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Short Communication

Identification of stable restorers for diverse cytoplasmic source in Sorghum [*Sorghum bicolor* (L.) Moench.]

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Abstract

In sorghum [*Sorghum bicolor* (L.) Moench.], *milo* is the lone source of cytoplasmic male sterility (CMS) extensively used in production of commercial hybrids. The hazards of such a narrow cytoplasmic base are apparent and consequently new diverse sources like A_2, A_3, A_4, *maldandi*, VZM and G_1 were identified. However, the commercial exploitation of these sources has not been possible because of the difficulty in fertility restoration on these sources. The present study was, therefore, undertaken to test different sorghum germplasm lines for their fertility restoration/maintenance on *maldandi* and *milo* cytoplasm. Twenty-five diverse accession were selected from minicore collection and crossed with two male sterile lines *viz.,* 104A (*milo*) and M 31-2A (*maldandi*). The resulting F_1s were classified as fertility restorers and maintainers based on seed set on bagged ear heads. The restoration studies indicated that 2 lines on *maldandi* and 6 on *milo* cytoplasm showed strong fertility restoration (> 90 % seed set).

Key words: Cytoplasmic male sterility, *maldandi*, *milo*, fertility restoration, seed set

Sorghum [*Sorghum bicolor* (L.) Moench.] is one of the important cereal crop cultivated globally for food, fodder, feed and fuel. It ranks fifth after wheat, rice, maize and barley in area and production. It is the second cheapest source of energy and micronutrient after pearl millet. It is mainly grown in semi-arid tropics of Asia, Africa, America and Australia. In Africa and Asia sorghum grain is mainly used as food, while in the United States and Australia it is used to feed cattle (Reddy et al. 2013). Globally, sorghum is grown in an area of 42.50 m ha to produce 59.91 mt, with the productivity of around 1.60 t/ha.

All the commercial hybrids of sorghum developed to date are based on *milo* (Stephens and Holland 1954) cytoplasm. This situation can predispose the crop for unforeseen wide spread damage in future. Restoration on *milo* (A_1) cytoplasm is quite easy as majority of the breeding lines act as restores on this cytoplasm. However, the hazards of such a narrow cytoplasmic base are apparent and consequently new diverse sources like CMS A_2, A_3, A_4, *maldandi*, VZM and G_1 were identified. The restoration on *non-milo* cytoplasm is difficult and work in this sphere is quite limited. Kishan and Borikar (1989) reported that majority of the breeding lines from Indian programme acts as restorer for *milo* cytoplasm and thus, identification of suitable restorer for *milo* (A_1) cytoplasm is quite easy. However, the A_2, A_3 and A_4 cytoplasm appear difficult for fertility restoration. Because of these limitations, A_2, A_3, A_4 and other cytoplasmic male sterile lines have not been used for commercial exploitation. Plenty of restorers are available for *milo* (A_1) cytoplasm and very popular commercial hybrids have been developed which revolutionized the sorghum production. But, there are no stable fertility restore's in other cytoplasm and to diversify the cytoplasm base in sorghum, there is need to identify stable restorers in A_2, A_3, A_4 and A_5 cytoplasm (Jilani 2000). Therefore, there is an urgent need to identify the restorers for diverse cytoplasmic male sterile lines.

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Maldandi and A_2 sources can be utilized more easily compared to the other sources. Use of indigenous *maldandi* source of male sterility instead of exotic appears to be good as *maldandi* source has larger grain size and less susceptible to shoot fly (Dhillon et al. 2005). The present investigation was conducted with an aim to identify stable restorers for the *maldandi* and *milo* source of male sterility. For this purpose, 25 diverse germplasm accessions were selected from the minicore collection to study their sterility/fertility restoration abilities on *maldandi* and *milo* sources of male sterility.

The male sterile lines used in this study were 104A and M31-2A representing *milo* and *maldandi* sources, respectively. The selected accessions were crossed to each of these two male sterile lines. Twenty-five hybrids one each of *milo* and *maldandi* were grown during *rabi* 2018-19 at Botany Garden, UAS Dharwad. The hybrids were grown each in a single row of four meters length with spacing of 45 cm x 15 cm and all the recommended agronomic practices were followed to raise the good crop. Three heads from each row were bagged three days before stigma emergence and the observations on seed set percentage were noted. Seed percentage was calculated by counting the number of seeds set out of the total number of spikelets per earhead (Kishan and Borikar, 1989). Based on the seed set percentage genotypes were grouped into different categories of restoration.

Seed set scoring was done based on seed set percentage as below Biradar et al. (1996).

Category	Seed set %
Strong restoration	>90 %
High restoration	80 to 90 %
Moderate restoration	60 to 80 %
Partial restoration	10 to 60 %
Maintainer	< 10 %
No seedset	0 %

Out of 25 hybrids obtained by crossing with *milo* based CMS line (104A), 12 exhibited satisfactory (> 60 %) seed setting, while one F_1 showed no seed set therefore it could be considered as maintainer. Six genotypes restored very high fertility (> 90 % seed set on F_1's) the mean seed set per cent of 95.96% and hence these were characterized as strong restorers. Most (13) of the lines evaluated were found to have seed set per cent of < 60 per cent. Five lines were moderate restorers with the mean seed set of 71.23 per cent. The mean seed set percentage of partial restorers (5 genotypes) was 39.55 per cent. Seven lines showed low restoration with the mean seed set in F_1's was 5.92 per cent.

