P. ISSN: 0971-8184 II E. ISSN: 0976-1926
DOI: 10.61949/0976-1926.2024.v37i02.09

Indian Journal of Plant Genetic Resources

RESEARCH ARTICLE

Restoration reaction in the F_1 hybrids derived from F_3 *maldandi* restorers on different cytoplasm in *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

Prashant Kariyannanavar*, M. C. Wali, B. D. Biradar, V. S. Kubsad, L. K. Verma, B. N. Prashantha, N. Pavan Kumar and Revanasiddayya

Abstract

In this study, a reported restorer on *maldandi* cytoplasm DSMR 8 was used to identify restorer variants in early segregating generation. Large F_2 population of the cross M31-2A × DSMR 8 were grown. Among them, fifteen superior restoring plants were selected and forwarded to F_3 generation. These fifteen F_3 plants were crossed to three male sterile lines having both *milo* and *maldandi* cytoplasmic sources (M31-2A, 401A and 104A) in L × T design. The results revealed that all the obtained hybrids on both *milo* and *maldandi* cytoplasm were fertile and conferred that *maldandi* restorers work well on the *milo* cytoplasm because the pollen parents (F_3 lines) used had *maldandi* restorer gene. Hybrids having parent's MR 4 (F_3 *Maldandi* Restorer line), MR 12, MR 1, MR 14 and MR 2 were found to be good *per se* performers for grain yield and restoration on. Hybrids having parent MR 1 were found to be the best performers for grain yield and restoration across all cytoplasm (M31-2A, 104A and 401 A). Through early generation combining ability it was possible to identify promising restorers with superior agronomical traits on *maldandi* as well as *milo* cytoplasm.

Keywords: Restoration reaction, early segregating generation, *maldandi* cytoplasm.

Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka-580005, India.

***Author for correspondence:**

pachi25psk@gmail.com

Received: 29/01/2024 **Revised:** 22/03/2024

Accepted: 18/06/2024

How to cite this article: Kariyannanavar P, MC Wali, BD Biradar, VS Kubsad, LK Verma, BN Prashantha, NP Kumar and Revanasiddayya (2024) Restoration reaction in the F_1 hybrids derived from F_3 *maldandi* restorers on different cytoplasm in *rabi* sorghum [*Sorghum bicolor* (L.) Moench]. *Indian J. Plant Genet. Resour.* 37(2): 263-265. **DOI:** 10.61949/0976-1926.2024.v37i02.09

Introduction

In the era of climate change, C_4 plants have their own role in combating global warming. C_4 plants require optimal temperature and possess higher photosynthetic efficiency which will make them mandatory crops to grow in the future as India committed to becoming a carbon-neutral state by 2070 to escape from the irreversible effects of climate change. Sorghum [*Sorghum bicolor* (L.) Moench] is a C_4 plant with higher photosynthetic efficiency and abiotic stress tolerance (Reddy *et al.,* 2009). It adapted to a diverse set of environments ranging from arid and semiarid to tropical regions throughout the world. On a global basis, sorghum is the fifth major cereal crop in the extent of production following wheat, rice, maize, and barley. Along with providing food and fodder, it plays a vital role in providing micronutrients at a low cost (Parthasarathy Rao *et al*., 2010). This is necessary for a country like India, where 25% of the population lives in poverty. Recently, India stood in the 'Serious' category in the Global Hunger Index 2022, positioning 107th place out of 121 countries. So, this crop addresses the issues of climate change, malnourishment and, to some extent, poverty through its sustainable "low cost and more micronutrient" phenomenon. To update and revive these crops, FAO announced 2023 year as the "International Year of Millets".Out of the several cytoplasm available in sorghum, only A_1 (*milo*) CMS system is predominantly used for commercial production of hybrids (Reddy *et al.* 2018), though it lacks good grain quality. In addition to the A_1 cytoplasm several other CMS sources like A_2, A_3, A_4, Indian A_4, A_5, A_6, 9E, and KS were described in sorghum. Among these *maldandi* (A_4) cytoplasm is known for its grain quality with shoot fly resistance. There has been a lack of good restorers in the *maldandi* cytoplasm. Identifying and utilizing the breeding program would be a win-win situation for quality and insect resistance. An identified restorer on *maldandi* DSMR 8 was used as a parent in basic crossing. In this study, an effort has been made to identify restorers on *maldandi* cytoplasm along with superior agronomical traits. Further, an attempt was made to validate the reaction of early segregating *maldandi* restorers on *milo* cytoplasm.

