Identification and Utilization of Smut Resistance in Pearl Millet

Research Bulletin no. 16

International Crops Research Institute for the Semi-Arid Tropics

Abstract

Citation: Thakur. R.P, King. S.B., Rai, K.N., and Rao, V.P. 1992. Identification and utilization of smut resistance in pearl millet. (In En. Summaries in En, Fr, Es.) Research Bulletin no. 16. Patancheru. A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 36 pp. ISBN 92-9066-217-4. Order Code: RBE 016.

This Bulletin describes the progress made at ICRISAT Center, on the identification and utilization of smut *{Tolyposporium penicillariae)* resistance in pearl millet *(Pennisetum glaucum)* from 1976 to 1990. This has been one of the major objectives of ICRISAT's research on pearl millet improvement. At ICRISAT Center, host-plant resistance has been central to the strategy of plant disease control, whose three major components arc identification, utilization, and deployment of resistance.

During the past 10 years, more than 10 700 entries from different sources were screened using a field-screening technique developed at ICRISAT Center. Sources of smut resistance in germplasm representing diverse ecogeographical zones have been identified. Following pedigree breeding and artificial screening methods, many smut-resistant lines were selected, of which a few were intermated to generate genetically more diverse and agronomically superior lines. Several lines with stable resistance have been identified, and six of these lines have been notified for use in resistance breeding programs.

Significant progress has been made in the use of these smut-resistant source lines in breeding programs to develop open-pollinated varieties, male-sterile lines, and hybrids. Several promising varieties have been produced so far.

This Bulletin, should be useful to breeders and pathologists involved in the genetic improvement of pearl millet. It is aimed at helping them achieve sustained increase in productivity by reducing grain yield losses from smut in pearl millet. Small quantities of seed of smut-resistant lines, described in this Bulletin, are available on request.

Résumé

Identification et l'utilisation de la résistance au charbon du mil. Ce bulletin décrit les progrès effectués au Centre ICRISAT, sur l'identification et l'utilisation de la résistance à la maladie du charbon (*Tolyposporium penicillariae*) chez le mil (*Pennisetum glaucum*) de 1976 à 1990. Ceci a constitué un des principaux objectifs des travaux de recherche sur l'amélioration du mil à l'ICRISAT. Au Centre ICRISAT, la stratégie de lutte contre les maladies des plantes a été axée sur la résistance des plantes hôtes avec trois principales composantes, à savoir, l'identification, l'utilisation et la mise en place de la résistance.

Au cours des 10 dernières années, plus de 10 700 entrées provenant de sources différentes ont été criblées suivant une technique de criblage au champ mise au point au Centre ICRISAT. Cette méthode a permis d'identifier des sources de résistance au charbon dans les ressources génétiques représentant des zones écogéographiques diverses. Grâce à la sélection généalogique et au criblage artificiel, plusieurs lignées résistantes au charbon ont été sélectionnées, dont certaines ont été intercroisées afin d'obtenir des lignées génétiquement plus diverses et agronomiquement supérieures. Certaines lignées ayant une résistance stable ont été identifiées, parmi lesquelles six lignées ont été notifiées pour l'utilisation dans les programmes de sélection pour la résistance.

Des progrès importants ont été réalisés dans l'utilisation de ces lignées de source de résistance au charbon au sein des programmes de sélection dans le but de mettre au point des variétés à pollinisation ouverte, des lignées mâles-stériles, ainsi que des hybrides. Nombre de variétés prometteuses ont ainsi été créées jusqu'à maintenant.

Ce document serait de grande utilité aux sélectionneurs et aux pathologistes travaillant sur l'amélioration génétique du mil. Il leur servirait de guide dans la réalisation d'une augmentation durable de la productivité en limitant les pertes de rendement en graines du mil dues au charbon. Des quantités limitées de semences des lignées résistantes au charbon décrites dans cette publication sont disponibles sur demande.

Resumen

Identificación y utilización de germoplasma resistante a carbón en mijo. Este boletín describe los resultados obtenidos por el ICRISAT desde 1976–1990 en la identificación y utilización de germoplasma resistante a carbón (*Tolyposporium penicillariae*) en mijo (*Pennisetum glaucum*). Este ha sido uno de los mayores objetivos en el programa de mejoramiento genético de este cultivo en el ICRISAT, cuya estrategia central para el control de enfermedades es obtener genotipos resistentes. El programa tiene tres componentes principales: identificación, utilización y desarrollo de resistencia.

Durante los últimos 10 años, más de 10 700 introducciones de diferentes orígenes fueron evaluadas usando la técnica desarrollada por el ICRISAT llamada "screening de campo". Fueron identificadas fuentes de resistencia al carbón provenientes de diversas zonas ecogeográficas. Con base en los métodos de pedigree y screening artificial, muchas líneas resistentes al carbón fueron seleccionadas; algunas de estas se usaron para generar genéticamente más diversidad y líneas superiores genéticamente. También fueron identificadas líneas con estable resistencia de las cuales seis fueron requeridas en los programas de mejoramiento para la resistencia del carbón.

En los programas de mejoramiento se han obtenido significativos avances con el uso de estas líneas resistantes al carbón en el desarrollo de variedades de polinización abierta, líneas estériles e híbridos. Además se han obtenido promisorias variedades.

Este boletín será de mucha utilidad para mejoradores y fitopatólogos relacionados con el mejoramiento de mijo. Ellos podrán lograr sustanciales aumentos en la productividad usando las líneas descritas en este informe. Pequeñas cantidades de éstas están disponibles en el ICRISAT.

Cover: Smut-infected panicles of pearl millet in a farmer's field. Inset: Green and black smut sori in place of grains in infected panicles, and a smut-resistant panicle.

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R.P. Thakur, S.B. King, K.N. Rai, and V.P. Rao

ICRISAT

Research Bulletin no. 16

International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

1992

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ISBN 92-9066-217-4

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Introduction

Smut of pearl millet *[Pennisetum glaucum* (L.) R. Br.], caused by *Tolyposporium penicillariae* Bref., is an important and wide-spread disease in most parts of the world where the crop is grown (Rachie and Majmudar 1980). A good account of geographical distribution of this disease, its economic importance, pathogen biology, disease cycle, and various control measures is available in some recent publications (Thakur 1987, 1990; Thakur and Chahal 1987; Thakur and King 1988a). At ICRISAT Center, host-plant resistance has been central to plant disease control. The three major components of this strategy are identification, utilization, and deployment of resistance.

Using a field-screening technique developed at ICRISAT Center (Thakur et al. 1983), we screened, during the past 10 years, more than 10 700 entries from our genetic resource collection and the various breeding projects from ICRISAT Center and All India Coordinated Pearl Millet Improvement Project. Sources of smut resistance were identified in germplasm originating from Cameroon, India, Lebanon, Mali, Niger, Nigeria, Senegal, Togo, and Uganda representing diverse ecogeographical zones (Thakur et al. 1986). Following pedigree breeding and artificial screening methods, several smut-resistant lines were selected, of which a few were intermated to generate genetically more diverse and agronomically superior lines. These lines were also evaluated for resistance to downy mildew *(Sclerospora graminicola* Sacc. Schroet) in the downy mildew nursery, in the field and in the greenhouse. Several lines resistant to both downy mildew and smut have been identified. Some of the selected lines were tested for 6-9 years for their smut resistance and stability through multilocational testing at key hot-spot locations in India and in western African countries, leading to the identification of several lines with stable resistance (Thakur et al. 1986). Six lines derived from germplasm accessions were notified for use in resistance breeding programs (Thakur and King 1988b).

About 400 smut-resistant lines were evaluated for various agronomic traits, and these were classified into several groups, each with a combination of desirable agronomic traits, and resistance to both smut and downy mildew. These lines were assigned ICMSR (ICRISAT Millet Smut Resistant) numbers with their pedigree and agronomic traits described.

Significant progress has been made in the use of these smut-resistant source lines in breeding programs to develop open-pollinated varieties and male-sterile lines (Andrews et al. 1985). From a Smut-Resistant Composite, based on ICMSR lines, several promising varieties have been produced, and one of these (ICMV 82132) performed well and was released as 'Kaufela' in Zambia, and as IKMV 8201 in Burkina Faso (ICRISAT 1992). ICMA 88006, a promising smut-resistant male-sterile line, was developed by transferring smut resistance into elite breeding lines. A number of promising smut-resistant B lines have been developed by crossing smut-resistant source lines with 843B which is the maintainer of a dwarf, high-tillering, large-seeded, and early-maturing male-sterile line of high general combining ability. Several of these B lines are currently being converted into male-sterile lines and many have been intercrossed to develop a Smut-Resistant B-Composite.

This bulletin describes the progress made on the identification and utilization of smut resistance in pearl millet at ICRISAT Center from 1976 to 1990. This information should be useful in achieving sustained increase in productivity by reducing grain yield losses from smut in pearl millet.

Materials and Methods

Screening method

The standard field-screening method (Thakur et al. 1983) was followed. This involved inoculating plants at the boot-leaf stage (Fig. 1) with an aqueous sporidial suspension (ca. 10^6 sporidia mL^{-1}) of *T. penicillariae* grown on potato-dextrose agar or potato agar for 3-5 days at 30°C. The inoculated boot was immediately covered with a parchment selfing bag (Fig. 2) and high relative humidity was maintained by 30-min sprinkler irrigation twice daily on rain-free days (Fig. 3). The bags were removed 20 days after inoculation and panicles were scored for smut severity using a smut severity assessment key (Fig. 4) (Thakur and King 1988a). During the early part of our work from 1979 to 1982, in addition to ICRISAT Center (latitude 17° 26'N), screening was done at Haryana Agricultural University, Hisar (latitude 29^0 10'N) in northern India where smut occurs naturally every year in the rainy season. At this location, panicles were either artificially inoculated or simply covered with parchment selfing bags, and no sprinkler irrigation was provided. Generally, adequate levels of smut appeared (>50% on the susceptible control cultivar) to clearly discern between susceptible and resistant plants.

The number of inoculated plants varied from 10 per entry in an inbred line and progeny row to about 200 in a segregating F_2 population. Mean and range of smut severity were computed for each entry, and individual panicles and lines that showed resistance to smut (<10% severity) and good seed set were selected and advanced to the next generation for further evaluation or utilization.

Figure 1. Inoculation of boot with aqueous sporidial suspension of *T. penicillariae.*

Figure 2. Covering the boot with parchment paper selfing bag immediately after inoculation.

Figure 3. Operation of overhead sprinkler irrigation (see overhead jet) to provide high relative humidity.

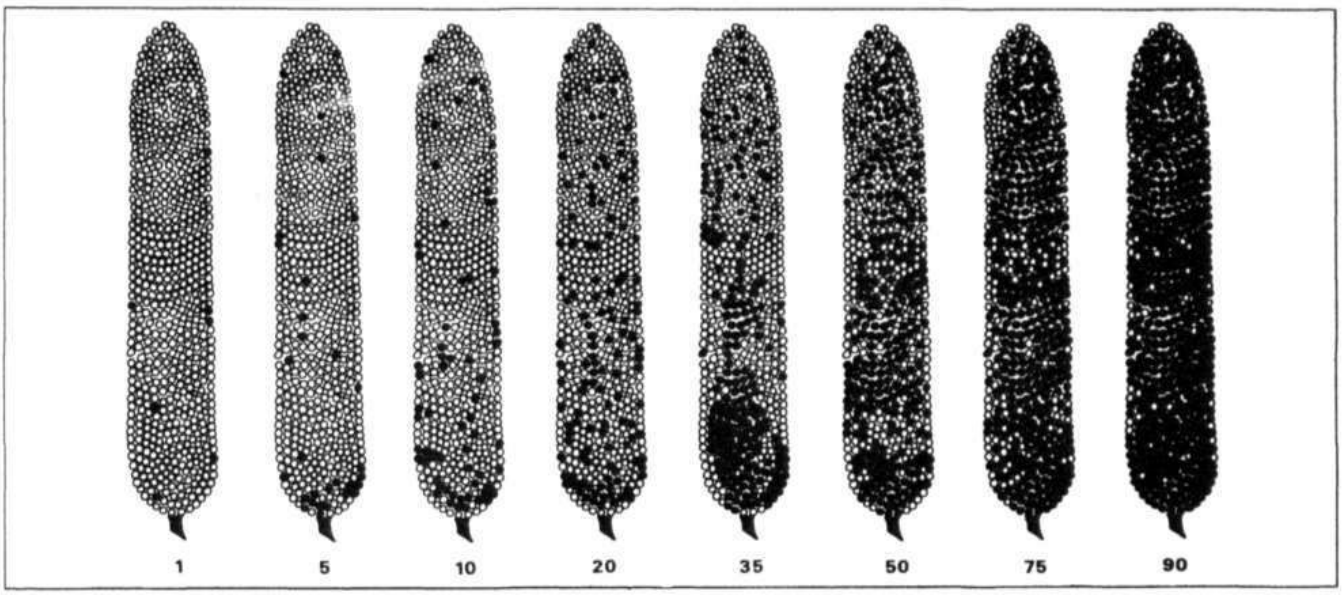

Figure 4. Smut severity rating scale used to score percentage of smut-infected florets in a panicle.

