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THE GLOSSY TRAIT IN SORGHUM: ITS CHARACTERISTICS AND SIGNIFICANCE IN CROP IMPROVEMENT

R.K. MAITI, K.E. PRASADA RAO, P.S. RAJU and L.R. HOUSE

International Crops Research Institute for the Semi-Arid Tropics, ICRISAT Patancheru P.O., Andhra Pradesh 502 324 (India)

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ABSTRACT

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Sorghum seedlings can be morphologically glossy or nonglossy: seedlings with dark green leaves (normal) are nonglossy, and seedlings with light yellow green and shining leaf surfaces are glossy.

A systematic study of the world sorghum germplasm collection indicated a low frequency of accessions with the glossy trait (only 495 of 17 536 germplasm accessions screened). A large proportion (84%) of the glossy lines were of Indian origin but some were from elsewhere (Nigeria, Sudan, Cameroun, Ethiopia, Kenya, Uganda, South Africa, and Mexico). Most of the glossy lines are in the durra group but some are from the taxonomic groups guinea, caudatum, and bicolor. Glossy lines vary in morphological, anatomical, and agronomic attributes, many being extremely late or photoperiod-sensitive and very tall. Some lines are early maturing, intermediate to dwarf in height and agronomically good. Studies have indicated that glossy lines contribute to shootfly resistance and seedling drought resistance. Source material for the glossy trait is maintained by the Genetic Resources Unit at ICRISAT.

INTRODUCTION

Breeders are interested in stabilizing yields under various stress conditions. A trait that combines resistance to different stress factors is potentially valuable.

Resistance to the sorghum shootfly (*Atherigona soccata*) has been tentatively associated with light green seedlings, characteristic of most of the winter (rabi) sorghum varieties of India (Blum, 1972; Rao et al., 1978) but there is no experimental or conclusive documentation to this effect. Some glossy lines have resistance to seedling drought stress and shootfly (Maiti and Bidinger, 1979; Maiti, 1980). Most of the glossy lines show the

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presence of trichome, and the role of trichomes in shootfly resistance and its inheritance have been studied (Maiti and Gibson, 1983; Gibson and Maiti, 1983).

Glossiness is clearly manifested in the seedling stage and gradually disappears as the seedling grows. Tarumoto (1980) worked on the glossy leaf character in sorghum cultivars. The difference between glossiness and nonglossiness was detected by the adherence of water sprayed on leaf blades. Inheritance studies showed that glossy is a simple recessive to nonglossy.

The present study involves different techniques used in identifying glossy lines, characterising glossy lines for their morpho-agronomic characters and testing them for resistance to shootfly and drought.

MATERIALS AND METHODS

Sorghum accessions numbering 17 536 from the ICRISAT germplasm collection at Patanchera were screened for the glossy trait in August 1981. Plants were grown in brick containers (160 cm long, 70 cm wide, 22 cm high) constructed at ground level and filled with soil. Eight seeds of each genotype were sown 4 cm deep in a hill. Ten hills were sown per row and 20 rows were sown across the length of the container, thus fitting 200 lines into each container. Sufficient water for germination and emergence was applied to each container after sowing. A week after plants emerged, they were carefully examined for 5 days for light yellowish green leaves with a glossy (shiny) appearance in bright sunlight. In contrast, the normal sorghum lines had dark green, nonglossy leaves. Any glossy line identified was marked by inserting a toothpick into the soil adjacent to it. For confirmation, suspected glossy lines were sown in single rows in brick containers, 20 lines in each container with the nonglossy cultivar 'Swarna' (IS 3924) as a control in three rows, one along each border and one in the center of the container. Seven and 10 days after plants emerged they were visually scored on a 1 to 5 scale for glossiness (1 = most glossy and 5 = nonglossy). The nonglossy 'Swarna' (IS 3924) was scored 5.

Glossy lines were visually scored for seedling vigor, using 1 as most vigorous and 5 as least vigorous (Maiti et al., 1981).

