GENETIC VARIABILITY FOR DEVELOPMENTAL AND YIELD ATTRIBUTES OF SORGHUM AND PIGEONPEA UNDER INTER AND INTRA-SPECIES COMPETITIONS

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Ms. BEENA SOMANATHAN NAIR has satisfactorily prosecuted the course of research and that the thesis entitled ''GENETIC VARIABILITY FOR DEVELOPMENTAL AND YIELD ATTRIBUTES IN SORGHUM AND PIGEONPEA UNDER INTER AND INTRA-SPECIES COMPETITION'' 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 him for a degree of any university.

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This is to certify that the thesis entitled ''GENETIC VARIABILITY FOR DEVELOPMENTAL AND YIELD ATTRIBUTES IN SORGHUM AND PIGEONPEA UNDER INTER AND INTRA-SPECIES COMPETITIONS'', submitted in partial fulfilment of the requirements for the degree of Master of Science in Agriculture of the Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by MS. BEENA SOMANATHAN NAIR 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 or has been published. Published part has been fully acknowledged. All the assistance and help received during the course of the investigation have been duly acknowledged by her.

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CONTENTS

PAGE

LIST OF TABLES

PAGE

LIST OF ILLUSTRATIONS

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D E C L A R A T I O N

I, BEENA SOMANATHAN NAIR, hereby declare that the thesis entitled ''GENETIC VARIABILITY FOR DEVELOPMENTAL AND YIELD ATTRIBUTES OF SORGHUM AND PIGEONPEA UNDER INTER AND INTRA-SPECIES COMPETITION'' is a result of the original research work done by me. It is further declared that the thesis or any part thereof has not been published earlier in any manner.

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ABSTRACT

In order to study the effect of interspecies competition and test the plant type concept, two experiments were conducted over two years during Kharif 1983 and 1984 under auspices of the All India Co-ordinated Sorghum Improvement Project. In experiment I, twenty genotypes of sorghum differing in canopy structure and genetic background including released and prerelease varieties, hybrids and some of the parental lines were grown in intercropping with a pigeonpea variety, HY 8 as well as solecropping. The intercropping represents inter-species competition while sole cropping represents intra-species competition. The competition effects due to sorghum, due to pigeonpea and due to sorghum x pigeonpea interaction were studied in second experiment by growing four sorghum hybrids and four different pigeonpea varieties in all possible combinations. Experiments were laid out in RBD with three replications. Developmental characters were recorded at three stages of growth and yield characters at maturity.

The study of variability for developmental characters of sorghum at three growth stages showed that there were significant variability for plant height and leaf length at all stages in individual two years. When data were pooled over two years, genotype x year interactions were significant in both inter and intra-species competition indicating that genotype x environment interactions for developmental characters adjusting to changing environmental situation was similar under both cropping systems. Plant height of sorghum was comparitively less in intercrop than that of sole crop, while leaf number and breadth were comparable in both cases. Significant differences were observed among sorghum genotypes for grain yield in both cropping systems. Mean over all genotypes under sole cropping was only 2% higher than that of intercropping. CSH 9, SPH 221, SPV 245 and SPV 351 in intercropping were high yielding genotypes, while SPH 221 and SPV 351 were found consistently superior in both types of competition.

The sorghum yield in intercrop was positively correlated with its yield in sole cropping. Thus, sorghum yield in sole cropping with optimum plant type provide a good selection criteria for intercropping.

Variation in HY8 was significant for length of branch at stage 3 but the genotype x year interactions were significant for number as well as length of branch at all three stages. Branch length of Pigeonpea was high in both years in association of CSH 5 and 168. More number of branches in HY8 were observed when intercropped with sorghum CSH 1, CSH 5 and CS 3541.

Pod and grain yield of HY8 in intercropping with CSH 5 and CSH 6 were significantly higher than others.

Grain yield of sorghum in solecropping was found to be significantly positively correlated with leaf length, panicle length and panicle weight. In intercropping, grain yield was positively related with leaf length, leaf breadth, panicle length and panicle weight. Thus growing high yielding varieties or hybrids with improved pigeonpea HY8 with differential late maturity did not change the yield components.In case of intercropped Pigeonpea, grain yield was correlated with number of pods per plant and pod weight. Thus these characters are major yield components in intercrop pigeonpea.

The study of different types of competitive effects revealed that there were significant difference in the competitive ability of sorghum for fodder yield, panicle weight and grain yield. CSH 9 was superior for leaf characters, panicle weight and grain yield while SPH 196 was superior for plant height and fodder yield.

Since the inter and intra genotypic competition between the species of crop plants is the main factor changing the behaviour both in pure and intercrop situation, selection of sorghum hybrids such as CSH 6, CSH 9, SPH 221 and variety SPV 351 minimize competition effects and maximizes complementary effects. Sorghum genotypes of 150-160 cm height, 100-110 days maturity with moderate number of leaves and large panicles represent optimum plant type suitable for productive intercropping system with a pigeonpea of differential maturity.

INTRODUCTION

INTRODUCTION

The advent of newer genotypes with reduced duration, greater levels of productivity and stability of sole crops usher an emerging era of productive and stable dryland cropping systems involving scientific intercropping as well as sequence cropping.

In the semi-arid tropics sorghum sole crop productivity has gone up due to a genotypic alteration in terms of shortening of duration of the crop to match the duration of rainy season, an improved harvest-index, exploitation of hybrid vigour, increased use of input and improved cultural practices. These have conferred a reduced vulnerability of sorghum thus leading to higher productivity (Rao, 1977).

Intercropping may have several advantages over sole cropping. It appears to make better use of sunlight, water and land. The practice is a kind of informal insurance against risk situations, on lands where crop production is subject to vagaries of weather, pests and diseases which affect individual crops differently. Either crop may not give as large a yield as sole cropping but combined yield is usually higher than either (Bains, 1968).

Several recent studies have shown substantial yield advantages from intercropping system compared with sole cropping (Singh, 1981; Waghmore et al., 1975) by the simple expedient of growing crops together (Willey, 1979). Both the component crops of a system share the same resources and thus show general and specific competition between them (Rao et al., 1979) They observed serious competition as well as complementation between two species. Singh and Jha, (1984) reported that, none of the legumes reduced sorghum yield by more than 10% but the legume yields in the intercropping system reduced due to competition with sorghum. This can however be minimised by appropriate choice of the crop varieties apart from agronomic manipulation. There is a strong evidence of a soybean x variety interaction suggesting a need to select for compatible genotypes of the participating crop species (Mak and Pillai, 1982). Therefore while crop varieties are being bred for wider adaptability and higher yield, its potential use as an intercrop deserves further consideration for breeding strategies. Sorghum is the major cereal crop of the SAT and is grown in intercropping with pigeonpea, groundnut and millets over vast areas. The root systems of the cereal-pulse mixtures tap water and nutrients from different layers of the soil. This often results in better utilization of the limited supplies of water and plant food in the soil. The competition for resources should depend on developmental characters and growth rythm. This should modify the expression of yield components in both inter and intracropping, as against sole cropping.

In monocropping of sorghum,grain yield was related with plant height but the relationship is reported to be curvilinear (Rana et al., 1984). Variation in plant height has consequence on panicle development, canopy structure and grain yield (Eastin and Wilson, 1981). It was stated that a curvilinear relationship exists between grain yield and leaf number (Stickler and Pauli, 1961). Giriraj and goud (1983) found that grain yield was positively associated with days to flower, number of leaves, leaf breadth, leaf area, plant height, panicle breadth, 100 seed weight and grain number per panicle. Rana et al., (1984) reported that excessive vegitative growth in terms of leafiness and fodder yield was disadvantageous for grain yield. Increase in height was desirable only in early genotypes. Early flowering and low leaf number were correlated with higher grain yield. These attributes of improved sorghum varieties may also minimize the competition with long duration species in intercropping systems.

Pigeonpea is grown more as an intercrop or mixed crop than as a sole crop, under widely diverse agroclimatic conditions in our country. In monocropping of pigeonpea, seed yield was found to have significant positive correlation with plant height, number of primary and secondary branches, number of clusters per plant and pods per plant in several studies (Malik et al., 1980). Number of pods was positively correlated with number of branches(Beohar and Nigam, 1972) and with maturity duration (Pankaja Reddy et al., 1975). Most of these characters manifest positive indirect effect on yield through number of branches(Veeraswamy et al., 1975).

Pulse production in the country is insignificant to meet the consumers' demands. There is possibility to intercrop the existing Kharif sorghums with pigeonpea to increase the pulse production in the country. Based on 115 experiments, Rao and Rana (1980) expressed the possibility for enhancing the pigeonpea production on the existing Kharif areas of sorghum through the practice of suitable intercropping.

Research on intercropping till date has been mainly concerned with the effect of agronomic manipulations such as spacing, date of sowing etc. Limited conceptual attempts have been made in order to breed a genotype suitable to intercropping. It is imperative that as a part of the breeding programme aimed at producing a genotype specifically suited to one or more systems, the desirable characteristics for each crop must be included as selection criteria. Comparisons among a set of varieties exhibiting differences for these contrasting characters which might reduce competition between species and confer intercropping advantages would be useful.

The objectives of the present investigation are therefore:

1. To study the genetic variability among the sorghum genotypes in inter and sole cropping.

2. To estimate the effect of sorghum genotypes on the

developmental and yield characters of pigeonpea intercrop.

3. To study the change in character associations in sorghum and pigeonpea under inter and intra-species competition.

4. To infer selection criteria for optimum plant type of sorghum to maximise yield of pigeonpea in intercropping system.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Growing of crop mixtures is an age-old practice in agriculture. Most farmers in the tropical countries practice mixed cropping, in which one crop is regarded as main crop and others as component crop. Literature on the following aspects of intercropping is reviewed

1. THEORITICAL CONSIDERATIONS
   - 1.1 Sole cropping
   - 1.2 Intercropping
   - 1.3 Inter and intra-species competition
   - 1.4 Land Equivalent Ratio
2. CHOICE OF COMPATIBLE CROP/VARIETIES
3. PERFORMANCE AND STABILITY OF INTERCROPPING
4. MECHANISM CAPABLE OF CAUSING TRANSGRESSIVE YIELD
5. YIELD COMPONENT ANALYSIS UNDER INTRA-SPECIES COMPETITION.
   - 5.1 Character associations in Sorghum
   - 5.2 Character associations in Pigeonpea
6. ROLE OF PLANT TYPE IN INTER-SPECIES COMPETITION.

1. THEORETICAL CONSIDERATIONS:

To define the terminology of cropping system is difficult because it has been used in a variety of ways even while describing same cropping pattern as is obvious from the literature. According to Gotoh and Chang (1979) a continuous monoculture of the same crop is defined as multiple cropping whereas other authors describe multiple cropping as growing of two or more crops in one year.

1.1 Sole cropping:- Sole cropping is the system of cropping in which only one genotype of a crop is grown in a field at a particular time. Plants of the same genotype share the resources and develop an intra- species competition. Depending upon plant type, optimum plant population differs. This system is the oldest system and most widely used due to certain advantages due to easier input application (mechanization, use of fertilizers and pesticides) and cultural operations at correct time. However, this system in tropics is risky due to aberrent weather conditions.

1.2 Intercropping: Inter cropping is a system of cropping in which two or more crops are grown simultaneously on the same field in certain predetermined ratios. Different crop species share the resources and depending upon their canopies and nutrient requirements generate the inter-species competition. The crops may be sown at the same time or not but they are simulataneous for significant part of their growing period. According to Krantz et al., (1976) this cropping system has the advantages of giving higher yield per hectare, in a given season and a greater stability of yield over seasons without costly inputs, better control of weeds, diseases and pests. In subsistence agriculture, it provides insurance against risks.

Cheng (1972) defines mixed cropping as the cropping system in which two or more separate crops, whether of the same or different kinds are grown on the same piece of land during a single year.

Kaushik (1951) and Dey et al., (1958) reported that mixed cropping of sorghum with pulses i.e. greengram, blackgram were more remunerative than pure sorghum. Misra (1959) and Bodade (1964) also reported similar results. Later, with dwarf cultivars also, the advantages of intercropping over pure cropping have been upheld (Lingegouda et al., 1972), Chandravanshi 1975; Krantz et al., 1976; Singh, 1977; Tarhalkar and Rao, 1979; Singh 1979).

1.3 Inter and intra-species competition

Competition is defined by Clements et al., (1929) as a purely physical process. With few exceptions such as crowding up of tuberous plants when grown too closely, an actual struggle between competing plants never occur. Competition arises from the reaction of one plant to the physical factors upon its competitors. In the exact sense the two plants, no matter how close, do not compete with each other as long as the water content, nutrient material, light and temperature are in excess of the needs of both. When the immediate single necessary factor falls below the combined demands of the plants, competition begins. But the results of an experiment conducted by Tomar et al, (1984) showed that intercropping of pigeonpea with sorghums significantly reduced grain yield of pigeonpea but combination proved remunerative equal to that of sole crop of pigeonpea.

According to Aberg et al., (1943) when the per plant yield of one genotype is higher in mixture than in monoculture, and the per plant yield of the other genotype is correspondingly lower, then the behaviour of the mixture components is said to be of 'compensating' type. If the plant relative yield (PRY) (based on per area relative yield of de Wit and van der Bergh, 1965) of a component is defined as the ratio of the per plant yield in mixture to that in monoculture, then in such a mixture, the PRY of the aggressor will be greater than unity; that of the subordinate will be less than unity.

de Wit (1960) has presented a model of intergenotypic competition based on the simple assumption that the biomass yield of each component is strictly proportional to the share of environmental resources it can acquire. According to this model, if the sharing is uneven, plants of one genotype, say i, will be larger in mixture than in monoculture while plants of the other component, genotype j, will be correspondingly smaller. In such a case, genotype i, is termed aggressor and genotype j may be termed the subordinate.

Schutz and Brim(1967) applied the term 'complimentary' to mixtures in which deviations of PRY from unity are of the type (+,-) other terms introduced by them are 'neutral' for cases where both components give their 'expected yields', i.e. cases of the type (0,0) mixtures of the type (+,0) and (-,0) were described as showing 'over-compensation' and 'under compensation' respectively.

To facilitate description of yield of mixtures and monocultures a number of terms and symbols are introduced. The mid monoculture yield is denoted by p. A mixture will be said to have 'over yielded' when the mixture biomass, M, has exceeded that of the more productive pure culture, P1 ie. when M>P1. This will be said to have 'under-yielded' when the mixture biomass has fallen below that of the less productive pure culture, P2 i.e. when M<P2. These two transgressive situations will be shown to have occurred with relatively low frequency compared with the cases where

P1>M>P2 (Trenbath, 1974).

Simmonds (1962) was concerned almost entirely with grain yield of cereals. He found that often M is approximately equal to P, sometimes P1>M>P, and occassionally M>P1. He noted that negative interactions (i. e. M<P) seemed to be rare.

According to Willey (1979) yield advantage occurs because component crop differ in their use of growth resources in such a way that when they are grown in combination they are able to 'complement' each other and so make better overall use of resources than when grown separately. In terms of competition this means that in some ways the component crops are not competing for exactly the same overall resources. Therefore it is expected that the interspecific mixtures have different ecological requirements. For instance, the growth pattern of the component crops can differ in time so that the crops make their major demands on resources at different times (better temporal use of resources).

In order to assess the yield advantages from different intercropping combinations some requirements have to be satisfied. So far, three main situations are described. Firstly, there is where the component crops are equally acceptable and there are no constraints which determine that both have to be grown, in which case the intercropping advantage can be assessed as the amount by which the combined intercrop yield (i.e. the total of both crops) exceeds that of the higher yielding sole crop. Secondly there is where the intercropping has to produce full yield of main crop and some additonal yield of second crop. For instance, in India, in the sorghum/pigeonpea intercrop the farmers objective is to produce a full yield of sorghum plus an extra yield from pigeonpea. Thirdly, there is the situation where the farmer needs to grow more than one crop, intercropped or not, in order to spread labour peaks, reduce risks etc.

1.4 Land equivalent ratio:

To help judge whether a series of m crops should be grown as an m component intercrop rather than as a sole crop, the concept of land equivalent ratio is used (IRRI 1974, 1975).

According to Trenbath (1976), if the overall yield, Yi, of the ith component from a unit area of intercrop is expressed as a fraction of the yield, Yii, of that component grown as sole crop over the same area, the LER of the intercrop is given as a sum of the fractions.

$$LER = \sum_{i=1}^{m} (Y / Y)$$

If this LER is unity, the various yields harvested from intercrop should have been obtained from the unit area planted to sole crops, each occupying an appropriate fraction of the total area. When LER=1 the overall yield per unit area of intercrop is never greater than that of the most productive sole crop.

If however, the LER exceeds unity and sole crop yields are identical, an LER of 1+X implies that the intercrop outyields sole crop by 100 X%. If X is large enough, such an advantage can provide a clear justification for intercropping.

Mead and Willey (1980) suggests some improvement in the use of LER function in assessing intercrop yield advantages, particularly in genotype evaluation. For instance, when combining different genotypes of each crop to determine the highest yielding combinations, overall comparison might be made with the highest yielding genotypes of each crop, but the relative biological efficiency of a given combination can be estimated from comparison with the specific sole genotype of that combination.

2. CHOICE OF COMPATIBLE CROPS/VARIETIES

Since it is the inter and intra genotypic competition between the species of crop plants which is the main factor changing the behaviour both in the pure and intercropping situation selection of genotypes to minimize competition effects and maximize complementary effects is relevant. This could be done by selection of complementing maturity periods or by improving canopy structures which would improve complementary effects.

Rogers and Lazemby (1966) found from their studies on rye grass that there are differences between varieties in the degree of plasticity (property of a genotype to adjust well to a new environment with modifications of the phenotype) and such differences were associated with potential tillering capacity of the varieties.

Freyman and Venkateswarlu (1977) conducted studies to develop a successful intercropping system by studying the mutual competitive effects of various crops and selecting the most promising combination under dryland conditions. They opined that sorghum exerted a small competitive effect on pigeonpea and vice versa than either crop exerted on itself. Highest yields were obtained by sorghum/pigeonpea combinations.

Singh (1979) summarising the results of intercropping experiments conducted at different locations from 1972-78 under the auspices of All India Co-ordinated Sorghum Improvement Project concluded that legume crops like pigeonpea, greengram, blackgram, soybean, cowpea, groundnut can be intercropped with sorghum under rainfed conditions. The choice of compatible crops however varied from location to location.

As reported by Tarhalkar and Rao (1980) using some recently developed cultivars, a study was conducted to obtain additional information on the productivity of sorghum-pigeonea system by modifying crop environment with base crop sorghum grown under various planting patterns and intercropped with two pigeonpea genotypes of diverse maturity and canopy structure and planted at two densities.

1. The sorghum (CSH 6) yeilds in various planting patterns were more or less at par, with a recovery of 97% of sorghum yield compared to the pure crop.

2. In the intercropped system reduction in sorghum yield was more (12%) with HY2 pigeonpea cultivar than with errect, long duration cultivar HY3A (3%).

3, Higher total yield and net returns were obtained in '60-30 paired row' followed by 'wide row 60' pattern of sorghum intercropped at the lower (27000 pl/ha)density of pigeonpea.

4. At wide row (60cm) patterns there was better expression of pigeonpea yield even at its full density. There was consistent increase (27%) in net returns when intercropped with pigeonpea at its full density.

Studies on intercropping of sorghum (CSH 5) as base crop, greengram (S8), cowpea (C 152) and pigeonpea (N 290-21) as intercrop in three different planting patterns by Umrani et al, (1984) showed that intercropping of sorghum with pigeonpea increased total productivity by 72% in terms of money valuation. The intercropping was beneficial under adverse conditions.

3. PERFORMANCE AND STABILITY OF INTERCROPPING

Scott (1967) found that yield stability can be improved by selection. Thus, apart from the identification of specific morphological characters that provide good intercropping performance, yield stability should constitute an important goal in evaluation of genotypes for intercropping.

Though there is some indication that the intercropping systems are more stable, it is the higher productivity under intercropping that provides greater strength to withstand adverse situations (Singh and Jha, 1984).

Allard (1961) compared pure lines, mechanical mixtures of the same purelines and F7-F8 bulks from crosses between the pure lines of lima beans (Phaseolus lunatus) and found that among populations made up of genetic stocks and grown in several environments (location and years) the productivity of mixtures was less than the pure lines and these were less than the bulks. However in terms of stability the mixtures performed better than pure lines and worse than bulks. There was little difference in stability of mixed populations where only two or three genotypes were involved, which suggests that genetic diversity endows intraspecific mixtures with the ability to produce consistently more or less irrespective of the number of attributes of their components.

The experiment conducted by Harper (1965) show that mixture of various flax and/or linseed varieties overyielded. Data of Khan (in Harper 1965) show two flax-linseed mixtures as over yielding by 13% and 14% Harpers- own expt. included the same two mixtures. At low density one overyielded by 38% while the yield of the other was non-transgressive.

Krantz et al., (1976) reported yield advantages as much as 50 or even 100% when early cereals (80 to 100) day crops were intercropped with 180 day pigeonpea). Also, it was found yield advantages ranging between 20-60% in a 120-day groundnut.

Rao et al.,(1979) observed serious competition as well as complementation between two species of an intercropping system. Both component crops of a system share the same physical resources and thus show general as well as specific competition between them. Studies on competition between species enabled characterization of complementary, aggressive and relatively neutral species. Under competition stress sorghum was found to be least sensitive. Studies on alternate planting patterns established that generally the interaction between intercropping systems and planting pattern was highly significant but in certain specific systems based on pigeonpea and sorghum the interaction was not significant.

Results of 89 experiments available on sorghum/pigeonpea intercrop have been pooled and some basis for understanding stability of performance was presented by Rao et al., (1979). Stability is evaluated by the coefficient of variation in yileds, behaviour of relative advantage of intercrop with changes in fertility and water use and regression of yields and returns from sole and intercrops against environmental index based on location mean performance. The relative advantage of intercropping remained more or less similar at different fertility levels. Regression analysis showed that intercrop system is superior to sole crops at all levels of yields and is more widely adoptable.

The results of multilocation studies on sorghum-based intrcropping systems conducted under the auspices of All India Co-ordinated Sorghum Improvement Project and used by Singh and Jha (1984) for the comparison of stability of the systems over seasons showed that intercropping systems are more stable than sole crop of either of the component crops due probably to higher productivity in intercropping. This gives greater strength to withstand adverse situations.

4. MECHANISM CAPABLE OF CAUSING TRANSGRESSIVE YIELD

The results reviewed by Trenbath (1974) show that mixtures have often been recorded as apparently yielding transgressively. Furthermore, the data indicate that record of mixtures over yielding are significantly more frequent than records of underyielding.

Aiyer (1949) reported that the intercropping of crop types with strongly contrasting nutrient requirements or uptake abilities seems finally to lead to high LERs.

Differences in length of growing season can lead to LER>1 in mixed intercrops of flax and linseed (Harper 1968) or barley (Hordeum vulgare) and oats (Avena sativa) (Trenbath 1974) and of early and late potatoes (Schepers and Sibma, 1976) When the earlier components have matured, conditions become favourable for the other component.

LER values exceeding 1 may be obtained due to several factors. One of which is the greater efficiency in the use of environmental resources. Such complementary use of resources is 'annidation' (Ludwig 1950, as quoted by Trenbath 1974). The various forms of annidation are:-

Annidation in space: The leaf canopies of intercrop components may occupy different vertical layers with the tallest component having foliage tolerant of strong light and high evaporation demand, and the shorter components having foliage requiring shade and/or relatively high humidity (Trenbath 1976). There are also annidation with respect to nutrients and annidation in time.

Overyielding by mixtures has in some instances been attributed to a more efficient utilization of light by their canopies. The use of mathematical models has suggested that the highest photosynthetic rate might be obtained from a canopy in which the steepness of the inclination of the leaves decrease with depth. This ideal leaf arrangement could be approached by a mixture of a tall erect-leaved genotype and a short, prostrate-leaved ones (Nilson, 1968).

Donald (1963) stated that the yield of mixtures studied usually lay between the yield of component culture crops in pure stands and there is no substantial evidence from these experiments that two pasture species can exploit the environment better than one.

According to de Wit and Van der Bergh (1965) relative yield total values lower than one are without any interest from an agronomic point of view. A necessary but not sufficient, condition for attainment of a total yield of mixture exceeding the yield of the highest yielding component in pure stand is that the relative yield total for the mixture is greater than one. So, it is expected that the more divergent the components in a mixture, the better the chance of the growth resources available to the plants in the mixture per unit area which will be larger than in pure stands i.e. the components occupy slightly different ecological niches. It is expected that interspecific mixtures have to a greater extent, similar ecological requirements.

Van der Bergh (1968) observed that even if the biomass increments of the mixture over the periods before and after the reversal are not transgressive compared with the increments in the monocultures over the same intervals, the biomass accumulated by the mixture over the whole growing season may yet be transgressive. Van der Bergh gave a hypothetical example of this in which the more aggressive component in each phase was the component with the greater biomass increment in its monoculture during that phase. In this example the total accumulation of biomass over the two phases was the same in each component monoculture, the association of greater aggressiveness and faster biomass accumulation within each phase resulted in overyielding by the mixture at final harvest.

