



Socio-economic impact and adoption of improved post-rainy sorghum (*Sorghum bicolor*) production technologies in Maharashtra

RAJENDRA R CHAPKE¹ and V A TONAPI²

ICAR-Indian Institute of Millets Research, Hyderabad, Telangana 500 030

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ABSTRACT

Low remuneration and poor adoption of sorghum [*Sorghum bicolor* (L.) Moench] production technologies were major constraints in drastic decline in area under cultivation. Therefore, evaluation of production potential, adoption, economic and other benefits of the technologies in social perspectives of the farmers was undertaken. The study was conducted with 200 adopted farmers under frontline demonstrations programme organized during five years from 2009-10 to 2013-14 in five districts in two prominent sorghum growing regions in Maharashtra, India. The yield potential and merits were measured by following before and after method, and data were collected through semi-structured interview schedule, group meetings, recorded data and empirical observations. The performance of the demonstrated technologies resulted into increase in adoption (27%), higher net returns (170%), followed by grain yield (58%) with better quality (78%) and fodder yield (26%). It enabled to motivate the farmers and increase in area under sorghum by 29% of the adopted farmers. Out of fifteen demonstrated practices, only five practices namely, use of high yielding variety, maintaining plant spacing, use of treated seeds or seed treatment, weed control measures and nitrogen fertilizer application were found suitable by the farmers which can be easily practiced and gave significant results with low cost. Furthermore, the additional returns helped them in spending significantly higher on purchase of household items (111%) followed by, on attending more social functions (109%), purchase of animals (91%), in start of new business (86%), deposit in bank (77%) and investment in farm development activities (62%). It also revealed that more number of family members and years of adoption under FLD programme resulted into high impact. The findings aptly indicated that the impact of the production technologies was very vital in meeting out the farmers' social, educational, health and financial needs apart from food and fodder. To boost-up the adoption, large family size of the farmers, their dependency on farming and continuing newly selected farmers with field demonstration of location-specific low-cost technologies up to five years should be considered.

Key words: Adoption, Impact of production technologies, Income utilization pattern, Post-rainy sorghum, Yield advantages

India has largest sorghum area [*Sorghum bicolor* (L.) Moench], comprising 16.30% of global area and 8.48% of production. It is grown in semi-arid climate where other cereal crops don't stand well (Paterson *et al.* 2009). Sorghum is the third cereal crop after rice and wheat in India, mostly grown under marginal and stress-prone areas of Semi-Arid tropics (SAT). With the threat of climate change looming large on the crop productivity, sorghum has an important role in food, feed and fodder security in dryland and rainfed agriculture.

Among all the sorghum growing states in India, Maharashtra ranked first in harvested area and production with 2.86 million hectares and 2.51 million tonnes, respectively during 2013-14. It is cultivated by all type of farmers in different types of soils mostly during rainy

(June-October) and post-rainy (September-January) seasons. National average yield of sorghum has doubled since 1980 due to adoption of both improved varieties and management practices by the farmers (Pray and Nagarajan 2009). Area-wise, Maharashtra (62.43%) and Karnataka (27.82%) were major states followed by Tamil Nadu (4.85%), Andhra Pradesh (3.39%) and Gujarat (1.50%). The post-rainy (*rabi*) sorghum produce is used both for human consumption and fodder for cattle. Thus, it is the key for the sustenance of human and livestock population. However, the productivity of post-rainy sorghum is lesser (783 kg/ha) than rainy sorghum (1026 kg/ha) during five years between 2010-11 and 2014-15 as it was mostly grown on residual moisture of rainy season under rain-fed condition with low fertilizers and inadequate technologies use (Deb *et al.* 2005). Low remuneration coupled with lack of policy and market supports were major limiting factors. Almost 31% area of post-rainy sorghum declined from 4.63 m ha during 2008-09 to 3.51 m ha during 2013-14 (Anonymous 2015).

¹Principal Scientist (e mail: chapke@millets.res.in), ²Director (e mail: tonapi@millets.res.in).