Identification and development of resistance

Various steps involved in the identification and development of smut resistance in pearl millet are shown in Figure 5.

Screening germplasm accessions

During the 1977-1986 period, 1747 germplasm accessions from 10 countries and unknown sources, obtained from ICRISAT's Genetic Resources Unit were screened (Table 1). Promising smut-resistant accessions were advanced following a pedigree approach from the seeds collected from the resistant panicles that were inoculated and bagged. These progeny lines were further advanced through the smut nursery and lines with consistently higher levels of smut resistance were identified.

Screening breeding material

More than 8960 entries from various breeding projects of ICRISAT Center and the All India Coordinated Pearl Millet Improvement Project (AICPMIP) were screened. These included hybrids, male-sterile lines, maintainer lines, pollinator lines, and open-pollinated varieties and their S_1 progenies (Table 2). Data were provided to ICRISAT breeders and AICPMIP scientists for their information.

Development of agronomically improved resistant lines

Seventy-one smut-resistant selections from 41 germplasm accessions were used to develop and select genetically diverse, agronomically superior inbred lines (Table 3). Seventeen of these were crossed with each other and with elite breeding lines having low smut susceptibility to generate 27 F_1s (Table 4). For convenience of handling, these crosses were assigned ICMPS (ICRISAT Millet Pathology Smut) numbers. These were subjected to pedigree selection for several generations in the smut nursery and a number of smut-resistant lines with consistently high levels of smut resistance and superior agronomic traits were identified. From these, 403 smut-resistant lines [designated with ICMSR (ICRISAT Millet Smut-Resistant) numbers] were evaluated at ICRISAT Center, both for disease reaction and agronomic traits. Agronomic traits considered for selection were: time to 50% flowering, panicle length, plant height, and 1000-grain mass. All lines were subjected to smut resistance screening in the smut nursery, and to downy mildew screening in the greenhouse and in the downy mildew nursery.

Multilocational testing

At various stages in the development of smut-resistant materials at ICRISAT Center, at least some materials were tested multilocationally in India and western Africa through the International Pearl Millet Smut Nursery

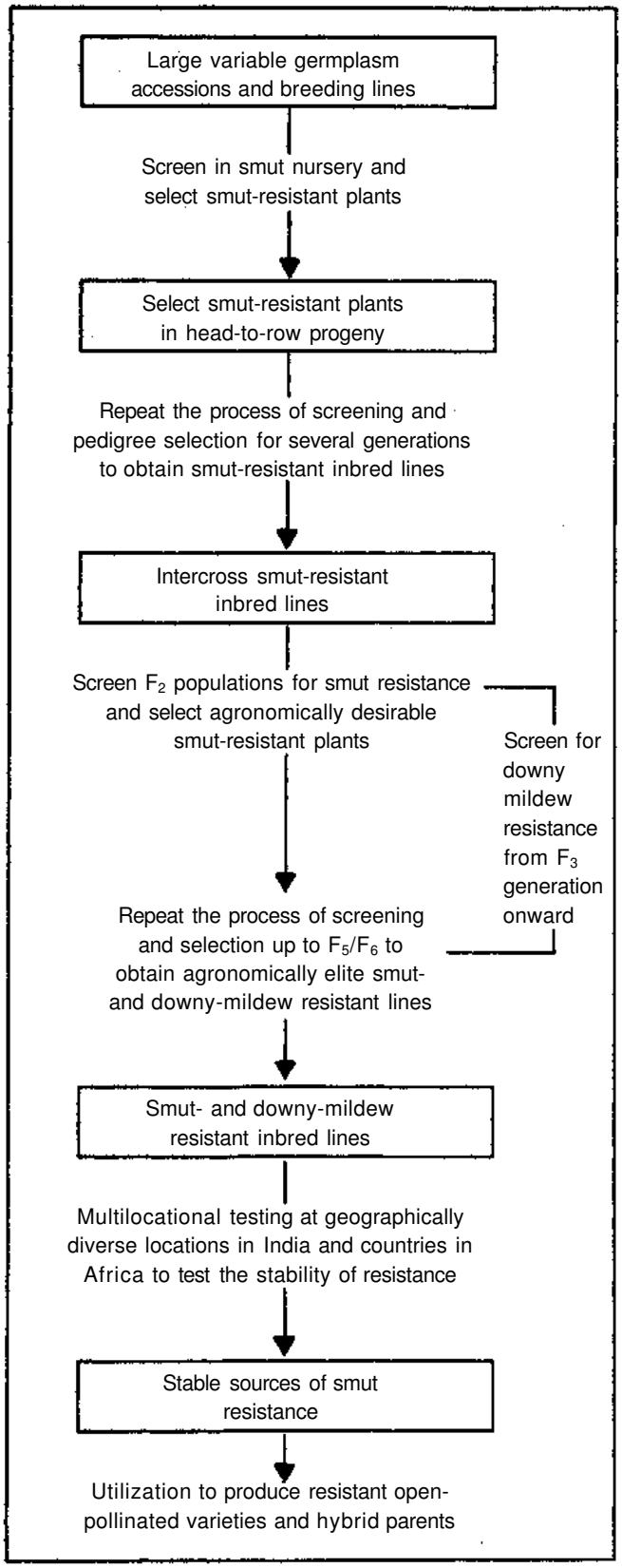

Figure 5. A generalized scheme to identify, develop, and use smut resistance in pearl millet.

(IPMSN). The test locations were generally those where smut is known to occur naturally at relatively high intensity every year. Locations in India were Gwalior, Hisar, Jamnagar, and Patancheru (under artificial inoculation), and those in western Africa were Bambey (Senegal), Kamboinse (Burkina Faso), Bengou and Sadore (Niger), and Kano and Samaru (Nigeria). These locations represent the major pearl millet-growing areas from latitude of 11° 11' N (Samaru) to 29° 10' N (Hisar) with mean maximum temperature 29° - 38° C during the rainy season.

In collaboration with plant pathologists from other research centers, about 30 entries were evaluated in the IPMSN every year from 1977 to 1987. The entries mainly included resistant lines, with two susceptible lines used as controls. Some promising entries were tested for 4-6 years to determine their stability to smut resistance across locations (environments). Some of the less promising entries were replaced by other entries every 2-3 years. In 1987 about 200 smut-resistant lines were further tested for smut reaction at Bengou, Niger.

Utilization of resistance

Smut-resistant lines have been used at ICRISAT Center to breed open-pollinated varieties and male-sterile lines.

Breeding open-pollinated varieties

The Smut-Resistant Composite (SRC) was constituted in the 1979 rainy season by recombining 37 smut-resistant lines derived from germplasm accessions. This population was carried through several cycles of recurrent selection for grain yield and smut resistance. Half-sib and S_1 progenies were screened in each cycle from C_0 to C_4 for smut resistance and grain yield, and the promising lines were recombined to increase the levels of resistance and yield in the population. Smut-resistant lines have also been introgressed into other pearl millet composites at ICRISAT Center, and about 3000 breeding lines in the recurrent selection and hybrid breeding program are now being routinely screened for smut resistance annually.

Breeding male-sterile lines

Phase I. In the first phase of the program, smut-resistant source lines were crossed with 81B, the maintainer line of a well-established male-sterile line, 81 A, which is dwarf, high-tillering, mid-late in maturity, has good general combining ability, and is currently used for the production of several commercial hybrids. A progeny derived -from a cross between 81B and a smut-resistant

source line, SRL 53, resembled 81B in general plant morphology and possessed high resistance to smut and downy mildew. It was crossed, in the 1981 dry season, with 843B, the maintainer line of 843A, which is dwarf, and is rated good for high tillering, early maturity, large seed mass, and general combining ability, but is susceptible to downy mildew. Pedigree breeding up to the F_7 generation for resistance to smut and downy mildew through screening in disease nurseries and visual selection for agronomic traits led to the identification of several promising nonrestorers (B lines). One of these was converted into a male-sterile line (ICMA 88006), which has been distributed to both public and private sector breeding programs for utilization in breeding experimental hybrids.

During 1988-1990, ICMA 88006 along with 81A, 843A, and other male-sterile lines were evaluated for grain yield and its components in replicated trials across 17 environments. It was also evaluated for downy mildew resistance in 15 trials and for smut resistance in five trials.

During the 1989 rainy season ICMA 88006 and 81A were crossed with a set of 39 restorer lines (R lines) and the hybrids produced were evaluated in replicated trials at Patancheru and Hisar to compare their general combining ability.

Phase II. In the second phase, 43 smut-resistant inbred lines derived from 22 smut resistance sources, and their hybrids produced on 843A and 843B, were evaluated for smut resistance in the 1985 rainy season to (a) examine the effect of smut resistance in one parent on smut severity of hybrids, and (b) use selected hybrids made on 843B to produce smut-resistant B-lines. Fifteen pairs of hybrids made on 843A and 843B with a diverse set of smut-resistant source lines were re-evaluated during the 1986 rainy season.

Based on good seed set under selfing, high smut resistance, and desirable agronomic traits, selfed seeds of 31 hybrids made on 843B were harvested and grown as F_2 populations in the 1986 dry season. Selection for resistance to smut, downy mildew, and improved agronomic traits continued up to F_7 when finally 55 lines from 11 initial crosses were selected. These were also topcrossed to three diverse composites to evaluate their general combining ability.

During the 1990 rainy season, 55 F_8 progenies were evaluated in a replicated yield trial at three locations (Patancheru, Gwalior, and Hisar); at Patancheru, topcrosses were evaluated in a replicated trial and testcrosses were evaluated in an unreplicated observation nursery. The F_8 progenies were also evaluated for downy mildew resistance in the disease nursery and greenhouse, and for smut resistance in the smut nursery. Based on yield and disease reactions, 37 promising progenies were selected to constitute a Smut-Resistant B-Composite, which will be improved particularly for downy mildew resistance, shorter plant height, and early maturity.

Inheritance of smut resistance

Three independent studies were conducted on the inheritance of smut resistance at ICRISAT Center. In the first study, Chavan et al. (1988) used four smut-resistant inbred lines (ICMSR 203, ICMSR 227, ICMSR 187, and ICMSR 192), and four smut-susceptible inbred lines (81B, 843B, B 282, and J 104). Diallel crosses, excluding reciprocals, were made to produce 28 F_1s. Parental lines and F_1s were evaluated in the smut nursery in a trial replicated three times during the 1986 rainy season. Smut severity data were analyzed to evaluate the general combining ability of these lines and the nature of gene action for smut resistance.

In the second study (Phookan 1987) three smut-resistant inbred lines (ICMSR 211, ICMSR 203, and ICMSR 221), and three smut-susceptible inbred lines (833B, 843B, and 834B) were crossed in a diallel fashion, excluding reciprocals. Backcross and F_2 progenies were also developed. Parental lines, F_1, F_2, and backcross progenies were evaluated in a trial replicated three times in the smut nursery during the 1987 rainy season. Smut severity data were subjected to standard statistical analyses to determine heritability and combining abilities for smut resistance.

In the third study (R.P. Thakur, unpublished), two smut-resistant inbred lines (ICMSR 186 and ICMSR 208) were crossed with two pairs of smut-susceptible A/B lines (5141A/5141B, and 81A/81B). Parental lines, F_1, F_2, and backcross progenies were evaluated in a trial in the smut nursery during the 1986 rainy season. Smut severity data were analyzed to evaluate the nature of gene action for smut resistance.

Effect of male-sterile cytoplasm on smut reaction

To determine the effect of sterile cytoplasm on smut reaction of F_1 hybrids, two smut-resistant inbred lines (ICMSR 158 and ICMSR 168) were crossed with a susceptible male-sterile line (5141A) and its maintainer line (5141B) in the 1983 dry season. The parental lines and their four crosses were evaluated during the 1983 rainy season in the smut nursery. Ten plants were inoculated in each of the three replications. Smut severity data were recorded as described earlier and subjected to standard statistical analyses.

Results and Discussion

Identification and development of smut resistance

Resistance in germplasm accessions

Of the 1747 germplasm accessions screened, 44 accessions originating from Cameroon, India, Lebanon, Mali, Niger, Nigeria, Senegal, Togo, and Uganda were resistant to smut (<10% mean smut severity) (Table 1). The geographical diversity of these resistance sources could indicate a diverse genetic base of smut resistance, although genetic studies are needed to confirm it. Several of these lines have been used to develop smut-resistant, agronomically elite lines, and also in constituting composites, especially the SRC.