Syme and Bremmer (1968) reported a series of experiments involving oats and barley varieties chosen to differ in flowering time, the results of an experiment performed under glass showed that in all four oats-barley mixtures, both components showed higher per plant shoot weights than in monoculture. While over yielding of dry matter did not occur, the RYT based on shoot weights averaged over the four (replicated) mixtures and two densities were 1-12. Such an RYT value in a mixture of which the two monoculture yields were very similar would be associated with the mixtures out yielding the monocultures by 12%.

According to Raper and Barber (1970) mutual avoidance by adjacent root system could lead to a late developing root system occupying deeper soil horizons in mixture than in monocultures.

Measuring panicle weights in a field experiment involving five mixtures of oat species, Trenbath found in one replicate five out of five mixtures over yielded; in the succeeding two replicates in a linear sequence of three, the number of overyielding mixtures were 2 and 1 out of 5. The trends in mixtures yield was tentatively related to an observed soil depth gradient. It was suggested that stratification of root systems had occured on the deep soil, leading to high RYT and over yielding but that this stratification had been prevented on shallow soil (Trenbath, 1970).

Trenbath (1974) reported that allelopathic effects can theoritically cause transgressive yielding, if an allelopathic substance produced by one component effects the

* RYT : Relative Yield Totals

growth rate of other component by changing only the rate of uptake of some limiting growth factor, the apparent relative competitive abilities of the mixture components will change but the total quantity of the factor taken up may not be much different from that in the absence of allelopathy. If this is so RYT will be close to unity. If, however, the substance changes the efficiency with which the growth factor is utilized, RYT will deviate from unity and transgressive yielding is possible.

Mechanical factor could again theoretically lead to transgressive yielding by a mixture. For e.g. let us suppose first that the component with potentially higher yield in monoculture is susceptible to lodging, and second that the other component resists lodging strongly enough to cause the mixture to stand while the susceptible monoculture lodges. If the lodged monoculture yields less than unlodged mixture, the mixture is expected to overyield.

Van der Bergh and de Wit (1960) reported an example where temporal sharing of the environment may have been responsible for a case of apparent mutual stimulation in mixture. In a mixture of two grass species which differed markedly in time of development, plants of both components had more tillers (53%, and 36%) than did plants in the corresponding monocultures.

5. YIELD COMPONENT ANALYSIS UNDER INTRA-SPECIES COMPETITION:

5.1 Character associations in sorghum

The relative contributions of different photosynthetic sites to the filling of the grain in grain sorghum (Sorghum vulgare cv. Brologa) were estimated by Fischer and Wilson 1971 by measuring the 14c in the grain after exposing various leaves and the head to radioactive carbondioxide.

Of the grain yield, 93% was due to assimilation by the head and upper four leves. The head contribution of 18% was due equally to direct assimilation of atmospheric carbondioxide and to reassimilation of CO2 released within the grain by respiration of material translocated from the leaves. The remaining 75% was equally assimilated by the upper four leaves, the flag leaf being the most efficient contributor per unit area and the third upper most leaf the least efficient.

Stickler and Pauli (1961) stated that a curvilinear relationship exists between grain yield and leaf area. Crook and Casedy (1974) observed that the yields of hybrids were positively correlated with days to bloom, height, leaf area, panicles per plant, kernal weight and test weight, but negatively with protein percentage and panicle exertion. Riecelle, (1974) observed associations between grain yield and days to blooming and plant height to be positive and significant.

Goud and Krishna Shastry (1974) reported that ear width and length are positively correlated with grain yield whereas plant height and number of leaves were negatively correlated with it.

Kambal and Abu-el-gasim (1976) reported that both in hybrids and parents, yield was positively and strongly correlated with number of grains per head, days to flowering, head diametre and leaf area and its components, leaf number and width. Goud and Asawa (1978) found that yield was positively correlated with plant height and negatively correlated with days to maturity.

Sindhu and Mehndiratta (1980) found that green fodder yield was highly and positively correlated with leaf number, stem thickness, leaf length and particularly leaf width.

Shahane and Borikar (1982) found that grain yield was highly & positively correlated with panicle weight, number of secondaries per panicle, panicle length and grain size while, Giriraj and Goud (1983) found that grain yield was positively associated with days to flower, number of leaves, leaf breadth, leaf area, plant height, panicle breadth, no. of whorls, number of primary branches, 100 seed weight and grain number per panicle.

Rana et al (1984) found that plant height maturity contributed positively to the fodder yield in Kharif. Excessive vegetative growth in terms of leafiness and fodder yield was disadvantageous for grain yield. Increase in height was desirable only in early genotypes. Early flowering and low leaf number were corrleated with higher grain yield.

Eastin and Wilson (1981) observed that grain yield was related with plant height. Variation in plant height has consequence on panicle development, canopy structure and grain yield.

5.2 Character associations in pigeonpea

Pankaj Reddy et al., (1975) found that seed yield per plant was signficantly positively correlated with plant height, number of primary and secondary branches, number of cluster/plant and pods/plant in several studies (Malik, 1981).

The overall picture of the study by Veeraswamy et al.(1975) revealed that the number of branches produced maximum influence both directly and indirectly on the seed yield. The number of days to first flowering had a direct negative influence on the yield. This study also had shown that the number of cluster and pods per plant did not have much direct influence on the seed yield though they exert an indirect influence through the number of branches.

Seed yield per plant in pigeonpea was found to have significant positive correlation with plant height, number of primary and secondary branches, number of clusters per plant and pods per plant in a number of studies by Munoz and Abrams (1971), Singh et al., (1972), Joshi (1973), Singh and Malhotra (1973), Veeraswamy et al., (1975), Bainival et al., (1981) and Malik et al., (1980).

Mukeswar and Muley (1974) also found that the grain yield was negatively correlated with plant height, days to maturity and seed weight, but was positively correlated with number of pods per plant, number of branches per plant and length of the pod. Seed yield was significantly positively correlated with number of pods per plant, number of seeds per pod and 100 seed weight, but negatively correlated with plant height in 6 x 6 diallel analysis reported by Dahiya et al., (1978).

Pods per plant showed significant positive association with clusters per plant and plant height (Singh and Malhotra, 1973, Pahuja et al., 1981 and Singh et al., (1972). Whereas, seed weight showed a negative correlation with number of pods per plant (Singh et al., 1972)

Saraf and Hegde (1984), reported in their correlation studies in pigeonpea, that grain yield was positively and significantly correlated with all the characters studied i.e. growth parametres such as plant hieght branches/

plant, leaf area index absolute growth rate, net assimilation rate, crop growth rate and relative growth rate and yield components such as pods/ plant, grains/ pod and test weight. On the basis of these studies , it is suggested to incorporate larger canopy size (LAI) and higher growth rate (AGR and CGR) coupled with high pod number/ plant for improvement in productivity of pigeonpea.

6. ROLE OF PLANT TYPE IN INTER-SPECIES COMPETITION

The competition for resources should depend on developmental characters and growth rythm. This should modify the expression of yield components in both inter and intra-crop.

The effectiveness of a competitor is an expression of its capacity to make rapid use of its immediate supplies and then, by growth of its roots or foliage to extend its exploitation into greater spatial part of the environ. The successful competitor is the plant which draws most rapidly from the pool or which can continue to withdraw from the pool when it is at low level or when its contents can no longer be tapped by other plants (Donald, 1963).

Donald (1968) termed the ideoptype to describe optimum plant type and defined ideotype as plant with model characteristics known to influence photosynthesis growth and grain yield in cereals.

Trenbath (1976) reported that the farmer may wish to select a crop variety with high ability in competition for light. Characters confining this are: rapid expansion of a tall canopy (Donald, 1963), larger leaves to minimize penumbra effects (Norman et al., 1971), a high allocation of dry matter to building a tall stem (Iwaki 1959) and rapid stem extension in response to shading (Williams, 1964).

The data from ICRISAT (1979) where pigeonpea of different maturities were inter cropped with sorghum and pearl millet genotypes of different maturities showed that inter cropped pigeonpea yields decreased with increased cereal maturity. The intercropped pigeonpea yield increased when the pigeonpea maturity increased. The ability to tiller in pearl millet genotypes when intercropped with groundnut genotypes was significantly and positively correlated with seed yield.

Andrew (1972) working with sorghum dwarf line which matures in 80 days intercropped with ex-Bornue a 90day maturity variety in North Nigeria found an yield advantage of 80% over sole sorghum yield.

Willey and Osiru (1972) working with a tall (2.8m) local East African maize variety which had a maturity period of 120 days intercropped with a fairly errect bean variety (Phaseolus vulgaris) which matured in about 90 days found 38% of yield advantage from mixing the two species over sole crop yields. They also intercropped a dwarf sorghum variety (Makerere selection) 65cm in height and maturing in 120 days with a fairly erect bean variety (P. vulgaris) which matured in about 90 days.The yield advantages of the mixtures were upto 55% higher than could be achieved by growing the crops separately.It was concluded that these yield advantages must have been due to a greater utilization of environmental resources.

Rhodes (1971) reported that in grass/legume breeding canopy structure is determined by five major morphological characters namely tiller angle, leaf length, leaf rigidity, leaf angle and tiller number.

Wein and Nangju (1976) found that climbing cultivars of legume caused increase in lodging of maize and lowered maize yield more severely than errect and speading cultivars.

Wein and Smithson (1979) in their genotype evaluation for intercropping situations found consistently positive correlation among pods/meter square and seed/pod with seed yield in all intercropping systems.

Rao et al., (1980) studying sorghum/pigeonpea intercrop found that the number and length of branches and canopy spread, as indicated by light interception and canopy width constitue important characters in determining the relative yields of pigeonpea in the intercropping. The desirable characters in pigeonpea genotypes in order to give better intercrop performance are more and longer branches and which spread well after the cereal harvest.

Ayyangar et al., (1935) demonstrated that diameter of panicle, weight of ear, length and thickness of ear and straw weight were positively correlated with grain yield. Swarup and Chaugle (1962) found a significant positive correlation between the plant height and grain yield in almost all crosses. Fodder yield was positively correlated with number of days to panicle emergence, plant height, stalk diameter and number of leves. Atkins et al., (1968) found highly significant correlations of yield with panicle weight. They suggested that the weights of unthreshed panicles may serve as expedient and effective selection criterion for grain yield.

MATERIALS AND METHODS

In order to study the effect of inter-species competition two experiments were conducted over two years during Kharif 1983 and Kharif 1984. In Experiment I, twenty genotypes of Sorghum differing in canopy structure and genetic background including released and prerelease varieties, hybrids and some of the parental lines were grown in intercropping with pigeonpea as well as sole cropping. The particulars of the variety are as follows:

Genotype (Parentage)	Height (cm)	Duration (days)	Characters			
			Leaf	Stem	Earhead	Seeds
CSH1	Dwarf (140-150)	Early (100)	Medium Semi-erect	Medium thick	Long, lax, long panicle branches	Bold sphe-recial
CSH 5 (2077 A x CS 3541)	Mid tall (150-200)	Early (100-110)	Large semi-erect	Thick	Semi-compact spindle shaped	Sphe-rical cream coloured
CSH 6 (2219 A x CS 3541	Mid tall (120-180)	Very early (90-95)	Medium, semi-erect	Medium thick	-do-	-do-
SPH 196 (296 A x SB 1085)	Tall (250)	Medium (110-115)	Medium, drooping	Thick	Semi-compact long elon-gated	Medium bold
CSH 9 (296 A x CS 3541)	Tall (170-210)	Early (100-110)	Medium, drooping	Thick	Semi-compact large, spindle shaped	Medium sphe-rical
SPH 221 (29 A x MR 750)	--------------- do	-----------------			Relati-vely loose, drooping panicle branches	Small sphe-rical

Genotype (Parentage)	Height (cm)	Duration (days)	Characters			
			Leaf	Stem	Earhead	Seeds
SPH 162 (296 A x SPV 126)	Tall (250)	Early (100 - 110)	Medium less leafy	Medium thick	Large, elongated semi-compact	Medium bold spherical
CS 3541	Dwarf (130-150)	Medium (100-110)	Semi-erect waxy margin	Medium thick	Compact, stout	Pearly, cream pear-shaped
SB 1085	Mid tall (160-170)	Medium (110-115)	Medium large	Thick	Obtuse semi-loose	Medium bold
296 B (1S 3922 x Karad local)	Dwarf (120-130)	Medium (105-110)	Drooping	Thick	Elongated semi-compact	Pearly cream spherical
2219 B	Dwarf (100-110)	Early (90-95)	Semi-erect	Thin	Compact	Pearly white pear shaped
168 (1S (3687 x AISPURI)	Dwarf (80-90)	Medium (115-120)	Broad large	Thick	Semi-spherical compact	Small round
SPV 126 (Mutant of CS 3541)	Mid tall (160-170)	Medium (110-115)	Medium large	Thick	Obtuse, semi-loose	Medium bold

Genotype (Parentage)	Height (cm)	Duration (days)	Characters			
			Leaf	Stem	Earhead	Seeds
SPV 245 (CS 3541 x 35)	Mid tall (160)	Mid late (110-115)	Medium large droop-ing	Medium thick	Oblong, semi-compact	Medium bold flat on one side
SPV 346 (SPV 35 x CS 3541)	Tall (190-200)	Medium (100-110)	Large, semi-enect	Medium thick	Oval	Medium bold white, pearly
SPV 351 (SC 108 x CS 3541)	Tall (160-190)	Early (100-110)	Medium tan colou-red	Medium thick	Semi-open, spindle shaped	Medium sized cream
SPV 462 (MR 8271 x IS 3691)	Tall (200-220)	Medium (110)	Medium droop-ing	Medium thick	Conical, semi-compact	Bold, flat on one side
SPV 472 (SPV 35 x E 35) x CS 3541	Tall (200-220)	Medium (115)	Medium large	Thick	Long	Medium bold, pear shaped
Y 75 (PJ 8 K)	Tall (200-220)	Medium (110)	Medium	Medium thick	Comp-act sphe-rical	Medium bold, yellow peri-carp

EXPERIMENTAL LAYOUT

All the sorghum genotypes were intercropped with a single variety of pigeonpea HY8 in such a way that one row of the same genotype of sorghum were grown on either side of the pigeonpea row.

The experiment was laid out in randomized complete block design with three replications. A plot was consisting of three rows,each 10m. long. Two side rows and half of the middle row was planted with the same variety of sorghum and another half of the middle row with HY8 pigeonpea.The sorghum rows were sown 60cm. apart with 7.5 centimetres (cm) between the plants of each row. Pigeonpea rows were sownn 120cm apart with 15cm between the plants of each row.

In experiment II four sorghum hybrids (CSH 1, CSH 6, CSH 9, SPH 126) and four pigeonpea varieties(HY6, HY8, HY9, HY3C) of different plant canopies were planted in all possible 16 intercrop combinations. The sole crop of these sorghum hybrids and pigeonpea varieties provided the control. Sorghum was sown at a spacing of 60 x 7.5 cms and pigeonpea varieties at 120 x 15cms. Each plot consisted of three rows, 5 metres long. Pigeonpea was sown in the middle row and sorghum on the two side rows in the intercropped plots. The solecrop plots consisted of three rows of the particular genotype.

Fertilizer dose of 60kg N and 40kg P was adopted. Plant protection against shootfly, stemborer, earheadbugs and aphids of sorghum and against podborers of pigeonpea were provided as and when required. Cultural operations were given whenever required.

The rainfall distribution in the crop season was as follows:

Monthly rainfall in mm (RF) and no. of rainy days (RD).

Month	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Total
1983(RF)	87.2	210.8	305.1	286.5	131.6	1.0	17.0	4.8	1044.0
(RD)	11	22	24	22	8	1	2	1	91
1984(RF)	92.3	171.7	147.7	99.2	80.4	6.4	0.0	0.0	597.7
(RD)	11	20	8	9	5	1	0	0	54

2. OBSERVATIONS:

Observations were recorded on both sorghum and pigeonpea at three stages of crop growth and at fourth on pigeonpea alone after the harvest of sorghum. The first observation was recorded 30 days after sowing, the second at 60 days after sowing and the third 90 days after sowing. The following observations on five competitive plants were recorded at various stages.

Sorghum:

1. **Plant height:** The height was recorded in cm from base to the topmost leaf whorl in vegetatiive stage and upto panicle top after flowering.

2. **Leaf number:** The number of leaves per plant were counted at the three stages. This excluded two seminal leaves which usually get dried or lost after seedling stage.

3. **Leaf length:** The length of the fourth well expended leaf from bottom was measured in cm.

4. **Leaf breadth:** The breadth of the fourth leaf selected for recording length was measured at the widest place.

5. **Panicle length:** Length of the panicle was recorded in cm from the place first panicle branch emerges to the apex.

6. **Number of branches per panicle:** The panicle branches originating from the rachis were counted.

7. **Panicle weight:** the weight of the five panicles together was recorded in gm The panicles were well dried in sun before weighment.

8. **Grain yield:** The dried heads were threshed and grain was again dried in sun. The total weight of the grains of the five panicles was recorded in gm

9. **Test weight:** 1000 grains were counted and weighed in gm

10. **Fodder Yield:** The weight of five fresh plants cut from the base was recorded in gm after harvesting the panicles.

Pigeonpea :

1. Plant height: The height was recorded in cm. from base to the tip of the main branch at all the stages.

2. **Branch number:** The number of primary branches per plant were counted.

3. **Branch length:** The length of the lowest branch was measured in cm. from the base of the branch to its tip.

4. **Number of pods:** The total number of fully filled pods were counted.

5. **Number of seed in ten pods:** Ten pods were chosn at random and the number of seeds were counted.

6. **Pod weight:** The total weight of pods from the five plants were recorded after they were well dried in sun.

7. **Seed weight:** The dried pods were threshed and total seed weight was recorded in gm.

8. **Test weight:** 100 seeds were counted and weighed in gm.

3. STATISTICAL METHODS:

The following statistical procedures were followed in analysing the data

3.1 Univariate analysis of means:

Analysis of variance (ANOVA) for between the stages of growth and between the genotypes were carried out for all growth charactres recorded in experiments 1 and 2. In experiment 1 the degrees of freedom were partitioned as shown in the following analysis of variance table for the growth characters i. e. plant height,leaf number,leaf length and leaf breadth in sorghum and for plant height,number of branches and branch length in pigeonpea and for post-harvest characters such as panicle weight ,seed yield fodder yield and test weight in sorghum and pod weight,seed yield and test weight in pigeonpea at three stages of growth.

Source	df	MSS	VR
Replication	2	MS1	
Genotype	19	MS2	MS2/MSE
Error	38	MSE	

df : degrees of freedom.

MSS : Mean sum of squares.

In experiment 1, for yield characters, the sum of squares of genotypes was further split into hybrids, parental lines and varietal groups as follows:

Source	df	MSS	VR
Reps.	2	MS1	
Genotype	19	MS2	MS2/MSE
Between groups	2	MS3	MS3/MSE
Within hybrids	6	MS4	MS4/MSE
Within parental lines	6	MS5	MS5/MSE
Within varieties	5	MS6	MS6/MSE
Error	38	MSE	

In experiment II treatment sum of squares was split into sorghum effects, pigeonpea effects and sorghum x pigeonpea effects following factorial model as follows:

Source	df	MSS	VR
Reps.	2	MS1	
Genotype	15		
Sorghum (S) effect	3	MS2	MS2/MSE
Pigeonpea (P) effect	3	MS3	MS3/MSE
S x P interaction	9	MS4	MS4/MSE
Error	30	MSE	

The date of both the experiments were pooled over the years as given in the following tables.

Experiment

Source	df	MSS	VR
Year	1	MS1	
Rep/ year	4	MS2	
Genotype	19	MS3	MS3/MSE
Genotype x year	19	MS4	MS4/MSE
Error	76	MSE	

Rep/ year: Replications within years.

Experiment II

Source		df	MSS	VR
Year(Y)		1	MS1	
Rep/Year		4	MS2	
Sorghum (S)	effect	3	MS3	MS3/MSE
Pigeonpea (P)	effect	3	MS4	MS4/MSE
S x P	interaction	9	MS5	MS5/MSE
S X Y	interaction	3	MS6	MS6/MSE
P X Y	interaction	3	MS7	MS7/MSE
S X P X Y	interaction	9	MS8	MS8/MSE
Error		60	MSE	.

The significance of different treatments were tested at 5% and 1% level.

3.2 Correlation coefficients:

Simple correlation:

Phenotypic correlations as a measure of association between two variables were estimated among ten characters of sorghum and nine characters of pigeonpea.

$$r = \frac{cov(x.\ y)}{\sqrt{(var(x)var(y))}} \text{ or } \frac{cov(x.\ y)}{\sqrt{\sigma^2 \chi\ \sigma^2 \chi}}$$

where r = correlation coefficient between x and y

cov x. y = covariance between x and y

var(x) = $\sigma^2\chi$ = Variance of independant variable x

var(y) = $\sigma^2 y$ = Variance of dependant variable y

The significance of r is tested by comparing the observed value of correlation coefficients with table value for (n-2) degrees of freedom.

The other way to test null hypothesis (r=0) is through the application of t-test as

$t = r(n-2/1-r^2)^{0.5}$

where r = correlation coefficient

t= total number of observations

This t value is tested against table value of t at (n-2) degrees of freedom.

3.3 Regression analysis:

The degree of dependance of one variate X on other Y is measured by correlation coefficient r between them. The regression coefficient of Y on X is the measure of change in Y for a unit change in X. The simple regression (b) is calculated for different characters as follows

$$b = \frac{cov(x.\ y)}{var(x)} \quad or \quad \frac{cov(x.\ y)}{\sigma^2 x}$$

where Y is the dependant variable and X is the independant variable.

$$cov(x, y) = \frac{\Sigma(X_i - \bar{X})(Y_i - \bar{Y})}{(n-1)}$$

$$or\ V_x\ or\ \sigma^2_x = \frac{\Sigma(x_i - \bar{x})^2}{n-1}$$

and Y,X are means of Y and X variables.

(a) Linear regression equation:Linear regression of Y on X is expressed as

$$Y = a + bx$$

where b is estimated as above and a is estimated by

$$a = (\bar{Y} - b\bar{X})$$

(b) Quadratic regression equation:is expressed as

$$Y = a + bx + cx^2$$

where a,b,c, are estimated as in the case (c)

(c) Multiple regression equation:The regression between more than two variables was expressed by means of the multiple regression function

$$Y = a + b_1(x_1 - \bar{x}\ ) + b_2(x_2 - \bar{x}_2) + b_3(x_3 - \bar{x}_3)\ldots$$

$$or \quad Y = a + b_1x_1 + b_2x_2 + b_3x_3\ldots$$

where Y is the dependant variable and x_1, x_2, x_3 are the independant variables.

For two independant variables, partial regression coefficients were obtained by the following simultaneous normal equations(Snedecor and Cochran, 1971).

$$\Sigma x_1^2 by_{1.2} + \Sigma x_1 x_2 by_{2.1} = \Sigma x_1 y$$

$$\Sigma x_1 x_2 by_{1.2} + \Sigma x_2 by_{2.1} = \Sigma x_2 y$$

From the above equations by1. 2 and by2. 1 are obtained as follows

$$by_{1.2} = \frac{(\Sigma x_2^2)(\Sigma x_1 y) - (\Sigma x_1 x_2)(\Sigma x_2 y)}{D}$$

$$by_{2.1} = \frac{(\Sigma x_1^2)(\Sigma x_2 y) - (\Sigma x_1 x_2)(\Sigma x_2 y)}{D}$$

where $D = (\Sigma x_1^2)(\Sigma x_2^2) - (\Sigma x_1 x_2)^2$

For three independant variables, the multiple regression was estimated by solving the following simultaneous equations.

$$\Sigma X_1^2 \ by_{1.23} + \Sigma X_1 X_2 \ by_{2.13} + \Sigma X_1 X_3 \ by_{3.12} = \Sigma X_1 Y$$

$$\Sigma X_1 X_2 \ by_{1.23} + \Sigma X_2^2 \ by_{2.13} + \Sigma X_2 X_3 \ by_{3.12} = \Sigma X_2 Y$$

$$\Sigma X_1 X_3 \ by_{1.23} + \Sigma X_2 X_3 \ by_{2.13} + \Sigma X_3^2 \ by_{3.12} = \Sigma X_3 Y$$

The covariance matrix (X_{ij}) among independant variables was converted into (C_{ij}) matrix with the right sides altered to the unit matrix.

1,0,0

0,1,0

0,0,1

Check that $C_{12} = C_{21}$. $C_{13} = C_{31}$ and $C_{23} = C_{32}$

The b_1 coefficients were estimated by multiplying the (C_{ij}) matrix with (Σyx 0) vector as

$$b_1 = C_{11} \quad \Sigma x_1 y + C_{21} \; \Sigma \; x_2 y + C_{31} \; \Sigma \; x_3 y$$

$$b_2 = C_{12} \quad \Sigma x_1 y + C_{22} \; \Sigma \; x_2 y + C_{32} \; \Sigma \; x_3 y$$

$$b_3 = C_{13} \quad \Sigma x_1 y + C_{23} \; \Sigma \; x_2 y + C_{33} \; \Sigma \; x_3 y$$

(d) ANOVA for regression analysis:The variance of dependant variable Y can be partitioned into two parts namely, the variance due to deviation from regression on x.

