**	362.000
Lodging (%)	2173.800	520.10**	1867.80**	247.80**	225.000
GRAIN YIELD COMPONENTS					
Days to 50% flowering (days)	29.410	126.20**	193.04**	25.90**	4.860
Plant height (cm)	8.470	2595.58**	18532.38**	307.11**	24.630
Agronomic score[2]	0.770	1.56**	3.80**	0.59**	0.320
Grain yield $plant^{-1}$ (g)	17.280	327.39**	682.89**	130.61**	15.830
100 seed weight (g)	0.450	0.85**	0.31**	0.11**	0.040

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.

** Significant at 1%.

* Significant at 5%.

Table 13. Anova for combining ability analysis for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1997.

Characteristic	Replication mean squares d.f. = 2	Line mean squares d.f. = 19	Tester mean squares d.f. = 5	Line x Tester mean squares d.f. = 95	Error mean squares d.f. = 238
DISEASE PARAMETERS					
Disease score[1]	10.250	5.41**	2.68**	1.72**	0.440
Length of the lesion (cm)	0.070	5.11**	1.54**	2.36**	0.180
Width of the lesion (cm)	0.001	0.02**	0.01**	0.01**	0.002
Area of the lesion (cm^2)	0.020	0.89**	0.27**	0.63**	0.050
Number of lesions (no)	1.300	36.45**	68.36**	29.18**	0.680
Number of flecks (no)	841.730	68217.94*	189803.49**	70539.77**	1477.200
GRAIN YIELD COMPONENTS					
Days to 50% flowering (days)	6.690	86.45**	33.42**	34.37**	1.170
Plant height (cm)	159.090	14281.42**	2223.36**	2321.06**	40.600
Agronomic score[2]	6.390	1.96**	1.13**	1.03**	0.290
Grain yield $plant^{-1}$ (g)	3.010	307.51**	216.62**	307.66**	5.140
100 seed weight (g)	0.020	0.85**	0.19**	0.40**	0.030

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
** Significant at 1%.
* Significant at 5%.

94011A (R, -1.11), SPLB 94009A (R, -0.99) and SPLB 94016A (MR, -0.88) during first year (Table 14), while SPLB 94014A (LS, -1.02), SPLB 94007A (MR, -0.85) and SPLB 94015A (MR, -0.85) in the second year (Table 16). Among the R-lines, during first year two R-lines i.e., ICSR 97 (MR, -1.29) and A 2267-2 (R, -0.64), while in second year single R-line, ICSR 119 (S, -0.29) contributed significantly to the GCA effects for disease resistance.

The cross combinations which have recorded significant SCA effect for disease resistance were SPLB 94009A x ICSR 91025 (R x LS, -1.57), SPLB 94001A x ICSR 97 (S x MR, -1.36) and SPLB 94021A x ICSR 97 (MR x MR, -1.32) during first year (Table 15), and SPLB 94017A x ICSR 26 (S x MR, -1.90), SPLB 94001A x ICSR 90030 (LS x S, -1.86), and SPLB 94019A x A 2267-2 (LS x R, -1.58) during second year (Table 17).

During first year, 4 A-lines (SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94011A) from R group and one restorer line (A 2267-2) from R group exhibited resistance$_{ds}$, while two A-lines (SPLB 94016A and SPLB 94019A) from MR group and one restorer line (ICSR 97) from MR group were found to express moderate resistance$_{ds}$ for disease damage score. While during second year, four A-lines (SPLB 94007A, SPLB 94010A, SPLB 94015A and SPLB 94016A) from MR group showed moderate resistance$_{ds}$ for disease damage score.

4.4.2 Length of the Lesion

SCA variance (0.411, 0.729) was more than GCA variance (0.005, 0.006) for both the years indicating the predominance of non-additive gene action. The degree of

Table 14. General combining ability (GCA) effects of different genotypes of sorghum for various disease resistant parameters and yield contributing characters, rabi season 1996.

Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
Resistant[3]												
SPLB 94004A	-0.22	0.81**	0.07**	0.40**	-4.31**	-61.08**	-2.04	1.93**	-4.79**	0.31*	-2.21*	-0.05
SPLB 94007A	-1.22**	-0.25**	-0.02*	-0.10**	-4.46**	-58.45**	-4.81	2.10**	-9.18**	0.25*	1.50	0.08*
SPLB 94009A	-0.99**	-0.21**	-0.03**	-0.12**	-0.67**	-13.39**	3.49	-0.46	0.88	-0.31*	6.89**	0.10**
SPLB 94010A	-0.33*	-0.35**	0.01	-0.02	3.91**	122.01**	-1.54	1.60**	-9.18**	0.08	1.71	0.14**
SPLB 94011A	-1.11**	-0.46**	-0.03**	-0.14**	2.15**	10.77*	1.49	2.43**	-8.57**	-0.08	-0.23	-0.06
SPLB 94015A	0.23	0.35**	0.06**	0.19**	-5.59**	-83.12**	-1.05	2.43**	-28.07**	0.47**	-5.19**	0.21**
Moderately Resistant[3]												
SPLB 94003A	0.34*	-0.21**	0.00	-0.08**	4.63**	63.90**	-6.97*	1.82**	-1.62	0.14	1.51	-0.06
SPLB 94006A	0.06	-0.24**	-0.02*	-0.12**	-2.54**	-70.43**	-4.26	3.21**	-1.40	0.42*	-5.88**	0.04
SPLB 94016A	-0.88**	-0.03	-0.02*	-0.06*	1.18**	25.51**	8.79*	-4.18**	-2.79*	-0.14	4.84**	0.04
SPLB 94019A	-0.38*	0.29**	0.00	-0.09**	-1.85**	21.03**	-2.50	-1.51**	-3.34**	-0.75*	6.96**	-0.16**
SPLB 94021A	0.51**	-0.27**	-0.01	-0.10**	1.52**	-14.57**	-8.24*	-0.18	-1.40	0.03	-5.72**	0.06
SPLB 94022A	-0.22	-0.19**	-0.02*	-0.09**	4.19**	1.30	0.03	-6.40**	1.27	-0.25*	2.89**	0.11**
Less Susceptible[3]												
SPLB 94012A	0.78**	0.09	0.00	0.00	-3.22**	-20.49**	-3.78	1.88**	20.82**	0.03	1.89*	0.45**
SPLB 94014A	0.78**	0.38**	0.06**	0.17**	-2.10**	20.68**	-7.68*	1.32*	16.54**	0.42*	-3.33**	0.20**
SPLB 94017A	-0.38*	-0.04	-0.01	-0.04	-0.09	-48.54**	9.65**	0.71	10.27**	0.03	-6.93**	-0.35**
SPLB 94024A	0.17	-0.25**	-0.03**	-0.13**	3.42**	50.20**	1.77	-3.46**	-11.34**	-0.03	2.17*	-0.05
SPLB 94025A	1.23**	0.64**	0.03**	0.28**	3.77**	91.08**	5.38	-3.51**	9.77**	-0.13	-0.64	-0.04
Susceptible[3]												
SPLB 94001A	-0.11	0.12	-0.01	0.01	0.23	-6.68	5.08	0.65	11.66**	-0.31*	5.30**	-0.52**

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
SPLB 94013A	0.34*	-0.31**	-0.03**	-0.14**	-3.01**	-41.77**	-0.63	1.49**	19.93**	0.03	-2.47**	0.33**
296A	1.39**	0.12	0.00	0.01	2.82**	12.04**	7.82*	-1.85**	-9.46**	-0.19	-3.04**	-0.06
S.E. (Line)	0.17	0.07	0.01	0.03	0.26	4.48	3.54	0.52	1.17	0.13	0.94	0.04
S.E. (G(I)-G(J)) Line	0.24	0.11	0.01	0.04	0.37	6.34	5.00	0.73	1.65	0.19	1.33	0.06
TESTERS												
Resistant[3]												
A 2267-2	-0.64**	-0.44**	-0.04**	-0.17**	3.36**	3.56	2.26	2.01**	30.71**	-0.18**	3.95**	0.03
Moderately Resistant[3]												
ICSR 97	-1.29**	-0.39**	-0.04**	-0.15**	-0.85**	-19.82**	-7.80**	0.01	-23.03**	0.38**	-3.86**	-0.07**
Less Susceptible[3]												
ICSR 91025	0.89**	0.29**	0.04**	0.14**	-0.48**	24.47**	0.21	-0.39	-6.66**	0.13	-1.21*	0.03
ICSR 119	0.34**	0.31**	0.01	0.08**	0.69**	18.66**	2.47	-1.45**	-3.93**	0.12	0.37	0.10**
Susceptible[3]												
ICSR 90030	0.13	0.14**	0.08**	0.06**	-2.22**	-15.84**	-4.87*	2.11**	3.36**	-0.18**	-3.13**	-0.09**
ICSR 26	0.56**	0.09*	0.01	0.32**	-0.50**	-11.03**	7.73**	-2.30**	-0.44	-0.27**	3.88**	0.00
S.E. (Tester)	0.09	0.04	0.01	0.02	0.14	2.46	1.94	0.28	0.64	0.07	0.52	0.02
S.E. (G(I)-G(J) Tester	0.13	0.06	0.01	0.02	0.20	3.47	2.74	0.40	0.91	0.10	0.73	0.03

1. Scored on a (1-9) scale
2. Scored on a (1-5) scale
3. The groups are based on disease score
**** Significant at 1%**
*** Significant at 5%**

Table 15. Specific combining ability (SCA) effects of different genotypes of sorghum for various disease resistant parameters and yield contributing characters, rabi season 1996.

Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm[2])	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% fl owering (days)	Plant height (cm)	Agron omic score[2]	Grain yield plant^{-1} (g)	100 seed weight (g)
R x R[3]												
SPLB 94004A X A 2267-2	-0.25	-0.53**	-0.06**	-0.37**	-5.76**	-66.01**	-7.70	-7.01**	-0.09	0.63	4.46	0.00
SPLB 94007A X A 2267-2	0.08	-0.34	-0.02	-0.06	-1.77**	29.93**	5.66	-2.85*	10.96**	-0.98**	11.29**	-0.13
SPLB 94009A X A 2267-2	0.53	0.14	0.01	0.06	-8.05**	-113.00**	21.98*	-1.96	-10.76**	0.24	17.36**	-0.19
SPLB 94010A X A 2267-2	-0.81	-0.50**	-0.07**	-0.18**	9.42**	109.56**	-9.66	-1.35	2.63	0.18	-7.20**	0.14
SPLB 94011A X A 2267-2	-0.36	-0.46**	-0.04*	-0.09	3.49**	-56.2**	-7.12	0.49	7.02*	0.68*	-13.51**	0.06
SPLB 94015A X A 2267-2	-0.03	0.76**	0.09**	0.34**	-2.19**	-22.64*	-5.97	0.82	-30.15**	-0.21	-11.49**	-0.10
R x MR[3]												
SPLB 94004A X ICSR 97	-0.27	-0.88**	-0.04*	-0.40**	0.20	20.68	0.92	-3.35**	0.31	-0.28	-4.06	0.24*
SPLB 94007A X ICSR 97	0.07	-0.33	-0.02	-0.06	0.40	13.28	3.68	0.15	1.36	0.45	0.09	0.21
SPLB 94009A X ICSR 97	-0.49	-0.06	0.01	0.03	0.41	-7.25	-4.62	0.38	1.31	0.01	-11.3**	-0.18
SPLB 94010A X ICSR 97	-0.49	-0.29	-0.06**	-0.15*	7.43**	101.48**	0.41	-4.35**	-0.31	-0.05	4.48	0.11
SPLB 94011A X ICSR 97	-0.38	0.21	0.01	0.05	-3.74**	-62.55**	-2.61	-0.51	7.42**	-0.22	7.49**	-0.42**
SPLB 94015A X ICSR 97	1.62**	0.23	-0.01	-0.01	1.83**	37.31*	4.69	1.82	16.92**	-0.77*	8.58**	0.20
R x LS[3]												
SPLB 94004A X ICSR 91025	0.98*	1.01**	0.19**	0.97**	3.55**	108.23**	-2.02	1.89	-7.74**	-0.04	-0.93	0.05
SPLB 94007A X ICSR 91025	-0.68	0.07	-0.01	-0.02	0.10	-17.77	0.75	1.05	-1.69	0.35	-4.31	0.02
SPLB 94009A X ICSR 91025	-1.57**	-0.19	-0.04*	-0.11	-0.86	25.37*	-7.55	-2.73*	41.92**	-0.09	-3.03	0.26*
SPLB 94010A X ICSR 91025	0.09	0.08	0.07**	0.04	-6.40**	-159.77**	-2.52	1.89	-6.69*	0.52	4.42	-0.04
SPLB 94011A X ICSR 91025	0.54	-0.68**	-0.06**	-0.24**	5.76**	48.94**	-2.37	-1.95	-8.63**	-0.65*	-2.37	0.06
SPLB 94015A X ICSR 91025	-0.46	-0.30	-0.01	-0.13	1.70**	-3.63	1.78	-1.28	-9.47**	0.13	-1.95	0.01
SPLB 94004A X ICSR 119	-0.23	-0.21	0.01	-0.06	-1.27*	-62.41**	8.42	5.79**	2.87	-0.01	-9.36**	-0.14

Contd..

Contd..

Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% fl owering (days)	Plant height (cm)	Agron omic score[2]	Grain yield plant^{-1} (g)	100 seed weight (g)
SPLB 94007A X ICSR 119	0.10	-0.16	0.01	-0.03	-2.05**	-70.40**	-6.60	4.29**	-7.74**	0.72*	0.53	-0.20
SPLB 94009A X ICSR 119	0.21	0.08	0.03	0.06	0.54	82.87**	-4.71	1.18	-2.80	-0.06	2.81	-0.03
SPLB 94010A X ICSR 119	1.54**	-0.49**	-0.06**	-0.26**	0.22	124.13**	-2.35	-0.21	7.26*	-0.12	3.52	-0.27*
SPLB 94011A X ICSR 119	-0.01	0.25	0.01	0.03	3.81**	164.87**	24.08**	-3.05*	-11.68**	-0.28	9.93**	0.10
SPLB 94015A X ICSR 119	0.66	1.23**	0.00	0.38**	-1.34*	-18.07	-1.46	1.95	19.48**	-0.17	3.82	0.42**
R x S[3]												
SPLB 94004A X ICSR 90030	0.55	0.91**	-0.01	0.22**	0.05	16.22	8.64	2.72*	2.27	0.31	1.09	-0.06
SPLB 94007A X ICSR 90030	-0.12	0.47**	0.01	0.09	2.80**	2.86	0.67	-1.11	-0.01	-0.30	-3.09	0.25*
SPLB 94009A X ICSR 90030	0.66	0.43*	0.00	0.06	5.58**	-19.80	-8.93	2.78*	-6.73*	-0.08	1.52	0.19
SPLB 94010A X ICSR 90030	-0.67	1.30**	0.14**	0.70**	-5.12**	-82.87**	-7.61	6.05**	-5.01	-0.13	-0.77	0.11
SPLB 94011A X ICSR 90030	0.44	-0.24	-0.01	-0.13	-2.57**	-29.37**	1.41	-0.45	-0.62	-0.30	2.91	0.25*
SPLB 94015A X ICSR 90030	-1.23**	-1.85**	-0.11**	-0.65**	-0.57	-72.87**	-1.42	-1.78	2.22	1.14**	-2.33	-0.23*
SPLB 94004A X ICSR 26	-0.78	-0.31	-0.09**	-0.36**	3.23**	-16.71	-8.26	-0.03	2.34	-0.62	8.80**	-0.10
SPLB 94007A X ICSR 26	0.55	0.28	0.03	0.09	0.52	42.10**	-4.16	-1.53	-2.89	-0.23	-4.51*	-0.16
SPLB 94009A X ICSR 26	0.66	-0.41*	-0.01	-0.10	2.39**	31.80**	3.83	0.34	-22.94**	-0.01	-7.37**	-0.05
SPLB 94010A X ICSR 26	0.33	-0.10	-0.03	-0.15*	-5.55**	-92.54**	21.74*	-2.03	2.11	-0.40	-4.46	-0.06
SPLB 94011A X ICSR 26	-0.23	0.93**	0.10**	0.38**	-6.75**	-65.70**	-13.38	5.47**	6.50*	0.77*	-4.45	0.07
SPLB 94015A X ICSR 26	-0.56	-0.07	0.04*	0.06	0.56	79.90**	2.38	-1.53	1.00	-0.12	3.38	-0.30**
MR x R[3]												
SPLB 94003A X A 2267-2	0.19	0.21	0.04*	0.10	13.87**	168.61**	0.30	-0.57	6.74*	-0.21	-0.19	0.28**
SPLB 94006A X A 2267-2	0.81	0.54**	0.04*	0.19**	-6.15**	-38.36**	-6.94	-0.96	4.85	-0.48	-9.34**	0.21
SPLB 94016A X A 2267-2	0.75	0.55**	0.05**	0.20**	-8.37**	-131.26**	13.35	8.43**	1.24	0.07	13.14**	-0.29**
SPLB 94019A X A 2267-2	0.58	0.80**	0.05**	0.21**	-3.35**	47.88**	-8.70	6.43**	5.13	0.35	4.83*	0.05
SPLB 94022A X A 2267-2	0.40	0.57**	0.65**	0.27**	-0.71	-15.25	6.55	-0.07	17.31**	-0.38	13.06**	0.25*

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
SPLB 94021A X A 2267-2	0.69	-0.23	-0.01	-0.04	5.15**	107.91**	-0.39	2.10	-6.82*	0.24	-6.02**	0.05
MR x MR[3]												
SPLB 94003A X ICSR 97	-0.38	-0.71**	-0.04*	-0.18**	5.11**	-28.16*	-6.21	2.93*	-4.47	-0.33	-6.97**	-0.43**
SPLB 94006A X ICSR 97	0.46	0.18	0.01	0.08	-1.59**	18.19	3.13	-1.96	-3.08	-0.38	11.87**	0.11
SPLB 94016A X ICSR 97	-0.27	-0.13	0.00	-0.02	1.17	32.95**	-7.84	-0.90	-11.69**	0.51	-7.78**	0.01
SPLB 94019A X ICSR 97	-0.43	-0.82**	-0.05**	-0.25**	-0.88	-53.34**	3.22	2.10	3.86	-0.22	3.30	-0.05
SPLB 94021A X ICSR 97	-1.32**	0.21	0.00	0.06	0.36	85.33**	7.11	-2.90*	1.92	0.34	-1.15	0.09
SPLB 94022A X ICSR 97	-0.27	-0.20	-0.01	-0.04	-6.91**	-71.81**	-1.15	-1.01	-4.08	-0.38	0.10	-0.23*
MR x LS[3]												
SPLB 94003A X ICSR 91025	-0.91*	0.35*	-0.01	0.07	-5.46**	66.48**	2.91	-2.34	-0.91	0.87**	0.75	0.03
SPLB 94006A X ICSR 91025	-0.63	0.08	0.013	0.03	1.45*	17.88	3.37	-1.73	17.20**	-0.15	3.94	0.11
SPLB 94016A X ICSR 91025	0.32	0.03	-0.01	-0.01	1.04	29.71**	-9.10	-1.34	-3.08	-0.59	-0.25	0.12
SPLB 94019A X ICSR 91025	0.48	-0.42*	-0.03	-0.18**	2.09**	-9.92	-1.56	-2.34	-7.52**	0.02	-0.10	0.17
SPLB 94021A X ICSR 91025	0.26	0.19	-0.01	0.01	-2.41**	-82.92**	4.18	1.66	-1.13	-0.09	2.18	-0.03
SPLB 94022A X ICSR 91025	0.32	-0.22	0.01	-0.07	-2.08**	39.48**	-4.09	0.89	-5.47	0.18	-1.96	-0.05
SPLB 94003A X ICSR 119	1.21**	-0.92**	-0.04*	0.25**	-0.71	-11.62	-1.95	-0.44	4.71	0.16	-12.88**	-0.23*
SPLB 94006A X ICSR 119	-0.84*	-0.43*	-0.01	-0.10	-4.66**	-71.42**	2.57	5.51**	-3.85	0.88**	-3.03	-0.10
SPLB 94016A X ICSR 119	-0.57	0.84**	0.02	0.25**	8.63**	-15.03	2.48	-0.27	19.21**	0.11	-3.15	0.20
SPLB 94019A X ICSR 119	-0.40	0.31	0.02	0.11	0.99	24.45*	-5.73	-0.77	3.09	-0.28	-6.06**	0.01
SPLB 94021A X ICSR 119	0.04	0.31	0.02	0.12	2.29**	7.45	-3.16	-2.44	1.15	-0.39	0.09	0.11
SPLB 94022A X ICSR 119	-0.90*	-0.30	-0.04*	-0.15*	-4.28**	-99.42**	-7.73	0.12	-6.52*	0.55	2.74	0.03
MR x S[3]												
SPLB 94003A X ICSR 26	-0.34	0.05	-0.03	-0.05	-3.04**	-33.26**	-4.93	-1.92	1.22	-0.12	4.41	-0.12
SPLB 94006A X ICSR 26	0.27	-0.19	-0.04*	-0.09	7.24**	90.07**	-2.12	-2.31	-2.33	-0.07	-3.54	-0.16
SPLB 94016A X ICSR 26	0.22	-0.63**	-0.02	-0.18**	-1.77**	3.87	-2.83	-0.25	-7.61**	0.16	0.61	0.11

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
SPLB 94019A X ICSR 26	0.38	0.71**	-0.04*	-0.26**	1.91**	0.61	9.65	-0.59	4.61	0.10	1.56	0.05
SPLB 94021A X ICSR 26	-0.17	-0.36*	-0.01	-0.11	-0.79	-34.09**	-8.42	-0.92	4.33	0.32	3.24	0.02
SPLB 94022A X ICSR 26	-1.11**	0.99**	0.04*	0.30**	-0.61	34.37**	-6.43	0.30	-5.00	-0.07	-0.50	0.04
SPLB 94003A X ICSR 90030	-0.67	-1.03**	-0.04*	-0.32**	2.29**	-101.66**	-2.17	1.50	-5.56	0.48	3.50	-0.01
SPLB 94006A X ICSR 90030	-0.06	-0.18	-0.03	-0.11	3.71**	-16.36	-0.02	1.44	-12.78**	0.20	0.09	0.05
SPLB 94016A X ICSR 90030	-0.45	-0.66**	-0.04*	-0.24**	-0.69	79.77**	3.94	-3.17*	1.94	-0.24	-2.57	-0.15
SPLB 94019A X ICSR 90030	-0.62	0.84**	0.05**	0.37**	-0.77	-9.69	3.12	-4.84**	-9.17**	0.03	-3.55	0.12
SPLB 94021A X ICSR 90030	0.49	-0.13	0.01	-0.04	-4.61**	-83.69**	0.69	2.50*	0.55	-0.41	1.67	-0.24*
SPLB 94022A X ICSR 90030	0.88*	0.22	0.02	0.04	3.86**	-20.29	-2.09	-2.61*	7.88**	0.20	2.32	0.14
LS x R[3]												
SPLB 94012A X A 2267-2	-0.58	0.22	-0.05**	-0.04	-3.15**	-59.67**	-7.42	-2.96*	-5.71*	-0.43	1.76	0.26*
SPLB 94017A X A 2267-2	-0.42	-0.62**	-0.02	-0.13	-1.23	-72.75**	13.65	3.21*	3.18	0.57	-10.48**	-0.14
SPLB 94024A X A 2267-2	1.08**	-0.48**	-0.02	-0.09	10.02**	117.68**	21.48*	2.32	13.18**	-0.48	-2.70	0.07
SPLB 94025A X A 2267-2	0.03	0.16	0.05**	0.11	-1.29*	-8.22	4.82	-0.96	5.13	-0.37	4.75*	-0.06
SPLB 94014A X A 2267-2	-0.92*	0.56**	0.03	0.16*	-2.40**	-3.30	-3.52	-2.74*	-27.09**	0.18	-3.68	-0.02
LS x MR[3]												
SPLB 94012A X ICSR 97	0.51	1.34**	0.07**	0.45**	-6.96**	-88.54**	5.84	3.76**	-6.20*	0.56	4.41	0.05
SPLB 94017A X ICSR 97	-0.10	0.19	0.00	0.03	10.43**	61.36**	3.53	0.21	-6.42*	-0.33	3.53	-0.10
SPLB 94024A X ICSR 97	0.01	0.31	0.00	0.09	-2.62**	-32.37**	-2.89	2.71*	-0.98	0.39	-10.17**	0.07
SPLB 94025A X ICSR 97	1.29**	-1.12**	-0.04*	-0.40**	5.97**	59.28**	-4.99	0.76	4.08	0.17	-6.50**	0.10
SPLB 94014A X ICSR 97	0.07	0.02	0.03	0.05	-2.15**	39.08**	2.65	3.04*	-10.31**	1.01**	-11.3**	-0.06
LS x LS[3]												
SPLB 94012A X ICSR 91025	-0.35	-0.09	0.00	-0.02	2.73**	-23.87*	-0.28	-1.39	-0.02	-0.09	0.44	0.05
SPLB 94017A X ICSR 91025	0.82*	0.60**	0.04*	0.21**	-2.33**	-39.08**	4.47	0.78	8.87**	0.24	1.86	-0.15

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm[2])	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% fl owering (days)	Plant height (cm)	Agron omic score[2]	Grain yield plant^{-1} (g)	100 seed weight (g)
SPLB 94024A X ICSR 91025	-0.74	-0.20	0.01	-0.04	0.62	52.65**	-0.80	-2.73*	3.81	-0.04	0.96	0.12
SPLB 94025A X ICSR 91025	0.54	-1.01**	-0.1**	-0.52**	1.94**	28.50**	-3.39	2.00	-8.97**	0.41	0.64	0.01
SPLB 94014A X ICSR 91025	0.65	-0.03	-0.05**	-0.09	0.21	-17.23	5.58	0.50	5.92*	0.18	-1.94	-0.10
SPLB 94012A X ICSR 119	-0.57	-0.35*	0.00	-0.08	2.09**	-13.17	-4.60	-1.16	2.26	-0.39	-1.46	0.06
SPLB 94017A X ICSR 119	-0.73	0.42*	0.03	0.16*	-2.62**	38.08**	-4.50	-0.66	-2.18	-0.06	-3.04	0.16
SPLB 94024A X ICSR 119	-0.29	0.20	0.00	0.06	6.23**	3.01	-6.23	0.18	-7.24*	-0.34	-0.67	-0.04
SPLB 94025A X ICSR 119	-0.68	0.75**	0.04*	0.26**	-5.15**	-90.50**	-3.32	-1.10	1.65	0.11	-3.73	0.18
SPLB 94014A X ICSR 119	-0.23	-0.57**	-0.08**	-0.27**	-0.16	44.66**	-3.72	-0.60	-3.46	0.22	1.45	-0.10
LS x S[3]												
SPLB 94012A X ICSR 26	1.22**	0.84**	0.05**	0.34**	1.88**	4.53	10.25	0.03	8.78**	-0.01	9.36**	-0.27*
SPLB 94017A X ICSR 26	0.05	-0.18	-0.01	-0.08	-3.98**	-6.49	-4.53	0.19	-4.00	-0.01	2.45	0.13
SPLB 94024A X ICSR 26	0.16	-0.32	-0.01	-0.09	3.39**	-34.59**	-2.08	0.03	0.94	0.04	10.49**	0.24*
SPLB 94025A X ICSR 26	-0.03	1.45**	0.10**	0.69**	-3.83**	-76.54**	27.27**	-1.92	-0.17	0.16	0.70	0.06
SPLB 94014A X ICSR 26	0.55	-0.01	0.04*	0.10	0.59	1.90	-5.65	1.25	4.72	-0.07	-3.68	-0.05
SPLB 94012A X ICSR 90030	0.22	-0.64**	-0.04*	-0.25**	-1.40*	53.09**	-0.60	2.44	4.99	-0.08	1.19	-0.03
SPLB 94017A X ICSR 90030	0.38	-0.41*	-0.04*	-0.20**	-0.26	18.88	-2.01	-3.73**	0.55	-0.41	5.68*	0.10
SPLB 94024A X ICSR 90030	0.83*	-0.16	-0.05**	-0.13	-6.33**	19.51	7.18	0.78	7.16*	0.31	-5.36*	-0.33**
SPLB 94025A X ICSR 90030	0.44	0.87**	0.06**	0.36**	-4.02**	63.96**	-4.76	0.50	2.72	-0.91**	1.85	0.03
SPLB 94014A X ICSR 90030	-0.45	-0.52**	-0.01	-0.16*	2.47**	-10.77	0.76	1.66	2.61	-0.13	-5.26*	0.02
S x R[3]												
SPLB 94001A X A 2267-2	-0.69	0.60**	0.00	0.09	-5.06**	-95.61**	-13.25	-5.40**	18.46**	0.57	-4.85*	0.34**
SPLB 94013A X A 2267-2	0.53	-0.13	0.02	0.02	-4.26**	-26.39*	-8.48	2.43	-3.15	-0.09	2.25	-0.05
296A X A 2267-2	0.14	-0.35*	-0.02	-0.09	5.98**	96.54**	8.72	0.76	4.57	-0.54	2.56	0.01

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
S x MR[3]												
SPLB 94001A X ICSR 97	-1.36**	-0.93**	-0.06**	-0.39**	5.10**	15.30	-10.80	-0.24	0.68	0.07	7.03**	-0.38**
SPLB 94013A X ICSR 97	-0.82*	-0.07	0.01	0.02	-1.59*	-20.67	-0.50	-1.24	5.25	0.34	-4.87*	0.16
296A X ICSR 97	0.79	1.34**	0.04*	0.38**	-6.15**	-89.01**	-0.32	-1.57	-3.36	-0.44	7.17**	-0.15
S x LS[3]												
SPLB 94001A X ICSR 91025	-0.13	-0.17	-0.06**	-0.19**	-0.92	-36.68**	24.67**	2.50*	-10.86**	0.24	4.36	-0.28**
SPLB 94013A X ICSR 91025	0.09	0.72**	0.04*	0.22**	-1.75**	-48.19**	-3.43	2.66*	2.53	0.24	1.53	0.04
296A X ICSR 91025	0.37	0.19	0.03	0.09	1.02	21.81*	-10.59	2.00	-8.08**	0.13	-4.23	0.16
SPLB 94001A X ICSR 119	1.66**	-0.57**	0.07**	-0.06	-2.76**	37.75**	9.68	-2.94*	-10.24**	-0.39	13.33**	0.23*
SPLB 94013A X ICSR 119	0.54	-0.32	-0.05**	-0.14*	1.28*	-77.52**	4.23	-0.10	1.48	-0.06	3.9	-0.39**
296A X ICSR 119	-0.51	-0.09	0.00	-0.03	-1.07	2.30	4.59	-2.77*	-7.46**	-0.17	1.21	0.00
S x S[3]												
SPLB 94001A X ICSR 26	0.44	-0.63**	-0.04*	-0.23**	-2.57**	-69.45**	-18.04**	6.91**	-2.06	-0.01	-9.11**	0.10
SPLB 94013A X ICSR 26	-0.67	-0.25	-0.06**	-0.14*	6.00**	165.01**	16.7	-3.92**	4.67	-0.68*	2.19	0.22*
296A X ICSR 26	-0.73	-0.34	-0.02	-0.11	1.17	-24.80*	-10.99	2.41	5.72*	0.88**	-9.57**	0.24*
SPLB 94001A X ICSR 90030	-0.89**	1.47**	0.07**	0.57**	6.21**	192.15**	3.14	-4.00**	9.16**	-0.08	3.24	0.04
SPLB 94013A X ICSR 90030	0.33	0.05	0.03	0.03	0.32	7.77	-8.51	0.16	-10.78**	0.26	-4.99*	0.02
296A X ICSR 90030	-0.06	-0.73**	-0.02	-0.23**	-0.95	-6.83	8.59	-0.84	8.61**	0.14	2.85	-0.25*
S.E. (Crosses)	0.42	0.18	0.02	0.07	0.64	10.98	8.66	1.27	2.87	0.33	2.30	0.11
S.E. (S(IJ)-S(JK)) Crosses	0.59	0.26	0.03	0.10	0.91	15.53	12.25	1.80	4.05	0.46	3.25	0.15

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
3. The groups are based on disease score.
**** Significant at 1%**
*** Significant at 5%**

R = Resistant
MR = Moderately Resistant
LS = Less Susceptible
S = Susceptible

Table 16. General combining ability (GCA) effects of different genotypes of sorghum for various disease resistant parameters and yield contributing characters, rabi season 1997.

Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm[2])	Number of lesion (no)	Number of flecks (no)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield plant[-1] (g)	100 seed weight (g)
LINES											
Moderately Resistant[3]											
SPLB 94004A	0.37*	0.20*	0.02*	0.16**	-0.69**	-11.56	-1.71**	-7.37**	-0.07	4.93**	-0.04
SPLB 94007A	-0.85**	-1.18**	-0.07**	-0.47**	1.19**	179.82**	1.13**	35.13**	-0.18	-4.65**	-0.05
SPLB 94010A	-0.46**	-0.80**	-0.05**	-0.37**	0.69**	-7.69	-0.37	31.80**	-0.46**	8.68**	0.17**
SPLB 94011A	-0.07	-0.37**	0.00	-0.14**	3.02**	151.46**	0.52*	-14.04**	0.27*	-5.10**	0.25**
SPLB 94013A	0.26	0.04	0.00	0.00	2.86**	134.45**	-1.04**	-19.04**	-0.18	-1.92**	0.12**
SPLB 94015A	-0.85**	-0.17	-0.01	-0.06	0.78**	70.56**	2.18**	-42.37**	0.32*	-4.60**	0.08*
SPLB 94016A	-0.41**	-0.34**	-0.03**	-0.18**	0.89**	100.85**	0.85**	-38.76**	0.16	-7.91**	0.18**
SPLB 94025A	0.43**	0.70**	0.04**	0.30**	-2.17**	-90.58**	-0.26	-8.48**	-0.07	0.64	0.15**
Less Susceptible[3]											
SPLB 94001A	0.43**	0.22*	0.00	0.04	-1.63**	-14.95	-2.43**	-16.82**	-0.18	1.61**	-0.03
SPLB 94003A	0.65**	0.42**	0.05**	0.31**	-0.42*	24.03**	1.29**	-2.37	-0.07	0.64	-0.16**
SPLB 94006A	0.09	-0.44**	-0.02*	-0.20**	-0.69**	78.26**	0.35	20.41**	0.21	-0.05	-0.20**
SPLB 94009A	-0.79**	-0.88**	-0.03**	-0.30**	-0.68**	36.3**	2.85**	25.96**	0.32*	0.21	0.06
SPLB 94014A	-1.02**	0.19	0.02*	0.16**	-0.98**	-6.65	0.68**	-42.73**	0.21	1.55**	0.09*
SPLB 94019A	0.26	0.59**	0.00	0.16**	0.91**	-30.22**	-0.04	34.3**	-0.46**	4.61**	-0.13**
SPLB 94021A	0.65**	0.40**	0.03**	0.19**	0.20	-41.52**	2.07**	52.07**	-0.29*	5.15**	-0.42**
SPLB 94022A	0.48**	0.71**	0.01	0.19**	-0.46*	-121.59**	-2.71**	21.52**	-0.07	2.49**	-0.33**
SPLB 94024A	-0.13	-0.06	-0.01	-0.08	-1.65**	-127.3**	-2.26**	-25.15**	-0.29*	0.91	0.14**
Susceptible[3]											
SPLB 94012A	0.21	0.20*	0.04**	0.11*	-1.72**	-63.27**	2.79**	3.18*	0.93**	-4.51**	0.43**
SPLB 94017A	0.65**	0.48**	0.01	0.20**	1.00**	-109.71**	2.02**	14.02**	0.16	-3.01**	-0.37**
296A	0.09	0.10	0.00	-0.01	-0.45*	-150.7**	-5.93**	-21.26**	-0.29*	0.33	0.06

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesion (no)	Number of flecks (no)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
S.E. (Lines)	0.16	0.10	0.01	0.05	0.19	9.06	0.25	1.50	0.13	0.53	0.04
S.E. (G(I)-G(J)) Lines	0.22	0.14	0.01	0.07	0.27	12.81	0.36	2.12	0.18	0.76	0.06
TESTERS											
Resistant[3]											
A 2267-2	0.24**	-0.10*	-0.01	-0.07*	0.36**	29.66**	0.09	-8.7**	0.11	-3.14**	-0.05**
Moderately Resistant[3]											
ICSR 26	-0.16	-0.14**	0.00	-0.05	1.11**	73.35**	0.41**	0.05	-0.01	-0.49	0.02
ICSR 97	-0.06	0.17**	0.01	0.08**	-0.59**	-25.37**	-0.41**	1.30	0.11	-0.82**	-0.03
Susceptible[3]											
ICSR 119	-0.29**	-0.19**	0.00	-0.06*	1.27**	19.46**	0.53**	10.19**	-0.11	2.10**	-0.06**
ICSR 90030	0.03	0.11*	0.01	0.04	-1.18**	-92.26**	-1.31**	-1.29	-0.21**	1.43**	0.09**
Highly Susceptible[3]											
ICSR 91025	0.23**	0.15**	0.01	0.06*	-0.98**	-4.83	0.68**	-1.54	0.12	0.92**	0.03
S.E. (Testers)	0.09	0.05	0.01	0.03	0.11	4.96	0.14	0.82	0.07	0.29	0.02
S.E. (G(I)-G(J)) Testers	0.12	0.08	0.01	0.04	0.15	7.02	0.20	1.16	0.10	0.41	0.03

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
3. The groups are based on disease score.
**** Significant at 1%**
*** Significant at 5%**

Table 17. Specific combining ability (SCA) effects of different genotypes of sorghum for various disease resistant parameters and yield contributing characters, rabi season 1997.

Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
MR x R[3]											
SPLB 94004A X A 2267-2	-0.02	-0.73**	-0.08**	-0.47**	2.94**	19.67	-1.59*	27.04**	-0.22	3.28*	-0.27**
SPLB 94007A X A 2267-2	-0.47	0.65**	0.08**	0.28*	-3.87**	-173.84*	-8.43**	-8.80*	-0.44	7.39**	0.43**
SPLB 94010A X A 2267-2	-0.52	-0.69**	-0.03	-0.19	0.03	141.53**	-2.59**	7.87*	-0.16	13.79**	0.02
SPLB 94011A X A 2267-2	0.09	0.56*	0.04*	0.26*	-1.50**	-103.94*	2.18**	23.70**	0.12	-6.16**	-0.39**
SPLB 94013A X A 2267-2	-0.24	0.10	-0.01	-0.03	-2.74**	-179.40*	2.74**	22.04**	-0.44	-7.94**	0.14
SPLB 94015A X A 2267-2	-0.80*	-1.63**	-0.12**	-0.59**	5.14**	107.28**	-0.15	-9.63**	-0.61**	5.74**	-0.09
SPLB 94016A X A 2267-2	-0.91*	-1.00**	-0.07**	-0.36**	-0.10	-73.34**	-2.15**	25.09**	0.23	10.52**	-0.33**
SPLB 94025A X A 2267-2	0.59	-0.21	0.01	-0.06	-0.64	-45.11*	2.29**	24.82**	-0.22	6.44**	0.17
MR x MR[3]											
SPLB 94004A X ICSR 26	0.04	1.85**	0.15**	1.20**	-3.15**	-46.75*	3.76**	-21.71**	0.23	-6.37**	0.86**
SPLB 94007A X ICSR 26	0.27	0.47*	0.03	0.15	-1.91**	158.17**	2.26**	-39.21**	1.01**	-8.12**	-0.86**
SPLB 94010A X ICSR 26	-0.12	0.35	0.03	0.13	-2.28**	37.98	2.76**	30.79**	0.62*	1.74	0.05
SPLB 94011A X ICSR 26	0.82*	1.18**	0.08**	0.59**	0.83	97.01**	3.20**	1.62	0.90**	-8.15**	-0.03
SPLB 94013A X ICSR 26	0.49	0.82**	0.11**	0.55**	2.48**	503.01**	3.42**	-5.05	-0.99**	-1.26	-0.06
SPLB 94015A X ICSR 26	-0.07	-0.77**	-0.05**	-0.38**	2.05**	28.30	0.20	-18.38**	-0.16	4.02**	0.07
SPLB 94016A X ICSR 26	-0.18	1.67**	0.03	0.50**	-5.66**	-320.99*	2.53**	-26.99**	1.01**	-8.40**	0.47**
SPLB 94025A X ICSR 26	0.66	-0.48*	-0.04*	-0.29*	0.67	4.07	-1.69**	22.73**	-0.43	-1.15	0.20*
SPLB 94004A X ICSR 97	1.28**	0.90**	0.04*	0.40**	0.76	-89.70**	-1.09	7.04	0.45	-10.17**	0.08

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Days to 50% fl owering (days)	Plant height (cm)	Agron omic score[2]	Grain yield plant^{-1} (g)	100 seed weight (g)
SPLB 94007A X ICSR 97	0.17	-1.05**	-0.10**	-0.36**	1.55**	73.65**	2.07**	-22.13**	-0.77*	16.41**	0.35**
SPLB 94010A X ICSR 97	0.11	-0.24	0.02	-0.06	-1.35**	-45.9*	1.91**	7.87*	-0.49	-0.06	-0.30**
SPLB 94011A X ICSR 97	-0.61	0.14	-0.01	-0.01	-5.95**	-275.78*	-7.65**	-12.96**	-0.22	0.32	0.39**
SPLB 94013A X ICSR 97	-0.94*	-0.94**	-0.05**	-0.41**	-3.32**	-113.91*	-2.09**	-21.30**	0.56	-4.66**	-0.11
SPLB 94015A X ICSR 97	-0.17	1.27**	0.04*	0.47**	-3.78**	-152.15*	0.68	22.04**	0.06	0.22	0.16
SPLB 94016A X ICSR 97	0.72	1.12**	0.08**	0.54**	-1.22*	-161.91*	0.68	8.43*	-0.11	-2.34	0.03
SPLB 94025A X ICSR 97	-0.44	-0.16	-0.04*	-0.19	0.98*	0.65	2.13**	-15.18**	-0.22	-1.88	0.12
MR x S[3]											
SPLB 94004A X ICSR 119	0.51	-0.80**	-0.01	-0.40**	2.03**	178.88**	1.31*	1.48	0.00	23.38**	0.04
SPLB 94007A X ICSR 119	-0.27	-0.74**	-0.08**	-0.24	7.15**	-4.24	0.47	12.31**	0.11	-6.71**	-0.18
SPLB 94010A X ICSR 119	-0.66	-0.42	-0.05**	-0.19	2.92**	-44.20*	-1.69**	8.98*	0.06	1.35	0.13
SPLB 94011A X ICSR 119	0.29	-0.35	-0.03	-0.20	1.27**	-3.74	0.08	-5.19	-0.33	4.80**	0.15
SPLB 94013A X ICSR 119	0.62	1.05**	0.08**	0.52**	3.35**	120.07**	1.31*	-25.19**	1.11**	-6.71**	0.09
SPLB 94015A X ICSR 119	0.07	0.59*	0.05**	0.20	-3.11**	132.09**	-0.25	-5.19	0.28	-1.50	0.22*
SPLB 94016A X ICSR 119	0.29	-0.23	0.02	-0.08	8.19**	479.93**	0.75	-13.80**	-1.56**	12.88**	0.05
SPLB 94025A X ICSR 119	0.46	-0.19	0.03	-0.03	-1.82**	-124.71*	-2.47**	-4.08	-0.33	0.73	0.05
SPLB 94004A X ICSR 90030	-0.47	0.03	-0.005	-0.06	0.29	3.46	-2.53**	16.29**	-0.57	8.98**	-0.11
SPLB 94007A X ICSR 90030	0.75**	0.51*	0.02	0.12	-0.66	-29.99	2.31**	27.12	-0.12	-3.91**	0.57**
SPLB 94010A X ICSR 90030	1.36**	0.47*	0.01	0.14	-0.57	-93.64**	3.14**	-32.88**	0.49	-21.51**	-0.15
SPLB 94011A X ICSR 90030	-0.69	-0.67**	-0.02	-0.26*	3.25**	145.18**	1.25*	-17.05**	-0.90**	18.07**	-0.26**
SPLB 94013A X ICSR 90030	0.64	0.03	-0.03	-0.09	0.63	-167.85*	-1.19	4.62	-0.12	3.36*	-0.1
SPLB 94015A X ICSR 90030	0.42	0.88**	0.10**	0.52**	-3.52**	-103.13*	-0.08	-23.71**	-0.29	3.84**	-0.23**

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
SPLB 94016A X ICSR 90030	-0.36	-0.98**	-0.09**	-0.43**	1.18*	98.98**	-3.42**	1.01	0.21	-6.32**	-0.26**
SPLB 94025A X ICSR 90030	-0.53	-0.09	0.00	-0.02	0.17	53.31*	-2.97**	17.40**	-0.23	-0.73	-0.47**
MR x HS[3]											
SPLB 94004A X ICSR 91025	-1.34**	-1.25**	-0.10**	-0.67**	-2.87**	-65.57**	0.16	-30.13**	0.10	-19.10**	-0.61*
SPLB 94007A X ICSR 91025	-0.45	0.16	0.04*	0.05	-2.27**	-23.75	1.32*	30.70**	0.21	-5.06**	-0.31**
SPLB 94010A X ICSR 91025	-0.17	0.51*	0.02	0.17	1.24**	4.23	-3.51**	-22.63**	-0.51	4.67**	0.24*
SPLB 94011A X ICSR 91025	0.11	-0.86**	-0.06**	-0.39**	2.10**	141.28**	0.93	9.87**	0.43	-8.88*	0.13
SPLB 94013A X ICSR 91025	-0.56	-1.06**	-0.10**	-0.52**	-0.40	-161.91*	-4.18**	24.87**	-0.12	17.21**	0.03
SPLB 94015A X ICSR 91025	0.55	-0.33	-0.02	-0.21	3.21**	-12.39	-0.40	34.87**	0.71*	-12.32**	-0.13
SPLB 94016A X ICSR 91025	0.44	-0.57*	0.02	-0.17	-2.38**	-22.68	1.60**	6.26	0.21	-6.34**	0.03
SPLB 94025A X ICSR 91025	-0.73	1.14**	0.04*	0.58**	0.65	111.78**	2.71**	-45.68**	1.43**	-3.42**	-0.07
LS x R[3]											
SPLB 94001A X A 2267-2	0.26	0.35	0.01	0.11	-2.31**	166.70**	-0.21	3.15	0.56	-1.46	0.32**
SPLB 94003A X A 2267-2	-1.30**	-1.36**	-0.12**	-0.72**	2.07**	344.55**	0.74	-4.63	0.12	0.57	-0.55**
SPLB 94006A X A 2267-2	1.59**	0.59*	0.01	0.14	-0.39	-167.34*	-3.32**	-40.74**	0.17	-11.14**	-0.04
SPLB 94009A X A 2267-2	0.81*	1.58**	0.16**	0.87**	0.95*	138.75**	2.18**	-57.96**	0.73*	-12.20**	-0.04
SPLB 94014A X A 2267-2	0.70	0.52*	0.06**	0.26*	3.87**	121.93**	2.02**	19.06**	0.51	-10.87**	0.33**
SPLB 94019A X A 2267-2	-1.58**	0.12	0.04*	0.12	-0.98*	-162.57*	-8.26**	-31.30**	0.84**	-12.40**	0.62**
SPLB 94022A X A 2267-2	-0.13	0.27	0.01	0.09	1.85**	-0.50	-2.26**	21.48**	-0.55	7.38**	-0.02
SPLB 94021A X A 2267-2	-0.3	0.56*	0.05**	0.28*	-2.61**	-123.03*	-0.04	7.59*	0.34	-7.14**	-0.33**
SPLB 94024A X A 2267-2	1.14**	0.63**	0.04*	0.30*	-0.30	-27.39	1.96**	14.82**	-0.33	-1.90	-0.52**

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield plant^{-1} (g)	100 seed weight (g)
LS x MR[3]											
SPLB 94001A X ICSR 26	-0.34	-1.06**	-0.07**	-0.45**	2.87**	-91.42**	-1.86**	14.40**	-0.32	0.22	-0.54**
SPLB 94003A X ICSR 26	-0.57	-1.13**	-0.11**	-0.69**	0.25	-87.13**	-3.91**	-20.05**	-0.10	4.86**	0.05
SPLB 94006A X ICSR 26	-0.01	-0.73**	-0.03	-0.28*	-1.34**	-151.83*	-8.30**	20.51**	-0.38	20.08**	0.66**
SPLB 94009A X ICSR 26	0.54	-0.15	-0.01	-0.11	1.38**	-20.27	-0.13	34.95**	-0.16	-12.05**	-0.44**
SPLB 94014A X ICSR 26	0.43	-1.33**	-0.11**	-0.67**	4.88**	261.82**	-1.97**	23.64**	-0.71*	6.54**	-0.30**
SPLB 94019A X ICSR 26	0.49	0.31	0.04*	0.17	-2.20**	-0.69	1.76**	-6.71	-0.38	14.82**	-0.55**
SPLB 94021A X ICSR 26	-0.23	0.37	0.00	0.07	0.51	-142.05*	-0.69	-1.16	0.46	-13.72**	0.11
SPLB 94022A X ICSR 26	-0.40	-0.20	0.01	-0.06	-1.04*	7.05	1.09	46.07**	-0.77*	13.73**	0.62**
SPLB 94024A X ICSR 26	0.21	0.67**	0.06**	0.36**	1.75**	1.29	5.31**	-0.60	0.46	-8.61*	-0.75**
SPLB 94001A X ICSR 97	1.22**	-0.14	-0.01	-0.12	0.64	54.36*	0.29	9.82**	0.56	-4.18**	-0.22*
SPLB 94003A X ICSR 97	0.33	0.64**	0.05*	0.32*	-1.41**	-16.89	0.57	28.70**	-0.55	8.39**	0.17
SPLB 94006A X ICSR 97	-0.78*	0.05	0.05**	0.06	5.61**	324.82**	4.52**	-12.41**	0.17	1.67	0.64**
SPLB 94009A X ICSR 97	0.11	-1.15**	-0.13**	-0.50**	3.48**	53.04*	-0.98	43.70**	-0.61*	-2.78*	-0.28**
SPLB 94014A X ICSR 97	0.00	-0.68**	-0.06**	-0.48**	-0.57	-111.44*	-0.82	-0.94	-0.16	3.34*	0.02
SPLB 94019A X ICSR 97	-0.61	-0.39	0.00	-0.18	1.30**	315.22**	2.91**	8.70*	0.17	-2.65*	-0.36**
SPLB 94021A X ICSR 97	-1.00**	-0.32	-0.02	-0.21	-0.52	-6.74	0.46	0.93	-0.33	17.54**	-0.14
SPLB 94022A X ICSR 97	0.17	-0.04	0.03	0.06	-1.13*	-40.74	0.24	-1.85	0.45	-7.94**	-0.66**
SPLB 94024A X ICSR 97	-0.89*	-0.24	-0.03	-0.17	-1.21*	-64.36**	-4.54**	-8.52*	-0.33	9.32**	0.37**
LS x S[3]											
SPLB 94001A X ICSR 119	0.12	0.33	0.03	0.13	-1.18*	-48.83*	4.03**	-9.08*	-0.89**	1.97	-0.10
SPLB 94003A X ICSR 119	0.23	-0.05	-0.02	-0.22	0.83	-67.48**	2.31**	-16.86**	0.67*	-14.74**	-0.10
SPLB 94006A X ICSR 119	-0.88*	-0.76**	-0.07**	-0.35**	-1.57**	56.13*	1.92**	47.03**	-0.28	5.82**	-0.20**

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^{2})	Number of lesions (no)	Number of flecks (no)	Days to 50% fl owering (days)	Plant height (cm)	Agron omic score[2]	Grain yield plant^{-1} (g)	100 seed weight (g)
SPLB 94009A X ICSR 119	-0.32	0.00	0.00	0.00	-6.85	-232.95*	0.75	4.81	0.61*	17.90**	0.24*
SPLB 94014A X ICSR 119	-0.10	2.27**	0.19**	1.49**	-4.64**	-90.76**	4.58**	-21.97**	0.06	8.35**	0.18
SPLB 94019A X ICSR 119	-0.04	-1.40**	-0.10**	-0.64**	6.84**	79.13**	0.97	6.48	-0.28	-10.5**	-0.40**
SPLB 94021A X ICSR 119	1.57**	1.28**	0.12**	0.84**	-2.74**	-60.66**	-0.14	2.03	0.22	-11.25**	-0.25*
SPLB 94022A X ICSR 119	-0.6	0.43	-0.04*	-0.04	-1.36**	-120.53*	-2.69**	25.92**	0.33	-6.72**	0.03
SPLB 94024A X ICSR 119	-0.32	-0.39	-0.04*	-0.23	-2.61**	-34.45	-3.14**	-27.41**	0.22	-1.20	0.13
SPLB 94001A X ICSR 90030	-1.86**	0.86**	0.07**	0.53**	-0.77	-39.75	-5.81**	-14.27**	0.54	-3.36*	0.29**
SPLB 94003A X ICSR 90030	0.25	1.24**	0.13**	0.94**	0.42	-28.06	2.14**	-22.05**	0.43	7.54**	0.32**
SPLB 94006A X ICSR 90030	-0.19	-0.40	-0.04*	-0.24	-2.38**	-80.09**	3.42**	25.18**	-0.51	1.89	-0.41**
SPLB 94009A X ICSR 90030	-0.31	-0.07	0.00	-0.09	3.88**	3.93	0.25	22.95**	0.04	-3.10	0.39**
SPLB 94014A X ICSR 90030	-0.08	-0.36	-0.05**	-0.34**	-0.95*	-40.38	-6.25**	-15.02**	-0.18	-5.64**	0.13
SPLB 94019A X ICSR 90030	0.64	-0.09	-0.03	-0.16	-1.97**	-108.22*	2.47**	14.62**	-0.18	10.84**	0.28**
SPLB 94021A X ICSR 90030	-0.42	-0.75**	-0.05**	-0.40**	-2.13**	-63.64**	0.69	0.18	-0.01	-6.97**	0.17
SPLB 94022A X ICSR 90030	0.42	-1.18**	-0.05**	-0.48**	1.06*	152.69**	6.81**	-69.27**	1.43**	-5.05**	-0.02
SPLB 94024A X ICSR 90030	0.36	-0.19	0.00	-0.04	2.65**	116.93**	-0.64	7.40*	-0.01	4.47**	0.32**
LS x HS[3]											
SPLB 94001A X ICSR 91025	0.61	-0.33	-0.03	-0.20	0.76	-41.05	3.54**	-4.02	-0.46	6.82**	0.25*
SPLB 94003A X ICSR 91025	1.05**	0.65**	0.06**	0.37**	-2.16**	-144.99*	-1.84**	34.87**	-0.57	-6.62**	0.11
SPLB 94006A X ICSR 91025	0.27	1.24**	0.10**	0.68**	0.06	18.31	1.77**	-39.57**	0.82**	-18.33**	-0.65**
SPLB 94009A X ICSR 91025	-0.84*	-0.21	-0.02	-0.17	-2.84**	57.50**	-2.07**	-48.46**	-0.62*	12.22**	0.12
SPLB 94014A X ICSR 91025	-0.95*	-0.41	-0.02	-0.26*	-2.58**	-141.17*	2.43**	-4.77	0.49	-1.73	-0.34**
SPLB 94019A X ICSR 91025	1.11**	1.45**	0.06**	0.69**	-2.98**	-122.88*	0.16	8.20*	-0.18	-0.12	0.41**

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Days to 50% fl owering (days)	Plant height (cm)	Agron omic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
SPLB 94021A X ICSR 91025	0.38	-1.14**	-0.08**	-0.58**	7.49**	396.13**	-0.29	-9.57**	-0.68*	21.54**	0.43**
SPLB 94022A X ICSR 91025	0.55	0.73**	0.04*	0.42**	0.62	2.03	-3.18**	-22.35**	-0.90**	-1.40	0.04
SPLB 94024A X ICSR 91025	-0.51	-0.48*	-0.02	-0.22	-0.29	7.97	1.04	14.32**	-0.01	-2.08	0.44**
S x R[3]											
SPLB 94012A X A 2267-2	0.14	0.34	0.02	0.17	2.98**	142.25**	1.57**	19.82**	0.12	5.65**	0.09
SPLB 94017A X A 2267-2	1.03**	-0.29	-0.04*	-0.27*	-1.89**	-123.28*	10.02**	-74.35**	-0.44	5.15**	0.46**
296A X A 2267-2	-0.08	-0.34	-0.04*	-0.20	-2.49**	-2.92	3.29**	10.93**	-0.33	5.28**	-0.005
S x MR[3]											
SPLB 94012A X ICSR 26	-0.12	0.53*	0.02	0.21	-2.78**	-143.57*	-1.74**	21.07**	-0.10	-2.07	-0.04
SPLB 94017A X ICSR 26	-1.90**	-1.89**	-0.09**	-0.75**	-1.51**	-61.73**	-6.97**	-58.10**	-0.32	-2.17	0.43**
296A X ICSR 26	-0.01	-0.48*	-0.03	-0.22	4.19**	-32.27	0.98	-17.82**	0.12	6.03**	0.03
SPLB 94012A X ICSR 97	0.44	-0.27	0.00	-0.09	-0.50	52.94*	2.74**	-58.52**	0.12	0.40	0.24*
SPLB 94017A X ICSR 97	1.00**	1.01**	0.12**	0.76**	6.99**	151.25**	0.85	22.32**	1.23**	-11.97**	-0.58**
296A X ICSR 97	-0.11	0.48*	0.01	0.17	-0.34	53.58*	-2.87**	-5.74	0.01	-8.97**	0.08
S x S[3]											
SPLB 94012A X ICSR 119	-0.66	-0.49*	-0.05**	-0.31*	-1.33**	-59.95**	-1.19	-2.41	0.00	-10.26**	-0.43**
SPLB 94017A X ICSR 119	-0.77*	0.00	-0.01	-0.14	-3.05**	-100.24*	-5.75**	26.76**	0.11	-6.96**	0.21*
296A X ICSR 119	0.46	-0.13	-0.01	-0.11	-2.32**	-53.48*	-1.14	-4.63	-0.11	-0.62	0.11
SPLB 94012A X ICSR 90030	-0.64	-0.31	-0.02	-0.15	1.31**	73.60**	-2.03**	25.73**	-0.57	-1.38	-0.11
SPLB 94017A X ICSR 90030	0.25	1.08**	0.04*	0.45**	-0.33	69.55**	1.42*	41.57**	0.21	-2.75*	-0.27**
296A X ICSR 90030	0.47	-0.02	0.03	0.07	-1.55**	37.11	1.03	-9.82**	0.32	1.72	-0.07

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Genotypes	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
S x HS[3]											
SPLB 94012A X ICSR 91025	0.83*	0.20	0.03	0.18	0.33	-65.26**	0.66	-5.68	0.43	7.66**	0.25*
SPLB 94017A X ICSR 91025	0.38	0.08	-0.01	-0.05	-0.20	64.45**	0.43	41.82**	-0.79*	18.70**	-0.24*
296A X ICSR 91025	-0.73	0.49*	0.05**	0.29*	2.51**	-2.02	-1.29*	27.09**	-0.01	-3.44**	-0.14
S.E. (Crosses)	0.38	0.24	0.02	0.13	0.48	22.19	0.62	3.68	0.31	1.31	0.10
S.E. (S(IJ)-S(JK) Crosses	0.54	0.34	0.03	0.18	0.67	31.38	-1.14	5.20	0.44	1.85	0.17

I. Disease score. **R = Resistant** **HS = Highly Susceptible**
2. Agronomic score. **MR = Moderately Resistant**
**** Significant at 1%.** **LS = Less Susceptible**
*** Significant at 5%.** **S = Susceptible**

dominance was 6.41 during the first year, while 7.79 in the second year studies. In both the years non-additive gene action plays an important role for the expression of the lesion length (Table 18).