Resistance in breeding material

During 1977-1990, a total of 8964 entries including open-pollinated varieties, hybrids, pollinators, male-sterile lines, and their maintainers, and population progenies from ICRISAT Center and AICPMIP trials and nurseries were screened (Table 2). A large proportion of breeding lines (65-90%) were susceptible, and hybrids and male-sterile lines were particularly more susceptible than open-pollinated varieties and male-fertile lines (Thakur et al. 1986). A great deal of variability for smut reaction was found among F_1 hybrids and pollinator lines. However, tests were often not repeated and sometimes materials were discarded because of poor agronomic performance. It would be desirable to study smut reaction of hybrids and their parental lines to understand the combining ability for smut resistance.

Smut-resistant lines with improved agronomic traits

Over several years, we identified at ICRISAT Center, 397 smut-resistant source lines designated as ICMSR lines, representing the best sources of resistance to smut (Table 5), using disease screening, breeding, and agronomic evaluation. These lines originate from a wide range of geographical regions, and represent a range of variability for agronomic attributes including time to 50% flowering (38-72 days), tillering (1-4 effective tillers per plant), panicle length (14-33 cm), plant height (80-228 cm), and 1000-grain mass (4.3-10.7 g). They generally show moderate to high levels of resistance to downy mildew also (Tables 5 and 6). However, evaluation of these lines was limited to ICRISAT Center, and agronomic expression and reaction to downy mildew could differ considerably at other locations.

The ICMSR lines with moderate to high levels of downy mildew resistance (<10% mean incidence) and above-average grain mass (>6.5g 1000^{-1} seeds) have been divided into different groups based on various agronomic attributes. This should enable easier identification of lines having specific combinations of agronomic attributes for time to 50% flowering, panicle length, and plant height (Table 6).

Identification of stable resistance

Multilocational testing in the IPMSN led to the identification of several lines as good sources of stable resistance to smut. Twelve of these lines showed high levels of smut resistance (mean severity of <l-3% compared with 54% severity in the susceptible control) during the 1983-86 IPMSN testing at locations in India, Niger, Nigeria, and Senegal (Table 7). These lines also showed high resistance to downy mildew (<l-4% incidence compared with 32% in the susceptible controls) in the Indian locations.

Several other lines derived from germplasm accessions also showed stable resistance and six of these were notified by the ICRISAT Plant Material Identification Committee (Table 8). These lines were subsequently registered in Crop Science (Thakur and King 1988b). As sources of stable resistance, they represent material most likely to provide durable resistance in hybrids and open-pollinated varieties.

Of the 397 smut-resistant lines identified at ICRISAT Center, 205 were also tested at Bengou, Niger, in 1987 and >90% of these lines were found resistant (<10% mean smut severity compared with >60% mean severity in the susceptible controls). These results, along with the results of multilocational testing in the IPMSN for more than 10 years, indicate that smut resistance identified at ICRISAT Center, using the standard screening technique (Thakur et al. 1983), is generally effective at other locations also. They also suggest that there is little evidence to indicate geographical variability for virulence in the pathogen populations.

Utilization of resistance

Smut-resistant lines are being used at ICRISAT Center to breed open-pollinated varieties and hybrid parents.

Breeding open-pollinated varieties

From the SRC, initiated in 1979, several smut-resistant varieties have been developed (Table 9). One of these, ICMV 82132 showed resistance to both smut and downy mildew, outyielding the released variety ICMV 1 (WC-C75) in the 1984 International Pearl Millet Adaptation Trial (IPMAT) and in the AICPMIP trials over 2-3 years. This variety also performed well in several tests and was released as 'Kaufela' in Zambia in 1989, and as IKMV 8201 in Burkina Faso, for cultivation by farmers (ICRISAT 1992). Several synthetic varieties have also been developed, and two of these, ICMS 8282 and ICMS 8283, have yields equivalent to the controls WC-C75, ICMS 7703, and BJ 104, and have good smut and downy mildew resistance (Andrews et al 1985, ICRISAT 1985). Inbred lines derived from the SRC have been introgressed in other composites at ICRISAT Center to increase their levels of smut resistance. In addition to the SRC, good levels of smut resistance have been incorporated into the Medium Composite and the New Elite Composite (ICRISAT 1985).

Breeding male-sterile lines

ICMA 88006 is the first pearl millet male-sterile line which is highly resistant to smut (mean severity 5%) and downy mildew (mean incidence 6%) compared with 81A (mean smut severity 44% and mean downy mildew incidence 18%) and 843A (mean smut severity 39% and mean downy mildew incidence 28%) (Table 10). The average grain yield of ICMA 88006 across 17 trials was 1.9 t ha^{-1} (5% less than 81A and 10% more than 843A). ICMA 88006 is a dwarf, large-seeded, and early-flowering line which produces high-yielding hybrids. Interestingly, ICMA 88006 has larger seed mass (12.3g 1000^{-1}) than 843A (10.8g 1000^{-1}).

Breeding B lines

Forty-seven of the 53 highly resistant (<1% smut severity) progenies developed during the second phase of the B-line breeding program, outyielded 8IB by a significant margin. Based on resistance to downy mildew, smut, grain yield, and other agronomic traits, 12 superior progenies were identified (Table 11). The best five lines from these are being converted into male-sterile lines. Forty-seven lines have been random-mated to make a Smut-Resistant B-Composite. This composite will be improved by recurrent selection for downy mildew resistance, short plant height, and early maturity.

Inheritance of smut resistance

In the first study (Chavan et al. 1988), all the crosses involving both resistant parents were, in general, less susceptible (<1% mean severity) than those involving one or both susceptible parents. Inheritance of smut resistance was dominant or partially dominant with both additive and nonadditive gene effects. The second study (Phookan 1987), involving three resistant and three susceptible inbred lines, indicated that both additive and dominance components were significant, dominance was partial, and heritability of resistance was high. The third study (R.P. Thakur, unpublished), involving four susceptible and two resistant inbred lines, showed resistance to be dominant with additive gene effects. The results also indicated higher susceptibility of cytoplasmic male-sterile lines and their hybrids than their corresponding maintainer lines and hybrids.

All the three studies clearly indicated that smut resistance was under the control of both additive and nonadditive effects and that dominance was either partial or complete. Heritability of resistance was high. This suggests that transfer of resistance from a stable resistance source to breeding lines will be easy, and because of additive gene effects there is a good possibility of increasing the levels of smut resistance in populations through recurrent selection.

Effect of male-sterile cytoplasm on smut reaction

Fifteen smut-resistant lines and their hybrids based on 843A and 843B were evaluated for smut resistance during the 1986 rainy season. The results indicated that hybrids based on 843A had greater smut severity than those based on 843B with the mean susceptibility of hybrids based on 843A being about four-fold greater than those based on 843B (Fig. 6). The higher susceptibility of 843 A hybrids could be due to their lower fertility restoration. All the smut-resistant source lines used as pollinators had <1% smut severity; 843A had 72% and 843B had 34% severity. However, in hybrids based on 843A, the mean smut severity was 13% with a range of <1—77% indicating that high smut resistance level in one of the parents may be adequate, in many cases, to produce highly smut-resistant hybrids on 843A.

In another study, two smut-resistant lines, ICMSR 158 and ICMSR 168, remained free from smut while 5141A developed 91% and 5141B 90% smut severity (Table 12). However, the F_1s of 5141A with ICMSR 158 and ICMSR 168 showed significantly higher smut severities (25-35%) than those of 5141B with ICMSR 158 and ICMSR

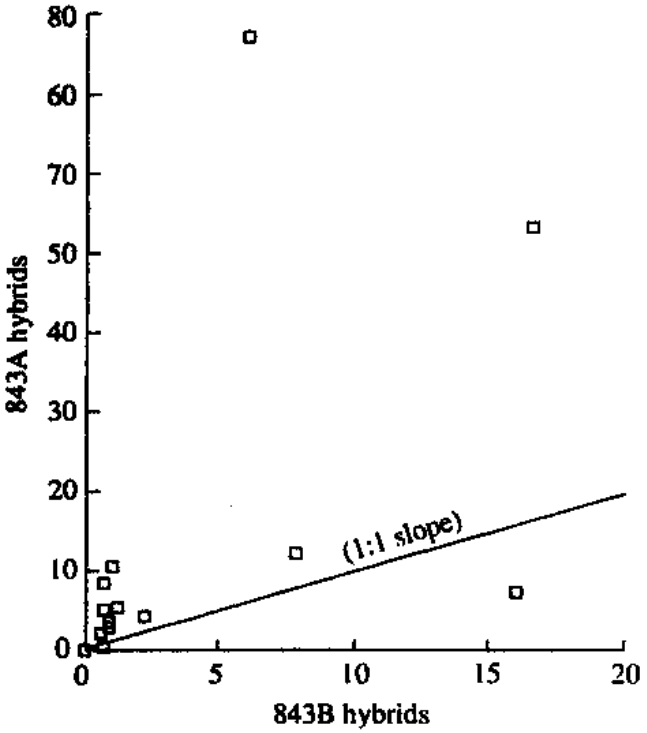

Figure 6. Smut severity relationships between hybrids based on 843A and those based on 843B including a common set of 15 smut-resistant lines.

168 (7-9%). The results again suggest that although there may be no significant difference between A and B lines for smut susceptibility, F_1 hybrids based on an A line are consistently more susceptible than those based on a B line. This suggests the existence of substantial cytoplasmic x nuclear interaction for smut susceptibility in the hybrids. The results of an inheritance study using cytoplasmic male-sterile lines (see above section) also support this conclusion. Higher smut susceptibility of A-line hybrids could also be due to lower fertility restoration in hybrids on A lines than those on B lines. Pollen shed in F_1 hybrids based on male-sterile lines has generally been observed to be much less than those based on male-fertile lines (C.T. Hash, ICRISAT, personal communication, 1990).

A more detailed study to confirm these results is needed. In the case of ergot disease of pearl millet, caused by *Claviceps fusiformis,* the positive influence of cytoplasmic male sterility and flowering event factors on susceptibility of F_1 hybrids has been demonstrated (Thakur et al. 1989,1991).

The smut-resistant source lines (ICMSR lines) described in this bulletin are selections from germplasm originating from diverse ecogeographical regions of pearl millet-growing areas in the semi-arid tropics. These provide perhaps the best available sources of resistance with diverse genetic bases in reasonably good agronomic back grounds for resistance breeding programs. A large number of these lines possess a fairly good level of resistance to downy mildew also. This makes their utilization easier and more attractive in disease resistance breeding programs. Information on inheritance of resistance, though not complete, reasonably indicates a high heritability and predominantly additive gene action, suggesting that selection efficiency for smut resistance could be quite high. This is clearly indicated by the high success rate of breeding smut-resistant, male-sterile lines and open-pollinated varieties, and improving the levels of smut resistance in several populations of pearl millet at ICRISAT Center. Information on smut-resistant lines is presented (Table 6) in a way that enables breeders to identify resistance sources in specific agronomic backgrounds. This information will be useful to breeders and other scientists in their smut resistance breeding programs. Seeds of these lines are maintained at ICRISAT Center and small quantities are available on request.

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Table 1. A summary of pearl millet genetic resource accessions screened for smut resistance, ICRISAT Center, 1977-86.

Country of origin	No. of accessions	
	Screened	Resistant[1]
Cameroon	40	4
India	684	12
Lebanon	15	1
Mali	90	8
Niger	390	2
Nigeria	216	10
Senegal	119	4
Togo	126	1
Uganda	37	2
USSR	7	0
Others	23	0
Total	1747	44

1. <10% mean smut severity; based on initial screening of 10 plants per line.

Table 2. Screening of 8964 pearl millet breeding materials from ICRISAT and All India Coordinated Pearl Millet Improvement Project (AICPMIP) for smut resistance, ICRISAT Center, 1977-90.

Year screened	ICRISAT					AICPMIP			
	IPMAT[1]	Hybrids	Populations	Pollinators	Inbreds	Hybrids	Populations	Pollinators	A/B[2] lines
1977	21	100	735	-[3]	-	-	-	-	-
1978	21	74	177	-	30	-	-	-	-
1979	21	27	654	25	23	-	-	-	-
1980	21	194	181	-	-	45	28	-	-
1981	21	-	25	-	-	38	36	-	-
1982	-	25	65	25	247	40	32	-	-
1983	-	-	-	-	-	37	37	20	-
1984	-	-	-	-	123	61	53	-	4
1985	20	-	-	-	-	63	54	-	-
1986	21	-	340	684	-	81	52	26	9
1987	24	-	836	980	-	91	33	42	48
1988	18	-	-	-	-	81	49	28	16
1989	.	-	1416	278	-	100	34	30	60
1990	-	-	-	-	-	85	50	12	37
Total	188	420	4429	1992	423	722	458	158	174

1. IPMAT = International Pearl Millet Adaptation Trial.
2. A/B = Male-sterile and maintainor lines.
3. - = Not included for screening.

Table 3. Origins of smut-resistant pearl millet selections.

