

Original Research Article

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Geographical and Racial Distribution of Restorers and Maintainers on Milo and Maldandi Cytoplasm from Minicore Collection of Sorghum

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ABSTRACT

To determine the distribution and geographic specificity of sterility maintainers and restorers in *Sorghum bicolor* (L.), 168 diverse sorghum germplasm accessions representing variation from 26 countries were crossed with a male-sterile lines milo and maldandi cytoplasm. The F₁ hybrids were classified as male-fertile or male-sterile based on the seed set on bagged ear heads. Among these, 43 (25.59 %) were classified as strong restorers with > 90 % seedset and 41 (24.40 %) as maintainers with zero seedset in the postrainy season. Maintainers on maldandi cytoplasm represented 16 out of 26 countries but were concentrated comparatively high in India and for restorers distributed in 15 countries. Maintainer and restorers for milo cytoplasm were distributed across globe. Most of the identified restorers and maintainers of milo and maldandi cytoplasm belongs to race of caudatum and its hybrid races like caudatum-bicolor, durra-caudatum, guinea-caudatum etc. These maintainer lines differ from one another in several morphological and agronomic characters such as flowering, plant height, panicle length and grain size. They may prove to be useful sources of material for generating new male-sterile lines. The restorers can be used to produce commercial hybrids.

Keywords

Cytoplasm,
Maintainers,
Restorers and Races.

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Introduction

The discovery of cytoplasmic male sterility in sorghum (Stephens and Holland, 1954), led to the development of high yielding commercial hybrids based on milo cytoplasmic source. Subsequently, additional sources of cytoplasmic male sterility designated as A2, A3, A4, Maldandi, VZM and G1 were identified (Worstell *et al.*, 1984 and Rao *et al.*, 1984). However, these sources have not been exploited, owing to the difficulty in restoration to these sources. It is desirable to have male-sterile lines with varying maturity levels to increase the scope for selecting restorers with good combining ability and

adaptation to diverse agroclimatic conditions (Rao *et al.*, 1989). Shaoqing *et al.*, (2005) reported that the wild rice accessions with *Rf* for Honglian (HL) CMS were distributed in Asia, Oceania, Latin American and Africa, but were centered mainly in Asia, whilst the wild restorer accessions for WA-CMS were limited only to Asia and Africa. An evaluation of the world collection of genetic stocks from different geographical regions as pollen parents in hybrid combination with diverse sources of male sterility will help to locate the areas of concentration of desirable alleles for fertility

restoration on diverse sources of male sterility. Even the identified restorers/maintainers of particular race is also important because for rabi sorghum improvement durra race genetic background is preferred due to superior grain quality unlike kharif caudatum background. The present investigation was aimed at identifying the distribution and geographic specificity of restorer/maintainer genes along with racial specificity for the milo and maldandi in the sorghum germplasm.

Materials and Methods

The male sterile lines utilized as testers in this study were 104A and M31-2A. 104A is based on milo cytoplasmic source and has the distinction of being used in several commercial hybrids. Male sterile line, M31-2A, representing Maldandi cytoplasm has very good grain quality traits like bold size seed, luster and corneous endosperm and resistant to biotic and abiotic stresses. 168 genotypes representing 26 countries were selected from minicore collection to identify restorers and maintainers on diverse cytoplasm. All the 168 male parents were crossed to two testers and developed 2 x 168 F₁ bulked seed of every cross (F₁) was planted in a row of 4m length. About 3 heads from each row were bagged 3 days before stigma emergence. The F₁ hybrids were evaluated at botanical garden, Department of genetics and plant breeding, UAS, Dharwad in *rabi* 2015-16. All the recommended agronomic practices were followed to raise a good crop. At maturity, numbers of seeds were counted out of total number of spikelets per ear head and seedset percentage was calculated.

Results and Discussion

The sterility maintaining/fertility restoring ability of the 168 diverse accessions showed grades of fertility, ranging from complete

sterility maintenance to complete fertility restoration. If there was no seed set in bagged ear heads of the hybrid, the accession was classified as a maintainer. If there were > 90 per cent seeds on the ear heads, it was classified as a strong restorer.

Of the 168 diverse sorghum germplasm lines evaluated, 43 (25.59 %) were classified as strong restorers, 41 (24.40 %) as maintainers, and remaining were classified as segregating for restoring/maintaining ability (Table 1).