Source	DF	SS	MSS
Regression	1	$\Sigma(y_i - y)^2$	MS_b
Error	n-2	$\Sigma(y_i - \hat{y})^2$	MS_c
Total	n-1	$\Sigma(y_i - \bar{y})^2$	

where Total SS = $\Sigma(Y_i - Y)^2 = \Sigma Y_i^2 \Sigma - (\Sigma Y_i)^2 / n$

Regression SS = $\Sigma(\hat{Y}_i - Y)^2 = b^2 \Sigma X_i^2 - b^2(\Sigma X_i^2)/n$ or $(covX.Y)^2/\sigma^2 X$

Error SS = $\Sigma(Y_i - \hat{Y}_i)$ = Total SS - Regression SS

Y_i = i^{th} observation of independant variable

Y = Mean of dependant variable

$\hat{Y}_i$ = Estimated value as $Y + b(X_i - X)$

The regression MS is tested against Error MS i.e. MSb/MSe to be compared with the F value for 1 and n-1 degrees of freedom. The other way to test the null hypothesis (b=0) is through the application of t test

$$t = b_{yx} / SE(b)$$

This t value is compared with t value from the table at the desired level of significance with error degrees of freedom. b_{yx} is the regression coefficient of Y on X and SE(b) the standard error of regression coefficient, where

$$SE(b) = (MS_e/V(x))^{0.5} \text{ or } (MS_e/\sigma^2 x)^{0.5}$$

(e) Estimation of optimum response (from quadratic regression):

(i) One independant variable case:

Let the regression equation with estimated coefficient(a,b,c) be

$$\hat{Y} = \hat{a} + \hat{b}X + \hat{c}X^2$$

Purpose is to find the value of X which optimizes Y. Differentiating Y with respect to X and equating it to zero

$$\frac{dy}{dx} = \hat{b} + 2\hat{c}X$$

$$= 0$$

$$\hat{X} = -\hat{b}/(2\hat{c}) \quad (=\text{Xopt.})$$

$$\text{and Yopt.} = \hat{a} + \hat{b}\hat{X}\text{opt.} + \hat{c}X^2\text{opt}$$

$$= \hat{a} - \hat{b}/(4\hat{c})$$

(ii) Two independant variable case:

The quadratic equation can be written as

$$Y = \hat{a} + \hat{b}_1 X_1 + \hat{b}_2 X_2 + \hat{b}_{11} X_1^2 + \hat{b}_{22} X_2^2 + \hat{b}_{12} X_1 X_2$$

Differentiating Y with respect to X_1 and X_2 and equating to zero we get

$$dy/dx_1 = \hat{b}_1 + 2\hat{b}_{11} X_1 + \hat{b}_{12} X_2 = 0$$

$$dy/dx_2 = \hat{b}_2 + b_{12} X_1 + 2\hat{b}_{22} X_2 = 0$$

Solving for X_1 and X_2 we get optimum values of X_1 and X_2 as

$$\begin{pmatrix} X_1\text{opt} \\ X_2\text{opt} \end{pmatrix} \quad \begin{pmatrix} 2\hat{b}_{11} & b_{12} \\ \hat{b}_{12} & 2\hat{b}_{22} \end{pmatrix} \quad \backslash \hat{b}_2$$

where A stand for inverse of matrix A

or,

$$\hat{X}_1\text{opt} = (\hat{b}_2\hat{b}_{12} - 2\hat{b}_1\hat{b}_{22})/D$$

$$\hat{X}_2\text{opt} = (\hat{b}_1\hat{b}_{12} - 2\hat{b}_2\hat{b}_{11})/D$$

$$D = 4\hat{b}_{11}\hat{b}_{22} - \hat{b}_{12}$$

Optimum Y can be obtained by subtituting optimum values of

X_1 and X_2 in the equation for Y.

(iii) For three independant variable X_1, X_2, X_3 case

Let the regression equation be

$$Y = \hat{a} + \hat{b}_1X_1 + \hat{b}_2X_2 + \hat{b}_3X_3 + \hat{b}_{11}X_1^2 + \hat{b}_{22}X$$
$$+ \hat{b}_{33}X_3^2 + \hat{b}_{12}$$
$$+ \hat{b}_{13}X_1X_3 + \hat{b}_{23}X_2X_3$$

Following the procedure as in case of two independant variables we get

the optimum Y as

$$\begin{pmatrix} X_1 opt \\ X_2 opt \\ X_3 opt \end{pmatrix} \qquad \begin{pmatrix} 2\hat{b}_{11} & \hat{b}_{12} & \hat{b}_{13} \\ \hat{b}_{12} & 2\hat{b}_{22} & \hat{b}_{23} \\ \hat{b}_{13} & \hat{b}_{23} & 2\hat{b}_{33} \end{pmatrix} \qquad \begin{pmatrix} \hat{b}_1 \\ \hat{b}_2 \\ \hat{b}_3 \end{pmatrix}$$

3.4. Land equivalent ratio:

A most appropriate function for assessing the yield advantages of interspecific mixtures of crop species that have different growth requirements and varying in terms of relative importance of each other is the Land equivalent ratio. It provides a standardised basis so that crops can be added to form combined yields. (Mead and Willey, 1980)

We estimated LER for the i treatment as

$$LERi = \frac{S_{abi}}{Y_{aai}} + \frac{S_{bai}}{Y_{bbi}}.$$

where, for i th treatment,

Y_{aai} = Mean of pure stand yield of species a

Y_{bbi} = Mean of pure stand yield of species b

S_{abi} = Mean yield of species a under intercropping

S_{bai} = Mean yield of species b under intercropping.

Let the standard error of Sabi, Sbai be SE1 and SE2 respectively and P, the correlation coefficient between them.

Also, let SE01 and SE02 be the standard error of Yaai Ybbi respectively. Then the SE of LERi is estimated by (M.Singh-Personal communication).

$$SE(LERi) = (A + B + C)^{\frac{1}{2}} \text{ where}$$

$$A = (SE_1^2 + ((S_{abi} / S_{aai})^2 SE^2 01) / (S_{aai})^2$$

$$B = (SE_2^2 + ((SE_{bai} + (S_{bai} / S_{bbi})^2 SE^2 02) / (S_{bbi})^2$$

$$C = 2P \; SE_1 SE_2 / (S_{aai} \; S_{bbi})$$

The comparison of the treatment on LER's can be made(Rao 1973,pp 389) by

$$Q = \sum_{i=1} LERi_i^2 / SE^2(LER_i) - (\sum_{i=1} LERi_i / SE^2(LER_i))^2 / \sum_{i=1} 1/SE^2(LER_i)$$

The results of the experiments conducted to estimate the inter and intra-species competition between sorghum and pigeonpea, the developmental characters at three stages and yield character at the final stage are presented under the following heads.

EXPERIMENT I:

1. STUDY OF GENETIC VARIABILITY IN SORGHUM AND PIGEONPEA

1.1 Developmental characters

1.1.1 Genetic variability in sorghum under inter-species competition.

1.1.2 Genetic variability in sorghum under intra-species competition.

1.1.3 Genetic variability in pigeonpea under inter-species competition.

1.2 Yield characters

1.2.1 Genetic variability in sorghum under inter-species competition.

1.2.2 Genetic variability in sorghum under intra-species competition.

1.2.3 Genetic variability in pigeonpea under inter-species competition.

2. CHARACTER ASSOCIATION AMONG DEVELOPMENTAL AND YIELD CHARACTERS:

2.1 Correlation in sorghum under inter-species competition.

2.2 Correlation in sorghum under intra-species competition.

1. STUDY OF GENETIC VARIABILITY IN SORGHUM AND PIGEONPEA.

1.1 Developmental characters

1.1.1 Genetic variability in sorghum under inter-species competition.

ANOVA and means of developmental characters for different sorghum genotypes at three growth stages (S1, S2 and S3) for the year 1983 and 1984 when grown as intercrop with HY8 variety of pigeonpea are presented in Tables 1 to 6. The differences between genotypes were highly significant for plant height, number of leaves per plant, leaf length and leaf breadth at all the three growth stages in both the years (Table 1). The pooled ANOVA over the two years for developmental characters at three stages of growth are presented in Table 2. The variation due to years was significant for all the characters except for plant height at S-2 stage. The genotype and genotype X year interactions were also highly significant for all characters except the genotype X year interaction for plant height at S1 stage and leaf breadth at S3 stage.

Comparison of the mean plant heights of various genotypes showed a variation of 77-227 cm (Table 3). The variety 168 recorded minimum height at stage (S3) of growth during both the years while SPH 196 was the tallest hybrid.

Table 1. ANOVA for developmental characters of sorghum in intercropping at three stages of growth during kharif 1983 and 1984.

Source	df	MSS					
		Stage 1		Stage 2		Stage 3	
		1983	1984	1983	1984	1983	1984
		Plant height (cm)					
Replication	2	54.7	142.9	139.0	100.9	153.2	233.8
Genotype	19	1125.7**	1588.8**	4607.0**	2342.5**	7711.3**	2298.8**
Error	38	86.3	333.0	250.3	345.2	300.2	357.9
		Leaf number					
Replication	2	3.2	0.5	0.6	4.1	2.0	9.0
Genotype	19	1.4**	2.4**	3.2**	3.2**	2.7**	2.3**
Error	38	0.4	0.6	0.5	0.9	0.6	0.9
		Leaf length (cm)					
Replication	2	47.0	300.1	13.0	66.9	13.8	106.9
Genotype	19	139.7**	118.6**	205.5**	218.8**	239.1**	161.0**
Error	38	28.5	30.0	18.3	32.9	23.9	28.4
		Leaf breadth (cm)					
Replicaton	2	1.5	0.2	2.0	2.5	2.1	6.1
Genotype	19	1.7**	1.7**	3.9**	1.9**	2.2**	1.7**
Error	38	0.6	0.6	I.4	0.4	0.4	4.7

**Significant at 1%.

Table 2. ANOVA of developmental characters of sorghum in intercropping at three stages of growth over two years 1983 and 1984.

Source	df	M S S					
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
		Plant height (cm)			Leaf number		
Year	1	18099.7**	1180.3	55395.1**	216.3**	472.1**	451.8**
Rep. / year	4	98.8	119.9	193.5	3.3	3.6	3.9
Genotype	19	2510.9**	6393.0**	9002.0**	3.6**	4.1**	5.4**
Geno. x year	19	203.6	556.5**	1008.1**	2.8**	7.1**	6.3**
Error	76	209.6	297.8	328.6	0.5	0.7	0.8
		Leaf length (cm)			Leaf breadth (cm)		
Year	1	17644.1**	16532.6**	16489.7**	468.8**	453.1**	203.1**
Rep. / year	4	77.7	70.1	68.3	3.0	2.8	3.9
Genotype	19	290.0**	261.3**	348.9**	3.6**	4.4**	10.4**
Geno. x year	19	205.6**	198.3**	196.7**	4.5**	4.2**	2.6
Error	76	209.6	25.5	26.1	0.6	0.9	2.6

** significant at 1%.

Table 3. Mean plant height of sorghum genotypes in intercropping over three stages of growth during kharif 1983 and kharif 1984.

Sl. No.	Genotype	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
		Sorghum plant height (cm)										
1	CSH 1	56.9	100.5	78.7	96.8	105.7	101.0	144.0	110.1	122.3	99.2	105.4
2	CSH 5	53.1	80.3	66.7	102.3	112.7	107.5	165.0	116.5	140.8	136.8	103.2
3	CSH 6	62.1	90.7	76.4	109.5	120.4	114.9	176.7	121.7	149.2	116.1	110.9
4	CSH 9	62.9	83.9	73.4	123.3	119.7	121.5	175.2	123.4	149.3	120.5	109.0
5	SPH 221	68.8	93.0	80.9	134.9	125.9	130.4	184.7	131.3	158.0	29.5	116.7
6	SPH 162	77.7	119.9	98.8	179.1	161.5	170.3	251.7	161.1	206.4	69.5	147.5
7	SPH 192	102.1	132.4	117.3	202.7	176.5	189.6	273.3	181.1	227.2	192.7	163.4
8	CS 3541	49.2	84.4	66.8	81.2	113.3	97.3	123.0	116.8	119.9	84.5	104.8
9	A 535	50.5	52.4	51.5	86.7	88.7	87.7	119.3	107.2	113.3	85.5	82.8
10	SB 1085	70.6	90.5	80.6	150.6	125.8	138.2	193.7	132.1	162.9	38.4	116.1
11	SPV 126	70.3	88.9	79.6	143.3	118.7	131.0	187.4	135.1	161.3	33.7	114.0
12	296B	42.3	62.9	52.6	73.6	77.9	75.8	96.4	86.1	91.3	70.8	75.6
13	2219B	40.4	57.6	49.0	66.5	81.1	73.8	114.3	84.1	99.2	73.8	74.3
14	168	37.7	51.8	44.8	79.5	68.7	74.1	82.2	72.2	77.2	69.8	64.2
15	SPV 245	53.0	67.6	60.3	94.4	103.6	99.1	29.5	103.8	116.7	92.3	91.7
16	SPV 346	60.4	90.4	75.4	117.3	136.0	126.7	160.9	139.8	150.4	12.9	122.1
17	SPV 351	52.7	73.4	63.1	96.6	104.0	100.3	140.9	117.5	129.2	96.7	98.4
18	SPV 462	71.0	101.9	86.5	136.5	139.5	138.0	197.6	150.9	174.3	135.0	130.7
19	SPV 472	68.5	113.7	91.1	153.5	152.5	153.0	202.3	153.1	177.7	141.4	139.8
20	Y 75	116.7	122.3	119.5	191.0	143.6	167.3	36.0	155.3	195.7	181.2	140.4
SE		5.4	10.5	8.3	9.2	10.7	9.9	10.0	10.9	10.4		
G MEAN		63.3	87.9	75.6	121.5	119.0	120.2	167.7	124.7	146.2		

G MEAN = Grand Mean

Table 4. Mean leaf number of sorghum in intercropping over three stages of growth during kharif 1983 and kharif 1984.

Sl. No.	Genotype	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
1	CSH 1	9.9	10.1	10.0	10.7	9.2	9.9	10.3	9.6	10.0	10.3	9.6
2	CSH 5	9.5	9.6	9.5	12.6	9.3	10.9	11.5	9.1	10.3	11.2	9.4
3	CSH 6	9.9	8.5	9.2	1.3	8.1	9.7	10.1	8.1	9.1	10.4	8.2
4	CSH 9	10.3	9.5	9.9	12.9	9.5	11.2	12.1	9.9	11.0	11.7	9.7
5	SPH 221	9.5	9.5	9.5	12.1	9.2	11.2	11.9	10.2	10.8	11.0	9.6
6	SPH 162	9.3	9.5	9.4	11.8	9.2	10.5	11.5	9.7	10.6	10.9	9.5
7	SPH 192	9.6	9.1	9.4	12.4	8.7	10.5	11.7	9.3	10.5	11.2	9.0
8	CS 3541	10.3	8.7	9.5	11.5	8.8	10.2	10.4	8.7	9.6	10.7	8.8
9	A 535	8.2	8.7	8.5	10.7	11.2	11.0	11.8	11.1	11.5	10.2	10.3
10	SB 1085	9.9	7.7	8.7	11.6	7.5	9.6	11.1	9.7	10.4	10.8	8.3
11	SPV 126	9.5	7.5	8.5	11.1	7.7	9.4	10.4	8.9	9.7	10.3	8.1
12	296B	8.9	9.3	9.1	11.6	8.7	10.2	10.5	9.0	9.8	10.3	9.1
13	2219B	9.1	7.2	8.2	9.3	6.5	7.9	8.3	7.4	7.9	8.9	7.1
14	168	9.0	8.9	9.0	9.8	9.0	9.4	10.4	8.2	9.3	9.7	8.7
15	SPV 245	8.8	8.7	8.8	11.6	8.7	10.2	11.7	8.4	10.1	10.7	8.7
16	SPV 346	8.6	8.8	8.7	11.3	8.0	9.7	11.9	9.5	10.7	10.6	8.8
17	SPV 351	8.6	9.4	9.0	10.9	8.1	9.5	10.9	9.6	10.3	10.2	9.0
18	SPV 462	7.8	7.3	7.6	10.1	7.2	8.8	10.2	8.5	9.4	9.4	7.7
19	SPV 472	8.7	9.5	9.1	10.7	9.7	10.2	10.4	10.3	10.4	9.9	9.8
20	Y 75	9.7	7.5	8.3	9.1	7.7	8.4	9.5	9.0	9.3	9.4	8.1
SE		0.4	0.4	0.4	0.4	0.6	0.5	0.5	0.6	0.5		
G Mean		9.3	8.8	9.0	11.2	8.6	10.1	10.8	9.2	10.0		

Table 5. Mean leaf length of sorghum in intercropping over three stages of growth during kharif 1983, and kharif 1984.

		Sorghum leaf length(cm)										
		Stage 1			Stage 2			Stage 3			Mean	
Sl. No.	Geno-type	1983	1984	Av.	1983	1984	Av.	1983	1984	Av.	1983	1984
1	CSH 1	83.1	55.1	69.1	82.1	53.9	68.0	77.9	53.6	65.8	81.0	54.2
2	CSH 5	84.9	65.9	75.4	79.5	64.7	72.1	85.2	68.3	76.8	83.2	66.3
3	CSH 6	78.9	54.5	66.7	79.8	52.8	66.3	78.5	49.8	64.2	79.1	52.4
4	CSH 9	91.3	60.9	76.1	93.9	59.9	76.9	91.7	66.3	79.0	92.3	62.4
5	SPH 221	93.7	66.6	80.2	99.3	65.1	82.2	94.3	70.8	82.6	95.8	67.5
6	SPH 162	91.7	66.2	78.9	95.9	69.1	82.5	94.0	67.9	80.9	93.8	67.8
7	SPH 192	87.1	65.8	76.5	89.3	68.1	78.7	87.8	67.0	77.4	88.1	66.9
8	CS 3541	76.2	52.9	64.6	76.5	56.9	66.7	72.8	62.6	67.7	75.2	57.4
9	A 535	81.0	61.2	71.1	80.3	70.8	75.6	84.3	70.7	77.5	81.9	67.6
10	SB 1085	75.4	60.1	67.8	80.7	59.7	70.2	80.1	63.5	71.8	78.7	61.1
11	SPV 126	84.6	57.6	71.1	84.9	64.7	74.8	84.3	65.1	74.7	84.6	62.5
12	296B	92.2	58.4	75.3	93.3	64.2	78.8	69.4	66.9	78.2	91.7	63.2
13	2219B	71.7	45.2	58.5	66.8	43.5	58.2	61.3	44.5	58.9	66.6	44.4
14	168	85.9	64.8	75.4	94.5	73.7	84.1	93.9	72.6	83.3	91.5	70.4
15	SPV 245	92.8	66.6	79.7	92.7	72.0	82.4	93.5	68.5	81.0	93.0	69.0
16	SPV 346	84.9	63.2	74.1	85.3	65.4	75.4	84.5	69.6	77.1	84.9	66.1
17	SPV 351	85.3	65.7	75.5	85.5	72.7	79.1	88.8	66.3	77.6	86.5	68.3
18	SPV 462	91.0	70.3	80.7	91.5	74.0	82.8	94.2	70.7	82.5	92.2	71.7
19	SPV 472	96.1	69.4	82.8	91.7	75.7	83.7	92.0	67.2	79.6	93.3	70.8
20	Y 75	78.3	58.5	68.4	75.9	58.7	67.3	72.9	62.7	67.8	75.7	58.6
SE		3.1	3.2	3.1	2.5	3.3	2.9	2.8	3.0	3.0		
G MEAN		85.3	61.5	73.4	85.9	64.1	75.0	85.1	64.7	74.9		

Table 6. Mean leaf breadth of sorghum in intercropping over three stages of growth during kharif 1983 and kharif 1984.

Sl. No.	Genotype	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
		Sorghum leaf breadth (cm)										
1	CSH 1	8.2	6.3	7.3	8.9	6.1	7.5	9.0	7.0	8.0	8.7	6.4
2	CSH 5	8.4	7.9	8.2	8.3	7.4	7.9	8.6	7.9	8.3	8.4	7.6
3	CSH 6	7.9	5.8	6.9	8.4	5.9	7.2	8.6	6.7	7.7	8.3	6.1
4	CSH 9	9.4	7.7	8.6	10.0	7.1	8.5	10.4	8.7	9.6	9.9	7.8
5	SPH 221	9.5	7.9	8.7	10.5	7.7	9.1	10.0	8.6	9.3	9.8	8.0
6	SPH 162	8.4	7.6	8.0	8.9	7.6	8.5	9.0	7.7	8.4	8.8	7.6
7	SPH 192	8.6	7.6	8.1	9.1	7.6	8.4	8.6	7.8	8.2	8.8	9.7
8	CS 3541	6.9	6.2	6.6	6.7	6.4	6.6	7.9	7.7	7.8	7.2	6.8
9	A 535	7.8	7.0	7.4	9.1	8.2	8.7	8.4	7.9	8.2	8.4	7.7
10	SB 1085	7.4	7.0	7.2	7.8	6.9	7.4	8.1	7.5	7.8	7.7	7.1
11	SPV 126	7.1	5.8	6.5	7.6	6.6	7.1	7.8	7.0	7.4	7.5	6.5
12	296B	9.3	7.4	8.4	10.1	8.3	9.2	10.0	8.8	9.4	9.8	8.2
13	2219B	6.7	8.3	7.5	7.0	5.9	6.5	7.2	5.9	6.6	7.0	5.7
14	168	8.4	7.0	7.7	9.8	8.4	9.1	9.8	8.9	9.4	9.3	8.1
15	SPV 245	8.3	6.9	7.6	8.9	7.8	8.4	9.6	7.7	8.7	8.9	7.5
16	SPV 346	8.1	6.4	7.3	8.2	6.9	7.6	8.8	7.9	8.4	8.4	7.1
17	SPV 351	7.5	6.9	7.1	7.6	7.9	7.8	8.9	8.1	8.4	8.0	7.6
18	SPV 462	7.8	7.2	7.5	7.8	7.8	7.7	8.2	8.1	8.2	7.9	7.6
19	SPV 472	8.4	7.9	8.2	10.6	8.4	9.5	9.5	7.7	8.6	9.5	8.0
20	Y 75	8.0	6.2	7.1	7.8	6.7	7.4	7.8	6.9	7.4	7.9	6.6
SE		0.4	0.4	0.4	0.7	0.4	0.6	0.4	0.4	0.9		
G MEAN		8.1	6.9	7.4	8.7	7.3	7.9	8.8	7.3	8.0		

Genotypes 168, 296B and 2219B were dwarf and statistically on par SPH 221, SPV 126, SB 1085 which were some of the medium tall genotypes and SPH 162, Y 75 and SPH 196 were the tallest at final stage.

Comparison of the plant heights between the two years showed maximum difference for SPH 196 while the least difference was exhibited by variety 168. The plant height of the genotypes ranged from 44.8 to 119.5 cm in S1 stage, 73.8 to 189.6 cm in S2 stage and 113.3 to 227.2 cm during S3 stage.

Comparison of the mean leaf number per plant showed that genotypes A 535, CSH 9, SPH 221, SPV 346 and SPH 162 recorded maximum number of leaves ranging from 10.6 to 11.5 per plant (Table 4). 2219B had the least number of leaves being 7.9 per plant, while the other genotypes were moderately leafy. The rate of increase in leaf number from the first growth stage was greatest in case of A 535 and SPV 462, whereas in other genotypes the rate of increase was slower. The mean leaf number of the genotypes ranged from 7.6 to 10.0 in S1, 7.9 to 11.2 during S2 and 7.9 to 11.5 during S3 stage. Leaf number was greater in Kharif 1983 than in 1984 in all the genotypes except A 535, SPV 472 and Y 75 which did not show significant differences between the years. The differences between the years was maximum in case of SPV 346 and CSH 9.

Leaf length was also minimum in case of 2219B, being 52.9 cm while maximum was recorded in genotypes 168, SPV 462, SPH 221, SPV 245, SPH 162, CSH 9, SPV 472 and 296B (Table 5). All other genotypes had medium long leaves. The rate of increase in length was similar in all genotypes. Mean leaf length ranged from 58.5 to 82.8 cm, 58.2 to 84.1 cm and 58.9 to 83.3 cm in S1, S2 and S3 stages respectively. All genotypes exhibited longer leaves in Kharif 1983 than in 1984, the differences being maximum in case of CSH 6, CSH 9, SPV 472, CSH 1 and SPV 462.

Least leaf breadth was recorded in case of genotypes 2219B, SPV 126, Y 75, CS 3541 and SB 1085, while in all the other genotypes leaf breadth was greater without much differences between these genotypes (Table 6). The rate of increase in leaf breadth was maximum in case of variety 168.