Origin/Pedigree[1]	Origin/Pedigree[1]	Origin/Pedigree[1]
Cameroon	Mali	Nigeria
P l0-S-l	P 455-S-1	EB 117-2-1
P 18-S-1	P 455-S-2	EB 132-2
P 19-S-1	P 455-S-2-3	EB 137-1-1
P 20-S-1	P 483-S-1	EBS 137-2
	P483-S-2	EB 209-1-6
India		
J 703-1-S-l	P 489-S-1	EB 229-4
J 797-1-S-3	P 489-S-1-5-1-4	EB 237-3-1
1 1974-S-2-3	P 489-S-1-5-7	WC FS 135
J 2222-S-1-3	P 489-S-2	WC FS 139
J 2226-S-l-l-DM-1	P 489-S-2-5-6-3	WC FS 151-1-1
	P 489-S-2-5-7	SSC FS 252
ICI 7517-S-1	P 489-S-2-8-1	SDS FS 40
ND 2282-79-1-S-1-1-DM-l	P489-S-2-10	SDS FS 135
ND 2282-79-1-S-3-4	P 489-S-2-10-1-3	700130-S-1-DM-l
ND2282-79-l-S-6-l-DM-l	P489-S-2-10-5	700479-S-6-1-DM-1
ND 2282-79-1-S-10-1-DM-1		700713
	P 489-S-2-11	
IP 2253-S-1	P 489-S-2-13	Togo
IP 2789-S-1	P 489-S-2-13-5	
IP 2789-S-2-DM-1		Togo 29-9-2-1
NW 1-10-1-S-4-2-2-1	P 489-S-3	
SAR 466-S-1-DM-1	P 489-S-3-1	
	P 489-S-3-1-3-1	
Lebanon		
NEP 588-5690-S-8-3	P 489-S-3-1-3-4	
NEP 588-5690-S-8-5	P 489-S-3-7	
NEP588-5690-S-8-6	P 489-S-3-7-2-2	
	P 492-S-1	
	P 494-S-1	
Mali		
	Niger	
P 250-S-2		
P 427-S-1	P 2594-S-2	
P 427-S-2		
P 446-S-1		
P 446-S-2		

1. Lines were screened and selected for smut resistance (S) and downy mildew resistance (DM) in the downy mildew screening nursery.

Table 4. Twenty-seven crosses, involving smut-resistant selections and agronomicaily elite breeding lines, designated as ICRISAT Millet Pathology Smut (ICMPS) numbers.

ICMPS no.	Pedigree
ICMPS 100[1]	[(J 1623 x WC 6-3) x EB 237-3-1]
ICMPS 200[1]	[EBS 137-2 x (J 1623 x WC 6-3)]
ICMPS 300	[WC FS 135 x SSC FS 252]
ICMPS 400	[SDS FS 135 x SSC FS 252]
ICMPS 500	[EB 137-1-1 XWC FS 139]
ICMPS 600	[EB 137-1-1 X SSC FS 252]
ICMPS 601	[SSC FS 252 x EB 137-1-1]
ICMPS 700	[EB 137-1-1 x EB 132-2]
ICMPS 800	[EB 137-1-1 x EB 209-1-6]
ICMPS 900	[EB 137-1-1 x EB 117-2-1]
ICMPS 1000	[EB 137-1-1 x SDS FS 40]
ICMPS 1100	IEB 137-1-1 x SDS FS 135]
ICMPS 1200	[EB 117-2-1 x SSC FS 252]
ICMPS 1300	[EB 117-2-1 x SDS FS 40]
ICMPS 1400	[IP 2253 x EB 237-3-1]
ICMPS 1500	[EB 237-3-1 x SSC FS 252]
ICMPS 1600[1]	[EB 237-3-1 x 111 B]
ICMPS 1700[1]	[EB 132-2 x (70-1 x 700594-5-1)]
ICMPS 1800[1]	[EB 132-2 x (J 25-1 x 700797-1-5-2)]
ICMPS 1900[1]	[EB 237-3-1 x (B 282 x J 804-1-21-2)]
ICMPS 2000[1]	[EB 237-1-1 x (J 934-7 x 700797-19-1-5)]
ICMPS 2100[1]	[SSC FS 252 x EB 24-1]
ICMPS 2200[l]	[EC 298-3 x 700130-S-l]
ICMPS 2300	[(ICI 7517-S-l x WC FS 151-1-1)-DM-l]
ICMPS 2400	[(ICI 7517-S-l x SSC FS 252-S-4)-DM-l]
ICMPS 2500	[(ICI 7517-S-1 x P-10-S-1)-DM-1]
ICMPS 2600	[(ICI 7517-S-l x EB 229-4-1-S-6-1)-DM-1]

1. Cross between smut-resistant and elite breeding lines.

Table 5. Pedigrees, agronomic characters[1], and disease reactions of smut-resistant lines derived from germplasm accessions and crosses involving smut-resistant derivatives of germplasm and/or breeding lines.

Identity	Pedigree	Time to 50% flower-ing (days)	Tillers/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut seve-rity (%)	DM[2] inci-dence (%)
ICMSR 001	JP 2253-S-1	55	2.6	24	153	9.2	3	1
ICMSR 002	IP 2789-S-2	51	1.6	20	157	8.0	0	24
ICMSR 003	IP 2789-S-2-DM-1	53	2.0	19	159	6.6	7	6
ICMSR 004	J 703-1-S-1	48	3.8	18	154	6.8	3	3
ICMSR 005	J 797-1-S-3	46	2.0	26	140	7.5	<i	1
ICMSR 006	J 1974-S-2-3	47	1.4	28	207	6.9	5	9
ICMSR 009	J 2222-S-1-3	47	1.2	33	183	5.8	10	32
ICMSR 010	J 2226-S-1-1-DM-I	45	2.6	26	143	6.2	<1	5
ICMSR 012	ND 2282-79-1-S-1-1-DM-1	62	2.2	19	158	6.9	1	3
ICMSR 013	ND 2282-79-1-S-3-4	51	1.2	20	179	6.1	<1	1
ICMSR 014	ND2282-79-1-S-6-1-DM-1	56	3.0	18	152	8.5	3	6
ICMSR 016	ND 2282-79-1-S-10-1-DM-1	49	2.6	26	171	7.1	2	2
ICMSR 018	NEP 588-5690-S-8-3	56	1.2	28	189	5.7	2	16
ICMSR 020	NEP 588-5690-S-8-5	58	1.6	27	167	7.3	0	1
ICMSR 021	NEP 588-5690-S-8-6	53	1.2	23	141	8.2	9	6
ICMSR 023	P 18-S-I	63	2.6	21	122	7.2	2	18
ICMSR 024	P 19-S-I	60	1.4	26	181	7.1	6	8
ICMSR 025	P 20-S-1	46	1.4	26	164	7.1	6	5
ICMSR 026	P 250-S-2	55	1.0	22	186	8.8	0	9
ICMSR 027	P 427-S-1	56	1.2	21	180	6.4	0	1
ICMSR 028	P 427-S-2	47	1.0	22	197	7.9	1	0
ICMSR 029	P 446-S-1	56	1.0	23	151	9.2	<1	4
ICMSR 030	P 446-S-2	58	1.0	17	122	8.0	<1	3
ICMSR 031	P 455-S-I	58	1.6	20	173	7.9	2	16
ICMSR 032	P 455-S-2	59	1.0	20	164	9.1	<1	23
ICMSR 033	P 455-S-2-3	59	1.2	20	152	6.9	9	0
ICMSR 034	P483-S-1	55	1.0	18	142	8.3	<1	5
ICMSR 035	P 483-S-2	47	1.0	14	112	5.9	<1	1
ICMSR 036	P489-S-1	58	1.4	21	155	5.7	0	0
ICMSR 037	P 489-S-1-5-1-4	56	1.2	15	124	6.8	1	4
ICMSR 038	P 489-S-1-5-7	53	1.0	19	154	6.3	0	2
ICMSR 039	P 489-S-2	55	1.2	20	190	8.0	0	0
ICMSR 040	P 489-S-2-5-6-3	56	1.0	18	166	5.3	0	10
ICMSR 041	P 489-S-2-5-7	41	1.2	17	166	7.1	0	2
ICMSR 042	P 489-S-2-8-1	48	1.4	21	187	5.4	0	5
ICMSR 043	P 489-S-2-10	50	1.2	19	145	7.9	0	4
ICMSR 044	P 489-S-2-10-1-3	58	1.8	21	175	6.0	0	0
ICMSR 045	P 489-S-2-10-5	56	1.0	21	185	7.1	0	3
ICMSR 046	P 489-S-2-11	52	1.0	19	176	6.4	0	0
ICMSR 047	P 489-S-2-13	50	1.8	18	184	8.2	0	16

Continued....

Table S. ***Continued.***

Identity	Pedigree	Time to 50% flower-ing (days)	Tillers/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass(g)	Smut seve-rity (%)	DM[2] inci-dence (%)
ICMSR 048	P 489-S-2-13-5	48	1.2	25	186	7.4	9	0
ICMSR 049	P 489-S-3	52	1.0	19	200	7.1	0	0
ICMSR 050	P 489-S-3-1	53	1.0	18	167	6.8	0	3
ICMSR 051	P489-S-3-1-3-1	56	1.0	16	165	7.2	0	5
ICMSR 052	P 489-S-3-1-3-4	49	1.0	17	151	*6.1*	0	7
ICMSR 053	P 489-S-3-7	49	1.0	22	204	6.8	0	0
ICMSR 054	P489-S-3-7-2-2	49	1.0	23	192	7.9	0	1
ICMSR 055	P 492-S-1	48	1.8	28	188	8.4	0	2
ICMSR 056	P 494-S-1	49	1.0	16	199	9.0	<1	6
ICMSR 057	P 2594-S-2	50	1.0	18	208	7.9	0	1
ICMSR 059	SAR 466-S-1-DM-1	59	1.0	23	228	8.1	3	6
ICMSR 060	700130-S-I-DM-I	50	2.4	16	127	7.6	1	3
ICMSR 061	700479-S-6-1-DM-1	46	1.0	21	197	7.0	<1	13
ICMSR 062	EB 7-2-3-S-1	45	1.4	24	181	6.2	3	23
ICMSR 063	EB 7-2-3-S-3	59	1.6	17	158	5.4	5	11
ICMSR 064	EB 7-2-3-S-4	49	1.8	20	182	7.5	2	25
ICMSR 065	EB 15-1-S-3-1	53	1.2	22	149	5.6	1	6
ICMSR 067	EB 24-1-S-2-2-DM-1	46	1.0	15	165	8.8	0	8
ICMSR 068	EB 24-1-S-5	50	1.8	29	199	7.6	1	5
ICMSR 069	EB 54-1-1-S-2-1-DM-1	53	1.8	24	173	7.1	6	0
ICMSR 070	EB 54-1-1-S-7-3	53	1.2	23	186	5.2	7	1
ICMSR 071	EB 54-1-S-7-3	59	2.4	26	201	6.2	4	1
ICMSR 072	EB 58-3-S-2	41	2.0	25	158	6.1	10	20
ICMSR 073	EB 59-1-3-S-1-1	50	1.4	23	142	7.5	5	0
ICMSR 074	EB 66-1-S-3-3	58	1.4	31	199	7.6	<1	3
ICMSR 075	EB 66-1-S-5-DM-1	60	2.0	23	207	7.2	<1	4
ICMSR 076	EB 74-3-S-1	57	1.0	22	177	7.7	3	4
ICMSR 077	EB 74-3-S-1-6	41	2.6	19	151	10.0	1	27
ICMSR 078	EB 80-1-1-S-5	59	2.0	25	171	7.4	3	35
ICMSR 079	EB 106-2-1-S-5	48	2.0	21	154	9.5	6	2
ICMSR 080	EB 106-2-1-S-6	41	3.4	18	139	10.0	4	12
ICMSR 081	EB 112-1-S-I-I	47	1.2	18	174	6.0	0	0
ICMSR 082	EB 116-1-1-S-3-1-DM-1	47	1.8	26	205	7.2	<1	3
ICMSR 083	EB 116-1-1-S-4-1-DM-1	46	1.8	23	173	10.1	1	3
ICMSR 084	EB 116-1-1-S-4-3	52	1.8	23	162	6.9	3	1
ICMSR 085	EB 116-1-1-S-7-DM-1	60	2.2	27	207	7.7	1	5
ICMSR 086	EB 117-2-1-S-1-3	49	2.2	26	194	8.0	3	2
ICMSR 087	EB 117-2-1-S-2-3	59	1.4	22	168	7.1	<1	8
ICMSR 088	EB 117-4-3-S-2-2-DM-1	54	1.2	26	178	7.1	<i	3
ICMSR 089	EB 117-2-1-S-2-2-DM-1	59	1.2	29	195	7.0	<1	0

Continued...,

Table 5. Continued.