Several extension programmes and efforts were made in transfer and refinement of recommended improved production technologies on the farmers' fields through institute village linkage programme (IVLP), operational research programme, lab to land programme before 1996 and frontline demonstrations (FLDs) since 1996 by the government of India. More than 2200 FLDs on only *rabi* sorghum production technologies were organized by ICAR-Indian Institute of Millets Research (ICAR-IIMR), Hyderabad in major sorghum growing regions of the country (Chari *et al.* 2008). Several reports indicated the significant impact of the demonstrated sorghum production technologies mainly on yields. But, adoption by farmers depends on the varieties' suitability to their needs and conditions, the availability of seed and other inputs, the availability of information about the varieties, and other factors. Impact has been especially strong in the regions/states of the Marathwada and the western Maharashtra in Maharashtra, and in the northern Karnataka; this area is known as 'Sorghum Bowl' of India (Deb and Bantilan 2003). However, neither the effect of the technologies were ascertained adequately on different parameters nor managed effectively.

Therefore, this study was conducted to ascertain impact of the demonstrated technologies on agro-economic, farming and farmers' livelihood aspects. The extent of adoption of these recommended production technologies were also assessed in order to replicate successful results. This study would help to develop effective extension strategies for popularizing the post-rainy sorghum technologies.

MATERIALS AND METHODS

The study was conducted in major post-rainy sorghum (September-January) growing regions namely, western Maharashtra and Marathwada in Maharashtra, India where the FLDs were conducted by ICAR-Indian Institute of Millets Research (ICAR-IIMR), Hyderabad on the farmers' fields continuously during five years from 2009 to 2013. Latest 11 national and state released sorghum varieties during last five years of the FLDs viz., 'CSV 18R', 'CSV 22R', 'PKV Kranti (PV 1549)', 'Phule Vasuda', 'Parbhani Moti (SPV 1411)', 'Parbhani Jyoti (SPV 1595)', 'Phule Chitra', 'Phule Revati', 'Phule Suchitra', 'Phule Anuradha' and 'CSV 26R' along with recommended cultivation practices were undertaken. The locally popular varieties namely, 'Maldhandi', 'Lakadi' and 'Dagadi', which were grown by the farmers along with their own cultivation practices, were taken as a check plot for comparison. Demonstration trials including both, improved and local practices were planted in the same farmers' field to assess the performance between them. The trials were monitored by the scientists and experts from sorghum sector. Only yield and economic data were recorded in each year. Therefore, this study mainly attempted to describe the institutional, social and agro-economic factors in relation to adoption and impact of the demonstrated technologies in retrospect (*after the-fact*). An ex-post-facto survey design was employed.

The sampling was done by selecting 200 farmers randomly from the study area out of total 769 numbers who were beneficiaries of the FLDs during 2009-2013. Thus, purposive random sampling method was followed for selection of respondents out of the participatory farmers of FLDs. Total 100 respondents from each region those who belonged to different categories (marginal, small, medium and large), were selected randomly, making sample size of 200.

Extent of adoption and impact was measured using personal interviews, group discussions and empirical observations along with records of FLD trials. The data were categorized in three stages viz., pre-FLDs, during FLDs and post-FLDs in order to evaluate impact of the latest demonstrated technologies using pre- and post-evaluation test. The adoption of the demonstrated technologies was ascertained on three-point continuum i.e. full, partial and no with assigning two, one and zero score, respectively. The extent of adoption was computed with adoption index using formula: $\{(Difference\ between\ post-\ and\ pre-FLDs) / (Adoption\ level\ at\ pre-FLDs) \times 100\}$. Similarly, other parameters like, change in grain yield, fodder yield, net returns and benefit-cost ratio were measured using formula: $\{(Difference\ between\ post-\ and\ pre-FLDs) / (pre-FLDs) \times 100\}$. Impact index was worked out by calculating average score of the four parameters viz., grain yield, fodder yield, net returns and benefit-cost ratio (B:C) of the demonstrated technologies under pre- and post-FLDs. The data were analyzed with descriptive statistics; mean, correlation and 't' test analysis. For the non-descriptive questions, the respondents were requested to indicate their level of rating on one to five-point Likert-type scales where one indicated the lowest rating and five indicated the highest rating. The qualitative data were summarized through content analysis to facilitate interpretation.