Mean leaf breadth ranged from 6.6 to 8.7 cm in S1, 6.5 to 9.5 cm in S2 and 6.6 to 9.6 cm in S3 stage. Comparison of the means between the years shows that the leaf breadth was greater in the year 1983 than in 1984 in all genotypes studied. Maximum difference of 2 cm was observed between the two years in case of CSH 1.

1.1.2 Genetic variability in sorghum under intra-species competition.

ANOVA and means of the developmental characters of sorghum at three stages of growth when grown as sole crop during Kharif 1983 and 1984 are presented in Tables 7 to 12. Genotypes were significantly different for all the characters at all the three stages of growth (Table 7) except for leaf number at S1 in 1984 and S2 in 1983. The pooled analysis over the years when sorghum was grown as sole crop is presented in Table 8. It shows that the difference between the years was highly significant for all the developmental characters at all the 3 stages. Genotypic variation and genotype X year interactions were also highly significant.

Comparison of mean plant heights of the genotypes revealed that SPH 196 and SPH 162 were the tallest genotypes (Table 9). Y 75, SPV 462 and SPV 472 were tall, variety 168, 2219B, 296B were dwarf and all other genotypes were medium tall. The rate of linear increase in heights was maximum in case of SPH 162 while minimum growth rate was recorded in case of 168. Mean plant height in S1, S2 and S3 stages were 56.9 to 120.6 cm, 92.3 to 205.6 cm and 92.4 to 241.0 cm respectively. Among the two years, Kharif 1983 recorded greater heights than 1984 for all the genotypes except CS 3541, SPH 162 showed the maximum difference between the two years.

Table 7. ANOVA of developmental characters of sorghum in sole cropping at three stages of growth during kharif 1983 and 1984.

Source	df	M S S					
		Plant height (cm)					
		Stage 1		Stage 2		Stage 3	
		1983	1984	1983	1984	1983	1984
Replication	2	78.0	38.5	47.6	42.9	335.5	55.4
Genotype	19	1347.0**	1573.0**	3005.2**	3036.5**	8306.3**	2713.6**
Error	38	133.2	465.0	642.5	304.5	175.4	340.3
		Leaf number					
Replication	2	0.9	1.4	1.1	0.3	9.0	0.4
Genotype	19	2.7**	1.2	1.3	2.7**	2.7**	2.1**
Error	38	0.6	0.9	0.7	0.3	0.6	1.0
		Leaf Length (cm)					
Replication	2	14.3	22.6	17.4	15.9	114.5	90.8
Genotype	19	154.3**	136.8*	79.1**	182.5**	177.6**	174.3**
Error	38	16.2	57.4	16.4	26.4	22.1	22.3
		Leaf breadth (cm)					
Replicaton	2	1.2	0.6	2.2	0.5	3.4	0.3
Genotype	19	1.9**	1.5**	0.6**	1.7**	1.8**	0.7**
Error	38	0.4	0.5	0.2	0.3	0.3	0.1

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

Table 8. ANOVA of sorghum characters at three stages of growth over two years 1983 and 1984.

Source	df	M S S Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
		Plant height (cm)			Leaf number		
Year	1	19631.2**	1861.3	48365.1**	531.2**	603.5**	528.1**
Rep./ year	4	128.8	50.6	277.3	262.5	225.3	280.5
Genotype	9	2832.4**	6481.7**	9939.9**	3.5**	2.4**	5.3**
Genotype x year	19	198.3	462.9	1108.6	2.9	3.3	6.1
Error	76	299.1	473.5	257.8	0.8	0.6	0.8
		Leaf length(cm)			Leaf breadth (cm)		
Year	1	13210.5**	1118.3**	1199.4**	501.3**	478.6**	461.4**
Rep./ year	4	9684.6	7780.4	8064.9	236.3	151.9	158.0
Genotype	9	286.2**	180.3**	230.3**	3.8**	1.5**	6.8**
Geno. x year	19	199.3	142.1	115.8	4.4	1.1	1.8
Error	76	36.8	21.4	22.2	0.5	0.2	0.2

** significant at 1%.

Table 9 Mean plant height of sorghum in sole cropping over three stages of growth during kharif 1983 and 1984.

Sl. No.	Genotype	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
1	CSH 1	64.1	88.3	76.2	148.9	110.7	129.8	160.7	118.7	139.7	124.6	105.9
2	CSH 5	66.1	84.6	73.4	158.1	114.4	136.3	195.1	127.9	161.5	139.7	109.0
3	CSH 6	76.1	98.8	87.5	146.3	118.3	132.3	185.9	124.7	155.3	136.1	114.0
4	CSH 9	72.6	85.5	79.1	132.5	124.9	128.7	197.2	131.8	164.5	134.1	114.0
5	SPH 221	77.7	95.7	86.7	140.0	140.4	140.2	216.3	144.3	180.3	144.7	126.8
6	SPH 162	99.4	122.1	110.8	198.9	172.1	185.5	290.7	174.9	232.8	196.3	156.4
7	SPH 192	109.9	147.5	128.7	215.7	195.5	205.6	290.0	193.8	241.9	205.2	178.9
8	CS 3541	52.6	99.7	76.2	116.2	133.3	124.8	132.0	129.5	130.8	100.3	120.8
9	A 535	54.3	59.4	56.9	131.5	92.0	111.8	150.3	107.9	129.1	112.1	86.4
10	SB 1085	82.5	120.5	101.5	165.7	150.3	158.0	205.0	152.2	178.6	151.1	141.0
11	SPV 126	76.2	93.4	84.2	122.7	146.0	197.3	153.7	175.5	132.1	131.0	105.0
12	296B	45.8	68.5	57.2	130.5	87.6	109.1	129.3	91.7	110.5	101.9	82.6
13	2219B	45.7	78.0	62.2	106.9	77.7	92.3	120.6	81.6	101.1	91.0	79.3
14	168	40.9	55.6	48.3	109.9	76.7	93.3	102.2	82.5	92.4	84.3	71.6
15	SPV 245	65.1	88.3	76.7	128.1	113.2	120.7	172.3	118.4	145.4	121.8	106.6
16	SPV 346	76.9	101.2	89.1	139.9	144.3	142.1	217.7	148.0	182.9	144.8	131.2
17	SPV 351	63.1	86.3	74.7	135.7	115.2	125.5	184.7	122.9	153.8	127.8	108.1
18	SPV 462	90.9	113.2	102.1	188.6	149.8	169.2	256.0	154.7	205.0	178.5	139.2
19	SPV 472	85.2	120.5	103.0	169.3	154.6	161.9	225.0	164.3	194.7	159.8	146.5
20	Y 75	120.8	120.4	120.6	203.6	163.4	183.5	244.7	164.9	204.8	189.7	149.6
SE		6.7	12.5	9.9	14.6	10.1	12.5	7.7	10.6	9.2		
G MEAN		73.3	96.4	84.9	149.4	129.0	139.2	193.7	134.4	164.1		

Table 10. Mean leaf number of sorghum in sole cropping over three stages of growth during kharif 1983 and 1984.

Sl. No.	Genotype	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
1	CSH 1	11.1	9.6	10.4	12.6	7.4	10.0	10.5	8.8	10.5	11.4	8.6
2	CSH 5	11.1	9.5	10.3	12.5	9.1	10.8	12.9	9.1	11.0	12.2	9.2
3	CSH 6	10.8	8.8	9.8	12.4	8.7	10.6	10.4	8.5	9.5	11.2	8.7
4	CSH 9	11.0	9.6	10.3	12.1	8.7	10.4	12.3	9.7	11.0	11.8	9.4
5	SPH 221	10.1	9.3	9.7	11.7	8.9	10.3	12.6	9.1	10.9	11.5	9.1
6	SPH 162	10.6	9.3	9.9	12.7	9.7	10.2	12.7	10.1	11.4	12.0	9.7
7	SPH 192	10.5	9.7	10.1	12.2	9.5	11.2	11.7	9.7	10.7	11.5	9.6
8	CS 3541	10.3	9.5	9.9	12.0	8.7	10.4	11.4	9.1	10.3	11.2	9.1
9	A 535	9.0	9.1	10.8	10.8	9.6	10.2	12.0	11.1	11.6	10.6	9.9
10	SB 1085	10.7	8.3	9.5	12.1	8.6	10.3	10.8	8.3	9.6	11.2	8.4
11	SPV 126	10.3	8.3	9.3	11.7	8.3	10.0	11.5	8.7	10.1	11.2	8.4
12	296B	8.9	10.0	9.5	11.0	7.9	8.4	12.9	10.1	11.5	10.9	9.4
13	2219B	9.5	8.3	8.9	11.6	6.1	8.9	9.9	6.9	8.4	10.4	7.1
14	168	8.2	9.3	8.7	10.4	8.5	9.5	12.2	8.9	10.6	10.3	8.9
15	SPV 245	9.3	8.7	9.0	11.6	8.7	10.2	12.1	9.5	10.8	11.0	9.0
16	SPV 346	8.7	8.3	8.5	11.3	8.1	9.7	11.6	8.6	10.1	10.5	8.3
17	SPV 351	8.4	8.4	8.4	10.8	7.5	9.2	12.2	8.7	10.0	10.5	8.2
18	SPV 462	8.8	8.7	8.8	11.2	8.3	8.9	10.9	7.9	9.4	10.3	8.3
19	SPV 472	9.2	8.9	9.0	11.3	9.5	10.4	11.3	10.1	10.7	10.6	9.5
20	Y 75	9.3	7.5	8.4	11.2	8.5	9.9	11.7	7.8	9.8	10.0	7.9
SE		0.5	0.6	0.5	0.5	0.6	0.5	0.4	0.3	0.5		
G MEAN		9.7	8.9	9.4	11.6	8.5	10.1	11.5	9.0	10.3		

Table 11. Mean leaf length of sorghum in sole cropping over three stages of growth during kharif 1983 and 1984.

		Sorghum leaf length(cm)										
		Stage 1			Stage 2			Stage 3			Mean	
Sl. No.	Geno-type	1983	1984	Av.	1983	1984	Av.	1983	1984	Av.	1983	1984
1	CSH 1	79.1	53.3	66,2	78.7	53.2	65.9	89.9	57.2	73.6	85.6	54.5
2	CSH 5	84.1	65.0	74.6	85.3	66.1	75.7	92.8	70.3	81.6	87.4	67.1
3	CSH 6	78.9	59.5	69.2	75.9	52.9	64.9	89.2	55.9	72.6	81.7	56.1
4	CSH 9	88.7	64.7	76.7	84.2	64.3	74.5	77.9	66.8	72.5	90.4	65.3
5	SPH 221	91.9	66.3	78.8	87.1	68.1	78.5	100.4	69.9	85.2	93.1	68.1
6	SPH 162	89.2	71.1	77.7	92.9	71.1	82.0	105.8	72.7	89.3	96.1	71.7
7	SPH 192	89.9	67.3	78.6	90.4	68.5	79.5	98.1	77.7	87.9	92.8	71.2
8	CS 3541	71.1	60.4	65.8	69.7	63.8	66.8	85.3	69.0	77.2	75.4	64.4
9	A 535	78.5	62.7	70.6	84.3	70.4	77.4	95.2	67.5	81.4	86.0	66.9
10	SB 1085	73.9	64.5	69.2	80.9	67.1	74.0	88.8	67.9	78.4	81.2	66.5
11	SPV 126	78.9	54.9	66.9	84.4	61.9	73.2	93.2	69.3	81.3	85.5	62.0
12	296B	85.3	69.1	77.2	79.1	69.4	74.3	97.7	73.6	85.7	87.4	70.7
13	2219B	66.7	47.1	56.9	64.5	44.4	54.5	90.9	44.4	67.9	74.0	45.3
14	168	77.4	70.7	74.1	91.2	75.6	83.4	90.6	72.2	81,4	86.4	72.8
15	SPV 245	87.2	64.0	75.6	90.1	68.8	79.5	99.5	66.6	83.1	92.3	66.5
16	SPV 346	81.1	68.8	74.9	86.2	67.1	76.7	91.1	68.1	79.6	86.2	68.0
17	SPV 351	82.5	67.9	75.2	86.6	69.3	77.9	95.1	65.5	80.3	88.0	67.6
18	SPV 462	90.3	61.9	76.1	91.2	67.9	79.6	96.5	73.8	85.2	92.7	67.8
19	SPV 472	90.1	69.7	79.9	92.5	74.3	83.6	100.1	75.4	87.8	94.2	73.3
20	Y 75	74.5	51.7	63.1	75.3	56.7	66.0	88.9	64.4	76.7	79.6	57.6
SE		2.3	4.4	3.6	2.7	3.0	2.7	2.3	2.7	2.7		
G MEAN		81.9	63.0	72.5	83.6	65.0	74.3	94.3	67.4	80.9		

Table 12. Mean leaf breadth of sorghum in sole cropping over three stages of growth during kharif 1983 and 1984.

Sl. No.	Inter crop	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
1	CSH 1	7.2	6.2	6.7	8.4	7.0	7.7	8.6	7.6	8.2	8.1	6.9
2	CSH 5	7.5	7.0	7.3	8.6	7.2	7.9	9.5	9.0	9.3	8.5	7.7
3	CSH 6	7.0	6.1	6.5	8.1	6.0	7.0	7.6	7.4	7.5	7.6	6.5
4	CSH 9	8.3	7.8	8.1	9.1	7.8	8.5	9.3	8.7	9.0	8.7	8.1
5	SPH 221	9.1	7.2	8.2	9.4	7.8	8.7	9.8	8.1	8.9	9.4	7.8
6	SPH 162	7.5	7.2	7.4	8.5	7.0	7.8	8.2	8.1	8.2	8.1	7.4
7	SPH 192	8.1	6.7	7.4	8.9	6.5	7.7	7.9	8.6	8.3	8.3	7.3
8	CS 3541	6.3	6.3	6.3	7.9	6.8	7.4	8.1	8.4	8.3	7.5	7.2
9	A 535	7.3	6.5	6.9	8.4	8.3	8.4	8.9	8.2	8.6	8.2	7.7
10	SB 1085	6.7	6.2	6.5	8.1	6.5	7.3	7.3	8.3	8.3	7.7	6.9
11	SPV 126	6.7	5.7	6.2	7.9	6.2	7.1	7.6	7.8	7.7	7.4	6.6
12	296B	8.2	8.2	8.2	9.3	8.4	8.9	9.7	8.7	9.4	9.0	8.4
13	2219B	6.9	8.2	7.6	8.3	8.4	8.4	8.9	8.3	8.6	8.0	8.3
14	168	5.9	5.7	5.8	7.9	5.9	6.9	7.1	6.7	6.9	6.9	6.1
15	SPV 245	7.2	6.3	6.8	8.2	6.9	7.6	9.0	8.2	8.8	8.2	7.1
16	SPV 346	6.3	6.8	6.6	7.8	6.9	7.4	8.1	8.1	8.1	7.4	7.3
17	SPV 351	6.1	6.6	6.3	7.7	6.9	7.3	7.9	8.2	8.1	7.3	7.2
18	SPV 462	7.4	6.5	7.0	8.6	6.7	7.6	8.3	8.3	8.3	8.1	7.2
19	SPV 472	7.2	7.1	7.2	8.5	7.6	8.1	8.8	8.2	8.5	8.2	7.6
20	Y 75	6.6	6.5	6.6	8.2	6.5	7.4	7.3	7.6	7.5	7.4	6.9
SE		0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.3		
G MEAN		7.1	6.9	7.0	8.3	7.0	7.8	8.4	8.1	8.3		

Sorghum leaf breadth(cm)

Maximum number of leaves per plant were recorded in case of SPH 162 and CSH 5 (Table 10). SPH 221, SPH 196, 296B, 168, SPV 245, SPV 472 and Y 75 possessed ten leaves. 2219B had the least (8) number of leaves while all other genotypes possessed 9-10 leaves with no significant differences between them. The rate of increase in leaf number from S1 to S3 was similar for all genotypes except CSH 1. Mean leaf number ranged from 7.5 to 10.0 in S1 stage, 8.4 to 11.2 in S2 stage and 9.4 to 11.6 in S3 stage. Leaf number was greater in Kharif 1983 than in 1984 for all genotypes.

Leaf length was maximum in case of genotypes SPH 196, SPV 462, SPH 162, SPV 472, 2219B, SPV 245 and SPH 221 (Table 11). Leaves were shortest in case of CSH 6, CSH 1, Y75 and CS 3541. All other genotypes had medium long leaves. Shortest leaves were observed in variety 2219B. The rate of increase in leaf length was maximum in SPH 196 and SPH 162. Leaf length was greater in 1983 than in 1984 for all genotypes except CS 3541. Maximum differences in length were observed in case of SPV 245, CSH 9, CSH 1, SPV 346 and 168 while the differences were slight in case of Y 75 and 296B.

Mean leaf length ranged from 63.1 to 79.9 cm in S1 stage, 65.9 to 83.6 cm in S2 stage and 72.5 to 89.3 cm in S3 stage.

Leaf length was more during 1983 than 1984 in all genotypes at all three growth stages. Maximum differences between the two years was observed in case of SPH 196 and SPH 221.

Broadest leaves were observed in case of 296B, CSH 5, CSH 9, SPH 221 followed by SPV 245, A 535, SPH 196, SPH 162, SPV 462 and SB 1085 (Table 12). Other genotypes had less broad leaves. The narrowest leaves were recorded in case of 2219B which was 6.9 cm followed by SPV 126 and CSH 6. The rate of increase in leaf width was greatest in case of CSH 5. Mean leaf breadth ranges were 5.8 to 8.2 cm, 6.9 to 8.9 cm and 6.9 to 9.3 cm in S1, S2 and S3 stages respectively. No differences in leaf width was observed between the two years for the genotypes CSH 6, SPH 162, CS 3541, SB 1085, SPV 126, 168, SPV 346, SPV 162 and Y 75. Other genotypes produced broader leaves during Kharif 1983 than in 1984, the differences being more than 0.5 cm.

1.1.3 Genetic variability in pigeonpea variety HY8 under inter-species competition.

ANOVA and means of various treatments of variety HY 8 of pigeonpea are given in Table 13 to 17. No significant differences for the developmental characters of Pigeonpea were observed at any of the growth stages in 1983 or 1984 except at stage 3 in 1983. Pooled analysis of pigeonpea characters over the two years 1983 and 1984 are presented in Table 14. Developmental characters differed significantly

Table 13. ANOVA for developmental characters of pigeonpea in intercropping at three stages of growth during kharif 1983 and 1984.

Source	df	M S S					
		Stage 1		Stage 2		Stage 3	
		1983	1984	1983	1984	1983	1984
				Plant height (cm)			
Replication	2	8.9	308.6	42.1	226.9	209.1	242.3
Genotype	19	46.8	106.8	115.1	69.4	104.5	90.0
Error	38	35.9	89.6	90.8	131.8	92.7	112.0
				Branch number			
Replication	2	4.9	0.7	3.7	15.8	10.0	13.6
Genotype	19	0.9	1.0	3.0	2.6	1.4	5.3
Error	38	1.0	1.0	1.9	4.0	2.6	4.5
				Branch length (cm)			
Replication	2	58.8	13.1	76.0	19.1	242.4	64.6
Genotype	19	12.7	65.8	66.4	75.0	167.2**	29.9
Error	38	18.5	50.3	49.0	49.6	77.0	24.6

**Significant at 1%.

Table 14. ANOVA for developmental characters of pigeonpea at three stages of growth in intercropping over two years 1983 and 1984.

Source	df	M S S								
		Plant height (cm)			Branch number			Branch length cm)		
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Year	1	6086.4**	1526.8**	135.1	278.4**	381.8**	403.5**	763.4**	1061.5**	1430.6
Rep./year	2	158.3	134.5	212.2	4.0	10.2	13.2	52.9	37.1	66.5
Genotype	19	55.9	50.1	108.3	2.1**	3.4	5.9	69.7	78.2	175.4**
Geno. x year	19	97.5	134.5	86.3	4.9**	9.3**	12.6**	104.2**	172.3**	186.4**
Error	76	62.4	111.0	101.8	0.9	2.9	3.5	34.3	49.3	50.7

** significant at 1%.

Table 15. Mean plant height of pigeonpea(HY8) in intercropping over three stages of growth during kharif 1983 and 1984.

Sl. No.	Inter crop	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
		Pigeonpea plant height (cm)										
1	CSH 1	67.3	78.1	72.7	102.7	103.5	103.1	120.9	110.9	115.9	96.9	97.5
2	CSH 5	69.3	86.6	77.9	98.5	113.5	106.0	110.0	123.3	116.7	92.6	107.8
3	CSH 6	62.5	85.3	73.9	94.9	114.6	104.8	112.1	128.2	120.2	89.9	109.4
4	CSH 9	66.9	84.9	75.9	103.4	109.4	106.4	119.4	122.6	121.0	96.6	105.6
5	SPH 221	71.7	88.7	80.2	108.7	115.0	118.9	125.9	124.7	125.3	102.1	109.4
6	SPH 162	69.9	84.9	77.4	111.2	110.3	110.8	126.5	120.8	123.7	102.5	105.3
7	SPH 192	75.4	80.7	78.1	113.7	108.7	111.1	125.9	131.7	128.8	105.0	106.9
8	CS 3541	74.5	82.8	78.7	108.5	109.6	109.0	118.7	115.5	116.6	100.5	102.6
9	A 535	69.3	80.4	74.9	102.9	105.1	103.9	116.7	115.5	116.0	96.3	100.3
10	SB 1085	57.7	92.7	75.2	86.8	117.5	102.2	108.4	120.7	114.6	84.3	110.3
11	SPV 126	68.9	83.1	76.0	100.9	107.7	104.3	110.4	115.1	112.8	93.4	101.9
12	296B	69.2	82.8	76.0	101.4	108.4	104.4	112.4	120.7	116.6	94.3	103.9
13	2219B	68.1	79.2	73.7	96.3	107.8	102.0	113.7	120.1	116.9	92.7	102.4
14	168	70.3	74.8	73.5	103.0	107.5	105.2	116.0	116.3	116.2	96.4	99.4
15	SPV 245	66.5	83.9	75.2	102.8	107.9	105.4	122.6	110.5	116.6	97.3	100.8
16	SPV 346	63.3	87.3	75.3	98.3	115.6	106.9	114.7	113.9	114.3	92.1	105.6
17	SPV 351	66.5	87.2	76.9	99.6	115.6	107.6	120.2	126.0	123.1	95.4	109.6
18	SPV 462	69.5	77.2	73.4	104.8	105.7	105.0	128.1	120.5	124.4	100.8	100.9
19	SPV 472	66.7	64.7	65.7	109.2	97.8	103.5	114.9	120.2	117.6	96.9	94.2
20	Y 75	66.2	79.9	73.1	98.6	108.3	103.5	117.1	120.1	118.6	93.9	102.8
SE		3.5	5.5	4.5	5.5	6.6	6.1	5.6	6.1	6.1		
G MEAN		67.9	82.2	75.1	102.3	109.4	105.9	117.7	119.9	118.8		

Table 16. Mean branch number of pigeonpea(HY8) in intercropping at three stages of growth during kharif 1983 and 1984.

Sl. No.	Genotype	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
1	CSH 1	5.9	4.9	5.3	9.2	8.3	8.8	10.3	14.4	12.4	8.5	9.2
2	CSH 5	5.6	4.8	5.2	9.7	8.7	9.2	9.6	12.7	11.2	8.3	8.8
3	CSH 6	4.8	5.1	5.0	8.1	8.5	8.3	9.6	11.2	10.3	7.5	8.2
4	CSH 9	4.6	4.8	4.7	7.6	9.8	8.7	8.1	10.1	9.1	6.8	8.2
5	SPH 221	4.9	5.3	5.1	7.9	8.1	8.0	8.1	10.4	9.3	6.9	7.9
6	SPH 162	5.5	3.9	4.7	8.8	8.0	8.4	9.2	10.7	9.9	7.8	7.5
7	SPH 192	5.6	4.5	5.0	8.5	5.4	6.9	8.5	11.7	9.1	7.5	7.2
8	CS 3541	5.9	5.3	5.6	9.5	8.3	8.9	10.7	12.7	11.7	8.7	8.8
9	A 535	4.9	5.2	5.1	9.1	8.9	9.6	9.5	12.1	10.8	7.8	8.7
10	SB 1085	4.6	5.6	5.2	6.5	8.9	7.7	7.3	10.1	8.7	6.1	8.2
11	SPV 126	5.4	4.9	5.2	8.4	7.9	8.2	9.1	12.0	9.6	7.6	8.3
12	296B	6.0	6.1	6.1	9.6	8.9	9.3	9.3	12.3	10.8	8.3	9.1
13	2219B	5.7	5.7	5.7	9.1	8.1	8.6	10.1	11.7	10.9	8.3	8.5
14	168	5.8	5.1	5.5	9.4	8.3	8.8	9.5	10.9	10.2	8.2	8.1
15	SPV 245	5.7	5.5	5.6	8.9	9.4	9.2	9.1	12.7	10.8	7.9	9.2
16	SPV 346	4.7	6.1	5.4	8.5	8.4	8.5	8.4	11.0	9.7	7.2	8.5
17	SPV 351	5.5	5.9	5.7	9.7	9.3	9.5	8.5	13.1	10.8	7.9	9.4
18	SPV 462	6.1	4.7	5.4	8.9	7.6	8.3	9.3	11.1	10.2	8.1	7.8
19	SPV 472	6.2	4.1	5.2	8.7	7.1	7.9	9.3	8.7	9.7	7.8	6.7
20	Y 75	6.2	5.3	5.8	9.4	8.7	9.5	10.3	13.1	11.7	8.6	9.1
SE		0.6	0.6	0.5	0.8	1.2	1.0	0.9	1.2	1.1		
G MEAN		5.5	5.1	5.3	9.1	8.3	8.7	8.8	11.6	10.2		

(Pigeonpea branch number)

Table 17. Mean branch length of pigeonpea(HY8) in inter ropping at three stages of growth during kharif 1983 and 1984.