Identity	Pedigree	Time to 50% flower-ing (days)	Tillers/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut seve-rity (%)	DM[2] inci-dence (%)
ICMSR 090	EB 117-2-1-S-6-DM-1	58	1.4	27	158	6.0	<1	1
ICMSR 091	EB 119-2-1-S-4-2-DM-1	67	1.2	30	224	7.1	1	2
ICMSR 092	EB 132-2-S-4-2	58	1.6	25	189	7.4	2	12
1CMSR 093	EB 132-2-S-4-4	51	1.0	19	196	7.1	1	11
ICMSR 094	EB 132-2-S-5-2	57	3.6	24	163	7.3	0	8
ICMSR 095	EB 132-2-S-5-2-DM-1	41	2.4	23	158	7.3	<1	14
ICMSR 096	EB 137-1-1-S-1-DM-1	51	1.8	27	166	8.0	<1	25
ICMSR 097	EB 137-1-1-S-6-2-DM-1	58	1.6	25	173	9.0	1	6
ICMSR 098	EB 137-1-1-S-8	59	1.4	29	186	8.8	<1	10
ICMSR 099	EB 137-1-2-S-1-1-DM-1	55	1.2	30	183	8.9	0	13
ICMSR 100	EB 137-1-2-S-3	49	1.2	22	168	8.8	<1	0
ICMSR 101	EB 137-1-2-S-3-2-DM-1	49	1.0	25	207	7.1	<1	8
ICMSR 102	EB 137-2-S-l	58	1.0	28	163	10.2	0	9
ICMSR 103	EB 137-2-S-2-2-DM-1	53	1.0	26	203	6.6	0	2
ICMSR 104	EB 137-2-S-2-2-DM-1-8-3	41	1.0	20	154	7.1	0	0
ICMSR 105	EB 137-2-S-5-2-DM-1	53	1.0	28	138	7.2	2	6
ICMSR 106	EB 137-2-S-7-1-DM-1	45	1.6	31	179	8.3	<1	6
ICMSR 107	EB 142-1-l-S-2-1	50	1.8	23	153	6.8	3	19
ICMSR 108	EB 147-1-3-S-l-l	59	2.8	22	179	7.3	4	3
ICMSR 109	EB 148-1-S-2-2	*58*	1.2	24	176	7.3	3	9
ICMSR 110	EB 170-1-1-S-1-2	52	1.4	22	149	7.6	3	3
ICMSR 111	EB 170-2-S-1-3	56	2.2	25	173	7.1	3	10
ICMSR 113	EB 188-2-3-S-1-DM-1	41	1.6	27	178	7.9	1	12
ICMSR 114	EB 209-1-6-S-4-1	57	1.0	22	168	6.6	<1	6
ICMSR 116	EB 209-1-6-S-4-1-DM-1	51	1.6	24	158	6.0	<1	6
ICMSR 118	EB 209-1-6-S-7	60	1.0	23	166	8.9	0	16
ICMSR 119	EB 218-1-S-2	53	1.0	19	184	6.2	<1	14
ICMSR 121	EB 218-3-2-S-4-1-DM-1	51	1.0	20	174	7.6	1	8
ICMSR 122	EB 229-4- 1-S-l -DM-1	48	2.2	24	169	7.8	7	2
ICMSR 123	EB 229-4-1-S-6-1	51	1.8	23	166	6.5	<1	8
ICMSR 124	EB 229-4-1-S-7-3-DM-1	52	1.4	18	178	5.5	0	18
ICMSR 125	EB 237-1-S-2-1-DM-1	48	2.4	27	197	5.5	1	0
ICMSR 126	EB 237-2-S-3	50	1.2	28	181	8.2	3	12
ICMSR 127	EB 237-2-S-5-2-DM-1	49	2.2	26	182	8.4	<1	0
ICMSR 128	EB237-3-1-S-2	57	1.2	27	180	8.0	3	11
ICMSR 129	EB 237-3-4-S-l	46	1.2	26	168	8.6	<1	5
ICMSR 130	EB 239-1-1-S-2	41	2.6	23	157	7.6	9	6
ICMSR 133	EBS 70-1-S-4	41	3.4	17	132	*8.6*	0	12
ICMSR 134	EBS 70-1-S-4-3	62	2.0	22	177	7.5	2	14
ICMSR 135	EBS 87-2-2-S-1	45	1.4	23	154	7.5	1	5

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 136	EBS 119-2-1-S-1-1	51	1.6	21	168	8.9	1	17
ICMSR 137	EBS 119-2-1-S-3-1-DM-1	49	2.0	28	167	7.8	1	0
ICMSR 138	EBS 137-2-S-1-DM-1	67	1.4	31	196	7.9	<1	41
ICMSR 139	F4 FC 1173-1-3	41	1.4	26	170	8.0	0	23
ICMSR 140	F4 FC 1173-1-3-S-1	46	1.6	22	180	7.5	<1	43
ICMSR 141	F4 FC 1173-1-8-S-1	46	1.8	21	147	9.4	<1	9
ICMSR 142	F4 FC 1196-3-1-S-1	46	2.8	29	154	7.2	0	13
ICMSR 143	F4 FC 1258-5-2-S-1	49	2.0	24	142	8.0	<1	0
ICMSR 144	F4 FC 1285-1-S-1	45	2.2	21	147	5.5	<1	5
ICMSR 145	F4 FC 1285-2-2-S-1	46	2.0	21	143	6.0	0	7
ICMSR 146	F4 FC 1285-2-3-S-1	58	2.4	26	153	7.6	0	18
ICMSR 147	F4 FC 1285-8-3-S-1	55	1.6	27	184	7.2	<1	13
ICMSR 148	F4 FC 1285-8-7-S-1	52	1.6	26	185	7.0	2	12
ICMSR 149	F4 FC 1291-2-3-S-1	49	2.6	20	163	6.6	<1	0
ICMSR 150	F4 FC 1474-2-1-S-1-DM-1	49	1.6	27	163	8.5	<1	3
ICMSR 151	F4 FC 1536-3-4-S-1	58	2.8	26	169	7.5	0	0
ICMSR 152	F4 FC 1536-6-3-S-1	56	1.4	19	168	7.7	1	25
ICMSR 153	GAM '75 BULK-S-1-3	57	2.2	27	192	8.8	0	0
ICMSR 154	GAM '75 BULK-S-3-1-DM-1	60	2.0	19	157	7.7	0	4
ICMSR 155	ICI 7516-S-2-5	48	1.2	16	127	5.3	0	9
ICMSR 156	ICI 7516-S-2-6	41	1.6	18	107	8.9	0	7
ICMSR 157	ICI 7516-S-2-7	39	1.6	16	107	7.3	0	37
ICMSR 158	ICI 7517-S-1	57	2.4	29	110	8.0	0	16
ICMSR 160	MC FS 171-S-1-3	50	1.8	21	154	8.7	<1	24
ICMSR 161	MC FS 179-S-1	56	2.6	17	145	9.1	1	19
ICMSR 162	MC FS 179-S-1-4-DM-1	56	1.4	17	140	6.9	0	13
ICMSR 163	MC FS 188-S-1	48	1.6	15	136	5.9	1	23
ICMSR 164	MLC SN 75-1-6-S-1	58	1.4	22	133	7.4	0	20
ICMSR 165	SC-2(M)2-12-S-3-3	48	1.2	26	184	5.2	<1	3
ICMSR 166	SDS FS 127-S-1-3	60	1.4	19	134	8.4	0	8
ICMSR 167	SSC FS 137-6-1-DM-1	45	1.0	25	189	9.1	1	5
ICMSR 168	SSC FS 252-S-4	57	1.0	26	188	7.6	0	0
ICMSR 169	UBI 7528-S-1-DM-1	45	1.0	21	201	8.9	<1	16
ICMSR 170	WC FS 42-S-1-2-DM-1	58	1.8	20	143	8.4	3	25
ICMSR 171	WC FS 82-S-3-2	57	1.2	31	179	7.8	2	1
ICMSR 172	WC FS 88-S-4-2	52	1.2	24	173	5.8	3	5
ICMSR 173	WC FS 88-S-5-5	48	1.0	26	176	9.4	1	0
ICMSR 174	WC FS 109-S-1-2	57	1.6	24	228	7.4	2	12
ICMSR 175	WC FS 142-S-1-1	51	1.6	18	139	8.0	1	10
ICMSR 176	WC FS 148-S-1	54	1.0	16	156	6.1	1	2

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 177	WC FS 151-S-1-1	49	1.0	25	170	7.0	1	5
ICMSR 178	WC FS 151-S-1-2-DM-1	58	1.2	21	165	7.7	<1	0
ICMSR 179	WC FS 151-S-1-2-DM-1-8	72	1.8	31	188	8.3	0	1
ICMSR 180	WC FS 178-S-2	45	2.2	17	177	6.0	<1	10
ICMSR 181	WC FS 346-S-2-2-DM-1	55	2.8	19	183	8.5	<1	4
ICMSR 182	WC FS 346-S-8	45	1.8	31	181	7.8	8	6
ICMSR 183	WC FS 346-S-8-3	53	1.6	21	155	7.1	<1	11
ICMSR 184	3/4 EB 43-S-1-1-DM-1	46	1.8	18	156	6.4	<1	6
ICMSR 185	3/4 EB 68-S-4-1-DM-1	45	3.2	17	174	5.9	<1	8
Developed entries								
ICMSR 186	ICMPS 100-5-1	48	2.4	18	155	6.3	0	4
ICMSR 187	ICMPS 200	46	1.0	23	148	7.3	0	0
ICMSR 188	ICMPS 200-5-5-5	43	3.2	23	156	7.9	0	3
ICMSR 189	ICMPS 300-2-1-5	48	1.4	20	140	5.8	0	3
ICMSR 190	ICMPS 300-3-4-3-2	58	2.0	20	126	9.7	0	1
ICMSR 191	ICMPS 400-5-4-3	45	3.2	24	173	6.8	<1	6
ICMSR 192	ICMPS 500-4-4-3	50	1.0	21	135	6.3	<1	4
ICMSR 193	ICMPS 600-1-3-2-2	56	1.2	26	140	5.0	0	45
ICMSR 194	ICMPS 600-1-3-5-5	54	1.4	26	148	7.6	<1	21
ICMSR 195	ICMPS 600-3-2-1	53	1.2	23	161	8.6	<1	65
ICMSR 196	ICMPS 600-5-1-1-5	56	1.4	23	148	6.4	0	70
ICMSR 197	ICMPS 600-5-1-6-2	56	1.6	25	155	8.0	0	5
ICMSR 198	ICMPS 601-6-1-4	51	1.2	20	184	6.2	<1	6
ICMSR 200	ICMPS 601-6-3-1	50	2.2	23	163	7.7	1	1
ICMSR 201	ICMPS 601-6-6-3	51	1.0	24	135	6.4	0	1
ICMSR 202	ICMPS 601-7-1-2	56	1.2	26	175	7.7	<1	1
ICMSR 203	ICMPS 700-1-5-4	41	1.6	21	161	7.4	0	14
ICMSR 204	ICMPS 800-3-1	45	2.0	21	159	7.5	6	23
ICMSR 205	ICMPS 900-1-4-1	51	1.6	21	102	6.8	<1	12
ICMSR 206	ICMPS 900-2-7-3-2	56	1.6	23	176	7.3	0	7
ICMSR 207	ICMPS 900-3-1	48	2.0	27	114	7.8	<1	3
ICMSR 208	ICMPS 900-9-3	45	1.4	21	144	5.7	0	2
ICMSR 209	ICMPS 900-5-4-3-2	54	1.6	24	136	7.2	0	5
ICMSR 210	ICMPS 900-9-1-2-2	45	2.4	20	133	4.3	0	6
ICMSR 211	ICMPS 900-9-3-2-2	56	2.0	23	137	5.6	0	8
ICMSR 212	ICMPS 900-9-3-2-4	56	2.0	22	161	7.9	0	3
ICMSR 213	ICMPS 900-9-3-2-5	56	2.2	23	164	7.1	<1	1
ICMSR 214	ICMPS 900-9-3-2-10	47	1.6	25	158	6.7	<1	5
ICMSR 215	ICMPS 900-9-3-3-1	56	1.8	25	149	10.7	0	2
ICMSR 216	ICMPS 1002-6-1	41	1.8	20	110	6.6	0	4

