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INFLUENCE OF CYTOPLASM ON THE OCCURRENCE OF LEAF BLIGHT (*EXSEROHILUM TURCICUM* (PASS.)) IN SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH)

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ABSTRACT

Analysis of the data revealed significant differences among the genotypes and genotype x interaction effects for all the characters under study. However, differences among cytoplasm's was observed for disease parameters like length and area of the lesion, and agronomic traits like plant height, agronomic desirability, grain yield plant $^{-1}$ and test weight. For disease related parameters, sterile cytoplasm has contributed significantly to resistance for length and area of the lesion. In case of agronomic traits, fertile cytoplasm has profound dominant effect on agronomic desirability (B-3.4 score/A-3.7 score), grain yield plant^{-1} (B-33.9 g plant^{-1} / A-29.8 g plant^{-1}) and test weight (B-2.98 g/ A-2.90g) while sterile cytoplasm exerted profound effect on plant height (A-191.2 cm/ B-194.1 cm) only.

INTRODUCTION

Sorghum, *Sorghum bicolor* (L.) Monech is the third most important cereal crop cultivated extensively in India after wheat and rice. It is grown in the tropical and subtropical climates; consequently, it is a unique crop of the semi-arid tropics (SAT). The crop is predominantly cultivated in West Africa, East Africa, South Africa and India. Of the total SAT production, Asia and Africa contribute about 65%, of which 34% is harvested in India alone. Globally, it is cultivated in an area of 44.1 m ha with a production of 6.4 m t and an a average yield of 1.4 t ha^{-1} (FAO, 1998).

Leaf blight caused by E*xserohilum turcicum* (Pass) Leonard and Suggs., (1974) is extensively distributed, and at times one of the most damaging foliar pathogens of the sorghum, causing significant grain losses due to the reduction of the photosynthetic leaf area.

In any breeding program, since cytoplasmic genes are also governing the traits, it is imperative to improve the females, so that it can influence on the off spring if the trait is governed by the materinal effects. Strong physiological relationship between the mother sporophyte and the embryo or the seed of the following generation is due to maternal effects, which may have some influence on the resulting progenies. It masks the genetic variance either due to additive maternal effects or due to maternal interaction thus rendering the breeding procedures less effective. No concerted effort has been made to study the influence of cytoplasm on the occurrence of the disease. Hence, an attempt has been made using paired A- and B-lines i.e., cytoplasmic male-sterile (CMS) lines and maintainer (B-) lines, respectively, which were crossed with R-lines (restorers) to produce two types of hybrids *viz.*, (A x R) and (B x R). These hybrids have the same nuclear background but different cytoplasm (male-sterile and fertile cytoplasms).

MATERIAL AND METHODS

Material and field evaluation : To study the influence of cytoplasm on the occurrence of leaf blight, seventeen male-sterile (A) lines were crossed with six restore (R) lines during rainy season 1996 and 1997 at ICRISAT Asia Center, Patanchereu, Hyderabad A.P., India. Simultaneously 17 corresponding maintainer lines (B-lines) were emasculated and then pollinated with the pollen from same six R-lines. The resultant 204 cross combinations (102, A x R hybrids and 102, B x R crosses) along with their respective parents were sown in a split plot

design replicated thrice during post rainy season, 1997. In this experiment, genotypes were taken as main plot treatments and cytoplasms as sub plot treatments and evaluated for leaf blight resistance under artificial disease epiphytotic conditions.

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

Inoculum Preparation : The leaves affected with leaf blight (Exserohilum turcicum (Pass.)) were collected from the field and cut into small pieces and surface sterilized with 0.1% mercuric chloride for one minute followed by washing with sterile distilled water. Leaf pieces were aseptically transferred to sterilized petri plates containing 20 ml of sterilized Potato Dextrose Agar media (PDA) and incubated at 20°c for encouraging the fungal growth. The fungal growth was aseptically transferred to flasks containing sterilized sorghum grains and incubated at 20°c for 15 days so that the sorghum grains were covered with mycelia and the conidia of fungus colonized grains was removed from the flasks, allowed to air dry and separated as far as possible.