Sl. No.	Inter crop	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.	Mean 1983	Mean 1984
		Pigeonpea branch length(cm)										
1	CSH 1	20.2	31.5	25.9	46.8	44.4	45.6	55.3	58.7	57.0	50.8	44.9
2	CSH 5	21.2	34.8	28.0	38.3	49.1	43.7	51.1	64.8	57.9	36.9	49.6
3	CSH 6	34.9	41.1	20.1	24.0	22.0	40.5	35.9	38.2	44.1	63.3	53.7
4	CSH 9	20.4	37.0	28.7	38.6	48.5	43.6	37.9	62.2	50.1	32.3	49.2
5	SPH 221	22.6	35.5	29.1	36.0	40.7	38.4	37.3	58.4	47.9	31.1	44.9
6	SPH 162	20.7	27.5	24.1	30.3	36.2	33.3	32.8	55.6	44.2	27.9	39.8
7	SPH 192	25.2	25.9	25.6	36.5	38.0	37.3	38.1	62.5	50.3	33.3	42.1
8	CS 3541	24.7	28.3	26.5	38.9	37.5	38.2	47.4	59.7	53.6	37.0	41.8
9	A 535	22.3	35.6	28.9	36.6	47.8	42.1	37.1	60.2	48.7	32.0	47.9
10	SB 1085	17.9	37.7	27.8	31.4	45.9	38.7	38.3	55.2	47.1	29.2	46.5
11	SPV 126	21.7	31.9	26.8	41.6	46.4	44.0	43.5	57.6	51.6	36.3	45.3
12	296B	20.1	29.8	24.9	37.5	45.5	41.5	37.9	59.8	48.9	31.9	45.1
13	2219B	20.3	32.5	26.4	37.5	47.3	42.4	47.1	56.5	51.8	34.9	45.4
14	168	24.8	29.7	27.3	48.8	44.3	46.6	52.2	62.8	57.5	41.9	45.6
15	SPV 245	20.4	32.8	26.6	38.9	47.0	42.9	45.5	52.1	48.8	34.9	44.0
16	SPV 346	17.7	39.8	28.8	34.2	53.2	43.7	28.4	59.7	44.1	26.8	50.9
17	SPV 351	22.1	41.3	31.7	43.5	52.7	48.1	44.5	61.2	52.9	36.7	51.7
18	SPV 462	23.7	38.5	31.1	39.8	45.8	42.8	34.9	58.8	46.9	32.5	47.7
19	SPV 472	22.2	33.9	28.1	43.3	42.9	43.1	49.9	55.5	52.7	38.5	44.1
20	Y 75	21.6	30.3	25.9	33.0	41.1	37.1	31.3	61.0	46.2	28.6	44.1
SE		2.5	4.1	3.4	4.0	4.1	4.0	5.1	2.9	4.1		
G MEAN		21.5	32.9	27.2	38.6	44.5	41.5	41.8	59.3	50.5		

between the two years.

Variation among different treatments was not significant for any of the characters except number of branches at stage 1 and branch length at stage 3. Inspite of competition from different types of sorghum varieties treatment X year interactions were highly significant for number of branches and branch length at all three growth stages while it was not significant for plant height.

Pigeonpea plant height under different treatments did not differ between the treatments (Table 15). Comparison of mean plant heights in the two years showed that the plants were taller in 1983 than in 1984 when HY 8 was grown in intercropping with CSH 5, CSH 6 and SB 1085. Mean plant height ranged from 65.7 to 78.7 cm , 102.0 to 118.9 cm and 112.8 to 128.8 cm in S1, S2 and S3 stages respectively. Significant differences observed in average branch number between the two years indicated that branch number was more in 1984 than in 1983 for all the genotypes except in case of HY 8 intercropped with CSH 9, SPH 162 and 168 which did not show differences between the two years, the differences being less than 2 (Table 16).

Mean branch length of the treatments was significantly different at stage 3 (Table 17). Branch length was relatively shorter in the treatments where HY8 was grown with SPV 346, Y 75, SPV 462, SPV 346, SPV 245, 296B, A 535, SPH 162 and SPH 196. Most of these genotypes are tall.

Longer branches were observed in all other treatments. Branch length ranged from 22.0 to 31.7 cm in S1, 33.3 to 48.1 in S2 and 44.25 to 57.5 cm in S3 stage.

1.2 Yield characters

1.2.1 Genetic variability for yield characters in sorghum under inter-species competition.

ANOVA and means of the yield characters of sorghum when grown as intercrop and sole crop are presented in Table 18 and Table 19 respectively.

Variation in all yield characters of sorghum like fodder yield, panicle weight, grain yield and test weight were highly significant in both intercrop and sole crop (Table 18).

ANOVA and means of yield characters of pigeonpea in intercropping are given in Table 20 and Table 21.

Comparison of means of yield characters in intercropping (Table 19) showed that the fodder yield ranged from 0.3 to 1.35 kg/5 plants panicle weight from 167.6 to 575.4 gm/5 heads, grain yield from 49.2 to 290.7 gm/5 heads and test weight from 22.8 to 38.0 gm. SPV 472, SPH 162, SPH 196, CSH 5 and CSH 9 yielded greater amount of fodder compared to other genotypes. Fodder yield was lowest in case of 2219B. Heavier panicles were produced in case of genotypes SPV 462, SPV 351, SPV 245, SPV 462, CSH 5, CSH 9,

Table 18. ANOVA of yield characters of sorghum in intercropping and sole cropping during kharif 1984.

Source	df	Fodder yield inter-crop	Fodder yield sole-crop	Panicle weight inter-crop	Panicle weight sole-crop	Grain yield inter-crop	Grain yield sole-crop	Test weight inter-crop	Test weight sole-crop
Rep.	2	0.05	0.01	4498.0	4232.0	5501.0	5334.0	9.3	2.5
Genotype	19	0.22**	0.14**	46572.0**	42698.0**	25142.0**	26991.0**	45.5**	30.0**
Between groups	2	0.60**	0.39**	350647.3**	255887.9**	130493.5**	83132.2**	327.8**	216.5**
Within hybrids	6	0.22*	0.13	57326.6**	66186.2**	23807.5**	27573.3**	6.2	12.3
Within Parental lines	6	0.18	0.22*	12603.0	24098.3	10045.6	9210.0	5.7	8.6
Within varities	5	0.11	0.11	36591.0**	30979.3**	27186.3**	25173.1**	27.4**	2.3
Error	38	0.08	0.07	6166.0	10231.0	3584.0	6225.0	8.1	12.4
Mean									
Hybrid		0.98	0.82	369.2	373.9	228.5	251.3	30.1	28.4
Parental lines		0.65	0.73	301.7	321.3	172.6	187.4	25.9	26.0
Varieties		0.96	0.74	347.6	327.8	216.9	217.3	30.1	29.3

** significant at 1%.; * Significant at 5%.

Table 19. Means of yield characters of sorghum in inter and sole cropping during kharif 1984.

Genotype	Fodder yield inter Crop	Fodder yield sole Crop	Panicle wt. inter Crop	Panicle wt. sole Crop	Grain yield inter Crop	Grain yield sole Crop	Test wt. inter Crop	Test wt. sole Crop
CSH 1	0.60	0.52	205.2	200.0	101.1	140.9	34.0	36.2
CSH 5	0.98	0.87	386.5	872.0	181.2	225.7	28.6	26.3
CSH 6	0.80	0.58	188.4	176.0	195.8	165.5	29.2	27.6
CSH 9	0.95	0.91	465.5	431.4	305.0	255.2	30.1	28.1
SPH 221	0.85	0.83	575.4	601.0	376.1	426.8	27.2	27.1
SPH 162	1.35	0.93	345.4	373.2	207.9	232.3	28.7	27.2
SPH 196	1.33	1.13	418.3	465.8	232.4	312.7	33.0	26.2
CS 3541	0.85	0.87	316.4	317.4	195.8	192.0	28.0	26.8
A 535	0.91	0.75	199.2	205.3	77.7	87.9	21.3	20.6
SB 1005	0.60	1.00	332.4	322.2	237.0	194.5	25.0	26.9
SPV 126	0.90	0.97	282.3	350.1	176.7	216.8	26.1	27.3
S96B	0.45	0.56	387.7	431.1	212.9	239.0	25.9	26.9
2219B	0.30	0.30	240.9	207.6	110.1	133.7	26.3	24.0
168	0.53	0.53	373.2	415.7	193.2	242.5	28.7	29.8
SPV245	0.57	0.67	440.7	416.7	290.7	290.9	29.1	28.7
SPV 346	0.85	0.73	332.7	396.0	207.8	281.7	33.8	28.2
SPV 351	0.83	0.92	461.7	429.8	303.0	309.9	27.8	26.3
SPV 462	0.78	0.73	398.9	288.1	270.8	183.6	27.8	31.5
SPV 472	1.02	0.96	284.0	257.4	180.3	159.1	38.0	32.6
Y 75	0.52	0.43	167.6	179.0	49.2	74.3	28.9	28.5
SE	0.16	0.15	45.3	58.4	34.6	45.6	1.7	2.0
G MEAN	0.80	0.76	328.8	337.0	195.3	209.1	28.6	27.9

Table 20. ANOVA for yield characters of pigeonpea (PP) when intercropped with sorghum hybrids, parental lines and varities during kharif 1984.

Source	df	M S S Pod yield	Grain yield	Test weight
Rep.	2	14.46	26481.00	5169.00
Between groups	2	484.35	24758.70**	9529.20**
PP within hybrids	6	1256.1	7481.80	2335.60
PP within parentallines	6	276.1	400.50	276.20
PP within varities	5	599.4	3364.30	887.50
Genotype	19	22.64	11193.00	3566.00
Error	38	25.7	6950.00	1830.00
SE		2.9	48.1	8.93
Mean		370.5	239.0	119.7
CD		8.34	138.08	25.53

** Significant at 1%.

Table 21. Means of yield characters of pigeonpea(HY8) in intercropping with sorghum during Kharif 1984.

Sl. No.	Genotype	Pod yield (gm/5 plants)	Grain yield (gm/5 plants)	Test weight (gm)
1.	CSH 1	400	197	91.7
2.	CSH 5	418	394	210.9
3.	CSH 6	437	336	171.0
4.	CSH 9	357	209	110.7
5.	SPH 221	347	201	104.8
6.	SPH 162	353	214	114.8
7.	SPH 196	403	156	73.1
8.	CS 3541	373	224	84.3
9.	A 535	333	279	140.5
10.	SB1085	380	234	121.6
11.	SPV 126	357	246	114.9
12.	S96B	347	237	117.3
13.	2219B	367	268	120.0
14.	168	347	235	118.3
15.	SPV 245	340	275	124.8
16.	SPV 346	383	165	103.8
17.	SPV 351	333	251	122.2
18.	SPV 462	353	170	80.9
19.	SPV 472	389	268	149.0
20.	Y 75	373	147	69.0
SE		2.9	48.1	8.9
G MEAN		370.5	239.0	119.7

SPH 162, SPH 221, SB 1082. 296B, 168 and SPV 346. Among them, heaviest panicles were observed in case of SPH 221 and CSH 9 and the panicle of 2219B, Y 75, A 535, CSH 6 were lighter than others.

Grain yield was maximum in case of CSH 9, SPH 221, SPV 351 SPV 245 and A 535. Other genotypes produced moderate grain yield. SPV 472, CSH 1, SPV 346, SPH 296 recorded greater test weight while A 535 and SPV 351 were lightest. All other genotypes were intermediate without significant differences among them.

1.2.2 Genetic variability for yield characters in sorghum under intra-species competition

Comparison of means of yield characters of sorghum when grown as sole crop revealed that fodder yield was low in case of 2219B, CSH 1, CSH 6, 296B, 168 and SPV 245 (Table 19). All other genotypes yielded more fodder. Mean fodder yield of the genotypes ranged from 0.3 to 1.39 kg/5 plants. Panicle weight among the genotypes ranged from 179.0 to 601.0 gm/5 heads, grain yield from 74.3 to 312.7 gm/5 heads and test weight from 20.6 to 36.2 gm. Panicles were heavy in case of CSH 9, SPV 351, 296B, SPV 245, 168, SPV 346, SPV 162, SPV 126, SB 1085, CS 3541. Heaviest panicles were obtained from SPH 221 and SPH 196. All the other genotypes had lighter panicles. Grain yield of SPH 221, SPH 196, CSH 9, SPV 351, SPV 346 and SPV 462 was maximum. All other genotypes were intermediate in their performance except Y 75 local variety which was least yielding.

Test weight of CSH 1, SPV 472 and SPV 462 was maximum while that of A 535, 2219B was minimum.

1.2.3 Genetic variability for yield characters in pigeonpea under inter-species competition.

From the ANOVA of pigeonpea yield characters (Table 20) it can be seen that there were no significant differences among the treatments for pod yield but test weight was found to be significantly different.

Comparison of mean test weight reveals that maximum test weight was recorded in the treatments where pigeonpea was intercropped with CSH 5 and minimum with Y 75, SPV 462, SPH 162 and CSH 1 (Table 21). Other treatments had intermediate test weight.

2. CHARACTER ASSOCIATIONS AMONG YIELD AND DEVELOPMENTAL CHARACTERS

2.1 Correlation between sorghum characters under inter-species competition.

Sorghum plant height was positively correlated with fodder yield and test weight (Table 22) Leaf length was positively correlated with leaf breadth, panicle weight and grain yield. Leaf breadth was observed to have positive correlations with panicle length, number of panicle branches, panicle weight and grain yield. Correlation was positive between panicle length, panicle weight and grain yield and between panicle weight and grain yield.

2.2 Correlation between sorghum characters under intra-species competition.

Significant positive correlations were observed between plant height and fodder yield at all 3 stages of growth and with leaf number and leaf length at the final stage. (Table 23). Leaf number was positively correlated with leaf length, leaf breadth, fodder yield and panicle length. Correlation of leaf length with leaf breadth, fodder yield, number of panicle branches, panicle weight and seed weight was positive. Fodder yield was positively corelated with panicle length, panicle weight, test weight. Positive correlation was observed between panicle weight and number of panicle branches between grain yield and panicle weight.

2.3 Correlation in pigeonpea under inter-species Competition :

In intercropping, positive correlation was observed between number of branches and branch length at stage 2 and between plant height and number of branches at stage 1 of growth (Table 24). Number of pods per plant was positively correlated with pod weight and seed weight whereas it was negatively correlated with test weight.

2.4 Correlation between sorghum and pigeonpea characters :

Table 22. Correlation coefficients between sorghum characters in intercropping. (DF = 18)

Sl. No.	Sorghum character	Stage	1	2	3	4	5	6	7	8	9	10
1.	Plant height	1	1.000									
		2	1.000									
		3	1.000									
2.	Leaf number	1	0.063	1.000								
		2	-0.066	1.000								
		3	0.343	1.000								
3.	Leaf length	1	0.285	0.339	1.000							
		2	0.165	0.419	1.000							
		3	0.229	0.489*	1.000							
4.	Leaf breadth	1	0.238	0.563**	0.793**	1.000						
		2	-0.056	0.527*	0.867**	1.000						
		3	-0.117	0.355	0.793**	1.000						
5.	Fodder yield	1	0.559*	0.406	0.506*	0.518*						
		2	0.703**	0.419	0.434	0.232						
		3	0.708**	0.502*	0.390	0.180	1.000					
6.	Panicle length	1	-0.055	0.574**	0.396	0.578**						
		2	0.022	0.305	0.315	0.352						
		3	0.014	0.205	0.317	0.542*	0.437*	1.000				
7.	No. of panicle branches	1	0.158	0.191	0.297	0.475*						
		2	0.090	0.249	0.188	0.458*						
		3	0.134	0.180	0.462*	0.491*	0.019	0.171	1.000			
8.	Panicle weight	1	0.010	0.362	0.683**	0.708**						
		2	0.142	0.181	0.592**	0.578**						
		3	0.159	0.232	0.707**	0.788**	0.338	0.721**	0.414	1.000		
9.	Grain yield	1	0.035	0.283	0.631**	0.631**						
		2	0.178	0.305	0.539*	0.472*						
		3	0.185	0.205	0.606**	0.695**	0.298	0.660**	0.251	0.721**	1.000	
10.	Test weight	1	0.568**	0.360	0.201	0.177						
		2	0.518**	0.073	0.038	-0.078						
		3	0.379	0.020	0.057	-0.072	0.255	-0.173	0.251	-0.078	-0.056	1.000

* Significant at 5%; ** Significant at 1%

Table 23. Correlation coefficient between sorghum characters in sole cropping

Sorghum character	stage	1	2	3	4	5	6	7	8	9	10
1. Plant height	1	1.000									
	2	1.000									
	3	1.000									
2. Leaf no.	1	-0.184	1.000								
	2	0.031	1.000								
	3	0.567**	1.000								
3. Leaf length	1	0.053	0.443	1.000							
	2	0.194	0.654**	1.000							
	3	0.497*	0.719**	1.000							
4. Leaf breadth	1	-0.254	0.548*	0.698**	1.000						
	2	-0.364	0.692**	0.651**	1.000						
	3	0.191	0.589**	0.815**	1.000						
5. Fodder yield	1	0.482*	0.252	0.543*	0.063						
	2	0.620**	0.464*	0.573**	0.047						
	3	0.648**	0.625**	0.664**	0.619**	1.000					
6. Panicle length	1	-0.209	0.657**	0.499*							
	2	-0.096	0.447*	0.340							
	3	-0.081	0.446*	0.328	0.610**	0.461*	1.000				
7. No. of panicle branches	1	0.010	0.164	0.392	0.633**						
	2	0.095	0.373	0.447*	0.560**						
	3	0.093	0.347	0.508*	0.392	0.042	0.268	1.000			
8. Panicle weight	1	-0.001	0.347	0.651**	0.522*						
	2	0.148	0.288	0.586*	0.381						
	3	0.125	0.255	0.552*	0.589*	0.485*	0.708**	0.507*	1.000		
9. Grain yield	1	0.069	0.251	0.598**	0.393						
	2	0.197	0.192	0.536**	0.263						
	3	0.173	0.178	0.486*	0.497*	-0.108	0.656**	0.419	0.976**	1.000	
10. Test weight	1	0.215	0.097	-0.002	0.106						
	2	0.164	-0.161	0.001	-0.010						
	3	0.164	-0.088	0.093	-0.028	0.462*	-0.311	-0.155	-0.199	-0.153	1.000

* Significant at 5%; **Significant at 1%

Table 24. Correlation coefficients between pigeonpea characters in intercropping (DF = 18)

Sl. no.	Pigeonpea character	Stage	1	2	3	4	5	6	7	8
1.	Plant height	1	1.000							
		2	1.000							
		3	1.000							
2.	Branch number	1	0.443	1.000						
		2	0.326	1.000						
		3	-0.348	1.000						
3.	Branch length	1	0.212	0.346	1.000					
		2	0.128	0.466*	1.000					
		3	0.471*	0.157	1.000					
4.	No. of pods /plant	1	0.028	-0.077	-0.063					
		2	0.013	0.247	0.154					
		3	-0.011	-0.025	-0.012	1.000				
5.	No. of seeds/ pod	1	-0.084	-0.262	-0.477*					
		2	0.094	-0.372	-0.338					
		3	0.287	-0.047	0.418	0.151	1.000			
6.	Pod weight	1	0.057	-0.019	-0.073					
		2	0.113	0.287	0.124					
		3	0.068	0.025	0.140	0.919**	0.278'	1.000		
7.	Grain yield	1	0.069	-0.074	0.044					
		2	0.165	0.263	0.197					
		3	0.129	-0.161	0.186	0.894**	0.329	0.944**	1.000	
8.	Test weight	1	-0.107	-0.275	0.035					
		2	0.011	-0.196	-0.248					
		3	0.345	-0.506*	0.144	-0.465*	0.025	-0.462*	-0.296	1.000

* Significant at 5%; ** Significant at 1%

The associations between sorghum and pigeonpea characters are presented in Table 25. Sorghum plant height had negative correlation with pigeonpea characters such as number of branches, number of pods and pod weight and positive correlation with test weight. Test weight of sorghum was negatively correlated with Pigeonpea plant height and positively correlated with seeds / pod.

Test weight of Pigeonpea was positively correlated with sorghum plant height, leaf length,leaf breadth, panicle weight and seed yield.

3. REGRESSION ANALYSIS OF PIGEONPEA CHARACTERS ON SORGHUM CHARACTERS :

ANOVA for simple and multiple regression is presented in Table 26a. Developmental characters and yield components which showed highly significant correlations at various stages of growth were chosen for regression analysis.

Table 26b gives the simple and multiple regression equations of pigeonpea characters on sorghum characters at 3 stages of crop growth and Table 26c gives the simple and multiple regression equation of sorghum characters on pigeonpea characters.

Equation 1 (Table 26b) is the regression equation of pod number of pigeonpea on sorghum plant height . R2 values indicate that the variation in pod number accounted by sorghum height was 15.0 % at 1st stage, 8.1 % at 2nd stage

Table 25. Correlation coefficients between sorghum characters and pigeonpea characters in intercropping. (DF = 18)

Sorghum	Stage	Pigeonpea. Plant height	Branch number	Branch length	Pods/ plant	Seeds /pod	Pod weight	Grain yield	Test weight
Plant height	1	-0.106	-0.570**	-0.240	-0.481*	0.385	-0.478*	-0.371	0.514*
	2	-0.123	-0.582**	-0.414	-0.408	0.308	-0.416	-0.281	0.515*
	3	0.417	-0.339	-0.031	-0.424	0.205	-0.435	-0.303	0.568*
Leaf number	1	-0.041	-0.240	-0.051	0.282	0.097	0.147	0.240	0.114
	2	-0.298	0.104	-0.079	0.427	-0.120	0.125	0.281	0.089
	3	0.022	-0.260	-0.153	0.094	-0.230	-0.135	0.038	0.289
Leaf length	1	-0.111	-0.362	0.340	-0.004	-0.192	-0.104	0.073	0.586**
	2	-0.205	-0.152	0.185	0.118	-0.382	-0.038	0.075	0.479*
	3	-0.093	-0.281	0.011	-0.014	-0.450	-0.199	-0.063	0.506*
Leaf breadth	1	-0.080	-0.403	0.184	0.054	-0.191	-0.087	0.081	0.577**
	2	-0.229	-0.039	0.176	0.176	-0.472*	0.016	0.123	0.405
	3	0.058	-0.302	0.215	-0.048	-0.414	-0.163	-0.048	0.502*
Fodder yield	1	0.034	-0.674**	-0.112					
	2	0.009	-0.467*	-0.305					
	3	0.396	-0.358	0.166	0.049	0.148	-0.042	0.076	0.401
Panicle length	1	0.351	-0.129	0.108					
	2	0.313	-0.009	0.013					
	3	0.472	-0.140	0.273	0.254	-0.094	0.275	0.294	0.177
Panicle bran- ches	1	0.035	0.047	-0.167					
	2	0.058	-0.198	-0.198					
	3	0.224	-0.016	0.199	-0.241	-0.285	-0.304	-0.249	0.347
Panicle weight	1	0.339	0.017	0.324					
	2	0.351	0.048	0.125					
	3	-0.281	-0.343	0.039	-0.048	-0.356	-0.110	-0.034	0.451*
Yield	1	0.363	0.036	0.395					
	2	0.357	0.076	0.134					
	3	0.242	-0.401	-0.116	-0.107	-0.379	-0.156	-0.089	0.462*
Test weight	1	-0.492*	-0.429	-0.210					
	2	-0.385	-0.470*	-0.220					
	3	-0.060	-0.263	-0.062	-0.178	0.556	0.224	-0.099	0.330

* Significant at 5%; ** Significant at 1%

Table 26a. ANOVA of regression analysis.

Equation+	d.f.		Stage 1		Stage 2		Stage 3	
	Regression	Deviation	Regression	Deviation	Regression	Deviation	Regression	Deviassion
	Regression of pigeonpea characters on sorghum characters							
1	2	17	20130.0*	7520.0	14967.0	8128.0	19679.0	7573.0
2	2	17	8994.0	2988.0	7339.0	3182.0	9324.0	2949.0
3	5	14	23.4	21.3	32.3	22.3	5.9	10.8
4	9	10	0.8	0.4	0.8	0.3	1.0*	0.2
	Regression of sorghum characters on Pigeonpea characters							
5	2	17	0.2	0.2	0.2	0.1	0.1	0.1
6	5	14	42.3**	5.4	-	-	-	-

+NB: for equations see table 26b, and 26c.
* Significant at 5%; ** Significant at 1%.