Leaf surface

Scanning electron microscopic observations of leaves of glossy and nonglossy lines were undertaken at the Centre for Overseas Pest Research (COPR), London. The material was prepared using 'silver dag' to hold freshly cut leaf samples from 2-week-old plants to stubs. JOEL SEM was operated at 18 kV with 1100 magnification and at 16 kV with 1500 and 200 magnifications. The abaxial surface of the leaf of each line was photographed at ×200, ×1100 and ×1500 which permitted us to describe

leaf epidemial structures, especially silica deposits, trichomes, and wax.

Glossy lines grown in the 1981 post-rainy season were grouped by geographic origin (Table I) and were classified taxonomically according to Harlan and De Wet (1972) (Table II).

TABLE I

Distribution of glossy lines by countries in the world sorghum germplasm collection evaluated at ICRISAT

Country of origin	Accessions screened	Entries with glossy trait
India	4027	417
Nigeria	1173	25
U.S.A.	1867	24
Sudan	2255	11
Cameroun	1835	8
Ethiopia	4113	3
South Africa	659	2
Mexico	234	2
Kenya	761	1
Uganda	612	1
Total	17356	494[a]

[1]Plus one line of unknown origin = 495.

TABLE II

Taxonomic distribution of glossy lines in the world sorghum germplasm collection evaluated at ICRISAT

Taxonomic group	No. of lines
Durra	400
Durra-bicolor	31
Durra-caudatum	26
Guinea	8
Durra-kafir	3
Caudatum	3
Bicolor	2
Guinea-caudatum	2
Caudatum-bicolor	1
Durra-guinea	1
Total	477

Shootfly resistant glossy lines in the germplasm collection

In December 1981, 495 glossy lines and 27 nonglossy lines were sown in a randomized block design with three replications. Sorghum cultivars CSH-1 (hybrid) and Swarna (variety), were the susceptible controls and were repeated after every 48 plots. Plants were scored for glossiness and seedling vigor. The number of plants per plot, the number of plants with shootfly eggs at 21 days, and the number of plants with dead hearts at 21 and 28 days after emergence were recorded. Dead hearts are recognized by the death of the expanding leaf in the center of the whorl. The fish meal technique (Starks, 1970) was used to enhance infestation.

Drought resistance of glossy lines

Drought resistance of 481 glossy seedling was evaluated (ICRISAT, 1981). M35-1, a resistant glossy cultivar, and Swarna, a nonglossy susceptible, were used as controls. Plants were grown in polyvinyl chloride (PVC) cylinders with closed bottoms (30 cm long and 10 cm in diameter) filled with equal weights of alfisol (red soil) in a glasshouse; each container formed one of three replications. Twenty seeds were sown in each container. Water (40 mm) was applied at sowing. Three days after the seedlings emerged, they were thinned to six per cylinder. Plants were rewatered only when seedlings in most of the cylinders were wilting severely and the susceptible control had died. Visual scores for wilting were recorded before rewatering and for recovery after rewatering (1 = minimum wilting and maximum recovery; 5 = maximum wilting and minimum recovery). The number of recovered plants per cylinder was also recorded.

RESULTS AND DISCUSSION

Systematic survey

Glossy lines are mostly of Indian Peninsular origin but some originated in Nigeria, Cameroun, Ethiopia, South Africa, Sudan, Uganda, Kenya, and Mexico, and some have been received from the U.S.A. (Table I) indicating that glossy lines have a diverse geographic origin. Durra sorghums of India are mostly from the drier central parts of the country, where land races probably evolved a resistance to shootfly and drought.

Glossy lines are relatively rare in the world collection. Only 495 (2.4%) were found in 17 536 germplasm accessions studied, and intensity of glossiness varied from 1 to 4, the maximum number being in the range 1—1.5 (Table IV).