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Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 217	ICMPS 1100-2-1-3	41	1.2	21	142	6.5	1	4
ICMSR 218	ICMPS 1200-3-4-2	45	1.4	24	147	8.2	3	2
ICMSR 219	ICMPS 1300-2-1-2	48	1.4	25	164	7.1	0	8
ICMSR 220	ICMPS 1400-1-6-2	48	1.4	24	150	5.8	0	3
ICMSR 221	ICMPS 1500-7-3-2	43	1.6	21	141	6.4	<1	0
ICMSR 222	ICMPS 1500-7-4-1-1	47	1.8	19	136	10.5	0	6
ICMSR 223	ICMPS 1600-2-4	42	1.8	25	176	6.2	0	3
ICMSR 224	ICMPS 1700-1-1-1	50	1.4	21	82	7.3	0	15
ICMSR 225	ICMPS 1700-2-5-2-2	58	1.0	16	172	7.8	0	2
ICMSR 226	ICMPS 1701-1	41	1.2	18	174	6.8	0	4
ICMSR 227	ICMPS 1800-3-1-2	48	1.0	20	168	6.7	0	4
ICMSR 228	ICMPS 1800-3-2-1-3	56	1.8	20	161	6.3	<1	1
ICMSR 229	ICMPS 1900-1-6	41	1.4	23	158	8.3	0	1
ICMSR 230	ICMPS 2000-5-2	42	1.8	20	160	5.3	0	8
ICMSR 232	ICMPS 2200-4-3-1	49	3.4	15	102	8.7	0	0
ICMSR 233	ICMPS 2300-4-1	52	3.0	31	190	6.4	<1	12
ICMSR 234	ICMPS 2400-20-2	56	1.8	23	158	6.4	0	8
ICMSR 235	ICMPS 2400-23-1	56	2.0	21	156	7.2	0	0
ICMSR 236	ICMPS 2400-23-3	46	1.6	21	172	7.4	0	3
ICMSR 237	(700713 × SC-2(M)-3-7-4-2-S-4)-5-4-1-5	41	4.2	18	132	5.5	2	0
ICMSR 238	(700713 × SC-2(M)-3-7-4-2-S-4)-5-3-3-5	56	1.4	17	178	5.7	0	6
ICMSR 239	(ICMPS 100-5-1 × ICMPS 1200-3-4-2)-1	45	1.8	19	161	7.6	<1	3
ICMSR 240	(ICMPS 100-5-1 × ICMPS 1200-3-4-2)-10	56	3.8	19	149	6.7	<1	0
ICMSR 241	(ICMPS 100-5-1 × ICMPS 1600-2-4)-11	56	2.2	22	157	8.3	0	4
ICMSR 242	(ICMPS 100-5-1 × ICMPS 1600-2-4)-17	56	1.4	21	146	7.9	0	4
ICMSR 243	(ICMPS 100-5-1 × ICMPS 1600-2-4)-22	45	1.0	19	150	5.7	0	3
ICMSR 244	(ICMPS 900-9-3 × ICMPS 1200-3-4-2)-1	56	2.8	28	156	6.4	0	6
ICMSR 245	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-3	49	1.2	22	159	5.2	0	0
ICMSR 246	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-4	49	1.0	21	134	4.9	0	0
ICMSR 247	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-7	49	1.8	23	143	9.0	0	3
ICMSR 248	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-9	56	2.0	24	165	8.3	0	3
ICMSR 249	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-10	49	2.6	23	159	8.1	0	1
ICMSR 250	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-16	56	1.2	22	155	6.6	0	2
ICMSR 251	(ICMPS 900-9-3 × ICMPS 1500-7-3-2)-19	49	2.2	20	147	8.0	0	3
ICMSR 252	(ICMPS 900-9-3 × ICMPS 1600-2-4)-1	56	1.2	21	143	6.7	0	1
ICMSR 253	(ICMPS 900-9-3 × ICMPS 1600-2-4)-4	56	2.2	26	156	7.0	0	0
ICMSR 254	(ICMPS 1200-3-4-2 × ICMPS 900-9-3)-3	49	1.6	20	139	7.2	1	1
ICMSR 255	(ICMPS 1200-3-4-2 × ICMPS 900-9-3)-8	49	1.8	23	162	7.5	1	4
ICMSR 256	(ICMPS 1200-3-4-2 × ICMPS 1500-7-3-2)-4	56	1.2	25	151	7.2	0	0
ICMSR 257	(ICMPS 1200-3-4-2 × ICMPS 1500-7-3-2)-6	56	2.0	22	156	7.0	0	0

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 258	(ICMPS 1200-3-4-2 × ICMPS 1500-7-3-2)-8	56	1.6	21	148	7.6	0	1
ICMSR 259	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-1	56	1.2	25	144	6.2	0	2
ICMSR 260	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-2	56	1.4	24	163	8.1	0	2
ICMSR 261	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-3	49	1.0	23	137	8.1	<1	2
ICMSR 262	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-4	58	1.2	21	157	7.3	0	2
ICMSR 263	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-5	45	1.4	22	139	6.8	0	0
ICMSR 264	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-7	56	1.2	26	151	6.1	0	0
ICMSR 265	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-8	56	1.4	21	130	6.3	0	3
ICMSR 266	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-18	56	1.2	26	164	5.1	0	3
ICMSR 267	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-19	56	2.0	24	153	6.6	<1	1
ICMSR 268	(ICMPS 1500-7-3-2 × ICMPS 1200-3-4-2)-1	56	2.2	24	140	8.1	1	0
ICMSR 269	(ICMPS 1500-7-3-2 × ICMPS 1200-3-4-2)-7	49	1.4	17	168	4.3	0	0
ICMSR 270	(ICMPS 1500-7-3-2 × ICMPS 1600-2-4)-14	56	1.6	22	152	6.1	0	2
ICMSR 271	(ICMPS 1600-2-4 × ICMPS 900-9-3)-10	58	1.6	27	178	7.6	0	0
ICMSR 272	(ICMPS 1600-2-4 × ICMPS 900-9-3)-25	56	1.2	23	136	7.6	0	2
ICMSR 273	(ICMPS 1600-2-4 × ICMPS 900-9-3)-26	56	1.6	25	142	7.7	0	3
ICMSR 274	(ICMPS 1600-2-4 × ICMPS 900-9-3)-27	56	1.0	24	168	6.7	0	0
ICMSR 275	(ICMPS 500-4-4-3 × ICMPS 1400-1-6-2)C3-2-4	49	1.2	25	158	7.4	0	5
ICMSR 276	(ICMPS 500-4-4-3 × ICMPS 1800-3-1-2)C3-1-1	56	1.0	23	150	6.1	0	3
ICMSR 277	(ICMPS 1300-2-1-2 × ICMPS 1800-3-1-2)C2-3-2	49	1.0	20	140	6.6	0	2
ICMSR 278	(ICMPS 100-5-1 × ICMPS 1200-3-4-2)-3	57	1.0	21	167	7.3	0	1
ICMSR 279	(ICMPS 100-5-1 × ICMPS 1200-3-4-2)-12	57	1.8	17	129	7.5	<1	4
ICMSR 280	(ICMPS 100-5-1 × ICMPS 1600-2-4)-13	57	1.8	18	148	5.4	0	1
ICMSR 281	(ICMPS 100-5-1 × ICMPS 1600-2-4)-16	57	1.8	23	145	6.5	0	0
ICMSR 282	(ICMPS 900-9-3 × ICMPS 1600-2-4)-3	57	1.0	24	152	6.4	0	0
ICMSR 283	(ICMPS 1200-3-4-2 × ICMPS 100-5-1)-1	57	1.6	23	161	7.1	<1	0
ICMSR 284	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-11	57	1.0	24	149	7.4	0	0
ICMSR 285	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-12	57	1.0	23	141	6.2	0	2
ICMSR 286	(ICMPS 1500-7-3-2 × ICMPS 900-9-3)-15	57	1.2	24	134	6.1	0	2
ICMSR 288	(ICMPS 1500-7-3-2 × ICMPS 1600-2-4)-1	57	1.4	22	145	6.0	0	3
ICMSR 289	(ICMPS 1500-7-3-2 × ICMPS 1600-2-4)-18	57	1.0	21	148	6.9	0	6
ICMSR 290	(ICMPS 1900-1-6 × ICMPS 400-5-4-3)C2-1-1	50	1.6	23	136	7.9	0	5
ICMSR 291	(ICMPS 1900-1-6 × ICMPS 400-5-4-3)C2-1-2	59	1.8	23	141	8.0	0	1
ICMSR 292	(ICMPS 1900-1-6 × ICMPS 500-4-4-3)C1-1-1	59	1.8	29	162	7.5	0	0
ICMSR 293	(ICMPS 1900-1-6 × ICMPS 1300-2-1-2)C1-3-3	57	3.2	21	165	6.7	0	3
ICMSR 294	(ICMPS 1900-1-6 × ICMPS 1300-2-1-2)C3-2-2	59	1.8	25	177	7.7	0	2
ICMSR 295	(ICMPS 1900-1-6 × ICMPS 1300-2-1-2)C3-3-3	57	1.4	22	196	7.8	0	2
ICMSR 296	(ICMPS 1900-1-6 × ICMPS 1800-3-1-2)C3-2-2	57	1.4	18	189	6.5	0	0
ICMSR 297	(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)C1-1-2	57	1.4	17	134	7.3	0	2
ICMSR 298	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C2-3-3	57	1.4	27	149	7.4	0	2

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 299	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C2-3-7	57	1.4	26	166	8.1	0	0
ICMSR 300	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C2-3-8	59	1.0	32	167	7.4	0	3
ICMSR 301	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C2-3-9	61	1.2	32	159	5.6	0	2
ICMSR 302	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C3-1-1	59	2.2	30	150	7.5	0	0
ICMSR 303	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C3-2-3	61	1.2	24	146	7.2	0	8
ICMSR 304	(ICMPS 1803-1-2 × ICMPS 1400-1-6-2)C3-2-4	55	2.2	24	154	8.2	0	8
ICMSR 305	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-5-1	47	1.4	19	91	5.7	0	<1
ICMSR 306	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-1-1	47	2.2	25	103	7.3	<1	6
ICMSR 307	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-2-3	47	2.4	22	96	5.5	<1	4
ICMSR 308	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-2-4	44	1.8	31	161	8.2	0	3
ICMSR 309	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-2-7	51	1.8	24	103	7.6	<1	5
ICMSR 310	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-2-8	45	1.0	21	97	6.3	0	1
ICMSR 311	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-2-13	54	2.4	24	100	7.0	0	6
ICMSR 312	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-7-4	50	1.8	23	113	8.9	0	2
ICMSR 313	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-7-5	49	2.4	22	85	7.2	0	3
ICMSR 314	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-7-6	45	2.4	26	92	8.5	1	14
ICMSR 315	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P2 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P2]-8-2	44	1.8	24	91	8.5	0	19
ICMSR 316	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-1-3	44	2.4	22	90	7.1	0	11
ICMSR 317	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-1-4	44	1.0	20	98	7.3	0	3

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 318	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-3-2	49	1.6	18	96	8.1	<1	0
ICMSR 319	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-6-4	49	2.2	22	80	6.5	0	0
ICMSR 320	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-6-6	49	1.0	23	84	5.8	0	1
ICMSR 321	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-7-2	52	2.0	29	152	7.2	<1	8
ICMSR 322	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P2]-7-6	52	2.2	26	98	7.6	0	8
ICMSR 323	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P11 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P3]-4-2	50	2.0	20	96	7.2	0	2
ICMSR 324	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P11 × (ICMPS 1400-1-6-2 × ICMPS 1800-1-3-2)P3]-4-6	50	1.8	20	98	7.3	0	2
ICMSR 325	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-3-2	56	1.0	20	177	8.0	0	58
ICMSR 326	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-5-4	56	1.0	21	152	6.8	0	0
ICMSR 327	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P7 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P2]-2-2	49	2.0	16	109	8.0	0	1
ICMSR 328	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P7 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P2]-2-3	56	1.6	18	141	9.8	0	36
ICMSR 329	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P7 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P2]-2-5	56	1.2	29	186	7.9	1	0
ICMSR 331	[(ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P4 × (ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P13]-6-2	56	1.0	18	142	8.7	0	6
ICMSR 332	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-1-1	49	1.8	24	144	8.6	0	0
ICMSR 333	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-4-5	58	1.6	21	168	8.9	<1	3
ICMSR 334	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-5-2	57	1.2	22	152	7.5	0	6

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 335	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-5-5	57	1.4	27	175	8.4	0	3
ICMSR 336	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P1]-5-6	57	1.8	23	163	7.9	0	5
ICMSR 337	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P7 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P2]-2-4	54	3.8	21	152	8.4	0	11
ICMSR 338	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-1-3	45	2.4	27	143	8.9	3	3
ICMSR 339	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-2-5	57	1.8	25	96	8.0	<1	1
ICMSR 340	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-7-2	57	2.0	25	152	7.6	0	11
ICMSR 341	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-7-4	49	2.2	24	134	8.3	<1	13
ICMSR 342	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-8-5	58	2.0	23	167	7.6	0	10
ICMSR 343	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-3-1	58	2.6	21	192	6.6	0	0
ICMSR 344	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-7-1	57	2.2	18	167	6.4	0	10
ICMSR 345	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6 × ICMPS 1300-2-1-2)P2]-7-2	58	1.4	21	172	8.6	0	0
ICMSR 346	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6)P11 × (ICMPS 1300-2-1-2)P3]-1-6	56	1.6	18	135	7.8	0	0
ICMSR 347	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6)P11 × (ICMPS 1300-2-1-2)P3]-2-5	56	1.2	26	165	6.9	0	4
ICMSR 348	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6)P11 × (ICMPS 1300-2-1-2)P3]-2-6	56	1.2	25	139	7.0	0	8
ICMSR 349	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6)P11 × (ICMPS 1300-2-1-2)P3]-2-7	56	1.8	25	133	7.4	0	33

Continued....