RESULTS AND DISCUSSION

Adoption of demonstrated technologies by the farmers

Between 2009 and 2013, total 769 frontline demonstrations on improved post-rainy sorghum production technologies were organized in farmers' fields in the study area. Practice-wise adoption of the demonstrated production technologies followed by the trial farmers in Western Maharashtra region were significantly higher than the pre-FLD stage (Table 1). More than 48% adoption was found in practicing seed treatment (85%), use of high yielding varieties (70%), use of nitrogen fertilizer (57%), following timely sowing (49%) and maintaining plant spacing (48%). Whereas, below 30% adoption was found in use of phosphorous, potassium fertilizer, pest control measures, land preparation in time, irrigation application, harvesting at proper time and maintaining seed rate. It may be due to getting low remuneration out of this crop and scarcity of labours in peak season. However, use of farm yard manure (FYM) was decreasing significantly over the period of five years. It may be due to obvious reason of

its scarcity and high cost. The above findings elicited that the sorghum farmers of Western Maharashtra region were comfortable with adopting five major practices namely, seed treatment, use of high yielding variety, use of nitrogen fertilizer, timely sowing and maintaining plant spacing. The similar findings were also supported by Chapke (2014) and Casley and Kumar (1992).

In Marathwada region, the adoption level was also significantly higher than the pre-FLD stage (Table 1). Majority of the farmers adopted practices such as, weed control (70%), maintaining plant spacing (63%), use of high yielding varieties (48%) and maintaining seed rate (48%). Whereas, adoption of pest control measures (29%), practicing seed treatment (24%), use of nitrogen, phosphate and potassium (N:P:K) fertilizers, following timely sowing, irrigation application, land preparation in time, and harvesting at proper time were below 30%, but was highly significant than the pre-FLD stage. Similarly, use of FYM decreased substantially over the period of five years. The above findings explicated that the sorghum farmers of Marathwada region preferred to continue with four major practices namely, weed control, maintaining plant spacing, use of high yielding varieties and maintaining seed rate. The lower adoption of recommended fertilizer dose was associated with less irrigation facilities and poor soil status of the Marathwada region compared to the Western Maharashtra region.

Discussion with farmers also revealed that the other groups of non-adopted farmers from nearby villages within 45 km radius and relatives of the adopted farmers and non-trial farmers were motivated seeing yield performance of the demonstrated cultivars and requested for seeds.

Adoption of the farm technology should not be regarded as an end in itself, but rather as a continuous decision-making process (Sombatpanit *et al.* 1996). Individuals pass through various learning and experimenting stages from awareness of the problem, its potential solutions and finally deciding whether to adopt or reject the given technology. Adoption of new technology normally passes through four different stages, which include awareness, interest, evaluation, and finally adoption (Rogers and Shoemaker 1971). At each stage, there are various constraints (social, economic, physical, or logistical) for different groups of farmers. Therefore, scientist community should not be rest on their achievements as the adoption process is highly dynamic. Whereas, the provision of support services, such as credit, access to inputs, training and extension services, also increased adoption (Gafsi and Brossier 1997, Paudel and Thapa 2004).

Yield and economic benefits from the demonstrated technologies

The higher adoption of the demonstrated technologies (103%) by the farmers in Western Maharashtra led to higher grains production (78%) with better quality (42%) and fodder yield by 30% over pre-FLD stage. The increased yields not only enabled them to obtain higher net returns (168%) and incremental increase of benefit-cost ratio (15%) but also motivated to increase in area under sorghum significantly than the pre-FLD stage. Whereas, very low increase in cost of production (11%) over the pre-FLD stage was observed. It may be due to adoption of low-cost or no-cost production technologies like, maintaining plant geometry, seed rate and plant protection measures