Ten and six A-lines during first and second year respectively were found to contribute significantly to the GCA variance for disease resistance by exhibiting minimum lesion length. Among restorer lines, two and three restorer lines during first and second years contributed significantly to the GCA variance for disease resistance. During first year (Table 14), the parental lines that contributed significantly for disease resistance were SPLB 94011A (R, -0.46), SPLB 94010A (R, -0.35) and SPLB 94013A (S, -0.31) among A-lines, while in restorers were A 2267-2 (R, -0.44) and ICSR 97 (MR, -0.39). During 1997 (Table 16), SPLB 94007A (MR, -1.18), SPLB 94009A (LS, -0.88) and SPLB 94010A (MR, -0.80) among A-lines, and ICSR 119 (S, -0.19), ICSR 26 (MR, -0.14) and A 2267-2 (R, -0.10) among restorer lines were found to contribute significantly for disease resistance.

Thirty two crosses during first (Table 14) and second year (Table 16) recorded significant SCA variance for disease resistance. The crosses that contributed significantly to the length of the lesion were SPLB 94015A x ICSR 90030 (R x S, -1.85), SPLB 94025A x ICSR 97 (LS x MR, -1.12), SPLB 94003A x ICSR 90030 (MR x S, -1.03) and SPLB 94025A x ICSR 91025 (LS x LS, -1.01) in the first year, while SPLB 94017A x ICSR 26 (S x MR, -1.89), SPLB 94015A x A 2267-2 (MR x R, -1.63), and SPLB 94009A x ICSR 119 (LS x S, -1.40) in the second year.

During first year (Table 15), four A-lines (SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94011A) from R group, three A-lines (SPLB 94003A, SPLB

Table 18. Variance estimates for various disease resistant parameters and yield contributing characters, rabi season 1996 and 1997.

Year	Variance estimates	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomic score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
1996	σ^2 GCA	0.05	0.01	0.0001	0.001	0.41	92.80	1.72	0.36	17.47	0.01	0.84	0.02
	σ^2 SCA	0.36	0.41	0.002	0.07	21.08	5273.04	7.61	7.02	94.16	0.09	38.26	0.02
	2 σ^2 SCA/ σ^2 GCA	2.00	6.41	3.39	5.74	5.09	5.33	1.49	3.14	1.64	3.02	4.76	2.45
1997	σ^2 GCA	0.01	0.01	0.00	0.0004	0.04	318.30	NR	0.13	29.43	0.002	-0.06	0.001
	σ^2 SCA	0.43	0.73	0.04	0.19	9.50	23020.53	NR	11.07	760.15	0.25	100.84	0.12
	2 σ^2 SCA/ σ^2 GCA	4.61	7.79	0.00	15.53	10.51	6.01	NR	6.58	3.59	7.87	-0.001	7.87

1. **Scored on a (1-9) scale.**
2. **Scored on a (1-5) scale.**
3. **NR – Not recorded.**

94021A and SPLB 94022A) from MR group, one A-line (SPLB 94024A) from LS group; one restorer line (A 2267-2) from R group and one restorer line (ICSR 97) from MR group were found to exhibit moderate resistance$_{II}$ for length of the lesion. However during second year (Table 17), two A-lines (SPLB 94011A and SPLB 94010A) from MR group and one restorer line (A 2267-2) from R group exhibited high resistance$_{II}$, while one restorer line (ICSR 119) from S group showed moderate resistance$_{II}$ for length of the lesion.

4.4.3 Width of the Lesion

For both the years, SCA variance (0.0023 and 0.0043) was greater than GCA variance (0.0001 and 0.0001) indicating the predominance of non-additive gene action governing the trait. The degree of dominance was 3.39 during first year, and was zero during second year (Table 18).

Among A-lines, eight lines during first year (Table 14), and five lines during second year (Table 16) contributed significantly to the GCA variance for disease resistance. The A-lines that contributed significantly for the disease resistance through width of the lesion are SPLB 94011A (R), SPLB 94009A (R), SPLB 94013A (S), and SPLB 94024A (LS) during first year (-0.03), while SPLB 94007A (-0.07, MR) and SPLB 94010A (MR, -0.05) during second year.

Among restorer lines, two lines i.e., A 2267-2 (R, -0.04) and ICSR 97 (MR, -0.04) showed significant contribution to the GCA variance for disease resistance through width of the lesion during first year, while none in the second year.

Among crosses, 31 crosses during first year (Table 15) and 33 crosses during second year (Table 17) recorded significant SCA variance for disease resistance. During first year the cross combinations involving the parents SPLB 94015A x ICSR 90030 (R x S, -0.11) and SPLB 04025A x ICSR 91025 (LS x LS, -0.10), while in the second year, SPLB 94009A x ICSR 97 (LS x MR, -0.13), SPLB 94003A x A 2267-2 (LS x R, -0.12), and SPLB 94015A x A 2267-2 (MR x R, -0.12) crosses were found to contribute high significant SCA variance.

During first year, SPLB 94011A (R) and SPLB 94024A (LS) were found to possess resistance for width of the lesion, while SPLB 94009A (R) was found to possess moderate resistance. During second year, SPLB 94010A (MR) and SPLB 94009A (LS) exhibited moderate disease resistance.

4.4.4 Area of the Lesion

SCA variance (0.066, 0.193) was greater than GCA variance (0.001, 0.0004) for both the years indicating the predominance of non-additive gene action. The degree of dominance was 5.74 during the first year and 15.53 in the second year indicating the predominance of non-additive gene action (Table 18).

Eleven A-lines during first year (Table 14) and six A-lines significantly recorded the GCA variance for disease resistance during second year (Table 16). The A-lines that contributed significant maximum value for the resistance are SPLB 94013A (S, -0.14), SPLB 94011A (R, -0.14) and SPLB 94024A (LS, -0.13) during the first year, and SPLB 94007A (MR, -0.47), SPLB 94010A (MR, -0.37) and SPLB 94009A (LS, -0.30) during the second year. Among restorer lines, two lines each during first year (A 2267-2 (R, -0.17) and ICSR 97 (MR, -0.15)) and second year (A 2267-2 (R, -0.07) and ICSR 119 (S, -0.06)) contributed significantly to the GCA variance for disease resistance.

Among 120 crosses studied, 29 crosses during first year (Table 15) and 30 crosses in the second year (Table 17) exhibited significant SCA variance for area of the lesion. The promising crosses among them were, SPLB 94015A x ICSR 90030 (R x S, -0.65), SPLB 94025A x ICSR 91025 (LS x LS, -0.52), SPLB 94004A x ICSR 97 (R x MR, -0.40) and SPLB 94025A x ICSR 97 (LS x MR, -0.40) during first year, while SPLB 94017A x ICSR 26 (S x MR, -0.75), SPLB 94003A x A 2267-2 (LS x R, -0.72) and SPLB 94003A x ICSR 26 (LS x MR, -0.69) in the second year.

In the first year, two A-lines (SPLB 94009A and SPLB 94011A) from R group, one A-line (SPLB 94003A) from MR group and one A-line (SPLB 94024A) from LS group exhibited resistance$_{al}$ for the area of the lesion, while one A-line (SPLB 94007A) from R group, two A-lines (SPLB 94003A and SPLB 94021A) from MR group, one R-line each from R (A 2267-2) and MR (ICSR 97) groups exhibited moderate resistance$_{al}$. On the other hand during the second year, two A-lines (SPLB 94010A and SPLB 94011A) from MR group and one restorer line from R group exhibited resistance for area of the lesion.

4.4.5 Number of Lesions

Non-additive gene action was found predominant for this character as SCA variance (21.077 and 9.501) was greater than GCA variance (0.406 and 0.043) for both the years. The degree of dominance was estimated to be 5.09 and 10.51 during first and second years, respectively (Table 18).

Among A-lines, nine lines during first year (Table 14) and eleven lines during second year (Table 16) contributed significantly to the GCA variance for number of lesions. During first year, the A-lines that contributed significantly to the disease resistance are SPLB 94015A (R, -5.59), 94007A (R, -4.46) and SPLB 94004A (R, -4.31), while in second year SPLB 94025A (MR, -2.17), SPLB 94012A (S, -1.72) and SPLB 94024A (LS < -1.65). Only four restorer lines during first year and three restorer lines during second year contributed significantly to the GCA variance for disease resistance in the desirable (negative) direction. ICSR 90030 (S) contributed maximum significant GCA effect for disease resistance during first (-2.22) and second (1.18) year. In addition, ICSR 97 (MR, -0.85) and ICSR 26 (S, -0.50) during first year and ICSR 91025 (HS, -0.98) and ICSR 97 (MR, -0.59) during second year also exhibited similar results.

Among crosses, 47 crosses during first year (Table 15), while 49 crosses during second year (Table 17) contributed significantly to the SCA variance. Cross combinations involving the parents, SPLB 94016A x A 2267-2 (MR x R, -8.37) during first year, and SPLB 94009A x ICSR 119 (LS x S, -6.85) during second year recorded minimum GCA effect followed by SPLB 94009A x A 2267-2 (R x R, -8.05) and SPLB 94012A x ICSR 97 (LS x MR, -6.96) during first year, while SPLB 94011A x ICSR 97 (MR x MR, -5.95) and SPLB 94016A x ICSR 26 (MR x MR, -5.66) during second year.

Studies during first year indicated that three A-lines (SPLB 94004A, SPLB 94007A and SPLB 94015A) from R group exhibited high resistance$_{al}$, while one A-line each from LS (SPLB 94014A) and S group (SPLB 94013A) and one R-line each from LS (ICSR 91025) and S group (ICSR 90030) were found to show resistance$_{al}$. The A-line SPLB 94009A from R group, two A-lines (SPLB 94006A and SPLB 94019A) from MR group, one A-line (SPLB 94012A) from LS group and one restorer line (ICSR 97) from MR group exhibited moderate resistance$_{al}$. During second year, one A-line (SPLB 94004A) from MR group, three A-lines (SPLB 94009A, SPLB 94024A and SPLB 94014A) from LS group exhibited high resistance$_{al}$, while one A-line (SPLB 94012A) from S group exhibited resistance$_{al}$.

4.4.6 Number of Flecks

SCA variance (5273.039, 23020.530) was more than GCA variance (92.800, 318.304) in two year studies. The degree of dominance was 5.33 and 6.01 for the first and second year respectively indicating overdominance for number of flecks (Table 18).

Significant contributions to the GCA variance for disease resistance were recorded by nine A-lines during first year and eight A-lines during second year. The promising A-lines that contributed to the resistance significantly are SPLB 95015A (R, -83.12), SPLB 94006A (MR, -70.43) and SPLB 94004A (R, -61.08) during first year (Table 14) and 296A (S, -150.70), SPLB 94024A (LS, -127.30) and SPLB 94022A (LS, -121.59) during second year (Table 16). Three restorer lines during first year and two restorer lines during second year contributed significantly to the GCA variance for disease resistance. The R-lines that contributed high significant value to the disease resistance are ICSR 97 (MR, -19.82), ICSR 90030 (S, -15.84) and ICSR 26 (S, -11.03) during first year, while ICSR 90030 (S, -92.26) and ICSR 97 (MR, -25.37) during second year.

Among the total crosses studied, 42 crosses exhibited significant contribution to the SCA variance for disease resistance during first year and 48 crosses during second year. SPLB 94010A x ICSR 91025 (R x LS, -159.77), SPLB 94016A x A 2267-2 (MR x R, -131.26) and SPLB 94009A x A 2267-2 during first year (Table 15), and SPLB 94016A x ICSR 26 (MR x MR, -320.99), SPLB 94011A x ICSR 97 (MR x MR, -275.78) and SPLB 94009A x ICSR 119 (LS x S, -232.95) during the second year (Table 17) were found desirable.

First year studies showed that four A-lines (SPLB 94004A, SPLB 94007A, SPLB 94009A and SPLB 94015A) from resistant group, two from MR group (SPLB 94006A and SPLB 94021A), LS group (SPLB 94012A and SPLB 94017A), S group (SPLB 94013A), one R-line from MR group (ICSR 97); and two restorer lines from S group (ICSR 90030 and ICSR 26) exhibited high resistance$_{nf}$. In the next year, one A-line (SPLB 94021A) from LS group, and one restorer line (ICSR 90030) from S group showed high resistance$_{nf}$, while one A-line (SPLB 94025A) from MR group, one A-line (SPLB 94022A) from LS group and two A-lines (SPLB 94012A and 296A) from S group exhibited resistance$_{nf}$.

4.4.7 Lodging

SCA variance (7.609) was greater than GCA variance (1.723) indicating the preponderance of non-additive gene action (Table 18). The degree of dominance was more than unity (1.49).

Three A-lines, two restorer lines, and one cross combination showed significant contribution to the GCA variance for lodging resistance. The parental lines that contributed to the maximum lodging resistant plants were SPLB 94021A (MR, -8.24), SPLB 94014A (LS, -7.68) and SPLB 94003A (MR, -6.97) among A-lines; and ICSR 97 (MR, -7.80) and ICSR 90030 (S, -4.87) among restorer lines (Table 14). Among crosses, the cross SPLB 94001A x ICSR 26 (S x S, -18.04) exhibited maximum significant contribution to the disease resistance (Table 15).

One A-line (SPLB 94003A) from MR group, one A-line (SPLB 94014A) from LS group and one restorer line (ICSR 97) from MR group exhibited significant negative GCA effects with moderate resistance.

4.4.8 Across the Disease Parameters

During the first year, the A-lines, SPLB 94007A, SPLB 94009A, SPLB 94006A and SPLB 94013A contributed significantly to the negative GCA effect for area of the lesion, number of lesions and number of flecks coupled with low mean values indicating their use in future breeding programmes. The lines SPLB 94003A, SPLB 94011A, SPLB 94016A and SPLB 94024A contributed significantly to the negative GCA effect for area of the lesion and positive effect for lesion number and fleck number. This indicates that in these genotypes the fungus infects the leaves at several sites but the spread of the pathogen was inhibited. On the other hand, SPLB 94004A and SPLB 94015A with significant positive contributions to the GCA effect for area of the lesion and negative GCA effect for number of lesions and flecks showed that though the number of infection sites are minimum the spread of the pathogen was rapid. However, SPLB 94025A recorded significant positive GCA effect for all the above three characters (Table 14).

Among the restorer lines, ICSR 97 contributed negatively to the GCA effect for all the above three characters and low mean performance for area of the lesion and number of flecks. However, it has recorded high mean value for number of lesions. While ICSR 90030 and ICSR 26 recorded negative GCA effect for number of lesions and number of flecks and positive effect for area of the lesion. While ICSR 119 recorded positive effects for area of the lesion, number of lesions and number of flecks.

Among the crosses, SPLB 94004A x A 2267-2, SPLB 94010A x ICSR 26, SPLB 94019A x ICSR 97, SPLB 94001A x ICSR 26 and SPLB 94022A x ICSR 119 with significant negative SCA effect for area of the lesion, number of lesions and number of flecks also recorded low mean values for the above three characters (Table 15). SPLB 94010A x A 2267-2, SPLB 94010A x ICSR 97, SPLB 94011A x ICSR 91025, SPLB 94025A x ICSR 97, SPLB 94025A x ICSR 91025 and SPLB 94013A x ICSR 26 recorded significant negative SCA effect for area of the lesion and positive SCA effect for number of lesions and number of flecks. While, SPLB 94015A x A 2267-2, SPLB 94010A x ICSR 90030, SPLB 94011A x ICSR 26, SPLB 94012A x ICSR 97, SPLB 94017A x ICSR 91025, SPLB 94006A x A 2267-2, SPLB 94025A x ICSR 119, SPLB 94025 x ICSR 26, 296A x ICSR 97, SPLB 94013A x ICSR 91025 and SPLB 94016A x A 2267-2 recorded significant positive SCA effect for area of the lesion and negative SCA effect for number of lesions and number of flecks and hence may not be useful in future. On the other hand, SPLB 94004A x ICSR 91025 and SPLB 94001A x ICSR 90030, recorded significant positive SCA effect for all the above three characters and hence may not be useful in future breeding programmes as the number of infection sites are more and the spread of the pathogen at each infection site was very rapid.

During the second year (Tables 16), among the A-lines, SPLB 94009A recorded negative GCA effect for area of the lesion and lesion number coupled with low mean values. The lines SPLB 94007A, SPLB 94011A and SPLB 94016A recorded negative GCA effect for area of the lesion and positive effect for lesion number and fleck number. This indicates that in these genotypes the fungus infects the leaves at several sites but the spread of the pathogen was inhibited. On the other hand, SPLB 94022A, SPLB 94025A and SPLB 94012A with positive GCA effect for area of the lesion and negative GCA effect for number of lesions and flecks shows that though the number of infection sites are minimum the spread of the pathogen was rapid.

Among the restorer lines, A 2267-2 and ICSR 119 exhibited negative GCA effect for area of the lesion and positive GCA effect for number of lesions and number of flecks. While ICSR 97 recorded positive GCA effect for area of the lesion and negative GCA effect for number of lesions and number of flecks. While none of the R-lines recorded negative effects for area of the lesion, number of lesions and number of flecks.

Among the crosses, SPLB 94004A x ICSR 91025, SPLB 94006A x ICSR 26, SPLB 94021A x ICSR 90030, SPLB 94014A x ICSR 91025 and SPLB 94012A x

ICSR 119 with negative SCA effect for area of the lesion, number of lesions and number of flecks also recorded minimum mean values for the above three characters indicating their further use in the breeding programmes. While, SPLB 94017A x A 2267-2 and SPLB 94017A x ICSR 26 with negative SCA effect recorded less mean value for area of the lesion and number of flecks and high mean value for number of lesions. SPLB 94013A x ICSR 97 with negative SCA effects for the above three characters recorded high mean value for area of the lesion and low mean value for number of lesions and number of flecks. SPLB 94015A x A 2267-2, SPLB 94007A x ICSR 97, SPLB 94004A x ICSR 119, SPLB 94011A x ICSR 90030, SPLB 94016A x ICSR 90030, SPLB 94011A x ICSR 91025, SPLB 94003A x A 2267-2, SPLB 94014A x ICSR 26, SPLB 94009A x ICSR 97, SPLB 94019A x ICSR 119, SPLB 94022A x ICSR 90030 and SPLB 94021A x ICSR 91025 recorded negative SCA effect for area of the lesion and positive SCA effect for number of lesions and number of flecks. While, SPLB 94007A x A 2267-2, SPLB 94011A x A 2267-2, SPLB 94004A x ICSR 26, SPLB 94016A x ICSR 26, SPLB 94015A x ICSR 97, SPLB 94016A x ICSR 97, SPLB 94015A x ICSR 90030, SPLB 94021A x A 2267-2, SPLB 94014A x ICSR 119, SPLB 94021A x ICSR 119, SPLB 94003A x ICSR 91025, SPLB 94019A x ICSR 91025 recorded positive SCA effect for area of the lesion and negative SCA effect for number of lesions and number of flecks. On the other hand, SPLB 94013A x ICSR 26, SPLB 94013A x ICSR 119, SPLB 94009A x A 2267-2, SPLB 94014A x A 2267-2, SPLB 94017A x ICSR 97 recorded positive SCA effect for all the above three characters and may not be useful in future breeding programmes.

4.4.9 Days to 50% Flowering

Non additive gene action was found to be of higher magnitude for days to 50% flowering in both the years and the degree of dominance was estimated to be 3.14 and 6.58 for the first and second year respectively (Table 18).

Out of 20 A-lines, six A-lines were found to contribute significantly to the GCA variance for earliness in both the years. The lines SPLB 94022A (MR, -6.40), SPLB 94016A (MR, -4.18) and SPLB 94025A (LS, -3.51) during first year (Table 14), while 296A (S, -5.93), SPLB 94022A (LS, -2.71) and SPLB 94001A (MR, -2.43) in the second year (Table 16) contributed maximum significant contributions for earliness. Only two restorer lines in both the years exhibited significant GCA variance for earliness. The restorer lines that contributed significantly to the earliness were ICSR 26 (S, -2.30) and ICSR 119 (LS, -1.45) during first year, while ICSR 90030 (S, -1.31) and ICSR 97 (MR, -041) during second year.

Among the crosses studied, 19 and 35 crosses during first and second year, showed significant variance for earliness. The notable among them which were early to flower were SPLB 94004A x A 2267-2 (R x R, -7.01), SPLB 94001A x A 2267-2 (S x R, -5.40) and SPLB 94019A x ICSR 90030 (MR x S, -4.84) during first year (Table 15), while SPLB 94007A x A 2267-2 (MR x R, -8.43), SPLB 94006A x ICSR 26 (LS x MR, -8.30) and SPLB 94019A x A 2267-2 (LS x R, -8.26) in the second year (Table 17).

During first year, one A-line (SPLB 94016A) from MR group and one A-line from S group (296A) showed significant negative GCA effect for earliness. During second year, none of the A-lines exhibited significant negative GCA effect for earliness, while one restorer line from S group showed significant negative GCA effect for medium flowering.

4.4.10 Plant Height

SCA variance (94.16, 760.15) was more than GCA variance (17.47, 29.43) for both the years. Over dominance was noticed for first (1.64) and second years (3.59), respectively (Table 18).

Significant contributions to the GCA variance for tallness were recorded by six A-lines during the first year (Table 14) and nine A-lines during second year (Table 16). SPLB 94012A (LS, 20.82), SPLB 94013A (S, 19.93) and SPLB 94014A (LS, 16.54) during first year and SPLB 94021A (LS, 52.07), SPLB 94007A (MR, 35.13) and SPLB 94019A (LS, 34.30) during second year are the A-lines that contributed towards tallness. Two restorer lines, A 2267-2 (R, 30.71) and ICSR 90030 (S, 3.36), during first year and only one tester, ICSR 119 (LS, 10.19), during second year exhibited significant contributions to the GCA variance for tallness.

Twenty two crosses during first year and 51 crosses during second year recorded significant SCA variance in the positive direction. The promising cross combinations for tallness in the first year (Table 15) are SPLB 94009A x ICSR 91025 (R x LS, 41.92), SPLB 94015A x ICSR 119 (R x LS, 19.48), SPLB 94016A x ICSR 119 (MR x LS, 19.21). While in the second year, the crosses were SPLB 94022A x ICSR 26 (MR x MR, 46.07) and SPLB 94009A x ICSR 97 (LS x MR, 43.70) were found to be promising (Table 17).

Studies indicated that during first year, three A-lines (SPLB 94012A, SPLB 94017A, and SPLB 94025A) from LS group, one A-line (SPLB 94013A) from S group, one restorer line (A 2267-2) from R group recorded significant negative GCA effect for medium height of the plant. During second year, one A-line from S group (SPLB 94017A) showed significant negative GCA effect for tallness, while SPLB 94022A from LS group, SPLB 94012A from S group were reported to be of medium height with significant GCA effect.

4.4.11 Agronomic Score

For the agronomic score, first and second years exhibited preponderance of non-additive gene action over the additive one. The degree of dominance was 3.02 and 7.87 for the first and second years, respectively (Table 18).

Four A-lines viz., SPLB 94019A (MR, -0.75), SPLB 94009A (R, -0.31), SPLB 94001A (S, -0.31) and SPLB 94022A (MR, -0.25) during 1996 (Table 14) and five A-lines, SPLB 94010A (MR, -0.46), SPLB 94019A (LS, -0.46), SPLB 94021A (LS, -0.29), SPLB 94024A (LS, -0.29) and 296A (S, -0.29), during 1997 (Table 16) recorded significant contributions to the GCA variance indicating the most favourable agronomically desirable genotypes. Three restorer lines, ICSR 26 (S, -0.27), A 2267-2 (R, -0.18) and ICSR 90030 (S, -0.18), contributed significantly to the GCA variance for agronomic desirability during first year. While in second year, only one tester (ICSR 90030, S) with maximum GCA of –0.21 seems to be the most desirable genotype across the seasons.

Five crosses during first year (Table 15), while 13 crosses during second year (Table 17) contributed significantly to the SCA variance for higher yields. The hybrids, SPLB 94007A x A 2267-2 (R x R, -0.98), SPLB 94025A x ICSR 90030 (LS x S, -0.91) and SPLB 94015A x ICSR 97 (R x MR, -0.77) during first year, while SPLB 94016A x ICSR 119 (MR x S, -1.56), SPLB 94013A x ICSR 26 (MR x MR, -0.99) and SPLB 94011A x ICSR 90030 (MR x S, -0.90) in the second year were found to be agronomically desirable with maximum significant contributions to the SCA effect.

During first year only one A-line (SPLB 94001A) from S group was found superior with significant negative GCA effect for agronomic desirability. While in the second year, none of the parental lines recorded significant negative GCA effect for agronomic desirability.

4.4.12 Grain Yield Plant^{-1}

Preponderance of non additive gene action was noticed in first and second year studies for the character grain yield plant^{-1}. The degree of dominance was 4.76 for first year and non-estimable in second year (Table 18) as the GCA variance was found to be negative (-0.059).

Significant contribution to the GCA variance for higher yield was recorded by 7 A-lines during first (Table 14) and second years (Table 16), respectively. The desirable A-lines for first year were SPLB 94019A (MR, 6.96), SPLB 94009A (R, 6.89) and SPLB 94001A (S, -5.30), while SPLB 94010A (MR, 8.68), SPLB 94021A (LS, 5.15) and SPLB 94019A (LS, 4.61) in the second year. Two restorer lines i.e., A 2267-2 (R, 3.95) and ICSR 26 (S, 3.88) during first year and two lines i.e., ICSR 119

(S, 2.10) and ICSR 90030 (S, 1.43) during second year were found desirable for higher yields.

Significant contributions to the SCA variance for higher yields were recorded by 17 crosses during first year and 42 crosses during second year. The cross combinations with maximum SCA for higher yield were SPLB 94009A x A 2267-2 (R x R, 17.36), SPLB 94001A x ICSR 119 (S x LS, 13.33) and SPLB 94016A x A 2267-2 (MR x R, 13.14) during first year (Table 15), while SPLB 94004A x ICSR 119 (MR x S, 23.38), SPLB 94021A x ICSR 91025 (LS x HS, 21.54) and SPLB 94006A x ICSR 26 (LS x MR, 20.08) in the second year (Table 17).

During first year, one A-line (SPLB 94009A) from R group, one (SPLB 94019A) from MR group, one (SPLB 94001A) from S group and one restorer line (A 2267-2) from R group exhibited significant positive GCA effect for average grain yields. During second year, one restorer line (ICSR 119) from S group exhibited significant positive GCA effect for high grain yield, while one restorer line (ICSR 90030) from S group exhibited significant positive GCA effect for average grain yield.

4.2.13 100 Seed Weight

In both the years, studies showed the maximum role of non-additive gene action, as the SCA variance (0.024, 0.124) was greater than GCA variance (0.002, 0.001). The degree of dominance was 2.45 and 7.87 for the first and second years, respectively (Table 18).

Significant contributions to the GCA variance for 100-seed weight were recorded by 8 and 9 A-lines during first and second year, respectively. Maximum GCA values was noticed in SPLB 94012A for the first (0.45) and second years (0.43), respectively. However, SPLB 94013A (S, 0.33), SPLB 94015A (R, 0.21) and SPLB 94016A (MR, 0.18) during first year, and SPLB 94011A (MR, 0.25) during second year possessed high GCA value. Only one tester i.e., ICSR 119 (LS, 0.10) in the first year (Table 14) and ICSR 90030 (S, 0.09) in the second year (Table 16) showed maximum contribution for 100 seed weight.

Among the 120 crosses evaluated, 13 crosses during first year and 30 crosses during second year exhibited significant positive contribution to the SCA variance for 100 seed weight. SPLB 94015A x ICSR 119 (R x LS, 0.42), SPLB 94001A x A 2267-2 (S x R, 0.34) and SPLB 94003A x A 2267-2 (MR x R, 0.28) during first year (Table 15), while SPLB 94004A x ICSR 26 (MR x MR, 0.86), SPLB 94006A x ICSR 26 (LS x MR, 0.66) and SPLB 94006A x ICSR 97 (LS x MR, 0.64) in the second year (Table 17) were found to be desirable for the increase in 100 seed weight.

During first year, one A-line each from LS group (SPLB 94014A) and from S group (SPLB 94013A) exhibited significant positive GCA effect for high grain yield, while one A-line (SPLB 94010A) from R group, one A-line (SPLB 94022A) from MR group, one A-line (SPLB 94012A) from LS group and one restorer line (ICSR 119) from LS group exhibited significant positive GCA effect for average grain yield. During second year, one A- line (SPLB 94013A) from MR group, one A-line (SPLB 94014A) from LS group and one A-line (SPLB 94012A) from S group exhibited significant positive GCA effect for high grain yield.

4.4.14 Across the Grain Components

During first year (Table 14), among the A-lines, SPLB 94015A, SPLB 94010A and SPLB 94007A recorded positive GCA effect for 100 seed weight. SPLB 94019A recorded negative GCA effect for days to 50% flowering and agronomic score and positive GCA effect for grain yield plant^{-1}. SPLB 94016A recorded negative GCA effect for days to 50% flowering and positive GCA effect for grain yield plant ^{1}; SPLB 94022A for days to 50% flowering and agronomic score negative GCA effect; and for grain yield plant $^{-1}$ and 100 seed weight positive GCA effect. Genotype, SPLB 94009A recorded for agronomic score negative GCA effects; and for grain yield plant $^{-1}$ and 100 seed weight positive GCA effect. In addition, the other superior hybrids were SPLB 94014A and SPLB 94013A for plant height and 100 seed weight, SPLB 94001A for plant height, agronomic desirability and grain yield plant^{-1}, SPLB 94012A for plant height, grain yield plant^{-1} and 100 seed weight, SPLB 94007A for plant height; and SPLB 94025A for days to 50% flowering and plant height. Among the restorer lines, ICSR 26 with negative GCA effect for days to 50% flowering, agronomic score and positive GCA effect for grain yield plant ^{1}. In ICSR 119 GCA effects were desirable for days to 50% flowering (negative effects) and 100 seed weight (positive effects). In ICSR 90030, the GCA effects were desirable for plant height and agronomic desirability, A 2267-2 for plant height; agronomic desirability and grain yield plant^{-1} (positive).

Among the crosses, SPLB 94011A x ICSR 119 and SPLB 94017A x ICSR 90030 recorded negative SCA effects for days to 50% flowering; and positive SCA effect for grain yield plant ^{1}. SPLB 94015A x ICSR 97 recorded negative SCA effect for agronomic desirability and positive SCA effect for plant height and grain yield

$plant^{-1}$. SPLB 94012A x A 2267-2 and SPLB 94004A x ICSR 97 showed negative SCA effect for days to 50% flowering and positive SCA effect for 100 seed weight; SPLB 94022A x A 2267-2 recorded positive SCA effect for plant height, grain yield $plant^{-1}$ and 100 seed weight; SPLB 94009A x ICSR 91025, for days to 50% flowering (negative effects), plant height and 100 seed weight (positive effects); SPLB 94001A x ICSR 119 for days to 50% flowering (negative), grain yield $plant^{-1}$ and 100 seed weight (positive); SPLB 94007A x A 2267-2 for days to 50% flowering, agronomic score (negative), plant height and grain yield $plant^{-1}$ (positive). In addition, SPLB 94011A x ICSR 97 and 94012A x ICSR 26 for plant height and grain yield $plant^{-1}$; SPLB 94014A x ICSR 26 for days to 50% flowering, agronomic desirability and 100 seed weight; SPLB 94001A x ICSR 91025 for plant height and agronomic desirability; SPLB 94024A x ICSR 26 for grain yield $plant^{-1}$ and 100 seed weight; SPLB 94001A x A 2267-2 for days to 50% flowering, plant height and 100 seed weight; SPLB 94001A x ICSR 90030 for days to 50% flowering and plant height; and SPLB 94015A x ICSR 119 and SPLB 94003A x A 2267-2 for plant height and 100 seed weight were found superior (Table 15).

During second year (Table 16), among the A-lines, SPLB 94024A recorded negative GCA effects for plant height and positive GCA effect for 100 seed weight. SPLB 94010A recorded desirable GCA effect for agronomic desirability and positive GCA effect for plant height, grain yield $plant^{-1}$ and 100 seed weight. Besides, SPLB 94014A for days to 50% flowering, grain yield $plant^{-1}$ and 100 seed weight; SPLB 94019A and SPLB 94021A for agronomic desirability, grain yield $plant^{-1}$ and test weight; SPLB 94004A and SPLB 94022A for days to 50% flowering, plant height and grain yield $plant^{-1}$; SPLB 94001A recorded negative GCA effect for days to 50%

flowering and positive GCA effect for grain yield plant^{-1}. Among the restorer lines, ICSR 90030 with negative GCA effect for days to 50% flowering and agronomic score and positive GCA effect for grain yield plant^{-1} and 100 seed weight was found desirable. While ICSR 119 recorded positive GCA effect for plant height and grain yield plant^{-1}.

Among the crosses, SPLB 94004A x A 2267-2, SPLB 94010A x A 2267-2, SPLB 94013A x ICSR 91025 recorded negative SCA effects for days to 50% flowering and positive SCA effect plant height for grain yield plant^{-1}. SPLB 94016A x A 2267-2 and SPLB 94006A x ICSR 26 recorded negative SCA effect for days to 50% flowering and positive GCA effect for plant height, grain yield plant^{-1} and 100 seed weight. SPLB 94024A x ICSR 90030 showed positive SCA effect for plant height, grain yield plant^{-1} and 100 seed weight; SPLB 94007A x ICSR 97 for agronomic desirability and positive SCA effect for plant height, 100 seed weight and grain yield plant^{-1}; SPLB 94022A x ICSR 26 for agronomic score (negative effects) and plant height, grain yield plant^{-1} and 100 seed weight (positive effects). In addition, SPLB 94004A x ICSR 90030 for days to 50% flowering, plant height and grain yield plant^{-1}; and SPLB 94014A x ICSR 26 for days to 50% flowering, plant height, agronomic desirability, grain yield plant^{-1} and 100 seed weight were found superior (Table 17).

4.5 Heterosis

The mean range of heterosis over the better parent (BP) and mid parent (MP) showed by 120 cross combinations for leaf blight disease incidence under various score parameters and yield attributing characters studied for two consecutive years are presented in Tables 19 to 22, respectively.

4.5.1 Disease Damage Score

The heterosis ranged from –55.50 to 40.24 (first year) and –49.32 to 27.66 (second year) over better parental value, and from –44.50 to 47.85 (first year) and –41.27 to 51.43 (second year) over mid parental value, (Tables 19 and 20, respectively).

In the case of disease damage score, negative heterosis was considered as desirable direction i.e., resistance. Significant heterosis for disease damage score was recorded by 26 (over MP) and 72 hybrids (over BP) during first year, while 32 (over MP) and 61 hybrids (over BP) during second year. Among these hybrids, maximum heterosis over the mid parent was showed by SPLB 94013A x ICSR 97 (S x MR, -44.50), SPLB 94009A x ICSR 91025 (R x LS, -42.77), SPLB 94001A x ICSR 97 (S x MR, -41.27) and SPLB 94009A x ICSR 97 (R x MR, -41.75) during first year (Table 18), while SPLB 94009A x ICSR 91025 (LS x HS, -41.25), SPLB 94009A x ICSR 90030 (LS x S, -39.84) and SPLB 94017A x ICSR 91025 (S x HS, -35.34) in the second year (Table 19). On the other hand, SPLB 94009A x ICSR 91025 (R x LS, -55.50), SPLB 94013A x ICSR 97 (S x MR, -54.57) and SPLB 94009A x ICSR 97 (R x MR, -50.11) during first year and SPLB 94009A x ICSR 91025 (LS x HS, -49.32), SPLB 94009A x ICSR 90030 (LS x S, -47.14), SPLB 94007A x ICSR 90030 (MR x S, -42.86) in the second year, recorded maximum heterosis over better parent. Two consequent year testing results indicate that the cross, SPLB 94009A x ICSR 91025 was found to be superior at both the levels of testing.

Table 19. Heterosis over better parent (BP) and mid parent (MP) for different genotypes of sorghum for various disease resistant parameters, rabi season 1996.

Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
R x R[2]												
SPLB 94004A X A-2267-2	20.12	26.38	-66.45**	-49.76**	-53.49**	-39.39**	-85.00**	-74.47**	-62.34**	-40.5	-49.21	-36.32
SPLB 94007A X A-2267-2	0.00	5.21	-56.13**	-52.61**	-40.00**	-37.50**	-71.43*	-71.01*	17.78	42.35	169.66**	217.22**
SPLB 94009A X A-2267-2	20.12	26.38	-23.23	-2.06	-26.09*	-17.07	-42.86	-21.57	-53.68**	-45.60**	-56.38	-52.41
SPLB 94010A X A-2267-2	11.00	11.00	-72.90**	-68.54**	-43.48**	-29.73*	-82.86**	-73.91	246.63**	318.26**	747.28**	759.01**
SPLB 94011A X A-2267-2	0.00	0.00	-77.42**	-70.34**	-52.17**	-42.11**	-88.57**	-82.98	90.22**	150.36**	32.99	69.10
SPLB 94015A X A-2267-2	40.24*	47.55**	3.95	23.76	3.13	20.00*	8.11	46.79*	-14.64	21.61	-1.84	32.93
R x MR[2]												
SPLB 94004A X ICSR 97	-28.69**	-16.75	-72.94**	-60.38**	-48.84**	-27.87**	-86.00**	-75.65**	-58.38**	-27.55	46.55	101.33**
SPLB 94007A X ICSR 97	-42.83**	-33.25*	-56.21**	-50.83**	-40.00**	-30.23*	-67.65*	-65.63*	-57.68**	-38.08*	38.44	80.23*
SPLB 94009A X ICSR 97	-50.11**	-41.75**	-37.87*	-18.29	0.00	0.00	-36.67	-17.39	-13.25	-3.46	80.15**	87.77**
SPLB 94010A X ICSR 97	-35.76**	-21.77	-59.76**	-51.60**	-16.67	-6.25	-66.67*	-51.22	122.74**	140.51**	495.36**	582.40**
SPLB 94011A X ICSR 97	-50.11**	-36.51*	3.52*	-8.8	-5.56	3.03	-36.67	-9.52	-34.02**	-31.53**	-4.83	8.88
SPLB 94015A X ICSR 97	21.41	41.75**	-16.67	-4.28	-25.00**	-4.00	-39.19**	-13.46	-54.28**	-25.43	37.36	101.25*
R x LS[2]												
SPLB 94004A X ICSR 91025	0.00	28.62*	-20.56**	1.80	18.60**	45.71**	-6.50	38.52**	-9.79	49.46	258.27**	365.18**
SPLB 94007A X ICSR 91025	-44.50**	-28.62*	-35.14**	-14.07	-18.52	-15.38	-47.14**	-28.85	-68.52**	-58.32**	9.54	33.93
SPLB 94009A X ICSR 91025	-55.50**	-42.77**	-44.02**	-16.43	-33.33**	-20.00	-62.86**	-39.53	-29.85*	-26.22	163.80**	175.07**
SPLB 94010A X ICSR 91025	-16.67	11.11	-39.00**	-14.82	22.22*	60.98**	-27.14	25.93	-47.73**	-43.28**	87.10*	98.72**
SPLB 94011A X ICSR 91025	-22.17*	7.73	-72.59**	-58.24**	-44.44**	-28.57*	-82.86**	-70.73**	54.35**	85.26**	142.07**	196.83**
SPLB 94015A X ICSR 91025	-16.67	7.18	-26.64**	-21.97*	-9.38	-1.69	-25.68	-23.61	-60.85**	-40.45	-11.69	23.26
SPLB 94004A X ICSR 119	-21.01*	3.52	-43.29**	-12.67	-25.58**	3.23	-57.50**	-24.78**	-48.14**	-12.24	-2.65	19.63
SPLB 94007A X ICSR 119	-31.60**	-10.35	16.67	19.26	-4.00	9.09	11.76	26.67	-61.46**	-46.79*	-15.22	-2.47

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94009A X ICSR 119	-26.22**	-3.31	36.96	67.26**	26.32	29.73*	73.08	114.29*	29.94*	31.64*	334.07**	384.92**
SPLB 94010A X ICSR 119	5.37	42.98**	-14.49	-5.60	5.26	21.21	-11.54	24.32	83.36**	87.09**	838.81**	850.75**
SPLB 94011A X ICSR 119	-31.60**	-3.78	31.16	65.30**	15.79	29.41	57.69	115.79*	64.78**	87.39**	333.46**	461.75**
SPLB 94015A X ICSR 119	0.00	31.06*	57.89**	96.72**	-6.25	17.65	45.95**	116.00**	-67.48**	-49.05*	49.58	99.06
R x S[2]												
SPLB 94004A X ICSR 26	-36.29**	-12.38	-50.22**	-27.67**	-48.84**	-34.33**	-74.50**	-57.85**	-22.40*	35.88	-55.40**	-26.13
SPLB 94007A X ICSR 26	-31.79**	-6.19	5.17	19.61	0.00	2.04	7.14	18.42	-54.42**	-32.50*	-7.80	48.19*
SPLB 94009A X ICSR 26	-27.29**	0.00	-32.18*	-9.92	-16.67	-4.76	-42.86	-17.24	8.96	23.71	19.14	67.96**
SPLB 94010A X ICSR 26	-22.65**	9.78	-22.99	-6.29	-8.33	15.79	-30.95	9.43	-28.67**	-21.36	27.71*	90.70**
SPLB 94011A X ICSR 26	-40.93**	-13.4	30.46*	78.04**	29.17*	58.97**	66.67**	159.26**	-63.04**	-62.49**	-37.68**	-22.54
SPLB 94015A X ICSR 26	-27.29**	0.00	-9.21	2.99	6.25	21.43**	-4.05	22.41	-66.63**	-45.12**	2.37	75.54**
SPLB 94004A X ICSR 90030	-20.88**	11.74	-19.48**	-11.64	-25.58**	-5.88	-40.00**	-19.46**	-35.16*	6.48	146.91**	223.78**
SPLB 94007A X ICSR 90030	-41.63**	-17.56	-41.58**	-13.28	0.00	0.00	-41.84**	-13.64	9.26	42.19*	125.89**	179.24**
SPLB 94009A X ICSR 90030	-29.13**	0.09	-41.58**	-5.13	-8.00	6.98	-47.96**	-10.53	90.15**	104.75**	154.80**	162.08**
SPLB 94010A X ICSR 90030	-37.50**	-9.09	-22.37**	19.92	68.00**	115.38**	27.55**	129.36**	-6.19	4.12	311.52**	342.90**
SPLB 94011A X ICSR 90030	-33.38**	-0.09	-65.79**	-43.6**	-8.00	15.00	-69.39**	-45.45*	-17.39	1.13	93.73**	134.93**
SPLB 94015A X ICSR 90030	-37.50**	-11.74	-86.84**	-83.55**	-34.38**	-26.32**	-88.78**	-87.21**	-67.92**	-51.80*	-70.86*	-58.98
MR x R[2]												
SPLB 94003A X A-2267-2	0.00	25.00	-18.71	29.90	0.00	24.32	-17.14	41.46	152.66**	261.55**	368.71**	504.07**
SPLB 94006A X A-2267-2	14.13	38.98*	-80.84**	-67.80**	-8.70	2.44	-2.86	9.68	-56.62**	-47.48**	-24.97	-17.58
SPLB 94016A X A-2267-2	0.00	18.14	-57.11**	-37.54**	-40.54**	-26.67**	-74.03**	-57.67**	-2.30	61.59	-8.68	-5.38
SPLB 94019A X A-2267-2	-6.60	16.75	-23.87**	1.51	-20.00*	-9.43	-39.13**	-11.81	-6.45	12.01	5.46	73.32**
SPLB 94021A X A-2267-2	21.41	47.85**	-50.97**	-47.22**	-30.43*	-21.95	-65.71*	-60	287.66**	300.65**	440.31**	565.12**
SPLB 94022A X A-2267-2	0.00	25.00	24.73	34.72*	24.00*	29.17*	-80.85**	-78.05**	1.46	21.55	193.14**	361.30**
MR x MR[2]												
SPLB 94003A X ICSR 97	-6.60	-3.41	44.38**	134.62**	44.44**	62.50**	113.33**	255.56**	-55.66**	-48.13**	24.91	45.20

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94006A X ICSR 97	-7.28	-7.28	-83.91**	-73.35**	5.56	5.56	-20.00	-15.79	-58.62**	-55.49**	26.41	30.78
SPLB 94016A X ICSR 97	-42.83**	-40.67**	-72.05*8	-60.27**	-54.05**	-38.18**	-87.66**	-79.35**	17.23	109.86**	214.68**	245.21**
SPLB 94019A X ICSR 97	-40.00**	-37.95**	-74.52**	-67.01**	-53.33**	-41.67**	-88.04**	-81.97**	-42.2**	-37.04**	-54.58**	-29.21*
SPLB 94021A X ICSR 97	-35.76**	-35.76**	-26.04	-17.22	0.00	0.00	-20.00	-12.73	11.72	46.62**	235.60**	354.00**
SPLB 94022A X ICSR 97	-34.00**	-31.75**	-48.90*8	-47.01**	-36.00**	-25.58*	-68.09**	-61.04**	-42.20**	-15.94	-4.64	57.94
MR x LS[2]												
SPLB 94003A X ICSR 91025	-22.17*	-15.09	-23.55*	32.89	-11.11	17.07	-31.43*	26.32	-54.49**	-39.72**	219.77**	297.76**
SPLB 94006A X ICSR 91025	-22.17*	-12.46	-79.24**	-68.50**	-11.11	6.67	-41.43**	-15.46	-29.06*	-22.73	42.15	49.33
SPLB 94016A X ICSR 91025	-22.17*	-9.58	-55.42**	-45.10**	-40.54**	-31.25**	-73.38**	-63.39**	38.66*	138.43**	274.54**	279.12**
SPLB 94019A X ICSR 91025	-11.17	-3.09	-44.52**	-39.54**	-26.67**	-22.81*	-56.52**	-50.62**	-8.42	-1.51	-31.74**	10.19
SPLB 94021A X ICSR 91025	0.00	12.46	-31.66**	-9.69	-18.52	-2.22	-44.29**	-17.89	-11.90	1.89	-33.33	-14.91
SPLB 94022A X ICSR 91025	-11.17	-3.09	-44.79**	-35.15**	-11.11	-7.69	-51.43**	-41.88*	37.03*	80.06**	245.42**	454.47**
SPLB 94003A X ICSR 119	10.58	23.57*	-36.23	-0.56	5.26	21.21	-30.77	12.5	9.15	38.11**	166.34**	249.69**
SPLB 94006A X ICSR 119	-26.22**	-15.09	-83.54**	-71.85**	15.79	18.92	7.41	9.43	-72.71**	-72.05**	-57.72	-52.44
SPLB 94016A X ICSR 119	-36.81**	-24.95*	-32.05*8	1.99	-32.43**	-10.71	-55.19**	-23.33*	172.21**	376.19**	262.67**	285.36**
SPLB 94019A X ICSR 119	-26.22**	-17.56	-15.48	16.96	-10.00	10.2	-22.83*	20.34	16.83	18.07	1.45	68.27**
SPLB 94021A X ICSR 119	-5.21	9.09	48.55**	51.29**	31.58	35.14*	103.85**	107.84**	86.25**	127.07**	269.86**	345.94**
SPLB 94022A X ICSR 119	-31.60**	-23.57*	-16.48	-5.00	-24.00*	-13.64	-40.43	-23.29	30.37*	78.78**	56.74	143.83*
MR x S[2]												
SPLB 94003A X ICSR 26	-22.65**	-8.03	-6.32	53.05*	-16.67	5.26	-21.43	37.5	-20.13**	-8.35	28.61*	57.59**
SPLB 94016A X ICSR 26	-31.79**	-14.24	-72.77**	-61.63**	-45.95**	-34.43**	-85.71**	-77.55**	-16.91	49.45**	27.63*	85.64**
SPLB 94006A X ICSR 26	-18.14*	0.00	-83.29**	-72.47**	-25.00*	-14.29	-38.1	-24.64	42.33**	56.33**	20.09	68.53**
SPLB 94019A X ICSR 26	-22.65**	-8.03	-55.48**	-42.98**	-33.33**	-25.93*	-68.48**	-56.72**	-9.63	0.50	-24.35**	-6.71
SPLB 94021A X ICSR 26	-18.14*	0.00	-32.76*	-23.78	-8.33	4.76	-40.48	-25.37	-2.24	30.30*	-32.83*	10.31
SPLB 94022A X ICSR 26	-40.93**	-29.76**	42.31**	45.51**	4.00	6.12	44.68*	52.81*	29.68**	90.93**	32.51*	142.13**
SPLB 94003A X ICSR 90030	-29.13**	-12.77	-80.00**	-63.72**	-8.00	17.95	-82.65**	-67.31**	24.38**	67.51**	63.11**	100.71**