Table 5. Continued.

Identity	Pedigree	Time to 50% flowering (days)	Tillers/plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass (g)	Smut severity (%)	DM[2] incidence (%)
ICMSR 351	[(ICMPS 200-5-5-5 × ICMPS 1700-1-1-1)P10 × (ICMPS 1900-1-6)P11 × (ICMPS 1300-2-1-2)P3]-6-3	56	1.0	25	165	7.2	0	12
ICMSR 352	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-1	57	2.6	24	169	7.8	0	0
ICMSR 353	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-2	49	2.0	23	178	7.0	0	0
ICMSR 354	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-3	57	2.0	27	183	7.9	0	0
ICMSR 355	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-4	57	2.6	23	173	6.1	0	1
ICMSR 356	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-5	49	2.8	21	156	8.6	0	1
ICMSR 357	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-6	49	3.2	20	186	7.5	0	1
ICMSR 358	[(ICMPS 1900-1-6 × ICMPS 400-5-4-2)P9 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P5]-8-7	57	2.0	24	159	7.5	0	3
ICMSR 359	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P3 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P10]-3-2	57	1.6	25	195	7.2	0	0
ICMSR 360	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P5 × (ICMPS 1900-1-6 × ICMPS 400-5-4-3)P8]-1-3	57	1.2	23	136	9.6	0	3
ICMSR 361	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P5 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P8]-6-1	57	2.2	25	151	6.9	0	2
ICMSR 362	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P5 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P8]-7-5	49	2.0	20	158	5.2	0	15
ICMSR 363	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P5 × (ICMPS 1400-1-6-2 × ICMPS 1800-3-1-2)P8]-10-2	57	1.0	24	184	8.0	0	0
ICMSR 364	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P5 × (ICMPS 1400-1-6-2)P6 × (ICMPS 1800-3-1-2)P7]-1-2	49	1.2	22	134	6.5	0	13
ICMSR 365	[(ICMPS 500-4-4-3 × ICMPS 1300-2-1-2)P5 × (ICMPS 1400-1-6-2)P6 × (ICMPS 1800-3-1-2)P7]-4-1	57	1.6	21	135	6.4	0	16

Continued....

Table 5. *Continued.*

Identity	Pedigree	Time to 50% flower-ing (days)	Tiller/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass(g)	Smut seve-rity (%)	DM[2] inci-dence (%)
ICMSR 366	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P5 x (ICMPS 1400-I-6-2)P6x (ICMPS 1800-3-I-2)P7]-4-2	57	1.8	21	164	9.3	0	5
ICMSR 367	[(ICMPS 500-4-4-3 x ICMPS 1300-2-I-2)P5 x (ICMPS 1400-1-6-2)P6 x (ICMPS 1800-3-I-2)P7]-6-I	57	1.0	26	152	9.2	0	0
ICMSR 368	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-2-4	57	1.4	27	163	7.0	0	4
ICMSR 369	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-2-5	49	1.0	26	143	7.2	0	1
ICMSR 370	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-2-7	57	1.0	24	156	6.0	0	0
ICMSR 371	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-3-I	57	1.0	29	160	6.2	0	0
ICMSR 372	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-4-I	49	1.2	26	139	8.1	0	0
ICMSR 373	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-5-I	49	1.4	26	132	6.1	0	3
ICMSR 374	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-5-2	57	1.6	28	161	6.6	0	1
ICMSR 375	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-5-4	57	1.6	24	151	6.1	0	3
ICMSR 376	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-5-5	49	1.8	24	155	7.0	0	5
ICMSR 377	[(ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P7 x (ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P6]-5-7	57	1.2	24	147	6.4	0	2
ICMSR 378	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)PI x (ICMPS 500-4-4-3 x ICMPS 1300-2-I-2)P9]-4-3	57	1.2	26	171	9.0	<1	5
ICMSR 379	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)P1 x (ICMPS 500-4-4-3)P3 x (ICMPS 1300-2-I-2)P10]-3-I	57	1.0	20	159	7.0	0	0
ICMSR 380	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-I-2)PI x (ICMPS 500-4-4-3)P3 x (ICMPS 1300-2-I-2)P10]-6-2	57	1.8	27	169	6.3	0	0

Continued....

Table 5. Continued.

Identity	Pedigree	Time to 50% flower-ing (days)	Tillers/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass(g)	Smut seve-rity (%)	DM[2] inci-dence (%)
ICMSR 381	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-1-2)P4 x (ICMPS 500-4-4-3 x ICMPS 1300-2-1-2) P12]-2-1	58	1.2	27	197	7.4	0	2
ICMSR 382	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-1-2)P4 X (ICMPS 500-4-4-3 x ICMPS 1300-2-1-2)P12]-1-7	57	1.2	27	172	6.7	0	3
ICMSR 383	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-1-2)P4 x (ICMPS 500-4-4-3)P14 x (ICMPS 1300-2-1-2)P13]-5-1	57	1.2	27	162	7.5	0	0
ICMSR 384	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-1-2)P4 X (ICMPS 500-4-4-3)P14 x (ICMPS 1300-2-1-2)P13]-5-2	57	1.2	28	178	5.9	0	3
ICMSR 385	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-1-2)P4 x (ICMPS 500-4-4-3)P14 x (ICMPS 1300-2-1-2)P13]-5-3	57	1.2	31	189	7.3	0	0
ICMSR 386	[(ICMPS 1400-1-6-2 x ICMPS 1800-3-1-2)P4 X (ICMPS 500-4-4-3)P14 x (ICMPS 1300-2-1-2)P13]-5-4	63	1.4	33	173	7.4	0	6
ICMSR 387	(P 455-S-1 x P 427-S-1)-1	44	1.8	21	153	9.5	8	1
ICMSR 388	(P446-S-1 x Togo 29-9-2-1)-8	40	1.4	22	151	7.9	0	5
ICMSR 389	(ICMPS 1700-1-3-2-1 x ICMPS 900-1-4-3-4)-3	50	1.4	27	108	8.9	0	8
ICMSR 390	(ICMPS 1700-1-3-2-1 x ICMPS 900-1-4-3-4)-8	52	1.4	23	109	8.5	<1	0
ICMSR 391	(ICMPS 1700-1-3-2-1 x ICMPS 900-1-4-3-4)-11	46	2.4	26	106	8.4	0	20
ICMSR 392	(ICMPS 1700-1-3-2-1 x ICMPS 900-1-4-3-4)-15	48	1.0	22	105	7.9	0	0
ICMSR 393	(ICMPS 1700-1-3-2-1 x ICMPS 900-1-4-3-4)-20	49	1.4	23	93	7.3	0	13
ICMSR 394	(ICMPS 1700-1-3-2-1 x ICMPS 900-1-4-3-4)-21	46	1.0	21	104	7.8	0	9
ICMSR 395	(ICMPS 1700-1-3-2-1 x ICMPS 1500-7-4-1-6)-1	45	1.4	22	134	6.4	<1	1
ICMSR 396	(ICMPS 1700-1-3-2-1 x ICMPS 1500-7-4-1-6)-8	45	1.2	21	99	8.1	<1	11
ICMSR 397	(ICMPS 1700-1-3-2-1 x ICMPS 1300-7-4-1-6)-42	40	2.2	15	131	8.7	0	1
ICMSR 398	(ICMPS 900-1-4-3-4 x NW 1-10-1-S-4-2-2-1)-18	41	1.4	23	105	5.7	0	14
ICMSR 399	(ICMPS 900-1-4-3-4 x NW 1-10-1-S-4-2-2-1)-36	51	3.2	23	99	6.4	0	0
ICMSR 400	(ICMPS 900-1-4-3-4 x ICMPS 1700-1-3-2-1)-1	49	3.4	26	125	9.4	0	3
ICMSR 401	(ICMPS 900-1-4-3-4 x ICMPS l700-1-3-2-1)-11	52	1.8	24	103	6.1	<1	2
ICMSR 402	(ICMPS 900-1-4-3-4 x ICMPS 1700-1-3-2)-2	48	1.0	23	93	7.6	<1	11

Continued.....

Table 5. Continued.

Identity	Pedigree	Time to 50% flower-ing (days)	Tillers/ plant (no.)	Panicle length (cm)	Plant height (cm)	1000-grain mass(g)	Smut seve-rity (%)	DM[2] inci-dence (%)
ICMSR 403	(ICMPS 900-1-4-3-4 x ICMPS 1700-I-3-2)-4	50	1.6	30	187	8.2	1	3
ICMSR 404	(ICMPS 900-1-4-3-4 x ICMPS 1700-I-3-2)-5	48	3.0	29	205	9.3	1	7
ICMSR 405	(ICMPS 900-1-4-3-4 x ICMPS 1700-I-3-2)-8	47	2.0	29	112	8.2	1	0
ICMSR 406	(ICMPS 1700-1-3-2 x ICMPS 900-I-4-3-4)-I	50	1.4	23	92	6.3	<1	0
ICMSR 407	(ICMPS 1700-1-3-2 x ICMPS 900-I-4-3-4)-8	44	2.6	24	101	7.4	0	21
ICMSR 408	(ICMPS 900-1-4-3-4 x ICMPS 1700-1-3-1)-1	49	2.0	28	115	10.6	0	4
ICMSR 409	(ICMPS 900-1-4-3-4 x ICMPS 1700-1-3-1)-6	41	2.2	20	92	9.7	0	11
ICMSR 410	(ICMPS 1700-1-3-1 x ICMPS 900-I-4-3-4)-4	49	1.6	21	89	8.2	0	24
ICMSR 411	(NW 1-10-1-S-4-2-2-1 x ICMPS 1700-1-3-2-1)-1	47	2.4	22	145	8.1	5	0
ICMSR 412	(ICMPS 1700-1-3-2 x NW 1-10-1-S-4-2-2-1)-2	48	2.2	21	132	7.6	0	6
ICMSR 413	(ICMPS 1500-7-4-1-6 x ICMPS 1700-1-3-1)-2	46	2.2	24	119	7.5	0	5
ICMSR 414	(ICMPS 1500-7-4-1-6 x ICMPS 1700-1-3-1)-3	38	2.2	17	116	9.9	0	0
ICMSR 415	(ICMPS 1500-7-4-1-6 x ICMPS 1700-1-3-1)-6	39	1.6	21	143	7.5	<1	2
ICMSR 416	(NW 1-10-1-S-4-2-2-1 x ICMPS 1500-7-4-I-6)-10	41	1.8	17	121	6.9	<1	4
ICMSR 417	(NW 1-10-1-S-4-2-2-1 x ICMPS 1500-7-4-I-6)-II	40	2.0	21	139	8.0	0	0
ICMSR 418	(ICMPS 1700-1-3-2-1 x NW 1-10-1-S-4-2-2-1)-32	44	3.0	22	157	9.0	<1	3

1. Values given for agronomic characters are based on the mean of five plants.
2. DM = Downy mildew.

Table 6. Number and identity of ICRISAT Millet Smut Resistant (ICMSR) lines grouped according to combinations of agronomic traits[1] associated with combined resistance to smut and downy mildew[2].

Name of the line	Group no.	Time to 50% flowering (days)	Panicle length (cm)	Plant height (cm)	No. of lines
ICMSR 156 ICMSR 216 ICMSR 232 ICMSR 306 ICMSR 312 ICMSR 313 ICMSR 317 ICMSR 318 ICMSR 319 ICMSR 323 ICMSR 324 ICMSR 327 ICMSR 392 ICMSR 394 ICMSR 413 ICMSR 414	1	<50	<25	<120	16
ICMSR 309 ICMSR 311 ICMSR 339 ICMSR 390 ICMSR 399 ICMSR 401	2	51-60	<25	<120	6
ICMSR 207 ICMSR 389 ICMSR 405 ICMSR 408	4	<50	>25	<120	4
ICMSR 322	5	51-60	>25	<120	1
ICMSR 4 ICMSR 28 ICMSR 41 ICMSR 42 ICMSR 43 ICMSR 52 ICMSR 54 ICMSR 56 ICMSR 60 ICMSR 67 ICMSR 73 ICMSR 81 ICMSR 83 ICMSR 100 ICMSR 104 ICMSR 135 ICMSR 141 ICMSR 143 ICMSR 144 ICMSR 145 ICMSR 149 ICMSR 155 ICMSR 167 ICMSR 177 ICMSR 180 ICMSR 184 ICMSR 185 ICMSR 186 ICMSR 187 ICMSR 188 ICMSR 189 ICMSR 191 ICMSR 192 ICMSR 200 ICMSR 208 ICMSR 210 ICMSR 214 ICMSR 217 ICMSR 218 ICMSR 219 ICMSR 220 ICMSR 221 ICMSR 222 ICMSR 223 ICMSR 226 ICMSR 227 ICMSR 229 ICMSR 230 ICMSR 236 ICMSR 237 ICMSR 239 ICMSR 243 ICMSR 245 ICMSR 246 ICMSR 247 ICMSR 249 ICMSR 251 ICMSR 254 ICMSR 255 ICMSR 261 ICMSR 263 ICMSR 269 ICMSR 275 ICMSR 277 ICMSR 290 ICMSR 332 ICMSR 353 ICMSR 356 ICMSR 357 ICMSR 376 ICMSR 388 ICMSR 395 ICMSR 397 ICMSR 411 ICMSR 412 ICMSR 415 ICMSR 416 ICMSR 417 ICMSR 418	7	<50	>25	121-200	79
ICMSR 1 ICMSR 14 ICMSR 26 ICMSR 27 ICMSR 29 ICMSR 30 ICMSR 34 ICMSR 36 ICMSR 37 ICMSR 38 ICMSR 39 ICMSR 40 ICMSR 44 ICMSR 45 ICMSR 46	8	51-60	<25	121-200	109

Continued....