Table 1 Adoption of demonstrated technologies by the farmers after FLD (%)

| Practice / item | Western Maharashtra | | Marathwada | | Pooled | |
|--|--|--------------------|--|-----------|--|--------------------|
| | Increased adoption over pre-demo stage (%) | 't' value | Increased adoption over pre-demo stage (%) | 't' value | Increased adoption over pre-demo stage (%) | 't' value |
| Land preparation in time | 12 | 3.08* | 9 | 3.93** | 10.5 | 4.65** |
| Use of high yielding variety | 70 | 14.28** | 48 | 43.37** | 58.5 | 22.44** |
| Seed treatment | 85 | 23.69** | 24 | 9.56** | 54.5 | 17.73** |
| Seed rate | 5 | 2.07* | 48 | 48.74** | 26.5 | 13.24** |
| Time of sowing | 49 | 9.51** | 15 | 5.74** | 31.75 | 10.26** |
| Spacing | 48 | 10.65** | 63 | 20.54** | 55.25 | 20.06** |
| Nitrogen (Urea) | 57 | 15.72** | 19 | 6.8** | 37.75 | 14.3** |
| P ₂ O ₅ (S.S.P.) | 29 | 6.75** | 3 | 2.28* | 15.5 | 6.56** |
| K ₂ O (MoP) | 24 | 6.12** | 17 | 5.62** | 20.25 | 8.24** |
| FYM | -11 | 1.52 ^{NS} | -6 | 2.93* | -5.75 | 2.77 ^{NS} |
| Insecticide used | 18 | 5.59** | 29 | 10.47** | 23.5 | 10.91** |
| Disease control | 03 | 2.28* | 5 | 3.32* | 3.75 | 4.02** |
| Weed control | 12 | 3.73** | 70 | 18.29** | 40.75 | 12.69** |
| Irrigations applied | 15 | 5.2** | 5 | 3** | 10 | 5.88** |
| Time of harvesting | 08 | 2.36* | 4 | 2.73** | 5.75 | 3.17** |

**Significant at P=0.01; *Significant at P=0.05; NS = Non significant

(Table 1). Nevertheless, effect of the FLD technologies in terms of benefit-cost ratio was not significant. It is elicited that only increase in productivity can't support farmers to get maximum benefit. Therefore, judicious use of inputs as per the recommendations coupled with adopting timely management practices also play vital role in achieving maximum profits per unit cost.

In the Marathwada region, the same trend of little increase in cost of production than the pre-FLD stage was observed. It is indicated that adoption of the demonstrated production technologies helped farmers to get maximum benefit with quality production.

Employment generation

Notably, most of the farmers engaged their family and hired labourer as their own resources in cultivation of sorghum. It was recorded that five years before ratio of hired and family labour used in the sorghum cultivation was 18:08, which became 25:06 (Table 3). It was shifting towards more on hired labourer by 39%. It may be due to the fact that young family members were not interested to do farm work; rather preferred to do work in non-agricultural sectors. Sorghum is a labour intensive crop, which consumed 52% cost for human labour alone out of total cost of cultivation. While, sorghum cultivation could provide small employment in the form of family labour and depended more on hired labourer up to 81%. This draws attention to the need of introduction of mechanization, wherever possible, for sustainable sorghum cultivation.

Income utilization pattern of sorghum farmers

Utilization of additional returns obtained from the improved sorghum cultivation by the FLD farmers in Western Maharashtra revealed (Table 2) that farmers could spend double on attending more social functions like,

marriage, birthday functions, etc. However, it could not help them much in high investment items like, start of business, purchase of costly dairy animals and making bank deposit.

The income utilization pattern of the farmers after FLD period in Marathwada region indicated that the additional returns only helped them in spending significantly higher on attending more social functions (116%) than before demonstration period. Due to scanty rainfall coupled with poor soil status, they tend to start subsidiary occupations like dairy and other small enterprise.