Table 26(b). Multiple regression equations at three stages (S) of crop growth of pigeonpea characters on sorghum characters.

EQUATION 1 : Y = Pigeonpea no. of pods.
X = Sorghum plant height.

S1	$Y = 429 + 0.73\ X - 0.015\ X^2$
S2	$Y = 384 + 1.23\ X - 0.011\ X^2$
S3	$Y = 199 + 4.45\ X - 0.024\ X^2$

EQUATION 2 : Y = Pigeonpea pod weight.
X = Sorghum plant height.

S1	$Y = 202 + 2.15\ X - 0.019\ X^2$
S2	$Y = 167 + 2.17\ X - 0.013\ X^2$
S3	$Y = 79 + 3.66\ X \quad 0.018\ X^2$

EQUATION 3 : Y = Pigeonpea no. of branches.
X = Sorghum plant height.
X = Sorghum fodder yield.

S1	$Y = 11.2 + 0.349\ X_1 + 22.8\ X_2 - 0.002\ X_1^2 - 4.9\ X_2^2 - 0.143\ X_1X_2$
S2	$Y = 37.2 + 0.192\ X_1 + 10.4\ X_2 - 0.001\ X_1^2 - 2.1\ X_2^2 - 0.144\ X_1X_2$
S3	$Y = 60.3 - 0.251\ X_1 + 23.4\ X_2 - 0.002\ X_1^2 - 6.6\ X_2^2 \quad 0.105\ X_1X_2$

EQUATION 4 : Y = Pigeonpea test weight.
X = Sorghum plant height, X = leaf length, X = leaf breadth.

S1	$Y = -6.1 + 0.005\ X_1 - 0.004\ X_2 + 4.58\ X_3 + 0.000091\ X_1^2 + 0.0114\ X_2^2 + 0.634\ X_3^2 + 0.00044\ X_1X_2 - 0.0046\ X_1X_3 - 0.206\ X_2X_3$
S2	$Y = -5.0 + 0.326\ X_1 - 0.688\ X_2 + 4.38\ X_3 - 0.000287\ X_1^2 - 0.00210\ X_2^2 + 0.28\ X_3^2 + 0.00224\ X_1X_2 - 0.0502\ X_1X_3 + 0.094\ X_2X_3$
S3	$Y = -21.8 + 0.2383\ X_1 - 0.658\ X_2 + 9.41\ X_3 - 0.000151\ X_1^2 + 0.0026\ X_2^2 + 0.414\ X_3^2 + 0.00066\ X_1X_2 - 0.0282\ X_1X_3 + 0.023\ X_2X_3$

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* Significant at 5%, ** significant at 1%.

Table 26c. Multiple regression equations at three stages of sorghum characters on Pigeonpea characters.

Equation 1 : Y = Fodder yield of sorghum
X = Pigeonpea number of branches

S1 $Y = 4.80 - 0.242\ X_1 + 0.00358\ X_1^2$

S2 $Y = 9.84 - 0.0399\ X_1 + 0.00434\ X_1^2$

S3 $Y = 6.4 - 0.206\ X_1 + 0.00188\ X_1^2$

Equation 2 : Y = Sorghum Test weight,

X = Pigeonpea height
X = Pigeonpea seeds/pod.

$$Y = -647 + 5.99\ X_1 + 22.28\ X_2 - 0.0036\ X_1^2 - 0.1191\ X_2^2 - 0.1488\ X_1 X_2$$

and 14.5 % at the 3rd stage.

Equation 2 (Table 26b) gives the regression of pod weight of Pigeonpea on sorghum height . Here again, the regression MSS were not significant at any of the stages (Table 26a). The percentage variance in pod weight accounted by sorghum height was 17.5 % , 12.1 % and 18.5 % in the 1st, 2nd and 3rd stasges of growth respectively.

In Equation 3 (Table 26b), i.e regression of Pigeonpea branch number on sorghum heights and fodder yield, the regression MSS was not significant (Table 26a) but in all above equations, the rate of change of Y was different from one stage to the other. The percentage variance in Pigeonpea branch number accounted by sorghum height and fodder yield was 2.4 %, 10.5 % and 10.0 % in the 3 stages respectively.

Equations 4 (Table 26b) gives the regression of test weight of Pigeonpea on sorghum plant height, leaf length and leaf breadth. The ANOVA for this regression (Table 26a) shows that regression MSS was significant only at the final growth stage. Equation 5 (Table 26b) gives the regression of fodder yield of sorghum on pigeonpea branch number and regression MSS was not significant for any of the stages (Table 26a). The regression of test weight of sorghum on Pigeonpea height and seeds per pod is shown in Equation 6 (Table 26). The ANOVA for this equation shows that the regression MSS is highly significant and percentage variance in test weight of sorghum accounted by Pigeonpea height and seeds per pod is 64.1 %.

4. STUDY OF COMPETITION EFFECTS DUE TO SORGHUM AND PIGEONPEA.

Data from experiment II was factorially analysed to test competition effects due to sorghum, due to pigeonpea and due to sorghum x pigeonpea interaction at three stages of growth for develomental characters and at final stage for yield characters.

4.1 Competition effects on developmental characters of sorghum.

ANOVA and means and competition effects of developmental characters of sorghum are presented in Tables 27 to 32. There were significant differences among sorghum effects for developmental characters at all stages of growth in both the years except leaf number and leaf breadth at S1 and S2 stages during Kharif 1983. Pigeonpea did not have any significant effect on sorghum characters, but Sorghum x Pigeonpea interaction was significant for leaf breadth at S1 stage in 1983.

Pooled ANOVA over the two years for the developmental characters at the three growth stages are presented in Table 28. Significant differences due to years were observed for

Table 27. ANOVA for competition effects of sorghum (S) and Pigeonpea (P) for developmental characters of sorghum in intercropping at three stages during kharif 1983 and 1984.

Source	df	M S S					
		Stage 1		Stage 2		Stage 3	
		1983	1984	1983	1984	1983	1984
Plant height (cm)							
Replication	2	684.3	1.6	3079.0	188.3	224.8	82.3
S effect	3	6081.3*	3039.6	2857.3	4060.4	33943.9	4509.2
P effect	3	193.3	1109.7**	274.9	610.4	196.4	400.2
S x P	9	100.1	294.8	420.5	146.1	69.2	126.7
Error	30	122.1	494.7	151.7	510.1	121.5	333.4
Leaf number							
Replication	2	1.94**	0.14	1.11*	1.55*	2.75**	0.52
S effect	3	1.25	5.50**	0.85	3.64**	13.92**	2.30**
P effect	3	0.42	0.74	0.33	0.17	0.28	0.38
S x P	9	0.32	0.32	0.17	0.25	0.19	0.58
Error	30	0.48	0.79	0.38	0.55	0.37	0.70
Leaf length (cm)							
Replication	2	1.38	3.84	12.96	62.97	28.53	49.32
S effect	3	332.09**	223.34	57.09	219.17	487.06	556.35
P effect	3	0.47	26.45	12.76	23.72	30.58*	40.84*
S x P	9	6.10	49.6	5.29	24.24	15.52	44.27*
Error	30	12.35	26.73	7.31	19.34	14.98	19.87
Leaf breadth (cm)							
Replicaton	2	2.14	2.88	79.63	0.8I	3.39	0.56
S effect	3	1.12	2.02**	35.78**	2.23	5.65	2.38
P effect	3	0.62	0.06	51.33**	0.29	0.26	0.22
S x P	9	0.19	0.50	43.75**	0.24	0.54	0.36
Error	30	0.49	0.47	0.47	0.28	0.43	0.32

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

Table 28. ANOVA of competition effects of sorghum and pigeonpea for developmental characters of sorghum in intercropping at three stages of growth over two years 1983 and 1984.

Source	df	MSS Stage 1	MSS Stage 2	MSS Stage 3	MSS Stage 1	MSS Stage 2	MSS Stage 3
		Plant height (cm)			Leaf number		
Year (Y)	1	24907.6	42313.6	82028.3	11.0	247.1	345.1
Rep / year	4	332.8	1600.6	153.5	1.1	1.1	1.6
Sorghum(S)	3	13120.8**	10787.2**	36531.5**	2.6**	0.8*	13.9**
Pigeonpea(P)	3	48.5	172.9	228.1	0.6	0.4	0.6
S x P	9	82.6	234.4	44.5	0.4	0.2	0.4
S x Y	3	142.8	993.5	4994.9	6.8	4.1	3.3
P x Y	3	319.5	17.2	29.1	1.3	1.0	0.1
S x P x Y	9	185.3	280.7	74.4	0.2	0.3	0.6
Error	60	161.6	159.3	98.4	0.5	0.4	0.5
		Leaf length (cm)			Leaf breadth (cm)		
Year	1	14808.3	25249.6	7597.2	109.6	319.0	69.3
Rep / year	4	2.6	23.3	39.0	2.5	28.7	2.0
Sorghum(S)	3	548.4**	300.5**	1053.2**	3.6**	26.2	7.9**
Pigeonpea(P)	3	14.3	30.4	22.3	0.4	44.4	0.1
S x P	9	23.6	8.4	22.9	0.5	13.1	0.4
S x Y	3	45.6	55.2	39.8	0.9*	25.1	1.2**
P x Y	3	19.2	8.6	9.9	0.6	21.9	0.2
S x P x Y	9	11.8	23.9	12.1	0.5	24.3	0.3
Error	60	20.2	12.3	20.6	0.3	27.4	0.3

** significant at 1%.

Table 29. Mean plant height of sorghum genotypes and competition effects in intercropping at three stages of growth during kharif 1983 and 1984.

Genotype Sorghum	Genotype Pigeon-pea	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.
		Sorghum plant height (cm)								
CSH 1	HY 6	63.3	96.5	79.9	163.9	110.7	137.3	155.1	117.0	136.1
CSH 1	HY 8	65.8	90.6	78.2	168.2	110.7	139.5	152.1	113.5	132.8
CSH 1	HY 9	66.7	91.2	78.9	177.6	112.5	145.1	151.9	111.4	131.6
CSH 1	HY 3C	70.4	89.7	80.1	165.6	112.0	138.8	154.9	117.7	136.3
CSH 6	HY 6	78.2	123.3	100.8	165.1	150.3	157.7	182.5	151.9	167.2
CSH 6	HY 8	81.4	107.0	94.2	171.4	127.1	149.3	173.5	128.9	151.2
CSH 6	HY 9	84.7	119.6	102.2	185.3	141.2	163.5	175.9	140.7	151.3
CSH 6	HY 3C	85.5	133.7	109.6	184.2	155.9	170.1	179.5	147.5	163.5
CSH 9	HY 6	67.3	111.9	89.1	186.0	128.2	157.7	190.5	137.1	163.6
CSH 9	HY 8	65.9	100.5	82.7	148.7	122.5	135.6	184.3	128.7	156.5
CSH 9	HY 9	63.6	130.3	96.9	162.7	141.1	151.9	183.7	143.5	163.6
CSH 9	HY 3C	66.8	121.7	94.3	168.8	148.6	158.7	192.4	156.0	174.2
SPH 196	HY 6	96.5	131.3	113.9	188.4	128.2	158.3	272.7	164.4	218.6
SPH 196	HY 8	123.4	108.9	116.4	206.7	122.5	164.6	262.7	162.4	212.6
SPH 196	HY 9	117.9	122.1	120.0	213.5	141.1	177.3	282.3	156.1	219.2
SPH 196	HY 3C	118.1	153.9	136.0	192.6	148.6	170.6	284.0	165.7	224.9
SE		9.0	18.2	10.3	10.1	18.4	10.3	11.5	14.9	16.0
G MEAN		82.2	114.4	99.4	178.0	136.3	154.6	198.6	140.1	169.4
		Competition effect (Ci)								
CSH 1		-15.7	-22.4	-20.1	-9.2	-24.8	-14.6	-45.1	-25.2	-35.2
CSH 6		0.3	6.5	2.3	-1.5	7.3	-35.4	-20.8	2.1	-9.3
CSH 9		-16.3	1.5	-8.5	-11.4	-1.2	-3.9	-11.0	1.2	-4.9
SPH 196		31.8	22.4	26.5	22.3	18.6	-13.0	76.8	22.0	49.4
SE(Ci)		4.5	9.1	5.2	5.0	9.2	5.2	5.4	7.5	8.0

Table 30. Mean leaf number of sorghum genotypes and competition effects at three stages of growth during kharif 1983 and 1984.

Genotype Sorghum	Pigeon-pea	Stage 1 1983	Stage 1 1984	Stage 1 Av.	Stage 2 1983	Stage 2 1984	Stage 2 Av.	Stage 3 1983	Stage 3 1984	Stage 3 Av.
CSH 1	HY 6	10.5	9.9	10.3	12.4	8.9	10.7	10.8	7.8	9.3
CSH 1	HY 8	10.9	9.7	10.3	12.4	9.2	10.5	10.4	7.4	9.4
CSH 1	HY 9	10.5	9.2	9.9	13.0	8.4	10.7	10.6	7.6	9.6
CSH 1	HY 3C	11.3	9.5	10.4	12.6	9.0	10.6	10.9	6.7	8.8
CSH 6	HY 6	10.4	9.3	9.8	12.4	8.9	10.7	10.6	7.2	9.4
CSH 6	HY 8	10.5	9.2	9.9	12.4	8.4	11.4	10.4	7.3	9.4
CSH 6	HY 9	10.7	9.3	10.0	12.6	8.4	10.4	10.7	7.0	8.9
CSH 6	HY 3C	10.8	9.4	10.1	12.6	8.4	10.4	10.2	7.5	8.9
CSH 9	HY 6	10.4	10.6	10.5	11.9	9.7	10.9	13.1	8.1	10.6
CSH 9	HY 8	10.4	10.4	10.4	12.2	9.6	10.9	12.4	7.3	9.9
CSH 9	HY 9	10.0	10.6	10.3	11.9	10.2	10.7	12.5	8.6	10.6
CSH 9	HY 3C	10.3	10.6	10.5	12.0	10.2	11.3	12.7	8.2	10.5
SPH 196	HY 6	10.4	11.4	10.9	12.0	9.4	10.5	12.4	8.3	10.4
SPH 196	HY 8	11.3	10.0	10.9	12.9	9.0	10.8	12.4	7.8	10.1
SPH 196	HY 9	10.6	10.1	10.4	12.6	9.2	10.9	12.0	7.8	9.9
SPH 196	HY 3C	11.1	10.9	11.0	12.5	9.2	10.9	11.7	8.4	10.1
SE		0.6	0.5	0.6	0.5	0.6	0.5	0.5	0.5	0.6
G MEAN		10.7	10.1	10.4	12.4	9.2	10.8	11.5	7.7	9.7
		Competition effects (Ci)								
CSH 1		0.4	-0.5	-0.1	0.2	-0.3	-0.2	-0.8	-0.3	-0.4
CSH 6		-0.1	-0.8	-0.4	0.1	-0.5	-0.3	-1.0	-0.4	-0.5
CSH 9		-0.4	0.5	0.0	-0.3	0.7	0.1	1.2	0.4	-0.7
SPH 196		0.2	0.6	0.4	0.1	0.0	0.0	0.7	0.4	-0.3
SE(Ci)		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 31. Mean leaf length of sorghum genotypes and competition effects in intercropping over three stages during kharif 1983 and 1984.

Genotype Sorghum	Pigeonpea	Sorghum leaf length (cm) Stage 1 1983	1984	Av.	Stage 2 1983	1984	Av.	Stage 3 1983	1984	Av.
CSH 1	HY 6	80.4	57.5	68.9	93.0	61.8	71.4	80.6	55.5	68.1
CSH 1	HY 8	82.3	53.3	67.8	94.4	55.4	74.9	75.1	57.7	66.4
CSH 1	HY 9	82.4	53.0	67.7	92.6	59.4	76.0	81.5	60.5	71.0
CSH 1	HY 3C	81.8	50.9	66.4	97.4	57.2	77.3	80.2	58.2	69.2
CSH 6	HY 6	76.1	51.8	63.9	93.7	61.0	77.4	78.5	66.1	72.3
CSH 6	HY 8	76.3	55.6	65.9	92.2	59.0	75.6	76.4	59.2	67.8
CSH 6	HY 9	77.8	56.2	67.0	92.8	56.4	74.6	75.4	59.8	67.6
CSH 6	HY 3C	75.8	60.2	68.0	93.6	62.2	77.9	77.2	62.9	70.1
CSH 9	HY 6	88.3	61.1	74.7	97.1	62.7	79.9	87.9	68.4	78.2
CSH 9	HY 8	86.9	60.2	73.6	98.4	63.2	80.8	88.8	68.0	78.4
CSH 9	HY 9	87.6	66.0	76.8	97.9	69.8	83.9	90.8	71.2	81.0
CSH 9	HY 3C	87.4	63.9	75.5	97.2	68.6	82.9	92.8	80.9	86.9
SPH 196	HY 6	88.4	67.6	78.0	96.4	69.8	83.1	91.9	72.7	82.3
SPH 196	HY 8	87.7	57.5	72.6	96.6	65.0	80.8	85.2	65.0	75.1
SPH 196	HY 9	84.3	55.6	69.9	95.4	66.6	81.0	84.8	66.8	75.8
SPH 196	HY 3C	89.0	64.7	76.9	99.9	65.3	82.6	88.8	71.2	80.0
SE		2.8	4.2	3.6	2.2	3.5	2.8	3.1	3.6	3.6
G MEAN		83.3	58.4	70.9	95.5	62.7	79.3	83.5	65.7	74.6
		Competition effects (Ci)								
CSH 1		0.0	-4.7	-3.2	-0.4	-4.2	-2.7	1.3	-7.7	-5.7
CSH 6		0.0	-2.4	-4.7	-0.1	-3.0	-2.7	-2.1	-3.7	-5.0
CSH 9		-0.2	4.3	4.3	-0.8	3.4	2.8	-0.3	6.5	6.5
SPH 196		0.2	3.1	3.5	1.6	4.0	2.7	1.3	5.0	3.9
SE(Ci)		1.4	2.1	1.8	1.1	1.6	1.4	1.6	1.8	1.8

Table 32. Mean leaf breadth of sorghum genotypes and competition effects in intercropping at three stages of growth during kharif 1983 and 1984.

Genotype		Sorghum plant height (cm)								
		Stage 1			Stage 2			Stage 3		
Sorghum	Pigeon-pea	1983	1984	Av.	1983	1984	Av.	1983	1984	Av.
CSH 1	HY 6	8.3	6.0	7.2	9.7	7.3	8.5	9.5	7.6	8.6
CSH 1	HY 8	9.2	6.0	7.6	9.8	7.1	8.5	9.7	7.4	8.6
CSH 1	HY 9	8.5	6.5	7.5	9.4	7.6	8.5	9.7	7.4	8.6
CSH 1	HY 3C	8.8	5.5	7.2	9.7	7.2	11.5	9.5	7.2	8.4
CSH 6	HY 6	7.9	6.4	7.2	8.8	7.4	8.1	8.9	8.1	8.5
CSH 6	HY 8	8.4	6.1	7.3	9.2	6.9	8.1	9.7	7.5	8.6
CSH 6	HY 9	8.3	5.6	6.9	9.3	7.2	8.3	8.6	7.6	8.1
CSH 6	HY 3C	8.0	6.8	7.4	8.9	7.6	8.3	8.8	8.0	8.4
CSH 9	HY 6	8.8	7.0	7.9	9.6	7.8	8.7	9.9	7.8	8.9
CSH 9	HY 8	8.9	7.0	7.9	10.4	7.8	9.1	10.5	8.0	9.3
CSH 9	HY 9	9.3	6.6	7.9	10.1	8.5	9.3	11.2	8.8	9.9
CSH 9	HY 3C	8.6	6.7	7.7	9.6	8.1	8.9	10.9	8.6	9.8
SPH 196	HY 6	8.6	6.9	7.8	9.4	8.4	8.9	7.8	8.6	9.2
SPH 196	HY 8	9.1	6.5	7.8	9.9	8.0	8.8	9.7	8.3	9.0
SPH 196	HY 9	8.4	6.9	7.7	9.4	8.0	8.7	9.1	8.1	8.6
SPH 196	HY 3C	8.5	7.0	7.8	9.6	7.7	8.7	9.7	8.6	9.2
SE		0.6	0.6	0.5	0.6	0.4	0.5	0.5	0.5	0.5
G MEAN		8.6	6.5	7.6	9.9	7.7	8.7	9.7	8.0	8.8
		Competition effect (Ci)								
CSH 1		0.2	-0.1	0.1	0.2	-0.1	0.3	0.5	-0.1	0.1
CSH 6		-0.3	0.1	-0.2	-0.3	0.2	0.2	-0.3	0.2	0.0
CSH 9		0.0	0.1	0.1	0.0	-0.2	0.1	-0.1	0.0	0.1
SPH 196		0.1	-0.1	0.0	0.1	0.1	-0.5	-0.1	-0.1	-0.2
SE(Ci)		0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3

all the characters. There were significant differences between sorghum genotypes for their developmental characters at all growth stages except for leaf length and leaf breadth at S2 stage. Sorghum x year interactions were significant for plant height at S2 and S3 stages and leaf number at all stages, while it was significant for leaf length at S2 and leaf breadth at S3 stage. The effects due to pieonpea, pigeonpea x year and Sorghum x Pigeonpea, and Sorghum x Pigeonpea x Year were or significant for any of the characters except Pigeonpea x Year interaction for leaf number at S1 stage. It indicated that competition was not created by Pigeonpea or Sorghum x Pigeonpea interaction over years.

Comparison of mean plant height of sorghum shows that there were no differences within the same genotype of sorghum in combination with different pigeonpea genotypes (Table 29). CSH 1 was significantly shorter compared to all the other sorghum hybrids. CSH 6 and CSH 9 did not differ in height but were significantly shorter than SPH 196 at the final growth stage. SPH 196 was the tallest hybrid with a mean height of 218.8 cm. During the S1 stage, CSH 1 and CSH 9 were similar in height but significantly shorter than SPH 196, while at S2 stage, the differences between CSH 9 and SPH 196 was not significant.

Significant differences were observed in plant heights between the two years. At S1 stage, all the hybrids recorded higher height in 1984 while in S2 and S3 stages, the heights were significantly more during Kharif 1983 than during 1984. CSH 1 was dwarf, CSH 6 and CSH 9 were medium tall while SPH 196 was tall at S3 stage in both the years. Mean leaf number was similar within each hybrid (Table 30). At S1 and S2 stages, the differences between the genotypes were not significant. All tne hybrids showed significant differences between the two years, number of leaves being more in 1983 than in 1984 at all growth stages except in case of CSH 9 and SPH 196 which were similar in leaf number during both the years at S1 stage.

Mean leaf length was more in CSH 9 and SPH 196 than in CSH 1 and CSH 6 at all the three growth stages (Table 31). Within the same hybrid of sorghum, no differences were observed when intercropped with different genotypes of sorghum except in case of SPH 196 where leaf length was significantly less when intercropped with HY6 than with HY9. All the hybrids had significantly longer leaves during Kharif 1983 than during 1984 at all growth stages. Mean leaf breadth was significantly greater in CSH 9 when compared to other hybrids at S3 stage whereas at S2 stage CSH 1 had broader leaves than CSH 9 (Table 32). No differences were observed when the same hybrid was intercropped with different pigeonpea genotypes. Average leaf breadth was more during Kharif 1983 than during 1984 at all growth stages.

4.2 Competition effect on developmental characters of pigeonpea.

ANOVA and means of developmental characters of different pigeonpea genotypes intercropped with sorghum hybrids are presented in Tables 33 to 37. Significant differences in height were observed during Kharif 1984 at S2 and S3 stages of growth whereas no differences were found for sorghum, pigeonpea or sorghum x pigeonpea effects during Kharif 1983. Number of branches were not significant at any of the stages during the two years. The genotypes differed significantly for branch length at S3 stage during Kharif 1983 and 1984. The pooled analysis over the two years are given in Table 34. Pigeonpea differed significantly over years at all stages of growth for all characters. Pigeonpea x year interactions were significant for height at all the stages.

Comparison of mean plant height showed that, the pigeonpea genotypes HY8 was significantly shorter than HY6, HY9 and HY3C which were similar in height (Table 35). Within the the same pigeonpea genotype no differences were observed in any of the treatments except in case of HY6 which recorded lower height in combination with CSH 1 than with CSH 9 and with SPH 196. Comparison of mean heights of the two years indicated that all the pigeonpea genotypes

Table 33. ANOVA for competition effects of Sorghum(S) and Pigeonpea(P) for develoopmental characters of pigeonpea in intercropping at three stages of growth during kharif 1983 and kharif 1984.