Materials and Methods

The identified restorer DSMR 8 was crossed with *maldandi* male sterile line. The obtained hybrids were forwarded to F_2 in *summer* of 2019. Around 300 to 400 F_2 plants were grown and selfed. Among them, the top 15 plants which are presumed to be restorer and agronomically superior were selected randomly and forwarded to F_3 in *rabi* 2019. Further, these 15 plants were used as pollen parents and crossed with male sterile lines *viz.,* M31-2A, 104 A and 401 A in L×T design during *Summer* 2020. Obtained 45 hybrids were evaluated in replicated trials during *rabi* 2020. The F_3 plants of the cross M31-2A × DSMR 8 were named as MR (*maldandi* restorer). All the necessary agronomical practices were followed. The detailed flow of the work is mentioned in Fig 1.

Results and Discussion

Restoration reaction

Carefully chosen 15 MR plants had restorer gene which was contributedby one of its strong restoring parents (DSMR 8). Upon crossing with three male sterile lines, 45 hybrids were able to set the seeds irrespective of the cytoplasmic background. Though MR lines were bearing *maldandi* restorer gene, when crossed with *milo* cytoplasm (104 A and 401 A) they were possible to set seed. This was logically evident from the current study that *maldandi* restorers work well on the *milo* cytoplasm as well, but the inverse need not be true (Arunkumar *et al.,* 2004 and Verma *et al.,* 2022)

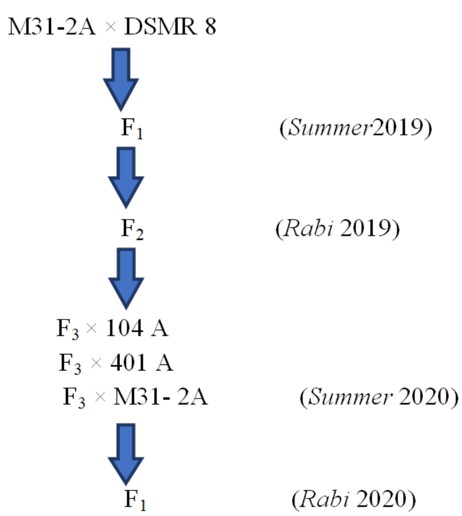

Fig 1: Schematic representation of the experiment conducted across different season

Further all 45 hybrids developed on *milo* (104 A and 401 A) and *maldandi* were evaluated for agronomic performance in replicated trails. The top hybrids for yield and yield-attributing traits were depicted in Table 1. On *maldandi* cytoplasm MR 4, MR 12, MR 1, MR 14 and MR 2 came out to be top hybrid parents for grain yield (Fig 2). Similarly, on *milo* (104 A) cytoplasm MR 2, MR 8, MR 1, MR 5 and MR 15 were superior while, on another *milo* (401 A) cytoplasm MR 11, MR 10, MR 5, MR 3 and MR1 came out to be best hybrid parents for grain yield traits (Table 2).

To be an ideal restorer, the genotype should have a tall plant height in order to shed pollen from the top. Similarly, better panicle length, weight and panicle width to generate and disseminate sufficient pollen. In the present investigation, hybrid M31-2A × MR 14 had shown desirable traits *viz.,* earliness (70 days), taller (230 cm), lengthier panicle (16 cm), wider panicle (8.50 cm) and better panicle weight (162.50 g) with bold seeded and high grain yield (149.50 g). These features made M31-2A × MR 14 an ideal restorer on *maldandi* cytoplasm. Similarly y, 104 A × MR 2 was early (70.06 cm), taller (207.50 cm), having panicle weight (132.50 g) with good grain yield (127.50 g), while 401 A × MR 11 was also showing the ideal character to be a good restorer. Hence both the crosses were the best restorer on *milo* cytoplasm. Interestingly, hybrids having MR 1 as a parent have shown top agronomical superiority across all the cytoplasm. Hence, MR 1 was the best restorer and good combiner for yield and yield attributing traits. Further, this line can be used as a potential parent in both *milo* and *maldandi*-based hybrid seed production.

From the performance of F_1 hybrids derived from F_3 MR lines, it was logically evident that only superior F_3 lines should be forwarded to F_4. Doing this in the early segregating generation will reduce the forwarding of junk material to

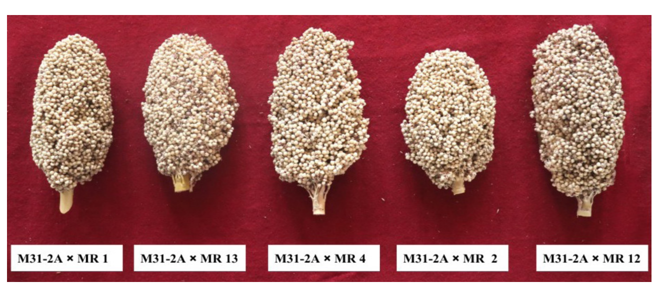

Fig 2: Top five hybrid combinations on *maldandi* cytoplasm for yield and yield attributing traits

