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Registration of ICSV 88032: A High Yielding Line Resistant to Sorghum Midge, *Stenodiplosis sorghicola*

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Sorghum [*Sorghum bicolor* (L.) Moench] midge [*Stenodiplosis sorghicola* (Coquilett)] is one of the most important pests of grain sorghum in Asia, Africa, Australia, and the Americas (Harris 1976, Sharma 1993). The larvae of sorghum midge feed on the developing ovary resulting in the production of chaffy spikelets. The damaged panicles present a blasted appearance. Midge damaged spikelets have a pupal case attached to the glumes or have a small exit hole of the midge parasite on the upper glume. Females lay 30–100 eggs singly in the spikelets at flowering during the morning hours, and die by the afternoon. Eggs hatch in 1–4 days. The larvae suck the contents of developing ovaries and complete development in 7–12 days. Larvae pupate inside the glumes, and the pupal period lasts for 3–8 days. Adults live for 2–48 h. Maximum midge abundance occurs during September-October. A small proportion of the larvae enter diapause in the spikelets in each generation, which may last as long as 3 to 4 years.

It is difficult to control sorghum midge with conventional insecticides, as the larvae remain hidden inside the spikelets. Therefore, it is important to develop midge-resistant cultivars to minimize the extent of losses due to this pest (Sharma 1993). Substantial progress has been made in identification and utilization of resistance to sorghum midge (Sharma et al. 1993). The accessions IS 2579C, IS 12666C, TAM 2566, AF 28, DJ 6514, IS 10712, IS 7005, IS 8891, and IS 8721 are diverse sources of resist-ance to sorghum midge (Sharma 1993), and efforts have been made to transfer resistance into high yielding cultivars in Asia, Australia, and USA. As a result of intensive efforts to breed for resistance to this pest, several midge-resistant varieties with high grain yield have been developed for cultivation by farmers or for use in the national sorghum improvement programs (Johnson et al. 1973, Agrawal et al. 1987, Sharma et al. 1994).

Sorghum line ICSV 88032 is highly resistant to sorghum midge, early, and less susceptible to leaf diseases. It combines high levels of resistance to sorghum midge with yield potential comparable to commercial cultivars. ICSV 88032 (PM 15936-1) is derived by pedigree breeding from a cross between ICSV 197 (midge-resistant line) and ICSV 1 (high-yielding sorghum variety). Its selection number is (ICSV 197 x ICSV 1)-22-1-1-1. The

segregating and the advanced lines were screened and selected for resistance to sorghum midge using the infester row and no-choice headcage screening techniques (Sharma et al. 1988a, b, 1992). In the international sorghum variety and hybrid adaptation trial, ICSV 88032 yielded 4.8 to 5.2 t ha^{-1} during the 1990-91 season compared to 5.0 to 5.3 t ha^{-1} for ICSV 112, a released commercial cultivar at Bhavanisagar and Patancheru (Table 1). At Surat, its grain yield was 2.6 and 4.6 t ha^{-1} compared to 2.9 and 3.4 t ha^{-1} for ICSV 112 during 1990 and 1991, respectively. In the preliminary variety trials of AICSIP, it yielded 3.1 t ha^{-1} compared to 2.8 t ha^{-1} for ICSV 112 in 1990/91 (Table 2). In the 1991 and 1992 advance variety trials of AICSIP, it yielded 4.0 and 3.6 t ha^{-1} compared to 4.2 and 3.1 t ha^{-1} for ICSV 112, respectively.

The plant height of ICSV 88032 is 185 to 201 cm, and plant color is tan. Leaves are drooping with yellow midrib, and the leaf sheath encloses the stem. The stem is thin and non-juicy. Panicles are long and loose with long rachis. Glumes are straw colored covering 1/3rd of the grain. It flowers in 67 to 68 days, and matures in 103 to111 days compared to 112 to115 days for CSV 10 and CSH 5. Grain of ICSV 88032 is pearly white, shining, plump, without sub-coat, and with white endosperm. Grain weight is 25 g per 1000 grains. Because of its pearly white grain, grain and food quality characteristics are comparable to ICSV 112.