Geographical distribution

In the present study, maintainers on milo represented across the globe with countries like India (5), U.S.A (4), Ethiopia (3), South Africa (2) and Tanzania (2) occupying more number than other countries. Maintainers on maldandi represented 16 out of 26 countries (Table 2), but they were mainly concentrated in India (8), South Africa (4), Cameroon (4), Yemen (3), U.S.A (2) and Ethiopia (2). In case of strong restorers on milo, they represented across the globe with countries like South Africa (6), India (5), U.S.A (4), Yemen (4), and Cameroon (4) occupying more number than other countries. Strong restorers on maldandi represented 15 out of 26 countries, but they were mainly concentrated in India (3), South Africa (2), Yemen (2) and Mali (2). These results suggest that not only indigenous lines but also exotic lines should be collected and screened for identifying new restorers on Indian cytoplasm (maldandi) preferably races like durra, kafir etc.

Contrary to this earlier in sorghum Goud *et al.*, (1998) reported that, restorers on milo were from 7 countries out of the 9 countries, whereas restorers on maldandi was concentrated mainly in India while for Maintainers (67) have their origin in 8 of the 9 countries.

Table.1 Classification of restoration based on mean seed set percentage

| Restoration class | Seed set % | Diverse sources of cytoplasm | | | |
|----------------------|------------|------------------------------|-----------------|------------------|-----------------|
| | | Milo | | Maldandi | |
| | | No. of restorers | Mean seed set % | No. of restorers | Mean seed set % |
| Strong restoration | >90 % | 43 | 94.34 | 19 | 94.47 |
| High restoration | 80 to 90 % | 1 | 81.23 | 4 | 82.96 |
| Moderate restoration | 60 to 80 % | 7 | 73.76 | 15 | 69.44 |
| Partial restoration | 10 to 60 % | 78 | 28.26 | 39 | 26.05 |
| Low restoration | <10 % | 17 | 6.39 | 23 | 7.04 |
| No seed set | 0 % | 22 | 0.00 | 37 | 0.00 |

Table.2 Geographical distribution of sterility maintainers with 0 percent seed set and fertility restorers with > 90 percent seed set on either of milo/maldandi cytoplasm in sorghum

| Origin | Total No. of lines | Number of lines | | | |
|--------------|--------------------|-----------------|-----------|-------------|-----------|
| | | Restorers | | Maintainers | |
| | | Milo | Maldandi | Milo | Maldandi |
| Bangladesh | 1 | 1 | 1 | - | - |
| Botswana | 2 | 1 | 1 | 1 | 1 |
| Cameroon | 8 | 4 | - | - | 4 |
| China | 2 | 2 | 1 | - | - |
| Ethiopia | 5 | 2 | - | 3 | 3 |
| Gambia | 1 | 1 | 1 | - | - |
| India | 14 | 5 | 3 | 5 | 8 |
| Japan | 1 | - | - | - | 1 |
| Kenya | 1 | 1 | - | - | - |
| Lesotho | 1 | - | - | 1 | 1 |
| Madagascar | 1 | 1 | 1 | - | - |
| Malawi | 1 | 1 | - | - | - |
| Mali | 3 | 2 | 2 | 1 | - |
| Myanmar | 1 | 1 | 1 | - | - |
| Niger | 2 | - | - | 1 | 1 |
| Senegal | 1 | - | - | 1 | - |
| Somalia | 3 | 2 | 1 | - | 1 |
| South Africa | 10 | 6 | 2 | 2 | 4 |
| Sudan | 2 | 1 | - | - | 1 |
| Swaziland | 3 | 1 | 1 | 1 | 2 |
| Tanzania | 3 | 1 | 1 | 2 | 2 |
| Turkey | 1 | - | - | - | 1 |
| U.S.A | 6 | 4 | - | 2 | 2 |
| Yemen | 7 | 4 | 2 | 1 | 3 |
| Zaire | 1 | 1 | 1 | - | - |
| Zimbabwe | 3 | 1 | - | 1 | 2 |
| Total | 84 | 43 | 19 | 22 | 37 |