Table 1: Top five best hybrids for yield and yield attributing traits on different *ms* sources

S. No.	*High yielding hybrids*	*Grain yield per plant (g)*	*Days to 50% flowering*	*Plant height (cm)*	*Panicle length (cm)*	*Panicle width (cm)*	*Panicle weight (g)*	*100 seed weight (g)*
Maldandi (M 31-2A)								
1	M 31-2A × MR 4	149.50	70.00	230.00	16.00	8.50	162.50	5.02
2	M 31-2A × MR 12	138.50	71.73	242.50	21.50	8.65	141.00	5.77
3	M 31-2A × MR 1	112.50	73.50	170.00	15.00	8.60	119.00	6.02
4	M 31-2A × MR 14	107.50	72.03	252.50	20.00	7.75	118.50	5.77
5	M 31-2A × MR 2	107.00	76.00	177.50	16.00	7.50	120.00	5.71
Milo (104 A)								
1	104 A × MR 2	127.50	70.06	207.50	22.00	8.50	132.50	5.23
2	104 A × MR 8	91.00	70.95	202.50	25.50	7.45	111.00	5.56
3	104 A × MR 1	83.00	73.00	180.00	21.00	7.40	92.00	4.85
4	104 A × MR 5	72.00	75.45	200.00	19.85	6.00	64.00	5.78
5	104 A × MR 15	53.50	77.45	184.00	18.00	5.55	72.50	4.65
Milo (401 A)								
1	401A × MR 11	106.00	69.45	212.50	22.00	7.50	116.00	5.55
2	401A × MR 10	90.00	69.95	172.50	21.50	8.50	101.00	4.99
3	401A × MR 5	85.00	71.45	179.00	17.00	7.25	95.00	5.31
4	401A × MR 3	82.00	70.44	210.00	19.00	7.00	101.00	5.04
5	401A × MR 1	80.00	69.45	192.50	17.25	5.45	87.00	4.76

Table 2: Top five best hybrids for grain yield on different *ms* sources

S. No.	*M31-2A (Maldandi)*	*104 A (Milo)*	*401A (Milo)*
1	MR 4	MR 2	MR 11
2	MR12	MR 8	MR 10
3	MR 1	MR 1	MR 5
4	MR 14	MR 5	MR 3
5	MR 2	MR 15	MR 1

the next generation. Though restoration is governed by major and minor genes, screening and selecting over the generation will reduce the environmental influence. Finally, it is possible to isolate potential transgressive segregants for restoration on *maldandi* cytoplasm. These are vital steps to identify promising restorers on *maldandi* cytoplasm because of restoration complexity and environmental influence on minor genes (Verma *et al.,* 2022 and; Elkonin *et al.,* 2005).

Author's Contribution

Conceptualization of research (MCW, BDB, SNC, VSK); designing of the experiment (MCW, BDB, SNC, VSK); contribution of experimental material (BDB).

Conflict of Interest

None.

Acknowledgments

The authors are grateful to ICRISAT for providing material and to the Department of Genetics and Plant Breeding, UAS, Dharwad, India, for providing all the necessary facilities and support for the research work.

References

Arunkumar B, BD Biradar and PM Salimath (2004) Inheritance of fertility restoration on *milo* and *maldandi* sources of male sterility in *Rabi* sorghum. [*Sorghum bicolor* (L.) Moench]. *Indian J. Genet.*64(4): 325-326.

Elkonin LA, VV Kozhemyakin and AG Ishin (2005) Influence of water availability on fertility restoration of CMS lines with the 'M 35', A4 and '9E' CMS inducing cytoplasms of sorghum. *Plant Breed.* 124: 565–571.

Parthasarathy Rao, PG Basavaraj, S Bhagavatula and W Ahmed (2010) "An Analysis of availability and utilisation of sorghum grain in India", *J. SAT Agric. Res.* 8: 1-6.

Reddy BVS, S Ramesh, PS Reddy and AA Kumar (2009) Genetic enhancement for drought tolerance in sorghum. *Plant Breed. Revolution* 31: 189-222.

Reddy PS (2018) Cytoplasmic nuclear male sterility in sorghum [(*Sorghum bicolor* (L.) Moench]. Current status and future prospects. *J. Res. PJTSAU* 46(1): 1-14.

Verma LK, BD Biradar, SS Patil, SN Chattannavar and VS Kubsad (2022) Comparative analysis of restoration behavior of *milo* (104A, 401A) and *maldandi* (M31-2A) based male sterile lines in sorghum. *Genet. Resour. Crop Evol.* 69: 559-566.