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94006A X ICSR 90030	-25.00**	-5.29	-80.59**	-73.53**	-12.00	2.33	-64.29**	-44.00**	25.51	39.82**	53.22	58.77
SPLB 94016A X ICSR 90030	-41.63**	-24.25*	-68.43**	-67.04**	-45.95**	-35.48**	-82.47**	-78.57**	45.97**	149.19**	441.11**	455.43**
SPLB 94019A X ICSR 90030	-37.50**	-23.08*	-17.63**	-9.28	6.67	16.36	5.10	8.42	-24.26	-16.67	-12.21	40.93**
SPLB 94021A X ICSR 90030	-12.5	10.5	-57.89**	-37.62**	4.00	20.93	-56.12**	-30.08	-15.44	-4.27	42.27	83.43*
SPLB 94022A X ICSR 90030	-16.63*	2.62	-46.58**	-27.76**	4.00	4.00	-45.92*	-26.9	175.64**	255.92**	197.61**	380.37**
LS x R[2]												
SPLB 94012A X A-2267-2	-17.64	7.73	-16.40	-8.14	-39.13**	-39.13**	-48.84*	-43.59	-24.45	-8.79	55.01	63.35
SPLB 94017A X A-2267-2	-38.83**	-18.44	-61.29**	-51.42*	-34.78**	-21.05	-74.29*	-63.27	-31.93**	4.00	-36.33	-28.59
SPLB 94024A X A-2267-2	-11.17	18.44	-61.94**	-52.42*	-34.78**	-21.05	-31.43	-2.04	19.59**	96.16**	257.00**	346.88**
SPLB 94025A X A-2267-2	-22.17*	3.78	-42.72**	-34.63*	-16.00	-12.5	-71.15**	-65.52**	102.90**	139.73**	171.59**	231.77**
SPLB 94014A X A-2267-2	-31.60**	-7.18	-31.68**	-7.76	-10.00	1.89	-37.50**	-8.4	45.36*	49.64**	231.54**	250.43**
LS x MR[2]												
SPLB 94012A X ICSR 97	-17.64	-9.67	-23.81	-19.55	-4.35	7.32	-25.58	-12.33	-73.15**	-71.03**	146.89**	192.59**
SPLB 94017A X ICSR 97	-45.00**	-38.14**	-13.02	12.64	0.00	9.09	-13.33	18.18	16.35**	50.00**	137.07**	196.38**
SPLB 94024A X ICSR 97	-33.33**	-25.02**	-18.34	5.34	-5.56	3.03	-20.00	9.09	-61.15**	-44.15**	91.69	115.31**
SPLB 94025A X ICSR 97	5.50	18.65	-59.71**	-55.73**	-28.00*	-16.28	-71.15**	-63.41**	103.99**	125.53**	291.86**	327.79**
SPLB 94014A X ICSR 97	-21.01*	-9.09	-29.5**	-7.54	3.33	29.17*	-26.04*	12.7	-43.14**	-28.68*	124.49**	141.60**
LS x LS[2]												
SPLB 94012A X ICSR 91025	-5.50	-2.83	-28.57**	-17.41	-7.41	0.00	-32.86*	-16.81	-20.33	-13.5	73.79*	91.49*
SPLB 94017A X ICSR 91025	-5.50	-5.50	-6.95	37.32*	0.00	28.57*	-5.71	57.14*	-74.98**	-64.17**	-13.45	1.17
SPLB 94024A X ICSR 91025	-22.17*	-22.17*	-45.95**	-20.45	-14.81	9.52	-54.29**	-23.81	-52.61**	-26.03**	209.84**	273.65**
SPLB 94025A X ICSR 91025	16.67	16.67	-43.24**	-36.77**	-37.04**	-34.62**	-64.29**	-59.02**	73.91**	84.19**	253.94**	315.95**
SPLB 94014A X ICSR 91025	5.37	8.19	-31.99**	-24.61**	-16.67	-12.28	-40.63**	-31.33*	-28.22	-21.43	165.50**	167.81**
SPLB 94012A X ICSR 119	-10.43	-5.5	-6.88	7.65	8.70	19.05	0.00	24.64	10.85	13.18	207.73**	216.13**
SPLB 94017A X ICSR 119	-31.60**	-29.76**	73.19**	107.83**	36.84*	52.94**	142.31**	215.00**	-58.11**	-42.27**	262.06**	296.56**

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94024A X ICSR 119	-15.8	-13.54	42.75*	70.56**	15.79	29.41	69.23	120.00*	-13.58**	30.92**	189.75**	269.86**
SPLB 94025A X ICSR 119	-5.21	-2.68	65.05**	97.67**	24.00	40.91**	101.92**	169.23**	12.03	12.68	134.37**	192.19**
SPLB 94014A X ICSR 119	-5.21	-5.21	-43.48**	-20.87	-23.33*	-6.12	-56.25**	-31.15	-0.72	15.02	356.51**	394.58**
LS x S[2]												
SPLB 94012A X ICSR 26	4.64	18.00*	44.44**	50.41**	20.83	23.40*	86.05**	88.24**	-25.31*	-17.71	-7.49	40.88*
SPLB 94017A X ICSR 26	-27.29**	-20.03*	-9.77	18.05	-12.5	7.69	-19.05	21.43	-74.60**	-67.79**	-37.76**	-2.24
SPLB 94024A X ICSR 26	-18.14*	-9.98	-29.31	-7.87	-16.67	2.56	-42.86	-14.29	-32.02**	-3.55	16.97	47.72**
SPLB 94025A X ICSR 26	-9.00	0.08	88.35**	104.21**	48.00**	51.02**	175.00**	204.26**	-10.86	0.57	16.14	50.10**
SPLB 94014A X ICSR 26	-4.50	2.49	-32.92**	-12.90	13.33	25.93*	-23.96*	5.8	-27.21**	-7.14	22.36	75.93**
SPLB 94012A X ICSR 90030	-12.50	2.41	-61.84**	-49.03**	-12.00	-8.33	-67.35**	-54.61**	-53.30**	-48.13**	298.73**	344.94**
SPLB 94017A X ICSR 90030	-25.00**	-14.29	-59.21**	-34.32**	-16.00	5.00	-66.33**	-41.07*	-50.42**	-27.98**	176.70**	227.23**
SPLB 94024A X ICSR 90030	-12.50	0.00	-57.89**	-32.35**	-24.00*	-5.00	-68.37**	-44.64*	-76.51**	-62.94**	219.35**	280.77**
SPLB 94025A X ICSR 90030	-4.13	9.57	-7.89	19.45**	36.00**	36.00**	23.47*	61.33**	12.75	22.23	361.16**	435.58**
SPLB 94014A X ICSR 90030	-20.88**	-11.65	-51.32**	-47.29**	6.67	16.36	-39.80**	-39.18**	43.91**	53.94**	254.24**	256.20**
S x R[2]												
SPLB 94001A X A-2267-2	-44.98**	-24.10**	5.29	15.70	-21.74	-20.00	-14.29	-6.49	-45.38**	-20.34	-72.18**	-55.94**
SPLB 94013A X A-2267-2	-27.29**	3.19	-60.29**	-54.40**	-33.33**	-28.00*	-73.68**	-67.39**	-9.27	-6.60	81.66*	140.73**
296A X A-2267-2	-21.77*	12.46	-33.55*	-30.17	-26.09	-19.05	-48.57	-41.94	146.07**	213.66	384.77	425.68
S x MR[2]												
SPLB 94001A X ICSR 97	-50.07**	-41.27**	-61.38**	-59.22**	-36.36**	-30.00*	-73.81**	-69.44*	1.01	21.50*	-46.47**	-20.29
SPLB 94013A X ICSR 97	-54.57**	-44.50**	-55.02**	-50.26**	-37.04**	-24.44*	-71.93**	-63.22**	-64.01**	-54.85**	9.06	56.93
296A X ICSR 97	-21.77**	-2.76	64.50**	79.94**	21.05	24.32	120.00**	131.58**	-49.24**	-48.85**	-15.65	-11.53
S x LS[2]												
SPLB 94001A X ICSR 91025	-25.04**	-21.07*	-30.50**	-19.64	-37.04**	-30.61**	-55.71**	-44.64*	-56.49**	-41.05**	-49.12**	-21.08
SPLB 94013A X ICSR 91025	-22.65**	-14.93	-12.74	-3.42	-7.41	-7.41	-18.57	-10.24	-75.04**	-72.68**	-18.15	11.95

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
296A X ICSR 91025	-8.74	2.41	-16.6	8.27	0.00	17.39	-15.71	21.65	20.60	39.44**	208.27**	219.44**
SPLB 94001A X ICSR 119	4.95	7.69	-16.93	-3.98	36.36**	46.34**	11.9	38.24	-48.17**	-32.80**	14.45	83.24**
SPLB 94013A X ICSR 119	-13.64	-7.32	-33.49**	-19.88	-40.74**	-30.43*	-59.65**	-44.58	7.02	23.98	7.19	39.48
296A X ICSR 119	-17.47*	-9.57	45.71*	46.76*	26.32	26.32	77.78*	81.13*	30.36**	42.39**	236.40**	273.63**
S x S[2]												
SPLB 94001A X ICSR 26	-18.14*	-14.29	-31.75*	-28.93*	-20.83	-17.39	-40.48	-40.48	-55.94**	-47.98**	-65.44**	-60.57**
SPLB 94013A X ICSR 26	-27.29**	-27.29**	-40.67**	-35.25*	-44.44**	-41.18**	-68.42**	-63.64**	23.18*	57.14**	100.36**	240.26**
296A X ICSR 26	-17.47*	-15.60*	-9.20	0.64	-8.33	2.33	-14.29	4.35	34.38**	38.49**	-5.01	34.43
SPLB 94001A X ICSR 90030	-37.50**	-31.83**	-5.53	26.19**	28.00*	36.17**	17.35	64.29**	12.43	54.76**	107.93**	220.44**
SPLB 94013A X ICSR 90030	-16.63*	-12.98	-54.21**	-40.92**	0.00	3.85	-52.04**	-39.35**	-8.58	-2.20	168.21**	270.12**
296A X ICSR 90030	-8.38	-6.45	-63.42**	-46.54**	0.00	13.64	-64.29**	-44.00**	17.74	39.00**	230.15**	237.43**

1. Scored on a (1-9) scale
2. The groups are based on the disease score.
** Significant at 1%
* Significant at 5%

R = Resistant
MR = Moderately Resistant
LS = Less Susceptible
S = Susceptible

Table 20. Heterosis over better parent (BP) and mid parent (MP) for different genotypes of sorghum for various disease resistant parameters, rabi season 1997

Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
MR x R[2]												
SPLB 94004A X A-2267-2	23.26	51.43**	49.79**	123.72**	8.57	49.02**	65.06**	182.47**	9.52	24.32	-3.42	13.76
SPLB 94007A X A-2267-2	0.00	19.40	-60.05**	-32.67*	-44.68**	-17.46	-77.61**	-58.14**	59.52**	81.08**	81.90**	83.34**
SPLB 94010A X A-2267-2	-17.50	-1.49	-63.79*	-56.92	-37.50**	-25.00	-78.57	-71.43	76.67**	140.91**	24.16**	35.36**
SPLB 94011A X A-2267-2	0.00	19.40	-58.62*	-50.77	-37.50**	-25.00	-75.86	-67.44	-6.67	27.27**	-41.09**	-18.35**
SPLB 94013A X A-2267-2	0.00	27.03	-42.73**	-6.86	-37.21**	-8.47	-64.86**	-35.80	33.33*	47.37**	-12.55	23.79*
SPLB94015A X A-2267-2	16.28	42.86**	-13.50	42.08**	-4.55	40.00**	-19.02	49.15*	64.29**	119.05**	26.72**	84.60**
SPLB 94016A X A-2267-2	-29.79**	-10.81	-41.33**	-0.19	-38.00**	-6.06	-60.79**	-26.14	-100.00**	-100.00**	-75.23**	-60.38**
SPLB 94025A X A-2267-2	-29.79**	-10.81	-54.44**	-30.89	-20.83	-5.00	-65.00*	-43.24	24.72**	69.47**	-36.57**	-10.71
MR x MR[2]												
SPLB 94004A X ICSR 26	6.38	11.11	-41.53**	-20.44*	-13.51	-11.11	-48.91**	-29.59*	46.88*	64.91**	-13.69	18.42
SPLB 94007A X ICSR 26	27.66*	37.93**	-47.98**	-43.85**	-40.43**	-33.33**	-63.68**	-62.08**	37.50	54.39*	-43.26**	-14.33
SPLB 94010A X ICSR 26	0.00	8.05	-65.93**	-44.77**	-37.84**	-24.59*	-78.26**	-62.26**	-20.00**	25.22*	-10.33	29.68*
SPLB 94011A X ICSR 26	-8.51	-1.15	-69.76**	-50.98**	-40.54**	-27.87*	-80.98**	-67.14**	-7.78	44.35**	-20.96**	38.48**
SPLB 94013A X ICSR 26	21.28	21.28	-23.99**	-10.24	-4.65	2.50	-16.30	-7.23	11.76	28.81	62.77**	83.53**
SPLB 94015A X ICSR 26	21.28	26.67*	-13.10	0.35	11.36	20.99*	15.76	22.77*	104.00**	121.74**	24.34	33.92
SPLB 94016A X ICSR 26	6.38	6.38	-10.28	-5.92	-6.00	8.05	-6.17	3.65	40.00	84.21*	138.18**	167.07**
SPLB 94025A X ICSR 26	0.00	0.00	-75.20**	-66.94**	-35.14**	-21.31	-83.70**	-75.41**	-40.45**	-7.02	71.19**	94.59**
SPLB 94004A X ICSR 97	-23.26	-23.26	106.44**	129.59**	42.86**	69.49**	192.77**	279.69**	-71.21**	-61.22**	-79.28**	-67.68**
SPLB 94007A X ICSR 97	-30.23*	-27.71*	-41.84**	-19.21	-34.04**	-12.68	-60.70**	-35.77*	-74.24**	-65.31**	-87.34**	-81.88**
SPLB 94010A X ICSR 97	-13.95	-10.84	-21.51	-3.31	-4.17	-4.17	-26.67	-9.59	13.33	30.77**	-52.30**	-28.66**
SPLB 94011A X ICSR 97	-23.26	-20.48	-66.13**	-58.28**	-37.50**	-37.50**	-77.78*	-72.97	38.89**	60.26**	-48.50**	-46.12**
SPLB 94013A X ICSR 97	-21.28	-17.78	10.76	43.77**	-20.93**	1.49	-11.49	35.75	-59.09**	-46.00**	-82.41**	-69.85**
SPLB 94015A X ICSR 97	0.00	0.00	-7.71	22.04	-9.09	17.65	-18.40	27.88	-65.15**	-47.13**	-84.34**	-72.78**
SPLB 94016A X ICSR 97	-14.89	-11.11	-17.11*	17.30	-42.00**	-21.62*	-51.98**	-19.85	-60.61**	-34.18	-86.71**	-75.86**
SPLB 94025A X ICSR 97	-29.79**	-26.67*	-60.08**	-54.38**	-12.50	-12.50	-63.33*	-58.10	-22.47**	-10.97	-81.46**	-68.30**
MR x S[2]												
SPLB 94004A X ICSR119	-11.67	2.91	28.92*	33.20*	2.70	5.56	33.70	40.57*	96.49**	151.69**	126.31**	127.00**
SPLB 94007A X ICSR119	-21.67*	-6.00	-61.47**	-51.49**	-44.68**	-38.10**	-78.61**	-70.65**	107.02**	165.17**	18.58*	39.10**
SPLB 94010A X ICSR119	-16.67	0.00	-41.77**	-20.55	-32.43**	-18.03	-60.87**	-40.00	15.56*	41.50**	78.47**	94.90**
SPLB 94011A X ICSR119	-33.33**	-20.00	-35.74**	-12.33	-21.62*	-4.92	-48.91*	-22.31	25.56**	53.74**	-43.89**	-14.17*
SPLB 94013A X ICSR119	-11.67	-0.93	-13.66	0.17	-20.93**	-15.00	-29.73*	-13.33	38.60**	73.63**	45.71**	82.68**
SPLB 94015A X ICSR119	-11.67	2.91	-27.55**	-14.05	-20.45**	-13.58	-42.94**	-27.06	-40.35**	-12.82	-9.85	17.27

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94016A X ICSR119	0.00	12.15	-31.33**	-11.59	-24.00**	-12.64	-48.46**	-26.65**	-31.58**	11.43	-47.40**	-22.70
SPLB 94025A X ICSR119	-21.67*	-12.15	-32.93*	-32.80*	-40.54**	-27.87*	-60.87**	-52.63*	-13.48	5.48	-8.54	13.87
SPLB 94004A X ICSR 90030	-32.86**	-16.81	-19.95*	-1.15	-5.41	-2.78	-24.29	-4.93	-11.76	28.21*	-16.86	39.81
SPLB 94007A X ICSR 90030	-42.86**	-27.27**	-55.08**	-52.44**	-48.94**	-42.86**	-76.62**	-72.43**	-61.18**	-43.59**	-65.36**	-38.93*
SPLB 94010A X ICSR 90030	-38.57**	-21.82*	-42.82**	-12.60	-24.32**	-8.20	-57.14**	-28.57	-63.33**	-62.29**	-53.33**	-19.41
SPLB 94011A X ICSR 90030	-28.57**	-9.09	-36.17**	-2.44	-18.92*	-1.64	-45.71**	-10.06	-32.22**	-30.29**	-80.20**	-62.59**
SPLB 94013A X ICSR 90030	-14.29	2.56	-22.07*	-18.61	-20.93**	-15.00	-32.43**	-30.56*	-55.29**	-36.13**	6.01	60.63
SPLB 94015A X ICSR 90030	-32.86**	-16.81	-13.30	-11.77	-29.55**	-23.46**	-38.04**	-33.33**	-47.06**	-15.09	10.74	63.53
SPLB 94016A X ICSR 90030	-32.86**	-19.66*	0.67	9.69	-22.00**	-10.34	-22.03**	-3.54	-55.29**	-22.45	205.33**	299.72**
SPLB 94025A X ICSR 90030	-38.57**	-26.50**	-13.03	4.81	-5.41	14.75	-17.14	16.00	-17.98	-16.09	-28.62	8.64
MR x HS^2												
SPLB 94004A X ICSR 91025	-17.81*	3.45	-24.24**	-1.81	-20.51*	-16.22	-38.10**	-17.13	-36.46**	-4.69	-15.91	10.75
SPLB 94007A X ICSR 91025	-27.4**	-6.19	-23.08**	-22.54**	-29.79**	-23.26**	-45.27**	-40.38**	-36.46**	-4.69	-15.24	23.93
SPLB 94010A X ICSR 91025	-35.62**	-16.81	-64.10**	-43.49**	-51.28**	-39.68**	-82.74**	-70.41**	59.38**	64.52**	8.25	51.00**
SPLB 94011A X ICSR 91025	-41.10**	-23.89*	-32.17**	6.79	-23.08**	-4.76	-47.02**	-9.64	-17.71*	-15.05*	-37.35**	7.98
SPLB 94013A X ICSR 91025	-21.92**	-5.00	-26.57**	-18.50*	-34.88**	-31.71**	-48.21**	-44.94**	-58.33**	-38.46**	-74.60**	-72.92**
SPLB 94015A X ICSR 91025	-27.4**	-8.62	-20.98**	-14.39	-18.18*	-13.25	-27.38**	-26.28*	-56.25**	-28.21*	-3.29	-1.85
SPLB 94016A X ICSR 91025	-8.22	11.67	-10.44	-8.30	-12.00	-1.12	-20.70**	-8.86	-47.92**	-8.26	38.13	63.30*
SPLB 94025A X ICSR 91025	-41.10**	-28.33**	-18.65*	3.10	-33.33**	-17.46	-44.64**	-18.42	-40.63**	-38.38**	-69.92**	-67.67**
LS x R^2												
SPLB 94001A X A-2267-2	-35.09**	-11.90	-48.66**	-24.09	-39.39**	-18.37	-70.27**	-50.00	10.42	17.78	13.16	49.66**
SPLB 94003A X A-2267-2	-20.00	3.90	-8.66	39.34	0.00	34.69*	-9.41	55.56	49.30**	87.61**	72.90**	129.56**
SPLB 94006A X A-2267-2	-17.54	11.90	-38.98**	-3.74	-25.00*	0.00	-54.74**	-21.10	-70.15**	-63.30**	-53.04**	-51.20**
SPLB 94009A X A-2267-2	-30.19**	-7.50	-54.85**	-23.90	-36.17**	-4.76	-71.64**	-46.98**	-7.14	5.41	-18.39*	-17.75*
SPLB 94014A X A-2267-2	-18.87	7.50	-36.87*	-7.43	-13.33	13.04	-46.27	-11.11	92.86**	128.17**	-4.06	58.29**
SPLB 94019A X A-2267-2	-34.00**	-14.29	1.27	35.02	-3.70	20.93	-2.33	47.37	-75.36**	-69.37**	-36.82**	-23.84**
SPLB 94021A X A-2267-2	-30.19**	-7.50	-42.91**	-9.87	-20.00*	9.80	-53.85**	-18.64	40.68**	64.36**	-41.80**	-5.22
SPLB 94022A X A-2267-2	-20.00	3.90	-46.28**	-11.76	-32.50**	-3.57	-63.19**	-32.91	13.73	24.73	-0.24	31.05**
SPLB 94024A X A-2267-2	-20.00	3.90	-69.16**	-50.90**	-44.44**	-23.08	-81.82**	-67.74*	73.81**	97.30**	15.72	47.32**
LS x MR^2												
SPLB 94001A X ICSR 26	-17.54	-9.62	-68.55**	-56.67**	-37.84**	-34.29**	-80.43**	-72.09**	79.17**	135.62**	23.50	52.12*
SPLB 94003A X ICSR 26	14.00	17.53	-39.31**	-19.73*	-18.92*	-14.29	-51.09**	-33.09*	-61.97**	-43.75**	137.95**	191.79**
SPLB 94006A X ICSR 26	10.53	21.15*	-43.75**	-29.46**	-18.92*	-13.04	-55.43**	-41.22**	-29.85**	2.17	-17.96	21.93
SPLB 94009A X ICSR 26	-37.74**	-34.00**	-24.80**	-18.82*	-19.15**	-9.52	-28.86**	-25.71**	-15.63	-5.26	-66.61**	-49.59**

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Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94014A X ICSR 26	26.42**	34.00**	-24.40**	5.19	13.51	25.37**	-14.67	25.10	-6.90	0.00	20.47	44.78
SPLB 94019A X ICSR 26	6.00	9.28	-64.72**	-46.48**	-16.22	-3.13	-71.2**	-53.30**	28.99**	89.36**	-19.61**	32.81**
SPLB 94021A X ICSR 26	18.87	26.00*	-22.98**	-3.54	2.70	5.56	-20.65*	1.39	-3.39	35.71*	19.80	39.83
SPLB 94022A X ICSR 26	-20.00	-17.53	-66.94**	-61.82**	-42.50**	-40.26**	-79.89**	-77.44**	-66.67**	-55.26**	-3.88	19.28
SPLB 94024A X ICSR 26	-6.00	-3.09	-41.94**	-28.36**	-10.81	-9.59	-47.28**	-34.01**	46.88*	64.91*	-20.66	1.74
SPLB 94001A X ICSR 97	-29.82**	-20.00	-44.20**	-39.02**	-36.36**	-26.32*	-64.86**	-56.30	71.21**	98.25**	-35.44**	6.97
SPLB 94003A X ICSR 97	-6.00	1.08	23.62	42.73**	9.09	26.32*	37.65	80.00**	33.80**	38.69**	-55.24**	-25.68**
SPLB 94006A X ICSR 97	-35.09**	-26.00*	-25.08*	-8.11	-18.75	-7.14	-37.89*	-15.71	-38.81**	-38.35**	-86.34**	-80.12**
SPLB 94009A X ICSR 97	-30.19**	-22.92*	-41.84**	-19.21	-40.43**	-21.13*	-65.67**	-43.90**	-53.03**	-36.73**	-85.90**	-79.83**
SPLB 94014A X ICSR 97	-11.32	-2.08	0.46	8.19	-6.67	3.70	-8.96	8.93	40.91**	95.79**	-65.12**	-35.74**
SPLB 94019A X ICSR 97	-14.00	-7.53	-4.30	3.49	3.70	9.80	13.33	15.91	140.58**	145.93**	-6.13	16.40**
SPLB 94021A X ICSR 97	-5.66	4.17	17.91	44.81**	2.86	22.03	22.12	70.47**	-19.70	-15.20	-80.20**	-63.73**
SPLB 94022A X ICSR 97	0.00	7.53	-50.96**	-35.15**	-25.00**	-6.25	-62.50**	-42.86*	-42.42**	-35.04**	-62.96**	-38.83**
SPLB 94024A X ICSR 97	-20.00	-13.98	-56.82**	-46.15**	-47.22**	-36.67**	-76.36**	-66.45**	7.58	44.90**	-59.27**	-33.81**
LS x S[2]												
SPLB 94001A X ICSR 119	-28.33**	-26.50**	-3.61	1.48	-24.32**	-20.00*	-26.09	-18.07	26.32*	37.14**	0.69	15.85
SPLB 94003A X ICSR 119	-5.00	3.64	-9.06	-8.15	-27.03**	-22.86*	-30.43	-27.68	-26.76**	-18.75	-70.60**	-66.01**
SPLB 94006A X ICSR 119	-16.67	-14.53	-11.19	-3.68	-10.81	-4.35	-7.37	-5.88	20.9*	30.65**	0.26	14.55
SPLB 94009A X ICSR 119	-33.33**	-29.20**	-41.61**	-26.49**	-36.17**	-28.57**	-62.69**	-48.81**	-52.63**	-39.33*	-67.37**	-61.72**
SPLB 94014A X ICSR 119	-33.33**	-29.20**	-17.27	-11.59	-24.32**	-16.42	-38.04*	-28.30	-21.05	4.65	-36.01**	-2.00
SPLB 94019A X ICSR 119	-11.67	-3.64	30.52*	59.71**	10.81	28.13**	43.48*	95.56**	84.06**	101.59**	72.62**	136.88**
SPLB 94021A X ICSR 119	-16.67	-11.50	20.61	31.01*	-24.32**	-22.22*	-30.77	-26.53	13.56	15.52	-2.00	47.52*
SPLB 94022A X ICSR 119	-11.67	-3.64	-5.23	12.42	-7.50	-3.90	-10.42	9.32	140.35**	153.7**	109.31**	138.81**
SPLB 94024A X ICSR 119	-33.33**	-27.27**	-41.23**	-35.01**	-27.03**	-26.03**	-55.45**	-51.49**	-8.77	16.85	2.04	11.95
SPLB 94001A X ICSR 90030	-14.29	-5.51	9.84	37.67**	-2.70	2.86	7.14	40.19*	-36.47**	-18.80	-24.13	20.63
SPLB 94003A X ICSR 90030	-18.57*	-5.00	-42.29**	-31.11**	-27.03**	-22.86*	-57.86**	-47.56**	-32.94**	-26.92**	10.12	74.67**
SPLB 94006A X ICSR 90030	-14.29	-5.51	-19.95*	-10.28	-13.51	-7.25	-30.00*	-16.60	-44.71**	-38.16**	-58.13**	-26.73
SPLB 94009A X ICSR 90030	-47.14**	-39.84**	-42.79**	-39.42**	-42.55**	-35.71**	-67.16**	-61.29**	-67.06**	-52.14**	-85.63**	-74.65**
SPLB 94014A X ICSR 90030	-24.29**	-13.82	-23.94**	-3.54	-2.70	7.46	-25.71*	0.48	-58.82**	-38.60**	-6.67	15.04
SPLB 94019A X ICSR 90030	-32.86**	-21.67*	-46.28**	-24.34	-27.03**	-15.63	-61.43**	-40.98*	30.59**	44.16**	-71.77**	-48.07
SPLB 94021A X ICSR 90030	-28.57**	-18.70*	-41.76**	-34.82**	-35.14**	-33.33**	-61.43**	-55.74**	-56.47**	-48.61**	71.08	116.60*
SPLB 94022A X ICSR 90030	-28.57**	-16.67	-38.30**	-37.21**	-30.00**	-27.27**	-54.86**	-54.23**	-43.53**	-29.41**	-56.41**	-30.42
SPLB 94024A X ICSR 90030	-32.86**	-21.67*	-12.50	-3.80	-13.51	-12.33	-24.29	-15.20	-42.35	-16.24	-31.04	12.00
LS x HS[2]												
SPLB 94001A X ICSR 91025	-40.93**	-33.38**	-34.03**	-13.32	-25.64**	-19.44*	-50.60**	-31.40*	-42.71**	-23.61*	-58.57**	-51.45**

Contd...

Contd...

Genotypes	Disease score[1]		Length of the lesion (cm)		Width of the lesion (cm)		Area of the lesion (cm^2)		Number of lesions (no)		Number of flecks (no)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94003A X ICSR 91025	-13.70	2.44	-2.10	22.99*	12.82	22.22*	10.71	47.04**	41.67**	62.87**	50.87**	75.96**
SPLB 94006A X ICSR 91025	-21.92**	-12.31	-2.10	16.02	-7.69	1.41	-9.52	15.59	-40.63**	-30.06**	-60.27**	-42.89**
SPLB 94009A X ICSR 91025	-49.32**	-41.27**	-26.57**	-26.06**	-29.79**	-23.26**	-48.26**	-43.63**	-32.29**	1.56	-71.01**	-57.60**
SPLB 94014A X ICSR 91025	-31.51**	-20.63*	-26.34**	-2.17	-17.95*	-7.25	-38.10*	-11.49	-15.63*	29.60**	17.85	48.58
SPLB 94019A X ICSR 91025	-17.81*	-2.44	-54.55**	-33.56**	-35.90**	-24.24*	-70.24**	-52.61**	35.42**	57.58**	9.08	76.13**
SPLB 94021A X ICSR 91025	-31.51**	-20.63*	-46.62**	-36.83**	-25.64**	-21.62*	-60.12**	-50.74**	-67.71**	-60.00**	-46.46*	-34.30
SPLB 94022A X ICSR 91025	-35.62**	-23.58**	-32.17**	-26.52**	-22.50**	-21.52*	-45.83**	-41.67**	-38.54**	-19.73*	16.91	38.12
SPLB 94024A X ICSR 91025	-27.40**	-13.82	-20.28*	-7.19	-23.08**	-20.00*	-38.10**	-25.18*	-16.67*	25.00**	-16.97	1.63
S x R[2]												
SPLB 94012A X A-2267-2	-38.33**	-14.94	-35.91**	-1.78	-12.50	16.67	-43.37*	-3.09	0.00	2.44	12.47	64.73**
SPLB 94017A X A-2267-2	-33.33**	-8.05	-48.87	-35.85	-37.50**	-25.00	-65.63	-52.17	102.38**	120.78**	-10.84	1.86
296A X A 2267-2	-38.57**	-11.34	-53.99**	-24.43	-22.22*	7.69	-64.39**	-35.62	-1.96	7.53	-48.99**	-26.73*
S x MR[2]												
SPLB 94012A X ICSR 26	-11.67	-0.93	-45.16**	-27.95**	-13.51	-7.25	-52.72**	-34.83**	97.50**	143.08**	79.69**	91.74**
SPLB 94017A X ICSR 26	-11.67	-0.93	-61.69**	-39.59**	-37.84**	-24.59*	-76.09**	-59.26**	154.29**	196.67**	9.46	53.55**
296A X ICSR 26	-4.29	14.53	-47.78**	-39.70**	-27.03**	-26.03**	-61.96**	-55.70**	7.84	44.74*	43.27*	57.93*
SPLB 94012A X ICSR 97	-38.33**	-28.16**	6.56	24.04	3.13	17.86	8.43	40.63	-21.21*	-1.89	-46.92**	-7.50
SPLB 94017A X ICSR 97	-38.33**	-28.16**	-40.86*	-31.03	-20.83	-20.83	-53.33	-45.45	12.12	46.53**	-64.71**	-45.84**
296A X ICSR 97	-4.29	18.58*	-27.55**	-4.19	-27.78**	-13.33	-48.48**	-23.16	-13.64	-2.56	-92.81**	-87.58**
S x S[2]												
SPLB 94012A X ICSR 119	-21.67*	-21.67*	20.46	22.83	-5.41	1.45	18.48	24.57	-49.12**	-40.21**	-47.48**	-31.20
SPLB 94017A X ICSR 119	-28.33**	-28.33**	1.61	32.46	-10.81	8.20	-9.78	33.87	-17.54	2.17	-33.11**	-30.47**
296A X ICSR119	-18.57**	-12.31	-25.34**	-11.44	-24.32**	-23.29*	-40.91**	-30.36	50.88**	59.26**	-44.44**	-29.02
SPLB 94012A X ICSR 90030	-18.57*	-12.31	-30.32**	-17.48	-24.32**	-18.84	-43.57**	-29.15	-30.59**	-5.60	87.66**	175.64**
SPLB 94017A X ICSR 90030	-32.86**	-27.69**	-13.30	28.09*	-5.41	14.75	-17.86	33.72	-63.53**	-48.33**	-50.04**	-15.03
296A X ICSR 90030	-24.29**	-24.29**	-27.39**	-26.12**	-8.11	-6.85	-33.57**	-31.62*	-63.53**	-54.41**	-56.33**	-34.66
S x HS[2]												
SPLB 94012A X ICSR 91025	-13.70	-5.26	10.26	37.50**	-5.13	4.23	3.57	38.65**	-66.67**	-52.94**	-18.12	-17.72
SPLB 94017A X ICSR 91025	-41.10**	-35.34**	-34.97**	-0.71	-17.95*	1.59	-47.62**	-12.00	-44.79**	-19.08	-30.16**	-5.76
296A X ICSR 91025	-27.40**	-25.87**	-21.21**	-14.65	-12.82	-9.33	-30.95**	-22.67	-57.29**	-44.22**	-44.01*	-41.76

1. Scored on a (1-9) scale.
2. The groups are based on the disease score.
**** Significant at 1%.** *** Significant at 5%.**

R = Resistant
MR = Moderately Resistant
LS = Less Susceptible
S = Susceptible
HS = Highly Susceptible

4.5.2 Length of the Lesion

Heterosis over mid parent ranged from –83.55 to 134.62 during first year and from –66.94 to 129.59 during second year. While heterobeltiosis ranged from –86.84 to 88.35 during first year (Table 19), and from –75.20 to 106.44 during second year (Table 20).

Negative heterosis was desirable in the case of length of the lesion, as genotypes with minimum lesion length are found superior for resistance. Among the crosses studied during first and second year, 49 and 39 hybrids showed resistance over mid parent and 75 and 83 hybrids over better parent for two consecutive years. Among these hybrids, maximum negative heterosis over MP were reported by SPLB 94015A x ICSR 90030 (R x S, -83.55), SPLB 94006A x ICSR 90030 (MR x S, -73.53) and SPLB 94006A x ICSR 97 (MR x MR, -73.35) during first year, while SPLB 94025A x ICSR 26 (MR x MR, -66.94), SPLB 94022A x ICSR 26 (LS x MR, 61.82) and SPLB 94010A x A 2267-2 (MR x R, -56.92) in the second year. Maximum negative heterobeltiosis i.e., feasible direction of heterosis was observed in the cross combinations, SPLB 94015A x ICSR 90030 (R x S, -86.84), SPLB 94006A x ICSR 97 (MR x MR, -83.91), SPLB 94006A x ICSR 119 (MR x LS, -83.54), SPLB 94006A x ICSR 26 (MR x S, -83.29) during first year, while SPLB 94025A x ICSR 26 (MR x MR, -75.20) SPLB 94011A x ICSR 26 (MR x MR, -69.76), SPLB 94024A x A 2267-2 (LS x R, -69.16) and SPLB 94001A x ICSR 26 (LS x MR, -68.55) in the second year.

4.5.3 Width of the Lesion

Heterosis over mid parent ranged from –42.11 to 115.38 (first year) and –42.86 to 69.49 (second year) and over better parent from -54.05 to 68.00 (first year) and -51.28 to 42.86 (second year) (Tables 19 and 20, respectively).

Heterosis in the negative direction was desirable for width of the lesion, as genotypes with minimum width were found to be superior. Of the 120 hybrids studied, 26 and 34 hybrids over mid parent, while 41 and 74 hybrids over better parent exhibited significant negative heterosis. Promising among them over mid parent are SPLB 94011A x A 2276-2 (R x R, -42.11), SPLB 94019A x ICSR 97 (MR x MR, -41.67) and SPLB 94013A x ICSR 26 (S x S, -41.18) during first year, while SPLB 94007A x ICSR 90030 (MR x S, -42.86), SPLB 94022A x ICSR 26 (LS x MR, -40.26) and SPLB 94010A x ICSR 91025 (MR x HS, -39.68) in the second year. However, desirable cross combinations over BP were recorded by SPLB 94016A x ICSR 97 (MR x MR, -54.05), SPLB 94004A x A 2267-2 (R x R, -53.49), SPLB 94019A x ICSR 97 (MR x MR, -53.33) and SPLB 94011A x A 2267-2 (R x R, -52.17) during first year, while SPLB 94010A x ICSR 91025 (MR x HS, -51.28), SPLB 94007A x ICSR 90030 (MR x S, -48.94) and SPLB 94024A x ICSR 97 (MR x MR, -47.22) in the second year.

4.5.4 Area of the Lesion

Range of heterosis over mid parent varied from –87.21 to 255.56 and –77.44 to 279.69 for two consecutive years respectively. While heterobeltiosis ranged from -88.78 to 175.00 and -83.70 to 192.77 for first (Table 19) and second years (Table 20), respectively.

Genotypes with minimum leaf area damage were found resistant for area of the lesion. Hence, negative heterosis was considered desirable. Significant negative heterosis noticed for two consecutive years in 39 and 46 hybrids over mid parent, while 64 and 81 hybrids over better parent. The promising hybrids which have exhibited maximum negative heterosis over mid parent are SPLB 94015A x ICSR 90030 (R x S, -87.21), SPLB 94011A x A 2267-2 (R x R, -82.98), and SPLB 94019A x ICSR 97 (MR x MR, -81.97) during first year, while SPLB 94022A x ICSR 26 (LS x MR, -77.44), SPLB 94025A x ICSR 26 (MR x MR, -75.41) and SPLB 94011A x ICSR 97 (MR x MR, -72.97) during second year. The cross combinations, SPLB 94015A x ICSR 90030 (R x S, -88.78), SPLB 94011A x A 2267-2 (R x R, -88.57) and SPLB 94019A x ICSR 97 (MR x MR, -88.04) during first year, while SPLB 94025A x ICSR 26 (MR x MR, -83.70), SPLB 94010A x ICSR 91025 (MR x HS, -82.74) and SPLB 94024A x A 2267-2 (LS x R, -81.82) in the second year were found superior over better parent.

4.5.5 Number of Lesions

Heterosis ranged from -72.68 to 376.19 (first year) and -69.37 to 196.67 (second year) over mid parent and from -76.51 to 287.66 (first year) and -75.36 to 154.29 (second year) over better parent values.

Heterosis on the negative side was considered desirable for number of lesions, as genotypes with minimum number of lesions were found superior for resistance. Out of 120 crosses studied, 33 and 37 hybrids over mid parent, and 51 and 57 hybrids over better parent exhibited significant negative heterosis for first (Table 19) and second years (Table 20), respectively. The notable among them with maximum heterosis were SPLB 94013A x ICSR 91025 (S x LS, -72.68), SPLB 94006A x ICSR 119 (MR x LS, -72.05) and SPLB 94012A x ICSR 97 (LS x MR, -71.03) for first year and SPLB 94019A x A 2267-2 (LS x R, -69.37), SPLB 94007A x ICSR 97 (MR x MR, -65.31) and SPLB 94006A x A 2267-2 (LS x R, -63.30) for second year. While significant high value of heterobeltiosis was noticed by SPLB 94024A x ICSR 90030 (LS x S, -76.51), SPLB 94013A x ICSR 91025 (S x LS, -75.04), and SPLB 94017A x ICSR 91025 (LS x LS, -74.98) during first year, and SPLB 94019A x A 2267-2 (LS x R, -75.36), SPLB 94007A x ICSR 97 (MR x MR, -74.24) and SPLB 94004A x ICSR 97 (MR x MR, -71.21) during second year.

4.5.6 Number of Flecks

The range over mid parent heterosis varied from -60.57 to 850.75 (first year) and -87.58 to 299.72 (second year), while from -72.18 to 838.81 (first year) and -87.34 to 205.33 (second year) over better parent (Tables 19 and 20, respectively).

Minimum number of flecks was desirable for resistance, hence heterosis on negative sign was considered. Significant contribution to the negative heterosis for two consecutive years was recorded by three and 36 hybrids over mid parent, and 12 and 58 hybrids over better parent. The cross combinations, SPLB 94001A x ICSR 26 (S x S, -60.57), SPLB 94001A x A 2267-2 (S x R, -55.94) and SPLB 94006A x ICSR 119 (MR x LS, -52.44) during first year (Table 19), while 296A x ICSR 97 (S x MR, -87.58), SPLB 94007A x ICSR 97 (MR x MR, -81.88) and SPLB 94006A x ICSR 97 (LS x MR, -80.12) in the second year (Table 20) recorded maximum negative heterosis. On the other hand the cross combinations, SPLB 94001A x A 2267-2 (S x R, -72.18), SPLB 94015A x ICSR 90030 (R x S, -70.86) and SPLB 94001A x ICSR 26 (S x S, -65.44) during first year, while SPLB 94007A x ICSR 97 (MR x MR, -87.34), SPLB 94016A x ICSR 97 (MR x MR, -86.71) and SPLB 94006A x ICSR 97 (LS x MR, -86.34) in the second year were observed to possess heterobeltiosis.

4.5.7 Lodging

Heterosis compared to mid parent ranged from –96.70 to 580.90, while heterobeltiosis from –97.71 to 349.80 (Table 21).

Since lodging was manifested due to disease, genotypes with minimum lodging were found to be desirable. Hence, negative heterosis was considered desirable. Twenty three and 47 cross combinations exhibited significant negative heterosis over mid parent and better parent, respectively. On the other hand, 36 hybrids were found to be non lodging since they are found to be superior over their counter mid parental and better parental values. Thus, heterosis for these hybrids was recorded as –100.00. Among the 120 cross combinations studied, SPLB 94021A x ICSR 90030 (LS x S, -96.70), SPLB 94014A x ICSR 90030 (LS x S, -94.01) and SPLB 94025A x ICSR 97 (MR x MR, -93.96) over mid parent, while SPLB 94021A x ICSR 90030 (LS x S, -97.71), SPLB 94025A x ICSR 97 (MR x MR, -96.88) and SPLB 94014A x ICSR 90030 (LS x S, -96.80) over better parent were found to be promising for the character, non lodging.

4.5.8 Across the Disease Parameters

During first year, SPLB 94004A x 26, SPLB 94015A x ICSR 90030, SPLB 94019A x ICSR 97 and SPLB 94001A x ICSR 91025 with significant negative heterosis over better parent for area of the lesion, number of lesions and number of flecks also recorded minimum mean values for the above three characters. SPLB 94025A x A 2267-2, SPLB 94025A x ICSR 97, SPLB 94025A x ICSR 91025, SPLB 94014A x ICSR 90030, SPLB 94013A x ICSR 26, SPLB 94014A x A 2267-2, SPLB 94011A x ICSR 91025, SPLB 94009A x ICSR 90030, SPLB 94016A x ICSR 97, SPLB 94016A x ICSR 91025, SPLB 94022A x ICSR 91025, SPLB 94016A x ICSR 119, SPLB 94003A x ICSR 90030, SPLB 94016A x ICSR 90030, and SPLB 94022A x ICSR 90030 had significant negative heterosis for area of the lesion and positive heterosis for number of lesions and number of flecks. All these crosses except six crosses also recorded low mean values for the above three characters. Of these six crosses, three crosses (SPLB 94025A x ICSR 91025, SPLB 94013A x ICSR 26 and SPLB 94016A x ICSR 90030) recorded low mean values for area of the lesion and the number of lesions and high mean value for number of flecks, two F_1 s (SPLB 94016A x ICSR 119 and SPLB 94022A x ICSR 90030) recorded low mean values for area of the lesion and number of flecks and high mean value for number of lesions and one F_1 (SPLB 94025A x ICSR 97) recorded low mean value for area of the lesion and high mean value for number of lesions and flecks. While, SPLB 94011A x ICSR 26 recorded positive heterosis over better parent for area of the lesion and positive heterosis for number of lesions and number of flecks and low mean value for all the above three characters. On the other hand, SPLB 296A and SPLB 94021A with ICSR

119; and SPLB 94022A x ICSR 26 recorded positive heterosis over better parent for all the three characters and may not be useful in future breeding programmes.

During second year, SPLB 94009A x ICSR 26, SPLB 94011A, SPLB 94009A, SPLB 94010A, SPLB 94007A, SPLB 94016A, SPLB 94006A, SPLB 94022A and 296A with ICSR 90030, SPLB 94009A, SPLB 94007A, SPLB 94022A, SPLB 94016A, SPLB 94006A and SPLB 94025A crossed with ICSR 97; SPLB 94016A, SPLB 94014A, SPLB 94015A and SPLB 94009A with ICSR 119; SPLB 94009A, SPLB 94015A, SPLB 94021A, SPLB 94025A, SPLB 94017A, SPLB 94013A, SPLB 94001A and 296A with ICSR 91025 and SPLB 94022A x ICSR 26 recorded negative heterosis over better parent for area of the lesion, number of lesions and number of flecks. All the above F1 s except SPLB 94009A with ICSR 26 recorded low mean values for all the three characters. However, the F_1, SPLB 94009A x ICSR 26, recorded high mean value for area of the lesion and low mean value for number of lesions and number of flecks. SPLB 94024A, SPLB 94001A, SPLB 94015A, SPLB 94010A and SPLB 94007A x A 2267-2; SPLB 94010A x ICSR 91025, SPLB 94012A x ICSR 26, SPLB 94007A, SPLB 94010A and SPLB 94013A with ICSR 119 recorded negative heterosis over better parent for area of the lesion and positive heterosis for number of lesions and number of flecks. Of all the above crosses, the cross, SPLB 94010A x ICSR 119, recorded low mean value for area of the lesion and high mean value for lesion number and fleck number. Whilst the other crosses exhibited varied mean performances. Low mean values for all the above three characters were recorded by SPLB 94024A and SPLB 94001A x A 2267-2, SPLB 94012A x ICSR 26, SPLB 94013A x ICSR 119, high mean value for area of the lesion and low mean value for number of lesions and flecks by SPLB 94015A x A 2267-2, low mean value for area of the lesion and number of flecks and high mean value for number of lesions by SPLB 94010A crossed with A 2267-2 and ICSR 91025; SPLB 94007A x ICSR 119 and low mean value for area of the lesion and number of lesions and high mean value for number of flecks by SPLB 94007A x A 2267-2. While, SPLB 94004A x ICSR 97 recorded positive heterosis over better parent for area of the lesion and positive heterosis for number of lesions and number of flecks. On the other hand, SPLB 94019A x ICSR 119 recorded positive heterosis over better parent for all the three characters and may not be useful in future breeding programmes.

4.5.9 Days to 50% Flowering

Mid parental heterosis ranged from -14.57 to 18.10 (first year) and –17.39 to 11.59 (second year), while heterobeltiosis from -16.08 to 14.47 (first year) and –21.13 to 10.00 (second year).

Significant negative heterosis during first and second years was recorded by 25 and 63 hybrids over mid parent, while 48 and 104 hybrids over better parent. The cross combinations, SPLB 94022A x ICSR 90030 (MR x S, -14.57), SPLB 94019A x ICSR 90030 (MR x S, -13.45) and SPLB 94022A x ICSR 97 (MR x MR, -12.40) during first year (Table 21), while SPLB 94009A x ICSR 91025 (LS x HS, -17.39), SPLB 94009A x A 2267-2 (LS x R, -17.14) SPLB 94009A x ICSR 97 (LS x MR, -16.55) in the second year (Table 22) showed significant maximum heterosis. The promising among the significant crosses over the better parent are SPLB 94022A x ICSR 90030 (-16.08, MR x S), SPLB 94016A x ICSR 90030 (MR x S, -14.12), SPLB 94019A x ICSR 90030 (MR x S, -13.95) and SPLB 94022A x ICSR 97 (MR x MR, -13.78) during first

Table 21. Heterosis over better parent (BP) and mid parent (MP) for different genotypes of sorghum for lodging (%) and various yield contributing characters, rabi season 1996.

Genotypes	Lodging (%)		Days to 50% flowering (days)		Agronomic score[1]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
R x R[2]										
SPLB 94004A X A-2267-2	-89.25	-86.12	-2.91	2.65	-8.25	0.14	47.39**	59.06**	18.73**	24.31**
SPLB 94007A X A-2267-2	-65.69**	-43.33	-3.53	-0.61	-39.94**	-36.81**	87.15**	91.35**	18.73**	25.05**
SPLB 94009A X A-2267-2	-5.78	58.3	0.41	1.25	-19.82	-19.82	148.3	159.00**	15.93**	16.57**
SPLB 94010A X A-2267-2	-100.00	-100.00	3.75	8.26**	-9.91	-5.21	-0.53	5.33	17.85**	24.11**
SPLB 94011A X A-2267-2	-24.97	50.07	7.09**	11.75**	0.00	0.00	-26.45	-26.23	16.10**	20.62**
SPLB 94015A X A-2267-2	-87.28**	-79.25	7.50**	9.55**	-9.91	-9.91	-39.45*	-20.17	8.61	10.69
R x MR[2]										
SPLB 94004A X ICSR 97	-100.00	-100.00	-6.31**	1.71	-16.75	-9.14	-15.05	-0.63	7.49	20.00**
SPLB 94007A X ICSR 97	-100.00*	-100.00	-2.35	-2.16	20.12	26.38	3.82	31.5	10.75*	24.31**
SPLB 94009A X ICSR 97	-100.00	-100.00	-4.72*	-1.22	-9.91	-9.91	-11.65	6.45	-1.3	5.03
SPLB 94010A X ICSR 97	-100.00*	-100.00	-7.88**	-1.27	0.00	5.21	15.25	49.85**	9.77*	11.59*
SPLB 94011A X ICSR 97	-100.00	-100.00	-2.36	4.65*	-9.91	-9.91	33.74*	66.98**	-14.33**	-5.05
SPLB 94015A X ICSR 97	-85.48*	-72.37	0.39	5.15*	-9.91	-9.91	92.95**	108.17**	0.98	9.93
R x LS[2]										
SPLB 94004A X ICSR 91025	-100.00	-100.00	4.40*	12.50**	-25.00*	-10.04	-33.70**	-18.5	13.55*	20.16**
SPLB 94007A X ICSR 91025	-100.00*	-100.00	1.18	2.18	11.00	17.46	-32.59**	-23.77	17.22**	24.76**
SPLB 94009A X ICSR 91025	-100.00*	-100.00*	-4.39*	-1.64	-30.03*	-22.33	-10.11	7.39	27.11**	27.81**
SPLB 94010A X ICSR 91025	-100.00	-100.00	3.60	10.21**	11.00	17.46	-2.49	6.75	7.74	12.28*
SPLB 94011A X ICSR 91025	-55.6	-11.20	0.00	6.38**	-39.94**	-33.33*	-31.92**	-21.71	13.55*	19.23**
SPLB 94015A X ICSR 91025	-85.42*	-76.05	0.80	4.78*	0.00	11.00	-47.19**	-23.45	6.23	9.43
SPLB 94004A X ICSR 119	5.02	16.90	14.47**	18.10**	-16.75	-13.17	-32.21*	-26.95	5.8	15.67**
SPLB 94007A X ICSR 119	-100.00*	-100.00*	0.79	6.42**	8.99	19.94	24.25	27.24	8.19	18.95**

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Genotypes	Lodging (%)		Days to 50% flowering (days)		Agronomic score[1]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94009A X ICSR 119	-73.84*	-63.55	1.69	3.45	-27.25*	-23.71	65.67**	72.54**	15.02**	19.72**
SPLB 94010A X ICSR 119	-59.76	-57.78	6.14*	8.04**	-18.26	-10.04	28.54*	36.32*	6.73	7.46
SPLB 94011A X ICSR 119	118.37	336.74*	3.51	5.36*	-27.25*	-23.71	64.16**	64.91**	13.65**	23.33**
SPLB 94015A X ICSR 119	-72.88*	-64.23	8.66**	9.37**	-9.26	-4.86	14.73	51.09*	19.45**	27.27**
R x S[2]										
SPLB 94004A X ICSR 26	-82.36**	-74.33	3.88	8.07**	-41.75**	-36.43**	95.70**	111.20**	0.00	10.99*
SPLB 94007A X ICSR 26	-78.67*	-78.39*	-7.06**	-2.67	-19.82	-15.64	17.54	38.61*	2.31	14.18**
SPLB 94009A X ICSR 26	-38.39	-36.04	-0.43	0.42	-30.03*	-30.03*	46.65**	63.53**	6.6	12.74*
SPLB 94010A X ICSR 26	2.19	34.61	0.87	3.54	-30.03*	-26.38	10.35	34.01	7.92	9.00
SPLB 94011A X ICSR 26	-86.80**	-73.6	11.64**	14.60**	0.00	0.00	14.59	32.96	5.61	16.36**
SPLB 94015A X ICSR 26	-50.11	-47.73	2.59	2.81	-9.91	-9.91	76.43**	106.34**	-11.88*	-4.64
SPLB 94004A X ICSR 90030	-77.34**	-62.04*	0.00	8.74**	-8.25	0.14	26.88	28.02	14.81**	20.86**
SPLB 94007A X ICSR 90030	-92.80**	-90.44**	-4.32*	-4.32*	-9.91	-5.21	1.45	12.64	30.74**	38.43**
SPLB 94009A X ICSR 90030	-94.67**	-93.17**	-2.74	1.02	-19.82	-19.82	65.65**	73.14**	29.63**	29.63**
SPLB 94010A X ICSR 90030	-100.00*	-100.00*	3.53	11.16**	-9.91	-5.21	4.65	19.95	16.84**	22.40**
SPLB 94011A X ICSR 90030	-82.66**	-65.33*	-3.14	4.00	-19.82	-19.82	24.94	36.32**	25.93**	31.53**
SPLB 94015A X ICSR 90030	-90.40**	-86.95**	-4.71*	0.00	40.24*	40.24**	-5.86	16.45	2.59	5.12
MR x R[2]										
SPLB 94003A X A-2267-2	-39.00	-35.24	0.80	2.86	-19.82	-19.82	43.12**	49.28**	18.28**	23.16**
SPLB 94006A X A-2267-2	-100.00*	-100.00*	0.00	3.03	-19.82	0.19	-46.32**	-40.28**	29.96**	29.96**
SPLB 94016A X A-2267-2	349.80*	580.90*	8.75**	12.99**	-33.25**	-27.15*	119.59**	150.63**	2.41	6.64
SPLB 94019A X A-2267-2	-100.00	-100.00	1.94	5.63*	-36.51**	-33.43**	84.38**	87.70**	16.10**	21.57**
SPLB 94021A X A-2267-2	-90.53*	-85.14	5.79*	6.01**	-9.91	-5.21	-16.83	-13.25	7.42	15.42**
SPLB 94022A X A-2267-2	-100.00	-100.00	0.00	1.23	0.00	0.00	45.87**	60.32**	20.20**	26.60**
MR x MR[2]										
SPLB 94003A X ICSR 97	-100.00	-100.00	1.96	2.77	20.12	20.12	40.00*	68.67**	0.98	3.85