Table.3 Distribution of sterility maintainers with 0 percent seedset and fertility restorers with > 90 percent seed set on either of milo/maldandi cytoplasm across different races in sorghum

| Race | Total No. of lines | Number of lines | | | |
|-------------------------|--------------------|-----------------|----------|-------------|----------|
| | | Restorers | | Maintainers | |
| | | Milo | Maldandi | Milo | Maldandi |
| Bicolor | 6 | 3 | 1 | 1 | 3 |
| Caudatum | 12 | 6 | 3 | 1 | 6 |
| Caudatum-bicolor | 7 | 5 | 3 | 1 | 2 |
| Durra | 10 | 4 | 2 | 4 | 6 |
| Durra-bicolor | 4 | 2 | - | 1 | 2 |
| Durra-caudatum | 8 | 5 | 2 | 2 | 3 |
| Guinea | 10 | 4 | 4 | 4 | 5 |
| Guinea-bicolor | 1 | 1 | - | - | - |
| Guinea-caudatum | 13 | 6 | 1 | 4 | 5 |
| Guinea-durra | 1 | 1 | - | - | - |
| Guinea-kafir | 1 | 1 | 1 | - | - |
| Kafir | 6 | 4 | 1 | 1 | 2 |
| Kafir-bicolor | 1 | 1 | 1 | - | - |
| Kafir-caudatum | 2 | - | - | 2 | 2 |
| Kafir-durra | 2 | - | - | 1 | 1 |
| Total | 84 | 43 | 19 | 22 | 37 |

The present study clearly showed that the frequency of restorers and maintainer alleles was almost equal in the world collection of sorghum. Hence, it can be inferred that no definite relationship could be established between distribution of restorer genes and geographical region. In fact the identification of restorers/maintainers from different countries helps to diversify the genetic background and it is possible to develop CMS lines and R-lines respectively in different genetic back grounds. It is desirable to have male sterile lines with varying maturity and height levels as it gives scope for selecting restorers with good combining ability and adaptation to diverse agro-climatic conditions (Goud *et al.*, 1998).

Racial distribution

In sorghum, though there are 5 different races (bicolor, caudatum, durra, guinea and kafir), only caudatum followed by durra races have

been exploited to a great extent for the development of parental lines and for exploitation of hybrid vigor in commercial hybrids. It has been found that other races like guinea, kafir do possess genes for yield and other traits of interest and needs to be exploited to enhance heterosis levels in commercial hybrids.

Most of the *rabi* sorghum varieties are only of *durra* type whereas *kharif* cultivars that were being grown belong to *caudatum* and *kafir* races. The strong restorers with > 90 per cent seed set in F₁'s identified on milo cytoplasm were more of caudatum (6), hybrid caudatum races like caudatum-bicolor (5), durra-caudatum (5), guinea caudatum (6) and kafir races (4). On maldandi cytoplasm, strong restorers identified were also more of caudatum (3), hybrid caudatum races like caudatum-bicolor (3), durra-caudatum (2), guinea (3) and durra (2) races (Table 3). The maintainers with zero per cent seed set in F₁'s

identified on milo cytoplasm were more of durra (4), guinea (4), guinea-caudatum (4), durra-caudatum (2) and kafir-caudatum (2) races. On maldandi cytoplasm, maintainers identified were also more of caudatum (6), durra (6), guinea (5), guinea-caudatum (5), durra-caudatum (3), caudatum-bicolor (2) and kafir-caudatum (2) races.

Generally for *rabi* sorghum improvement strong restorers/maintainers identified of *durra* race are useful because of grain quality but to diversify genetic background genotypes of other races like *caudatum*, *kafir* etc., also has to be utilized. Reddy *et al.*, (2003) reported that genetic improvement of *rabi* sorghum is hindered by lack of phenotypic variability among breeding lines. Umakanth *et al.*, (2006) reported that other races like guinea, kafir do possess genes for yield and other traits of interest like restorer genes and needs to be exploited to enhance heterosis levels in commercial hybrids.

Diversification of hybrid parents

In the present study the B-lines on either of cytoplasm identified of *durra* race were IS2389, IS4360, IS6421, IS 3971, IS 17980, IS 12883, IS 19859 and IS32787, while B-lines of *caudatum* race were IS24348, IS9745, IS29335, IS29914, IS 2382, IS 20632 and IS 22986. In case of R-lines on either of cytoplasm of *durra* race were IS23891, IS 4581, IS 22720, IS 28614 and IS 4698, while of *caudatum* race were IS 14861, IS 21083, IS 17941, IS 26617, IS 28614, IS 19389, IS 31651 and IS 24348.

For *rabi* hybrid development, B and R-lines need to be diversified by creating separate gene pools through crossing between *caudatum* based B-lines and *durra* based B-lines and between *caudatum*-based R-lines and *guinea/durra*-based R-lines for various selected traits. Such diverse crossings

between *caudatum* and *durra* races will help to increase the yield traits keeping grain quality traits for *rabi* sorghum. Reddy *et al.*, (2008) reported that F₁'s made on *caudatum*-based seed parents with *durra*-based pollinators resulted in high heterosis under postrainy season condition.

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