Out of fifteen demonstrated practices, only five practices namely, use of high yielding variety, maintaining plant spacing, use of treated seeds or seed treatment, use weed control measures and nitrogen fertilizer application were found to be adopted by the farmers. Impact of the demonstrated technologies was observed with higher adoption level resulting in higher grain yield with better quality and fodder yield, and ultimately net returns. This impact enabled to motivate the farmers to extend area under sorghum. The shifting trend towards more hired labourer use prompted to introduce mechanization in sorghum cultivation, wherever possible. It is also concluded that more number of family members and number of years of

| Labourer | Pre-demo | Post-demo | Change over pre-demo stage (%) |
|----------|-------------|-------------|--------------------------------|
| Total | 26 (100) | 31 (100) | 19 |
| Hired | 18 (69) | 25 (81) | 39 |
| Family | 08 (31) | 06 (19) | -25 |

Figures in parentheses indicates percentage

Table 2 Indicators of impact assessment of *rabi* sorghum FLDs

| Indicator | Western Maharashtra | | Marathwada | | Pooled | |
|---------------------------|--------------------------------|--------------------|--------------------------------|-----------|--------------------------------|-----------|
| | Change over pre-demo stage (%) | 't' value | Change over pre-demo stage (%) | 't' value | Change over pre-demo stage (%) | 't' value |
| Area of sorghum (ha) | 27 | 3.97** | 36 | 4.63** | 29 | 5.24** |
| Adoption level | 103 | 31.94** | 24 | 41.12** | 27 | 45.4** |
| Cost of production (₹/ha) | 11 | 2.68** | 11 | 38.30** | 11 | 5.63** |
| Grain yield (q/ha) | 78 | 13.58** | 28 | 3.36** | 58 | 10.63** |
| Fodder yield (q/ha) | 30 | 6.60** | 23 | 7.76** | 26 | 9.36** |
| Net returns (₹/ha) | 168 | 2.24** | 170 | 9.95** | 170 | 5.46** |
| Benefit-cost ratio | 15 | 1.15 ^{NS} | 28 | 7.96** | 22 | 3.2** |
| Quality of grain | 42 | 10.09** | 136 | 26.53** | 78 | 20.92** |
| Labourer used | 133 | 10.56** | 43 | 13.35** | 19 | 7.87** |
| Hired labourer | 122 | 7.49** | 64 | 12.82** | 39 | 11.08** |
| Family labourer | 167 | 5.53** | 20 | 7.03** | -25 | 7.86** |

**Significant at P=0.01; *Significant at P=0.05; NS = Non significant

Table 4 Utilization of additional returns obtained from sorghum cultivation

| Item (Human needs) | Western Maharashtra | | Marathwada | | Pooled | |
|--------------------------------|--------------------------------|--------------------|--------------------------------|--------------------|--------------------------------|--------------------|
| | Change over pre-demo stage (%) | 't' value | Change over pre-demo stage (%) | 't' value | Change over pre-demo stage (%) | 't' value |
| Education | 49 | 13.6** | 57 | 9.98** | 52 | 16.26** |
| Health | 54 | 18.22** | 49 | 6.75** | 52 | 15.31** |
| Food | 39 | 10.58** | 39 | 1.89 ^{NS} | 39 | 3.76** |
| Purchase of animals | 01 | 1.00 ^{NS} | 90 | 2.35* | 91 | 2.32* |
| Next crop cultivation | 53 | 6.11** | 45 | 4.63** | 52 | 6.81** |
| New business | 02 | 1.42 ^{NS} | 86 | 3.86** | 86 | 3.73** |
| Bank deposit | 00 | 00 ^{NS} | 77 | 1.84 ^{NS} | 77 | 1.83 ^{NS} |
| Purchase of household items | 62 | 12.04** | 111 | 3.65** | 111 | 10.44** |
| Investment in farm development | 13 | 19.32** | 63 | 1.89 ^{NS} | 62 | 1.93 ^{NS} |
| Attending social functions | 100 | 16.62** | 116 | 3.50** | 109 | 11.7** |

