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FULL-LENGTH RESEARCH ARTICLE

# Adoption and Socio-economic Benefits of Improved Post-rainy Sorghum Production Technology

Rajendra R. Chapke[1] · Vilas A. Tonapi[1]

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**Abstract** Low remuneration and adoption of sorghum production technologies were among the major constraints for drastic reduction in its cultivation. Therefore, evaluation of production potential, adoption, economic and other benefits of the technologies in social perspectives of the farmers was felt essential. The study was conducted with 200 adopted farmers under field trials organized during 5 years from 2009–2010 to 2013–2014 in five districts in two prominent sorghum growing regions in Maharashtra State of India. The yield potential and merits were measured by following before and after method, and data were collected through semi-structured interview schedule. The performance of the demonstrated technologies resulted in increased adoption (27%), higher net returns (170%), followed by grain yield (58%) with better quality (78%) and fodder yield (26%), and found to be significantly positive over the pre-FLD. It enabled to motivate farmers and increase in area under sorghum by 29%. Furthermore, the additional returns helped them in spending significantly higher on purchase of household items (111%), followed by 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%).

**Keywords** Adoption · Low remuneration · Adoption of technologies · Grain yield · Fodder yield · Income utilization pattern · Post-rainy sorghum · Yield advantages

## Introduction

Sorghum (*Sorghum bicolour* [L.] Moench) is one of the most important cereal crops in the world grown in 108 countries covering 35.7 m ha with a total production of 63.56 m tons in 2014. India has largest sorghum area, comprising 16.30% of global area and 8.48% of production, whereas USA was the largest producer with 17.29% of production in the world [9]. It is a staple food for millions of poorest and most food-insecure people in the semi-arid tropics (SAT) of Africa, Asia and Latin America. More than 300 million people in more than 30 countries depend on sorghum as the main source of energy and protein [12].

India is the main producer of sorghum in Asia. Sorghum is the third cereal crop after rice and wheat in India, mostly grown under marginal and stress-prone areas of SAT. With the threat of climate change looming large on crops' productivity, sorghum has an important role in food, feed and fodder security in dryland agriculture. However, the area has declined drastically from 10.25 million ha in 1999–2000 to 5.82 million ha in 2014–2015. The total production also declined from 8.68 million tons to 5.39 million tons [4]. Major reasons for decline in the area and production are low remuneration and lack of policy support compared to commercial crops (cotton, soybean, wheat and paddy), fast changing lifestyle and food habits of the people due to urbanization, and low social status attached to the consumption of sorghum coupled with inconvenience in food preparation. Nowadays, the people in semi-

✉ Rajendra R. Chapke
chapke@millets.res.in

1 ICAR-Indian Institute of Millets Research, Hyderabad 500 030, India

urban or urban areas have very limited time to spend in food preparation coupled with inadequate skill to prepare traditional food like sorghum *roti* (bread). They prefer food which is easy for preparation and requires less time. In view of this, an initiative for promotion of ready-to-cook and ready-to-eat value-added sorghum products (biscuits, noodles, pasta, flex, etc.) has been taken by ICAR-Indian Institute of Millets Research (ICAR-IIMR), Hyderabad. It enables to increase demand of sorghum in the market and also cater the need of diabetic and coeliac patients as these food products are almost gluten free [17]. For this, there is a need of quality sorghum production.

It is one of the cheapest sources of energy, high content of digestive fibres, protein, vitamins and minerals [1, 2]. In terms of nutrient intake, sorghum accounts for about 35% of the total intake of calories, protein, iron and zinc in the dominant production/consumption areas [13]. Besides, being a major source of staple food for human beings, it also serves as an important source of fodder, feed and industrial raw material. It is grown mainly in both rainy and post-rainy seasons on all soil types in semi-arid climate where other cereal crops do not stand well [14]. The rainy season (*kharif*) sorghum is grown during June–October. It is dependent on natural rainfall and prone to grain mould diseases and, thereby, used for animal/poultry feed, while post-rainy season (*rabi*) sorghum is grown during September–January. It is grown on residual moisture of rainy season and primarily used for human consumption.

Among all the sorghum growing states in India, Maharashtra State ranked first in harvested area and production with 2.86 million hectares and 2.51 million tons, respectively, during 2013–2014. In 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%). National average yield of sorghum has doubled since 1980 due to adoption of both improved varieties and management practices by the farmers [16]. The post-rainy 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 (840 kg/ha) than rainy sorghum (1033 kg/ha) during 2013–2014. Almost 31% area of post-rainy sorghum has reduced from 4.63 m ha during 2008–2009 to 3.51 m ha during 2013–2014 [3]. Low remuneration coupled with lack of policy and market supports were among the major demotivating factors.