Table 6. *Continued.*

Name of the line			Group no.	Time to 50% flowering (days)	Panicle length (cm)	Plant height (cm)	No. of lines
ICMSR 49	ICMSR 50	ICMSR 51	8	51-60	<25	121-200	109
ICMSR 65	ICMSR 76	ICMSR 84					
ICMSR 87	ICMSR 94	ICMSR 97					
ICMSR 108	ICMSR 109	ICMSR 110					
ICMSR 111	ICMSR 114	ICMSR 154					
ICMSR 166	ICMSR 172	ICMSR 176					
ICMSR 178	ICMSR 181	ICMSR 190					
ICMSR 197	ICMSR 206	ICMSR 209					
ICMSR 211	ICMSR 212	ICMSR 213					
ICMSR 215	ICMSR 225	ICMSR 228					
ICMSR 234	ICMSR 235	ICMSR 238					
ICMSR 240	ICMSR 241	ICMSR 242					
ICMSR 248	ICMSR 250	ICMSR 252					
ICMSR 256	ICMSR 257	ICMSR 258					
ICMSR 259	ICMSR 260	ICMSR 262					
ICMSR 265	ICMSR 267	ICMSR 268					
ICMSR 270	ICMSR 272	ICMSR 273					
ICMSR 274	ICMSR 276	ICMSR 278					
ICMSR 279	ICMSR 280	ICMSR 281					
ICMSR 282	ICMSR 283	ICMSR 284					
ICMSR 285	ICMSR 286	ICMSR 288					
ICMSR 289	ICMSR 291	ICMSR 293					
ICMSR 294	ICMSR 295	ICMSR 296					
ICMSR 297	ICMSR 304	ICMSR 326					
ICMSR 331	ICMSR 333	ICMSR 334					
ICMSR 336	ICMSR 342	ICMSR 343					
ICMSR 344	ICMSR 345	ICMSR 346					
ICMSR 348	ICMSR 352	ICMSR 355					
ICMSR 358	ICMSR 359	ICMSR 360					
ICMSR 361	ICMSR 363	ICMSR 366					
ICMSR 370	ICMSR 375	ICMSR 377					
ICMSR 379							
ICMSR 12			9	>60	<25	121-200	l
ICMSR 5	ICMSR 10	ICMSR 16	10	<50	>25	121-200	21
ICMSR 55	ICMSR 68	ICMSR 86					
ICMSR 106	ICMSR 125	ICMSR 127					
ICMSR 129	ICMSR 137	ICMSR 150					
ICMSR 165	ICMSR 173	ICMSR 308					
ICMSR 338	ICMSR 369	ICMSR 372					
ICMSR 373	ICMSR 400	ICMSR 403					
ISMSR 20	ICMSR 74	ICMSR 88	11	51-60	>25	121-200	
ICMSR 89	ICMSR 90	ICMSR 98					
ICMSR 102	ICMSR 105	ICMSR 151					
ICMSR 153	ICMSR 168	ICMSR 171					
ICMSR 202	ICMSR 244	ICMSR 253					

Continued.....

Table 6. ***Continued.....***

Name of the line	Group no.	Time to 50% flowering (days)	Panicle length (cm)	Plant height (cm)	No. of lines
ICMSR 264 ICMSR 266 ICMSR 271 ICMSR 300 ICMSR 302 ICMSR 321 ICMSR 354 ICMSR 367 ICMSR 368 ICMSR 371 ICMSR 374 ICMSR 378 ICMSR 380 ICMSR 381 ICMSR 382 ICMSR 383 ICMSR 384 ICMSR 385	11	51-60	>25	121-200	39
ICMSR 179 ICMSR 386	12	>60	>25	121-200	3
ICMSR 53 ICMSR 57 ICMSR 101	13	>50	>25	>200	3
ICMSR 59 ICMSR 75	14	51-60	<25	>200	2
ICMSR 6 ICMSR 82 ICMSR 404	16	<50	>25	>200	3
ICMSR 85 ICMSR 103	17	51-60	>25	>200	2
ICMSR 91	18	>60	>25	>200	1

1. All lines had a 1000-grain mass of >6.5 g.
2. Combined resistance indicates <5% smut severity, and <10% downy mildew incidence.

Table 7. Reactions of smut-resistant, agronomically elite lines to smut and downy mildew in multilocational testing In the International Pearl Millet Smut Nursery, 1983-1986.

Entry	Smut severity (%)					Downy mildew incidence (%)[5]
	1983[1]	1984[2]	1985[3]	1986[4]	Mean	
ICMPS 100-5-1	2	0	<1	<1	<1	2
ICMPS 200-5-5-5	2	<1	8	3	3	<1
ICMPS 700-1-5-4	1	<1	<1	<1	<1	<1
ICMPS 900-1-4-1	2	1	<1			1
ICMPS 900-3-1	3	<1	1			1
ICMPS 900-9-3	4	0	<1			4
ICMPS 1300-2-1-2	3	<1	<1			3
ICMPS 1400-1-6-2	2	<1	1			1
ICMPS 1500-7-3-2	3	0	<1			1
ICMPS 1600-2-4	3	<1	6	3	3	1
ICMPS 1800-3-1-2	1	<1	<1		<1	<1
ICMPS 2000-5-2	4	<1	<1		<1	1
Susceptible control	49	52	63	53	54	32

1. Mean of eight locations: Gwalior, Hisar, Jamnagar, and Patancheru (India), Sadore (Niger), Kano and Samaru (Nigeria), and Bambey (Senegal).
2. Mean of four locations: Gwalior, Hisar, Jamnagar, and Patancheru (India).
3. Mean of three locations: Hisar and Patancheru (India), and Bengou (Niger).
4. Mean of six locations: Hisar and Patancheru (India), Bengou and Sadore (Niger), Samaru (Nigeria), and Bambey (Senegal).
5. Mean of four locations: Gwalior, Hisar, Jamnagar, and Patancheru (India) in 1983 and 1984, and two locations, Hisar and Patancheru (India) in 1985 and 1986.

Table 8. Agronomic traits of six stable, smut-resistant lines identified by the ICRISAT Plant Material Identification Committee in 1985.

ICRISAT name (pedigree)	Origin	Mean smut severity (%)[1]	Time to 50% flowering (days)[2]	Plant height (cm)[2]	Panicle length (cm)[2]	1000-grain mass (g)[2]
ICML 5 (SSC FS 252-S-4)	Uganda	<1	50	130-150	20-25	9.0
ICML 6 (ICI 7517-S-1)	Patancheru	<1	53	65-100	25-30	6.0
ICML 7 (EBS 46-I-2-S-2)	Nigeria	<I	44	135-145	20-24	9.8
ICML 8 (EB 112-1-S-I-I)	Nigeria	<1	53	140-160	20-24	8.1
ICML 9 (NEP 588-5690-S-8-4)	Lebanon	<1	45	150-160	25-28	7.6
ICML 10 (P 489-S-3)	Senegal	<1	60	150-180	22-26	8.3
Control						
ICMV 1 (WC-C75)	Patancheru	29	46	130-140	18-22	8.3

1. Based on 4-7 years of testing at Hisar, Jamnagar (India), and Bambey (Senegal) through the International Pearl Millet Smut Nursery (IPMSN).
2. Based on the 1984 rainy season results at ICRISAT Center.

Table 9. Performance of Smut-Resistant Composite (SRC) bulks and varieties derived from them for grain yield and smut severity, during the 1986 rainy season.

Populations and varieties	Smut severity (%)[1]	Grain yield ($t ha^{-1}$)[2] Mean	Trial mean (%)
SRC-C3	1	2.02	112
ICMH 85427	1	2.01	111
ICMH 85429	1	1.95	108
SRC-C2	4	1.93	105
ICMV 82131	4	1.93	(07
ICMH 84216	2	1.87	104
ICMH 84313	I	1.87	104
ICMV 82132	4	1.85	103
ICMH 85426	2	1.82	100
SRC-CO	7	1.80	99
ICMH 84410	3	1.78	98
SRC-C1	3	1.75	97
ICMV 82130	5	1.58	86
ICMPS 100-5-1	0	1.23	66
ICMS 7704	10	1.91	107
WC-C75	13	1.75	97
SE	±1.3	± 7.6	
Mean	3.7	1.82	100

1. Based on 40 inoculated plants from each of four replications in a smut nursery at Patancheru.
2. Based on yield trials at Patancheru (high fertility, smut nursery, downy mildew nursery) and Bhavanisagar (high fertility).

Table 10. Mean grain yield, time to 50% flowering, plant height, downy mildew incidence, smut severity, and 1000-grain mass of ICMA 88006.

Character	No. of trials	Mean performance ICMA 88006	81A	843A
Grain yield ($t ha^{-1}$)	17	1.9	2.0	1.7
Time to 50% flowering (d)	17	50	54-	42
Plant height (cm)	17	113	108	92
Downy mildew incidence (%)[1]	15	6.0	18.5	28.0
Smut severity (%)[1]	5	5.3	43.6	38.8
1000-grain mass (g)	8	12.3	6.9	10.8

1. Based on downy mildew screening in field and greenhouse. and smut

Table 11. Grain yield, time to 50% flowering, plant height, tillering ability, seed sire, downy mildew and smut reactions, and topcross grain yield of 12 promising smut-resistant B-lines(SRB lines).

SRB line	Grain yield (t ha^{-1})		Time to 50% flowering (d)	Plant height (cm)	No. of panicles per plant	1000-seed mass (g)	Downy mildew incidence(%)[1]		Smut severity (%)
	SRB line	Topcross[2] hybrid					Field	Green-house	
SRBL-5	1.8	2.8	43	145	1.5	9.6	0.0	3.3	0.0
SRBL-6	1.7	2.5	43	138	1.4	12.7	0.8	4.1	0.0
SRBL- 8	1.5	2.6	46	124	1.4	9.4	3.9	12.0	0.0
SRBL -12	1.6	2.8	44	100	1.5	9.9	5.6	5.9	0.0
SRBL -22	1.6	2.4	43	152	1.7	11.2	0.0	6.5	0.1
SRBL - 28	1.4	2,6	43	154	1.6	13.3	0.0	2.8	0.0
SRBL-31	1.6	2.6	46	175	1.5	10.6	0.0	4.7	5.4
SRBL - 33	1.6	2.9	45	155	2.0	11.6	0.9	1.3	0.0
SRBL - 41	1.7	2.5	49	152	2.5	7.9	5.0	4.9	0.0
SRBL - 42	1.8	2.7	47	155	2.0	8.6	0.8	3.6	0.0
SRBL-48	1.7	2.8	49	170	2.0	10.9	1.9	3.5	0.0
SRBL-53	1.7	3.1	52	170	2.3	7.9	23.6	5.7	0.0
81B	0.9	2.9	51	112	1.6	7.0	13.7	16.2	53.3
843B	l.l	2.3	40	91	2.1	10.5	24.9	20.0	12.6
SE	±0.119	±0.144	±1.1	±4.0	±0.11	-	-		-

1. Downy mildew screening in field and greenhouse and smut screening in the field at ICRISAT Center.
2. Mean of topcrosses with three diverse populations.

Table 12. Smut reactions of parental lines and F_1 hybrids, ICRISAT Center, 1983 rainy season.

Parental line/hybrid	Smut severity (%)	
	Mean[1]	Range
SSC FS 252-S-4 (ICMSR 168)	0	0-0
ICI 7517-S-1 (ICMSR 158)	0	0-0
5141A	91	70-98
5141B	90	70-98
5141 A x ICMSR 168	35	0-75
5141B x ICMSR 168	7	0-50
5141 A x ICMSR 158	25	1-70
514IB x ICMSR 158	9	1-45
SE	±6.7	

1. Mean of 10 panicles from each of three replications.

RA-00219

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

Patancheru, Andhra Pradesh 502 324, India

ISBN 92-9066-217-4 Order code: RBE 016 Printed at ICRISAT Center 91-492