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Genotypes	Lodging (%)		Days to 50% flowering (days)		Agronomic score[1]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94006A X ICSR 97	-100.00*	-100.00	-3.53	-3.34	0.00	24.95	2.71	38.51*	6.51	13.94**
SPLB 94016A X ICSR 97	-12.61	2.72	-10.63**	-4.62*	-8.25	0.14	16.65	29.26	3.26	6.20
SPLB 94019A X ICSR 97	-81.05	-67.63	-5.81**	-5.08*	-36.51**	-33.43**	43.05**	80.61**	-5.54	5.45
SPLB 94021A X ICSR 97	-100.00*	-100.00	-8.27**	-5.48*	10.21	15.96	-24.00	-8.43	5.48	6.00
SPLB 94022A X ICSR 97	-100.00	-100.00	-13.78**	-12.40**	-18.92	-18.92	40.46*	61.57**	-2.28	-0.66
MR x LS[2]										
SPLB 94003A X ICSR 91025	-100.00	-100.00	-1.20	-1.20	-39.94**	-33.33*	-15.5	0.95	5.86	9.06
SPLB 94006A X ICSR 91025	-91.45**	-85.66	-0.79	0.20	12.36	28.48	-29.66*	-26.77*	10.99*	12.22*
SPLB 94016A X ICSR 91025	-47.48	-21.22	4.80**	11.02**	-50.00**	-40.03**	-7.65	18.95	12.76*	16.16**
SPLB 94019A X ICSR 91025	-100.00	-100.00	-8.14**	-6.69**	-45.50**	-36.91**	0.00	13.53	1.47	7.36
SPLB 94021A X ICSR 91025	-100.00*	-100.00	1.20	3.47	-11.00	-5.82	-35.05**	-22.41	0.97	7.38
SPLB 94022A X ICSR 91025	-100.00	-100.00	-7.20**	-6.45**	-19.82	-11.00	-20.02	-0.17	6.73	11.23*
SPLB 94003A X ICSR 119	-85.35	-78.88	-3.19	1.26	-9.26	-4.86	-31.29	-28.44	2.39	2.92
SPLB 94006A X ICSR 119	-73.81*	-64.04	3.53	9.32**	17.98	52.73**	-36.33**	-29.07*	10.24**	15.36**
SPLB 94016A X ICSR 119	33.9	134.8	-4.83*	-3.56	-25.00*	-21.77	28.85	46.87*	20.48**	21.10**
SPLB 94019A X ICSR 119	-81.28	-76.25	-10.47**	-4.94*	-45.50**	-45.50**	20.35	22.72	6.83	16.79**
SPLB 94021A X ICSR 119	-100.00*	-100.00	-3.77	-1.50	-27.25*	-19.94	-4.88	-0.93	11.94*	15.09**
SPLB 94022A X ICSR 119	-78.15	-61.36	-10.98**	-7.59**	-9.26	-4.86	46.94**	61.26**	15.49**	16.27**
MR x S[2]										
SPLB 94003A X ICSR 26	-86.77**	-77.61	-6.00**	-2.49	-19.82	-19.82	78.65**	99.22**	-0.99	1.18
SPLB 94016A X ICSR 26	-37.27	17.69	-4.31	-2.20	-33.25**	-27.15*	115.06**	118.59**	9.90*	12.31*
SPLB 94006A X ICSR 26	-72.28*	-71.89	-6.67**	-2.26	-9.91	12.57	-25.36	-5.56	1.32	7.72
SPLB 94019A X ICSR 26	-33.97	3.93	-11.24**	-6.53**	-45.50**	-42.86**	69.6**	99.27**	1.32	12.45*
SPLB 94021A X ICSR 26	-100.00*	-100.00*	-2.94	-1.49	-9.91	-5.21	36.65*	52.38**	5.48	6.69
SPLB 94022A X ICSR 26	-71.55*	-46.39	-11.79**	-9.21**	-30.03*	-30.03*	80.19**	90.87**	9.90*	11.00*
SPLB 94003A X ICSR 90030	-100.00*	-100.00*	-1.56	-0.59	10.21	10.21	48.65**	55.37**	7.93	11.79*

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Genotypes	Lodging (%)		Days to 50% flowering (days)		Agronomic score[1]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94006A X ICSR 90030	-93.00**	-90.88**	0.00	0.00	10.21	37.71	-30.74*	-16.97	22.22**	22.91**
SPLB 94016A X ICSR 90030	-68.51**	-39.11	-14.12**	-8.18**	-33.25**	-27.15*	47.78*	55.75**	6.90	10.71*
SPLB 94019A X ICSR 90030	-85.95**	-75.36**	-13.95**	-13.45**	-36.51**	-33.43**	24.47	37.66**	17.41**	23.59**
SPLB 94021A X ICSR 90030	-97.71**	-96.70**	-2.74	0.41	-19.82	-15.64	3.35	8.02	-2.26	4.48
SPLB 94022A X ICSR 90030	-89.82**	-80.27*	-16.08**	-14.57**	-9.91	-9.91	63.82**	65.63**	16.84**	22.40**
LS x R^2										
SPLB 94012A X A-2267-2	-100	-100	-2.77	-0.40	-30.03*	-30.03*	53.81**	71.95**	18.02**	31.00**
SPLB 94017A X A-2267-2	-62.75**	-31.02	3.18	5.70*	0.00	0.00	-42.80**	-25.77	2.25	10.53
SPLB 94024A X A-2267-2	42.59	115.55	-4.84*	-3.28	-39.94**	-39.94**	37.94*	61.97**	24.54**	25.93**
SPLB 94025A X A-2267-2	-63.48**	-36.6	-2.09	-1.89	-30.03**	-30.03*	68.81**	96.79**	14.81**	15.46**
SPLB 94014A X A-2267-2	-100.00	-100.00	-2.8	-0.62	0.00	5.21	-1.97	1.35	0.00	12.03*
LS x MR^2										
SPLB 94012A X ICSR 97	-100.00	-100.00	1.18	1.58	30.03*	30.03*	-26.34	-16.64	5.11	9.37
SPLB 94017A X ICSR 97	-96.00**	-92.15**	-3.15	-2.77	-9.91	-9.91	41.67	49.6	-12.05*	1.12
SPLB 94024A X ICSR 97	-100.00*	-100.00	-5.52*	-4.39*	11.11	11.11	-8.02	-1.16	0.98	6.9
SPLB 94025A X ICSR 97	-96.88**	-93.96*	-7.88**	-5.07*	0.00	0.00	-4.29	3.68	3.26	9.88
SPLB 94014A X ICSR 97	-100.00	-100.00	-3.54	-2.97	-0.90	4.27	36.31*	74.10**	5.88	11.28*
LS x LS^2										
SPLB 94012A X ICSR 91025	-100.00	-100.00	-0.80	-0.40	-19.82	-11.00	-15.3	7.23	8.11	18.81**
SPLB 94017A X ICSR 91025	-80.37**	-63.54**	0.39	0.79	-9.91	0.00	-40.24**	-14.49	-4.76	4.00
SPLB 94024A X ICSR 91025	-78.07	-66.56	-7.99**	-7.63**	-19.82	-11.00	-12.61	15.24	16.12**	16.12**
SPLB 94025A X ICSR 91025	-87.57**	-78.32	-2.40	-0.21	-9.91	0.00	-23.15	0.73	12.45*	13.08*
SPLB 94014A X ICSR 91025	-72.55	-66.75	1.20	1.40	11.00	17.46	-40.92**	-33.85*	-5.88	4.40
SPLB 94012A X ICSR 119	-82.1	-77.02	-4.76*	0.00	-27.25*	-23.71	23.01	37.32*	14.11**	21.41**
SPLB 94017A X ICSR 119	-82.11**	-69.76**	-5.56*	-0.84	-18.26	-14.29	-24.85	-2.59	5.80	19.23**

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Genotypes	Lodging (%)		Days to 50% flowering (days)		Agronomic score[1]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94024A X ICSR 119	-69.75	-65.19	-8.07**	-4.20	-27.25*	-23.71	27.93	50.03**	9.22	13.07*
SPLB 94025A X ICSR 119	-72.35**	-58.97	-6.28**	-4.07	-18.26	-14.29	0.92	17.49	17.06**	21.85**
SPLB 94014A X ICSR 119	-100.00	-100.00	-4.39*	0.21	0.00	10.04	4.89	8.61	0.00	7.42
LS x S[2]										
SPLB 94012A X ICSR 26	-35.83	1.71	-4.37*	-0.42	-19.82	-19.82	138.78**	148.38**	1.20	5.97
SPLB 94017A X ICSR 26	-76.48**	-66.14**	-5.56*	-1.65	-19.82	-19.82	59.61**	83.09**	-1.98	12.08*
SPLB 94024A X ICSR 26	-54.66	-44.58	-9.28**	-6.25**	-19.82	-19.82	167.61**	172.24**	11.22*	17.01**
SPLB 94025A X ICSR 26	1.29	16.38	-8.37**	-7.01**	-19.82	-19.82	88.22**	89.83**	5.61	11.69*
SPLB 94014A X ICSR 26	-90.77**	-83.64	-3.19	0.62	-9.91	-5.21	-2.27	16.33	-2.06	3.58
SPLB 94012A X ICSR 90030	-93.15**	-87.93**	-0.39	0.20	-9.91	-9.91	52.16**	56.75**	9.01*	20.40**
SPLB 94017A X ICSR 90030	-81.88**	-79.29**	-9.02**	-8.49**	-19.82	-19.82	28.46	56.10*	10.00	19.52**
SPLB 94024A X ICSR 90030	-73.97**	-60.86*	-8.62**	-7.35**	0.00	0.00	17.84	28.15	3.66	4.24
SPLB 94025A X ICSR 90030	-85.95**	-83.48**	-9.02**	-6.08**	-39.94**	-39.94**	41.93*	53.11*	18.52**	18.52**
SPLB 94014A X ICSR 90030	-96.80**	-94.01**	-1.96	-1.19	0.00	5.21	-30.86*	-22.45	0.88	12.46*
S x R[2]										
SPLB 94001A X A-2267-2	-94.67**	-90.57**	-4.88*	-3.7	-9.91	-5.21	39.13*	45.12**	13.48*	29.76**
SPLB 94013A X A-2267-2	-71.93	-70.16	0.78	4.42*	-19.82	-11	13.55	23.81	2.04	14.75**
296A X A-2267-2	274.22	484.4	2.09	5.61*	-50.00**	-45.43	34.86*	63.65**	18.73**	20.30**
S x MR[2]										
SPLB 94001A X ICSR 97	-100.00*	-100.00*	-0.40	1.19	-19.82	-15.64	2.00	22.89	-29.32**	-14.40*
SPLB 94013A X ICSR 97	-100.00	-100.00	-5.81**	-5.08*	10.21	22.33	-43.63**	-25.1	4.96	10.77*
296A X ICSR 97	314.9	360.27	-8.67**	-2.94	-33.25**	-27.15*	85.42**	91.73**	-5.54	2.29
S x LS[2]										
SPLB 94001A X ICSR 91025	-40.56*	5.62	3.20	4.03	-11.00	-5.82	9.44	30.74*	-15.75*	-2.75
SPLB 94013A X ICSR 91025	-100.00	-100.00	1.16	2.76	12.36	12.36	-26.29*	-21.61	1.17	12.66**

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Genotypes	Lodging (%)		Days to 50% flowering (days)		Agronomic score[1]		Grain yield $plant^{-1}$ (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
296A X ICSR 91025	-82.07	-72.23	-0.40	5.06*	-33.25**	-19.94	-47.66**	-29.09	17.22**	20.08**
SPLB 94001A X ICSR 119	-54.01**	-29.12	-6.10**	-2.53	-36.51**	-30.13*	106.76**	115.34**	2.39	21.70**
SPLB 94013A X ICSR 119	-11.40	27.88	-6.20**	-0.41	-18.26	-5.36	6.12	15.88	-5.83	1.57
296A X ICSR 119	40.64	150.5	-1.75	-0.88	-33.25**	-30.38**	12.61	36.48	10.24*	16.82**
S x S[2]										
SPLB 94001A X ICSR 26	-93.50**	-92.04**	4.88*	7.95**	-30.03*	-26.38	30.00	44.97*	-8.58	10.14
SPLB 94013A X ICSR 26	-9.23	53.7	-11.63**	-6.94**	-39.94**	-33.33*	13.01	40.62*	8.75*	15.48**
296A X ICSR 26	-62.59*	-29.26	2.16	3.95	-16.75	-9.14	8.38	14.67	11.22*	19.72**
SPLB 94001A X ICSR 90030	-75.00**	-72.52**	-9.41**	-7.78**	-19.82	-15.64	66.35**	73.87**	1.11	16.17*
SPLB 94013A X ICSR 90030	-100.00*	-100.00*	-4.65*	-4.09	0.00	11.00	-33.91*	-22.21	4.08	16.48**
296A X ICSR 90030	-63.23**	-28.59	-8.62**	-2.71	-25.00	-18.14	34.26	51.42**	7.41	9.43

1. Scored on a (1-5) scale
2. The groups are based on the disease score.
**** Significant at 1%**
*** Significant at 5%**

R = Resistant
MR = Moderately Resistant
LS = Less Susceptible
S = Susceptible
HS = Highly Susceptible

Table 22. Heterosis over better parent (BP) and mid parent (MP) for different genotypes of sorghum for various yield contributing characters, rabi season 1997

Genotypes	Days to 50% flowering (days)		Plant height (cm)		Agronomic score²		Grain yield plant⁻¹ (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
MR x R²										
SPLB 94004A X A-2267-2	-4.23**	-2.868	-19.09**	-3.78	0.00	8.05	-45.47**	-40.40**	-32.26**	-26.32**
SPLB 94007A X A-2267-2	-2.82*	-1.43	-11.36**	10.48**	-14.00	-11.34	-28.72**	-26.46**	-32.26**	-28.81**
SPLB 94010A X A-2267-2	-4.29**	-3.60**	16.82**	45.61**	-34.00**	-31.96**	-12.76	-12.64	-12.90**	-11.48*
SPLB 94011A X A-2267-2	-5.56**	-3.55**	-3.18	29.09**	-46.00**	-44.33**	67.81**	74.78**	3.23	16.36**
SPLB 94013A X A-2267-2	-11.84**	-7.59**	18.18**	24.70**	-40.00**	-38.14**	-16.67*	-10.90	0.00	7.46
SPLB94015A X A-2267-2	-7.89**	-3.45**	-28.18**	-12.22**	-6.00	-3.09	-36.18**	-16.67	-6.45	0.00
SPLB 94016A X A-2267-2	-2.82*	-1.43	9.09**	29.73**	-14.00	-11.34	104.75**	138.36**	3.23	12.28*
SPLB 94025A X A-2267-2	-7.25**	-3.76**	13.64**	19.90**	-36.17**	-28.57**	72.60**	92.01**	3.23	23.08**
MR x MR²										
SPLB 94004A X ICSR 26	-5.63**	1.52	7.65*	14.38**	-42.50**	-36.99**	1.46	28.96**	7.69	7.69
SPLB 94007A X ICSR 26	-5.63**	1.52	4.12	16.83**	-40.00**	-27.71*	11.58*	35.35**	14.29**	18.52**
SPLB 94010A X ICSR 26	-10.00**	-3.82**	4.12	16.83**	-34.00**	-20.48	-0.39	17.94**	-3.33	3.57
SPLB 94011A X ICSR 26	-6.94**	0.75	7.65*	30.71**	-26.00**	-10.84	-19.49**	-1.58	-15.38**	-12.00**
SPLB 94013A X ICSR 26	-11.84**	-2.19	15.23**	23.71**	-40.00**	-27.71*	8.44	20.89**	-19.44**	-6.45
SPLB 94015A X ICSR 26	-11.84**	-2.19	1.76	11.61**	-26.00**	-10.84	12.30*	64.23**	18.52**	20.75**
SPLB 94016A X ICSR 26	-4.23**	3.03*	0.00	6.25	-26.00**	-10.84	-19.49**	7.61	46.15**	46.15**
SPLB 94025A X ICSR 26	-9.38**	-7.20**	21.83**	30.79**	-10.81	-5.71	39.70**	80.10**	30.77**	44.68**
SPLB 94004A X ICSR 97	0.00	2.16	-3.33	2.47	-7.50	5.71	45.37**	70.91**	6.67	14.29**
SPLB 94007A X ICSR 97	-2.82*	-0.72	12.78**	12.78**	-14.00	7.50	7.41	19.81**	-10.00*	-6.90
SPLB 94010A X ICSR 97	-2.86*	-1.45	3.76	3.76	-26.00**	-7.50	1.35	10.01	3.33	3.33
SPLB 94011A X ICSR 97	-6.94**	-4.29**	3.76	13.58**	-34.00**	-17.50	-1.82	10.47	-3.33	7.41
SPLB 94013A X ICSR 97	-10.53**	-5.56**	-8.63**	9.09**	-20.00*	0.00	-12.61	-11.30	-11.11**	-3.03
SPLB 94015A X ICSR 97	-13.16**	-8.33**	-5.71	-3.30	-34.00**	-17.50	7.18	47.91**	-3.33	1.75
SPLB 94016A X ICSR 97	-2.82*	-0.72	-11.33**	-6.01	-6.00	17.50	-51.70**	-39.88**	20.00**	28.57**
SPLB 94025A X ICSR 97	-10.29**	-7.58**	-21.32**	-6.06	-10.81	-1.49	-14.16*	2.56	0.00	17.65**

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Genotypes	Days to 50% flowering (days)		Plant height (cm)		Agronomic score[2]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
MR x S[2]										
SPLB 94004A X ICSR119	-2.82*	0.00	10.00**	16.88**	17.50	34.29**	-50.38**	-37.71**	6.67	14.29**
SPLB 94007A X ICSR119	-7.04**	-4.35**	11.76**	25.41**	-34.00**	-17.50	-6.10	12.39	10.00*	13.79**
SPLB 94010A X ICSR119	-4.29**	-2.19	13.53**	27.39**	-14.00	7.50	-48.47**	-39.84**	13.33**	13.33**
SPLB 94011A X ICSR119	-8.33**	-5.04**	-1.76	19.29**	-46.00**	-32.50**	29.83**	56.62**	0.00	11.11**
SPLB 94013A X ICSR119	-7.89**	-2.10	8.12**	16.08**	-6.00	17.50	-16.94**	-8.78	-5.56	3.03
SPLB 94015A X ICSR119	-7.89**	-2.10	-14.71**	-6.45	-6.00	17.50	-25.29**	8.26	20.00**	26.32**
SPLB 94016A X ICSR119	-2.82*	0.00	14.71**	21.88**	0.00	25.00*	0.37	32.65**	23.33**	32.14**
SPLB 94025A X ICSR119	-8.96**	-6.87**	3.05	10.63**	-10.81	-1.49	34.96**	71.89**	3.33	21.57**
SPLB 94004A X ICSR 90030	-2.82*	1.47	0.00	7.12*	-7.50	1.37	-26.81**	-12.03	-7.69	-5.88
SPLB 94007A X ICSR 90030	-15.49**	-11.76**	-9.25**	2.61	-34.00**	-20.48	5.11	20.05**	14.29	20.75**
SPLB 94010A X ICSR 90030	-7.14**	-3.70**	8.09**	22.22**	-34.00**	-20.48	-1.47	9.60	20.00**	30.91**
SPLB 94011A X ICSR 90030	-6.94**	-2.19	4.05	27.21**	-40.00**	-27.71**	21.07**	39.45**	40.00**	42.86**
SPLB 94013A X ICSR 90030	-11.84**	-4.96**	5.08	11.89**	-34.00**	-20.48	11.94	16.65*	-11.11**	4.92
SPLB 94015A X ICSR 90030	-11.84**	-4.96**	2.31	13.10**	-34.00**	-20.48	-7.21	30.18**	18.52**	23.08**
SPLB 94016A X ICSR 90030	-4.23**	0.00	-17.34**	-11.46**	0.00	20.48	-6.58	18.67*	19.23**	21.57**
SPLB 94025A X ICSR 90030	-9.23**	-8.53**	3.05	9.73**	-10.81	-5.71	-7.66	12.72	16.00**	26.09**
MR x HS[2]										
SPLB 94004A X ICSR 91025	-4.23**	-1.45	13.45**	35.66**	-25.00*	-25.00*	118.24**	123.72**	-7.69	-2.04
SPLB 94007A X ICSR 91025	-5.63**	-2.90	1.79	27.53**	-46.00**	-40.00**	112.79**	120.57**	-17.86**	-9.80
SPLB 94010A X ICSR 91025	-4.29**	-2.19	12.11**	40.45**	-46.00**	-40.00**	9.32	16.62*	-20.00**	-9.43
SPLB 94011A X ICSR 91025	-5.56**	-2.16	8.97**	45.95**	-34.00**	-26.67**	39.88**	43.61**	0.00	2.13
SPLB 94013A X ICSR 91025	-13.16**	-7.69**	10.76**	17.62**	-46.00**	-40.00**	66.67**	89.46**	-11.11**	8.47
SPLB 94015A X ICSR 91025	-11.84**	-6.29**	12.11**	37.74**	-26.00**	-17.78	18.88*	47.73**	-18.52**	-12.00*
SPLB 94016A X ICSR 91025	-4.23**	-1.45	17.94**	41.02**	-34.00**	-26.67**	24.05**	36.09**	-15.38**	-10.20
SPLB 94025A X ICSR 91025	-10.45**	-8.40**	15.25**	22.38**	-7.50	-3.90	32.60**	38.52**	13.04*	18.18**

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Genotypes	Days to 50% flowering (days)		Plant height (cm)		Agronomic score²		Grain yield plant⁻¹ (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
LS x R²										
SPLB 94001A X A-2267-2	-1.45	-1.45	25.91**	49.73**	-29.79**	-26.67**	55.56**	67.60**	-19.35**	-5.66
SPLB 94003A X A-2267-2	1.45	2.19	-5.45*	12.43**	-14.89	-8.05	27.36**	40.44**	9.68*	9.68*
SPLB 94006A X A-2267-2	-2.86*	-2.16	10.45**	27.89**	-40.00**	-38.14**	19.15**	27.55**	-22.58**	-15.79**
SPLB 94009A X A-2267-2	-18.31**	-17.14**	-1.36	22.95**	-40.00**	-38.14**	22.58**	26.46**	6.45	11.86*
SPLB 94014A X A-2267-2	-2.86*	-2.16	18.18**	30.00**	-26.00**	-23.71*	-25.01**	-23.58**	-25.71**	-21.21**
SPLB 94019A X A-2267-2	-2.90*	-2.19	-20.45**	-7.89**	-29.79**	-29.79**	77.38**	82.48**	3.23	16.36**
SPLB 94021A X A-2267-2	-2.90*	-2.19	12.27**	30.00**	-26.00**	-23.71*	18.35*	30.50**	12.90*	14.75**
SPLB 94022A X A-2267-2	-1.45	-0.73	19.09**	30.02**	-21.28*	-17.78	63.82**	90.71**	3.23	8.47
SPLB 94024A X A-2267-2	-10.14**	-5.34**	4.55	20.10**	-36.17**	-25.00*	99.25**	100.28**	0.00	8.77
LS x MR²										
SPLB 94001A X ICSR 26	-11.59**	-6.15**	15.88**	23.13**	-30.23**	-21.05	-10.48	12.47	-7.69	0.00
SPLB 94003A X ICSR 26	-7.35**	-2.33	4.12	10.63**	0.00	9.59	-22.44**	-0.72	3.23	12.28*
SPLB 94006A X ICSR 26	-10.00**	-3.82**	13.53**	16.97**	-20.00*	-3.61	-23.55**	-14.86**	3.85	3.85
SPLB 94009A X ICSR 26	-21.13**	-15.15**	-1.76	10.23**	-26.00**	-10.84	-15.08	3.01	17.86**	22.22**
SPLB 94014A X ICSR 26	-7.14**	-0.76	27.78**	31.43**	-40.00**	-27.71*	-28.12**	-13.68*	-17.14**	-4.92
SPLB 94019A X ICSR 26	-4.41**	0.78	19.41**	23.03**	-29.79**	-17.50	69.64**	105.31**	11.54*	16.00**
SPLB 94021A X ICSR 26	-8.82**	-3.88**	17.65**	21.21**	-20.00*	-3.61	-30.88**	-11.52	0.00	7.14
SPLB 94022A X ICSR 26	-5.88**	-0.78	-12.57**	-9.35**	-13.95	-2.63	-50.73**	-34.14**	-17.86**	-14.81**
SPLB 94024A X ICSR 26	-3.23*	-2.44	21.76**	24.32**	-18.18	-18.18	28.12**	50.88**	11.54*	11.54*
SPLB 94001A X ICSR 97	-7.25**	-6.57**	20.00**	27.21**	-30.23**	-17.81	30.54**	51.47**	-6.67	7.69
SPLB 94003A X ICSR 97	0.00	0.00	11.33**	18.02**	7.50	22.86	-37.07**	-25.42**	6.45	8.20
SPLB 94006A X ICSR 97	-7.14**	-5.80**	-1.88	7.17	-26.00**	-7.50	18.64**	20.26**	0.00	7.14
SPLB 94009A X ICSR 97	-18.31**	-16.55**	5.26	5.26	-34.00**	-17.50	-4.04	7.03	10.00*	13.79**
SPLB 94014A X ICSR 97	-2.86*	-1.45	5.56	21.41**	-6.00	17.50	-49.01**	-43.75**	-17.14**	-10.77*
SPLB 94019A X ICSR 97	-1.47	-1.47	-1.88	7.17	-57.45**	-48.05**	28.75**	43.23**	3.33	14.81**
SPLB 94021A X ICSR 97	-2.94*	-2.94*	6.25	16.04**	-26.00**	-7.50	-32.36**	-19.83*	3.33	3.33

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Genotypes	Days to 50% flowering (days)		Plant height (cm)		Agronomic score²		Grain yield plant⁻¹ (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94022A X ICSR 97	0.00	0.00	-9.84**	4.43	-6.98	9.59	-40.01**	-25.32**	6.67	10.34*
SPLB 94024A X ICSR 97	-10.29**	-6.15**	-1.84	8.11*	12.12	17.46	-38.22**	-33.35**	0.00	7.14
LS x S²										
SPLB 94001A X ICSR 119	-10.14**	-8.82**	21.76**	29.38**	-37.21**	-26.03*	29.46**	60.59**	13.33**	30.77**
SPLB 94003A X ICSR 119	-1.47	-0.74	15.88**	23.13**	-17.50	-5.71	-43.74**	-28.86**	0.00	1.64
SPLB 94006A X ICSR 119	-2.86*	-0.73	17.65**	21.21**	-20.00*	0.00	-52.3**	-47.67**	-6.67	0.00
SPLB 94009A X ICSR 119	-18.31**	-15.94**	1.76	14.19**	-26.00**	-7.50	-27.20**	-12.87	20.00**	24.14**
SPLB 94014A X ICSR 119	-4.29**	-2.19	16.67**	20.00**	-14.00	7.50	-47.33**	-37.60**	-17.14**	-10.77*
SPLB 94019A X ICSR 119	0.00	0.74	2.94	6.06	-51.06**	-40.26**	-21.67**	-6.47	0.00	11.11*
SPLB 94021A X ICSR 119	-1.47	-0.74	13.53**	16.97**	-40.00**	-25.00*	-48.30**	-34.63**	6.67	6.67
SPLB 94022A X ICSR 119	-2.94*	-2.22	-9.84**	-6.52*	0.00	17.81	-29.85**	-7.29	3.33	6.90
SPLB 94024A X ICSR 119	-7.46**	-3.88**	-5.88	-3.90	21.21	26.98	-32.34**	-21.42**	-3.33	3.57
SPLB 94001A X ICSR 90030	-13.04**	-10.45**	13.87**	21.98**	-37.21**	-28.95*	5.75	25.49**	8.00	14.89*
SPLB 94003A X ICSR 90030	0.00	2.26	-13.29**	-7.12*	17.50	28.77*	-4.25	15.99*	-12.90**	-3.57
SPLB 94006A X ICSR 90030	-7.14**	-3.70**	4.05	8.11*	-40.00**	-27.71*	-13.82*	-10.30	-3.85	-1.96
SPLB 94009A X ICSR 90030	-18.31**	-14.71**	-3.47	9.15**	-40.00**	-27.71*	29.36**	47.76**	21.43	28.30**
SPLB 94014A X ICSR 90030	-10.00**	-6.67**	9.44**	11.61**	-40.00**	-27.71*	10.44	24.77**	-11.43**	3.33
SPLB 94019A X ICSR 90030	-10.29**	-8.27**	-7.51**	-3.90	-29.79**	-17.50	18.10**	34.55**	24.00**	26.53**
SPLB 94021A X ICSR 90030	-7.35**	-5.26**	4.05	8.11*	-40.00**	-27.71*	7.25	29.91**	0.00	9.09
SPLB 94022A X ICSR 90030	-13.24**	-11.28**	0.00	2.81	-30.23**	-21.05	5.11	33.51**	10.71*	16.98**
SPLB 94024A X ICSR 90030	-13.85**	-11.81**	0.00	2.98	0.00	0.00	-30.83**	-23.51**	19.23**	21.57**
LS x HS²										
SPLB 94001A X ICSR 91025	-10.14**	-8.82**	12.11	34.05**	-15.24	-11.88	-100.00	7.38	-14.59*	17.88**
SPLB 94003A X ICSR 91025	0.00	0.74	6.28**	27.08**	25.00*	25.00*	-29.9**	-27.47**	-35.48**	-25.93**
SPLB 94006A X ICSR 91025	-4.29**	-2.19	13.45**	32.11**	-26.00**	-17.78	-7.17	5.64	-7.69	-2.04
SPLB 94009A X ICSR 91025	-19.72**	-17.39**	-13.45**	8.43**	-20.00*	-11.11	-14.15	-11.01	21.43**	33.33**
SPLB 94014A X ICSR 91025	-4.29**	-2.19	12.11**	24.07**	-26.00**	-17.78	-8.54	-4.04	-22.86**	-6.90
SPLB 94019A X ICSR 91025	0.00	0.74	7.62**	25.33**	-42.55**	-37.93**	148.12**	157.93**	25.00**	27.66**

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Genotypes	Days to 50% flowering (days)		Plant height (cm)		Agronomic score[1]		Grain yield plant^{-1} (g)		100 seed weight (g)	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
SPLB 94021A X ICSR 91025	-1.47	-0.74	12.11**	30.55**	-40.00**	-33.33**	40.51**	45.40**	-6.67	5.66
SPLB 94022A X ICSR 91025	-5.88**	-5.19**	19.73**	31.53**	-37.21**	-34.94**	114.31**	135.11**	17.86**	29.41**
SPLB 94024A X ICSR 91025	-10.45**	-6.98**	4.48	20.73**	-25.00*	-17.81	49.51**	60.47**	0.00	6.12
S x R[2]										
SPLB 94012A X A-2267-2	-4.23**	-2.86*	19.55**	26.14**	-26.00**	-23.71*	-10.93	4.49	-18.75**	-17.46**
SPLB 94017A X A-2267-2	-2.90*	-2.19	22.73**	27.66**	-29.79**	-29.79**	10.61	37.28**	-12.90**	3.85
296A X A 2267-2	-5.71**	-5.04**	9.09**	44.14**	-46.00**	-44.33**	55.29**	96.27**	-9.68*	0.00
S x MR[2]										
SPLB 94012A X ICSR 26	-2.82*	4.55**	-3.55	3.54	-20.00*	-3.61	-47.26**	-29.07**	-18.75**	-10.34*
SPLB 94017A X ICSR 26	-8.82**	-3.88**	3.45	12.60**	-29.79**	-17.50	-0.19	40.31**	0.00	10.64
296A X ICSR 26	-11.43**	-5.34**	0.00	20.14**	-20.00*	-3.61	-53.68**	-33.95**	3.85	5.88
SPLB 94012A X ICSR 97	-4.23**	-2.16	-17.77**	-1.82	-20.00*	0.00	-8.56	14.62	0.00	3.23
SPLB 94017A X ICSR 97	-5.88**	-5.88**	-12.81**	5.36	-14.89	3.90	3.13	36.00**	-6.67	9.80
296A X ICSR 97	10.00**	11.59**	-2.26	5.69	-34.00**	-17.50	1.55	36.12**	0.00	9.09
S x S[2]										
SPLB 94012A X ICSR 119	-5.63**	-2.90*	13.20**	21.53**	-14.00	7.50	-31.37**	-8.72	6.25	9.68*
SPLB 94017A X ICSR 119	-4.41**	-3.70**	11.82**	21.72**	-21.28*	-3.90	-23.95**	5.83	13.33**	33.33**
296A X ICSR119	-11.43**	-9.49**	7.65*	29.33**	-40.00**	-25.00*	-3.05	36.90**	3.33	12.73*
SPLB 94012A X ICSR 90030	-9.86**	-5.88**	8.12**	15.14**	-40.00**	-27.71*	-3.83	22.98**	3.12	15.79**
SPLB 94017A X ICSR 90030	-10.29**	-8.27**	1.97	10.11**	-36.17**	-25.00*	3.64	39.18**	8.00	17.39**
296A X ICSR 90030	-15.71**	-12.59**	-3.47	16.78**	-34.00**	-20.48	10.44	50.66**	20.00**	20.00**
S x HS[2]										
SPLB 94012A X ICSR 91025	-7.04**	-4.35**	7.62**	14.29**	-40.00**	-33.33**	67.03**	84.77**	3.12	20.00**
SPLB 94017A X ICSR 91025	-1.47	-0.74	13.45**	18.78**	-36.17**	-31.03**	142.34**	184.95**	4.35	9.09
296A X ICSR 91025	-11.43**	-9.49**	-1.35	30.95**	-20.00*	-11.11	13.72	36.39**	-24.00**	-20.83**

1. Scored on a (1-5) scale. R = Resistant LS = Less Susceptible **HS = Highly Susceptibl**

2. The groups are based on the disease score. MR = Moderately Resistant **S = Susceptible**

**** Significant at 1%.** *** Significant at 5%.**

year, while SPLB 94009A x ICSR 26 (-21.13, LS x MR), SPLB 94009A x ICSR 91025 (LS x HS, -19.72), SPLB 94009A x A 2267-2 (LS x R, -18.31), SPLB 94009A x ICSR 97 (LS x MR, -18.31), SPLB 94009A x ICSR 119 (LS x S, -18.31) and SPLB 94009A x ICSR 90030 (LS x S, 18.31) during second year. The female parent with majority of the restorer lines like ICSR 91025, ICSR 97 and A 2267-2 was found to be hete otic for flowering (Tables 21 and 22).

4.5.10 Agronomic Score

Significant negative heterosis was considered desirable for agronomic score as it was scored on a 1-5 scale where 1 was excellent and 5 was poor. Heterosis over mid parent ranged from –45.50 to 52.73 and –48.05 to 34.29 during first (Table 21) and second years (Table 22), respectively. While heterosis over better parent ranged from –50.00 to 40.24 and -57.45 to 25.00 during first and second years, respectively.

Significant heterosis (desirable) was showed by 24 and 43 cross combinations over mid parent while 36 and 83 crosses over better parent during first and second years, respectively. Among the 120 hybrids studied, maximum heterosis was recorded by SPLB 94019A x ICSR 119 (MR x LS, -45.50), 296A x A 2267-2 (S x R, -45.43) and SPLB 94019A x ICSR 26 (MR x S, -42.86) during first year, and SPLB 94019A x ICSR 97 (LS x MR, -48.05), 296A x A 2267-2 (S x R, -44.33) and SPLB 94011A x A 2267-2 (MR x R, -44.33) during second year. While the desirable cross combinations with maximum heterobeltiosis were SPLB 94016A x ICSR 91025 (MR x LS, -50.00), 296A x A 2267-2 (S x R, -50.00), SPLB 94019A x ICSR 91025 (MR x LS, -45.50), SPLB 94019A x ICSR 26 (MR x S, -45.50) and SPLB 94019A x ICSR 119 (MR x L

S, -45.50) during first year, and SPLB 94019A x ICSR 97 (LS x MR, -57.45), SPLB 94019A x ICSR 119 (LS x S, -51.06), SPLB 94011A x A 2267-2 (MR x R, -46.00), SPLB 94011A x ICSR 119 (MR x S, -46.00), SPLB 94007A x ICSR 91025 (MR x HS, -46.00), SPLB 94010A x ICSR 91025 (MR x HS, -46.00), SPLB 94013A x ICSR 91025 (MR x HS, -46.00) and 296A x A 2267-2 (-46.00, S x R) during second year.

4.5.11 Grain Yield Plant^{-1}

The range for heterosis varied from –40.28 to 172.24 (first year) and –47.67 to 184.95 (second year) over mid parent. While heterobeltiosis ranged from –47.66 to 167.61 (first year) and –53.68 to 148.12 (second year).

Studies on the heterosis showed that 57 and 65 crosses recorded significant positive heterosis during first (Table 21) second years (Table 22), respectively. While 42 and 40 crosses during first and second year exhibited significant heterosis. The promising hybrids which have contributed significantly to positive heterosis over mid parent were SPLB 94024A x ICSR 26 (LS x S, 172.24), SPLB 94009A x A 2267-2 (R x R, 159.00) and SPLB 94016A x A 2267-2 (MR x R, 150.63) during first year, and SPLB 94017A x ICSR 91025 (LS x HS, 184.95), SPLB 94019A x ICSR 91025 (LS x HS, 157.93) and SPLB 94016A x A 2267-2 (MR x R, 138.36) during second year. While SPLB 94024A x ICSR 26 (LS x S, 167.61), SPLB 94009A x A 2267-2 (R x R, 148.30) and SPLB 94012A x ICSR 26 (LS x S, 138.78) during first year, and SPLB 94019A x ICSR 91025 (LS x HS, 148.12), SPLB 94017A x ICSR 91025 (S x HS, 142.34) and SPLB 94004A x ICSR 91025 (MR x HS, 118.24) during second year recorded maximum heterobeltiosis.

4.5.12 100 seed weight

Heterosis over mid parent ranged from –14.40 to 38.43 and –28.81 to 46.15 during first and second years (Tables 21 and 22), respectively. While over the better parent value, the range was from –29.32 to 30.74 during first year, and from –35.48 and 46.15 during second year.

Out of 120 cross combinations studied, 80 and 53 crosses during first and second year were reported to possess significant positive heterosis. While significant positive heterobeltiosis was showed by 50 crosses during first year and 34 crosses during second year. Significant positive heterosis over mid parent was observed by SPLB 94007A x ICSR 90030 (R x S, 38.43), SPLB 94011A x ICSR 90030 (R x S, 31.53) and SPLB 94012A x A 2267-2 (LS x R, 31.00) during first year, and SPLB 94016A x ICSR 26 (MR x MR, 46.15), SPLB 94025A x ICSR 26 (MR x MR, 44.68) and SPLB 94011A x ICSR 90030 (MR x S, 42.86) during second year. While the hybrids SPLB 94007A x ICSR 90030 (R x S, 30.74), SPLB 94006A x A 2267-2 (MR x R, 29.96) and SPLB 94009A x ICSR 90030 (R x S, 29.63) during first year and SPLB 94016A x ICSR 26 (MR x MR, 46.15), SPLB 94011A x ICSR 90030 (MR x S, 40.00) and SPLB 94025A x LCSR 26 (MR x MR, 30.77) during second year were found to be superior for maximum heterobeltiosis.

4.5.13 Across the Grain Components

During the first year, SPLB 94009A x ICSR 91025, SPLB 94010A x ICSR 97, SPLB 94007A x ICSR 90030, SPLB 94024A x ICSR 91025 and SPLB 94025A x ICSR 119 recorded negative heterosis for days to 50% flowering and positive heterosis for 100 seed weight over better parent; SPLB 94007A x ICSR 90030, SPLB 94022A x ICSR 91025, SPLB 94024A x ICSR 91025 and SPLB 94025A x ICSR 119 for days to 50% flowering (negative) and 100 seed weight (positive) over mid parent; SPLB 94019A x ICSR 97, SPLB 94022A x ICSR 97, SPLB 94012A, SPLB 94017A and SPLB 94025A with ICSR 26 and SPLB 94001A x ICSR 90030 for days to 50% flowering, (negative) and grain yield plant^{-1} (positive) over better parent and SPLB 94019A x ICSR 97 for days to 50% flowering (negative) and grain yield plant^{-1} (positive) over mid parent; SPLB 94016A and SPLB 94012A with ICSR 119, SPLB 94019A x ICSR 90030 and SPLB 94013A x ICSR 26 for days to 50% flowering and agronomic score (negative) and 100 seed weight (positive) over better parent; SPLB 94019A x ICSR 119 for days to 50% flowering and agronomic score (negative) and 100 seed weight (positive) over mid parent; SPLB 94003A x ICSR 26 for days to 50% flowering (negative) and grain yield plant^{1} (positive) over better parent; SPLB 94022A x ICSR 119, SPLB 94001A x A 2267-2 and SPLB 94024A x ICSR 26 and SPLB for days to 50% flowering (negative) and grain yield plant^{-1} and 100 seed weight (positive) over better parent; SPLB 94022A x ICSR 119, SPLB 94022A x ICSR 90030, SPLB 94024A x ICSR 26, SPLB 94025A x ICSR 26, SPLB 94017A x 90030 and SPLB 94001A x ICSR 90030 for days to 50% flowering (negative) and grain yield plant^{-1} and 100 seed weight (positive) over mid parent; SPLB 94019A x ICSR 26, SPLB 94016A x ICSR 90030 for days to 50% flowering and agronomic score (negative) and grain yield plant^{-1} (positive) over better parent and mid parent; SPLB 94001A x ICSR 119 for days to 50% flowering and agronomic score (negative) and grain yield plant^{-1} (positive) over better parent; SPLB 94019A x ICSR 26, SPLB 94022A x ICSR 26, SPLB 94016A x ICSR 90030, SPLB 94019A x ICSR 90030, SPLB 94025A x ICSR 90030 and SPLB 94013A x ICSR 26 for days to 50% flowering and agronomic score (negative) and grain yield plant^{-1} and 100 seed weight (positive) over mid parent; SPLB 94024A x A 2267-2, SPLB 94025A x ICSR 90030 and SPLB 94022A x ICSR 26 for days to 50% flowering and agronomic score (negative) and grain yield plant^{-1} and 100 seed weight (positive) over better parent;

During second year, SPLB 94025A and SPLB 94001A x ICSR 91025; SPLB 94025A and SPLB 94024A x 90030 and SPLB 94015A, SPLB 94010A, SPLB 94016A with ICSR 119 recorded negative heterosis for days to 50% flowering and positive heterosis for 100 seed weight over better parent; SPLB 94025A x ICSR 119, SPLB 94024A x ICSR 26, SPLB 94016A x A 2267-2 for days to 50% flowering (negative) and grain yield plant ^{1} (positive) over better parent; SPLB 94017A x ICSR 119; SPLB 94010A, SPLB 94015A, SPLB 94017A and 296A with ICSR 90030; SPLB 94009A and SPLB 94016A x ICSR 26 for days to 50% flowering and agronomic score (negative) and 100 seed weight (positive) over better parent; SPLB 94025A x ICSR 26 for days to 50% flowering (negative) and grain yield plant^{-1} and 100 seed weight (positive) over better parent; SPLB 94001A, SPLB 94009A and SPLB 94007A with ICSR 119; SPLB 94021A x A 2267-2; SPLB 94015A, SPLB 94019A and SPLB 94007A with ICSR 26; 94011A x ICSR 90030; SPLB 94009A x ICSR 97 and SPLB 94022A x ICSR 91025 for days to 50% flowering and agronomic score (negative) and grain yield plant^{-1} and 100 seed weight (positive) over better parent; SPLB 94011A x ICSR 119, SPLB 94009A and SPLB 94011A with ICSR 90030; SPLB 94012A, SPLB 94013A, SPLB 94011A, SPLB 94015A, SPLB 94007A, SPLB 94004A, SPLB 94016A and SPLB 94024A with ICSR 91025 and SPLB 94001A x ICSR 90030, SPLB 94006A, SPLB 94009A, SPLB 94011A, SPLB 94021A, SPLB 94024A and SPLB

94025A with A 2267-2; SPLB 94006A and SPLB 94001A with ICSR 97 and 296A x A 2267-2 for days to 50% flowering and agronomic score (negative)and grain yield plant^{-1} (positive) over better parent; SPLB 94019A x A 2267-2, SPLB 94019A x ICSR 90030 for days to 50% flowering, plant height and agronomic score (negative) and grain yield plant^{-1} (positive) over better parent; SPLB 94009A x ICSR 91025, SPLB 94009A and SPLB 94007A with ICSR 90030 for days to 50% flowering, plant height and agronomic score (negative) and 100 seed weight (positive) over better parent; SPLB 94016A x ICSR 97 and SPLB 94016A x ICSR 90030 for days to 50% flowering and plant height (negative) and 100 seed weight (positive) over better parent; SPLB 94003A x A 2267-2 plant height (negative) and 100 seed weight (positive) over better parent;

In the first year, the F_1 hybrids SPLB 94007A x A 2267-2 (R x R), SPLB 94009A and SPLB 94011A with ICSR 119 (R x LS), SPLB 94009A x ICSR 26 (R x S), SPLB 94016A and SPLB 94019A with A 2267-2 (MR x R). SPLB 94003A, SPLB 94016A, SPLB 94019A and SPLB 94021A with ICSR 26 (MR x S), SPLB 94012A and SPLB 94025A with A 2267-2 (LS x R), SPLB 94012A and SPLB 94024A with ICSR 26 (LS x S) and SPLB 94001A with ICSR 119 and ICSR 90030 (S x S) recorded significant positive heterosis for grain yield plant^{-1} over MP and BP along with maximum yields. Similarly, SPLB 94009A x A 2267-2 (R x R) and SPLB 94001A x ICSR 91025 (S x LS) also exhibited significant positive heterosis over MP along with maximum grain yields.

In the second year, maximum grain yields coupled with significant positive heterosis over MP and BP were recorded by SPLB 94011A x A 2267-2 (MR x R), SPLB 94011A x ICSR 119 (MR x S), SPLB 94011A x ICSR 90030 (MR x S), SPLB

94004A x ICSR 97 (MR x MR), SPLB 94007A and SPLB 94015A with ICSR 26 (MR x MR), SPLB 94004A and SPLB 94007A with ICSR 91025 (MR x HS), SPLB 94025A x ICSR 119 (MR x S), SPLB 94013A x ICSR 91025 (MR x HS), SPLB 94006A and SPLB 94025A with A 2267-2 (MR x R), SPLB 94019A, SPLB 94022A and SPLB 94024A with A 2267-2 (LS x R), SPLB 94001A and SPLB 94019A with ICSR 97, SPLB 94019A and SPLB 94024A with ICSR 26 (LS x MR), SPLB 94009A x ICSR 90030 and SPLB 94001A x ICSR 119 (LS x S), SPLB 94019A x ICSR 91025, SPLB 94022A and SPLB 94024A with ICSR 91025 (LS x HS), SPLB 94017A x ICSR 91025 (S x HS) and SPLB 94025A x ICSR 26 (MR x MR). While, SPLB 94013A x ICSR 26 (MR x MR) and SPLB 94013A x ICSR 90030 (MR x S) had significant positive heterosis over MP coupled with high grain yield plant^{-1}.

4.6 MATERNAL EFFECTS

The influence of cytoplasm on the occurrence of the leaf blight disease, was analysed following split plot technique by involving 17 A- and B-lines, 6 R-lines and 102 cross combinations with genotypes as main treatments and cytoplasms (A / B) as sub-treatments.

The data from the analysis of variance (Table 23) revealed significant difference among the genotypes at 5% level for all the characters under study. However, differences among subtreatments i.e., cytoplasms was observed for length and area of the lesion, plant height, agronomic score, grain yield plant^{-1} and 100-seed weight. The genotypes x cytoplasm interaction was found significant for all the characters under study except for 100-seed weight. The results of genotypes, cytoplasms and their genotypes x cytoplasm interaction effects for various disease resistant parameters and yield contributing characters

Table 23. Anova table for genotypes, cytoplasms and genotypes x cytoplasms interaction effects for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1997.

Characteristic	Replication mean squares d.f. = 2	Genotypes mean squares d.f. = 130	Error-1 mean squares d.f. = 260	Cytoplasms mean squares d.f. = 1	Genotypes x Cytoplasms mean squares d.f. = 130	Error-2 mean squares d.f. = 262
DISEASE PARAMETERS						
Disease score[1]	15.681	3.725*	0.455	0.654	0.703*	0.261
Length of the lesion (cm)	0.046	5.238*	0.128	2.401*	1.070*	0.139
Width of the lesion (cm)	0.001	0.027*	0.001	0.005	0.007*	0.001
Area of the lesion (cm^2)	0.007	1.228*	0.037	0.477*	0.274*	0.035
Number of lesions (no)	1.214	54.200*	0.646	2.230	24.202*	0.686
Number of flecks (no)	2247.780	155252.270*	1259.040	302.250	52404.280*	1211.320
GRAIN COMPONENT CHARACTERS						
Days to 50% flowering (days)	5.430	84.050*	1.242	0.007	3.551*	0.825
Plant height (cm)	174.250	7792.701*	44.48	1905.420*	454.080*	11.470
Agronomic score[2]	8.492	1.900*	0.376	7.118*	0.656*	0.214
Grain yield $plant^{-1}$ (g)	5.734	476.150*	7.117	3031.120*	136.508*	8.434
100 seed weight (g)	0.032	0.680*	0.021	0.902*	0.145	0.020

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
** Significant at 1%.
* Significant at 5%.

are presented in Tables 24 and 25, respectively. Throughout this presentation, the group reference of the lines such as high resistance (HR), resistance (R), moderate resistance (MR), less susceptible (LS), susceptible (S) and highly susceptible (HS) reaction was based on disease damage score.

4.6.1 Disease Damage Score

Irrespective of the cytoplasm, there was no significant difference in the performance of genotypes with B-cytoplasm (4.68) and A-cytoplasm (4.72) for disease damage score (Table 24).

Genotypes, cytoplasm interaction indicated that, among A-lines, SPLB 94011B (R, 3.7) was found resistant with minimum disease damage score and was not statistically significant with SPLB 94011A (R, 4.0). Majority of the A-lines did not exhibit differences. However, SPLB 94006 was the only A-line from LS group, which showed significant difference in response to two cytoplasms.

Among the crosses, majority of crosses resulting with (A x R) and (B x R) parental lines could not exhibit significant differences for disease reaction. However crosses involving crosses of SPLB 94015 x A 2267-2 and SPLB 94016 x A 2267-2 (MR x R), SPLB 94004, SPLB 94007 and SPLB 94025 with ICSR 26 and SPLB 94007 and SPLB 94016 with ICSR 97 (MR x MR), SPLB 94015 and SPLB 94025 with ICSR 119, SPLB 94004, SPLB 94010, SPLB 94011 and SPLB 94015 with ICSR 90030 (which were derived from MR x S group) exhibited significant differences with respect to cytoplasms. The crosses, SPLB 94016 x A 2267-2 and SPLB 94007 x ICSR 97 with minimum disease damage score were statistically significant in response to cytoplasms used. However, SPLB 94025B x A 2267-2 (MR x R, 3.0) with minimum disease damage score exhibited no significant difference with its A-line hybrid.

Table 24. Mean performance for (A x R) hybrids and (B x R) crosses of sorghum for various disease resistant parameters, rabi season 1997.

Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	A-B)	A	B	(A-B)
LINES																		
Moderately Resistant (MR[2])																		
SPLB 94004	4.3	4.7	-0.4	2.33	4.25	-1.92	0.34	0.46	-0.12	0.83	2.00	-1.17	3.2	2.8	0.4	261.5	230.9	30.6
SPLB 94007	4.0	4.0	0.0	4.23	3.65	0.58	0.47	0.37	0.10	2.01	1.36	0.65	3.2	2.5	0.7	368.7	123.3	245.4
SPLB 94010	4.0	4.7	-0.7	1.16	1.18	-0.02	0.24	0.20	0.04	0.28	0.23	0.05	9.0	5.5	3.5	312.6	286.3	26.3
SPLB 94011	4.0	3.7	0.3	1.16	0.53	0.63	0.24	0.17	0.07	0.29	0.09	0.20	9.0	7.1	1.9	845.5	816.3	29.2
SPLB 94015	4.3	4.3	0.0	3.63	3.96	-0.33	0.44	0.42	0.02	1.62	1.68	-0.06	2.1	2.1	0.0	139.7	261.7	-122.0
SPLB 94016	4.7	5.0	-0.3	4.50	4.06	0.44	0.50	0.47	0.03	2.26	1.91	0.35	1.3	1.8	-0.5	93.8	236.1	-142.3
SPLB 94025	4.7	4.7	0.0	2.48	3.26	-0.78	0.24	0.34	-0.10	0.60	1.11	-0.51	8.9	3.9	5.0	157.6	169.7	-12.1
Less Susceptible (LS[2])																		
SPLB 94001	5.7	5.0	0.7	2.24	2.46	-0.22	0.33	0.35	-0.02	0.74	0.85	-0.11	4.8	4.2	0.6	191.9	213.5	-21.6
SPLB 94003	5.0	4.7	0.3	2.54	2.35	0.19	0.33	0.26	0.07	0.84	0.62	0.22	7.1	4.2	2.9	189.7	116.4	73.3
SPLB 94006	5.7	6.7	-1.0	2.95	2.87	0.08	0.32	0.32	0.00	0.95	0.91	0.04	6.7	5.2	1.5	346.3	319.5	26.8
SPLB 94009	5.3	4.7	0.6	3.40	2.34	1.06	0.39	0.37	0.02	1.33	0.86	0.47	2.3	3.3	-1.0	132.1	76.1	56.0
SPLB 94014	5.3	5.0	0.3	2.17	2.60	-0.43	0.30	0.34	-0.04	0.67	0.87	-0.20	2.9	4.4	-1.5	79.5	153.7	-74.2
SPLB 94019	5.0	4.7	0.3	1.58	1.48	0.10	0.27	0.28	-0.01	0.43	0.42	0.01	6.9	11.3	-4.4	568.2	477.0	91.2
SPLB 94021	5.3	5.3	0.0	2.96	3.43	-0.53	0.35	0.38	-0.03	1.04	1.32	-0.28	5.8	5.7	0.1	85.4	109.6	-24.2
SPLB 94022	5.0	5.0	0.0	3.63	2.56	1.07	0.40	0.35	0.05	1.44	0.90	0.54	5.1	5.4	-0.3	195.7	367.2	-171.5
SPLB 94024	5.0	5.7	-0.7	3.08	2.64	0.44	0.36	0.36	0.00	1.10	0.97	0.13	3.2	4.3	-1.1	213.9	434.3	-220.4
Susceptible (S[2])																		
SPLB 94017	6.0	6.7	-0.7	1.33	0.97	0.36	0.24	0.17	0.07	0.32	0.16	0.16	3.5	9.4	-5.9	281.2	269.6	11.6
TESTERS																		
Resistant (R[2])																		
A 2267-2	2.7	2.7	0.0	0.79	0.79	0.00	0.16	0.16	0.00	0.14	0.13	0.01	4.2	4.2	0.0	374.6	374.6	0.0

Contd..

Contd..

Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	A-B)	A	B	(A-B)
Moderately Resistant (MR[2])																		
ICSR 26	4.7	4.7	0.0	4.96	3.85	1.11	0.37	0.38	-0.01	1.83	1.46	0.37	2.5	4.9	-2.4	119.7	140.6	-20.90
ICSR 97	4.3	5.0	-0.7	1.86	1.73	0.13	0.24	0.23	0.01	0.45	0.39	0.06	6.6	7.4	-0.8	927.1	912.5	14.60
Susceptible (S[2])																		
ICSR 119	6.0	5.7	0.3	1.82	1.87	-0.05	0.37	0.26	0.11	0.65	0.49	0.16	5.7	4.5	1.2	259.9	227.7	32.20
ICSR 90030	7.0	6.7	0.3	3.76	3.76	0.00	0.37	0.37	0.00	1.40	1.39	0.01	8.5	6.8	1.7	49.5	39.5	10.00
Highly Susceptible (HS[2])																		
ICSR 91025	7.3	7.7	-0.4	4.29	4.29	0.00	0.39	0.39	0.00	1.68	1.68	0.00	9.6	9.3	0.3	135.6	131.6	4.00
CROSSES																		
MR x R																		
SPLB 94004 X A 2267-2	5.3	5.3	0.0	3.49	4.17	-0.68	0.38	0.41	-0.03	1.36	1.69	-0.33	4.6	0.4	4.2	361.8	116.3	245.50
SPLB 94007 X A 2267-2	4.0	3.7	0.3	1.69	1.65	0.04	0.26	0.24	0.02	0.45	0.40	0.05	6.6	11.9	-5.3	681.4	644.1	37.30
SPLB 94010 X A 2267-2	3.3	3.3	0.0	0.42	0.42	0.00	0.15	0.15	0.00	0.06	0.06	0.00	15.9	8.7	7.2	465.1	329.8	135.30
SPLB 94011 X A 2267-2	4.0	4.0	0.0	0.48	0.58	-0.11	0.15	0.16	-0.01	0.07	0.09	-0.02	8.4	6.5	1.9	498.1	564.1	-66.00
SPLB 94015 X A 2267-2	5.0	3.7	1.3	3.14	2.22	0.92	0.42	0.28	0.14	1.32	0.61	0.71	6.9	6.9	0.0	474.7	798.3	-323.60
SPLB 94016 X A 2267-2	3.3	4.3	-1.0	2.61	2.70	-0.09	0.29	0.29	0.00	0.75	0.79	-0.04	0.0	7.0	-7.0	92.8	378.3	-285.50
SPLB 94025 X A 2267-2	3.3	3.0	0.3	1.13	0.56	0.57	0.19	0.15	0.04	0.21	0.08	0.13	11.1	11.9	-0.8	237.6	426.2	-188.60
MR x MR																		
SPLB 94004 X ICSR 26	5.0	6.0	-1.0	2.90	4.00	-1.10	0.32	0.33	-0.01	0.94	1.31	-0.37	4.7	6.7	-2.0	225.7	285.7	-60.0
SPLB 94007 X ICSR 26	6.0	4.3	1.7	2.58	2.74	-0.16	0.28	0.33	-0.05	0.73	0.91	-0.18	4.4	6.9	-2.5	209.2	291.2	-82.0
SPLB 94010 X ICSR 26	4.7	4.3	0.4	1.69	2.12	-0.43	0.23	0.28	-0.05	0.40	0.59	-0.19	7.2	4.5	2.7	280.3	518.4	-238.1
SPLB 94011 X ICSR 26	4.3	4.0	0.3	1.50	2.43	-0.93	0.22	0.29	-0.07	0.35	0.70	-0.35	8.3	8.5	-0.2	668.3	797.2	-128.9
SPLB 94015 X ICSR 26	5.7	5.7	0.0	4.31	4.65	-0.34	0.49	0.45	0.04	2.12	2.08	0.04	5.1	4.5	0.6	173.7	289.6	-115.9
SPLB 94016 X ICSR 26	5.0	4.7	0.3	4.45	4.65	-0.20	0.47	0.36	0.11	2.13	1.68	0.45	3.5	3.1	0.4	285.1	222.9	62.2
SPLB 94025 X ICSR 26	4.7	3.7	1.0	1.23	2.17	-0.94	0.24	0.25	-0.01	0.30	0.54	-0.24	5.3	3.7	1.6	269.8	58.2	211.6
SPLB 94004 X ICSR 97	3.3	3.7	-0.4	4.81	4.61	0.20	0.50	0.54	-0.04	2.42	2.47	-0.05	1.9	2.2	-0.3	192.1	203.5	-11.4
SPLB 94007 X ICSR 97	3.0	4.0	-1.0	2.46	1.60	0.86	0.31	0.24	0.07	0.79	0.38	0.40	1.7	7.8	-6.1	117.4	439.8	-322.4
SPLB 94010 X ICSR 97	3.7	3.7	0.0	1.46	1.54	-0.08	0.23	0.23	0.00	0.32	0.35	-0.03	10.2	15.5	-5.3	442.2	733.2	-291.0

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Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	A-B)	A	B	(A-B)
SPLB 94011 X ICSR 97	3.3	3.7	-0.4	0.63	0.78	-0.15	0.15	0.19	-0.04	0.10	0.15	-0.05	12.4	23.9	-11.5	477.5	1136.7	-659.2
SPLB 94015 X ICSR 97	4.3	4.3	0.0	3.35	3.15	0.20	0.40	0.37	0.03	1.33	1.18	0.15	2.3	2.5	-0.2	145.2	163.3	-18.1
SPLB 94016 X ICSR 97	4.0	5.3	-1.3	3.73	2.91	0.82	0.29	0.36	-0.07	1.09	1.08	0.01	2.6	3.4	-0.8	123.2	390.5	-267.3
SPLB 94025 X ICSR 97	3.3	3.7	-0.4	0.99	2.89	-1.90	0.21	0.29	-0.08	0.22	0.85	-0.63	6.8	4.7	2.1	171.9	109.0	62.9
MR x S																		
SPLB 94004 X ICSR 119	5.3	5.3	0.0	3.21	3.34	-0.13	0.38	0.38	0.00	1.23	1.26	-0.03	11.2	7.8	3.4	591.8	199.3	392.5
SPLB 94007 X ICSR 119	4.7	5.0	-0.3	1.63	2.49	-0.86	0.26	0.35	-0.09	0.43	0.86	-0.43	11.8	7.7	4.1	437.2	361.1	76.1
SPLB 94010 X ICSR 119	5.0	5.0	0.0	1.45	2.16	-0.71	0.25	0.27	-0.02	0.36	0.58	-0.22	10.4	14.5	-4.1	557.9	468.9	89.0
SPLB 94011 X ICSR 119	4.0	4.0	0.0	1.60	1.36	0.24	0.29	0.28	0.01	0.47	0.37	0.10	11.3	0.4	10.9	474.4	68.2	406.2
SPLB 94015 X ICSR 119	5.3	3.7	1.6	2.63	3.60	-0.97	0.35	0.47	-0.12	0.93	1.72	-0.79	3.4	0.3	3.1	234.3	125.7	108.6
SPLB 94016 X ICSR 119	6.0	5.3	0.7	3.09	3.56	-0.47	0.38	0.46	-0.08	1.17	1.65	-0.48	3.9	9.0	-5.1	136.7	352.8	-216.1
SPLB 94025 X ICSR 119	4.7	3.7	1.0	1.67	3.13	-1.46	0.22	0.33	-0.11	0.36	1.02	-0.66	7.7	4.7	3.0	237.7	172.0	65.7
SPLB 94004 X ICSR 90030	4.7	3.3	1.4	3.01	5.47	-2.46	0.35	0.42	-0.07	1.05	2.29	-1.24	7.5	1.3	6.2	217.4	184.9	32.5
SPLB 94007 X ICSR 90030	4.0	4.3	-0.3	1.90	2.75	-0.85	0.24	0.29	-0.05	0.46	0.81	-0.35	3.3	3.9	-0.6	127.7	69.4	58.3
SPLB 94010 X ICSR 90030	4.3	5.3	-1.0	2.15	4.23	-2.08	0.28	0.42	-0.14	0.59	1.78	-1.19	3.3	5.8	-2.5	145.9	204.9	-59.0
SPLB 94011 X ICSR 90030	5.0	3.7	1.3	2.40	1.33	1.07	0.30	0.25	0.05	0.76	0.33	0.43	6.1	7.9	-1.8	167.4	150.1	17.3
SPLB 94015 X ICSR 90030	4.7	6.0	-1.3	3.26	3.02	0.24	0.31	0.32	-0.01	1.01	0.96	0.05	4.5	3.6	0.9	154.7	73.0	81.7
SPLB 94016 X ICSR 90030	4.7	5.3	-0.6	4.53	4.21	0.32	0.39	0.44	-0.05	1.77	1.84	-0.07	3.7	3.0	0.7	286.4	79.8	206.6
SPLB 94025 X ICSR 90030	4.3	4.7	-0.4	3.27	2.64	0.63	0.35	0.31	0.04	1.16	0.82	0.34	7.3	4.5	2.8	112.5	98.3	14.2
MR x HS																		
SPLB 94004 X ICSR 91025	6.0	5.7	0.3	3.25	3.71	-0.46	0.31	0.33	-0.02	1.04	1.21	-0.17	6.1	12.9	-6.8	219.9	312.6	-92.7
SPLB 94007 X ICSR 91025	5.3	5.3	0.0	3.30	4.46	-1.16	0.33	0.42	-0.09	1.10	1.86	-0.76	6.1	1.6	4.5	312.5	99.1	213.4
SPLB 94010 X ICSR 91025	4.7	4.3	0.4	1.54	1.63	-0.09	0.19	0.23	-0.04	0.29	0.38	-0.09	15.3	4.9	10.4	338.4	194.2	144.2
SPLB 94011 X ICSR 91025	4.3	4.0	0.3	2.91	1.57	1.34	0.30	0.24	0.06	0.88	0.37	0.51	7.9	11.8	-3.9	529.7	177.3	352.4
SPLB 94015 X ICSR 91025	5.3	6.0	-0.7	3.39	3.58	-0.19	0.36	0.38	-0.02	1.20	1.35	-0.15	4.2	5.1	-0.9	135.1	205.1	-70.0
SPLB 94016 X ICSR 91025	6.7	6.7	0.0	4.03	3.63	0.40	0.44	0.41	0.03	1.80	1.50	0.30	5.0	6.8	-1.8	187.3	325.6	-138.3
SPLB 94025 X ICSR 91025	4.3	4.7	-0.4	3.49	2.91	0.58	0.26	0.28	-0.02	0.92	0.83	0.09	5.7	10.7	-5.0	47.4	130.2	-82.8
LS x R																		
SPLB 94001 X A 2267-2	3.7	3.7	0.0	1.15	0.91	0.24	0.19	0.18	0.01	0.22	0.17	0.05	5.3	8.3	-3.0	423.9	374.1	49.8

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Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	A-B)	A	B	(A-B)
SPLB 94003 X A 2267-2	4.0	4.7	-0.7	2.32	2.80	-0.48	0.33	0.42	-0.09	0.77	1.18	-0.41	10.6	10.3	0.3	647.7	687.6	-39.9
SPLB 94006 X A 2267-2	4.7	5.0	-0.3	1.80	0.87	0.93	0.24	0.19	0.05	0.43	0.17	0.26	2.0	4.1	-2.1	175.9	151.1	24.8
SPLB 94009 X A 2267-2	3.7	3.7	0.0	1.91	1.81	0.10	0.30	0.29	0.01	0.57	0.52	0.05	3.9	4.2	-0.3	305.7	160.8	144.9
SPLB 94014 X A 2267-2	4.3	4.7	-0.4	1.37	1.37	0.00	0.26	0.34	-0.08	0.36	0.46	-0.10	8.1	9.4	-1.3	359.4	423.3	-63.9
SPLB 94019 X A 2267-2	3.3	4.3	-1.0	1.60	0.75	0.85	0.26	0.21	0.05	0.42	0.16	0.26	1.7	14.3	-12.6	359.0	540.1	-181.1
SPLB 94021 X A 2267-2	3.7	3.7	0.0	1.69	1.30	0.39	0.28	0.28	0.00	0.48	0.36	0.12	8.3	8.3	0.0	218.0	403.3	-185.3
SPLB 94022 X A 2267-2	4.0	4.3	-0.3	1.95	1.57	0.38	0.27	0.25	0.02	0.53	0.40	0.13	5.8	6.5	-0.8	373.7	280.5	93.2
SPLB 94024 X A 2267-2	4.0	4.0	0.0	0.94	1.03	-0.09	0.20	0.17	0.03	0.19	0.17	0.02	7.3	7.0	0.3	433.5	554.1	-120.6
LS x MR																		
SPLB 94001 X ICSR 26	4.7	5.0	-0.3	1.56	2.90	-1.34	0.23	0.32	-0.09	0.36	0.94	-0.58	8.6	6.2	2.4	237.0	274.1	-37.1
SPLB 94003 X ICSR 26	5.7	6.3	-0.6	3.01	3.13	-0.12	0.30	0.40	-0.10	0.90	1.25	-0.35	2.7	4.5	-1.8	451.4	491.2	-39.8
SPLB 94006 X ICSR 26	6.3	6.0	0.3	2.79	2.68	0.11	0.30	0.31	-0.01	0.82	0.82	0.00	4.7	4.1	0.6	284.1	241.3	42.8
SPLB 94009 X ICSR 26	3.3	3.3	0.0	3.73	3.06	0.67	0.38	0.26	0.12	1.43	0.80	0.63	2.7	3.5	-0.8	123.1	155.3	-32.2
SPLB 94014 X ICSR 26	6.7	5.0	1.7	3.75	2.82	0.93	0.42	0.27	0.15	1.57	0.77	0.80	2.7	2.3	0.4	144.2	104.7	39.5
SPLB 94019 X ICSR 26	5.3	4.0	1.3	1.75	2.22	-0.47	0.31	0.26	0.05	0.53	0.58	-0.05	8.9	5.1	3.8	456.8	179.9	276.9
SPLB 94021 X ICSR 26	6.3	6.7	-0.4	3.81	3.61	0.20	0.37	0.31	0.06	1.46	1.13	0.33	5.7	1.4	4.3	143.4	132.3	11.1
SPLB 94022 X ICSR 26	4.0	4.7	-0.7	1.63	2.71	-1.08	0.23	0.26	-0.03	0.37	0.70	-0.33	1.7	3.8	-2.1	188.1	197.1	-9.0
SPLB 94024 X ICSR 26	4.7	4.0	0.7	2.88	2.59	0.29	0.33	0.31	0.02	0.97	0.80	0.17	4.7	1.7	3.0	169.7	153.3	16.4
SPLB 94001 X ICSR 97	4.0	3.7	0.3	1.25	2.50	-1.25	0.20	0.28	-0.08	0.26	0.69	-0.43	11.3	4.7	6.6	598.5	351.5	247.0
SPLB 94003 X ICSR 97	4.7	5.7	-1.0	3.14	2.41	0.73	0.36	0.29	0.07	1.17	0.70	0.47	9.5	6.9	2.6	415.0	182.9	232.1
SPLB 94006 X ICSR 97	3.7	4.3	-0.6	2.21	1.61	0.60	0.26	0.24	0.02	0.58	0.39	0.19	4.1	1.7	2.4	126.6	145.7	-19.1
SPLB 94009 X ICSR 97	3.7	3.0	0.7	2.46	1.49	0.97	0.28	0.27	0.01	0.69	0.41	0.28	3.1	1.9	1.2	130.7	83.1	47.6
SPLB 94014 X ICSR 97	4.7	4.7	0.0	2.18	2.13	0.05	0.28	0.31	-0.03	0.61	0.65	-0.04	9.3	12.0	-2.7	323.4	386.0	-62.6
SPLB 94019 X ICSR 97	4.3	4.7	-0.4	1.78	1.30	0.48	0.28	0.22	0.06	0.50	0.28	0.22	16.6	7.0	9.6	870.3	351.7	518.6
SPLB 94021 X ICSR 97	5.0	5.0	0.0	3.49	1.95	1.54	0.36	0.28	0.08	1.26	0.54	0.72	5.3	6.3	-1.0	183.6	316.4	-132.8
SPLB 94022 X ICSR 97	5.0	4.3	0.7	1.78	2.09	-0.31	0.30	0.27	0.03	0.53	0.56	-0.03	3.8	7.4	-3.6	343.4	390.6	-47.2
SPLB 94024 X ICSR 97	4.0	3.7	0.3	1.33	3.35	-2.02	0.19	0.37	-0.18	0.26	1.23	-0.97	7.1	1.7	5.4	377.6	346.5	31.1
LS x S																		
SPLB 94001 X ICSR 119	4.3	4.7	-0.4	2.40	2.52	-0.12	0.28	0.32	-0.04	0.68	0.81	-0.13	7.2	5.9	1.3	261.7	345.1	-83.4

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Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	A-B)	A	B	(A-B)
SPLB 94003 X ICSR 119	5.7	5.7	0.0	2.31	2.52	-0.21	0.27	0.27	0.00	0.63	0.69	-0.06	5.2	6.1	-0.9	76.4	142.5	-66.1
SPLB 94006 X ICSR 119	5.0	4.7	0.3	2.62	2.76	-0.14	0.33	0.29	0.04	0.88	0.82	0.06	8.1	4.6	3.5	347.2	325.7	21.5
SPLB 94009 X ICSR 119	4.0	3.3	0.7	2.47	4.21	-1.74	0.30	0.41	-0.11	0.75	1.75	-1.00	2.7	3.5	-0.8	120.3	90.3	30.0
SPLB 94014 X ICSR 119	4.0	3.7	0.3	2.05	3.15	-1.10	0.28	0.29	-0.01	0.57	0.91	-0.34	4.5	3.5	1.0	166.3	103.0	63.3
SPLB 94019 X ICSR 119	5.3	5.0	0.3	3.25	2.05	1.20	0.40	0.27	0.13	1.32	0.56	0.76	12.7	13.0	-0.3	980.8	361.5	619.3
SPLB 94021 X ICSR 119	5.0	5.7	-0.7	2.57	3.00	-0.43	0.28	0.34	-0.06	0.72	1.03	-0.31	6.7	7.1	-0.4	254.7	227.1	27.6
SPLB 94022 X ICSR 119	5.3	5.0	0.3	3.44	2.29	1.15	0.37	0.28	0.09	1.29	0.65	0.64	13.7	6.5	7.2	544.0	366.9	177.1
SPLB 94024 X ICSR 119	4.0	4.0	0.0	1.81	2.22	-0.41	0.27	0.30	-0.03	0.49	0.67	-0.18	5.2	7.7	-2.5	265.2	576.4	-311.2
SPLB 94001 X ICSR 90030	6.0	5.3	0.7	4.13	2.48	1.65	0.36	0.28	0.08	1.50	0.69	0.81	5.4	6.4	-1.0	145.6	163.0	-17.4
SPLB 94003 X ICSR 90030	5.7	6.7	-1.0	2.17	3.63	-1.46	0.27	0.44	-0.17	0.58	1.57	-0.99	5.7	6.5	-0.8	208.9	155.3	53.6
SPLB 94006 X ICSR 90030	6.0	5.7	0.3	3.01	3.55	-0.54	0.32	0.35	-0.03	0.98	1.24	-0.26	4.7	2.7	2.0	145.0	88.9	56.1
SPLB 94009 X ICSR 90030	3.7	4.3	-0.6	2.42	2.84	-0.42	0.27	0.31	-0.04	0.66	0.87	-0.21	2.8	3.4	-0.6	53.0	124.8	-71.8
SPLB 94014 X ICSR 90030	5.3	4.3	1.0	2.86	2.64	0.22	0.36	0.39	-0.03	1.04	1.05	-0.01	3.5	3.8	-0.3	74.2	104.6	-30.4
SPLB 94019 X ICSR 90030	4.7	4.7	0.0	2.02	1.68	0.34	0.26	0.25	0.01	0.54	0.42	0.12	11.1	11.4	-0.3	160.4	459.4	-299.0
SPLB 94021 X ICSR 90030	5.0	5.0	0.0	2.19	2.91	-0.72	0.24	0.27	-0.03	0.54	0.79	-0.25	3.7	4.7	-1.0	146.1	106.3	39.8
SPLB 94022 X ICSR 90030	5.0	4.3	0.7	2.32	3.71	-1.39	0.28	0.39	-0.11	0.65	1.45	-0.80	4.7	8.1	-3.4	85.3	295.4	-210.1
SPLB 94024 X ICSR 90030	4.7	4.3	0.4	3.29	2.91	0.38	0.32	0.38	-0.06	1.06	1.10	-0.04	4.9	5.9	-1.0	147.5	172.5	-25.0
LS x HS																		
SPLB 94001 X ICSR 91025	4.3	3.7	0.6	2.82	4.00	-1.18	0.29	0.38	-0.09	0.82	1.52	-0.70	5.5	5.8	-0.3	79.5	163.5	-84.0
SPLB 94003 X ICSR 91025	6.3	6.0	0.3	4.20	4.67	-0.48	0.44	0.34	0.10	1.85	1.59	0.26	13.6	4.1	9.5	286.2	116.1	170.1
SPLB 94006 X ICSR 91025	5.7	4.7	1.0	4.20	3.43	0.77	0.36	0.31	0.05	1.52	1.07	0.45	5.7	4.3	1.4	137.6	50.6	87.0
SPLB 94009 X ICSR 91025	3.7	3.7	0.0	3.15	3.54	-0.39	0.33	0.36	-0.03	1.04	1.28	-0.24	6.5	4.8	1.7	106.9	129.4	-22.5
SPLB 94014 X ICSR 91025	5.0	6.7	-1.7	3.16	3.39	-0.23	0.31	0.37	-0.06	1.02	1.25	-0.23	8.1	7.5	0.6	159.8	333.8	-174.0
SPLB 94019 X ICSR 91025	6.0	4.7	1.3	1.95	3.21	-1.26	0.25	0.25	0.00	0.50	0.80	-0.30	12.9	5.9	7.0	619.8	182.5	437.3
SPLB 94021 X ICSR 91025	5.0	5.3	-0.3	2.29	3.33	-1.04	0.29	0.33	-0.04	0.66	1.10	-0.44	3.1	5.5	-2.4	72.6	140.2	-67.6
SPLB 94022 X ICSR 91025	4.7	4.3	0.4	2.91	2.41	0.50	0.31	0.24	0.07	0.90	0.58	0.32	5.9	7.5	-1.6	228.8	113.7	115.1
SPLB 94024 X ICSR 91025	5.3	4.3	1.0	3.42	3.12	0.30	0.30	0.31	0.01	1.04	0.95	0.09	8.0	6.9	1.1	177.6	184.9	-7.3
S x R																		
SPLB 94017 X A 2267-2	4.0	3.7	0.3	0.68	0.55	0.13	0.15	0.14	0.01	0.11	0.07	0.04	8.5	15.3	-6.8	334.0	545.1	-211.1

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Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	A-B)	A	B	(A-B)
S x MR																		
SPLB 94017 X ICSR 26	5.3	4.7	0.6	1.90	2.75	-0.85	0.23	0.24	-0.01	0.44	0.66	-0.22	8.9	6.5	2.4	307.8	325.0	-17.2
SPLB 94017 X ICSR 97	3.7	4.0	-0.3	1.10	0.98	0.12	0.19	0.17	0.02	0.21	0.18	0.03	7.4	12.9	-5.5	327.2	390.9	-63.7
S x S																		
SPLB 94017 X ICSR 119	4.3	4.0	0.3	2.53	1.40	1.13	0.33	0.20	0.13	0.83	0.30	0.53	4.6	7.2	-2.6	188.1	424.9	-236.8
SPLB 94017 X ICSR 90030	4.7	5.3	-0.6	3.26	2.39	0.87	0.35	0.28	0.07	1.15	0.68	0.47	3.1	4.5	-1.4	140.5	107.1	33.4
S x HS																		
SPLB 94017 X ICSR 91025	4.3	4.7	-0.4	2.79	1.89	0.90	0.31	0.22	0.09	0.86	0.42	0.45	5.3	4.5	0.8	196.4	87.5	108.9
MEAN	4.72	4.68	0.04	2.53	2.62	-0.09	0.30	0.31	-0.01	0.84	0.88	-0.04	6.26	6.15	0.11	279.9	280.0	-0.1
	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C
S. Em	0.39	0.04	0.42	0.21	0.03	0.30	0.02	0.03	0.03	0.11	0.01	0.15	0.5	0.06	0.68	20.49	2.54	28.42
C.D. (5%)	0.76	0.07	0.82	0.40	0.05	0.60	0.04	0.05	0.06	0.22	0.03	0.30	0.9	0.12	1.33	40.15	4.98	55.7

1. Scored on a (1-9) scale. G = Genotypes G x C = Genotype x Cytoplasm interaction
2. The groups are based on the disease score C = Cytoplasms

Comparison between genotypes showed that the disease damage score ranged from 3.8 to 6.3 (A-lines), 2.7 to 7.5 (restorer lines) and 3.2 to 6.7 (crosses). While, minimum score was recorded by SPLB 94011 (R, 3.8) followed by SPLB 94007 (4.0, R) among A-lines and A 2267-2 (R, 2.7) followed by ICSR 97 (MR, 4.7) and ICSR 26 (4.7, MR) among restorer lines. Among the crosses, SPLB 94025 x A 2267-2 (MR x R) with minimum score of 3.2 was statistically significant with genotypes exhibiting disease damage score of ≥3.96. Other crosses with minimum disease damage score (3.3) were SPLB 94010 x A 2267-2 (MR x R), SPLB 94009 x ICSR 97 (LS x MR) and SPLB 94009 x ICSR 26 (LS x MR). The cross, SPLB 94011 x A 2267-2 (involving two parents with least disease damage score) also recorded lowest disease damage score.

4.6.2 Length of the Lesion

Comparison of cytoplasms showed that genotypes with A-cytoplasm (2.53 cm) contribute to resistance significantly (C.D.=0.05) than B-cytoplasm (2.62 cm).

The interaction of genotypes x cytoplasms indicated that among A-lines, SPLB 94011B (MR) with minimum length (0.53 cm) was significantly different from SPLB 94011A (1.16 cm). On the other hand, SPLB 94017A (S), with minimum length (1.33 cm), was not significantly different from its counter B-line (0.97 cm). The A-lines, SPLB 94004, SPLB 94011, SPLB 94019 and SPLB 94025 (MR) and SPLB 94009, SPLB 94019 and SPLB 94022 (LS) exhibited significant differences with respect to cytoplasms. Among the restorer lines, A 2267-2 (R) recorded minimum value of 0.79 cm. The F_1, SPLB 94010 x A 2267-2 (MR x R) recorded minimum length of 0.42 cm in combination with both A- and B-cytoplasms indicating the absence of cytoplasmic effect on the expression of the character in the cross. However, the hybrid was statistically significant with crosses having lesion length of ≥1.02 cm (Table 23). Majority of the crosses did not exhibit differences, while SPLB 94004 and SPLB 94015 with A 2267-2 (MR x R), SPLB 94004, SPLB 94011 and SPLB 94025 with ICSR 26 and SPLB 94007, SPLB 94016 and SPLB 94025 x ICSR 97 (MR x MR), SPLB 94007, SPLB 94010, SPLB 94015 and SPLB 94025 with ICSR 119; and SPLB 94004, SPLB 94007, SPLB 94010, SPLB 94011 and SPLB 94025 with ICSR 90030 (MR x S) exhibited significant differences. On the other hand, the crosses which recorded less length and exhibited significant differences between A- and B-cytoplasms were SPLB 94019 x A 2267-2 (MR x R) and SPLB 94006 x A 2267-2 (LS x R).

Results among genotypes showed that length of the lesion ranged from 0.85 to 4.28 cm (A-lines), 0.79 to 4.41 cm (restorer lines) and 0.42 to 4.71 cm (crosses). SPLB 94011 (MR, 0.85 cm) followed by SPLB 94017 (S, 1.15 cm) and SPLB 94010 (MR, 1.17 cm) among A-lines, and A 2267-2 (R, 0.79 cm) followed by ICSR 97 (MR, 1.79 cm) and ICSR 119 (LS, 1.85 cm) among R-lines recorded minimum length. The cross, SPLB 94010 x A 2267-2 (MR x R) recorded minimum length of 0.42 cm followed by SPLB 94011 x A 2267-2 (MR x R, 0.53 cm).

4.6.3 Width of the Lesion

Cytoplasmic studies showed that genotypes with B-cytoplasm (0.31 cm) recorded almost same width of the lesion as genotypes with A-cytoplasm (0.30 cm) indicating no difference in the performance of the genotypes (Table 24).

The results of genotypes x cytoplasms effect revealed that majority of the A-lines did not exhibit significant differences. However the A-lines, SPLB 94004, SPLB 94007, SPLB 94011 and SPLB 94025 (MR) and SPLB 94003 and SPLB 94017 (S) showed significant differences with respect to cytoplasms. While SPLB 94011B (R) and SPLB

94017B (LS) with minimum width of 0.17 cm were significantly different to their respective A-lines. On the other hand, SPLB 94010A (R), SPLB 94011A, SPLB 94025A and SPB 94017A (S) also recorded minimum width of the lesion. The three A-lines except SPLB 94010A was found to be significantly different from its corresponding B-line. Similarly, SPLB 94017B x A 2267-2 (S x R) with minimum width of the lesion (0.14 cm) was significantly different from its corresponding A x R hybrid (0.15 cm). Other A x R hybrids with minimum width and which do not differ with its corresponding B x R hybrids were SPLB 94011A x A 2267-2 (MR x R), SPLB 94010A x A 2267-2 (MR x R), SPLB 94001A x A 2267-2 (LS x R), SPLB 94017A x A 2267-2 (S x R) and SPLB 94011A x ICSR 97 (S x MR). Among the crosses studied, majority of the crosses did not exhibit significant differences in response to different cytoplasms, while SPLB 94015 x A 2267-2 (MR x R), SPLB 94011 and SPLB 94016 with ICSR 26 and SPLB 94007, SPLB 94016 and SPLB 94025 with ICSR 97 (MR x MR), SPLB 94007, SPLB 94015, SPLB 94016 and SPLB 94025 with ICSR 119 (MR x S) and SPLB 94004, SPLB 94010 x ICSR 90030 (MR x S); and SPLB 94007 and SPLB 94011 with SPLB 91025 (MR x HS) exhibited significant differences between (A x R) and their corresponding (B x R) hybrids.

Comparison between genotypes showed that the range varied from 0.20 cm to 0.49 cm (A-lines), 0.16 cm to 0.39 cm (R-lines) and 0.15 cm to 0.52 cm (crosses). Minimum width of the lesion was recorded by SPLB 94017 (S, 0.20 cm) and SPLB 94011 (R, 0.21 cm) among A-lines, A 2267-2 (R, 0.16 cm) and ICSR 97 (MR, 0.23 cm) among R-lines, and SPLB 94011 x A 2267-2 (MR x R, 0.15 cm), SPLB 94010 x A 2267-2 (MR x R, 0.15 cm) and SPLB 94017 x A 2267-2 (S x R, 0.15 cm) among crosses. Certain crosses were significantly different as compared to crosses having minimum width of ≥0.20 cm.

4.6.4 Area of the Lesion

Among cytoplasms, genotypes with B-cytoplasm recorded significantly more area (0.88 cm^2) than genotypes with A-cytoplasm (0.84 cm^2) and both were statistically different from each other (C.D. = 0.03).

Comparison of genotype, cytoplasm interaction revealed that majority of the A-lines did not exhibit significant differences for area of the lesion. SPLB 94011B (MR) recorded minimum area (0.09 cm^2) and was significantly different from its corresponding A-line (0.29 cm^2). On the other hand, SPLB 94010A (R, 0.28 cm^2) with minimum area of the lesion was not significantly different from its corresponding B-line. However SPLB 94004, SPLB 94007, SPLB 94016 and SPLB 94025 (MR); and SPLB 94009 and SPLB 94022, (LS) showed significant differences between their cytoplasms. Among the hybrids studied, the promising hybrids with minimum area of the lesion and which were not significantly different from its counterpart i.e., (A x R) hybrids were SPLB 94011B x A 2267-2 (MR x R, 0.09 cm^2), SPLB 94010B x A 2267-2 (MR x R, 0.06 cm^2), SPLB 94017B x A 2267-2 (S x R 0.07 cm^2), SPLB 94025B x A 2267-2 (MR x R, 0.0.8 cm^2) and SPLB 94011A x ICSR 97 (MR x MR, 0.17 cm^2). Among the parents involving moderately resistant A-line as the female parent, the crosses SPLB 94004 and SPLB 94015 with A 2267-2, SPLB 94004, SPLB 94011, SPLB 94016 and SPLB 94007 with ICSR 26, SPLB 94007, SPLB 94015, SPLB 94016 and SPLB 94025 with ICSR 119 (S), SPLB 94004, SPLB 94007, SPLB 94010, SPLB 94011 and SPLB 94025 with ICSR 90030 (S); and SPLB 94007, SPLB 94011 and SPLB 94016 with ICSR 91025 (HS), exhibited significant differences between A and B cytoplasms, while majority of the crosses did not show significant difference with respect to cytoplasms (Table 24).

Genotypic comparison showed that, the range for the area of the lesion varied from 0.19 to 2.09 cm^2 among A-lines, 0.14 to 1.68 cm^2 among restorer lines and 0.06 to 2.45 cm^2 among crosses. SPLB 94011 (R, 0.19 cm^2) and SPLB 94017 (LS, 0.24 cm^2) among lines, A 2267-2 (R, 0.14 cm^2) and ICSR 97 (MR, 0.42 cm^2) among restorer lines, and SPLB 94010 x A 2267-2 (MR x R, 0.06 cm^2) and SPLB 94011 x A 2267-2 (MR x R, 0.08 cm^2) among crosses were desirable with minimum area of the lesion.

4.6.5 Number of Lesions

The results of two types of cytoplasmic effects showed that genotypes with B-cytoplasm recorded less number of lesions (6.15) than A-cytoplasm (6.26). The difference between the two cytoplasm means was equal to critical difference (0.12) indicating that there was no significant difference between the two cytoplasms (Table 24).

The genotype x cytoplasm effects revealed that among A-lines, SPLB 94016A (MR, 1.3) and SPLB 94015A (2.1, MR) with minimum number of lesions were not significantly different from their corresponding B-lines. The A-lines, SPLB 94010, SPLB 94011 and SPLB 94025 (MR), SPLB 94003, SPLB 94006, SPLB 94014 and SPLB 94019 (LS) and SPLB 94017 (S) showed significant differences with respect to cytoplasms. Among the crosses studied, SPLB 94004B x A 2267-2 (MR x R) recorded minimum number of lesions (0.4) and was significantly different from its corresponding (A x R) hybrid (4.60). On the other hand, SPLB 94016A x A 2267-2 (MR x R) recorded zero lesions, whilst its corresponding (B x R) hybrid recorded 7.0 lesions indicating the significant difference. SPLB 94015B x ICSR 119 (MR x LS, 0.3) was significantly different from its corresponding A- line hybrid (3.4). Whilst, SPLB 94011B x ICSR 119 (MR x S, 0.4) was significantly different from its B-line cross (11.3). Majority of the F_1 s involving moderately resistant female parents with R, MR, S and HS male parents showed significant differences between (A x R) hybrids and their respective (B x R) crosses.

Comparison between genotypes showed that the range for number of lesions varied from 1.6 to 9.1 for A-lines, 3.7 to 9.4 for restorer lines and 1.9 to 18.2 for crosses. Less number of lesions were recorded by SPLB 94016 (MR, 1.6) and SPB 94015 (MR, 2.1) among A-lines, ICSR 26 (MR) and A 2267-2 (R, 4.2) among restorer lines; and SPLB 94015 x ICSR 119 (MR x LS, 1.9) and SPLB 94004 x ICSR 97 (R x MR, 2.1) among F_1 s. Similarly the F_1, SPLB 94016 x ICSR 26 (involving parents with minimum lesion area) also recorded few lesions (3.3).

4.6.6 Number of Flecks

The difference between the genotypes with A-cytoplasm (279.9) and B-cytoplasm (280.0) was almost negligible and the behaviour of A- and B-cytoplasms with respect to fleck number was similar (Table 24).

Genotype, cytoplasm interaction showed that lines with minimum flecks and which were significantly different from its counter-cytoplasm were SPLB 94016A (MR, 93.8), SPLB 94014A (LS, 79.5) and SPLB 94009B (LS, 76.1). However, SPLB 94021A (LS) though recorded few flecks (85.4) was not significantly different from SPLB 94021B (LS, 109.6). Significant differences between two types of cytoplasm were exhibited by SPLB 94007, SPLB 94015 and SPLB 94016 (MR) and SPLB 94003, SPLB 94009, SPLB 94014, SPLB 94019, SPLB 94022 and SPLB 94024 (LS). Majority of the crosses from all groups showed significant differences in response to two types of cytoplasms used.

The range for number of flecks between the genotypes varied from 97.5 to 830.9 for A-lines, 44.5 to 919.8 for restorer lines and 88.8 to 807.1 for crosses. The genotypes, SPLB

94021 (LS, 97.5) and SPLB 94009 (LS, 104.1) among A-lines; and ICSR 90030 (S, 44.5), and ICSR 26 (MR, 130.2) among restorer lines, and SPLB 94025 x ICSR 91025 (MR x HS, 88.8), SPLB 94009 x ICSR 90030 (LS x S, 88.9) and SPLB 94014 x ICSR 90030 (LS x S, 89.4) among crosses recorded less number of flecks. The F_1 i.e., SPLB 94021 x ICSR 90030 involving two parents with minimum number of flecks resulted to less number of flecks (126.20).

4.6.7 Days to 50% Flowering

Genotypes with A (65.5 days) and B (65.6 days) cytoplasmic background attained to 50% flowering at the same time (Table 25).

The interaction of genotype, cytoplasm effects indicated that half of the A-lines (SPLB 94007A, SPLB 94004A, SPLB 94015A and SPLB 94016A) from MR group were significantly different from their corresponding B-lines for flowering (lateness), while the remaining A-lines and their respective B-lines did not contribute to significant differences in flowering. SPLB 94009A (LS) with early flowering (59 days) was not significantly different from its B-line (60 days). Similarly was the case with A-line, SPLB 94024A (LS, 62 days). Among the 102 crosses studied, 27 (A x R) hybrids exhibited significant differences from their respective B-line hybrids. The crosses which were early to flower but were not statistically different from their corresponding (B x R) hybrids (CD = 1.45) were SPLB 94024A x ICSR 90030 (LS x S, 56 days), SPLB 94025A x ICSR 26 (MR x MR, 58 days) SPLB 94009A x ICSR 26 (LS x MR, 56 days), SPLB 94009A x A 2267-2 (LS x R, 58 days), SPLB 94009A x ICSR 97 (LS x R, 58 days), SPLB 94009A x ICSR 119 (LS x S, 58 days), SPLB 94009A x ICSR 90030 (LS x S, 58 days) and SPLB 94009A x ICSR 91025 (LS x HS, 57 days).

Table 25. Mean performance for (A x R) hybrids and (B x R) crosses of sorghum for various yield contributing characters, rabi season 1997.

Genotypes	Days to 50% flowering (days)			Plant height (cm)			Agronomic score[1]			Grain yield $plant^{-1}$ (g)			100 seed weight (g)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
LINES															
Moderately Resistant (MR[2])															
SPLB 94004	71	74	-3	150	143	7	4.0	4.0	0.0	20.8	21.5	-0.7	2.6	2.8	-0.2
SPLB 94007	71	69	2	133	140	-7	5.0	4.3	0.7	23.5	20.6	2.9	2.8	1.6	1.2
SPLB 94010	70	70	0	133	137	-4	5.0	4.7	0.3	25.0	30.6	-5.6	3.0	3.1	-0.1
SPLB 94011	72	71	1	110	113	-3	5.0	4.3	0.7	23.1	29.7	-6.6	2.4	2.9	-0.5
SPLB 94015	76	74	2	140	137	3	5.0	5.0	0.0	13.3	24.7	-11.4	2.7	3.8	-1.1
SPLB 94016	71	75	-4	150	140	10	5.0	5.0	0.0	18.0	17.5	0.5	2.6	2.6	0.0
SPLB 94025	64	65	-1	197	202	-5	3.7	3.7	0.0	20.0	33.9	-13.9	2.1	2.4	-0.3
Less Susceptible (LS[2])															
SPLB 94001	69	68	1	150	150	0	4.3	4.0	0.3	21.5	19.3	2.2	2.2	2.1	0.1
SPLB 94003	68	67	1	150	150	0	4.0	4.0	0.0	20.4	24.8	-4.4	3.1	3.1	0.0
SPLB 94006	70	69	1	160	173	-13	5.0	4.7	0.3	28.9	28.0	0.9	2.6	2.7	-0.1
SPLB 94009	59	60	-1	137	133	4	4.7	3.0	1.7	11.5	25.0	-13.5	3.2	2.8	0.4
SPLB 94014	70	71	-1	180	180	0	5.0	5.0	0.0	24.1	25.4	-1.3	3.5	3.3	0.2
SPLB 94019	68	68	0	160	158	2	4.7	3.7	1.0	23.7	24.5	-0.8	2.4	2.8	-0.4
SPLB 94021	68	68	0	160	160	0	5.0	4.0	1.0	20.4	31.3	-10.9	3.0	2.8	0.2
SPLB 94022	68	68	0	183	187	-4	4.3	3.3	1.0	18.0	24.8	-6.8	2.8	3.3	-0.5
SPLB 94024	62	63	-1	163	160	3	3.3	3.3	0.0	25.3	19.6	5.7	2.6	2.5	0.1
Susceptible (S[2])															
SPLB 94017	68	70	-2	203	210	-7	4.7	4.7	0.0	15.3	14.2	1.1	2.1	2.8	-0.7
TESTERS															
Resistant (R[2])															
A 2267-2	69	69	0	220	223	-3	4.7	4.7	0.0	25.1	28.9	-3.8	3.1	3.2	-0.1

Contd..

Contd..

Genotypes	Days to 50% flowering (days)			Plant height (cm)			Agronomic score[1]			Grain yield plant^{-1} (g)			100 seed weight (g)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
Moderately Resistant (MR[2])															
ICSR 26	61	61	0	170	173	-3	3.3	3.0	0.3	36.3	23.1	13.2	2.6	2.9	-0.3
ICSR 97	68	67	1	133	130	3	3.0	3.0	0.0	29.7	30.3	-0.6	3.0	3.5	-0.5
Susceptible (S[2])															
ICSR 119	67	67	0	170	173	-3	3.0	3.0	0.0	35.1	30.3	4.8	3.0	2.9	0.1
ICSR 90030	65	64	1	173	157	16	3.3	3.7	-0.4	31.3	34.8	-3.5	2.5	1.9	0.6
Highly Susceptible (HS[2])															
ICSR 91025	67	67	0	223	227	-4	4.0	4.0	0.0	21.9	22.6	-0.7	2.3	2.3	0.0
CROSSES															
MR x R															
SPLB 94004 X A 2267-2	68	69	-1	178	185	-7	4.7	4.3	0.4	13.7	18.5	-4.8	2.1	2.5	-0.4
SPLB 94007 X A 2267-2	69	69	0	195	180	15	4.3	4.0	0.3	17.9	18.3	-0.4	2.1	1.9	0.2
SPLB 94010 X A 2267-2	67	68	-1	257	263	-6	3.3	2.7	0.6	21.9	32.4	-10.5	2.7	2.5	0.2
SPLB 94011 X A 2267-2	68	69	-1	213	195	18	2.7	2.7	0.0	42.1	36.7	5.4	3.2	2.6	0.6
SPLB 94015 X A 2267-2	70	68	2	158	243	-85	4.7	4.0	0.7	16.0	19.1	-3.1	2.9	2.8	0.1
SPLB 94016 X A 2267-2	69	69	0	240	227	13	4.3	3.7	0.6	51.3	48.2	3.1	3.2	3.3	-0.1
SPLB 94025 X A 2267-2	64	64	0	250	257	-7	3.0	2.7	0.3	43.3	46.8	-3.5	3.2	3.3	-0.1
MR x MR															
SPLB 94004 X ICSR 26	67	65	2	183	187	-4	2.3	3.3	-1.0	36.8	31.1	5.7	2.8	2.8	0.0
SPLB 94007 X ICSR 26	67	66	1	177	177	0	3.0	3.3	-0.3	40.5	40.9	-0.4	3.2	3.1	0.1
SPLB 94010 X ICSR 26	63	67	-4	177	173	4	3.3	2.7	0.6	36.1	31.2	4.9	2.9	3.5	-0.6
SPLB 94011 X ICSR 26	67	68	-1	183	173	10	3.7	4.0	-0.3	29.2	30.0	-0.8	2.2	2.5	-0.3
SPLB 94015 X ICSR 26	67	67	0	173	192	-19	3.7	3.7	0.0	40.7	30.3	10.4	3.2	2.9	0.3
SPLB 94016 X ICSR 26	68	67	1	170	173	-3	3.7	4.0	-0.3	29.2	35.5	-6.3	3.8	3.1	0.7
SPLB 94025 X ICSR 26	58	56	2	240	223	17	3.3	3.3	0.0	50.7	52.8	-2.1	3.4	2.9	0.5
SPLB 94004 X ICSR 97	71	74	-3	145	140	5	3.7	4.7	-1.0	43.1	39.3	3.8	3.2	3.2	0.0
SPLB 94007 X ICSR 97	69	68	1	150	170	-20	4.3	3.3	1.0	31.9	37.5	-5.6	2.7	2.9	-0.2
SPLB 94010 X ICSR 97	68	67	1	138	157	-19	3.7	3.3	0.4	30.1	36.5	-6.4	3.1	3.4	-0.3

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Genotypes	Days to 50% flowering (days)			Plant height (cm)			Agronomic score[1]			Grain yield plant^{-1} (g)			100 seed weight (g)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
SPLB 94011 X ICSR 97	67	68	-1	138	133	5	3.3	3.3	0.0	29.1	44.7	-15.6	2.9	3.3	-0.4
SPLB 94015 X ICSR 97	66	67	-1	132	137	-5	3.3	4.7	-1.4	31.8	32.5	-0.7	2.9	3.3	-0.4
SPLB 94016 X ICSR 97	69	70	-1	133	177	-44	4.7	4.7	0.0	14.3	15.5	-1.2	3.6	3.7	0.0
SPLB 94025 X ICSR 97	61	61	0	155	165	-10	3.3	5.3	-2.0	25.5	30.7	-5.2	3.0	3.2	-0.2
MR x S															
SPLB 94004 X ICSR 119	69	70	-1	187	187	0	4.7	4.3	0.4	17.4	18.7	-1.3	3.2	3.2	0.0
SPLB 94007 X ICSR 119	66	69	-3	190	177	13	3.3	3.3	0.0	32.9	16.4	16.5	3.3	3.8	-0.5
SPLB 94010 X ICSR 119	67	66	1	193	187	6	4.3	3.3	1.0	18.1	29.6	-11.5	3.4	3.2	0.2
SPLB 94011 X ICSR 119	66	68	-2	167	152	15	2.7	4.7	-2.0	45.5	44.3	1.2	3.0	3.3	-0.3
SPLB 94015 X ICSR 119	70	70	0	145	155	-10	4.7	4.7	0.0	26.2	29.3	-3.1	3.6	3.7	-0.1
SPLB 94016 X ICSR 119	69	70	-1	195	183	12	5.0	4.3	0.7	35.2	35.9	-0.7	3.7	3.6	0.1
SPLB 94025 X ICSR 119	61	62	-1	203	220	-17	3.3	3.3	0.0	47.3	46.1	1.2	3.1	3.2	-0.1
SPLB 94004 X ICSR 90030	69	67	2	173	157	16	3.7	4.0	-0.3	22.9	49.9	-27.0	2.4	3.2	-0.8
SPLB 94007 X ICSR 90030	60	59	1	157	157	0	3.3	3.0	0.3	32.9	32.7	0.2	3.2	3.1	0.1
SPLB 94010 X ICSR 90030	65	66	-1	187	167	20	3.3	2.3	1.0	30.9	43.9	-13.0	3.6	3.3	0.3
SPLB 94011 X ICSR 90030	61	65	-4	180	177	3	3.0	2.3	0.7	37.9	27.3	10.6	3.5	2.9	0.6
SPLB 94015 X ICSR 90030	67	66	1	177	170	7	3.3	3.0	0.3	29.1	36.3	-7.2	3.2	3.1	0.1
SPLB 94016 X ICSR 90030	68	66	2	143	173	-30	5.0	2.7	2.3	29.3	32.1	-2.8	3.1	3.2	-0.1
SPLB 94025 X ICSR 90030	59	60	-1	203	187	16	3.3	3.7	-0.4	28.9	25.0	3.9	2.9	2.9	0.0
MR x HS															
SPLB 94004 X ICSR 91025	68	68	0	253	243	10	3.0	3.7	-0.7	47.7	34.3	13.4	2.4	2.7	-0.3
SPLB 94007 X ICSR 91025	67	66	1	227	240	-13	2.7	3.0	-0.3	50.1	47.5	2.6	2.3	2.7	-0.4
SPLB 94010 X ICSR 91025	67	67	0	250	237	13	2.7	2.7	0.0	27.3	30.4	-3.1	2.4	3.1	-0.7
SPLB 94011 X ICSR 91025	68	65	3	243	253	-10	3.3	2.7	0.6	32.3	45.5	-13.2	2.4	3.2	-0.8
SPLB 94015 X ICSR 91025	67	67	0	250	257	-7	3.7	3.7	0.0	26.0	30.2	-4.2	2.2	2.7	-0.5
SPLB 94016 X ICSR 91025	68	67	1	263	260	3	3.3	3.7	-0.4	27.1	35.2	-8.1	2.2	2.3	0.1
SPLB 94025 X ICSR 91025	60	60	0	257	247	10	3.7	3.7	0.0	29.0	33.5	-4.5	2.6	2.5	0.1

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Genotypes	Days to 50% flowering (days)			Plant height (cm)			Agronomic score[1]			Grain yield $plant^{-1}$ (g)			100 seed weight (g)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
S x R															
PLB 94001 X A 2267-2	68	67	1	277	287	-10	3.3	3.0	0.3	39.0	50.6	-11.6	2.5	2.6	-0.1
PLB 94003 X A 2267-2	70	72	-2	208	218	-10	4.0	3.7	0.3	31.9	35.1	-3.2	3.4	3.1	0.3
PLB 94006 X A 2267-2	68	67	1	243	247	-4	3.0	3.0	0.0	34.4	31.1	3.3	2.4	2.7	-0.3
PLB 94009 X A 2267-2	58	57	1	217	213	4	3.0	2.3	0.7	30.7	45.6	-14.9	3.3	3.5	-0.2
PLB 94014 X A 2267-2	68	70	-2	260	257	3	3.7	3.3	0.4	18.8	22.0	-3.2	2.6	2.8	-0.2
PLB 94019 X A 2267-2	67	66	1	175	253	-78	3.3	2.3	1.0	44.5	54.5	-10.0	3.2	3.0	0.2
PLB 94021 X A 2267-2	67	67	0	247	247	0	3.7	3.3	0.4	29.7	38.9	-9.2	3.5	3.1	0.4
PLB 94022 X A 2267-2	68	67	1	262	257	5	3.7	2.7	1.0	41.1	45.5	-4.4	3.2	2.9	0.3
PLB 94024 X A 2267-2	62	63	-1	230	247	-17	3.0	2.7	0.3	50.5	54.1	-3.6	3.1	3.0	0.1
S x MR															
SPLB 94001 X ICSR 26	61	62	-1	197	200	-3	3.0	2.7	0.3	32.5	42.2	-9.7	2.4	2.9	-0.5
SPLB 94003 X ICSR 26	63	66	-3	177	185	-8	4.0	3.7	0.3	28.1	30.0	-1.9	3.2	3.2	0.0
SPLB 94006 X ICSR 26	63	62	1	193	197	-4	4.0	3.7	0.3	27.7	34.2	-6.5	2.7	2.6	0.1
SPLB 94009 X ICSR 26	56	55	1	167	180	-13	3.7	3.7	0.0	30.8	20.3	10.5	3.3	3.3	0.0
SPLB 94014 X ICSR 26	65	64	1	230	237	-7	3.0	3.0	0.0	26.1	41.6	-15.5	2.9	3.3	-0.4
SPLB 94019 X ICSR 26	65	66	-1	203	200	3	3.3	2.7	0.6	61.5	50.6	10.9	2.9	3.0	-0.1
SPLB 94021 X ICSR 26	62	62	0	200	190	10	4.0	3.7	0.3	25.1	32.2	-7.1	3.0	2.8	0.2
SPLB 94022 X ICSR 26	64	64	0	160	200	-40	3.7	3.0	0.7	17.9	35.3	-17.4	2.3	2.6	-0.3
SPLB 94024 X ICSR 26	60	59	1	207	207	0	2.7	3.0	-0.3	46.5	47.9	-1.4	2.9	3.0	-0.1
SPLB 94001 X ICSR 97	64	68	-4	180	173	7	3.0	3.0	0.0	38.7	32.2	6.5	2.8	2.2	0.6
SPLB 94003 X ICSR 97	68	67	1	167	180	-13	4.3	3.0	1.3	18.7	35.1	-16.4	3.3	3.3	0.0
SPLB 94006 X ICSR 97	65	65	0	157	152	5	3.7	4.0	-0.3	35.2	22.0	13.2	3.0	3.1	-0.1
SPLB 94009 X ICSR 97	58	58	0	140	142	-2	3.3	3.7	-0.4	28.5	27.1	1.4	3.3	3.5	-0.2
SPLB 94014 X ICSR 97	68	68	0	190	198	-8	4.7	4.7	0.0	15.1	19.1	-4.0	2.9	3.2	-0.3
SPLB 94019 X ICSR 97	67	66	1	157	170	-13	2.0	2.0	0.0	38.2	49.9	-11.7	3.1	3.3	-0.2
SPLB 94021 X ICSR 97	66	67	-1	170	163	7	3.7	3.7	0.0	20.1	31.8	-11.7	3.1	3.2	-0.1
SPLB 94022 X ICSR 97	68	65	3	165	183	-18	4.0	2.3	1.7	17.8	47.1	-29.3	3.2	3.3	-0.1
SPLB 94024 X ICSR 97	61	61	0	160	163	-3	3.7	3.3	0.4	18.3	28.1	-9.8	3.0	3.2	-0.2

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Genotypes	Days to 50% flowering (days)			Plant height (cm)			Agronomic score[1]			Grain yield $plant^{-1}$ (g)			100 seed weight (g)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
LS x S															
SPLB 94001 X ICSR 119	62	62	0	207	213	-6	2.7	3.0	-0.3	45.4	44.4	1.0	3.4	2.8	0.6
SPLB 94003 X ICSR 119	67	67	0	197	193	4	3.3	3.0	0.3	19.7	29.7	-10.0	3.1	3.3	-0.2
SPLB 94006 X ICSR 119	68	67	1	200	200	0	4.0	2.7	1.3	16.7	35.4	-18.7	2.8	3.3	-0.5
SPLB 94009 X ICSR 119	58	59	-1	173	160	13	3.7	3.3	0.4	25.5	33.7	-8.2	3.6	3.4	0.2
SPLB 94014 X ICSR 119	67	70	-3	210	202	8	4.3	5.0	-0.7	18.5	17.2	1.3	2.9	3.2	-0.3
SPLB 94019 X ICSR 119	68	66	2	175	200	-25	2.3	2.0	0.3	27.5	53.2	-25.7	3.0	3.4	-0.4
SPLB 94021 X ICSR 119	67	68	-1	193	163	30	3.0	3.3	-0.3	18.1	27.4	-9.3	3.2	3.3	-0.1
SPLB 94022 X ICSR 119	66	65	1	165	203	-38	4.3	3.0	1.3	24.6	30.7	-6.1	3.1	2.8	0.3
SPLB 94024 X ICSR 119	62	60	2	160	180	-20	4.0	3.7	0.4	23.7	29.7	-6.0	2.9	3.1	-0.2
SPLB 94001 X ICSR 90030	60	58	2	197	207	-10	2.7	2.7	0.0	33.1	34.3	-1.2	2.7	2.8	-0.1
SPLB 94003 X ICSR 90030	68	67	1	150	157	-7	4.7	3.7	1.0	30.0	32.8	-2.8	2.7	2.6	0.1
SPLB 94006 X ICSR 90030	65	62	3	180	180	0	3.0	2.7	0.3	27.0	29.6	-2.6	2.5	3.2	-0.7
SPLB 94009 X ICSR 90030	58	58	0	167	160	7	3.0	3.0	0.0	40.5	41.4	-0.9	3.4	3.1	0.3
SPLB 94014 X ICSR 90030	63	66	-3	197	187	10	3.0	3.3	-0.3	34.6	27.3	7.3	3.1	3.3	-0.2
SPLB 94019 X ICSR 90030	61	58	3	160	177	-17	3.3	3.0	0.3	37.0	37.3	-0.3	3.1	3.2	-0.1
SPLB 94021 X ICSR 90030	63	62	1	180	180	0	3.0	2.7	0.3	33.6	32.3	1.3	3.0	3.2	-0.2
SPLB 94022 X ICSR 90030	59	58	1	183	183	0	3.0	3.0	0.0	32.9	34.1	-1.2	3.1	3.2	-0.1
SPLB 94024 X ICSR 90030	56	56	0	173	183	-10	3.3	3.0	0.3	21.7	48.5	-26.8	3.1	3.2	-0.1
LS x HS															
SPLB 94001 X ICSR 91025	62	61	1	250	247	3	3.7	3.7	0.0	23.3	43.4	-20.1	2.7	3.3	-0.6
SPLB 94003 X ICSR 91025	68	67	1	237	253	-16	5.0	3.0	2.0	15.3	37.1	-21.8	2.0	2.4	-0.4
SPLB 94006 X ICSR 91025	67	67	0	253	253	0	3.7	3.3	0.4	26.8	32.0	-5.2	2.4	2.6	-0.2
SPLB 94009 X ICSR 91025	57	57	0	193	190	3	4.0	3.7	0.3	20.2	29.0	-8.8	3.4	3.8	-0.4
SPLB 94014 X ICSR 91025	67	68	-1	250	223	27	3.7	2.3	1.4	22.1	19.7	2.4	2.7	2.9	-0.2
SPLB 94019 X ICSR 91025	68	66	2	240	230	10	2.7	2.7	0.0	58.7	49.0	9.7	3.0	2.7	0.3
SPLB 94021 X ICSR 91025	67	66	1	250	260	-10	3.0	3.0	0.0	30.7	44.1	-13.4	2.8	3.0	-0.2
SPLB 94022 X ICSR 91025	64	62	2	267	243	24	2.7	3.0	-0.3	46.9	47.6	-0.7	3.3	3.0	0.3
SPLB 94024 X ICSR 91025	60	60	0	233	233	0	3.0	3.0	0.0	37.9	28.0	9.9	2.6	2.7	-0.1

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Genotypes	Days to 50% flowering (days)			Plant height (cm)			Agronomic score[1]			Grain yield plant^{-1} (g)			100 seed weight (g)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
x R															
PLB 94017 X A 2267-2	67	68	-1	270	283	-13	3.3	3.0	0.3	27.7	53.9	-26.2	2.7	2.9	-0.2
x MR															
PLB 94017 X ICSR 26	62	63	-1	210	217	-7	3.3	2.7	0.6	36.2	47.1	-10.9	2.6	2.8	-0.2
PLB 94017 X ICSR 97	64	67	-3	177	197	-20	4.0	3.0	1.0	30.6	46.7	-16.1	2.8	2.6	0.2
x S															
PLB 94017 X ICSR 119	65	67	-2	227	223	4	3.7	3.3	0.4	26.7	31.1	-4.4	3.4	2.7	0.7
PLB 94017 X ICSR 90030	61	61	0	207	203	4	3.0	2.7	0.3	32.5	48.7	-16.2	2.7	2.9	-0.2
x HS															
PLB 94017 X ICSR 91025	67	63	4	253	270	-17	3.0	3.3	-0.3	53.0	35.5	17.5	2.4	2.3	0.1
IEAN	65.5	65.6	-0.1	191.2	194.1	-0.1	3.66	3.43	0.23	29.82	33.88	-4.1	2.90	2.98	-0.08
	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C
. Em	0.6	0.1	0.7	38.5	0.25.	2.8	0.35	0.03	0.38	1.54	0.21	2.37	0.08	0.01	0.11
.D. (5%)	1.2	0.2	1.5	77.1	0.50	5.7	0.71	0.07	0.77	3.08	0.42	4.75	0.18	0.02	0.22

. Scored on a (1-5) scale. **G = Genotypes** **G x C = Genotype x Cytoplasm interaction**

. The groups are based on the disease score **C = Cytoplasms**

Between the genotypes, the range for days to 50% flowering varied from 60 to 75 days (A-lines), 61 to 69 days (restorer lines), and 56 to 73 days (crosses). The genotypes which were early to flower were SPLB 94009 (LS, 60 days) and SPLB 94024 (LS, 63 days) among A-lines, ICSR 26 (MR, 61 days) and ICSR 90030 (S, 65 days) among restorer lines; and SPLB 94024 x ICSR 90030 (MR x S, 56 days), SPLB 94009 x ICSR 26 (LS x MR, 56 days), SPLB 94025 x ICSR 26 (MR x MR, 57 days) and SPLB 94009 x ICSR 91025 (LS x HS, 57 days) among the crosses. However, the two A-lines recorded significant differences between their cytoplasms.