Of 477 glossy accessions classified (IBPGR/ICRISAT, 1980), 461 belong to durra and its intermediate races durra-bicolor, durra-caudatum, durra-kafir, and durra-guinea (Table II). The glossy lines appeared in all the five

TABLE III

Analysis of variance of seedling vigor, glossy scores, and shootfly incidence indices

Source of variation	df	Mean sum of squares			
		Seedling vigor	Glossy score	Percent plants with eggs	Percent dead hearts
Replication	2	0.82 NS	25.56**	12572.37**	3095.9**
Genotype	494	1.73**	1.04**	826.54**	768.34**
Error	988	0.54	0.26	221.26	174.64
Glossy lines					
C.V.		28.5	32.9	33.0	32.9
Mean		2.6	1.5	45.0	40.2
Range		1.0—4.7	1.0—4.7	12.6—94.7	7.9—90.1
LSD at 5%		1.2	0.8	23.8	21.1
Nonglossy lines					
CSH-1		4.0	5.0	80.1	80.8
Swarna		4.0	5.0	74.8	74.8

**$P < 0.01$.
NS, not significant.

basic races and in all the ten intermediate races except bicolor-guinea and bicolor-kafir. About 10% of the accessions collected from India, 2% from Nigeria, and about 1.5% from the U.S.A. were glossy.

Seedling morphology. During the seedling state (10—12 days after emergence) sorghum can be easily classified for the glossy trait. The appearance of glossiness differs from genotype to genotype, being quite early in some (2 days after emergence), and late in others (15 or more days after emergence).

It is very difficult to identify glossiness after plants have grown beyond the seedling stage. Soil fertility does not affect the glossy expression (Maiti, 1981, unpublished).

Seedling vigor. The seedling vigor score of the glossy lines varied widely from 1 to 5. In general, nonglossy lines were more vigorous than glossy lines.

Flowering and plant height of glossy sorghum

In both rainy and post-rainy seasons glossy lines varied widely in days to flowering. Many lines from West Africa were found to have a wide difference in plant height, and days to 50% flowering between rainy (long day) and post-rainy (short day) seasons indicated photoperiod-sensitivity.

During the rainy season, days to 50% flowering ranged from 45—55 to 156—165 days with the greatest number (150 entries) flowering in 66—75 days. In the post-monsoon season, days to 50% flowering ranged from 45—55 days to 106—115 days with the greatest number (175) also flowering in the 156—165-day group.

Plant height ranged from 50—100 cm to 500—550 cm in the rainy season and from 100—150 cm to 250—300 cm in the post-rainy season. Most cultivars ranged from 200 to 350 cm in both seasons.

Leaf surface. Both glossy and nonglossy lines had extruded strands of wax along the veins between silica bodies (Fig. 1).

Fig. 1. Scanning electron micrograph (SEM) of leaf surface of IS 4663, a glossy line, showing bilobed silica crystals (A) and, extruded strands of epicuticular wax (× 1500).

Both glossy and nonglossy lines have an apparent morphous waxy cuticle, but at higher magnification, on glossy lines, it appears as patchy aggregations of large, irregularly crystals (Fig. 2). Density of the aggregations in the cuticle differed with variety within glossy lines but areas of smooth wax were always visible. Silica bodies were rarely covered by wax

Fig. 2. Scanning electron micrograph (SEM) of leaf surface of glossy sorghum line showing large prismatic wax crystals (× 3000).

crystals. Smooth wax was also present in the nonglossy lines. Unlike glossy, most of the nonglossy leaf surfaces (under higher magnification) were covered by densely packed, small, uniform, needle-shaped wax crystals (Fig. 3). Silica bodies were generally covered by the wax layer. These observations confirm the findings of Tarumato et al., 1981.

Shootfly resistance. All the 495 glossy germplasm lines were screened for shootfly resistance. There was significant variation in glossy sorghum for seedling vigour ($P < 0.10$). Shootfly incidence on glossy sorghums also varied widely in terms of egg laying and dead hearts (Figs. 4 and 5). Comparing dead heart incidence with glossiness (Table III), it may be seen that there is increase in susceptibility with decrease in the intensity of glossiness.

The positive correlations of glossy scores with percentages of plants with eggs ($r = 0.43$) and dead hearts ($r = 0.46$) were highly significant ($P < 0.01$) though the coefficients were not high.