ICSV 88032 is highly resistant to sorghum midge. It suffered 12–14% midge damage compared to 18–20% in the resistant check, DJ 6514; and 90 to 94% in the susceptible check, CSH 1 (Table 3). Visual damage ratings varied from 2.1–3.4 compared to 1.3–1.8 in DJ 6514, and 8.4–9.0 in CSH 1. Its resistance to sorghum midge has been confirmed across locations in India (Table 4), Latin America, and West Africa. During 1995/96, ICSV 88032 suffered 16–31% midge damage compared to 9–26% in ICSV 197 (resistant check), and 38–83% in Swarna – the susceptible check. The loose panicle of ICSV 88032 makes it less susceptible to head bugs and earhead caterpillars. Its susceptibility to shoot fly and stem borer is similar to that of ICSV 112 and CSH 5.

ICSV 88032 can be used for cultivation in midge-endemic areas. It can be used as a donor for combining resistance to sorghum midge, leaf diseases, grain quality, and high yield. It can escape terminal drought because of

Table 1. Grain yield (t ha^{-1}) of ICSV 88032 in India in the 1990-1991 International Sorghum Variety and Hybrid Adaptation Trial.

Genotype	Bhavanisagar	Patancheru		Surat	
	1990	1990	1991	1990	1991
ICSV 88032	5.1	5.2	4.8	2.6	4.6
Controls					
ICSV 112	5.0	5.1	5.3	2.9	3.4
CSH 11	4.7	6.7	6.0	4.0	5.4
Trial mean	4.01	4.6	4.4	3.0	4.6
SE±	0.79	0.32	0.23	0.19	0.29

Table 2. Performance[1] of ICSV 88032 across nine locations in India (All India Coordinated Sorghum Improvement Project Trial, 1990/91).

Genotype	Plant ht (cm)	Days to 50% flowering	Days to maturity	Fodder yield (t ha^{-1})	Grain yield (t ha^{-1})
ICSV 88032	198	68	111	8.5 (18)	3.06 (2)
Controls					
CSV 10	219	74	112	9.5 (10)	2.62 (10)
ICSV 112	193	76	115	9.3 (13)	2.84 (7)
Trial mean	217	74	114	9.3	2.45
LSD at 5%	26	3	5	1.51	0.64

[1] Mean across nine locations (Parbhani, Akola, and Karad (Maharashtra), Dharwad (Karnataka), Patancheru (Andhra Pradesh), Surat (Gujarat), Udaipur (Rajasthan), and Kanpur and Jhansi (Uttar Pradesh).
Figures in parentheses indicate the ranking in the trials.

Table 3. Relative susceptibility of ICSV 88032 to sorghum midge under no-choice headcage screening and natural infestation (ICRISAT, Patancheru, 1985-88).

Genotype	Damage rating[1]		Midge damage (%)	
	Natural infestation	Headcage screening	Natural infestation	Headcage screening
ICSV 88032	3.4 ± 0.76	2.1 ± 0.13	14	12
Controls				
DJ 6514 (R)	1.3 ± 0.14	1.8 ± 0.43	18	20
CSH 1 (S)	8.4 ± 0.28	9.0 ± 0.16	90	94
SE±	-	-	6.7	7.5
LSD at 5%	-	-	18.4	21.0

[1] Damage rating (1=<10% midge damage, and 9 = > 80% midge damage).
R = Resistant check. S = Susceptible check.

Table 4. Resistance of ICSV 88032 to sorghum midge across locations in India (1986-88).

Genotype	Dharwad	Patancheru		Bhavanisagar	Warangal	Mean
		Rainy season	Postrainy season			
ICSV 88032	3.5[1]	2.0	2.0	3.0	3.0	3.5 ± 0.20
Controls						
DJ 6514 (R)	2.0	1.0	1.5	2.0	1.0	1.5 ± 0.20
CSH 1 (S)	9.0	8.0	9.0	8.0	8.0	8.4 ± 0.21
SE±	0.21	0.16	0.18	0.21	0.18	-
LSD at 5%	0.57	0.45	0.49	0.58	0.51	-

[1] Damage rating (1 =<10% midge damage, and 9 = > 80% midge damage). R = Resistant check. S = Susceptible check.

its early maturity. It has hard corneous grain, which is associated with good grain quality. The use of midge-resistant varieties in integrated pest management in sorghum is promising as the levels of resistance to sorghum midge are quite high. This new cultivar will provide greater flexibility in planting times to obtain maximum yields, and proper utilization of available rainfall without risking midge damage.