Source	df	MSS Stage 1 1983	MSS Stage 1 1984	MSS Stage 2 1983	MSS Stage 2 1984	MSS Stage 3 1983	MSS Stage 3 1984
Plant height (cm)							
Replication	2	10.2	356.4	700.0	1114.3	231.9	514.2
S.effect(S)	3	16.6	67.1	367.4	89.4	217.5	160.0
P.effect(P)	3	43.8	172.9	45.9	481.1	3059.0**	1649.7**
S x P	9	23.8	52.48	42.0	132.8	246.5	499.6
Error	30	47.0[illegible]	78.48	117.0	152.7	220.4	431.5
Branch number							
Replication	2	3.90	2.89	2.8[illegible]	4.86	76.82	1.47
S.effect(S)	3	0.66	2.19	0.0[illegible]	2.89	16.51**	1.73
P.effect(P)	3	10.17**	5.88	9.2	7.13	34.96**	3.14
S x P	9	0.60	1.50	0.7[illegible]	0.67	9.90	2.25
Error	30	0.95	2.08	5.3[illegible]	9.02	6.65	10.91
Branch length (cm)							
Replication	2	50.52	146.65	13.06	106.40	102.30	427.73
S.effect(S)	3	7.30	80.31	17.01	21.22	353.2**	16.16
P.effect(P)	3	90.50**	63.75	83.3**	35.52	217.3	649.85**
S x P	9	11.59	48.17	17.14	55.93	56.5	155.18**
Error	30	28.30	57.06	18.6	53.37	108.2	44.86

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

Table 34. ANOVA for competition effects of Sorghum(S) and Pigeonpea(P) for pigeonpea characters at three stages of growth over two years 1983 and 1984.

Source	df	M S S								
		Plant height (cm)			Branch number			Branch length		
		Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
Year(Y)	1	4539.3	17810.6	10703.3	27.5	133.5	153.3	5750.5	8614.6	1049.1
Rep / year	4	183.5	795.6	367.8	3.4	3.7	38.7	98.6	62.4	265.0
S.effect(S)	3	70.6	76.4	510.6	2.5	1.4	9.6	21.0	27.7	144.6
P.effect(P)	3	70.4	270.3	5522.6**	22.4	13.8	19.4	241.1*	175.5*	387.1**
S x P	9	47.2	72.5	409.7	0.7	0.7	4.6	13.3	44.1	33.1
S x Y	3	15.7	452.9*	16.2	0.3	1.4	7.2	68.6	12.4	213.2*
P x Y	3	205.2*	473.2*	1354.4**	0.9	3.6	34.2*	6.3	17.0	598.1**
S x P x Y	9	46.1	143.8	54.4	0.4	0.6	7.6	8.5	36.4	92.6
Error	60	57.2	126.8	249.4	1.3	1.5	9.2	43.7	30.7	84.9

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

Table 35. Mean plant height of pigeonpea genotypes and competition effects in intercropping over three stages of growth during kharif 1983 and 1984.

Genotype		Sorghum plant height (cm)								
		Stage 1			Stage 2			Stage 3		
Sorghum	Pigeon-pea	1983	1984	Av.	1983	1984	Av.	1983	1984	Av.
HY 6	CSH 1	76.2	96.5	86.4	98.6	139.7	119.2	182.2	152.1	167.2
HY 6	CSH 6	72.8	98.4	85.6	106.3	134.1	120.2	182.7	155.9	169.3
HY 6	CSH 9	75.9	99.3	87.6	91.2	128.7	109.9	178.6	151.7	165.2
HY 6	SPH 196	76.2	95.5	85.9	92.8	122.2	109.2	189.3	156.9	173.1
HY 8	CSH 1	73.3	84.1	78.7	103.0	105.2	104.1	133.7	110.0	121.9
HY 8	CSH 6	80.4	94.9	87.7	110.2	119.4	114.8	141.7	147.9	144.8
HY 8	CSH 9	80.7	89.5	85.1	95.6	117.8	106.7	171.8	144.3	158.1
HY 8	SPH 196	80.2	95.9	88.1	92.8	129.5	111.2	155.0	142.4	148.7
HY 9	CSH 1	80.1	85.7	82.9	106.1	117.9	112.0	186.3	151.0	168.7
HY 9	CSH 6	80.3	90.2	85.3	96.4	124.2	110.3	183.8	137.3	160.6
HY 9	CSH 9	74.4	97.9	86.2	91.5	128.7	110.1	186.0	161.5	173.0
HY 9	SPH 196	82.2	86.9	84.6	94.4	124.0	109.2	186.0	161.6	173.8
HY 3C	CSH 1	77.0	87.1	82.1	99.1	116.4	107.8	170.5	172.5	171.5
HY 3C	CSH 6	80.0	89.5	84.8	99.4	119.8	109.6	177.1	174.4	175.8
HY 3C	CSH 9	80.7	85.4	83.1	92.8	120.7	106.8	176.0	156.9	166.5
HY 3C	SPH196	79.4	93.5	86.5	91.8	124.5	108.2	167.6	154.4	161.0
SE		5.6	7.8	6.1	8.8	10.1	9.2	12.1	16.9	12.8
G MEAN		78.2	91.9	85.0	97.6	123.6	111.3	173.0	151.9	162.5
		Competition effects (Ci)								
HY 6		1.5	3.5	2.5	-4.1	3.5	-0.2	4.8	5.5	5.1
HY 8		-0.3	-1.4	-0.8	-5.5	-1.1	-3.1	1.7	-1.9	-0.2
HY 9		0.2	-1.1	-0.5	4.9	-0.7	2.2	-5.1	-1.7	-3.3
HY 3C		-1.4	-1.1	-1.2	4.7	-1.8	1.1	-1.5	-1.9	-1.7
SE (Ci)		2.8	3.9	3.0	4.4	5.0	4.6	6.0	8.5	6.4

Table 36. Mean branch number of pigeonpea genotypes and competition effects in intercropping over three stages of growth during kharif 1983 and 1984.

Genotype		Sorghum plant height (cm)								
		Stage 1			Stage 2			Stage 3		
Sorghum	Pigeon-pea	1983	1984	Av.	1983	1984	Av.	1983	1984	Av.
HY 6	CSH 1	6.4	6.5	6.5	10.0	7.8	8.9	12.7	7.1	9.9
HY 6	CSH 6	5.0	5.6	5.3	9.9	6.6	8.3	12.3	8.4	10.4
HY 6	CSH 9	4.6	5.8	5.2	9.2	6.6	7.9	10.8	7.6	9.2
HY 6	SPH 196	4.9	5.5	5.2	10.1	6.8	8.5	13.0	8.5	9.8
HY 8	CSH 1	4.7	6.6	5.7	10.0	8.2	9.1	11.2	9.1	10.1
HY 8	CSH 6	5.5	7.2	6.4	9.6	7.3	8.5	12.2	9.5	10.9
HY 8	CSH 9	4.9	4.3	4.6	10.6	7.2	8.9	14.4	8.1	11.3
HY 8	SPH 196	4.7	6.2	5.5	8.9	6.7	7.8	11.2	7.8	9.5
HY 9	CSH 1	3.8	5.0	4.4	8.0	5.6	6.5	11.1	7.2	9.2
HY 9	CSH 6	3.6	4.7	4.4	8.4	5.6	7.0	7.4	7.8	7.6
HY 9	CSH 9	3.3	5.3	4.3	8.8	5.6	7.2	14.0	8.0	11.0
HY 9	SPH 196	3.6	4.2	3.9	9.0	5.2	7.1	8.6	8.8	8.7
HY 3C	CSH 1	3.4	5.2	4.3	7.8	7.1	7.5	8.3	10.1	9.2
HY 3C	CSH 6	3.4	4.7	4.1	8.4	7.6	8.0	9.5	9.6	9.6
HY 3C	CSH 9	3.5	4.0	3.8	7.6	6.3	7.0	10.8	8.0	9.4
HY 3C	SPH196	3.3	5.0	4.2	8.0	5.6	6.8	6.3	8.0	7.2
SE		0.8	1.2	0.9	0.8	1.2	1.0	3.3	1.4	2.4
G MEAN		4.3	5.3	4.9	9.0	6.6	7.8	10.9	8.3	9.6
		Competition effects (Ci)								
HY 6		-0.2	-0.4	-0.3	0.1	-0.5	-0.1	0.0	-0.0	0.0
HY 8		-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.5	-0.4	-0.1
HY 9		0.2	0.5	0.3	0.0	0.1	0.0	-1.6	0.4	-0.6
HY 3C		0.1	0.1	0.1	0.0	0.5	0.2	1.0	0.0	0.7
SE (Ci)		0.4	0.6	0.5	0.4	0.6	0.5	1.6	0.7	1.2

Table 37. Mean branch length of pigeonpea genotypes and competition effects in intercropping at three stages of growth during kharif 1983 and 1984.

Genotype		Pigeonpea branch length (cm)								
		Stage 1			Stage 2			Stage 3		
Sorghum	Pigeon-pea	1983	1984	Av.	1983	1984	Av.	1983	1984	Av.
HY 6	CSH 1	27.7	40.8	34.3	42.6	64.1	53.4	67.8	74.0	70.9
HY 6	CSH 6	26.3	40.8	33.5	37.8	55.8	46.8	78.3	70.0	74.2
HY 6	CSH 9	28.3	45.6	36.9	41.2	51.6	46.4	63.8	70.4	67.1
HY 6	SPH 196	23.4	41.8	32.6	33.8	55.3	44.6	61.1	69.6	65.4
HY 8	CSH 1	26.9	37.4	32.2	37.6	50.2	43.9	70.0	59.8	64.9
HY 8	CSH 6	25.7	47.8	36.8	35.2	60.4	47.8	65.6	66.2	65.9
HY 8	CSH 9	25.2	34.4	29.8	33.4	56.8	45.1	69.3	74.6	71.9
HY 8	SPH 196	26.8	41.3	34.1	38.0	55.8	46.9	62.0	66.6	64.3
HY 9	CSH 1	26.8	36.5	31.7	37.0	56.2	46.6	81.8	70.9	76.4
HY 9	CSH 6	22.5	38.2	30.4	33.8	52.2	43.0	75.3	69.9	72.6
HY 9	CSH 9	21.9	41.9	31.9	33.4	56.8	45.1	69.3	74.6	71.9
HY 9	SPH 196	21.0	39.0	30.0	33.6	50.4	42.0	63.2	77.7	70.5
HY 3C	CSH 1	19.1	29.4	24.3	32.0	49.8	40.9	70.5	86.2	78.4
HY 3C	CSH 6	21.6	49.4	35.5	35.4	57.1	46.3	60.8	91.1	75.9
HY 3C	CSH 9	19.9	35.1	27.5	32.4	55.6	44.0	63.6	77.7	70.7
HY 3C	SPH 196	21.9	41.0	31.5	33.0	49.6	41.3	55.8	73.0	64.4
SE		4.3	6.2	5.3	3.5	5.9	4.5	10.4	5.5	7.4
G MEAN		24.1	39.6	31.8	36.1	55.0	45.5	66.9	73.4	70.2
		Competition effect (Ci)								
HY 6		-1.0	4.0	1.4	-1.7	-0.2	-0.9	-5.1	0.5	-2.3
HY 8		0.0	-4.0	-2.0	0.1	-1.5	-0.7	-2.6	-1.0	-1.8
HY 9		0.2	0.8	0.5	0.5	-0.3	0.1	0.9	-1.1	-0.1
HY 3C		0.8	-0.8	0.0	1.0	2.1	1.6	6.9	1.5	4.2
SE(Ci)		2.1	3.1	2.6	1.8	2.9	2.2	5.2	2.8	3.7

Table 38. ANOVA for competition effect of sorghum (S) and Pigeonpea (P) for yield characters of sorghum in intercropping during kharif 1984.

Source	df	M S S			
		Fodder yield	Panicle weight	Grain yield	Test weight
Replication	2	0.24	16844	4687	0.08
Sorghum effect(S)	3	0.49**	214278**	75594**	0.31
Pigeonpea effect(P)	3	0.61**	3029	1870	0.05
S x P	9	0.08	2098	1528	0.08
Error	30	0.05	6945	3020	0.12

** Significant at 1%.

yield characters of sorghum genotypes in intercropping during kharif 1984.

Genotype Sorghum	Genotype Pigeon-pea	Fodder yield (kg/5 plants	Panicle weight (g/5 heads	Grain yield (g/5 heads	Test weight (g)
CSH 1	HY 6	0.70	132	71.0	31.6
CSH 1	HY 8	0.45	122	47.7	32.1
CSH 1	HY 9	0.52	108	39.6	32.7
CSH 1	HY 3C	0.40	127	69.8	31.8
CSH 6	HY 6	0.62	184	92.7	26.9
CSH 6	HY 8	0.52	212	103.6	31.0
CSH 6	HY 9	0.53	200	102.5	28.3
CSH 6	HY 3C	0.37	171	84.3	30.4
CSH 9	HY 6	0.88	471	275.6	30.5
CSH 9	HY 8	0.38	425	272.4	27.4
CSH 9	HY 9	0.75	409	193.0	29.6
CSH 9	HY 3C	0.82	398	220.6	28.1
SPH 196	HY 6	0.75	294	138.7	26.8
SPH 196	HY 8	1.00	337	164.4	31.8
SPH 196	HY 9	1.08	347	152.6	28.4
SPH 196	HY 3C	0.92	260	133.7	27.5
SE		0.18	68	44.8	0.9
G MEAN		0.67	262	135.1	29.7
		Competition effect (Ci)			
CSH 1		-0.07	-7.94	-9.36	0.73
CSH 6		0.08	-11.69	-11.89	-0.89
CSH 9		-0.05	-3.69	13.21	-0.07
SPH 196		0.04	23.31	8.04	0.23
SE(Ci)		0.1	34	22.4	0.5

grew taller during Kharif 1983 than 1984 at all stages except in combinations of CSH 1 and SPH 196.

Mean branch number was lower in HY3C than in HY6 and HY8 S1 recorded lowest branch number compared to other genotypes while at S3 stage all genotypes were similar in branch number within the genotypes intercropped with different sorghum hybrids, no significant differences were observed (Table 36). Mean branch number was more during Kharif 1983 than 1984 at S2 stage in all the genotypes and at Stage 3 in case of HY9.

No differences in mean branch length were observed between the genotypes at any of the three growth stages. There was no difference between the treatments involving the same pigeonpea genotype also. Comparison of mean branch length of the two years showed that in case of all pigeonpea genotypes branch length was more during Kharif 1984 than 1983 at all stages except that of HY6 and HY9 did not differ at S3 stage.

4.3 Competition effects on yield characters of sorghum.

ANOVA and means of yield characters of sorghum like fodder yield, panicle weight, grain yield and test weight are given in Table 38 and 39 respectively. Sorghum effects were significant all for these characters except test weight. There was no significant effect of pigeonpea genotype on yield characters of sorghum. Sorghum x pigeonpea interaction was also non-significant. Comparison of means (Table 39) showed that fodder yield was low in case of CSH 1 CSH 6 and CSH 9 than SPH 196. Within the same hybrid, for fodder yield, no differences existed when grown with different genotypes of pigeonpea except CSH 6 which gave lower fodder yield with HY3C than with the other pigeonpea genotypes. Mean panicle weight and grain yield were lowest in case of CSH 1. The yield of CSH 9 was maximum followed by SPH 196 and CSH 6. Each sorghum hybrid gave similar grain yield in all the pigeonpea treatments except CSH 1 in combination with HY9.

Mean test weight of CSH 1 was the maximum (32.1g). In case of SPH 196, CSH 9 and CSH 6 test weight was 28.6 to 29.2 g and significantly not different. CSH 1 gave similar test weight with all pigeonpea genotypes. CSH 6 showed lower test weight when intercropped with HY6 than with HY8 and HY3C. CSH 9 gave heavier seeds with HY6 than with HY8 while the reverse was the case in case of SPH 196.

4.4 Competition effects on yield characters of pigeonpea.

ANOVA and means of yield characters of pigeonpea are shown in Table 40 and 41 respectively. Results indicate that there were no differences between the pigeonpea genotypes for pod and grain yields but test weight differences were significant. Sorghum had no effect on pigeonpea yield characters. Sorghum x pigeonpea interactions were also not significant.

Table 40. ANOVA of yield characters of pigeonpea in intercropping during kharif 1984.

Source	df	M S S		
		Pod yield	Grain yield	Test weight
Replication	2	7253	2969	193
Sorghum effect(S)	3	9690	500	590
Pigeonpea effect(P)	3	10179	6499	1276*
S x P	9	6380	2771	342
Error	30	11369	3763	426

* Significant at 5%.

Table 41. Means and competition effects of yield characters of pigeonpea genotypes in intercropping during kharif 1984.

Genotype: Pigeon-pea	Genotype: Sorghum	Pod yield (g/ 5 plants (g)	Grain yield (g/ 5 plants (g)	Test weight (gm)
HY 6	CSH 1	210	118.5	113.5
HY 6	CSH 6	212	116.1	120.2
HY 6	CSH 9	214	130.9	105.5
HY 6	SPH 196	149	97.1	90.6
HY 8	CSH 1	225	124.4	109.2
HY 8	CSH 6	279	144.4	121.7
HY 8	CSH 9	243	140.2	123.0
HY 8	SPH 196	227	144.8	115.1
HY 9	CSH 1	249	140.0	127.7
HY 9	CSH 6	255	155.5	125.6
HY 9	CSH 9	267	140.9	106.6
HY 9	SPH 196	289	207.7	114.6
HY 3C	CSH 1	278	150.1	127.1
HY 3C	CSH 6	315	139.3	123.3
HY 3C	CSH 9	180	129.7	143.6
HY 3C	SPH 196	125	199.6	152.2
SE		87.1	50.1	16.9
G MEAN		232	136.3	121.4
		Competition effect (Ci)		
HY 6		-8.9	9.2	0.6
HY 8		-32.9	3.6	-2.7
HY 9		6.3	7.0	0.3
HY 3C		34.8	-19.8	1.8
SE(Ci)		43.6	25.0	8.3

Comparison of mean test weights indicated that, on an average HY6 recorded least (106.4 g) test weight, HY8 and HY9 were intermediate while maximum (136 g) test weight was observed in case of HY3C. There were significant difererences within the HY6 genotypes when intecropped with different sorghum hybrids. Test weight of HY6 was higher when grown with CSH 1 and CSH 6 but low with SPH 196.

Figure 1(a) shows the linear regression of Pigeonpea yield on sorghum plant height in Experiment I. This linear association was found to be non-significant indicating that the height of sorghum genotype does not influence the grain yield of pigeonpea intercropped with it.

Figure 1(b) and 1(c) represents the linear association of intercrop grain yield of sorghum on its yield in sole crop in Experiment I and II respectively. The highly significant linear relation obtained here show that the genotypes which yielded high in intercrop also yielded highly in sole crop. From this it can be inferred that the different sorghum genotypes are not affected differently for their yield by the pigeonpea genotype grown in association with it.

As shown in Figure 1(d), the linear relation of pigeonpea intercrop yield on sole crop yield in Experiment II was insignificant with the percentage variance in intercrop yield accounted by sole crop yield being 43%. However this is based on the limitation of observing only three distinct points in the pigeonpea yield in sole crop.

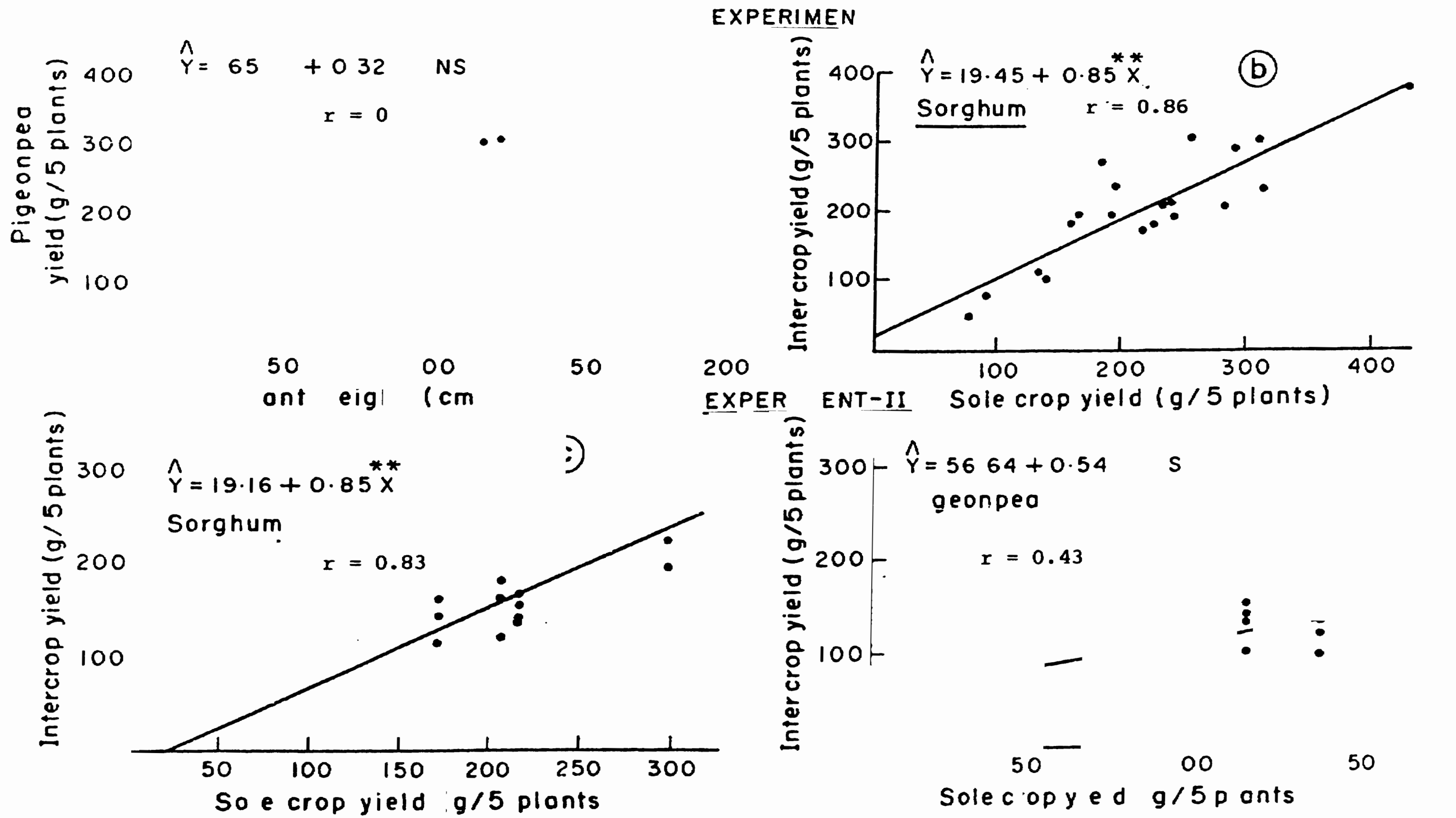

FIG. I. LINEAR REGRESSION OF PIGEONPEA GRA YIEI ON SORGHUM HEIGHT AND ERCROP YIELD ON SOLE CROP

DISCUSSION

Sorghum have evolved in East Africa and spread to other parts of the tropical and temperate world. In the evolution of traditional tropical cultures, there appears to have been parallelism between type of cultivars and agricultural systems. The tropical cultivars are tall (250-300 cm) and late maturing (150-180 days) compared to the duration of rainy season and are generally characterised by higher biological but low economic yield. They exhibit superiority of individual performance under low plant density relative to their yield under high population pressure. Subnormal or early cessation of rain results in reduction of yield to total crop failure. Thus the growing of local cultivars as well as traditional mixed cropping involving such varieties has been predominantly a strategy of subsistence for dryland farmer to avert the total risk and obtain some degree of insurance towards complete crop failure.

As the agriculture advanced in developing and developed world, the subsistence mix cropping based agricultural system was transformed to more intensive and productive sole cropping system. The utilisation of dwarf and photoinsensitive genes in sorghum, evolution of new hybrids and varieties have helped elevation of yield levels and practice of intensive cropping. It also offered the oppurtunity for intercropping with pulses to augment their extra production in the country (Rao and Rana 1980).

The design and development of stable and productive intercropping systems takes into consideration the choice of crops and varieties based on inter and intra-species competition; genotype x density interactions and alternate planting patterns so as to maintain the yields of the principal crops comparable to its sole crop yield and obtaining additional production of intercrop (Rao and Rana, 1982). The identification of suitable genotypes is likely to be one of the major ways in which intercropping performance can be improved. Willey and Rao (1979) have further envisaged the objectives of selection as the selection of genotypes which minimise intercrop competition and maximise complementary effects. Ideally this should involve the identification of suitable plant characters which can best achieve these effects and serve as the basis for selection criteria in future.

1. VARIABILITY IN SORGHUM IN INTRA AND INTRACROPPING SYSTEMS:

The major genotypic change in trasnforming tropical cultivars into more productive forms involves redistribution of dry matter production and reduction in height and maturity through tropical x temperate crosses (Rao and Rana, 1982). Most of these varieties and hybrids are early maturing (100-115 days), high yielding (30-40 q/ha) and widely adaptable in the country (Rana, et al., 1972, Rao et al, 1980 and Rana and Rao, 1984). The study of some of these popular hybrids along with their parents and promising high yielding varieties under rainfed agriculture revealed significant variability for developmental characters such as plant height, leaf number, leaf length at three stages of plant growth in individual two years. When data were pooled over years, significant differences among genotypes existed while grown as sole as well as intercrop with pigeonpea. In both types of cropping which can be referred to as intra and inter-species competitions respectively genotype x year interaction was significant except for plant height at early stages of plant growth. Therefore, genotype x environment interactions for developmental character to adjust against the changing environmental situation appear to be alike under both the cropping systems. The comparison of range as presented below indicates that plant height of sorghum in intercroppping system was comparatively less than that observed in sole cropping irrespective of hybrid or variety. While leaf number and leaf breadth were comparable, leaf length was slightly reduced in intercropping system.

