# M 35-1 derived sorghum varieties for cultivation during the postrainy season

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## Abstract

The variety M 35-1 dominates the postrainy season sorghum areas in India. Several varieties were developed at ICRISAT incorporating genes from M 35-1. Participatory plant breeding was carried out to select for farmer-preferred traits. The resultant 23 varieties were tested in comparison to M 35-1 in randomized complete block design for two consecutive years. Two varieties, SP 18008 and SP 18034, were promising and significantly outyielded the check M 35-1. SP 18008 and SP 18034 had a plant height of 2.7 m and 2.0 m, grain yield of 620 and 610 g $m^{-2}$, flowering time 76 to 82 days and 100-grain weight of 3.9 to 4.0 g.

## Introduction

Sorghum (*Sorghum bicolor*) is an important rainfed crop that provides staple food for the poor people in the semi-arid tropics. In India, sorghum is an important grain and fodder crop and is grown on 9.5 million ha in both rainy and postrainy seasons. During postrainy season, it is predominantly grown on Vertisols with residual soil moisture. Postrainy sorghums are very crucial for food and fodder security in the drought prone areas of Maharashtra, Karnataka and Andhra Pradesh states of India as there is no alternative cereal grown during this season, when only 8% of the annual rainfall is received (Gorad et al. 1995). The grain productivity of postrainy sorghum in India is very low as much of the cultivated area is under landraces that are poor in grain yield. Delayed sowing, low inputs (fertilizers) and poor adoption of improved management techniques also contribute to low productivity. Developing high-yielding postrainy season-adapted variety/hybrid is the main objective in almost all the crop improvement programs. Though strong efforts have been made to develop hybrids with wider adaptability to varied production environments, the results are not encouraging (Madhusudana et al. 2003). The postrainy season crop was grown on 4.8 million ha in 2005–06 (CMIE 2007). This accounted for nearly 54% of total sorghum growing area but contributed less than 30% to the total sorghum grain production. Average postrainy season production was 2.3 million t during 2005–06 and productivity was 477 kg $ha^{-1}$. For the past 25 years, several programs in India attempted to improve varieties and/or hybrid parents through pedigree breeding approach. This very low rate of productivity increase calls for a change in production strategy including breeding.

Postrainy season-adapted sorghums grow well in short daylength (photoperiod sensitivity), flower and mature irrespective of temperature fluctuations and sowing dates (thermo-insensitivity within the postrainy season varieties), are tolerant to terminal moisture stress and resistant to stalk rot/charcoal rot, produce high biomass (grain and stover) and have large lustrous grain with semicorneous endosperm. Tolerance to shoot fly, lodging (mechanical) and rust are also required (Rao 1982, Rana et al. 1985, Seetharama et al. 1990). All these characters are exemplified best in M 35-1, a variety selected from a local landrace nearly 60 years ago at Mohol in Maharashtra, which produces high stable yields of grain and stover across different sowing dates (Reddy et al. 1987). Delay in flowering due to late sowing is less in M 35-1 compared to rainy season cultivars such as CS 3541 (Reddy et al. 1983). As a result, M 35-1, a landrace selection developed in 1930s still dominates the postrainy season sorghum areas in India. Therefore, an effort was made at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India to develop new varieties for postrainy season through incorporation of genes from M 35-1.

## Materials and methods

To develop appropriate varieties for postrainy season, crosses were made involving postrainy landrace varieties (M 35-1 and six M 35-1 bulks) and improved postrainy season-adapted varieties (SPV 1359, NTJ 2 and SPV 1380) with good grain yield potential at ICRISAT, Patancheru during 1999–2000 postrainy season. As a part of participatory plant breeding (PPB) program, the progenies derived from these crosses were selected by a farmer

under farmers' (rainfed) condition and by the breeder in research station conditions (with initial two irrigations) from $F_2$ generation onwards that resulted in 25 advanced progenies. Also from M 35-1 bulk (M 35-1 has non-tan plant color), tan plant colored selections were made. They were further advanced with selection for grain yield to obtain 33 varieties. The 58 varieties thus obtained were evaluated along with the postrainy season-adapted varietal checks, M 35-1 (variety popular with the farmers) and SPV 1411 (variety released for postrainy season cultivation and named Parbhani moti due to its pearly white grains) during 2006 postrainy season. From these varieties, based on grain yield (≥370 g $m^{-2}$), grain size (≥3.7 g $100^{-1}$ grains) and grain luster (≤3.0; luster score taken on a 1 to 5 scale, where 1= highly lustrous and 5 = non-lustrous), 13 PPB derived varieties (7 farmer selections and 6 breeder selections) and ten M 35-1 tan plant derivatives were selected and evaluated during 2007 postrainy season along with the checks M 35-1 and SPV 1411.