Inoculation : Sorghum plants were artificially inoculated following whorl–drop method of inoculation (Frederiksen and Franklin, 1978) with the inoculum prepared as above. The inoculation was carried at 30 days after emergence of coleoptile. The second inoculation was given one week after the first inoculation. All the plants in each entry were inoculated by placing two or three grains of seed inoculum in the whorl. The high humid conditions were created by providing overhead sprinklers on the same day after inoculation until the disease had spread. It took 40 days for the spread of disease.

Observations : The observations were taken on disease damage score (scored on a 1-9 scale on plot basis where 1 = highly resistant and 9 = highly susceptible), length of the lesion (cm), width of the lesion (cm), area of the lesion (cm^2), number of lesions, number of flecks, lodging (%), days to 50% flowering, plant height (cm), agronomic desirability (scored on a 1-5 scale on plot basis where 1 = excellent and 5 = poor), grain yield $plant^{-1}$ (g) and test weight (g for 100 grains). The genotypes were grouped into different disease reaction groups viz., highly resistant (HR), resistant (R), moderately resistant (MR), less susceptible (LS), susceptible (S) and highly susceptible (HS) reactions taking overall disease damage score as the basis for presentation of the data.

RESULTS AND DISCUSSIONS

The results from the analysis of variance (Table 1) revealed significant difference among the genotypes at 5% level for all the characters under study. However, differences among sub treatments i.e., cytoplasms was observed for disease related parameters like length and area of the lesion, and agronomic traits like plant height, agronomic score, grain yield $plant^{-1}$ and test weight. The genotypes x cytoplasm interaction was found significant for all the characters under study except for seed weight. The results of genotypes, cytoplasm's and their genotypes x cytoplasm interaction effect for various disease resistant parameters and yield contributing characters are presented in Table 1 and 2, respectively.

Disease related parameters : Irrespective of the cytoplasm, there was no significant difference in the performance of genotypes with male-fertile cytoplasm (4.68) and male-sterile cytoplasm

Table 1. Anova table for genotypes, cytoplasms and genotypes x cytoplasms effects for various disease resistant parameters and yield contributing characters of sorghum, post rainy season, ICRISAT, Patancheru, 1997.

Mean sum of squares

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

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

(4.72) for overall disease damage score. (Table 2). The genotypes with male-sterile cytoplasm (2.53 cm) had contributed significantly to resistance (C.D=0.05) than genotypes with male-fertile cytoplasm (2.62 cm) by exhibiting minimum length of the lesion.

Genotypes with male-sterile cytoplasm (0.30 cm) recorded almost same width of the lesion as genotypes with male-fertile cytoplasm (0.31 cm) indicating no difference between male-sterile and male-fertile cytoplasms. Considering area of the lesion, genotypes with sterile cytoplasm recorded significantly less leaf area damage (0.84 cm^2) than genotypes with fertile cytoplasm (0.88 cm^2) and both were significantly different from each other; consequently male-sterile cytoplasm contributing towards resistance.

On the other hand, the results of two types of cytoplasm effects on lesion number showed that genotypes with male-fertile cytoplasm recorded less number of diseased lesions (6.15) than male sterile cytoplasm (6.26). The difference between the two- cytoplasm means was equal to critical difference (0.12) indicating that there was no significant difference between the two cytoplasm with respect to the disease. The shows the similarity in the behavior of cytoplasm's on lesion number.

Considering fleck number, there is negligible difference between sterile (279.9) and fertile (280.0) cytoplasm indicating their identical behavior on the occurrence of the disease.