Seedling drought resistance. Results of testing 481 glossy lines for drought resistance at Patancheru indicated that there were significant differences

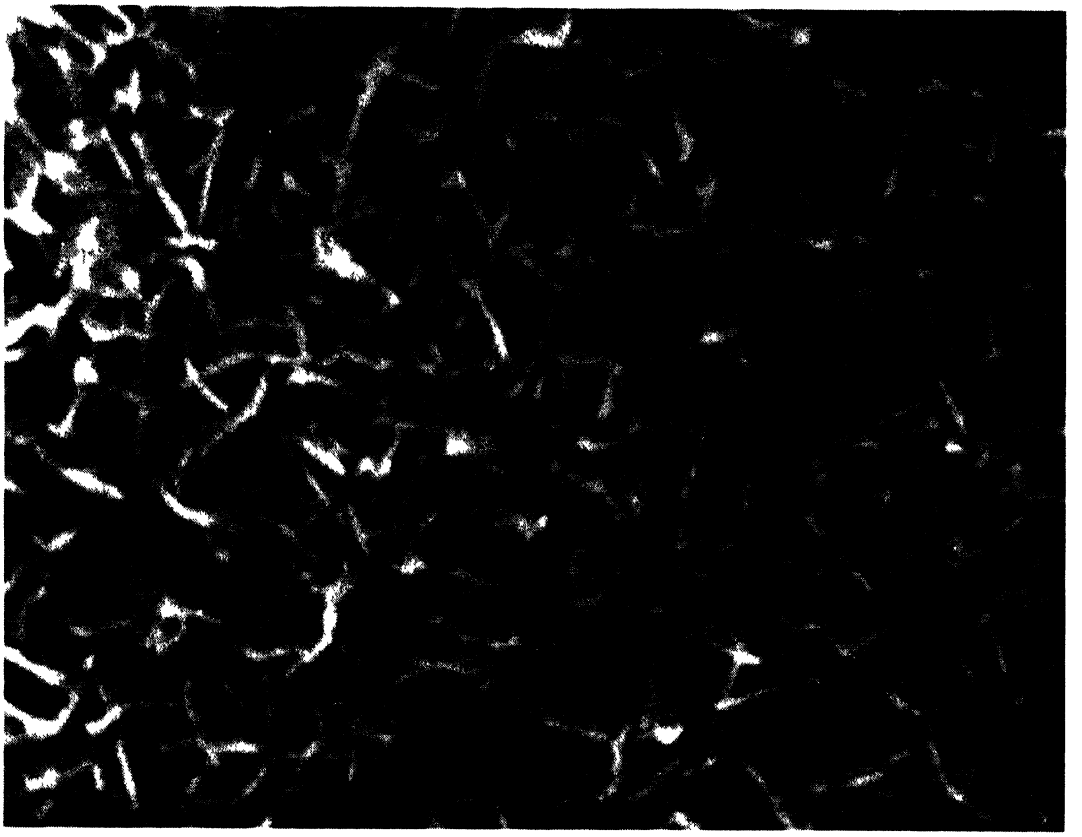

Fig. 3. Scanning electron micrograph (SEM) of leaf surface of nonglossy line showing small needle-shaped wax crystals (× 3000).

($P < 0.05$) among glossy lines for all seedling drought resistance factors investigated: visual scoring for wilting, recovery score, and recovered plants. This was in line with several ICRISAT studies indicating that a major proportion of lines with seedling drought resistance are from the glossy group (Maiti, 1980, 1981).

Interestingly, some glossy germplasm lines (IS 5604, IS 4664, IS 5359, IS 4712, IS 3676, IS 5622, IS 4661, IS 1054, IS 2314, and IS 2312) in the seedling stage resisted both shootfly and drought. S. Woodhead, working in COPR, London (personal communication, 1980) also found that IS 2312 resists shootfly and drought in the seedling stage.

Because of the association of the glossy trait with shootfly and seedling drought resistance, glossiness can be used to identify shootfly and seedling drought resistant genotypes in the preliminary screening of large germplasm and breeding populations. Although glossy lines in general were poorer yielding than nonglossy lines at Patancheru, some had good yields, e.g. IS 4663, IS 4405, IS 5642, IS 4776, IS 5667, IS 4473, IS 1096, IS 2280, IS 5621, IS 5067, IS 4661, IS 2314 and IS 1054. Further breeding input is required.