4.6.8 Plant Height

The cytoplasmic studies showed that the genotypes with A cytoplasm were significantly dwarf (191.2 cm) than A cytoplasm (194.1 cm) and the difference between the two mean values was higher than the C.D. value (0.48)

Genotype, cytoplasm interaction showed that the A-lines, 94004, 94007 and 94016 (MR), 94006 (LS) and 94017 (S) were significantly different from their B-lines for plant height, while the rest of the parental lines did not contribute to significant differences. Among the 102 hybrids studied, majority (66) of the A-line hybrids were significantly different from their B-line hybrids. The cross, 94015A x ICSR 97 (MR x MR) was found to be dwarf (132.0 cm) and was not significantly different from its B-line hybrid. Similarly was the cross 94011A x ICSR 97. On the other hand, the cross, 94001B x A 2267-2 with a height of 287.0 cm exhibited significant difference from its corresponding B-line hybrid (Table 25).

Comparison between genotypes showed that the plant height ranged from 112 to 207 cm (A-lines), 132 to 225 cm (restorer lines), and 134 to 282 cm (crosses). Among A-lines, SPLB 94011 (MR, 112 cm) followed by SPLB 94009 (LS, 135 cm) and SPLB 94010 (R, 135 cm) were dwarf and did not exhibit significant differences between the two types of cytoplasms used. Among restorer lines, ICSR 97 (MR, 132 days) was found to be dwarf. The crosses which could not show considerable height of the plant and did not exhibit significant differences with respect to (A x R) and (B x R) hybrids were SPLB 94015 x ICSR 97 (MR x MR, 134 cm) and SPLB 94011 x ICSR 97 (MR x MR, 136 cm).

4.6.9 Agronomic Score

Cytoplasmic studies showed that least score of 3.4 was recorded by genotypes with B-cytoplasm and were significantly different (CD = 0.063) from A-cytoplasm (3.7).

Results of genotype x cytoplasm effects indicated that SPLB 94024 (MR, 3.3) and SPLB 94025 (MR, 3.7) did not show significant differences with respect to two types of cytoplasms used (Table 25). The A-lines with significant differences between cytoplasms were SPLB 94009, SPLB 94019, SPLB 94021 and SPLB 94022 (LS). Majority of the crosses did not exhibit significant differences between A-line and B-line hybrids. However, SPLB 94019A x ICSR 97 (MR x MR, 2.0) and SPLB 94019A x ICSR 119 (MR x LS, 2.3) exhibited agronomic desirability and were not significantly different from their corresponding B-line hybrids (CD = 0.711). While the crosses which exhibited differences with respect to cytoplasms were SPLB 94004, SPLB 94007 and SPLB 94015 with ICSR 97 (MR x MR); and SPLB 94010 and SPLB 94011 with ICSR 119 and SPLB 94016 x ICSR 90030 (MR x S).

Between the genotypes, agronomic score ranged from 3.3 to 5.0 (A-lines), 3.0 to 4.7 (restorer lines) and 2.0 to 4.7 (crosses). Among A-lines, SPLB 94024 (MR) were agronomically desirable (3.3) and was not significantly different from SPLB 94025 (MR, 3.7) (CD = 0.684). ICSR 97 (MR) and ICSR 119 (LS) among restorer lines recorded minimum score of 3.0. Among the crosses, SPLB 94019 x ICSR 97 (LS x MR, 2.0), SPLB 94019 x ICSR 119 (LS x S, 2.2) and SPLB 94009 x A 2267-2 (LS x R, 2.7), SPLB 94011 x A 2267-2 (MR x R, 2.7), SPLB 94011 x ICSR 90030 (MR x S, 2.7) and SPLB 94010 x ICSR 91025 (MR x HS, 2.7) were found to be agronomically desirable.

4.6.10 Grain Yield Plant^{-1}

Among the cytoplasms, genotypes with B-cytoplasm recorded maximum grain yield (33.9 g) than genotypes with A-cytoplasm (29.8 g) and the two cytoplasms were significantly different from each other (CD: 0.404).

Study of genotype, cytoplasm interaction indicated that, the B-line SPLB 94025B (MR) recorded maximum grain yield (33.9 g) and was significantly different from it's A-line SPLB 94025A (20 g). Similar was the case with SPLB 94021B (LS). On the other hand, SPLB 94006A (LS) with maximum grain yield of 28.9 g was not significantly different from its corresponding B-line (28.0 g). The A-lines with significant difference from their respective B-lines were SPLB 94010, SPLB 94011, SPLB 94015 and SPLB 94025 (MR) and SPLB 94009, SPLB 94019, SPLB 94021 and SPLB 94022 (LS). The crosses involving B-lines with maximum grain yield and significantly different (CD: 6.121) from their corresponding A-line hybrids were SPLB 94017B x A 2267-2 (LS x R, 53.9 g), SPLB 94019B x A 2267-2 (MR x R, 54.5 g), and SPLB 94019B x ICSR 119 (MR x LS, 53.2 g). On the other hand, B-line hybrids which recorded maximum yields and were not significantly different from their corresponding A–line hybrids were SPLB 94024B x A 2267-2 (MR x R, 54.1 g) and SPLB 94025B x ICSR 26 (MR x MR, 52.8 g). About 50% of the cross combinations in each group exhibited significant differences with two types of cytoplasms used. SPLB 94010A, a MR female parent with all the restorer lines except ICSR 91025 was significantly different from its corresponding B-line hybrid (Table 25).

Genotypic comparison showed that grain yield plant^{-1} ranged from 14.8 to 28.4 g (A-lines), 22.2 to 33.1 g (R-lines) and from 14.9 to 56.1 g (crosses). Highest grain yield plant^{-1} was recorded by SPLB 94006 (LS, 28.4 g) and SPLB 94010 (R, 27.8 g) among A-lines, and ICSR 90030 (S) among R-lines (33.1 g). Though the two crosses viz., SPLB 94019 x ICSR 26 (MR x MR, 56.1 g) and SPLB 94019 x ICSR 91025 (MR x S, 53.9 g) recorded maximum grain yields did not exhibit significant difference with respect to maternal cytoplasmic effect. The F_1, involving parents with high grain yield, SPLB 94006 x ICSR 90030 (LS x S, 28.3 g), was found to be low to medium seed yielder.

4.6.11 100 Seed Weight

Genotypes with B-cytoplasm recorded higher seed weight (2.98 g) than A cytoplasm (2.90 g). It also indicated the significant difference among the seed weight with the derivatives of cytoplasm used (Table 25).

Comparison of genotypes x cytoplasms effects showed that the B cytoplasmic line i.e., SPLB 94015B (MR, 3.8 g) showed maximum seed weight and significant difference with its counterpart (which was derived with A cytoplasm-2.7 g). On the other hand, SPLB 94014A (LS, 3.5 g) with bold seeds was not significantly different from its A-line (3.3 g). The A-lines, SPLB 94007A, SPLB 94011A, SPLB 94015A and SPLB 94025A (MR), SPLB 94009A, SPLB 94019A, SPLB 94021A and SPLB 94022A (LS); and SPLB 94017A (S) were significantly different from their corresponding B-parents. The crosses of B-lines which exhibited maximum seed weight and significant differences with their corresponding (A x R) hybrids were SPLB 94009B x ICSR 91025 (LS x S, 3.8 g), SPLB 94010B x ICSR

26 (R x MR, 3.5 g) and SPLB 94009B x ICSR 97 (LS x MR, 3.5 g). On the other hand, the crosses SPLB 94016B x ICSR 97 (MR x MR, 3.7 g), SPLB 94015B x ICSR 119 (MR x LS, 3.7 g) and SPLB 94016B x ICSR 119 (MR x LS, 3.6 g) recorded maximum seed weight and were not significantly different from its corresponding (A x R) hybrid (CD = 0.221).

Comparison between genotypes showed that the 100 seed weight for A-lines ranged from 2.2 to 3.4 g, for restorer lines from 2.2 to 3.2 g and for crosses from 2.0 to 3.7 g. Among A-lines, SPLB 94014 (LS) recorded maximum seed weight of 3.4 g and was significantly different (CD = 0.161) from SPLB 94010 (R, 3.1 g) and SPLB 94003 (3.1 g, MR). ICSR 97 (MR) and A 2267-2 (R) among restorer lines recorded 100 seed weight of 3.2 g. Whilst among crosses, SPLB 94016 x ICSR 97 (MR x MR, 3.7 g) and SPLB 94016 x ICSR 119 (MR x LS, 3.7 g) recorded bold seeds. However, the F_1, SPLB 94014 x ICSR 97 (high x high parents) recorded moderate seed weight of 3.1 g.

4.7 CORRELATIONS

Character associations among various disease resistant parameters and its association with the yield contributing characters are presented in Table 26 for *rabi*, 1996 and 1997 seasons, respectively.

4.7.1 Disease Damage Score

Resistance as indicated by disease damage score, showed significant positive association with fleck number only during second year (Table 26). However resistance as indicated by disease damage score recorded significant negative association with lodging in the first year, while with length of the lesion, width of the lesion, area of the lesion and total leaf area damage in both the years Positive association of disease damage score with

Table 26 . Correlation coefficients among various disease resistant parameters and yield contributing characters, rabi season 1996 and 1997. (n=146)

Characteristic	Year	Disease score[1]	Length of the lesion (cm)	Width of the lesion (cm)	Area of the lesion (cm^2)	Number of lesions (no)	Total leaf area damage (cm^2)	Number of flecks (no)	Lodging (%)	Days to 50% flowering (days)	Plant height (cm)	Agronomi score[2]	Grain yield $plant^{-1}$ (g)	100 seed weight (g)
Disease score[1]	96	1.000	0.223**	0.304**	0.246**	0.065	0.318**	0.151	0.208**	0.033	0.115	-0.103	-0.013	0.104
	97	1.000	0.478**	0.416**	0.414**	0.004	0.465**	-0.209**	NR	0.111	0.048	0.032	-0.095	-0.207*
Length of the lesion (cm)	96		1.000	0.652**	0.764**	-0.283**	0.465**	-0.075	0.134	-0.010	-0.080	-0.067	0.026	-0.067
	97		1.000	0.875**	0.955**	-0.315**	0.565**	-0.372**	NR	0.033	-0.113	0.149	-0.176*	-0.034
Width of the lesion (cm)	96			1.000	0.891**	-0.354**	0.499**	0.002	-0.053	0.037	-0.076	0.099	-0.039	0.045
	97			1.000	0.928**	-0.264**	0.556**	-0.208**	NR	0.169*	-0.025 *	0.245**	-0.224**	0.009
Area of the lesion (cm^2)	96				1.000	-0.293**	0.576**	-0.007	0.038	-0.049	-0.076	0.062	-0.052	-0.035
	97				1.000	-0.305**	0.571**	-0.302**	NR	0.130	-0.144	0.224**	-0.174*	-0.028
Number of lesions (no)	96					1.000	0.397**	0.616**	0.126	-0.179*	0.146	-0.231**	0.061	0.065
	97					1.000	0.438**	0.586**	NR	0.059	0.124	-0.176*	0.037	-0.129
Total leaf area damage	96						1.000	0.461**	0.137	-0.214*	0.200**	-0.224**	0.131	0.103
(cm^2)	97						1.000	0.143	NR	0.115	0.037	0.104	-0.156	-0.157
Number of flecks (no)	96							1.000	-0.060	-0.124	-0.065	-0.323**	0.226**	0.264**
	97							1.000	NR	0.269**	-0.082	-0.031	0.025	-0.065
Lodging (%)	96								1.000	-0.123	-0.065	-0.135	0.066	-0.402**
	97								NR	NR	NR	NR	NR	NR
Days to 50% flowering	96									1.000	0.163*	0.123	-0.160	-0.021
(days)	97									1.000	-0.094	0.433**	-0.203*	-0.097
Plant height (cm)	96										1.000	-0.377*	0.339*	0.437*
	97										1.000	-0.349**	0.304**	-0.144
Agronomic score[2]	96											1.000	-0.517**	-0.109
	97											1.000	-0.603**	-0.042
Grain yield $plant^{-1}$ (g)	96												1.000	0.208**
	97												1.000	0.182*
100 seed weight (g)	96													1.000
	97													1.000

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
** Significant at 1%.
* Significant at 5%.
NR-Not recorded

100 seed weight was noticed in the second season only. On the other hand, resistance as indicated by disease damage score had no association with days to 50% flowering, plant height, agronomic score, grain yield plant^{-1} and 100 seed weight in the first year, whereas with lesion number in both the years,

4.7.2 Length of the Lesion

Length of the lesion showed significant positive association with width of the lesion, area of the lesion and total leaf area damage in both the seasons. This showed an increase in the length of the lesion contributed to increase in area of the lesion. On the other hand, length of the lesion showed significant negative association with number of flecks and grain yield plant^{-1} in the second season , while with number of lesions in both the seasons. Thus an increase in length of the lesion led to a decrease in number of lesions thereby increasing the lesion area per each lesion. However, it had no association with lodging and number of flecks in the first year, while with days to 50% flowering, agronomic score and 100 seed weight in both the seasons.

4.7.3 Width of the Lesion

Correlation studies for both the years indicated that width of the lesion recorded significant positive association with area of the lesion and total leaf area damage. However, width of the lesion showed significant negative association with number of flecks in the second season only. On the other hand, significant negative correlation was observed with number of flecks, lodging per cent, days to 50% flowering, plant height, agronomic score and grain yield plant^{-1} in the first year, while with number of lesions in both the seasons. On the other hand negative associations were observed with plant height, agronomic score and grain yield plant^{-1}, while significant positive association with days to 50% flowering in the second year. No correlation with seed weight was noticed in both the seasons.

4.7.4 Area of the Lesion

Area of the lesion showed significant negative association with number of flecks in the second season only, whereas with number of lesions in both the years. Also exhibited significant positive association with total leaf area damage in both the years However, significant negative association with agronomic score and grain yield plant^{-1} was reported in the second year. No significant association was noticed with number of flecks, lodging, agronomic score and grain yield plant^{-1} in the first year, while with days to 50% flowering, plant height and 100 seed weight in both the years.

4.7.5 Number of Lesions

Lesion number showed significant positive association with fleck number and total leaf area damage in both the years. Thus as the lesion number increased, the fleck number also increased. On the other hand, significant negative association was noticed with days to 50% flowering in the first year and positive association with agronomic score in both the years. While, it has recorded no association with lodging, plant height, grain yield plant^{-1} and 100 seed weight in 1996; and days to 50% flowering, plant height, grain yield plant^{-1} and 100 seed weight in the second year.

4.7.6 Total Leaf Area Damage

During first year, total leaf area damage exhibited significant positive association with fleck number, plant height and agronomic score, while significant negative association with days to 50% flowering. Total leaf area damage has not shown any form of association with lodging, grain yield plant^{-1} and 100 seed weight in the first year, while with any of the characters in the second year.

4.7.7 Number of Flecks

Significant positive association of number of flecks was observed with days to 50% flowering in the second year, while with agronomic score, grain yield plant^{-1} and 100 seed weight in the first year. However, no significant association was observed with lodging, days to 50% flowering and plant height in the first year; and plant height, agronomic score, grain yield plant^{-1} and 100 seed weight in the second year.

4.7.8 Lodging

Lodging showed significant negative association with 100 seed weight; and non significant positive association with agronomic score and grain yield plant^{-1} in the first year. The association with days to 50% flowering and plant height was negative and non-significant.

4.7.9 Days to 50% Flowering

Days to 50% flowering recorded significant positive association with plant height in the first year. While significant negative relationship with agronomic desirability and grain yield plant^{-1} was noticed in the second year. However, no significant association was observed with agronomic desirability, grain yield plant^{-1} and 100 seed weight in the first year; and plant height and 100 seed weight in the second year.

4.7.10 Plant Height

Plant height exhibited significant positive association with agronomic score and grain yield plant^{-1} in both the years. In addition, significant positive association was also noticed with 100 seed weight in the first year However, no significant positive correlation was observed with 100 seed weight in the second year.

4.7.11 Agronomic Score

Agronomic score recorded significant positive association with grain yield plant^{-1} in both the years. While no significant positive association with 100 seed weight was reported in both the years. (Table 26)

4.7.12 Grain Yield Plant^{-1}

Grain yield plant^{-1} showed significant positive association with 100 seed weight in both the years.

4.8 VARIABILITY

Since the efficiency of selection largely depends on the extent of genetic variability present in the population, knowledge of variability for important disease parameters provide a meaningful insight for further improvement of the disease characters. The results from the analysis of variance were used for calculating variability parameters like phenotypic and genotypic variance, genotypic and phenotypic coefficient of variation, heritability (broad sense), genetic advance and genetic advance as per cent of mean for various disease resistant parameters and yield contributing characters for *rabi* 1996 and *rabi* 1997, respectively and are presented in Table 27.

4.8.1 Genotypic and Phenotypic Variances

In general, the phenotypic variance (PV) was more than genotypic variance (GV) indicating the influence of environment in controlling the characters. Maximum genotypic and phenotypic variances were reported by fleck number during first (7660.8, 8042.1) and second years (33761.83, 32322.46), respectively followed by plant height. On the other hand, disease parameters like lesion number recorded medium GV and PV of 35.36 and 36.59, respectively, during first year; and low variability of 9.94 and 10.60 during second year. On the other hand, of all the disease resistant parameters, width of the lesion exhibited very low genotypic variance (0.003 and 0.005) and phenotypic variance (0.004 and 0.007) for rabi 1996 and 1997 respectively. Other disease resistance parameters like disease damage score recorded low genotypic variance (0.89) and phenotypic variance (1.33) during second year than first year (1.69 and 2.21, respectively). While low variability was noticed for length of the lesion for both the years but the difference between phenotypic variance and genotypic variance was narrow (0.18) for second year compared to the first year (0.97).

Among the yield contributing characters, grain yield plant^{-1} recorded medium GV (54.90) and PV (70.44) during first year; and high GV (101.20) and PV (106.22) during second year. Other characters like 100 seed weight (0.10, 0.14 and 0.16, 0.19) and agronomic score recorded low variability (genotypic and phenotypic) during first year (0.10, 0.14 and 0.24, 0.56) and second year (0.16, 0.19, and 0.46, 0.74), respectively. Data given in Table 27 showed that lodging recorded very high variability (244.50 and 463.80) and the difference between GV and PV was also high (219.30) indicating great influence of the environment.

Table 27. Variability parameters for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1996 and 1997.

Characteristic	Year	Genotypic variability (GV)	Phenotypic variability (PV)	Genotypic coefficient of variability (GCV)	Phenotypic coefficient of variability (PCV)	Heritability (H^2)	Genetic advance (GA)	Genetic advance as % of mean (GG)
DISEASE PARAMETERS								
Disease score[1]	96	1.690	2.210	25.000	28.590	76.470	2.340	45.000
	97	0.890	1.330	19.650	24.030	66.920	1.590	33.130
Length of the lesion (cm)	96	0.790	1.760	48.310	72.100	44.890	1.230	66.850
	97	0.990	1.170	37.730	40.940	84.930	1.890	71.590
Width of the lesion (cm)	96	0.003	0.004	23.810	27.500	75.000	0.100	43.480
	97	0.005	0.007	22.810	26.990	71.430	0.120	38.710
Area of the lesion (cm^2)	96	0.170	0.180	45.730	48.090	95.100	13.590	1527.000
	97	0.270	0.320	58.380	63.560	84.380	0.980	110.110
Number of lesions (no)	96	35.360	36.590	68.980	70.170	96.640	12.040	139.680
	97	9.940	10.600	52.020	53.720	93.750	6.290	103.800
Number of flecks (no)	96	7660.800	8042.100	65.620	67.230	95.260	175.980	131.940
	97	32322.460	33761.830	67.560	69.050	95.740	362.390	136.190
Lodging (%)	96	244.500	463.800	121.210	166.950	52.720	23.390	181.320
	97	NR	NR	NR	NR	NR	NR	NR
GRAIN COMPONENT CHARACTERS								
Days to 50% flowering (days)	96	17.320	22.070	5.180	5.840	78.480	7.590	9.440
	97	18.630	19.790	6.540	6.740	94.140	8.630	13.080
Plant height (cm)	96	575.860	600.880	15.990	16.330	95.840	48.400	32.250
	97	1496.030	1536.450	20.150	20.420	97.370	78.620	40.950
Agronomic score[2]	96	0.240	0.560	16.220	24.780	42.860	0.660	21.850
	97	0.460	0.740	18.250	23.190	61.960	1.100	29.730
Grain yield $plant^{-1}$ (g)	96	54.900	70.440	29.880	33.840	77.940	13.480	54.350
	97	101.200	106.220	34.390	35.240	95.270	20.230	69.160
100 seed weight (g)	96	0.100	0.140	10.170	12.030	71.430	0.550	17.680
	97	0.160	0.190	13.790	15.030	84.210	0.760	26.210

1. Scored on a (1-9) scale.
2. Scored on a (1-5)scale.
NR - Not recorded.

4.8.2 Genotypic and Phenotypic Coefficients of Variance

Since genotypic and phenotypic variances were associated with units, genotypic and phenotypic coefficients of variation were worked out for all the characters under study (Table 27)

Variability studies indicated that among the disease parameters, maximum GCV was recorded by lesion number (68.98) followed by fleck number (65.62) and length of the lesion (48.31). While width of the lesion (23.81) and disease damage score (25.00) recorded low variability during first year. Maximum genetic variability in the second year was recorded by fleck number (67.56) followed by area of the lesion (58.38), lesion number (52.02) and length of the lesion (37.73). On the other hand, disease damage score recorded lowest GCV (19.65) followed by width of the lesion (22.81).

Among the yield parameters, during first year, grain yield plant^{-1}(29.88), agronomic score (16.22), plant height (15.99), 100 seed weight (10.17) and days to 50% flowering (5.18) recorded GCV in decreasing order of magnitude. During second year also, grain yield plant^{-1} recorded maximum GCV (34.39) followed by plant height (20.15) and agronomic score (18.25). Whilst days to 50% flowering (6.54) and 100 seed weight (13.79) recorded low GCV. Lodging also recorded very high GCV of 121.21.

Length of the lesion recorded maximum PCV (72.10) followed by lesion number (70.17) and fleck number (67.23). On the other hand, disease damage score (28.59) and width of the lesion (27.50) recorded low PCV during first year. While maximum PCV during second year, was recorded by fleck number (69.05) and followed similar trend as GCV for other disease parameters i.e. area of the lesion (63.56), lesion number (53.72), length of the lesion (40.94), width of the lesion (26.99) and disease damage score (24.03) recorded PCV in the decreasing order of magnitude. Maximum difference between PCV and GCV (23.79) was recorded for length of the lesion during first year, while it was narrow (3.21) in the second year.

Further studies indicated that among the yield parameters, maximum PCV was recorded by grain yield plant^{-1} (33.84 and 35.24) followed by agronomic score (24.78 and 23.19) and plant height (16.33 and 20.42). Whilst days to 50% flowering recorded low PCV (5.84 and 6.74) followed by 100 seed weight (12.03 and 15.03). In general, PCV and GCV values were higher during first year than second year.

4.8.3 Heritability and genetic advance

Heritability and genetic advance are important selection parameters. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. The heritability and genetic advance for different characters under study are given in Table 27.

In general, heritability estimates for the second year were higher than first year. Very high heritability among the disease resistant parameters in the first year was recorded by lesion numbers (96.64), fleck number (95.26) and area of the lesion (95.10). While length of the lesion recorded heritability of 44.89% only. Disease damage score (76.47%) and width of the lesion (75.00%) also recorded high heritability. While, in the second year fleck number (95.74), lesion number (93.75), length of the lesion (84.93) and area of the lesion (84.38) recorded very high heritability. High heritability was recorded by width of the lesion (71.43) and disease damage score (66.92).

Studies on heritability indicated that very high heritability among the yield contributing characters was recorded by plant height (95.84 and 97.37) followed by days to 50% flowering (78.48 and 94.14), grain yield plant^{-1} (77.94 and 95.27) and 100 seed weight

(71.43 and 84.21) during 1996 and 1997, respectively. While agronomic score recorded high heritability of 42.86 and 61.96 during first and second years, respectively.

Genetic advance as per cent of mean followed similar trend as heritability for both the years. Very high genetic advance as per cent of mean was recorded by lesion number (139.68) and fleck number (131.94) during first year, while fleck number (136.19) and lesion number (103.80) in the second year. Other characters like length of the lesion (66.85 and 71.59) and width of the lesion (43.48 and 38.71) also recorded high genetic advance, whilst disease damage score recorded low genetic advance of 45.00 and 33.13 during first and second years, respectively.

Maximum genetic advance among the yield contributing characters for both the years was recorded by grain yield plant^{-1} (54.35 and 69.16) and plant height (32.25 and 40.95). While days to 50% flowering (9.44 and 13.08), agronomic score (21.85 and 29.73) and 100 seed weight (17.68 and 26.21) recorded low genetic advance as per cent of mean.

4.9 EPIDEMIOLOGY OF THE DISEASE

The data collected on the latent period i.e., time of appearance of symptoms after inoculation (HAI), area of the lesion (cm^2) at different time intervals after inoculation and sporulation capacity (ml^{-3}) for the genotypes selected from different groups of both (A x R) hybrids and (B x R) crosses are presented in Table 28. However, the grouping of the genotypes was done based on the average disease damage score for two consecutive years.

4.9.1 Time of Appearance of Symptoms

Among the A-lines, the susceptible genotype (296A) exhibited early symptoms of the disease (36h). While the resistant line, SPLB 94011 showed symptoms at 98h after

Table 28. Latent period, area of lesion at different time intervals after inoculation and sporulation capacity for selected genotypes of sorghum, rabi season 1997.

Genotypes	Disease reaction group[1]	Time of appearance of symptoms (HAI)	Area of the lesion (cm^2) at different time intervals after inoculation										Sporulation capacity (ml^{-1})
			10 DAI	12 DAI	14 DAI	17 DAI	19 DAI	21 DAI	24 DAI	26 DAI	28 DAI	Mean	
SPLB 94011B	R	98	0.020	0.040	0.060	0.063	0.063	0.067	0.120	0.123	0.123	0.073	4.37
SPLB 94011A	R	98	0.010	0.013	0.023	0.043	0.060	0.060	0.097	0.097	0.097	0.070	4.80
SPLB 94007B	MR	72	0.047	0.097	0.190	0.360	0.420	0.480	0.480	0.480	0.480	0.102	3.83
SPLB 94007A	MR	72	0.013	0.050	0.207	0.210	0.253	0.270	0.257	0.257	0.257	0.469	8.77
SPLB 94025B	LS	72	0.043	0.160	3.470	6.860	7.060	7.060	7.060	7.060	7.060	0.076	7.04
SPLB 94025A	LS	72	0.090	0.340	4.830	8.207	8.207	8.207	8.207	8.207	8.207	0.056	11.92
296A	S	36	0.010	0.017	0.160	0.520	0.600	1.500	2.240	4.500	5.830	0.197	13.13
A 2267-2	R	72	0.010	0.010	0.033	0.037	0.083	0.090	0.090	0.090	0.090	0.102	18.56
ICSR 90030	S	48	0.010	0.013	0.440	0.770	1.120	1.400	1.670	2.020	2.020	1.690	7.61
SPLB 94011B X A 2267-2	R x R	72	0.020	0.040	0.060	0.060	0.067	0.067	0.113	0.117	0.117	0.337	5.84
SPLB 94011A X A 2267-2	R x R	72	0.020	0.030	0.033	0.060	0.080	0.100	0.103	0.103	0.103	0.041	7.83
SPLB 94011B X ICSR 90030	R x S	48	0.010	0.010	0.013	0.040	0.150	0.173	0.173	0.173	0.173	1.697	5.03
SPLB 94011A X ICSR 90030	R x S	48	0.017	0.033	0.093	0.127	0.647	0.720	0.860	0.860	0.860	6.056	10.71
SPLB 94007B X A 2267-2	MR x R	72	0.010	0.020	0.023	0.033	0.033	0.060	0.063	0.063	0.063	0.188	6.80
SPLB 94007A X A 2267-2	MR x R	72	0.013	0.020	0.023	0.057	0.103	0.150	0.180	0.183	0.183	0.717	2.93
SPLB 94007B X ICSR 90030	MR x S	72	0.060	0.090	0.840	1.590	1.970	2.230	2.590	2.710	3.190	5.093	2.33
SPLB 94007A X ICSR 90030	MR x S	72	0.077	0.160	1.043	1.620	2.060	2.180	2.690	2.690	2.690	0.088	6.36
SPLB 94025B X A 2267-2	LS x R	72	0.013	0.013	0.060	0.080	0.083	0.087	0.150	0.153	0.153	0.205	4.77
SPLB 94025A X A 2267-2	LS x R	72	0.013	0.013	0.013	0.053	0.147	0.360	0.363	0.363	0.363	1.709	5.75
SPLB 94025B X ICSR 90030	LS x S	48	0.013	0.023	0.030	0.293	0.297	0.297	0.297	0.297	0.297	0.804	9.99
SPLB 94025A X ICSR 90030	LS x S	48	0.010	0.010	0.140	0.810	0.917	1.080	1.160	1.163	1.163	1.630	4.16
296A X A 2267-2	S x R	48	0.010	0.010	0.013	0.110	0.430	0.667	2.000	2.000	2.000	0.059	4.91
296A X ICSR 90030	S x S	36	0.023	0.030	0.290	1.020	1.550	1.920	3.200	3.320	3.320	1.052	2.91
Mean		64.890	0.025	0.054	0.526	1.001	1.148	1.271	1.485	1.610	1.689	0.979	6.972
S.Ed.		T =0.026		G=0.136			TxG=0.123						
LSD (5%)		0.051		0.315			0.246						

1. The groups are based on the average disease score for two years.

DAI = Days after inoculation. **T= Time** **T x G = Time x Genotype interaction**

HAI = Hours after inoculation. **G= Genotypes**

inoculation. Moderately resistant and less susceptible genotypes expressed symptoms at the same time i.e. at 72h after inoculation. Susceptible (ICSR 90030) and resistant (A 2267-2) restorer lines exhibited symptoms at 48 and 72h after inoculation respectively The hybrid, 296A x ICSR 90030 (S x S) showed symptoms at early stages i.e. at 36h after inoculation. While, hybrids belonging to R x S (SPLB 94011 x ICSR 90030) group, LS x S (SPLB 94025 x ICSR 90030) group and S x R (296A x A 2267-2) group expressed symptoms at 48h after inoculation. On the other hand, in the crosses SPLB 94011 x A 2267-2 (R x R), SPLB 94007 x A 2267-2 (MR x R), SPLB 94007 x ICSR 90030 (MR x S) and SPLB 94025 x A 2267-2 (LS x R) symptoms were noticed at 72h after inoculation.

4.9.2 Rate of Growth of Area of the Lesion

The data collected on area of the lesion (cm^2) at 10 DAI, 12 DAI, 14 DAI, 17 DAI, 19 DAI, 21 DAI, 24 DAI, 26 DAI and 28 DAI for the genotypes selected from different groups of both (A x R) hybrids and (B x R) crosses and their parents were analysed by repeated measures analysis of variance. Results showed significant differences among the genotypes, time intervals, and genotypes x time intervals at 1% and 5% level.(Table 28)

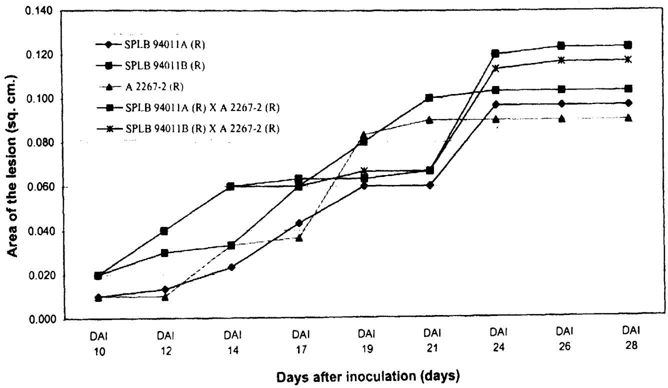
The results revealed that maximum leaf area affected among the parents was observed for SPLB 94025A (6.056 cm^2) and SPLB 94025B (5.093 cm^2) followed by 296A (1.709 cm^2). SPLB 94025A and SPLB 94025B exhibited significant differences (CD=0.136) at 5% level of significance (Table 28). Minimum area of the lesion was recorded by the resistant line (SPLB 94011B, 0.076 cm^2) which was not statistically different from SPLB 94011A (0.056 cm^2). Among testers, A 2267-2 (0.059 cm^2) exhibited minimum affected area, while ICSR 90030 recorded maximum affected area.

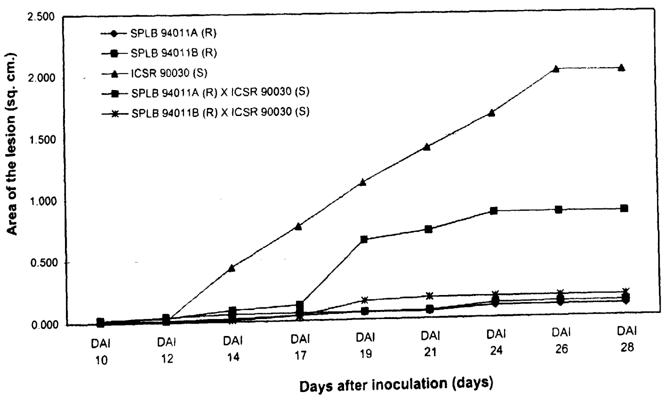
The area of the lesion showed a continuous increase from 10 DAI to 28 DAI and maximum area of the lesion was observed at 28 DAI which was statistically significant from the lesion area recorded at 26 DAI. Considering the rate of increase in lesion area at different time intervals, the pattern of lesion spreading was different for different genotypes. The difference was also noticed among the genotypes with different cytoplasmic backgrounds i.e., sterile and fertile cytoplasms.

The resistant parents, SPLB 94011B and SPLB 94011A, followed more or less similar trend. SPLB 94011A showed an increase upto 19 DAI (from 0.010 cm^2 to 0.060 cm^2) after which it remained constant till 21 DAI (0.060 cm^2). Again an increase in lesion area was observed from 21 DAI to 24 DAI (0.060 to 0.097 cm^2) and remained constant till 28 DAI (Fig. 1). The susceptible genotype, 296A recorded a continuous increase in leaf area till 28 DAI (0.010 cm^2 to 5.830 cm^2). Among testers, an increase in leaf area from 0.010 cm^2 (10 DAI) to 0.090 cm^2 (21 DAI) was noticed by A 2267-2 (R). Thereafter the lesion area remained constant till 28 DAI

The hybrids involving ICSR 90030 as the male parent recorded greater increase in lesion area. and average lesion area over different time intervals. Considering resistant x resistant hybrids, significant difference was not observed with respect to cytoplasm's. The hybrid SPLB 94011B x A 2267-2 over different time intervals (interaction effect) did not exhibit significant difference between any two-time intervals. SPLB 94011B x A 2267-2 increased till 19 DAI (from 0.020 cm^2 to 0.067 cm^2) and remained constant till 21 DAI and again showed an increase from 21 DAI to 26 DAI (0.067 to 0.117 cm^2) and afterwards remained constant. SPLB 94011A x A 2267-2 recorded an increase in leaf area till 24 DAI (0.020 cm^2 to 0.103 cm^2) and remained constant from 24 DAI to 28 DAI. While SPLB 94011B x ICSR 90030 (0.010 to 0.173 cm^2) and SPLB 94011A x ICSR 90030 showed an

Figure 1. Growth of blight lesion area at different intervals after inoculation for resistant (R) x resistant (R) and resistant (R) x susceptible (S) hybrids





increase till 21 DAI (0.017 cm^2 and 0.720 cm^2) and thereafter remained constant (Fig 1). The significant difference between cytoplasms was observed from 19 DAI for SPLB 94011A x ICSR 90030 (R x S), 17 DAI for SPLB 94025A x ICSR 90030 (LS x S) (Fig. 3) and at 28 DAI for SPLB 94007A x ICSR 90030 (MR x S) (Fig 2).

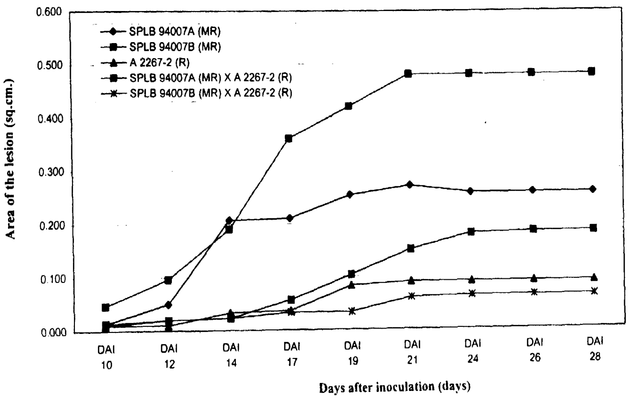
The hybrid between susceptible and resistant parents (296A x A 2267-2) recorded a continuous increase in lesion area from 0.010 cm^2 to 2.000 cm^2 (10 DAI to 24 DAI) and then remained constant (2.000 cm^2) till 28 DAI. More or less similar trend was observed for S x S hybrid (296A x ICSR 90030) which exhibited a continuous increase in lesion area till 26 DAI (from 0.023 cm^2 to 3.320 cm^2). However, increase in lesion area remained constant from 26-28 DAI (Fig. 4).

4.9.3 Sporulation Capacity

The data on sporulation capacity (Table 28) revealed that among A-lines maximum number of spores ml^{-3} was observed in 296A (13.13 spores ml^{-3}) followed by SPLB 94025A (11.92 spores ml^{-3}). While minimum number of spores were recorded by resistant (SPLB 94011B, 4.37 and SPLB 94011A, 4.80) and moderately resistant (SPLB 94007B, 3.83 spores ml^{-3}) A-lines. Among the testers, A 2267-2 exhibited maximum number of spores ml^{-3} (18.56), while ICSR 90030 recorded minimum number of spores (7.61 spores ml^{-3}).

Among the hybrids studied, SPLB 94011A x ICSR 90030 (R x S) recorded maximum number of spores (10.71spores ml^{-3}). While its corresponding B-line resulting hybrid recorded 5.03 spores ml^{-3} only, which is half the number of spores recorded by its corresponding A line. Of all the hybrids studied, minimum number of spores were noticed by SPLB 94007B x ICSR 90030 (MR x S, 2.33 spores ml^{-3}), while its corresponding A line

Figure 2. Growth of blight lesion area at different intervals after inoculation for moderately resistant (MR) x resistant (R) and moderately resistant (MR) x susceptible (S) hybrids



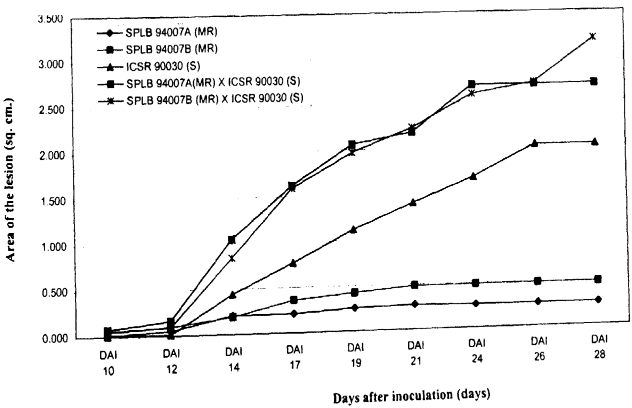
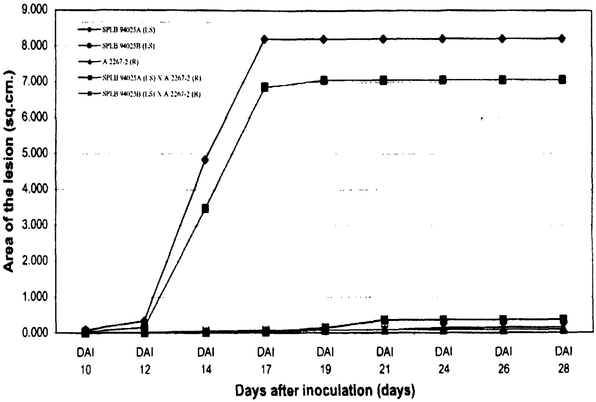


Figure 3. Growth of blight lesion area at different intervals after inoculation for less susceptible (LS) x resistant (R) and less susceptible (LS) x susceptible (S) hybrids



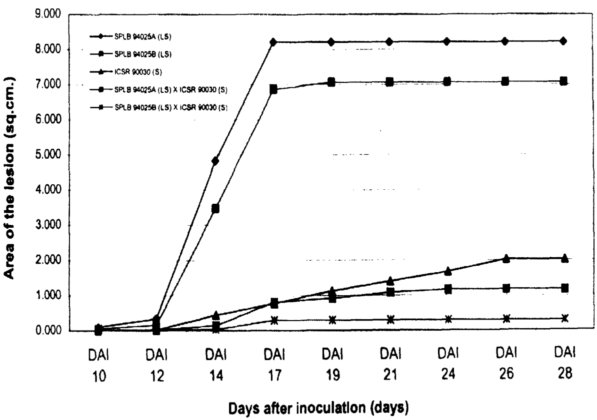
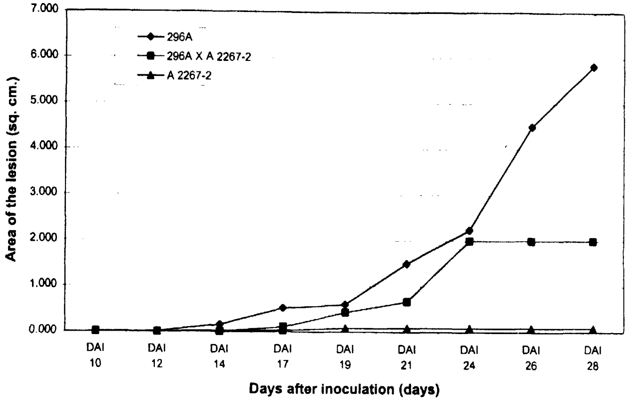
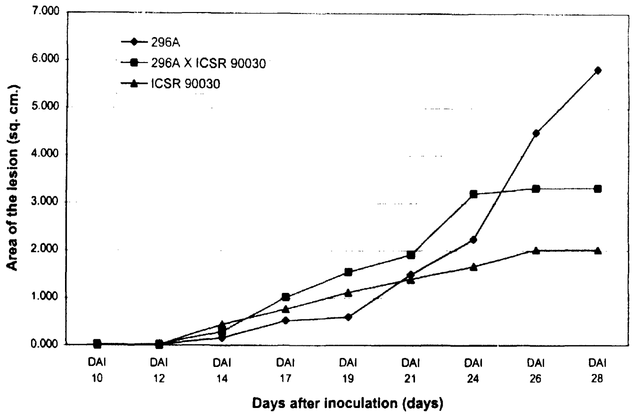


Figure 4. Growth of blight lesion area at different intervals after inoculation for susceptible (S) x resistant (R) and susceptible (S) x susceptible (S) hybrids





hybrid recorded 6.36 spores ml^{-3}. Similar behaviour was seen for the hybrids SPLB 94007A x A 2267-2 (MR x R, 2.93 spores ml^{-3}) and SPLB 94007B x A 2267-2 (MR x R, 6.80 spores ml^{-3}). The hybrid 296A x ICSR 90030 (S x S) also recorded minimum number of spores (2.91 spores ml^{-3}).

Discussion

CHAPTER V

DISCUSSION

Sorghum is an important grain and fodder crop of the country. Leaf blight is one of the most important foliar diseases of sorghum affecting grain and fodder yield and its quality. The safest and the most economical way to combat the disease is through the development of resistant or moderately resistant varieties having high yielding potential. At present most of the varieties and the hybrids under cultivation are susceptible to majority of foliar diseases (AICSIP, 1989). This might be due to earlier breeders have not put their concerted effort to develop leaf blight resistance. Since the disease is taking a severe toll in the recent years, there is a need to put efforts in this direction to develop leaf blight resistant hybrids. The information on genetics of the leaf blight disease resistance is of paramount importance in developing hybrids. Very limited studies were conducted on this aspect so far. Keeping this in view, the present investigation was initiated at ICRISAT-Patancheru during *rabi* 1996 and 1997 using 20 cytoplasmic male-sterile (CMS) lines, 17 male sterile maintainer (B) lines, and six restorer (R) lines crossed in a line x tester design to obtain 120 (A x R) hybrids and 102 (B x R) crosses.

5.1 MEAN PERFORMANCE

The incidence and severity of the disease on the host plant involves several complex interactions. The study of disease resistance is based upon disease intensity, i.e., length, width and area of the lesion, number of lesions and number of flecks. While, lodging (per cent) is an indirect measure to score the disease and scoring for disease severity with all the above parameters were integrated. A critical analysis of mean performance of the parents and hybrids for two consecutive years revealed significant genetic variation among the genotypes for various disease resistant parameters and grain yield characters.

Disease damage score, primarily reflecting difference in area of the lesion and lesion number ranged from low to high in both resistant and susceptible genotypes. Parental lines exhibited differential response to the disease parameters like length of the lesion, width of the lesion, area of the lesion, number of lesions and number of flecks. Moreover, the differences in overall disease damage score among genotypes indicated the presence of variability among parents and hybrids for susceptibility or resistance to blight. The mean disease damage score was more in 1996 compared to 1997 indicating that the disease was more in the first year than in the second year. When the other disease resistant parameters were taken into consideration, the average length, width and area of the lesion; and number of flecks were more in the second year, while, the mean number of lesions was more in the first year than second year (Tables 6 and 7). Berger (1973) and Shenoi and Ramalingam (1983) opined that the differentials in relative humidity are mainly responsible for the spread of the disease in epidemic proportions. A relative humidity of 80 per cent and the coincidence of rigorous crop growth stages with high relative humidity favour spread of leaf blight proportions. Relative humidity, is an important factor in the production of conidia on sorghum as in the case of maize (Leach *et al.*, 1977). Increase in temperature, coupled with decrease in relative humidity and increasing wind speeds aid in the liberation of conidia and their dispersal by wind (Kenneth, 1964, Berger, 1970 and Leach, 1975). Increase in the concentrations of air-borne conidia of *Exserohilum turcicum* following rainy days is due to sporulation on hosts (Meredith, 1966). Thus the damage caused by the leaf blight disease is strongly influenced by the environment.

5.1.1 Disease Parameters

Desirable parents and the hybrids selected on the basis of their *per se* performance for various traits are presented in Tables 29 and 30. The data indicated that among the parental lines, SPLB 94011A recorded minimum disease damage score (highly resistant) and length of the lesion, while SPLB 94010A with minimum width and area of the lesion (Table 29). On the other hand, among R-lines, A 2267-2 was found resistant in both the seasons, while the other R-line, ICSR 97 had disease expressed over the least width of the lesion although it was moderately resistant (based on disease damage score).

Crosses, involving the male parent, ICSR 97 with SPLB 94011A, SPLB 94009A and SPLB 94007A (R_{ds} x MR_{ds}); and SPLB 94016A (MR_{ds} X MR_{ds}) in the first year; and SPLB 94007A x ICSR 97 and SPLB 94011A x ICSR 97 (MR_{ds} X MR_{ds}) in the second year recorded the lowest disease damage score indicating that the restorer parent, ICSR 97 had stable resistance across the seasons, while another selected R-line, A 2267-2 contributed to the production of four resistant hybrids (SPLB 94010A x A 2267-2, SPLB 94016A x A 2267-2, SPLB 94019A x A 2267-2 and SPLB 94025A with A 2267-2) in the second year. Among the two selected resistant female lines, SPLB 94011A resulted in the production of the resistant hybrid in both the years, whereas SPLB 94010A only in the second year.

In the first year, none of the hybrids selected on the basis of the individual disease parameters was found common with those selected on the basis of overall disease damage score (Table 30). This shows that none of the individual disease parameters has had profound effect on the expression of the overall disease. On the other hand, various characters in the second year, i.e., length, width and area of the lesion; and number of

Table 29. Selected parents of sorghum based on the *per se* performance of different genotypes for various disease resistant parameters, rabi season 1996 and 1997.

	1996				1997			
Characteristic	**Parents**	**Group**[2]	**Mean value**	***per se* reaction**[3]	**Parent**	**Group**[2]	**Mean value**	***per se* reaction**[3]
Disease score[1]	SPLB 94011A	R	2.7	R	SPLB 94007A	MR	4.0	MR
	SPLB 94010A	R	3.0	R	SPLB 94010A	MR	4.0	MR
	A 2267-2	R	3.0	R	SPLB 94011A	MR	4.0	MR
Length of the lesion (cm)	SPLB 94011A	R	0.81	MR	SPLB 94010A	MR	1.16	HR
	SPLB 94009A	MR	0.39	MR	SPLB 94011A	MR	1.16	HR
	ICSR 119	LS	1.38	MR	A 2267-2	R	0.79	HR
Width of the lesion (cm)	SPLB 94010A	R	0.14	R	SPLB 94010A	MR	0.24	MR
	SPLB 94003A	MR	0.14	R	SPLB 94011A	MR	0.24	MR
	ICSR 97	MR	0.18	MR	SPLB 94025A	MR	0.24	MR
					SPLB 94017A	S	0.24	LS
					A 2267-2	R	0.16	HR
Area of the lesion (cm^2)	SPLB 94003A	MR	0.06	R	SPLB 94010A	MR	0.28	R
	SPLB 94010A	R	0.11	R	SPLB 94011A	MR	0.29	R
	ICSR 119	LS	0.26	MR	A 2267-2	R	0.14	R
Number of lesions (no)	SPLB 94016A	MR	1.00	HR	SPLB 94016A	MR	1.30	HR
	SPLB 94004A	R	1.30	HR	SPLB 94015A	MR	2.10	HR
	A 2267-2	R	4.80	R	ICSR 26	MR	2.50	HR
Number of flecks (no)	SPLB 94022A	MR	12.20	HR	SPLB 94014A	LS	79.50	HR
	SPLB 94015A	R	21.47	HR	SPLB 94021A	LS	85.40	HR
	ICSR 119	LS	42.70	HR	ICSR 90030	S	49.50	HR
Lodging (%)	SPLB 94011A	R	0.00	MR				
	296A	S	2.08	MR				
	ICSR 97	MR	1.67	MR				

1. Scored on a (1-9) scale.
2. The groups are based on the disease score.
3. *per se* reaction is based on their respective character.

Table 30. Selected hybrids of sorghum based on the *per se* performance of different genotypes for various disease resistant parameters, rabi season 1996 and 1997.