A total of 25 genotypes were crossed on *maldandi* based CMS line (M31-2A). Among them 4 hybrids showed more than 60 per cent seed setting on selfing. Out of these, two genotypes were found to be strong restorers, which showed > 85 per cent seed set. The mean seed set per cent of the F_1's produced by strong restorers was 97.79. Fourteen accessions evaluated for restoration ability shows zero seed set and were designated as maintainers. One genotype recorded strong restoration with the mean seed set per cent of 87.71 per cent. The mean seed set per cent of three genotypes (partial restorers) was 64.52 per cent.

Table 1. Restoration status of genotypes on *milo* (104A) and *maldandi* (M31-2A) source of male sterility

S.No.	Genotypes	Seed set per cent	
		Maldandi (M31-2A)	Milo (104A)
1	IS 22720	0.00	5.25
2	IS 26617	0.00	7.31
3	IS 4581	0.00	9.82
4	IS 15945	0.00	10.25
5	IS 4515	0.00	48.42
6	IS 25989	0.00	58.65
7	IS 27887	0.00	60.65
8	IS 4698	0.00	69.33
9	IS 20743	0.00	70.23
10	IS 29654	0.00	76.36
11	IS 19975	0.00	80.00
12	IS 23590	0.00	82.65
13	IS 31651	0.00	92.32
14	IS 30451	0.00	98.25
15	IS 602	2.06	6.76
16	IS 20679	2.66	10.23
17	IS 26025	3.56	96.66
18	IS 32439	8.69	3.02
19	IS 995	14.25	95.85
20	IS 24462	14.82	10.23
21	IS 23891	27.25	92.85
22	IS 28313	64.52	0.00
23	IS 29269	87.71	3.36
24	IS 11619	95.60	5.62
25	IS 19450	99.98	99.65

Table 2. Classification of restoration based on mean seed set per cent in maldandi and milo cytoplasm

Restoration class	Seed set (%)	*Maldandi*		*Milo*	
		No. of restorers	Mean seed set %	No. of restorers	Mean seed set %
Strong restoration	> 90 %	2	97.79	6	95.93
High restoration	80 to 90 %	1	87.71	1	82.65
Moderate restoration	60 to 80 %	1	64.52	5	71.23
Partial restoration	10 to 60 %	3	18.78	5	39.55
Low restoration	< 10 %	4	4.24	7	5.92
No seed set	0 %	14	0.00	1	0.00

The magnitude of fertility restoration reflected that there is considerable differences in restoration pattern between the male sterile lines. Proportion of the germplasm lines restoring > 90 per cent fertility in F_1's on *milo* cytoplasm was more as compared to *maldandi*. Out of 50 hybrids evaluated, 25 each on *maldandi* and *milo* cytoplasm, 11 on *milo* and 4 on *maldandi* cytoplasm set more than sixty per cent seed. Six lines exhibited more than 90 per cent restoration on *milo* and two lines on *maldandi* cytoplasm. In contrast, no. of genotypes with per cent seed set in F_1's was high on *maldandi* cytoplasm compared to *milo* cytoplasm were few. There was difference in fertility restoration across diverse cytoplasmic sources even the male parent was same. The genotype IS 19450 exhibited 99 per cent seed set on both *milo* as well as *maldandi* cytoplasm. Fourteen genotypes showed no seed set in F_1's of *maldandi* cytoplasm whereas, only one genotype on *milo* cytoplasm. The differential behaviour of restoration pattern on these two CMS lines may be due to variable expression and interaction of restorer genes with the cytoplasm.In sorghum cumulative effect of restorer genes or may be modifier genes results in variation of fertility restoration Reddy et al. (2003).

The restoring ability was measured in terms of seed set per cent observed in F_1s. The restoration studies indicated that two lines on *maldandi* and 6 lines on *milo* cytoplasm showed strong restoration (> 90 % seed set). Among the tested lines, on *maldandi* and *milo* cytoplasm did not set seed and hence they were characterized as maintainers. However, 12 lines showed more than 60 per cent restoration on *milo* but only 4 lines on *maldandi* cytoplasm indicating milo cytoplasm is more effective system of restoration. So, there is a need for large scale screening of local Indian and exotic germplasm to identify stable restorers on *maldandi* cytoplasm to develop commercial hybrids.

Authors' contribution

Conceptualization of research (NS, BB); Designing of the experiments (NS, BB); Contribution of experimental materials (NS, BB); Execution of field/lab experiments and data collection (NS, BB); Analysis of data and interpretation (NS, BB); Preparation of manuscript (NS, BB).

Declaration

The authors declare no conflict of interest.

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