This line has been released as ICSV 88032 by the Plant Material Release Committee of ICRISAT, and the seed is available in the Genebank at ICRISAT.

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Registration of Sorghum Varieties ICSV 735, ICSV 758, and ICSV 808 Resistant to Sorghum Midge, *Stenodiplosis sorghicola*

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Sorghum [*Sorghum bicolor* (L.) Moench] is one of the most important cereals in the semi arid tropics (SAT). It provides food, feed and forage, but grain yields on peasant farms are generally low, partly due to insect pest damage. Nearly 150 species of insects have been recorded as pests of sorghum, of which sorghum midge [*Stenodiplosis sorghicola* (Coquillett)] is the most important worldwide (Harris 1976). As a result of feeding by the sorghum midge larvae on the developing ovary, the damaged spikelets become chaffy. Midge damage is sometimes confused with poor seed setting due to unfavorable weather, genetic sterility, and damage by head bugs and other insects (Sharma 2001). The midge-damaged panicles have pupal cases attached to the tip of the damaged spikelets, and often have a pinhole in the glumes, through which midge parasites have emerged. Sorghum midge is widely distributed in Asia, Australia, Americas, Mediterranean Europe, and Africa (CIE 1990). It has spread as diapausing larvae in chaffy spikelets in sorghum seed to most of the countries where sorghum is grown. Annual losses due to sorghum midge have been estimated to be $ 292 million in the SAT (ICRISAT 1992).

Early planting, cultural practices, natural enemies, resistant varieties, and insecticides have been recommended for pest management in sorghum. However, it is difficult to plant at times when insect damage can be avoided. Insecticides are costly, and beyond the reach of resource-poor farmers in the SAT. Therefore, it is important to develop cultivars with resistance to sorghum midge which maintains high grain yield. Nearly 15,000 sorghum germplasm accessions have been screened for resistance to sorghum midge at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, and 25 lines have been identified as resistant to sorghum midge across seasons and locations in India. The germplasm accessions IS 2579C, TAM 2566, AF 28, DJ 6514, IS 3461, IS 8918, IS 8891, IS 7005, IS 10712, IS 22881, and IS 27103 are stable and diverse sources of resist-ance to sorghum midge (Sharma et al. 1993, Henzell et al. 1997). Efforts to develop sorghum cultivars with resistance to sorghum midge were initiated in the USA under the sorghum conversion program (Johnson et al. 1973), at ICRISAT (Sharma et al. 1993), and in Australia (Henzell et al. 1997), and several lines with high levels of resistance to sorghum midge have been developed. The midge-resistant varieties ICSV 735, ICSV 758, and ICSV 804 developed at ICRISAT have been found to perform well across locations in Myanmar, and have been released.

The sorghum midge-resistant varieties ICSV 735, ICSV 758, and ICSV 804 have been released as Yezin 6, Yezin 7, and Yezin 5, respectively in Myanmar. These varieties combine resistance to sorghum midge with yield potential close to the commercial cultivars Yezin 1 and Yezin 3. ICSV 735 (PM 14355-2-6) is derived from (ICSV 197 x ICSV 1)-9-1-1-2-6, ICSV 758 (PM 14403-1-1)

Table 1. Grain and fodder yield of midge-resistant sorghum genotypes fertilized with farmyard manure across three locations (Yezin Elite Sorghum Variety Trial 1993-94, Myanmar).

	Grain yield (t ha^{-1})				Fodder yield (t ha^{-1})			
Variety	Myingyan	Mahlaing	Zaloke	Mean	Myingyan	Mahlaing	Zaloke	Mean
ICSV 735	1.417	2.421	0.628	1.489	8.7	8.4	0.4	5.8
ICSV 758	1.309	3.533	1.004	1.947	3.4	6.9	0.3	3.6
ICSV 804	1.130	3.371	0.663	1.721	4.5	8.3	0.4	4.4
Control								
Local variety	0.502	1.094	2.659	0.622	6.2	12.3	1.5	6.7
SE	±0.1797	±0.3293	±0.1612	±0.1726	±0.60	±0.60	±0.10	±0.40