As indicated earlier, male-sterile cytoplasm was found significantly more dominant for length and area of the lesion, while male-fertile cytoplasm for number of lesions. On the other hand, the effect of cytoplasm on the disease score, width of the lesion and number of flecks was not significant. The nuclear genes perhaps determine the response to the disease spores in terms of number of lesions, while the genes in the cytoplasm have dominant role in spreading the disease in terms of length and area of lesions. Moreover, the leaf area damage had no relationship with the width of the lesion, number of flecks and overall disease damage

Table 2. Mean performance (AxR) hybrids and (BxR) of Sorghum of various disease resistant parameters and yield contributing characters, post rainy season, ICRISAT, Patancheru, 1997

Genotypes	Disease score[1]			Length of the lesion (cm)			Width of the lesion (cm)			Area of the lesion (cm^2)			Number of lesions (no)			Number of flecks (no)		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
Overall Mean	4.72	4.68	0.04	2.53	2.62	-0.09	0.3	0.31	-0.01	0.84	0.88	-0.04	6.26	6.15	0.11	279.9	280	-0.10
	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C
S.Em	0.39	0.04	0.42	0.21	0.03	0.30	0.02	0.03	0.03	0.11	0.01	0.15	0.50	0.06	0.68	20.49	2.54	28.42
C.D. (5%)	0.76	0.07	0.82	0.40	0.05	0.60	0.04	0.05	0.06	0.22	0.03	0.30	0.90	0.12	1.33	40.15	4.98	55.7

Genotypes	Days to 50% flowering			Plant height (cm)			Agronomic score1			Grain yield			100 seed weight		
	Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms			Cytoplasms		
	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)	A	B	(A-B)
Overall Mean	65.5	65.6	-0.10	191.2	194.1	-0.10	3.66	3.43	0.23	29.82	33.8	-4.10	2.9	2.98	-0.08
	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C	G	C	G x C
S.Em	0.60	0.10	0.70	38.50	0.25	2.80	0.35	0.03	0.38	1.54	0.21	2.37	0.08	0.01	0.11
C.D. (5%)	0.60	0.10	0.70	3.90	0.30	2.80	0.35	0.03	0.38	1.54	0.21	2.37	0.08	0.01	0.11

1. Scored on a (1-9) scale G = Genotypes G x C = Genotype x Cytoplasm interaction C = Cytoplasm

1. Scored on a (1-5) scale

(score); hence, it can be concluded that the observed highly significant effect of sterile cytoplasm on the above character could be non influential in designing the breeding programme for hybrids. Frederiksen *et al* 1978 indicated that some maternal factors condition on resistance to leaf blight in sorghum. However, in maize, several hybrids when tested in reciprocal combinations showed similar disease reactions to *Helminthosporium turcicum* suggesting the absence of cytoplasmic effects (Hooker, 1975). Neither maternal nor reciprocal effects were significant for mean lesion area, rate of increase in lesion size and shape in maize (Sigulas *et al* 1988).

Yield attributes : In case of agronomic traits, genotypes with male-sterile (65.5 days) and male-fertile (65.6 days) cytoplasmic background attained to 50% flowering at the same time (Table 2). On the other hand, the effect cytoplasm was significant on plant height and yield attributes such as desirability for ear head size and shape, grain yield plant^{-1} and 100 seed weight. The fertile cytoplasm had profound dominant effect on agronomic desirability (B-3.4 score/A3.7 score), grain yield plant^{-1} (B-33.9 g/A-29.8 g) and 100 seed weight (B-2.98 g/2.90 g), whilst sterile cytoplasm exerted profound effect on plant height (A-191.2 cm/B-194.1 cm) only. This shows that.

- Higher fodder yields can readily be achieved through hybrids developed on male-steriles.
- High grain yield coupled with bold seeds in the B-lines would not be expressed in the male-sterile lines. Therefore to develop high yielding bold grain hybrids from male-steriles, it is all the more important to have really high yielding bold grain cytoplasm male-sterile / maintainer lines.

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