Range at stage-3 in inter and sole cropping system.

Sorghum genotype	System	Plant height	Leaf number	Leaf length	Leaf breadth
Hybrids (N=7)	INT.	122-228	9.1-11.0	64.2-82.6	7.7-9.6
	SOLE	139-242	9.5-11.4	72.5-89.3	7.5-9.3
Parental lines(N=7)	INT.	77-163	7.9-11.5	58.9-83.3	6.6-9.4
	SOLE	92-179	8.4-11.6	67.9-85.7	6.9-9.4
Improved varieties(N=5)	INT.	117-177	9.3-10.7	77.1-81.0	7.4-8.7
	SOLE	132-205	9.4-10.8	79.6-87.8	8.1-8.8

Most hybrids and improved varieties used in these studies represent optimum height and maturity suitable to obtain high yield. Rana _et al_ (1984) defined such model sorghum variety which should flower in 68 days (105-110 days maturity) and have 175 cm plant height. Their predictions based on leaf number showed that 8-10 leaves contributes to higher grain. The hybrids, SPH 162, SPH 196 and varieties SPV 462 and SPV 472 happened to be taller than the predicted plant type but conformed to the similar maturity group. It is however, the early maturity which plays major role in determining the high grain yield (Rana _et al_, 1984), Quinby (1972) also reported the control of plant size and leaf number by maturity genes.

The leaf number, size, and orientation are important characters for light interception. Plant height determines the vertical disposition of the leaves and shade effect. While leaf canopy characteristics ascertain the photosynthetic potential and ultimate contribution to plant growth, these may also become important factor to cause competition with other species mainly through affecting light interception. The use of mathematical models has suggested that the highest photosynthetic rate might be obtained from a canopy in which the steepness of the inclination of the leaves decrease with depth and this ideal leaf arrangement could approach by a mixture of a tall erect leaved genotype and a short, prostrate-leaved ones (Nilson, 1968)

The grain yield under intra and inter species competition show significant genotypic variation and it is possible to identify superior genotypes. The grain yield variation of 78.4-426.8 g/5 plants under intra species competition and 49.2-376.1 g/5 plants under inter-species competition were observed though mean over all sorghum genotypes under sole cropping was only 2% higher than that of inter cropping. SPH 221, SPH 196, and SPV 351 in sole cropping and SPH 221, CSH 9, SPV 351 and SPV 245 in intercropping were high yielding genotypes. The improved hybrid SPH 221 and variety SPV 351 were found consistently superior under both types of competition effects. Under rainfed situation, these genotypes exhibited 159 and 129 cm plant height, 10.8 and 10.3 leaves, 87.6 and 77.6cm long and 9.3 and 8.4 cm broad and represented ideal productive plant type. Other genotypes such as hyrid CSH 9 and varieties SPV 245 are also comparable to these genotypes in plant framework.

The comparison of grain yield of inter vs. sole cropping of sorghum enabled to identify certain genotypes which have high relative yield efficiency in intercropping situation. The hybrids such as CSH 6 and CSH 9 and varieties such as SB 1085 and SPV 462 were 120% of their yield obtained under sole cropping while yields of CS 3541, SPV 245, SPV 351 and SPV 472 were equal under both the cropping systems.

The ratio of yield under intercropping and solecropping does not appear to be positively associated with the <u>per se</u> performance since highest yielding hybrid SPH 221 showed relative yield efficiency of 0.88. However, there is positive and significant association between sole crop yield vs. inercrop yield of sorghum. Thus, improved genotypes in solecropping are expected to yield higher in intercropping also. Hybrids show advantage over its parental lines but their yields were marginally superior than high yielding varieties.

Yield advantages in intercroping may arise due to better utilisation of resources by some hybrids and varieties in intercropping than in pure stand de Wit (1965) also expected that more divergent the components in a mixture, the better the chance of the growth resources available to the plants in the mixture per unit area which will be larger than in pure stand. Trenbath (1974) reported such transgressive yield due to allelopathic effects where an allelopathic substance produced by one component effects the growth rate of other component by changing only the rate of uptake of some limiting growth factor altering the apparent relative competitive abilities of the mixture components.

In the present case, where sorghum represents a fast growth rythm and pigeonpea a slow one, improved sorghum genotypes show greater efficiency in the use of environmental resources. The leaf canopies of sorghum in intercrop system occupy different vertical layer and this could make better utilisation of light than in sole cropping. Similar complementary use of soil nutrient resources and annidation in time are also possible as reported by Trenbath (1976). Under such complementary situation in intercropping, a sorghum genotype possessing better response to nutrient uptake will be more advantageous.

2. VARIABILITY IN PIGEONPEA UNDER DIFFERENT INTERCROPPING TREATMENTS:

The pigeonpea variety HY8 was selected on the basis of different maturity (160 - 170 days) and plant architecture. with terminal (cymose) flowering habit. The variability among the various treatments of HY8 pigeonpea can be attributed to competition effects due to its association with different sorghum varieties. Significant variation in HY8 was observed for the length of branch at stage 3 but the genotype x year interactions were significant for number as well as length of branch at all the three stages. Thus the differences in pigeonpea plant canopy can be attributed to its interaction with year. The length of branch at final stage varied 44-57.9 cm. Long branches of HY8 were observed in association of sorghum hybrids CSH 1, CSH 5, CSH 6 and varieties CS 3541 and 168. All these happen to be popular recommended hybrids and varieties of sorghum. The varieties CS 3541 and 168 are dwarf while others are mid tall (150-170 cm) type. In case of the sorghum genotypes CSH 9, SPH 196, SPV 351 and local cultivar Y 75, length of pigeonpea branch was long in one of the years particularly in 1984 showing interaction in association of more vigorous sorghum genotypes. Average number of branches at stage 3 ranged from 9.1-12.4. More number of branches were observed in association of sorghum CSH 1, CSH 5 and CS 3541.

Significant variation observed for pod as well as grain yield may be due to inter-species competition with different sorghum genotypes. High pod and grain yields of HY8 pigeonpea were obtained when intercropped with CSH 5 and CSH 6.

3. ROLE OF PLANT TYPE IN COMPETITION

3.1 Effect of competition on yield components

Correlated characterstics show tendency to express together and its magnitude depends on the variability expresed in the material. The competition for resources which depends on developmental characters and differential growth rythm may therefore modify the expression of yield components.

It is earlier reported in sorghum that plant height and maturity show positive association with grain yield (Subba Reddy and Rao, 1971; Riecelli, 1974) and may have strong pleotropic effect on it (Rao et al., 1973). However, positive correlations of grain yield with days to bloom, height, leaf area, and test weight were reported by Cook and Cassady (1974) All these studies were conducted in monocropping.

In the present studies, high yielding hybrids, parental lines and varieties derived from temperate x tropical, derivative x derivative or temperate x derivative crosses were utilised which represent a different type of variability. Parental lines were selected for short height, earliness, and per se performance while varieties in different cycles were selected for high yield and medium tall stature. When correlations were computed using such material grown as sole crop, grain yield was found to be significantly correlated with leaf length, panicle length and panicle weight. Goud and Krishna Shastry (1974) found that ear length was positively correlated with grain yield whereas plant height and number of leaves were negatively

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This shows a vital shift from the observation made in earlier studies using temperate x tropical crosses. This can be explained since relatively early genotypes were more productive in all the height groups while increase in height was only useful in early maturing dwarf group (Rana et al, 1984). They reported that correlation between leaf number and grain yield was negative. This led them to predict the optimum plant type in sorghum represented by 68 days flowering, and 175 cm plant height. Low leaf number even in early talls was found to be important. Most of the high yielding hybrids and varieties conform to this sort of plant type. This has reduced the variability for maturity, plant height, leaf characters and panicle components resulting in various non-significant correlations with grain yield reported earlier.

The shift in correlations in intercropping as compared to sole cropping can be attributed to competition effect. In intercropping grain yield in sorghum was positively correlated to leaf length, leaf breadth, panicle length and panicle weight. These correlations are similar to that observed when sorghum was grown in its pure stand. Thus growing high yielding varieties or hybrid with improved pigeonpea variety HY8 with differential late maturity did not change the yield components. This can be attributed to the lack of competition by HY8 pigeonpea variety with sorghum in general.

In pigeonpea, comparison of correlations between sole vs intercrop in pigeonpea is not possible since one single plot was provided for sole crop. The study of pattern of variability in intrcropping pigeonpea revealed that grain yield was positively correlated with number of pods per plant as well as with pod weight. Thus these characters are major yield components in inter crop pigeonpea. Number, length of branches and plant height did not show any significant relationship with grain yield.

3.2 Consideration for suitable plant type for intercropping:

The correlation between sorghum and pigeonpea characters when grown in intercropping system may enable to identify characters which are potential to cause serious competition to neighbouring species. Sorghum plant height adversely effected the number of branches and pod weight of pigeonpea as indicated by negative correlations at different stages. However, test weight of pigeonpea was positively correlated with sorghum plant height, leaf length, leaf breadth, panicle weight and grain yield. Therefore, the factors which promoted the test weight in pigeonpea also enhance grain yield in sorghum. Longer panicle of sorghum is associated with higher plant height in pigeonpea.

Number of leaves in improved varieties of sorghum is optimum(9-11)and does not effect the growth or yield components of pigeonpea.

In case of pigeonpea, Veeraswamy et al.,(1975)reported positive effect of number of branches and negative effect of days to first flower on seed yield. Similar observations were made by Pankaja Reddy et al(1975) indicating positive correlation of seed yield of pigeonpea with its plant height, number of branches and number of pods. Thus the sorghum characters which influence these yield components of pigeonpea may likely influence the seed yield of pigeonpea. Sorghum plant height and fodder yield are a couple of such characters which have negative effect on important yield components of pigeonpea.Excesive plant height and vegetative growth of sorghum are thus undesirable for intercropping system involving pigeonpea as companion crop. Such tall sorghum genotypes may prove more competitive since a rapid expansion of tall canopy(Donald, 1963), a high allocation of dry matter to build a tall stem (Iwaki, 1959) and larger leaves to minimise penumbra effects(Norman et al., 1971) are reported to induce high competitive effects.

The pigeonpea yield is not significantly correlated with any of the sorghum growth characters including plant height or fodder yield inspite of the fact that some important yield components of pigeonpea were adversely

Table 42. Relative yield efficiency in intercrop as compared to sole crop.

Sl. No.	Genotype	Grain yield g/5 plants: Sorghum Inter crop (Yab)	Sorghum Sole crop (Yaa)	Yab/ Yaa	Pigeonpea Inter crop (Yba)	Pigeonpea Sole crop (Ybb)	Yba/ Ybb
1	CSH 1	101.1	140.9	0.72	197.0	148.7	1.3
2	CSH 5	181.2	225.7	0.80	394.0	148.7	2.6
3	CSH 6	195.8	165.5	1.20	336.0	148.7	2.2
4	CSH 9	305.0	225.1	1.20	209.0	148.7	1.4
5	SPH 221	376.0	426.8	0.88	201.0	148.7	1.4
6	SPH 162	207.9	232.3	0.89	214.0	148.7	1.4
7	SPH 196	232.3	312.6	0.74	156.0	148.7	1.0
8	CS 3541	195.8	192.0	1.00	224.0	148.7	1.5
9	A 535	77.6	93.0	0.83	279.0	148.7	1.8
10	SB 1085	237.0	194.4	1.20	234.0	148.7	1.6
11	SPV 126	170.7	216.8	0.79	246.0	148.7	1.6
12	296B	212.9	238.9	0.89	237.0	148.7	1.6
13	2219B	110.1	133.6	0.82	268.0	148.7	1.8
14	168	193.2	242.5	0.79	235.0	148.7	1.6
15	SPV 245	290.7	290.8	1.00	275.0	148.7	1.8
16	SPV 346	207.8	281.7	0.74	165.0	148.7	1.1
17	SPV 351	302.9	309.9	0.98	251.0	148.7	1.6
18	SPV 462	270.7	183.6	1.50	170.0	148.7	1.1
19	SPV 472	100.3	159.1	1.10	268.0	148.7	1.8
20	Y 75	49.1	78.3	0.62	147.0	148.7	1.0
SE		18.8	18.4	0.05	13.4	0.0	0.1
G MEAN		200.9	217.2	0.93	235.3	148.7	1.6

Table 43. Relative yield efficiency in intercrop and Land Equivalent Ratio Experiment II. (K 1984)

Genotype combinations		Sorghum yield			Pigeonpea yield			
Sorghum	Pigeon-pea	Inter crop (Yab)	Sole crop (Yaa)	Yab/ Yaa	Inter crop (Yba)	Sole crop (Ybb)	Yba/ Ybb	LER
CSH 1	HY6	142.0	172.0	0.83	118.5	139.5	0.85	1.67
CSH 1	HY8	113.0	172.0	0.66	124.3	163.3	0.76	1.41
CSH 1	HY9	158.0	172.0	0.92	140.0	164.5	0.85	1.77
CSH 1	HY3C	140.0	172.0	0.81	150.1	117.5	1.27	2.08
CSH 6	HY6	177.5	207.5	0.86	116.1	139.5	0.83	1.69
CSH 6	HY8	118.0	207.5	0.57	144.4	163.5	0.88	1.45
CSH 6	HY9	160.0	207.5	0.77	155.5	164.5	0.94	1.72
CSH 6	HY3C	179.0	207.5	0.86	39.3	117.5	1.18	2.04
CSH 9	HY6	275.6	297.9	0.92	130.9	139.5	0.94	1.86
CSH 9	HY8	272.4	297.9	0.91	140.2	163.5	0.86	1.79
CSH 9	HY9	193.0	297.9	0.65	140.9	164.5	0.86	1.50
CSH 9	HY3C	220.6	297.9	0.74	129.7	117.5	1.10	1.84
SPH 196	HY6	138.7	216.8	0.64	97.1	139.5	0.69	1.34
SPH 196	HY8	164.7	216.8	0.76	144.8	163.5	0.89	1.65
SPH 196	HY9	152.6	216.8	0.70	207.7	164.5	1.26	1.46
SPH 196	HY3C	133.7	216.8	0.62	99.6	117.5	0.85	1.46
SE		12.4	11.8	0.03	8.8	5.0	0.04	0.06
G Mean		171.8	223.6	0.76	129.9	146.2	0.94	1.67

affected by tall sorghum genotypes. This is possible since HY8 pigeonpea variety is relatively late and has enough competition-free time (60 days) to compensate the loss after the sorghum harvest due to profuse canopy spread promoting high pod number. Rao et al., (1979) also reported that the desirable characters in pigeonpea in order to give better intercrop performance are more and longer branches and which spread well after the cereal harvest. The data from ICRISAT (1979) where pigeonpea of different maturities were intercropped with sorghum and pearl millet genotypes of different maturities also show that intercropped pigeonpea yields increased with decreased cereal maturity.

While competition to pigeonpea can be reduced due to maturity differential, another aspect of consideration is to select for the varieties with higher potential branch number. Such variety should be able to produce optimum number of branches inspite of competition from sorghum.

The earlier studies on the productivity of sorghum-pigeonpea system revealed that the CSH 6 yields in various planting patterns were more or less at par with its yields in pure stand (Tarhalkar and Rao,1980) and sorghum - pigeonpea system was stable (Rao, et al.,1979).CSH 6 provided a good choice for intercropping earlier. Since better sorghum hybrids such as CSH 9 and SPH 221 are now available (Rana and Rao, 1984), potentiality examined in the present study indicates that cropping systems based on these mid tall hybrids with 110 days maturity are highly productive. However, per ha plant population of pigeonpea in CSH 9 based system is recommended to be lower than that required in combination of CSH 6 (AICSIP 1983-84). Thus a plant like CSH 9 or SPH 221 appears to be suitable model for more productive intercropping system in the present context.

4. TESTING THE PLANT TYPE CONCEPT TO OBTAIN TRANSGRESSIVE YIELD:

In order to test the plant type concept developed in the preceding section, the competition effects were further examined in a specific experiment by growing four sorghum hybrids and four different types of pigeonpea varieties in all possible combinations. Two sorghum hybrids viz., CSH 1 and CSH 6 represented early (100 days) medium tall stature and non-dense leaf canopy while other two hybrids i.e. CSH 9 and SPH 196 represented 110 days maturity but mid tall and tall heights respecively The competition effects were subdivided into effects due to sorghum, due to pigeonpea and due to the interaction of sorghum x pigeonpea.

The differences in the developmental characters, fodder yield, panicle weight and grain yield of sorghum due to its own main effects were significant at almost all the stages of crop growth. Effects on developmental or yield characters of sorghum due to pigeonpea or due to interaction of two species were not significant. It is fairly clear from it that general competitive ability of different sorghum genotypes is quite prominant. CSH 9 was superior than other hybrids for leaf characters, panicle weight and grain yield while SPH 196 was superior for plant height and fodder yield When competition effects on pigeonpea characters were studied, effects due to pigeonpea were not significant except for its height at stage 3 and branch length, in one of the years only. Similarly, effects due to sorghum, pigeonpea and their interaction were not significant for yield characters of pigeonpea. It is clear that when suitable model genotypes of sorghum like CSH 9 are intercropped with different pigeonpea varieties, the competition effects are greatly minimised. In a study of sorghum CSH 6 based intercropping systems using pigeonpea, groundnut, soybean and castor as separate intercrops, Rao et al,(1979) have also observed that interaction in certain specific systems based on pigeonpea and sorghum was not significant though other species showed specific competition. Competition begins when the immediate single necessary factor (water content, nutrients, light and temperature) falls below the combined demands of the plants. Then effectiveness of a competitor is an expression of its capacity to make rapid use of its immediate supplies and by growth of its roots or foliage to extend its exploitation into greater spatial part of the environ (Donald, 1963). Since the inter and intra genotypic competition between the species of crop plants is the main factor changing the behaviour both in the pure and intercropping situations, selection of midtall sorghum genotypes with 100-110 days maturity such as CSH 6 and CSH 9 minimizes competition effects. The complementary effects can further be differential achieved by selecting pigeonpea cultivars with maturity periods and improving the canopy structures to capitalise the complementary effects.

In the first experiment with HY8 pigeonpea, the sorghum intercrop yield was higher in case of CSH 6, CSH 9, SB1085, SPV 462 and SPV 472 as compared to its sole crop yield (Table 42)However, in case of pigeonpea, intercrop yields are more pronounced than sole crop in experiment I and in certain combinations in experiment II e.g. CSH 1-HY3C, CSH 6-HY3C, CSH 9-HY3C and SPH 196-HY9 (Table 43). It is expected since intercrop pigeonpea grew in competition free period after sorghum harvest while middle rows of pigeonpea sole crop were growing continuously in competition with its border rows. HY3C pigeonpea intercrop due to the differences in its growth rythms and canopy structure, water and nutrient rquirements, appear to perform better. In single row spatial arrangement of sorghum-pigeonpea system, complementary effects are much higher in experiment I than observed by Rao et al (1979) and Tarhalkar and Rao 1980) in paired row system. The yields of most intercrop combinations (sorghum + pigeonpea) are higher than the yield of best sole crop. This represents the situation of transgressive yield. Aiyer (1949) also reported that the intercropping of crop types with strongly contrasting nutrient requirements or uptake abilities seems finally to lead to high LERs. Transgressive yields and high LERs may be due to annidation (Ludwig, 1950). Such annidation appears due to greater efficiency in the use of environmental resources in space (Trenbath, 1976), greater biomass production in mixture (Van der Bergh, 1968), divergent ecological requirements (dewit and Van der Bergh, 1965) and allelopathic effects (Trenbath, 1974).

Thus an intercropping system based on CSH 9 type hybrid and late maturing pigeonpea (150-170 days) presents a productive and least competitive system.

Therefore the suitable plant type is a mid tall (170 - 200 cm), early maturing (100 - 110 days) variety with medium large drooping leaves and long spinadle shaped, semi-compact panicle with bold seeds.

SUMMARY

In order to study the effect of inter-species competition, two experiments were conducted during 1983 and 1984. In experiment I, 20 genotypes of sorghum of differing canopy structure and genetic background were intercropped with a late maturing pigeonpea variety HY8 and were also grown as solecrop. The effects of competition were also studied.Genetic variability and character associations in inter and solecropping systems were studied for developmental (growth) characters at three stages and yield characters in sorghum and pigeonpea. For testing the plant type concept amenable to for intercropping developed through the first experiment, the competition effects were subdivided into the effects due to sorghum, due to pigeonpea and due to sorghum x pigeonpea interaction. These effects were examined in a specific experiment by growing four sorghum hybrids and four different pigeonpea varieties in all possible combinations. The important findings of the present investigation are as follows.

1. There were significant variability for developmental characters of sorghum such as plant height, leaf length at three stages of plant growth in individual two years. When data were pooled over two years, significant differences among genotypes existed while grown as sole as well as intercrop with pigeonpea. In both types, intra and inter species competition, genotype x year interaction was significant except for plant height at early stages of plant growth. Therefore, genotype x environment interactions for

developmental character to adjust against the changing envirommental situation appear to be alike under both the cropping systems.

2. The range of plant height of sorghum in intercrop was comparatively less than that of sole crop irrespective of hybrid or variety, leaf number and leaf breadth of sorghum were comparable but leaf length was slightly reduced in intercropping system.

3. The sorghum grain yield under intra as well as inter-species copetition show significant genotypic variation. Though grain yield variation of 78.4-426.g/5 plants under intra species competition and 49.2-376.1 g/5 plants under inter-species competition were observed, mean over all sorghum genotypes under sole cropping was only 2% higher than that of intercropping. CSH 9, SPH 221, SPV 245 and SPV 351 in intercropping were high yielding sorghum genotypes.

4. The improved hybrid , SPH 221 and variety SPV 351 were found consistently superior under both types of competition effects under rainfed situations, these genotypes exhibited midtall plant height, 10.8 and 10.3 leaves with 87.6 and 77.6 cm long and 9.3 and 8.4 cm broad leaves.

5. The yields of hybrids such as CSH 6 and CSH 9 and varieties such as SB1085 and SPV 462 in intercropping were

120% of their yield obtained under sole cropping while yield of CS 3541, SPV 245, SPV 351 and SPV 472 were equal under both cropping systems. Yield advantages under intercropping over sole cropping does not appear to be positively associated with the performance under intercropping since highest yielding hybrid SPH 221 under both type of competitions showed relative yield efficiency of 88% under intercropping.

6. Significant variation in HY8 was observed for length of branch at stage 3 but the genotype x year interatins were significant for number as well as length of branch at all three stages. Branch length of pigeonpea was high in both years in association of CSH 5 and 168. More number of branches in HY8 were observed in association of sorghum CSH 1, CSH 5 and CS 3541.

7. Pod and grain yield of HY8 in association of CSH 5 and CSH 6 were significantly higher than others. Pod yield was also high when grown with SPH 196.

8. When correlations were computed using these genotypes, in sole cropping, grain yield of sorghum was found to be significantly positively correlated with leaf length, panicle length and panicle weight. In intercropping, grain yield was positively related with leaf length, leaf breadth, panicle length and panicle weight. Thus growing high yielding varieties or hybrids with improved pigeonpea HY8

with differential late maturity did not change the yield components.

9. In case of intercropped pigeonpea, grain yield was correlated with number of pods per plant and pod weight. Thus these characters are major yield components in intercrop pigeonpea.

10. The pigeonpea yield is not significantly correlated with any of the sorghum growth characters including plant height or fodder yield in spite of the fact that some important yield components of pigeonpea were adversely affected by tall sorghum genotypes.

11. The sorghum yield in intercrop was positively correlated with its yield in sole cropping. Thus, sorghum yield in sole cropping with optimum plant type provide a good selection criteria for intercropping.

12. The study of different types of competitive effects revealed that there was significant difference in the competitive ability of sorghum for fodder yield, panicle weight and grain yield. It is fairly clear from it that general competitive effects due to sorghum are quite prominent. CSH 9 was superior for leaf characters, panicle weight and grain yield while SPH 196 was superior for plant height and fodder yield.

13. Since the inter and intra genotypic competition between the species of crop plants is the main factor changing the behaviour both in pure and intercrop situation, selection of sorghum hybrids such as CSH 6, CSH 9, SPH 221 and variety SPV 351 minimizes competition effects and maximizes complementary effects. This could be done by selecting differential maturity periods of two species and improving canopy structure.

14. Some of the combinations which gave high LER values are CSH 1 - HY3C, CSH 6 - HY3C, CSH 9 - HY6, CSH 9 - HY3C. Pigeonpea yield was also high in combination of SPH 196 - HY9.

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* Original not seen.

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