The varieties were sown in the field in a randomized complete block design (RCBD) with three replications during 2006 and 2007 (postrainy season). Each entry was sown in 2 rows, 2 m long and 75 cm apart. The seedlings were thinned to a spacing of 15 cm between plants at 10 days after seedling emergence (DAE). Data were recorded for the traits time to 50% flower (days), plant height (m), stay green score (taken on a 1 to 5 scale, where 1 = most green and 5 = least green), lodging score (taken on a 1 to 5 scale, where 1 = no lodging and 5 = 80% of plants lodged), grain yield (g $m^{-2}$) and 100-grain weight (g) and subjected to statistical analysis.

## Results and discussion

The combined ANOVA depicted significant differences among the 25 genotypes for all the traits except stay green score (Table 1). Also, genotypes differed significantly in their performance over the years for all the traits except plant height. However, genotypes interacted significantly with the year of evaluation for the traits time to 50% flower, lodging score and 100-grain weight. Therefore, combined results for the traits plant height and grain yield and individual year-wise results for the traits time to 50% flower, lodging score and 100-grain weight are given in Table 2 and discussed below.

For grain yield, 15 varieties (all the 13 PPB varieties and two M 35-1 bulk varieties) performed significantly better over the popular check M 35-1 (350 g $m^{-2}$) and two varieties (SP 18008, farmer selection and SP 18034, breeder selection) over SPV 1411 (480 g $m^{-2}$). The plant height ranged from 2.0 to 2.9 m among the selected top 15 varieties (M 35-1: 3.0 m and SPV 1411: 2.7 m). Among the 15 varieties, time to 50% flower ranged from 74 to 82 days during 2006 (M 35-1: 82 days) and 74 to 81 days (M 35-1: 75 days) during 2007 (postrainy season), lodging score ranged from 1.0 to 4.3 during 2006 (M 35-1: 2.3) and 1.7 to 3.3 (M 35-1: 2.3) during 2007 (postrainy season), 100-grain weight ranged from 3.7 to 4.5 g during 2006 (M 35-1: 4.0 g) and 3.8 to 4.5 g (M 35-1: 4.7 g) during 2007 (postrainy season).

Earlier also, several varieties such as CSV 7R, CSV 8R and CSV 14R were developed using selections from segregating populations derived from the crosses among Indian locals, M 35-1 and IS 2644 with American germplasm lines. Marginal improvement was achieved for grain yield over the most popular landrace variety M 35-1. The variety CSV 216R released in 2000 is a landrace selection from postrainy germplasm from Maharashtra. CSV 18 is the latest postrainy season variety released in 2005 derived from a cross CR 4 × IS 18370. Most of these varieties could not become popular as they did not match the grain quality of M 35-1 (Umakanth 2008). The two varieties (SP 18008 and SP 18034) developed at ICRISAT with a plant height of 2.7 m and 2.0 m, grain yield of 620 and 610 g $m^{-2}$, flowering time 78 and 82 days during 2006 and 76 and 77 days during 2007 (postrainy season), having a lodging score of 1.7 and 1.0 during 2006 and 2.3 and 1.7 during 2007 (postrainy season) and 100-grain weight of 3.9 g each during 2006 and 4.0 g during 2007 (postrainy season) are worth-testing in All India Coordinated yield trials during (postrainy season) for grain yield, shoot fly resistance

**Table 1. Analysis of variance of grain yield traits in postrainy season-adapted varieties during 2006 and 2007 (postrainy season), ICRISAT, Patancheru, India[1].**

| Source of variation | df | Time to 50% flower (days) | Plant height (m) | Lodging score | Stay green score | Grain yield (g $m^{-2}$) | 100-grain weight (g) |
|---|---|---|---|---|---|---|---|
| Genotype | 24 | 16.27** | 0.42** | 2.09** | 0.6 | 2.58** | 0.19** |
| Year | 1 | 229.65** | 0.01 | 11.35** | 14.78** | 48.09** | 1.97** |
| Genotype × Year | 24 | 8.73** | 0.1 | 1.75** | 0.52 | 1.6 | 0.15** |
| Error | 94 | 4.32 | 0.07 | 0.69 | 0.45 | 1.11 | 0.05 |

1. ** = Significant at $P \leq 0.01$.

**Table 2. Performance of postrainy season-adapted lines for agronomic traits during 2006 and 2007 (postrainy season), ICRISAT, Patancheru, India.**