Characteristic	1996 Cross combination	1996 Group[2]	1996 Mean value	1996 *per se* reaction[3]	1997 Cross combination	1997 Group[2]	1997 Mean value	1997 *per se* reaction[3]
Disease score[1]	SPLB 94011A X ICSR 97	R X MR	2.3	HR	SPLB 94007A X ICSR 97	MR X MR	3.0	R
	SPLB 94009A X ICSR 97	R X MR	2.3	HR	SPLB 94011A X ICSR 97	MR X MR	3.3	R
	SPLB 94007A X ICSR 97	R X MR	2.7	R	SPLB 94010A X A 2267-2	MR X R	3.3	R
	SPLB 94009A X ICSR 91025	R X LS	2.7	R	SPLB 94004A X ICSR 97	MR X MR	3.3	R
	SPLB 94016A X ICSR 97	MR X MR	2.7	R	SPLB 94009A X ICSR 26	LS X MR	3.3	R
					SPLB 94016A X A 2267-2	MR X R	3.3	R
					SPLB 94019A X A 2267-2	LS X R	3.3	R
					SPLB 94025A X A 2267-2	MR X R	3.3	R
Length of the lesion (cm)	SPLB 94011A X A 2267-2	R X R	0.35	MR	SPLB 94016A X A 2267-2	MR X R	0.00	HR
	SPLB 94010A X A 2267-2	R X R	0.42	MR	SPLB 94011A X A 2267-2	R X R	0.48	HR
	SPLB 94015A X ICSR 90030	R X S	0.50	MR	SPLB 94010A X A 2267-2	R X R	0.42	HR
	SPLB 94024A X A 2267-2	LS X R	0.59	MR	SPLB 94011A X ICSR 97	MR X MR	0.63	HR
	SPLB 94017A X A 2267-2	LS X R	0.60	MR	SPLB 94017A X A 2267-2	S X R	0.68	HR
Width of the lesion (cm)	SPLB 94011A X A 2267-2	R X R	0.11	R	SPLB 94016A X A 2267-2	MR X R	0.00	HR
	SPLB 94010A X A 2267-2	R X R	0.13	R	SPLB 94010A X A 2267-2	R X R	0.15	HR
	SPLB 94019A X ICSR 97	MR X MR	0.14	R	SPLB 94011A X A 2267-2	R X R	0.15	HR
	SPLB 94012A X A 2267-2	LS X R	0.14	MR	SPLB 94011A X ICSR 97	R X MR	0.15	HR
	SPLB 94001A X ICSR 97	S X MR	0.14	R	SPLB 94025A X A 2267-2	MR X R	0.19	R
					SPLB 94010A X ICSR 91025	MR X HS	0.19	R
					SPLB 94024A X ICSR 97	LS X MR	0.19	R
					SPLB 94017A X ICSR 97	S X MR	0.19	R
Area of the lesion (cm^2)	SPLB 94011A X A 2267-2	R X R	0.04	R	SPLB 94017A X A 2267-2	LS X R	0.15	R
	SPLB 94010A X A 2267-2	R X R	0.06	R	SPLB 94010A X A 2267-2	MR X R	0.06	HR
	SPLB 94017A X A 2267-2	LS X R	0.09	R	SPLB 94011A X A 2267-2	R X R	0.07	HR
	SPLB 94022A X A 2267-2	MR X R	0.09	R	SPLB 94016A X A 2267-2	MR X R	0.00	HR
	SPLB 94010A X ICSR 97	R X MR	0.10	R	SPLB 94011A X ICSR 97	MR X MR	0.10	HR
	SPLB 94007A X A 2267-2	R X R	0.10	R				

Contd..

Contd.

Characteristic	1996 Cross combination	1996 Group[2]	1996 Mean value	1996 *per se* reaction[3]	1997 Cross combination	1997 Group[2]	1997 Mean value	1997 *per se* reaction[3]
Number of lesions (no)	SPLB 94013A X ICSR 91025	S X LS	1.53	HR	SPLB 94016A X A 2267-2	MR X R	0.00	HR
	SPLB 94004A X A 2267-2	R X R	1.80	HR	SPLB 94007A X ICSR 97	R X MR	1.70	HR
	SPLB 94007A X ICSR 91025	R X LS	1.90	HR	SPLB 94019A X A 2267-2	MR X R	1.70	HR
	SPLB 94015A X ICSR 90030	R X S	1.90	HR	SPLB 94022A ICSR 26	MR X MR	1.70	HR
	SPLB 94006A X ICSR 119	MR X S	2.00	HR	SPLB 94004A X ICSR 97	MR X MR	1.90	HR
Number of flecks (no)	SPLB 94015A X ICSR 90030	R X S	14.87	HR	SPLB 94013A X ICSR 91025	MR X S	39.30	R
	SPLB 94004A X A 2267-2	R X R	22.87	HR	SPLB 94025A X ICSR 91025	MR X S	47.40	HR
	SPLB 94006A X ICSR 119	MR X S	23.20	HR	SPLB 94009A X ICSR 90030	LS X S	53.00	HR
	SPLB 94009A X A 2267-2	R X R	23.57	HR	296A X ICSR 97	S X MR	66.70	HR
	SPLB 94017A X A 2267-2	LS X R	28.67	HR	296A X ICSR 90030	S X S	64.20	HR

1. Scored on a (1-9) scale.

2. The groups are based on the disease score.

3. *per se* reaction is based on their respective character.

lesions appeared to have played a significant role in contributing to the overall disease damage score. This may be due to favourable environment for the disease development during first year. Of the five hybrids selected for the minimum length of the lesion, three were found common with those selected on the overall disease damage score. Of the hybrids preferred for various characters, four for the width and the number of lesions, while the other three for the area of the lesion were found common with those selected on the basis of the overall disease damage score. This dependence of occurrence of disease related characters with seasons elucidate the role of different weather parameters such as temperature, relative humidity etc.

Hence, it can be presumed that the resistance in different genotypes may be attributed to various disease-related characters besides disease damage score. In addition, the genotypic and environmental variations might have played the considerable role for exhibiting the differential performance among the genotypes studied under the different environmental conditions in the present investigation. Turner and Hart (1975) also have suggested that the spread of *Exserohilum turcicum* conidia in maize is localized and that spore production is affected significantly by host genotype.

5.1.2 Yield Component Characters

Among the early flowering hybrids, SPLB 94022A x ICSR 26 and SPLB 94009A x ICSR 119 in the first year and SPLB 94025A x ICSR 26 and SPLB 94009A x ICSR 90030 in the second year were found to be moderately resistant coupled with high yields. On the other hand, among the hybrids which were late to flower, resistance with high yield was recorded by SPLB 94009A x ICSR 97 in the second year, while moderate resistance coupled with high yield by SPLB 94019A x A 2267-2 in the first year (Tables 31 and 32).

The hybrids which exhibited dwarfness coupled with resistance and average yield was recorded by SPLB 94011A x ICSR 97, while moderate resistance with short stature and low yield was recorded by SPLB 94024A x ICSR 97 and SPLB 94015A x ICSR 91025. However, among the tall hybrids, resistance with low yield was showed by SPLB 94017A x A 2267-2 in the first year, while moderate resistance coupled with high yield by SPLB 94001A x A 2267-2, SPLB 94022A x ICSR 91025 and SPLB 94017A x A 2267-2 in the second year.

The hybrid, SPLB 94007A x A 2267-2 was found favourable for earhead shape and size, resistance and high yield, while SPLB 94011A x ICSR 91025, SPLB 94003A x ICSR 91025, SPLB 94016A x ICSR 91025 and SPLB 94019A x ICSR 119 for moderate resistance and average yields besides agronomic desirability. However, the hybrid, SPLB 94019A x ICSR 97 exhibited moderate resistance coupled with agronomic desirability and high yield.

In the first year, the hybrids, SPLB 94010A x A 2267-2 (R_{ds} x R_{ds}), SPLB 94007A x ICSR 97, SPLB 94010A x ICSR 97 (R_{ds} x MR_{ds}), and SPLB 94009A x ICSR 91025 (R_{ds} x LS_{ds}) produced bold seed and when considered for their disease reaction all the four hybrids were also found resistant_{ds}. However, grain yield plant^{-1} for these hybrids was at moderate levels. In the second year, SPLB 94013A x A 2267-2 (MR_{ds} x R_{ds}), SPLB 94016A x ICSR 26, SPLB 94013A x ICSR 97 and SPLB 94016A x ICSR 97 (R_{ds} x MR_{ds}) exhibited for bold seed. However, only one hybrid showed moderate resistance_{ds} coupled with average yield.

Table 31. Selected parents of sorghum based on the *per se* performance of different genotypes for various yield contributing characters, rabi season 1996 and 1997.

Characteristic	1996				1997			
	Parents	Group[2]	Mean value	*per se* reaction[3]	Parents	Group[2]	Mean value	*per se* reaction[3]
Days to 50% flowering (days)-early	SPLB 94004A	R	71	E	SPLB 94009A	LS	59	E
	SPLB 94010A	R	73	E	SPLB 94024A	LS	62	E
	SPLB 94011A	R	73	E	ICSR 26	MR	61	E
	ICSR 119	LS	76	E				
Days to 50% flowering (days)-late	SPLB 94019A	MR	86	Lt	SPLB 94013A	MR	76	Lt
	SPLB 94013A	S	86	Lt	SPLB 94015A	MR	76	Lt
	ICSR 97	MR	85	Lt	ICSR 97	MR	68	Lt
	ICSR 90030	S	85	Lt				
Plant height (cm)-dwarf	SPLB 94009A	R	95	S	296A	S	113	S
	296A	S	105	S	SPLB 94011A	MR	110	S
	ICSR 97	MR	117	S	ICSR 97	MR	133	S
Plant height (cm)-tall	SPLB 94013A	S	157	M	SPLB 94013A	MR	197	M
	SPLB 94012A	LS	155	M	SPLB 94012A	S	197	M
	A 2267-2	R	157	M	ICSR 91025	HS	223	T
Agronomic score[2]	SPLB 94006A	MR	2.0	D	SPLB 94024A	LS	3.3	UD
	SPLB 94013A	S	2.7	D	SPLB 94025A	MR	3.7	UD
	ICSR 91025	LS	2.7	D	ICSR 97	MR	3.0	D
					ICSR 119	S	3.0	D
Grain yield plant^{-1} (g)	SPLB 94006A	MR	27.30	A	SPLB 94006A	LS	28.87	L
	SPLB 94013A	S	26.10	A	SPLB 94013A	MR	28.80	A
	ICSR 91025	LS	29.70	A	ICSR 26	MR	36.27	H
100 seed weight (g)	SPLB 94014A	LS	3.4	H	SPLB 94013A	MR	3.6	H
	SPLB 94013A	S	3.4	H	SPLB 94014A	LS	3.5	H
	ICSR 97	MR	3.1	A	A 2267-2	R	3.1	A

1. Scored on a (1-5) scale.
2. The groups are based on the disease score.
3. *Per se* reaction is based on their respective character.

E = Early	**S = Short**
M = Medium	**T = Tall**
Lt = Late	**D = Agronomically desirable**
L = low	**UD = Agronomically undesirable**
A = Average	
H = High	

Table 32. Selected hybrids of sorghum based on the *per se* performance of different genotypes for various yield contributing characters, rabi season 1996 & 1997.

Characteristic	1996				1997			
	Parents	Group[2]	Mean value	*per se* reaction[3]	Parents	Group[2]	Mean value	*per se* reaction[3]
Days to 50% flowering (days) - early	SPLB 94022A x ICSR 90030	MR x S	71	E	SPLB 94009A x ICSR 26	LS x MR	56	E
	SPLB 94022A x ICSR 26	MR x S	72	E	SPLB 94024A x ICSR 90030	LS x S	56	E
	SPLB 94022A x ICSR 97	MR x MR	73	E	SPLB 94009A x ICSR 91025	LS x HS	57	E
	SPLB 94022A x ICSR 119	MR x LS	73	E	SPLB 94009A x ICSR 90030	LS x S	58	E
	SPLB 94016A x ICSR 90030	MR x S	73	E	SPLB 94009A x ICSR 97	LS x MR	58	E
					SPLB 94009A x A 2267-2	LS x R	58	E
					SPLB 94025A x ICSR 26	MR x MR	58	E
Days to 50% flowering (days) - late	SPLB 94010A x ICSR 90030	R x S	88	L	SPLB 94004A x ICSR 97	MR x MR	71	L
	SPLB 94019A x A 2267-2	MR x R	88	L	SPLB 296A x ICSR 97	S x MR	77	L
	SPLB 94006 A x ICSR 119	MR x LS	88	L	SPLB 94003A x A 2267-2	LS x R	70	L
					SPLB 94013A x ICSR 119	MR x S	70	L
					SPLB 94015A x ICSR 119	MR x S	70	L
					SPLB 94015A x A 2267-2	MR x R	70	L
Plant height (cm)-dwarf	SPLB 94024A x ICSR 97	LS x MR	112	S	SPLB 94015A x ICSR 97	MR x MR	132	S
	SPLB 296A x ICSR 97	S x MR	120	S	SPLB 94016A x ICSR 97	MR x MR	133	S
	SPLB 94015A x ICSR 97	R x MR	122	S	SPLB 94010A x ICSR 97	MR x MR	138	S
	SPLB 94015A x ICSR 91025	R x LS	122	S	SPLB 94011A x ICSR 97	MR x MR	138	S
Plant height (cm)-tall	SPLB 94013A x A 2267-2	S x R	203	T	SPLB 94001A x A 2267-2	LS x R	277	T
	SPLB 94012A x A 2267-2	LS x R	202	T	SPLB 94017A x A 2267-2	S x R	253	T
	SPLB 94024A x A 2267-2	LS x R	201	T	SPLB 94022A x ICSR 91025	LS x HS	267	T
	SPLB 94017A x A 2267-2	LS x R	200	T	SPLB 94016A x ICSR 91025	MR x HS	263	T

Contd...

Contd..

Characteristic	1996				1997			
	Parents	Group[2]	Mean value	*per se* reaction[3]	Parents	Group[2]	Mean value	*per se* reaction[3]
Agronomic score[1]	SPLB 94007A x A 2267-2	R x R	2	D	SPLB 94019A x ICSR 97	LS x MR	2	D
	SPLB 94011A x ICSR 91025	R x LS	2	D	SPLB 94019A x ICSR 119	LS x S	2.3	D
	SPLB 94003A x ICSR 91025	MR x LS	2	D	SPLB 94004A x ICSR 26	MR x MR	2.3	D
	SPLB 94016A x ICSR 91025	MR x LS	2	D				
	SPLB 94019A x ICSR 91025	MR x LS	2	D				
	SPLB 94019A x ICSR 119	MR x LS	2	D				
Grain yield $plant^{-1}$ (g)	SPLB 94019A x ICSR 26	MR x S	2	D	SPLB 94013A x A 2267-2	MR x R	3.6	H
	SPLB 94024A x A 2267-2	LS x Q	2	D	SPLB 94016A x ICSR 97	MR x R	3.6	H
	SPLB 94025A x ICSR 90030	LS x S	2	D	SPLB 94015A x ICSR 119	MR x S	3.6	H
	SPLB 296A x A 2267-2	S x Q	2	D	SPLB 94010A x ICSR 90030	MR x S	3.6	H
	SPLB 94013A x ICSR 26	S x S	2	D				
100 seed weight (g)	SPLB 94010A x A 2267-2	R x R	3.5	H				
	SPLB 94007A x ICSR 97	R x MR	3.4	H				
	SPLB 94010A x ICSR 97	R x MR	3.4	H				
	SPLB 94009A x ICSR 91025	R x LS	3.5	H				

1. Scored on a (1-5) scale.

2. The groups are based on the disease score.

3. *Per se* reaction is based on their respective character.

E = Early **S = Short**

M = Medium **T = Tall**

Lt = Late **D = Agronomically desirable**

L = low **UD = Agronomically undesirable**

A = Average

H = High

Among the hybrids, SPLB 94009A x ICSR 90030 was not only found stable in yield performance with good agronomic desirability in both the years but also possessed other appreciable traits like medium flowering habit and medium plant height in the first year, while dwarfness with early flowering habit in the second year. In addition, this hybrid recorded the lowest number of flecks with minimal damage on leaf area during the second year.

5.1.3 Desirable Hybrids for Various Characters

Genotypes on the basis of the disease damage score were classified into HR_{ds}, R_{ds}, MR_{ds}, LS_{ds}. S_{ds} and HS_{ds} groups (Tables 6 and 7). The LS_{ds}, S_{ds} and HS_{ds} groups are not preferable, as they are readily vulnerable to the disease, consequently resulting in possible disease epidemics. Hence, having resistant crop varieties are by far the effective, most economical and least hazardous measures of disease control (Micke, 1974). He further opined that even a moderate level of resistance could be of great value under an integrated control program. Further immune or highly resistant (vertical resistance) varieties or hybrid promote a great directional selection pressure favouring resistance-breaking varieties. Hence, development of partially resistant varieties or hybrids (horizontal resistance) is by and large more sensible than to develop near immune cultivars (Russell, 1978). Therefore, most preferred R-line with $resistance_{ds}$ and $average_{gy}$ grain yield $plant^{-1}$ was A 2267-2 in the first year, and with $high_{gy}$ yield and moderate $resistance_{ds}$ was ICSR 26 in the second year, while among A-lines SPLB 94003A, SPLB 94006A, SPLB 94019A and SPLB 94021A were preferred for moderate $resistance_{ds}$ and $average_{gy}$ yields in the first year (Tables 6 and 8); and SPLB 94013A in the second year. On the other hand, among the hybrids, SPLB 94004A x A 2267-2 and SPLB 94009A x A

2267-2 (R_{ds} x R_{ds}), SPLB 94009A x ICSR 119 and SPLB 94011A x ICSR 119 (R_{ds} x LS_{ds}), SPLB 94004A x ICSR 26 (R_{ds} x S_{ds}), SPLB 94016A x A 2267-2, SPLB 94019A x A 2267-2 and SPLB 94022A x A 2267-2 (MR_{ds} x R_{ds}), SPLB 94022A x ICSR 119 (MRds x LS_{ds}), SPLB 94016A x ICSR 26 and SPLB 94022A x ICSR 26 (MR_{ds} x S_{ds}), SPLB 94012A x A 2267-2 and SPLB 94025A x A 2267-2 (LS_{ds} x R_{ds}), SPLB 94014A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94001A x ICSR 91025 (S_{ds} x LS_{ds}); and SPLB 94001A x ICSR 90030 (S_{ds} x S_{ds}) in the first year, while SPLB 94011A x A 2267-2 (MR_{ds} x R_{ds}), SPLB 94010A x ICSR 26 and SPLB 94025A x ICSR 26 (MR_{ds} x MR_{ds}), SPLB 94011A x ICSR 119 and SPLB 94025A x ICSR 119 (MR_{ds} x S_{ds}), SPLB 94022A, SPLB 94024A, SPLB 94001A and SPLB 94006A with A 2267-2 (LS_{ds} x R_{ds}), SPLB 94024A x ICSR 26 (LS_{ds} x MR_{ds}), SPLB 94019A x ICSR 97, SPLB 94001A x ICSR 97 and SPLB 94006A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94001A x ICSR 119, SPLB 94019A x ICSR 90030 and SPLB 94009A x ICSR 90030 (LS_{ds} x S_{ds}), SPLB 94022A x ICSR 91025 (LS_{ds} x LS_{ds}), 296A x A 2267-2 (S_{ds} x R_{ds}); and SPLB 94017A x ICSR 91025 (S_{ds} x HS_{ds}) in the second year (Tables 7 and 9) were found superior with moderate levels of resistance coupled with grain yield plant^{-1}. The most desirable hybrids based on $high_{gy}$ grain yield plant^{-1} and moderate $resistance_{ds}$ for disease damage score, minimum length, width and area of the lesion were SPLB 94004A x A 2267-2 (R_{ds} x R_{ds}), SPLB 94011A x ICSR 119 (R_{ds} x LS_{ds}), SPLB 94016A x A 2267-2 (MR_{ds} x R_{ds}), SPLB 94022A x ICSR 119 (MR_{ds} x LS_{ds}) and SPLB 94001A x ICSR 91025 (S_{ds} x LS_{ds}) in the first year; whereas SPLB 94006A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 94001A x ICSR 119, SPLB 94019A x ICSR 90030 and SPLB 94009A x ICSR 90030 (LS_{ds} x S_{ds}) in the second year. The most preferred hybrid based on $high_{gy}$ grain yield plant^{-1} and least total leaf area damage in the second year was SPLB 94022A x A 2267-2 (LS_{ds} x R_{ds}). Therefore, these parents and the hybrids may be recommended for use as components in commercial cultivation with Integrated Disease Control measures.

5.1.4 Types of Crosses and Resistant Hybrids

It is generally expected that the crosses between resistant parents (R_{ds} x R_{ds}) could produce resistant hybrids. An analysis of the data presented in Tables 6 and 7 for various disease parameters showed that R_{ds} x R_{ds} group of crosses produced hybrids, of which 50% were resistant for disease damage score and width of the lesion, 67% to area of the lesion, while 50% were highly resistant to number of lesions and number of flecks. On the other hand, crosses made between resistant and moderately resistant parental lines (R_{ds} x MR_{ds}), produced hybrids, of which 50% were resistant based on overall disease damage score, 33% had least width of the lesion, 67% had minimum area of the lesion and 17% had minimum number of lesions. In the second year, parents with moderate levels of resistance (MR_{ds} x MR_{ds}) produced hybrids, of which 25% showed resistance, 25% had minimum length and width of the lesion, 31% showed resistance for area of the lesion and number of flecks; and 19% for number of lesions, while 33% were highly resistant for overall disease damage (score). However, majority of the other combinations with few exceptions did not show favourable disease parameters.

Further analysis of the other types of hybrids revealed that they did not produce the hybrids that would match with the desirable disease parameters as noticed in the hybrids of MR_{ds} x MR_{ds} combination (Table 6 and 7). On the basis of overall disease damage score, R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, MR_{ds} x MR_{ds} and LS_{ds} x R_{ds} combinations in the first year, whereas MR_{ds} x MR_{ds}, LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} combinations in the second year appeared to be most favourable as they produced resistant hybrids for various disease related characters (atleast four) besides disease damage score. Therefore, it can be concluded that parents with moderate levels of resistance have high probability of producing resistant hybrids with desirable levels of disease parameters. At least one of the parents should possess either resistance or moderate resistance to obtain resistant hybrids.

The S_{ds} x R_{ds} group of crosses for area of the lesion and S_{ds} x S_{ds} group of crosses for number of flecks gave resistant hybrids in both the years. Drolsom (1954) reported that the rare recovery of the resistant types in the progenies of crosses of S x R parents was possible though there was only a small number of factors concerned with leaf blight reaction. In crosses between susceptible A-lines and resistant R-lines, F_1 hybrids were significantly more resistant than the susceptible A-lines. Compared to the male-steriles, F_1 hybrids and R-lines (resistant sources) showed 62% and 83% less leaf blight, respectively (Hepperly and Rios, 1987). Similarly, Bergquist and Hasias in 1973 also reported the production of only flecks on F_1 hybrids of resistant sorghum male lines crossed to susceptible cytoplasmic sterile A-line suggesting a dominant gene(s) conditioning resistance. The occurrence of resistant hybrids in the above group of crosses might be due to overdominance for resistance and hypersensitive reaction in S_{ds} x S_{ds} group of crosses; and dominance in S_{ds} x R_{ds} group of crosses. Hooker (1961) found a new type of resistance to *Helminthosporium turcicum*, which is characterized by the formation of chlorotic lesion and is monogenic in inheritance. The expression of the over dominance may or may not be uniform over the years due to interaction of genes. Hence, it is imperative to test the performance of the crosses further. In addition, all the hybrids exhibiting over dominance for resistance need to be tested under greenhouse conditions to study the effect of the environment under controlled conditions and the interaction of the disease with the environmental factors. The reduced resistance and increased variability of the F_1 hybrids compared to resistant sources, suggests that unidentified genetic loci and alleles other than the single dominant allele are influential as determinants of leaf blight resistance in sorghum (Hepperly and Rios, 1987).

5.1.5 Disease Reaction Groups

Grouping of parental lines based on disease reaction under different environmental conditions provide a key information on variability and stability in disease reaction. The A-lines (SPLB 94004A, SPLB 94007A, SPLB 94010A, SPLB 94011A and SPLB 94015A) which were resistant (based on disease damage score) in the first year (Table 6), exhibited moderate resistance in the second year (Table 7); the other resistant$_{ds}$ line, SPLB 94009A exhibited less susceptibility$_{ds}$ in the second year. This implies that these lines were moderately resistant$_{ds}$ or less susceptible$_{ds}$ but showed resistance$_{ds}$ only under certain environmental conditions. And this might be due to the disease escape mechanism. Hence, these parental lines can be used basically as moderately resistant or less susceptible lines. The MR$_{ds}$ A-lines, SPLB 94003A, SPLB 94006A, SPLB 94019A, SPLB 94021A and SPLB 94022A were found less susceptible$_{ds}$ in the second year and the LS$_{ds}$ A-lines, SPLB 94012A and SPLB 94017A in the first year were found susceptible$_{ds}$ in the second year. However, SPLB 94025A, a less susceptible$_{ds}$ A-line in the first year was MR$_{ds}$ in the second year. Similar was the reaction with the A-lines, SPLB 94001A and SPLB 94013A (S$_{ds}$ in the first year and LS$_{ds}$ in the second year). SPLB 94016A (MR$_{ds}$), SPLB 94024A and SPLB 94014A (LS$_{ds}$) and 296A (S$_{ds}$) were stable in expression for disease reaction$_{ds}$. The environmental conditions prevailing during the course of experimentation might have influenced the expression of genes.

Elliott and Jenkins, 1946 also opined that differences in genetic composition of the host, differences in virulence of the fungus, or other factors may complicate the problem of resistance to the disease in corn.

Among the restorer lines, a susceptible$_{ds}$ restorer line i.e., ICSR 26 in the first year exhibited moderate resistance$_{ds}$ in the second year. During first year, the lines, ICSR 119 and ICSR 91025 were found to be less susceptible$_{ds}$. However in the second year, ICSR 119 became susceptible$_{ds}$, while ICSR 91025 highly susceptible$_{ds}$. It indicates that environment is playing a pivotal role in the expression of the disease. A 2267-2 (R$_{ds}$), ICSR 97 (MR$_{ds}$) and ICSR 90030 (S$_{ds}$) were stable in expression over the years. It can be concluded that the expression of resistance$_{ds}$, or moderate resistance$_{ds}$ or susceptibility$_{ds}$ to the disease over the two years is not stable and depends on environmental conditions. Hence, needs further testing in green house conditions and sick plots or disease nurseries to study the influence of environment on the occurrence, spread and the intensity of the disease besides stable resistance. Based upon the present results, it can be revealed that the parental lines with stable resistance can be used with no risk as donors in breeding for disease resistance programme.

The disease resistant parameters namely length, width and area of the lesion, number of lesions and number of flecks were found to vary for all the parental lines tested over a period of two years. The cultivars with favourable disease patterns for maximum number of disease parameters and disease damage score are considered to be desirable because they are expected to provide stable resistance across seasons and locations. Therefore the data presented in the Tables 6 and 7 are analysed with a view of identifying stable resistant hybrids.

In the first year, the parental lines which exhibited similar favourable pattern in disease reaction for disease related characters besides disease damage score were SPLB 94009A (R) for area of the lesion, SPLB 94010A and SPLB 94011A (R) for width of the lesion and area of the lesion, SPLB 94003A and SPLB 94022A (MR) for length of the lesion and lodging, SPLB 94021A (MR) and SPLB 94025A (LS) for length, width and area of the lesion, SPLB 94012A (LS) for length and width of the lesion, SPLB 94014A (LS) for length of the lesion; and SPLB 94001A (S) for number of flecks and lodging among A-lines, while A 2267-2 (R) for number of flecks, ICSR 97 (MR) for length, width and area of the lesion, number of lesions and lodging, ICSR 119 (LS) for lodging, ICSR 91025 for length, width and area of the lesion; and ICSR 90030 for length of the lesion among the R-lines.

In the second year, SPLB 94010A and SPLB 94011A (MR), and SPLB 94014A, SPLB 94001A and SPLB 94022A (LS) for width of the lesion, SPLB 94004A for length and area of the lesion and number of flecks, SPLB 94025A (MR), and SPLB 94021A and SPLB 94024A (LS) for length, width and area of the lesion, SPLB 94019A and SPLB 94003A (LS) for number of flecks, SPLB 94006A for length and area of the lesion and number of flecks; and 296A for length and area of the lesion among A-lines, whereas A 2267-2 (R) for area of the lesion and number of lesions, ICSR 97 (MR) for width of the lesion; and ICSR 90030 (S) and ICSR 91025 (HS) for length and area of the lesion and number of flecks among restorer lines showed similar pattern of disease reaction for the above characters besides disease damage score. The resistant and the moderately resistant parental lines which showed similar disease reaction for disease damage score and their respective characters can be used in future programmes. The non-uniformity in disease reaction indicated that the resistance in these genotypes is contributed by different parameters. Therefore, it emphasizes the need to take several other parameters, like length of the lesion, width of the lesion, area of the lesion, number of lesions, number of flecks and lodging into consideration while determining the resistance or susceptibility of a genotype. 280

Considering the above analysis, the following parental lines have favourable patterns for disease damage score and disease parameters.

Parental lines	Ye	Disease reaction	Disease parameters
A-lines			
SPLB 94010A	96	R	width and area of the lesion, disease damage score
SPLB 94011A	96	R	width and area of the lesion, disease damage score
SPLB 94009A	96	R	area of the lesion, disease damage score
SPLB 94010A	97	MR	width of the lesion, disease damage score
SPLB 94011A	97	MR	width of the lesion, disease damage score
SPLB 94004A	97	MR	length and area of the lesion, number of flecks, disease damage score
SPLB 94025A	97	MR	length, width and area of the lesion, disease damage score
Restorer lines			
A 2267-2	96	R	number of lesions, disease damage score
A 2267-2	97	R	area of the lesion, number of lesions, disease damage score
ICSR 97	97	MR	width of the lesion, disease damage

5.1.6 Response based on total leaf area damage and fleck number

The basic components of the disease are leaf area damage and the number of flecks. Leaf area, reflects the spread of the disease, while the fleck number, the hypersensitive reaction. Considering the above, the genotypes with low fleck number and less leaf area damage are most desirable ones as indicated in the section 4.3. The parental lines and the hybrids falling in disease severity group 1 i.e., resistant group are considered desirable for future breeding works and are very useful as seed parents for controlling leaf blight disease (Tarumoto *et al.*, 1977). The genotypes (parental lines and the hybrids involving resistant parental lines) which fall in this category were

First year:

Parents:

A-lines:

SPLB 94004A, SPLB 94010A, SPLB 94015A, SPLB 94007A, SPLB 94009A, SPLB 94011A, SPLB 94003A, SPLB 94006A, SPLB 94012A, SPLB 94013A, SPLB 94014A, SPLB 94016A, SPLB 94017A, SPLB 94021A, SPLB 94022A, SPLB 94024A, SPLB 94025A and 296A (Table 10).

R-lines:

A 2267-2, ICSR 26, ICSR 97, ICSR 119, ICSR 91025 and ICSR 90030

Hybrids:

SPLB 94004A, SPLB 94007A, SPLB 94015A, SPLB 94009A, SPLB 94006A, SPLB 94012A, SPLB 94013A, SPLB 94022A, SPLB 94016A, SPLB 94017A and SPLB 94011A crossed with A 2267-2; SPLB 94004A, SPLB 94007A, SPLB 94015A, SPLB 94006A, SPLB 94012A, SPLB 94013A, SPLB 94022A, SPLB 94014A, SPLB 94024A, SPLB 94009A, SPLB 94003A, SPLB 94017A, SPLB 94011A and 296A crossed with ICSR 97; SPLB 94004A, SPLB 94007A, SPLB 94015A, SPLB 94012A, SPLB 94021A, SPLB 94017A, SPLB 94011A and 296A with ICSR 26; SPLB 94004A, SPLB 94007A,

SPLB 94015A, SPLB 94006A, SPLB 94012A, SPLB 94013A and SPLB 94022A crossed with ICSR 119; SPLB 94009A, SPLB 94007A, SPLB 94015A, SPLB 94006A, SPLB 94012A, SPLB 94013A, SPLB 94014A, SPLB 94017A and SPLB 94021A crossed with ICSR 91025; and SPLB 94004A, SPLB 94007A, SPLB 94015A, SPLB 94006A, SPLB 94003A, SPLB 94013A, SPLB 94009A, SPLB 94017A and SPLB 94021A crossed with ICSR 90030.

Second year:

Parents:

A-lines:

SPLB 94004A, SPLB 94010A, SPLB 94015A, SPLB 94001A, SPLB 94003A, SPLB 94006A, SPLB 94012A, SPLB 94009A, SPLB 94013A, SPLB 94014A, SPLB 94016A, SPLB 94017A, SPLB 94021A, SPLB 94022A, SPLB 94024A, SPLB 94025A and 296A (Table 11).

R-lines:

ICSR 26, ICSR 119 and ICSR 90030

Hybrids:

SPLB 94003A, SPLB 94006A, SPLB 94015A, SPLB 94001A, SPLB 94012A, SPLB 94014A, SPLB 94016A, SPLB 94025A, SPLB 94021A, SPLB 94009A, SPLB 94017A, SPLB 94024A and 296A crossed with ICSR 119; SPLB 94004A, SPLB 94006A, SPLB 94013A, SPLB 94021A, SPLB 94022A, SPLB 94025A, SPLB 94010A, SPLB 94015A, SPLB 94001A,SPLB 94012A, SPLB 94014A, SPLB 94016A, SPLB 94017A, SPLB 94024A, SPLB 94009A and 296A crossed with ICSR 26; SPLB 94004A, SPLB 94010A, SPLB 94015A, SPLB 94001A, SPLB 94003A, SPLB 94006A, SPLB 94012A, SPLB

94013A, SPLB 94014A, SPLB 94016A, SPLB 94017A, SPLB 94021A, SPLB 94022A, SPLB 94024A, SPLB 94025A and 296A crossed with ICSR 90030.

Irrespective of the differential reactions to the disease, a perusal of the data over two consecutive years revealed that the hybrids of SPLB 94012A, SPLB 94015A and SPLB 94006A crossed with ICSR 119; SPLB 94004A, SPLB 94012A, SPLB 94015A, SPLB 94017A, SPLB 94021A and 296A crossed with ICSR 26; and SPLB 94004A, SPLB 94006A, SPLB 94003A, SPLB 94015A, SPLB 94013A, SPLB 94021A and SPLB 94017A crossed with ICSR 90030 were resistant, while SPLB 94003A x ICSR 26 was moderately resistant and were found to be stable in disease expression over two years.

Thus a large number of parental lines and hybrids showed considerable promise when analysed for disease severity and hypersensitive reactions. This could be attributed to ICRISAT's specific leaf blight resistant male-steriles programme which provided base material for this work and finding of large number of favourable male-sterile lines and the hybrids in this study showed that the ICRISAT male sterile breeding programme has been quite promising.

5.2 INHERITANCE OF INDIVIDUAL CHARACTERS IN VARIOUS HYBRID AND PARENT GROUPS

In sorghum, quantum jump in production became possible following the discovery of male sterility (Stephens, 1964), which led to the development of hybrids. Since hybrids utilize the phenomenon of hybrid vigour, the yield potentials are very high. Hence there is every need to develop hybrids with resistance to different biotic and abiotic stresses for which a basic knowledge of the type of parents that give resistant hybrids is needed. The behaviour of hybrids in relation to parents can be considered following discrete / discontinuous and continuous / quantitative analysis. The former analysis can be done on individual cross basis or on the basis of groups of crosses involving similar type of parents. The grouping of highly resistant, resistant, moderately resistant, less susceptible, susceptible and highly susceptible reactions is done based on standard deviation as detailed in the chapter 4. Unlike, quantitative analysis, this discontinuous classification based analysis is simple to comprehend. Therefore, the continuous measurements are made into discrete classes to allow an interpretation of the inheritance in a simple mendelian fashion. The results (Chapter 4, Section 2) thus obtained are briefly discussed below:

Of all the gene actions over dominance, complete dominance and partial dominance for disease resistant parameters and yield contributing characters are preferable in developing commercial hybrids. On the other hand, the traits, which are recessive, are not preferable because it involves breeding of resistant females and males to produce resistant hybrids. Different types of gene action (MR_{ds} x MR_{ds} (67%) group of hybrids showed overdominance for resistance, dominance for resistance to length of the lesion was exhibited by 83% of R_{ds} x R_{ds} group of hybrids, partial dominance for resistance to lesion area was observed by 42% of the hybrids from R_{ds} x LS_{ds} group, overdominance for susceptibility to lesion number was noticed by R_{ds} x MR_{ds} (17%) group and susceptibility was dominant over resistance to fleck number in R_{ds} x LS_{ds} (8%) group of hybrids, moderate resistance was dominant over susceptibility in MR_{ds} x S_{ds} (38%) group for width of the lesion) were encountered in the material for various disease resistant parameters and yield contributing characters (Tables 6 to 9). The expression of over dominance may or may not be uniform during two seasons due to the interaction of the alleles. Therefore, though desirable, the genotypes exhibiting over dominance need to be further tested. The crosses with dominant reaction are most preferred over others as they can withstand, oppose or overcome the pathogenic invasion with normal yield. The involvement of the different types of gene action in the expression of resistance or susceptibility could be due to quantitative genes (governed by large number of genes with high influence of the environment).

The following combinations of hybrids (grouped on the basis of the disease damage score) showed overdominant reaction for the resistance to the following traits:

First year:

Disease damage score: R x MR, MR x MR, S x MR and LS x MR

Length of the lesion: MR x MR, S x S, S x LS, LS x S and LS x LS

Width of the lesion: MR x MR , S x MR and S x S

Area of the lesion: S x MR, MR x MR, LS x MR, MR x S, S x LS, S x S and MR x LS

Number of lesions: R x R, R x MR, R x LS, R x S, MR x R, S x R, MR x MR, S x LS, MR x LS, LS x MR, LS x LS, LS x S, S x MR and S x S

Number of flecks: R x R, R x LS, R x S, MR x R, MR x MR, MR x LS, LS x R, LS x LS, S x R, S x MR, S x LS, MR x S and LS x S

Second year:

Disease damage score: MR x MR and LS x MR

Length of the lesion: MR x R, MR x MR, MR x S, MR x HS, LS x R, S x R and S x MR

Width of the lesion: MR x R, MR x MR, MR x S, MR x HS, S x R and S x MR

Area of the lesion: MR x R, MR x MR, MR x S, MR x HS and S x MR

Number of lesions: MR x R, MR x MR, MR x S, MR x HS, LS x R, LS x MR, LS x S, LS x HS, S x S and S x HS

Number of flecks: MR x R, MR x MR, MR x S, MR x HS, LS x MR, LS x S, LS x HS, S x MR, S x S and S x HS

The cross combinations, which exhibited dominant reaction for various disease-related characters including disease damage score, are as follows:

First year:

Disease damage score: R x R, R x MR, R x LS, LS x R and S x R

Length of the lesion: R x R and R x MR

Width of the lesion: R x R, R x MR, R x LS, S x R and LS x R

Area of the lesion: R x R, R x MR, R x S, R x LS

Number of lesions: R x R, R x MR, R x LS, R x S, MR x MR

Number of flecks: R x LS, R x S and LS x R

Second year:

Disease damage score: MR x MR and LS x MR

Length of the lesion: MR x R

Width of the lesion: MR x R

Area of the lesion: MR x R

Number of lesions: MR x R, LS x R and S x R

Number of flecks: LS x R and S x R

These groups of hybrids may be deployed in the breeding programme.

In the literature, the following inheritance was noted for various disease parameters concerning leaf blight. Resistance to northern leaf blight in most of the corn strains is a quantitative character and is multigenic in inheritance (Jenkins and Robert, 1952) and might be governed by 3-12 pairs of genes (Hirose and Toda, 1970). However, Tarumoto and Isawa (1975) found resistance to *Helminthosporium turcicum* to be dominant in sorghum-sudan grass hybrid and suggested monogenic inheritance. The complete or partial dominance observed in our studies for various disease related characters in different groups in two consecutive years (for e.g.: R_{ds} x R_{ds} group for length of the lesion and partial dominance for resistance in R_{ds} x LS_{ds} group of hybrids for area of the lesion) was in conformity with the findings of Tarumoto and Isawa (1975) who reported complete or partial dominance for resistance to leaf blight in sorghum-sudan grass hybrids. The highly resistant hybrids obtained in our studies for various disease parameters in different groups (R_{ds} x R_{ds}, R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, R_{ds} x S_{ds}, MR_{ds} x R_{ds}, MR_{ds} x MR_{ds}, MR_{ds} x LS_{ds}, MR_{ds} x S_{ds}, LS_{ds} x R_{ds}, LS_{ds} x MR_{ds}, LS_{ds} x LS_{ds}, LS_{ds} x S_{ds}, S_{ds} x R_{ds}, S_{ds} x MR_{ds}, S_{ds} x LS_{ds}, S_{ds} x S_{ds}, MR_{ds} x HS_{ds}, LS_{ds} x HS_{ds} and S_{ds} x HS_{ds} groups) in both the years is in conform with the findings of Tarumoto and Isawa (1972) who observed highly resistant F_1 hybrids from R x S parents. The parents exhibiting the above type of disease reaction also resulted in either susceptible or highly susceptible or less susceptible F_1 hybrids indicating that susceptibility is either completely dominant or partial dominant or over dominant. The dominance of susceptibility as observed in F_1 hybrids is in conformity with the findings of Snyder (1949-50) and Drolsom (1954) for *Helminthosporium turcicum* in sudan grass. Tarumoto and Isawa (1975) reported complete or partial dominance for resistance to leaf blight in sorghum-sudan grass hybrids. In the hybrids where parental types are recovered, few factors governed leaf blight reaction. However, the occurrence of plants more susceptible than either parent implied that different genes controlled resistance in the two parents, or the modifying factors might be present (Drolsom, 1954). As observed in our experiments, Jenkins and Robert (1952) also reported that the different resistant male inbred lines behaved somewhat differently in their crosses with susceptible female lines (intermediate, most dominant and least dominant) indicating genetic differences among male lines with respect to disease resistance. Similarly the susceptible female lines when crossed with the resistant male lines indicate genetic differences among the susceptible lines further suggesting that resistance to *Helminthosporium turcicum* appears to be controlled by rather a large number of genes with polymeric gene action.

Therefore, it can be concluded that the inheritance of resistance is not uniform in different crosses and it depends on the type of genotypes involved in the crosses. The differential reactions of the resistant A-lines with susceptible R-lines, and those of the susceptible A-lines with resistant R-lines indicate that resistance to *Helminthosporium turcicum* is controlled by rather a large number of genes (Jenkins and Robert, 1952). Further involvement of more number of genes and their interactions differently in different combinations could be due to host pathogen interaction since pathogenic specificity is not classified into different groups. Thus, the mode of inheritance of leaf blight reaction in sorghum does not appear to be simple. Therefore an attempt has been made to analyse the inheritance of the disease effect on quantitative as well as qualitative characters following line x tester analysis.

5.3 COMBINING ABILITY

Combining ability analysis provides information about the relative performance of the additive and non-additive genes to a plant breeder for the development of an efficient hybridization programme. It also helps in the selection of the suitable parents and the identification of superior hybrid combinations. Parents can be selected based on either *per se* performance or general combining ability or both. The *per se* performance, however, is not a reliable index as a line with high yield potential may not necessarily exhibit its superiority in cross combinations (Srinivasa *et al.*, 1979). Therefore, there is a constant need to identify and select potential combiners, which can produce combinations superior to the existing ones. The ratio of GCA to SCA variance provides estimates of the predominance of additive or non-additive gene effects. Hence, in the present investigation, 20 cytoplasmic male-sterile lines developed at ICRISAT-Patancheru were crossed with six restorer lines and the resulting 120 (A x R) hybrids along with their parents were evaluated for various leaf blight resistant parameters and other yield contributing characters. The data revealed significant differences among parental lines and their hybrids for two consecutive years indicating genetic differences among genotypes for all the characters under study. The significance of line x tester mean squares indicated that A-lines do not appear to behave consistently over different R-lines and *vice versa* (Tables 12 and 13). This was also evident, when the inheritance was discussed earlier using discontinuous classes through Mendelian Genetics.

SCA variance was more than GCA variance for all the characters under study for two consecutive years (Table 18), except for width of the lesion and grain yield plant^{-1} in the second year (non-estimable). This indicates that non-additive gene action played an important role in the inheritance of these characters and is in conformity with the findings of Khehra *et al.* (1984) for reaction of *Dreschlera maydis* in maize. Since most of the characters showed non-additive gene action, it would be beneficial to develop a population by crossing these parents inter-se before initiating random mating in F_2 to allow higher recombinants. This is likely to break unfavourable linkages and confer a wide genetic base. However, Weiji *et al.*, 1956 reported the importance of both additive and non-additive gene effects for number of lesions, area of lesions and amount of spores per lesion area. Similarly in maize, GCA variance was of higher magnitude than SCA variance indicating that the additive component was in greater proportion than the dominance component (Hughes and Hooker, 1971 and Ramamurthy *et al.*, 1980). Sigulas *et al.*, 1988 also reported that in maize GCA effects were much larger than SCA effects for mean lesion area, lesion expansion rate and the shape of the lesion area expansion curve. The relative importance of non-additive gene effects was generally small and varied with the population involved and to a lesser extent, with the year of study (Hughes and Hooker, 1971). The predominance of non-additive gene action for plant height, grain yield plant^{-1} and 100 seed weight was in conformity with the findings of Kukadia *et al.* (1983) except for days to 50% flowering.

The parental lines, SPLB 94007A and ICSR 97 in the first year; and SPLB 94014A and ICSR 119 in the second year were good general combiners (Tables 14 and 16). However the cross SPLB 94007A x ICSR 97 in the first year resulted in non-significant positive SCA effect with low mean values. Whilst in the second year, it has resulted in significant negative SCA effect with low mean values. The crosses, SPLB 94009A x ICSR 91025 in the first year, and SPLB 94017A x ICSR 26 in the second year, which recorded significant SCA effects involved H_{ds} x L_{ds} GCA parents and L_{ds} x H_{ds} GCA parents indicating the operation of non additive gene action which is further confirmed by variance components. The first cross has also recorded lower mean value for disease damage score indicating the importance of these hybrids in the improvement of the character.

For length of the lesion, SPLB 94011A and A 2267-2 in the first year, and SPLB 94007A and ICSR 119 in the second year recorded low mean performance and maximum negative GCA effects. Hence, they were found to be good general combiners and may serve as good donor sources. The crosses, SPLB 94015A x ICSR 90030 (L_{ll} x L_{ll} GCA parents) in the first year, and SPLB 94017A x ICSR 26 (L_{ll} x H_{ll} GCA parents) in the second year recorded significant SCA effects and low mean values. Of which the latter hybrid had at least one parent as a good general combiner. The superior performance of the first cross might be due to better nicking ability of both the parents, indicating the operation of the non-additive gene action.

The parental lines, SPLB 94024A and A 2267-2 in the first year, and SPLB 94010A in the second year were found to be good general combiners with low mean values for width of the lesion and may serve as good donor sources. None of the restorer lines in the second year recorded significant GCA values. The crosses, SPLB 94015A x

ICSR 90030 (L_{wl} x L_{wl}) in the first year, and SPLB 94009A x ICSR 97 (H_{wl} x L_{wl}) in the second year, with lower mean values, recorded negative SCA effect indicating the operation of complementary gene action.

In the first year, SPLB 94013A and A 2267-2 and in the second year, SPLB 94007A and A 2267-2 recorded for negative GCA effects. Only one restorer line, A 2267-2, recorded low mean values in both the years and may serve as good donor source for developing resistance to area of the lesion. The hybrids, SPLB 94015A x ICSR 90030 (L_{al} x L_{al} GCA parents) in the first year, and SPLB 94017A x ICSR 26 (L_{al} x L_{al} GCA parents) in the second year exhibited high negative SCA effects, coupled with low mean values indicating the importance of non-additive gene action and hence, direct selection may not be effective for this character.

Considering number of lesions, SPLB 94007A and ICSR 90030 in the first year and SPLB 94025A and ICSR 90030 in the second year recorded for negative GCA effects. Parents though recorded low mean values in the first year, resulted in positive significant SCA effects. This indicated the predominance of non-additive gene action and the parents may not be genetically different from each other. The hybrids, SPLB 94016A x A 2267-2 (L_{nl} x L_{nl}) and SPLB 94009A x ICSR 119 (H_{nl} x L_{nl}) recorded for significant negative SCA effects in the first and second years, respectively, indicating the predominance of non-additive gene action. Since non-additive gene action was found predominant, breeding method-involving selection, intermating the selects and reselection may help to improve this trait.

The parents, SPLB 94015A and ICSR 97 in the first year, while 296A and ICSR 90030 in the second year were considered to be good general combiners for number of flecks. Except ICSR 97, other three restorers recorded low mean values for number of flecks and may serve as good donor sources. However, the crosses between them resulted in significant to non-significant positive SCA effects. This indicated the predominance of non-additive gene action and the parents may not be genetically different from each other. SPLB 94010A x ICSR 91025 (L_{nf} x L_{nf}) in the first year, and SPLB 94016A x ICSR 26 (L_{nf} x L_{nf}) in the second year, recorded negative SCA effects coupled with low mean indicating the importance of non-additive gene action in the inheritance of the character.

Considering lodging, SPLB 94021A and ICSR 97 were considered to be good general combiners. However, the cross between these two lines has resulted in non-significant positive SCA effect coupled with non-lodging in the F_1 generation. The cross, SPLB 94001A x ICSR 26 (L_{lp} x L_{lp}) with negative SCA effect coupled with low mean value indicated the importance of non-additive gene action.

The parents and hybrids with significant negative GCA / SCA effects to area of the lesion, number of lesions and the number of flecks coupled with low mean values are highly desirable (as discussed in section 4.4.8) and can be preferably used as donors in the future breeding programmes. In these sets of parents and the hybrids, the number of infection sites and the spread of the pathogen at each and every site of infection is minimum. Weiji *et al.,* 1956 observed negative GCA effects for resistant lines and positive GCA effects for susceptible lines. The negative effect of SCA usually occurred in crosses involving resistant and susceptible crosses indicating that resistance is partly dominant. The next set of crosses from the point of desirability are those which have exhibited negative GCA / SCA effect for area of the lesion, and positive GCA / SCA effect for number of lesions and number of flecks. In these genotypes, the pathogen causes minimum leaf damage in spite of the presence of more infection sites on a leaf. One of the defensive mechanisms like localized infections (hypersensitive reaction) might be responsible for the restricted growth of the pathogen. These genotypes could be considered as tolerant varieties, as they resist the spread of the pathogen besides normal yield. Hypersensitive reactions characterize varietal resistance in seedlings and mature plants. Bergquist and Masias, 1973 and Frederiksen *et al.*, 1975 reported that hypersensitive reactions characterize varietal resistance in seedlings and mature plants. Muller (1959) viewed hypersensitivity as the resistant response of the host plant. It is useful in a long epidemic in which disease increases with small beginnings to a relatively great amount. The effect of horizontal resistance is enhanced when the entire area is covered with crop varieties showing horizontal resistance. The amount of inoculum will be slow and consequently, the development of the disease will be slow. Thus horizontal resistance may be preferable as it is stable and considerable amount of yield is expected inspite of widespread disease. The rate and the extent of necrosis or horizontal resistance in leaf tissue appear to measure quantitatively the resistance to sorghum leaf blight.

The lines, SPLB 94022A and ICSR 26 in the first year, and 296A and ICSR 90030 in the second year were good general combiners for earliness. However, the crosses between them, though recorded low mean values, resulted in non-significant positive SCA effects. The crosses, SPLB 94004A x A 2267-2 (L_{df} x L_{df}) in the first year, and SPLB 94007A x A 2267-2 (L_{df} x L_{df}) in the second year recorded negative SCA effect indicating the predominance of non-additive gene action. However, the cross in the first year also recorded low mean values indicating its possible use in future programs. For lateness, SPLB 94006A and ICSR 90030 in the first year (Table 14), and

SPLB 94009A and ICSR 91025 in the second year (Table 16) were good general combiners. The former parents also recorded high mean values and may serve as good donors. However, the crosses between them exhibited non-significant positive SCA effect indicating the importance of non-additive gene action. The other cross resulted in significant positive SCA effect. The hybrids, SPLB 94016A x A 2267-2 (L_{df} x H_{df}) in the first year, and SPLB 94017A x A 2267-2 (H_{df} x L_{df}) in the second year, with high mean values recorded positive SCA effects indicating the predominance of non-additive gene action. Based on the performance of parents, it can be concluded that GCA of the parents in general had no bearing on the SCA effects of the crosses.

Considering plant height, SPLB 94015A and ICSR 97 in the first year and SPLB 94014A and A 2267-2 in the second year were good combiners. Crosses SPLB 94015A x A 2267-2 (H_{ph} x L_{ph}) in the first year, and SPLB 94017A x A 2267-2 (L_{ph} x H_{ph}) in the second year with low and high mean values exhibited negative SCA effects. Both the crosses involve low GCA and high GCA combining parents indicating the predominance of non-additive gene action for this trait.

Since agronomic score is rated on a 1-5 scale, where, 1 is excellent and 5 is poor; parents and crosses with negative combining ability effects were selected. Among the parents, SPLB 94019A and ICSR 26 in the first year, and SPLB 94010A and ICSR 97 in the second year recorded significant large negative GCA effects and may serve as good donors. Among the parents, only restorer lines exhibited negative GCA effect coupled with low mean values. However, the crosses between them resulted in non-significant positive and negative SCA effects indicating the predominance of non-additive gene action and the parents may not be genetically different from each other. The crosses which recorded significant SCA effects involved L_{as} x H_{as} (SPLB 94007A x A 2267-2 and SPLB 94016A x ICSR 119) parents for two consecutive years indicating the operation of non-additive gene action.

The parents SPLB 94019A and A 2267-2 in the first year, and SPLB 94010A and ICSR 119 in the second year were considered as good general combiners for grain yield plant^{-1}. However, the crosses between them resulted in positive (significant and non-significant) SCA effects indicating additive gene action. The crosses, SPLB 94009A x A 2267-2 (H_{gy} x H_{gy}) in the first year, and SPLB 94012A x ICSR 91025 (H_{gy} x H_{gy}) in the second year coupled with high and low mean values recorded positive SCA effects. Both the crosses involve H_{gy} x H_{gy} combining parents indicating the importance of additive gene action.

Among parents, SPLB 94012A and ICSR 119 in the first year, and ICSR 94012A and ICSR 90030 in the second year were considered to be good general combiners for 100 seed weight. However, the crosses between them resulted in non-significant positive and negative SCA effect. SPLB 94015A x ICSR 119 (H_{tw} x H_{tw}) and SPLB 94006A x ICSR 90030 (L_{tw} x H_{tw}) in the first and second years, respectively with high and low mean values recorded significant positive SCA effects. Thus, the superior combinations involved at least one parent with high GCA effects indicating that a single high general combiner in the cross combination might result in good specific combinations.