**Significant at P=0.01; *Significant at P=0.05; NS = Non significant

Table 5 Definition, correlation of socio-economic variables and impact of the demonstrations

| Code | Variable | Definition and measurement | Mean | SD | Correlation (r) |
|-----------------|---|---|--------|---------|-----------------|
| X ₁ | Age | Age of the farmers, measured in years | 45.03 | 9.85 | 0.016 |
| X ₂ | Education | Formal education acquired by the farmers (if illiterate = 0, otherwise = increasing numbers of schooling years) | 9.49 | 4.79 | 0.063 |
| X ₃ | Occupation | Occupation of farmers (Farming only=1 and farming plus other business = 2) | 1.05 | 0.22 | 0.190 |
| X ₄ | Family size | Members of farmer's family living together in numbers | 6.00 | 2.93 | 0.326** |
| X ₅ | Land holding | Land holdings of farmers measured in hectare | 3.51 | 3.93 | 0.017 |
| X ₆ | Adoption period under FLDs | Period during which farmers were adopted for frontline demonstration programme in years | 1.92 | 1.45 | 0.389** |
| X ₇ | Percentage change in area under sorghum | The percentage change in area of sorghum was calculated as a ratio of the increase in the area apportioned by the farmer for sorghum in post-FLD over the area in the pre-FLD period. | 44.23 | 76.68 | 0.115 |
| X ₈ | Percentage increase in adoption level | The percentage change in adoption level of demonstrated technologies was calculated as a ratio of the increase in the adoption level at post-FLD period over the adoption level at pre-FLD stage. | 68.34 | 65.51 | 0.169* |
| X ₉ | Percentage change in cost of production | The percentage change in operational cost of production incurred was calculated as a ratio of the increase in operational cost of production in post-FLD period over the operational cost of production incurred in the pre-FLD period. | 16.36 | 32.61 | -0.096 |
| X ₁₀ | Percentage change in grain yield | The percentage change in grain yield of sorghum was calculated as a ratio of the increase in the grain yield in post-FLD over the grain yield obtained in the pre-FLD period. | 57.74 | 48.32 | 0.279** |
| X ₁₁ | Percentage change in fodder yield | The percentage change in fodder yield of sorghum was calculated as a ratio of the increase in the fodder yield in post-FLD over the fodder yield obtained in the pre-FLD period. | 23.11 | 34.59 | 0.177* |
| X ₁₂ | Percentage change in net returns | The percentage change in net returns obtained from sorghum was calculated as a ratio of the increase in net returns in post-FLD over the net returns obtained in the pre-FLD period. | -23.90 | 2066.30 | 0.833** |
| X ₁₃ | Percentage change in benefit-cost ratio | The percentage change in benefit-cost ratio obtained from sorghum was calculated as a ratio of the increase in net returns in post-FLD over the benefit-cost ratio obtained in the pre-FLD period. | 97.99 | 275.34 | 0.471** |

**Significant at P=0.01; *Significant at P=0.05

adoption under FLD programme resulted into high impact. The findings aptly indicated that effect of the production technologies was very vital in motivating farmers to adopt demonstrated technologies to meeting out their social, educational, health and financial needs apart from food and fodder. Moreover, even small changes in use of low-cost recommended practices and timely management can have large effects on yields and monetary benefits, which supports their livelihood.

Despite the fact, the demonstrated improved technology was found promising and the farmers would like to continue with their own inputs arrangement after withdrawal from the scheme (post-FLD period), they were unable to access required key inputs like, quality seeds of high yielding varieties and agro-chemicals due to lack of its availability in time at village level. Therefore, the inputs support mechanism in convergence mode needs to be developed at grass-root level and marketing facilities. Since, it is labour intensive crop, suitable mechanization wherever possible should be introduced especially for harvesting operations to overcome labour problems which takes major share of input-cost. These were the limiting factors in the adoption process. To boost-up the adoption, large family size of the farmers, their dependency on farming and continuing newly selected farmers with field demonstration of location-specific low-cost technologies up to five years should be considered. Farmers have diversified needs and worked under several socio-economic and farming constraints which had become their primary concern in motivational perspectives before they decided for any changes and adoption of the new practices. The role of the farmers in the whole system is more on the receiving end as 'passive subjects' rather than 'active stake holders' despite the fact that sorghum crop constitutes one of their main sources of livelihood.

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