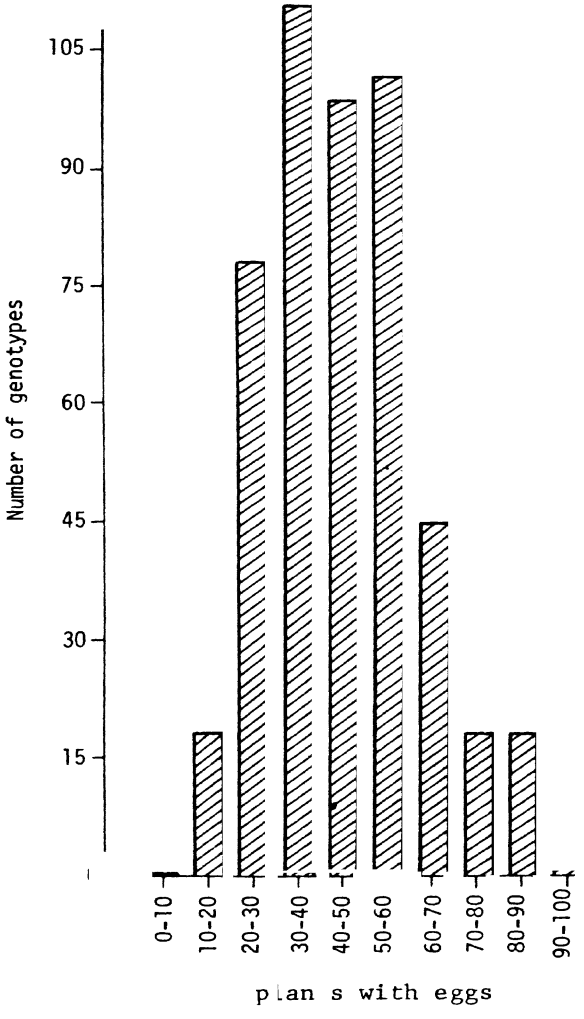

Fig. 4. Variability in percentages of p ants v sh fly eggs in glossy sorghum ines.

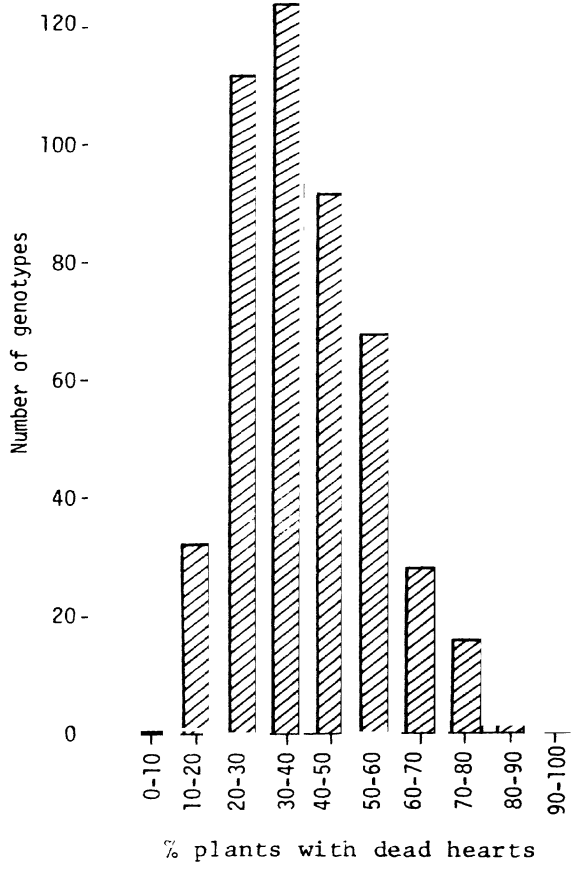

Fig. 5. Variabili y in percenta ges of pla ts wi shootfly dead hearts in gl y sorghum lines.

TABLE IV

Variability of intensity of glossiness

Glossy score	Number of lines
1—1.5	271
1.6—2.0	180
2.1—2.5	23
2.6—3.0	7
3.1—3.5	5
3.6—4.0	9

1 = most glossy, 4 = least glossy.

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