Among the yield attributes, the parental lines and the hybrids which exhibited significant effects for yield attributes including yield are SPLB 94019A with negative GCA effect for days to 50% flowering and agronomic desirability and positive GCA effect for grain yield plant^{-1}, SPLB 94016A and 94024A with negative GCA effect for days to 50% flowering and positive GCA effect for grain yield plant^{-1}, SPLB 94022A for days to 50% flowering and agronomic desirability (negative) and grain yield plant^{-1} and 100 seed weight (positive) and SPLB 94009A for agronomic desirability (negative), grain yield plant^{-1} and 100 seed weight (positive), SPLB 94001A for agronomic desirability (negative); and plant height and grain yield (positive); and SPLB 94012A with positive effects for plant height, grain yield plant^{-1} and 100 seed weight among the A-lines; ICSR 26 with negative GCA effect for days to 50% flowering, agronomic desirability and positive GCA effect for grain yield plant^{-1} and A 2267-2 for agronomic desirability and positive effect for plant height and grain yield plant^{-1} among R-lines; and SPLB 94011A x ICSR 119 and SPLB 94017A x ICSR 90030 with negative SCA effects for days to 50% flowering and positive SCA effect for grain yield plant^{-1}, SPLB 94015A x ICSR 97 with negative SCA effect for agronomic desirability and positive SCA effect for plant height and grain yield plant^{-1}, SPLB 94022A x A 2267-2 with positive SCA effect for plant height, grain yield plant^{-1} and 100 seed weight, SPLB 94001A x ICSR 119 for days to 50% flowering (negative), grain yield plant^{-1} and 100 seed weight (positive), SPLB 94007A x A 2267-2 for days to 50% flowering, agronomic desirability (negative) and plant height and grain yield plant^{-1} (positive), SPLB 94011A x ICSR 97 and SPLB 94012A x ICSR 26 for plant height and grain yield plant^{-1}; and SPLB 94024A x ICSR 26 with positive effect for grain yield plant^{-1} and 100 seed weight among hybrids in the first year, while SPLB 94010A with desirable GCA effect for plant height, grain yield plant^{-1} and 100 seed weight, SPLB 94014A for days to 50% flowering, grain yield plant^{-1} and 100 seed weight, SPLB 94019A and SPLB 94021A for agronomic desirability, plant height and grain yield plant^{-1}; and SPLB 94004A and SPLB 94022A for days to 50% flowering, plant height and grain yield plant^{-1}. SPLB 94001A with negative effect for days to 50% flowering and positive GCA effect for grain yield plant^{-1} among the A-lines, ICSR 90030 with negative GCA effect for days to 50% flowering and agronomic desirability and positive GCA effect for grain yield plant^{-1} and 100 seed weight; and ICSR 119 for plant height and grain yield plant^{-1} (positive) among the R-lines, and SPLB 94004A x A 2267-2, SPLB 94010A x A 2267-2 and SPLB 94013A x ICSR 91025 with negative SCA effects for days to 50% flowering and positive GCA effect for plant height and grain yield plant^{-1}, SPLB 94016A x A 2267-2 and SPLB 94006A x ICSR 26 with negative SCA effect for days to 50% flowering and positive GCA effect for plant height, grain yield plant^{-1} and 100 seed weight. SPLB 94007A x ICSR 97 for agronomic desirability (negative) and positive SCA effect for grain yield plant^{-1} and 100 seed weight, SPLB 94022A x ICSR 26 for agronomic desirability (negative effects) and plant height and grain yield plant^{-1} (positive effect); and SPLB 94024A x ICSR 90030 for plant height, grain yield plant^{-1} and 100 seed weight in the second year were found desirable.

The lines showing favourable GCA for different traits are given in Tables 33 and 34 for different years. Considering this, the favourable GCA effects for different traits were located in different genotypes. A breeding programme may be designed with multiple crosses to breed favourable GCA alleles for several characters together into a few genotypes. The hybrids SPLB 94016A x A 2267-2 and SPLB 94015A x ICSR 90030 may be considered as the best because they possessed desirable effects in both the years for more than one trait. As indicated in the results (Tables 6 to 9 and 14 to17), the following parental lines showed favourable mean performance and high desirable GCA effect for various disease related characters including overall disease damage (score):

Table 33. Parents showing superior general combining ability (GCA) effects for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1996 and 1997.

Characteristic	1996			1997		
	Genotypes	Group[3]	GCA value	Genotypes	Group[3]	GCA value
LINES						
Disease score[1]	SPLB 94007A	R	-1.22	SPLB 94014A	LS	-1.02
Length of the lesion (cm)	SPLB 94011A	R	-0.46	SPLB 94007A	R	-1.18
Width of the lesion (cm)	SPLB 94024A	LS	-0.03	SPLB 94010A	R	-0.05
Area of the lesion (cm^2)	SPLB 94013A	S	-0.14	SPLB 94007A	R	-0.47
Number of lesions (no)	SPLB 94007A	R	-4.46	SPLB 94025A	MR	-2.17
Number of flecks (no)	SPLB 94015A	R	-83.12	296A	S	-150.70
Lodging (%)	SPLB 94021A	R	-8.24			
Days to 50% flowering (days)-early	SPLB 94022A	MR	-6.40	296A	S	-5.93
Days to 50% flowering (days)-late	SPLB 94006A	MR	3.21	SPLB 94009A	LS	2.85
Plant height (cm)	SPLB 94015A	R	-28.1	SPLB 94014A	LS	-42.73
Agronomic score[2]	SPLB 94019A	MR	-0.75	SPLB 94010A	R	-0.46
Grain yield $plant^{-1}$ (g)	SPLB 94019A	MR	6.96	SPLB 94010A	R	8.68
100 seed weight (g)	SPLB 94012A	LS	0.45	SPLB 94012A	LS	0.43
TESTERS						
Disease score[1]	ICSR 97	MR	-1.29	ICSR 119	LS	-0.29
Length of the lesion (cm)	A 2267-2	R	-0.44	ICSR 119	LS	-0.19
Width of the lesion (cm)	A 2267-2	R	-0.04	None are significant		
Area of the lesion (cm^2)	A 2267-2	R	-0.17	A 2267-2	R	-0.07
Number of lesions (no)	ICSR 90030	S	-2.22	ICSR 90030	S	-1.18

Contd..

Contd..

Characteristic	1996 Genotypes	1996 Group[3]	1996 GCA value	1997 Genotypes	1997 Group[3]	1997 GCA value
Number of flecks (no)	ICSR 97	MR	-19.82	ICSR 90030	S	-92.26
Lodging (%)	ICSR 97	MR	-7.80	ICSR 90030	S	-1.31
Days to 50% flowering (days)-early	ICSR 26	S	-2.30			
Days to 50% flowering (days)-late	ICSR 90030	S	2.11	ICSR 91025	S	0.68
Plant height (cm)	ICSR 97	MR	-23.03	A 2267-2	R	-8.70
Agronomic score[2]	ICSR 26	S	-0.27	ICSR 97	MR	0.38
Grain yield $plant^{-1}$ (g)	A 2267-2	R	3.95	ICSR 119	LS	2.10
100 seed weight (g)	ICSR 119	S	0.10	ICSR 90030	S	0.09

1. Scored on a (1-9) scale.

2. Scored on a (1-5) scale.

3. The groups are based on the disease score.

Table 34. Hybrids showing superior specific combining ability (SCA) effects for various disease resistant parameters and yield contributing characters of sorghum, rabi season 1996 and 1997.

Characteristic	1996 Genotypes	1996 Group[3]	1996 SCA	1997 Genotypes	1997 Group[3]	1997 SCA
Disease score[1]	SPLB 94009A X ICSR 91025	R X LS	-1.57	SPLB 94017A X ICSR 26	LS X MR	-1.90
Length of the lesion (cm)	SPLB 94015A X ICSR 90030	R X S	-1.85	SPLB 94017A X ICSR 26	LS X MR	-1.89
Width of the lesion (cm)	SPLB 94015A X ICSR 90030	R X S	-0.11	SPLB 94009A X ICSR 97	LS X MR	-0.13
Area of the lesion (cm^2)	SPLB 94015A X ICSR 90030	R X S	-0.65	SPLB 94017A X ICSR 26	LS X MR	-0.75
Number of lesions (no)	SPLB 94016A X A 2267-2	MR X R	-8.37	SPLB 94009A X ICSR 119	LS X LS	-6.85
Number of flecks (no)	SPLB 94010A X ICSR 91025	R X LS	-159.77	SPLB 94016A X ICSR 26	MR X MR	-320.99
Lodging (%)	SPLB 94001A X ICSR 26	S X S	-18.04			
Days to 50% flowering (days)-early	SPLB 94004A X A 2267-2	R X R	-7.01	SPLB 94007A X A 2267-2	R X R	-8.43
Days to 50% flowering (days)-late	SPLB 94016A X A 2267-2	MR X R	8.43	SPLB 94017A X A 2267-2	LS X R	10.02
Plant height (cm)	SPLB 94015A X A 2267-2	R X R	-30.15	SPLB 94017A X A 2267-2	LS X R	-74.35
Agronomic score[2]	SPLB 94007A X A 2267-2	R X R	-0.98	SPLB 94016A X ICSR 119	MR X LS	-1.56
Grain yield $plant^{-1}$ (g)	SPLB 94009A X A 2267-2	R X R	17.36	SPLB 94021A X ICSR 91025	LS X S	21.54
100 seed weight (g)	SPLB 94015A X ICSR 119	R X S	0.42	SPLB 94006A X ICSR 26	LS X MR	0.66

1. Scored on a (1-9) scale.
2. Scored on a (1-5) scale.
3. The groups are based on the disease score.

Trait	Year	Disease reaction	A-lines	R-lines
Disease damage score	1996	R_{ds}	SPLB 94007A, SPLB 94009A, SPLB 94010A and SPLB 94011A	A 2267-2
Length of the lesion	1997	HR_{ll}	SPLB 94010A and SPLB 94011A	A 2267-2
Width of the lesion	1996	R_{wl}	SPLB 94011A and SPLB 94024A	
Area of the lesion	1996	R_{al}	SPLB 94009A, SPLB 94011A, SPLB 94003A and SPLB 94024A	
	1997	R_{al}	SPLB 94010A and SPLB 94011A	A 2267-2
Number of lesions	1996	R_{nl}	SPLB 94014A and SPLB 94013A	ICSR 91025, ICSR 90030
	1996	HR_{nl}	SPLB 94004A, SPLB 94007A and SPLB 94015A	
	1997	R_{nl}	SPLB 94012A	
	1997	HR_{nl}	SPLB 94004A, SPLB 94009A, SPLB 94024A and SPLB 94014A	
Number of flecks	1997	R_{nf}	SPLB 94022A and SPLB 94025A	
	1997	HR_{nf}	SPLB 94021A	ICSR 90030

Therefore, it is suggested that the above parents should be deployed in the breeding programme to produce leaf blight resistant hybrids.

5.4 HETEROSIS

Heterosis may be defined as the superiority of an F_1 hybrid in one or more characters over its parents. Heterosis leads to an increase in vigour, adaptability, quality, quantity; and pest and disease resistance. The estimates of heterosis also provide information about the type of gene action involved in the expression of various quantitative traits. Thus the commercial exploitation of heterosis has become important for most of the crop plants including sorghum. Though the selection of parents could be made on visual examination of desirable traits, the more rational approach would be to base the selection on *per se* performance, combining ability effects and F_1 heterosis. Hence heterosis (over mid-parent and better parent) exhibited by 120 hybrids for various blight resistant parameters and yield-contributing characters for two consecutive years are briefly discussed (Tables 19 to 22).

A perusal of the data presented in Tables 19 and 21 and section 4.5 revealed that the area of the lesion, number of lesions and number of flecks may be dominant in the highly desirable hybrids which exhibited negative heterosis for the above three disease related characters. However, the exact nature of genetic inheritance can be obtained by studying segregation of these hybrids. It can be concluded that the parental lines involved in these hybrids may be further used in the breeding programme to produce hybrids with highly desirable traits (resistance). This set of highly desirable hybrids may be used in the epidemic areas. On the other hand, in the desirable (negative heterosis for area of the lesion and positive heterosis for number of lesions and number of flecks) and the less desirable (positive heterosis for area of the lesion and negative heterosis for number of lesions and number of flecks) hybrids, the genes present in the host plant against these three disease parameters may be controlled by individual genes as the pattern of expression in different hybrids is varied in the present study.

It can be summarized that the hybrids with positive heterosis for plant height, grain yield plant^{-1} and 100 seed weight coupled with negative heterosis for flowering and desirability for earhead size and shape may be of paramount importance in any breeding programme. The hybrids viz., SPLB 94024A x A 2267-2, SPLB 94025A x ICSR 26, SPLB 94001A x ICSR 90030, SPLB 94024A x ICSR 26, SPLB 94019A x ICSR 26 and SPLB 94001A x ICSR 119 were found desirable for grain yield plant^{-1} besides other yield attributes in both the years of study.

As indicated earlier, the rational approach would be to base the selection of parents on *per se* performance, combining ability effects and F_1 performance and its heterosis. The hybrids selected for high SCA, heterosis and mean performance and the type of GCA of these parents are summarized as Tables 35 and 36 for various leaf blight resistant parameters.

The top five hybrids for overall disease damage (score) and other disease characters (Table 35) for the year 1996 indicated that of the 30 hybrids, 14 hybrids were between low x low GCA parents, nine between low x high, five between high x low and three between high x high GCA parents. Of the 30 hybrids, which showed high SCA in the second year, 13 hybrids were derived from each low x low and low x high GCA parents; and two each from high x low and high x high GCA parents (Table 36). The large number of low x low GCA parents figuring in top ranks for different characters is of immense interest, due to non-additive gene action.

5.5. MATERNAL EFFECTS

In any breeding programme, since cytoplasmic genes are also governing the traits it is imperative to improve the females, so that it can influence on the offspring if the trait is governed by the maternal effects. Strong physiological relationship between the mother saprophyte and the embryo or the seed of the following generation is due to maternal effects, which may have some influence on the resulting progenies. It masks the genetic variance either due to additive maternal effects or due to maternal interaction thus rendering the breeding procedures less effective. Hence, paired A- and B-lines, i.e., cytoplasmic male-sterile (CMS) lines and maintainer lines, respectively, were crossed with R-lines (restorers) to produce two types of hybrids, (A x R) and (B x R). These

Table 35. Top five entries selected on the basis of SCA along with GCA of the parents, per cent heterosis over BP and MP, mean performance and disease reaction, rabi season 1996.

Characteristic	Cross combinations	SCA value	GCA of the parents	Heterosis BP	Heterosis MP	Mean value	Disease reaction[2]
Disease score[1]	SPLB 94009A x ICSR 91025	-1.57	L x L	-55.5**	-42.77**	2.7	R
	SPLB 94015A x ICSR 90030	-1.23	H x L	-37.50**	-11.74	5.0	MR
	SPLB 94021A x ICSR 97	-1.32	H x H	-35.76**	-35.76**	3.0	R
	SPLB 94022A x ICSR 26	-1.11	M x L	-40.93**	-29.76**	4.3	MR
	SPLB 94001A x ICSR 97	-1.36	M x H	-50.07**	-41.27**	3.3	R
Length of the lesion (cm)	SPLB 94015A x ICSR 90030	-1.85	L x L	-86.84**	-83.55**	0.50	MR
	SPLB 94025A x ICSR 97	-1.12	L x H	-59.71**	-55.73**	0.83	MR
	SPLB 94025A x ICSR 91025	-1.01	L x L	-43.24**	-36.77**	1.47	MR
	SPLB 94001A x ICSR 97	-0.93	L x H	-61.38**	-59.22**	0.73	MR
	SPLB 94003A x ICSR 119	-0.92	H x L	-36.23	-0.56	0.88	MR
Width of the lesion (cm)	SPLB 94015A x ICSR 90030	-0.11	L x L	-34.38*	-26.32**	0.21	MR
	SPLB 94025A x ICSR 91025	-0.10	L x L	-37.04*	-34.62**	0.17	MR
	SPLB 94004A x ICSR 26	-0.09	L x L	-48.84*	-34.33**	0.22	MR
	SPLB 94014A x ICSR 119	-0.08	L x L	-23.33*	-6.12	0.23	LS
	SPLB 94010A x A 2267-2	-0.07	L x H	-43.48*	-29.73*	0.13	R
Area of the lesion (cm^2)	SPLB 94015A x ICSR 90030	-0.65	L x L	-88.78**	-87.21**	0.28	MR
	SPLB 94025A x ICSR 91025	-0.52	L x L	-64.29**	-59.02**	0.25	MR
	SPLB 94004A x ICSR 97	-0.40	L x H	-86.00**	-75.65**	0.11	R
	SPLB 94025A x ICSR 97	-0.40	L x H	-71.15**	-63.41**	0.15	R
	SPLB 94001A x ICSR 97	-0.39	L x H	-73.81**	-69.44**	0.11	R
Number of lesions (no)	SPLB 94009A x A 2267-2	-8.05	H x L	-53.68*	-45.60**	3.2	HR
	SPLB 94016A x A 2267-2	-8.37	L x L	-2.30	61.59	4.7	HR
	SPLB 94012A x ICSR 97	-6.96	H x H	-73.15*	-71.03**	2.3	HR
	SPLB 94022A x ICSR 97	-6.91	L x H	-42.20*	-15.94	4.9	R
	SPLB 94011A x ICSR 26	-6.75	L x H	-63.04*	-62.49**	3.4	HR

Contd..

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Character	Cross	SCA value	GCA of the parents	Heterosis		Mean value	Disease reaction[2]
				BP	MP		
Number of flecks (no)	SPLB 94010A x ICSR 91025	-159.77	L x L	87.10*	98.72	92.80	R
	SPLB 94009A x A 2267-2	-113.00	H x L	-56.38	-52.41	23.57	HR
	SPLB 94016A x A 2267-2	-131.26	L x L	-8.68	-5.38	44.20	HR
	SPLB 94003A x ICSR 90030	-101.66	L x H	63.11**	100.71	133.10	HR
	SPLB 94022A x ICSR 119	-99.42	L x L	56.74	143.83	66.93	R
Lodging (%)	SPLB 94001A x ICSR 26	-18.04	L x L	-93.50**	-92.04**	3.7	MR
Grain yield plant^{-1} (g)	SPLB 94009A x A 2267-2	17.36	H x H	148.30	159.00**	54.10	High
	SPLB 94016A x A 2267-2	13.14	H x H	119.59**	150.63**	47.90	High
	SPLB 94022A x A 2267-2	13.06	H x H	45.87**	60.32**	31.80	High
	SPLB 94006A x ICSR 97	11.87	L x L	2.71	38.51*	28.07	Average
	SPLB 94001A x ICSR 119	13.33	H x L	106.76**	115.34**	44.93	High

1. Scored on a (1-9) scale.
2. The groups are based on their respective character.
L = Parents with low GCA effects.
H = Parents with high GCA effects.

Table 36. Top five entries selected on the basis of SCA along with GCA of the parents, per cent heterosis over BP and MP, mean performance and disease reaction, rabi season 1997.

Characteristic	Cross combinations	SCA value	GCA of the parents	Heterosis BP	Heterosis MP	Mean value	Disease reaction[2]
Disease score[1]	SPLB 94003A x A 2267-2	-1.30	L x L	-20.00	3.90	4.0	MR
	SPLB 94019A x A 2267-2	-1.58	L x L	-34.00	-14.29	3.3	R
	SPLB 94004A x ICSR 91025	-1.34	L x L	-17.81	3.45	6.0	S
	SPLB 94017A x ICSR 26	-1.90	L x H	-11.67	-.93	5.3	LS
	SPLB 9401A x ICSR 90030	-1.86	L x L	-28.57**	-9.09	6.0	S
Length of the lesion (cm)	SPLB 94017A x ICSR 26	-1.89	L x H	-61.69**	-39.59**	1.90	R
	SPLB 94015A x A 2267-2	-1.63	H x H	-13.5	42.08**	3.14	LS
	SPLB 94019A x ICSR 119	-1.40	L x H	30.52*	59.71**	3.25	LS
	SPLB 9403A x A 2267-2	-1.36	L x H	-8.66	39.34	2.32	MR
	SPLB 94014A x ICSR 26	-1.33	L x H	-24.40**	5.19	3.75	S
Width of the lesion (cm)	SPLB 9403A x A 2267-2	-0.12	L x H	0	34.69*	0.33	LS
	SPLB 94015A x A2267-2	-0.12	H x H	-4.55	40.00**	0.42	S
	SPLB 9403A x ICSR 26	-0.11	L x L	-18.92*	-14.29	0.30	MR
	SPLB 9409A x ICSR 97	-0.13	L x L	-40.43**	-21.13*	0.28	MR
	SPLB 94014A x ICSR 26	-0.11	L x L	13.51	25.37*	0.42	S
Area of the lesion (cm^2)	SPLB 9403A x A 2267-2	-0.72	L x H	-9.41	55.56	0.77	MR
	SPLB 9403A x ICSR 26	-0.69	L x H	-51.09**	-33.09	0.90	LS
	SPLB 9404A x ICSR 91025	-0.67	L x L	-38.10**	-17.13	1.04	LS
	SPLB 94017A x ICSR 26	-0.75	L x H	-76.09**	-56.26**	0.44	R
	SPLB 94014A x ICSR 26	-0.67	L x H	-14.67	25.1	1.57	S
Number of lesions (no)	SPLB 94014A x ICSR 97	-5.95	L x H	38.89**	60.26**	12.50	HS
	SPLB 94016A x ICSR 26	-5.66	L x L	40	84.21*	3.50	R
	SPLB 9409A x ICSR 119	-6.85	H x L	-52.63**	-39.33*	2.70	HR
	SPLB 94014A x ICSR 119	-4.64	H x L	-21.05	4.65	4.50	R
	SPLB 94015A x ICSR 97	-3.78	L x H	-65.15**	-47.13**	2.30	HR

Contd..

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Characteristic	Cross combinations	SCA value	GCA of the parents	Heterosis		Mean value	Disease reaction[2]
				BP	MP		
Number of flecks (no)	SPLB 94011A x ICSR 97	-275.78	L x H	-48.50**	-46.12**	477.50	HS
	SPLB 94016A x ICSR 26	-320.99	L x L	138.18**	167.07**	285.10	LS
	SPLB 9409A x ICSR 119	-232.95	L x L	-67.37**	-61.72**	120.30	HR
	SPLB 9407A x A 2267-2	-173.84	L x L	81.90**	83.34**	681.40	HS
	SPLB 94013A x A 2267-2	-179.4	L x L	-12.55	23.79*	327.60	LS
Grain yield plant^{-1} (g)	SPLB 94011A x ICSR 90030	18.07	L x H	21.07**	39.45**	37.93	High
	SPLB 9404A x ICSR 119	23.38	H x H	-50.38**	-37.71**	17.40	Low
	SPLB 94013A x ICSR 25	17.21	L x H	66.67**	89.46**	48.00	High
	SPLB 9406A x ICSR 26	20.08	L x L	-23.55**	-14.86**	27.70	Average
	SPLB 94021A x ICSR 25	21.54	L x H	40.51**	45.40**	30.70	Average

1. Scored on a (1-9) scale.

2. The groups are based on their respective character.

L = Parents with low GCA effects.

H = Parents with high GCA effects.

hybrids have the same nuclear background but different cytoplasms. These are male-sterile and fertile cytoplasms.

As indicated earlier, male-sterile cytoplasm was found significantly more dominant for length and area of the lesion. On the other hand, the effect of cytoplasm on the disease score, width of the lesion, number of lesions and number of flecks was not significant (Table 24). The nuclear genes perhaps determine the response to the disease spores in terms of width and number of flecks, while the genes in the cytoplasm have dominant role in spreading the disease in terms of length and number of lesions. Moreover, the leaf area damage had no relationship with the width of the lesion, number of flecks and overall disease damage (score); Hence, it can be concluded that the observed highly significant effect of sterile cytoplasm on the above character could be non influential in designing the breeding programme for hybrids. Frederiksen *et al.*, 1978 indicated that some maternal factors condition resistance to leaf blight in sorghum. However, in maize, several hybrids when tested in reciprocal combinations showed similar disease reactions to *Helminthosporium turcicum* suggesting the absence of cytoplasmic effects (Hooker, 1975). Neither maternal nor reciprocal effects were significant for mean lesion area, rate of increase in lesion size and shape in maize (Sigulas *et al.*, 1988).

In case of agronomic traits, the effect of cytoplasm was significant on plant height and yield attributes such as desirability for earhead size and shape, grain yield plant^{-1} and 100 seed weight, while sterile cytoplasm exerted profound effect on plant height only (Table 25). This shows that

1. Higher fodder yields can readily be achieved through hybrids developed on male-steriles.

2. High grain yield and 100 seed weight in the B-lines would not be expressed in the A-lines. Therefore to develop high yielding bold grain hybrids from male-steriles, it is all the more important to have really high yielding bold grain cytoplasmic male-sterile / maintainer lines.

5.6 CORRELATIONS

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. In the present study, knowledge of the association between various disease resistant characters among themselves and their association with yield helps in identification of component characters for developing leaf blight resistant hybrids along with yield. Correlation studies for various disease resistant and yield contributing characters for two consecutive years (Table 26) are briefly discussed.

5.6.1 Association among Disease Resistant Characters

Resistance exhibited significant negative association with length, width and area of the lesion; and total leaf area damage. As the genotypes tend towards susceptibility the length, width, and area of the lesion increased. Though the association with number of flecks is negative it is non-significant indicating the negative relationship between these two traits. This clearly shows that there is an increase in fleck number in resistant genotypes indicating hypersensitivity playing a role in resistance further restricting the spread of the pathogen. In the second year, the association with length, width, area of the lesion and total leaf area damage is similar as that of the first year. Whilst significant positive association was observed with number of flecks indicating less number of flecks in the resistant genotypes contributing to resistance in the second year. From the data it is clear that non-significant positive association between overall disease damage (score) and the number of lesions in both the years indicated the independent behaviour of these two characters. The increase in fleck number in the resistant genotypes may indicate the possibility of hypersensitive reaction exhibited by the resistant genotypes towards disease resistance.

The positive association of the length of the lesion with the width and the area of the lesion; and total leaf area damage for two years indicated that as the length and width of the lesion increases, thereby area of the lesion will be more resulting to increase of total leaf area damage. The significant correlation between lesion length and per cent leaf area was also reported by Hooker, 1975. The close relationship indicates that genes controlling these characters are closely linked, pleiotropic or developmentally related (Liang, 1967). Whilst lesion number in both the years and fleck number in the second year decreases. Thus the increase in the susceptibility of the genotype as judged on the basis of visual ratings might be due to an increase in total leaf area damage and a decrease in number of lesions and flecks. Tuleen and Frederiksen, 1977 also reported that the extent and the rate of flecking formation decreased with susceptibility.

The positive association of the width and the area of the lesion with total leaf area damage for two years, negative association with number of lesions in both the years and number of flecks in the second year was observed. The number of lesions exhibited significant positive association with number of flecks and total leaf area damage in both the years. From this it can be concluded that susceptibility of a genotype might be associated with more number of lesions. Though the resistant genotypes exhibit damaged leaf area to some extent, the resistance might be associated with less number of lesions, and less number of flecks. Thus the disease reaction of a genotype could be judged based either on disease damage score, lesion number and fleck number or taking total leaf area damage or area of the lesion alone into consideration. Since leaf area reflected reasonably on the disease damage score / resistance and the fleck number and leaf area damage negative correlation is not consistent across the seasons it is possible to breed genotypes with less leaf area damage and with less fleck number.

5.6.2 Disease Vs Adaptation Characters

Width of the lesion in the second year showed positive association with days to 50% flowering and negatives association with plant height. However, Tarumoto and Isawa, 1975 reported non-significant association between disease grade and plant height. Total leaf area damage and lesion number exhibited negative association with days to 50% flowering in the first year, while number of flecks with days to 50% flowering in the second year. On the other hand, the positive association of total leaf area damage with plant height in the first year shows that tall and early genotypes although exhibited some level of hypersensitive reaction in the first year, they are found susceptible to the disease because they supported more leaf area damage. Snyder, 1949-50 found that resistance to *Helminthosporium turcicum* was associated with late maturity in Sudan grass as is seen with width of the lesion and days to 50% flowering in the second year. This may be partly the result of a physiological change-taking place within the plant.

5.6.3 Disease Vs Yield Characters

The association of disease resistant parameters with grain yield plant^{-1} was different from its association with agronomic desirability. The positive association of lesion number with agronomic desirability in both the years; and total leaf area damage and fleck number with agronomic desirability in the first year indicated that the genotypes with large leaf area damage and high fleck number are poor yielders. Positive association of fleck number with grain yield plant^{-1} and 100 seed weight in the first year indicated that fleck number lead to increased grain yield plant^{-1} and 100 seed weight by exhibiting hypersensitive response to the disease thereby inhibiting the spread of the pathogen. While width and area of the lesion showed significant negative association with agronomic desirability and grain yield plant^{-1} in the second year. Lodging exhibited negative association with 100 seed weight in the first year. As the percentage of leaf area damage increases the desirability of the genotype for agronomic performance tends to be poor and the grain yield plant^{-1} and the 100 seed weight also decreases. Thus the occurrence of the disease reduces the grain yield of the plant. Raymundo and Hooker, 1981 observed positive correlation coefficients between area infected and yield and reported that substantial loss of grain yield plant^{-1} was associated with high levels of diseased leaf area in maize.

Since the association of grain yield plant^{-1} with susceptible disease parameters are not consistent over the seasons, it is possible to breed for high yield in less susceptible background since these plants are having escape mechanism and endurance, otherwise to breed resistant lines in high yielding background.

5.6.4 Association among Yield Contributing Characters

The positive association of grain yield plant^{-1} with 100 seed weight in both the years shows that as the grain yield plant^{-1} increases, 100 seed weight also increases due to increase in the size of the seed and is in confirm with the findings of Giriraj and Goud (1983) and Dabholkar *et al.* (1970). However, 100 seed weight had a less correlation with grain yield plant^{-1} in the studies reported by Liang (1967) indicating that seed weight in sorghum had little predictive value in relation to grain yield. However, Singh and Baghel (1977) observed non-significant correlation between grain yield plant^{-1} and 100 seed weight.

The positive association of days to 50% flowering with plant height in the first year as also reported by Patil and Thombre, 1983 and association with agronomic desirability and grain yield plant^{-1} in the second year showed that genotypes with late flowering tend to be tall with less preferred agronomic desirability and grain yield plant^{-1}. Hence, it would be essential to breed early flowering genotypes to obtain higher grain yields. The significant negative association of days to 50% flowering with grain yield plant^{-1} is in contrast to the findings of Giriraj and Goud (1983).

The association of plant height with agronomic desirability for earhead shape and size and grain yield plant^{-1} in both the years and 100 seed weight in the first year was positive. The mean height of the plant in the second year was more than the first year and the plants grew taller and might have accumulated more dry matter for maximum expression of vegetative characters. The net result would be an increase in source, which in turn promotes photosynthetic efficiency (Goud and Sastry, 1974). The significant positive association of plant height with grain yield plant^{-1} and 100 seed weight is in conform with the findings of Patil and Thombre, 1983, Giriraj and Goud, 1983; and

Shinde, 1981. Further negative and significant correlation of days to 50% flowering with grain yield plant^{-1} was also reported by Shinde, 1981.

5.7 GENETIC VARIABILITY

In the process of improvement of genetic pattern of crop plants in relation to their economic use, desirable plants are continuously being selected from genetically variable populations. Selection can act effectively only on heritable differences but cannot create variability. Variability is, therefore, one of the key factors that determine the amount of progress expected from selection. Variation of phenotypic values is, therefore, determined by variance attributed to genotypic values and environmental deviations. Success of breeder in changing the characteristics of population, therefore, depends upon the degree of correspondence between the phenotypic and the genotypic values. A qualitative measure, which provides information about correspondence between genotypic and phenotypic variances, is heritability. Heritability estimates along with genetic advance are more helpful in predicting the gain under selection than heritability estimates alone.

Moderate coefficients of variability reported for overall disease damage (score) in two consecutive years are in contrary with the findings of Hughes and Hooker, 1971, Hooker, 1971, and Satyanarayana, 1995 who reported high estimates of phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) for disease damage score in maize for *Helminthosporium turcicum* leaf blight, suggesting that the selection based on this trait would facilitate a successful isolation of resistant types. Difference between PCV and GCV estimates for two years are very narrow indicating the greater role of genetic factors and minor role of environmental factors in influencing the expression of disease inheritance and offering greater scope for selection of desirable resistant parents (Satyanarayana, 1995). Among the yield contributing characters, days to 50% flowering recorded very low variability followed by 100 seed weight and plant height. The low variability recorded for days to 50% flowering is in contrast with the findings of Raghu Ram Reddy *et al.*, 1996 who reported the presence of high phenotypic variance indicating the influence of environment.

High heritability coupled with high genetic advance as per cent of mean recorded for area of the lesion, number of lesions and number of flecks in both the years indicates the importance of additive gene action and selection on these traits will be a rewarding one only in the passing generation of pedigree method or single seed descent method. The breeder can accumulate favourable additive genes into the pureline which will pose a resistant desirable genotype.

High heritability coupled with moderate genetic advance as per cent of mean recorded for disease damage score, length of the lesion (first year), plant height and grain yield plant^{-1} indicates ambiguous gene action. Such traits are merely governed by non-additive genes. Selection on these traits will give conflicting results in the passing generations. Satyanarayana (1995) and Ramamurthy *et al.*, 1980 reports similar results of heritability for disease score in maize. On the contrary, high expected genetic advance was recorded for disease damage score in maize (Johnson *et al.*, 1955 and Panse, 1967) and plant height (Patil and Thombre, 1983) owing to higher additive gene effects. High heritability accompanied with high expected genetic advance for grain yield plant^{-1} was reported by Kukadia *et al.*, 1983, Patil and Thombre, 1983; and Cheralu and Rao, 1989 indicating that the selection would be effective for these characters.

High heritability coupled with low genetic advance as per cent of mean noticed for days to 50% flowering and 100 seed weight indicates the high influence of the environment on the genotype leading to unstable expression of the genotype. The gene action is governed by merely non-additive genes. Selection on such traits will lead to slippage of traits under investigation in the subsequent generations. The presence of high heritability and low genetic advance over mean indicates the presence of non-additive type of gene action and the high heritability might be due to environment and the high heritability estimates may not necessarily mean an increased genetic advance (Johnson *et al.*, 1955). Raghu Ram Reddy *et al.* (1996) also reported the presence of high heritability and low genetic advance for days to 50% flowering. Similarly, high heritability and low expected genetic advance for days to 50% flowering, and 100 seed weight was also recorded by Kukadia *et al.*, 1983. Patil and Thombre, 1983 noticed high heritability for days to 50% flowering, plant height, grain yield plant^{-1} and 100 seed weight as reported in the present study.

Since the favourable genes (leaf diseases parameters) were dispersed in different genotypes, multiple crossing is suggested to accumulate all these favourable genes into one genotype. Since high heritability was noted for many of these traits it is expected that such breeding programme would be successful in realising the favourable alleles of various traits into a few genotypes.

5.8 EPIDEMIOLOGY PARAMETERS

Disease development is determined essentially by four factors: infection, latent period, pathogen sporulation and loss of infectious tissue (Van der Plank, 1963). Resistance affects one or more of these processes and thus influences the outcome of a potential epidemic. The types of resistance currently employed against *Helminthosporium turcicum* act in a diverse way (Hooker, 1961 and Hooker, 1975). Polygenic resistance reduces the number of lesions produced, while chlorotic lesion resistance primarily suppresses fungal growth and sporulation (Raymundo and Hooker, 1981).

The rate of growth of lesion differs and the increase is not always linear. This implies that multiple measurements might accurately assess the reaction to *Exserohilum turcicum*. Sigulas *et al.*, 1988 also suggested that a genetic interaction exists with time and the entries with similar means early in the season could be markedly different at a later date. The limited spread of the disease as observed in the resistant lines is in confirm with the findings of Raymundo (1978) and Pataky *et al.* (1986) who suggested that the spread of leaf blight in the hybrids of maize with qualitative and quantitative resistance is limited primarily to neighbouring plants and would not reach levels that would cause significant yield reduction.

Late appearance of symptoms, minimum rate of lesion growth and less number of spores are considered useful because genotypes with such traits could offer stability in resistance and deployed in different environments. Sigulas *et al.*, 1988 opined that favourable genotypes would be those in which disease development was delayed and growth rate was slow. The parents and the hybrids, which confirm to the above conditions are of paramount importance in this context. These were SPLB 94025A, SPLB 94025B, 296A, SPLB 94025B x ICSR 90030 and 296A x A 2267-2. The latent period for sporulation inheritance (dominance / recessivity) was not found to be consistent and appeared to be dependent on the genotype. Turner and Hart (1975) also have suggested that the spread of *Exserohilum turcicum* is localized and that spore production is affected significantly by the host genotype. Consequently, large amounts of initial inoculum or conditions that result in excessive secondary inoculum production and dissemination are probably necessary for severe epidemics of leaf blight in maize (Pataky *et al.*, 1986).

These studies which were carried out at ICRISAT with the available A, B and R lines are only preliminary and further research in this area is required to confirm the results.

5.9 FUTURE LINE OF WORK

1. Combining the various favourable disease resistant parameters into one or two genotypes.
2. Characterizing these parents for disease epidemiology parameters, in-depth study of the mode of inheritance and their interrelationship; and breeding for disease resistance based on above traits.
3. Characterizing the biochemical basis of disease resistance and breeding for resistance on these criteria.
4. Development of appropriate molecular markers for leaf blight disease resistance.

Summary

CHAPTER VI

SUMMARY

The present investigation entitled "Genetic analysis of leaf blight (*Exserohilum turcicum* (Pass.)) resistance and its influence on yield in sorghum (*Sorghum bicolor* (L.) Moench)", was taken up to study the mode of inheritance of resistance to leaf blight. Studies were initiated at ICRISAT-Patancheru during 1996 and 1997 by using 20 cytoplasmic male-sterile (A) lines, 17 male-sterile maintainer (B) lines and six restorer (R) lines crossed in a line x tester design to obtain 120 (A x R) hybrids and 102 (B x R) crosses.

A critical analysis of mean performance of the parents and hybrids for two consecutive years revealed significant genetic variation among the genotypes for disease damage (score), various disease resistant parameters and grain yield characters. Parental lines exhibiting a range of disease damage (score) showed differential response to the disease related characters like length, width and area of the lesion, number of lesions and number of flecks. Moreover, the differences in disease damage score over the seasons among the genotypes indicated the presence of variability among them for resistance or susceptibility to the disease.

Considering the disease damage score, two female lines (SPLB 94010A and SPLB 94011A) and two male parents (A 2267-2 and ICSR 97) were found to be resistant. Among the two selected resistant female lines, SPLB 94011A resulted in the production of resistant hybrids in both the seasons, whereas SPLB 94010A only in the second year. Among the restorer parents, ICSR 97 provided stable resistant hybrids

in both the seasons, while another selected R-line, A 2267-2 contributed to the production of four resistant hybrids in the second year.

In the first year, overall disease damage (score) was less than in the second year. In the first year, none of the individual disease parameters have had profound effect on the expression of the overall disease damage (score). On the other hand, in the second year, length, width and area of the lesion, and number of lesions appeared to have played a significant role in contributing to the overall disease damage (score).

The hybrid, SPLB 94009A x ICSR 90030 was found not only stable in yield performance with good agronomic desirability in both the years but also possessed other appreciable traits like medium flowering habit and medium height in the first year, and dwarfness with early flowering habit in the second year. In addition, this hybrid also recorded the lowest number of flecks with minimal leaf area damage during the second year, while in the first year less length, width and area of the lesion and number of flecks.

The most preferred A-lines for moderate resistance and average yields were SPLB 94003A, SPLB 94006A, SPLB 94019A and SPLB 94012A in the first year, while SPLB 94013A in the second year. In the first year the R-line, A 2267-2 was most preferable with resistance and average yield, while ICSR 26 with high yield and moderate resistance. The hybrids with early flowering, moderate resistance and high yield were SPLB 94022A x ICSR 26 and SPLB 94009A x ICSR 119 in the first year; and SPLB 94025A x ICSR 26 and SPLB 94009A x ICSR 90030 in the second year. On the other hand, among the hybrids which were late to flower, resistance with high yield was recorded by SPLB 94009A x ICSR 97 in the second year, while moderate resistance coupled with high yield by SPLB 94019A x A 2267-2 in the first year. The most desirable hybrids based on maximum grain yield plant^{-1} and moderate resistance for overall disease damage (score), minimum length, width and area of the lesion were SPLB 94004A x A 2267-2 (R_{ds} x R_{ds}), SPLB 94011A x ICSR 119 (R_{ds} x LS_{ds}), SPLB 94016A x ICSR 119 (MR_{ds} x R_{ds}), SPLB 94022A x ICSR 119 (MR_{ds} x LS_{ds}) and SPLB 94001A x ICSR 91025 (S_{ds} x LS_{ds}) in the first year, whereas SPLB 94004A x ICSR 97 (LS_{ds} x MR_{ds}), SPLB 9401A x ICSR 119, SPLB 94019A x ICSR 90030 and SPLB 94009A x ICSR 90030 (LS_{ds} x S_{ds}) in the second year.

Host plant resistance is the most effective, economical and least hazardous measure of disease control as it can withstand or oppose the spread of the pathogen. The parents and hybrids were grouped as shown below into various classes for disease damage score. HR_{ds} = Highly resistant, R_{ds} = Resistant, MR_{ds} = Moderately resistant, LS_{ds} = Less susceptible, S_{ds} = Susceptible and HS_{ds} = Highly susceptible. Thus, on the basis of overall disease damage score, R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, MR_{ds} x MR_{ds} and LS_{ds} x R_{ds} groups in the first year, and MR_{ds} x MR_{ds}, LS_{ds} x R_{ds} and LS_{ds} x MR_{ds} combinations in the second year were found to give resistant hybrids. The resulting hybrids of these combinations / crosses also showed low number of lesions and flecks and less length, width and area of the lesion. Therefore, these combinations were expected to produce stable resistant hybrids. This showed further that at least, one of the parents should possess either resistance or moderate resistance to obtain resistant hybrids.

Grouping of the parental lines based on the disease damage score under different environmental conditions provides a key information on variability and stability in disease reaction. The parental lines which exhibited stable performance in the pattern of disease reaction were SPLB 94016A (MR_{ds}), SPLB 94024A and SPLB 94014A (LS_{ds}) and 296A (S_{ds}) among A-lines; and A 2267-2 (R_{ds}), ICSR 97 (MR_{ds}) and ICSR 90030 (S_{ds}) among R-lines.

The disease resistant parameters, namely, length of the lesion, width of the lesion, area of the lesion, number of lesions and number of flecks were found to vary for all the parental lines tested over two years. The parental lines which had desirable pattern of disease reaction for overall disease damage (score) and other disease related characters in the first year were SPLB 94009A (R_{ds}) for area of the lesion, SPLB 94010A (R_{ds}) and SPLB 94011A (R_{ds}) for width and area of the lesion; SPLB 94003A and SPLB 94022A (MR_{ds}) for length of the lesion and lodging, SPLB 94021A (MR_{ds}) for length, width and area of the lesion among A-lines, while A 2267-2 (R_{ds}) for number of flecks, ICSR 97 (MR_{ds}) for length, width and area of the lesion, number of lesions and lodging among the R-lines. On the other hand, in the second year, SPLB 94010A and SPLB 94011A (MR_{ds}) for width of the lesion, SPLB 94004A (MR_{ds}) for length and area of the lesion and number of flecks, SPLB 94025A (MR_{ds}), for length and width of the lesion, and area of the lesion among A-lines, whereas A 2267-2 (R_{ds}) for area of the lesion and number of lesions and ICSR 97 (MR_{ds}) for width of the lesion among R-lines exhibited similar pattern of disease reaction for the above disease related characters besides disease damage score. Three hybrids selected for less disease damage (score) in the second year also had less length and area of the lesion. These were SPLB 94011A x ICSR 97, SPLB 94010A x A 2267-2 and SPLB 94016A x A 2267-2. Four hybrids selected for less disease damage (score) in the second year also had less width of the lesion and a few lesions. These were SPLB 94025A x A 2267-2, SPLB 94011A x ICSR 97, SPLB 94010A x A 2267-2 and SPLB 94016A x A 2267-2.

Considering total leaf area damage and fleck number into considerations, the parental lines and the hybrids with minimum leaf area damage and less fleck number were considered to be resistant. Irrespective of differential response to the disease, a perusal of data over two consecutive years showed that the hybrids made on, SPLB 94012A, SPLB 94015A and SPLB 94006A with ICSR 119, SPLB 94004A, SPLB 94012A, SPLB 94015A, SPLB 94017A, SPLB 94021A and 296A with ICSR 26; and SPLB 94004A, SPLB 94006A, SPLB 94003A, SPLB 94015A, SPLB 94013A, SPLB 94021A and SPLB 94017A as females with ICSR 90030 as male were found to be resistant and stable in expression. On the other hand, SPLB 94003A x ICSR 26 was moderately resistant over both the years with less area damage and medium fleck number.

The behaviour of the hybrids in relation to the parents can be considered following discrete or discontinuous and continuous or quantitative analysis. The former analysis can be done on individual cross basis or on the basis of groups of crosses involving similar types of parents. Unlike, quantitative analysis, this discontinuous classification based analysis is simple to comprehend. Therefore, the continuous measurements are made into discrete classes to allow an interpretation of the inheritance in a simple mendelian fashion. Different types of gene action like over dominance and partial dominance for resistance / susceptibility were encountered in the material for various disease resistant parameters and other yield attributes.

The hybrids which exhibited dominant reaction for resistance based on overall disease damage (score) were R_{ds} x R_{ds}, R_{ds} x MR_{ds}, R_{ds} x LS_{ds}, LS_{ds} x R_{ds} and S_{ds} x R_{ds} in the first year, while MR_{ds} x R_{ds} and LS_{ds} x R_{ds} in the second year. On the other hand, R_{ds} x MR_{ds}, MR_{ds} x MR_{ds}, LS_{ds} x MR_{ds} and S_{ds} x MR_{ds} groups in the first year and MR_{ds} x MR_{ds} and LS_{ds} x MR_{ds} in the second year showed over dominant reaction for resistance to the overall disease damage (score). The types of genotypes involved in a cross might influence the pattern of inheritance. The mode of inheritance of leaf blight reaction in sorghum thus does not appear to be simple. Therefore, in the present study an attempt has been made to analyze the inheritance quantitatively following line x tester analysis.

Analysis of the combining ability revealed significant genetic variation among parental lines and their hybrids for various characters studied. The significance of line x tester mean squares indicated that the A-lines do not appear to behave consistently over different R-lines and *vice versa*. Non-additive gene action played an important role in the inheritance of various disease related characters like length and area of the lesion, number of lesions and number of flecks including disease damage score and other yield attributes except yield. Hence epistasis appears to be an integral part of the disease resistance in the sorghum population.

The parents and hybrids with significant negative GCA / SCA contributions for area of the lesion, number of lesions and number of flecks coupled with low mean values were considered to be highly desirable, as they contribute to resistance to the disease. These were SPLB 94007A, SPLB 94009A, SPLB 94006A and SPLB 94003A among A-lines, ICSR 97 among R-lines and SPLB 94004A x A 2267-2, SPLB 94010A x ICSR 26, SPLB 94019A x ICSR 97, SPLB 94001A x ICSR 26 and SPLB 94022A x ICSR 119 among hybrids in the first year, while SPLB 94009A among A-line, and SPLB 94004A x ICSR 91025, SPLB 94006A x ICSR 26, SPLB 94021A x ICSR 90030, SPLB 94014A x ICSR 91025 and SPLB 94012A x ICSR 119 in the second year. Moreover, the favourable GCA traits were located in different genotypes. For e.g., the following parental lines showed low mean performance and high desirable GCA effect for various disease related characters including overall disease damage (score). These were SPLB 94007A, SPLB 94009A, SPLB 94010A SPLB 94011A and A 2267-2 (R_{ds}) for disease score, SPLB 94011A and SPLB 94024A resistant for width of the lesion, SPLB 94009A, SPLB 94011A, SPLB 94003A and SPLB 94024A resistant for area of the lesion, SPLB 94014A, SPLB 94013A, ICSR 91025 and ICSR 90030 resistant for number of lesions, SPLB 94004A, SPLB 94007A and SPLB 94015A highly resistant to number of lesions in the first year, while SPLB 94010A, SPLB 94011A and A 2267-2 highly resistant to length of the lesion, SPLB 94010A and SPLB 94011A resistant to area of the lesion, SPLB 94012A resistant to number of lesions, SPLB 94004A, SPLB 94009A, SPLB 94024A and SPLB 94014A highly resistant to number of lesions. SPLB 94022A and SPLB 94025A resistant to number of flecks; and SPLB 94021A and ICSR 90030 highly resistant to number of flecks in the second year only. The hybrids, SPLB 94016A x A 2267-2 and SPLB 94015A x ICSR 90030 were of paramount importance as they possessed desirable effects in both the years for more than one trait.

The area of the lesion, number of lesions and number flecks may be dominant in the highly desirable hybrids (for resistance) which exhibited heterosis in the desirable direction for the above three disease related characters. In the first year, 14 out of 30 hybrids selected on SCA effects for various disease related characters were derived from parents having low x low GCA (for their respective characters), while 13 hybrids in the second year were derived from low x low and low x high GCA parents.

Male-sterile cytoplasm was found contributing significantly more to length and area of lesion. On the other hand, the effect of the cytoplasm on disease score, width of the lesion, number of lesions and the number of flecks was not significant. Since area of the lesions had no relationship with the width of the lesion, number of flecks and overall disease damage (score), it can be concluded that the observed highly significant effect of male-sterile cytoplasm on the above character could not influence the design of the hybrids breeding programme.

The length, width and area of the lesion increased as the genotypes tended towards susceptibility. The increase in fleck number in the resistant genotypes in the first year and their decrease in second year indicated the importance of hypersensitive reaction in imparting resistance further restricting the spread of the pathogen. On the other hand, susceptibility of a genotype might be associated with less number of lesions and less number of flecks. Thus the disease reaction of a genotype could be judged based on either disease damage score, lesion number and fleck number or taking total leaf area damage or area of the lesion alone into consideration. The genotypes with large leaf area damage and high fleck number were poor yielders.

Thus the occurrence of the disease reduces the grain yield of the plant. Moderate coefficients of variability, very high to high heritability and moderate genetic advance over mean were reported for the overall disease damage (score). High heritability coupled with high genetic advance as per cent of mean was observed for area of the lesion, number of lesions and number of flecks.

The parents (SPLB 94025A, SPLB 94025B, 296A) and the hybrids (SPLB 94025B x ICSR 90030 and 296A x A 2267-2) with delayed disease development and minimum growth rate of the lesion area were found desirable. The latent period for sporulation inheritance (dominance / recessivity) was not found to be consistent and appeared to be dependent on the genotype. Early appearance of the disease (lesion) was found to be mostly dominant over late appearance of the symptoms.

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APPENDIX

Weekly meteorological data during the crop growth period (1996-1998)

Date	Rainfall (mm)	Evaporation (mm)	Temperature c max	Temperature c min	Relative Humidity I	Relative Humidity II	Wind (km/h)	Sunshine (h)
29.9 to 5.10.96	59.6	29.5	28.4	21.8	91.9	73.6	11.2	3.1
6.10 to 12.10.96	0.0	42.8	30.6	18.3	87.4	41.0	3.4	8.8
13.10 to 19.10.96	11.0	32.3	28.5	19.7	85.0	63.4	4.9	5.4
20.10 to 26.10.96	13.0	22.5	28.8	21.0	92.7	65.7	6.5	5.8
27.10 to 2.11.96	0.0	32.9	29.6	15.6	88.3	40.7	4.2	9.3
3.11 to 9.11.96	22.4	33.1	29.4	17.7	84.9	47.7	6.7	8.8
10.11 to 16.11.96	0.0	35.6	29.8	16.3	86.1	41.9	3.3	10.0
17.11 to 23.11.96	0.0	27.8	28.4	14.3	86.3	47.1	3.8	7.4
24.11 to 30.11.96	0.0	30.7	28.2	12.2	91.0	38.4	3.7	10.1
1.12 to 7.12.96	0.0	27.2	27.5	14.6	88.7	42.6	3.7	6.1
8.12 to 14.12.96	0.0	28.6	28.1	14.1	81.4	39.4	4.4	6.8
15.12 to 21.12.96	0.0	30.0	28.4	13.6	83.6	38.4	5.1	7.3
22.12 to 28.12.96	0.0	33.2	27.3	11.7	91.0	34.9	3.9	8.6
1.1 to 7.1.97	0.0	4.3	26.5	12.0	88.9	35.9	5.7	9.2
8.1 to 14.1.97	0.1	4.3	25.9	15.7	90.9	50.0	8.9	6.7
14.1 to 21.1.97	1.5	3.8	26.8	15.8	92.0	52.6	6.3	7.0
21.1 to 28.1.97	0.0	4.9	28.4	12.4	88.4	29.1	5.4	10.2
29.1 to 4.2.97	0.0	4.9	29.4	13.6	86.3	29.9	6.0	10.1
5.2 to 11.2.97	0.0	5.6	31.3	14.3	88.7	27.7	4.3	10.2
12.2 to 18.2.97	0.0	6.7	26.7	11.0	84.6	17.9	4.2	10.7
19.2 to 25.2.97	0.0	6.8	32.4	15.7	82.0	27.0	5.6	10.3
26.2 to 4.3.97	0.0	7.7	34.0	15.1	78.0	19.6	5.4	10.2
1.10 to 7.10.97	2.8	4.4	30.6	19.3	89.0	55.0	3.5	8.1
8.10 to 14.10.97	0.0	4.8	31.2	18.9	86.4	44.9	3.8	8.9
15.10 to 21.10.97	0.0	4.9	31.3	20.0	88.4	46.7	4.9	8.1
22.10 to 28.10.97	0.6	4.4	30.0	19.8	92.0	53.3	7.3	6.8
29.10 to 4.11.97	7.5	3.8	29.5	19.8	94.9	71.3	8.5	7.4
5.11 to 11.11.97	0.1	4.1	29.7	17.9	91.6	48.7	4.8	7.5
12.11 to 18.11.97	6.7	3.4	29.0	19.8	96.3	62.4	5.1	5.0
19.11 to 25.11.97	0.0	3.9	29.0	19.8	91.0	58.4	8.0	8.0
26.11 to 2.12.97	0.5	4.4	29.2	20.4	90.7	57.9	9.0	7.9
3.12 to 9.12.97	3.6	4.1	28.1	18.1	93.6	52.4	10.6	7.0
10.12 to 16.12.97	0.1	2.6	26.9	17.1	93.0	63.6	6.5	6.9
17.12 to 23.12.97	0.4	2.6	27.5	18.7	95.7	59.7	9.3	5.5
24.12 to 31.12.97	0.0	4.6	29.4	17.6	95.0	43.3	7.8	8.1
1.1 to 7.1.98	0.0	4.2	27.8	14.0	94.5	42.7	5.8	9.0
8.1 to 14.1.98	0.0	3.8	28.4	12.5	97.4	39.9	13.8	9.5
15.1 to 21.1.98	0.0	4.6	31.3	15.8	93.0	42.4	7.1	9.0
22.1 to 28.1.98	0.0	5.0	30.5	17.9	88.7	40.1	9.1	9.0
29.1 to 4.2.98	0.0	5.1	30.9	18.0	93.1	41.0	5.6	8.8
5.2 to 11.2.98	0.0	5.4	30.4	17.1	83.0	38.7	7.9	8.3
12.2 to 18.2.98	0.0	6.2	31.1	15.7	79.1	33.9	6.4	9.7
19.2 to 25.2.98	0.0	6.8	33.1	15.8	74.4	24.9	6.4	10.2
26.2 to 4.3.98	4.2	7.3	34.3	16.4	81.3	31.4	7.3	9.4