| Entry no. | Pedigree | Plant height (m) (Combined) | Grain yield (g m$^{-2}$) (Combined) | Time to 50% flower (days) 2006 | Time to 50% flower (days) 2007 | Lodging score[1] 2006 | Lodging score[1] 2007 | 100-grain weight (g) 2006 | 100-grain weight (g) 2007 |
|---|---|---|---|---|---|---|---|---|---|
| SP 18008 | (M 35-1 × SPV 1359)-5-2-3-1-1 | 2.7 | 620 | 78 | 76 | 1.7 | 2.3 | 3.9 | 4.0 |
| SP 18034 | (M 35-1 × SPV 1359)-1-1-4-1-2 | 2 | 610 | 82 | 77 | 1.0 | 1.7 | 3.9 | 4.0 |
| SP 18015 | (M 35-1 × SPV 1359)-8-2-1-1-1 | 2.7 | 570 | 79 | 76 | 3.0 | 3.0 | 4.0 | 4.2 |
| SP 18005 | (M 35-1 × SPV 1359)-1-1-1-1-5 | 2.5 | 560 | 79 | 77 | 3.0 | 2.0 | 4.0 | 4.4 |
| SP 18006 | (M 35-1 × SPV 1359)-5-1-4-1-1 | 2.9 | 560 | 79 | 76 | 1.7 | 2.0 | 4.1 | 4.3 |
| SP 18024 | (M 35-1 Bulk 2 × SPV 1359)-2-1-2-1-4 | 2.4 | 560 | 81 | 75 | 2.3 | 2.7 | 4.2 | 4.4 |
| SP 1515 | M 35-1-Bulk-3-11-1-1-4-6 | 2.3 | 560 | 75 | 74 | 3.7 | 1.7 | 4.1 | 4.0 |
| SP 18033 | (M 35-1 × SPV 1359)-1-1-4-1-1 | 2.1 | 550 | 79 | 76 | 1.3 | 2.0 | 4.1 | 4.0 |
| SP 18016 | (M 35-1 × SPV 1359)-8-2-1-1-2 | 2.8 | 510 | 80 | 76 | 3.0 | 3.3 | 3.7 | 3.9 |
| SP 18018 | (M 35-1 × SPV 1380)-1-1-2-1-1 | 2.6 | 510 | 77 | 76 | 3.3 | 3.0 | 3.9 | 4.5 |
| SP 18046 | (M 35-1 Bulk 2 × SPV 1359)-3-1-1-1-4 | 2.5 | 510 | 78 | 75 | 2.3 | 1.7 | 3.7 | 4.2 |
| SP 18058 | (NTJ 2 × SPV 1380)-3-1-2-1-3 | 2.1 | 500 | 80 | 81 | 2.7 | 3.3 | 3.7 | 3.8 |
| SP 1521 | M 35-1-Bulk-3-15-1-2-2-2 | 2.4 | 500 | 74 | 75 | 4.3 | 2.3 | 4.5 | 4.1 |
| SP 18031 | (M 35-1 × SPV 1359)-1-1-3-1-4 | 2.5 | 490 | 81 | 76 | 2.0 | 3.0 | 4.0 | 4.0 |
| SP 18032 | (M 35-1 × SPV 1359)-1-1-3-1-5 | 2.4 | 490 | 80 | 76 | 3.7 | 2.3 | 3.7 | 4.3 |
| SP 1507 | M 35-1-Bulk-3-5-4-1-2-4 | 2.2 | 470 | 74 | 76 | 3.7 | 2.7 | 3.9 | 4.4 |
| SP 1533 | M 35-1-Bulk-6-3-1-1-3-6 | 2.5 | 470 | 77 | 76 | 3.7 | 2.3 | 3.9 | 3.8 |
| SP 1518 | M 35-1-Bulk-3-15-1-1-1-6 | 2.5 | 450 | 82 | 75 | 4.3 | 1.7 | 3.9 | 4.1 |
| SP 1529 | M 35-1-Bulk-6-3-1-1-1-3 | 2.7 | 450 | 78 | 76 | 3.3 | 2.7 | 3.9 | 4.1 |
| SP 1516 | M 35-1-Bulk-3-15-1-1-1-1 | 2.5 | 430 | 76 | 75 | 3.7 | 2.7 | 3.9 | 4.0 |
| SP 1527 | M 35-1-Bulk-3-15-1-3-4-2 | 2.1 | 430 | 78 | 79 | 3.0 | 2.0 | 3.7 | 3.5 |
| SP 1520 | M 35-1-Bulk-3-15-1-2-1-2 | 2.6 | 420 | 75 | 74 | 4.0 | 2.0 | 3.9 | 4.4 |
| SP 1511 | M 35-1-Bulk-3-11-1-1-3-3 | 2.5 | 400 | 76 | 75 | 3.7 | 3.7 | 4.0 | 4.3 |
| M 35-1 | M 35-1 (Check) | 3 | 350 | 82 | 75 | 2.3 | 2.3 | 4.0 | 4.7 |
| SPV 1411 | SPV 1411 (Check) | 2.7 | 480 | 78 | 76 | 3.3 | 1.7 | 3.6 | 4.6 |
| Mean | | 2.5 | 500 | 77 | 76 | 3.2 | 2.4 | 3.9 | 4.2 |
| CV (%) | | 10.9 | 21.2 | 2.63 | 1.78 | 28.19 | 33.1 | 7.81 | 3.75 |
| LSD at $P \leq 0.05$ | | 0.31 | 121 | 3.28 | 2.2 | 1.45 | 1.31 | 0.49 | 0.25 |

1. Lodging score recorded on a 1 to 5 scale, where 1 = no lodging and 5 = >80% of the plants lodged.

and grain quality to check the stability of the lines across locations before their recommendation to the farmers. Small quantities of these lines are available with sorghum breeding program at ICRISAT, Patancheru.

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