More than 2200 frontline demonstrations (FLDs) on only *rabi* sorghum production technologies were conducted by the ICAR-IIMR in major sorghum growing areas of the country [6]. Several reports indicated that there was a significant impact of the improved sorghum production technologies mainly on yields. But, not all released varieties and cultivation practices resulted in impact, of course; 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 [18]. Impact appears to be strong in the regions/states, namely Marathwada and western Maharashtra in Maharashtra State, and in northern Karnataka state; this area is known as 'Sorghum Bowl' of India [7]. However, neither the impact of the demonstrated technologies was ascertained adequately with different parameters nor it was managed effectively for further expansion. The area decline in *rabi* sorghum is lower than the *kharif* sorghum because the farmers have very limited options in *rabi* season except sorghum in rainfed areas unlike *kharif* season. It is a major source of their livelihood in rainfed and dryland areas, while the productivity and profitability of *rabi* sorghum were low mainly due to low adoption of improved production technologies [8]. Therefore, this study was conducted to ascertain impact of the demonstrated technologies on agro-economic, farming and farmers' livelihood aspects, so that the sorghum growers can be motivated and build up confidence for sustainable sorghum cultivation. The extend of adoption of these recommended production technologies was also assessed in order to replicate the successful results. This study ultimately will direct to develop effective strategies for further development.

## Materials and Methods

### Study Area, Research Design and Selection of the Respondents

This study was conducted in major sorghum growing regions, namely western Maharashtra and Marathwada in Maharashtra State of India where the FLDs were conducted on post-rainy sorghum (September–January) in the farmers' fields continuously during 5 years from 2009 to 2013 by ICAR-Indian Institute of Millets Research, Hyderabad, under macro-management scheme of Ministry of Agriculture and Farmers Welfare, Government of India. The study mainly attempted to describe the institutional, social and agro-economic factors in relation to adoption and effect of the demonstrated technologies in retrospect (*after the fact*). An ex-post-facto survey design was employed which involves data collection after a naturalistically occurring event [4, 10]. Purposive random sampling method was followed for selection of respondents out of the beneficiary farmers of FLDs. Thus, 100 respondents from each region those who were well-responsive, cooperative and maintained records of the cultivation were selected randomly, making sample size of total 200.

### Development of Interview Schedule and Data Collection

Initially, benchmark data on socio-personal and agro-economic profile of the trial farmers were collected before initiating the FLD trials (pre-FLDs) with the help of semi-structured interview schedule which was prepared including experts' suggestions. Subsequently, the trial data of the selected farmers during adoption period were recorded on various parameters like performance of the demonstrated technologies, acreage under crop, socio-personal profile of the farmers, attitude, yield difference, seed exchange, if any, level of adoption, labour use pattern, economics and utilization of additional income. The adoption period of individual farmers was varying from 2 to 5 years as they were changing. Finally, data were collected after withdrawal from the trials (post-FLDs) for the purpose of evaluating impact of demonstrated technologies from the same set of farmers conducting personal interviews, group discussions, empirical observations, memory data and field records of the FLD trials.

### Measurement of Adoption and Impact of the Latest Sorghum Technologies

Extend of adoption and impact were measured using suitable methods as mentioned earlier. The data were categorized in three stages, namely pre-FLDs, during FLDs and post-FLDs, in order to evaluate impact 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 extend of adoption was computed with adoption index using formula: {(Difference between post- and pre-FLDs)/(Adoption level at pre-FLDs) × 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) × 100}. Impact index was worked out by calculating average score of the four parameters, namely grain yield, fodder yield, net returns and benefit–cost ratio (B/C) of the demonstrated technologies obtained under pre- and post-FLD period. The data were analysed 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 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, frontline demonstrations on improved post-rainy sorghum production technologies were organized in farmers' fields in the highest sorghum growing state, Maharashtra in the country. In western Maharashtra region, latest national- and state-level released varieties, namely CSV 18R, CSV 22R, Phule Vasudha and Phule Suchitra (soil type-specific, high yield potential above 3.00 t/ha and insect/pest resistant) along with recommended cultivation practices were undertaken in the trials and compared with oldest ruling variety, M 35-1 (*Maldandi*), which was low yielder below 2.00 t/ha. Practice-wise adoption of the demonstrated production technologies followed by the trial farmers was found significantly higher than the pre-FLD stage (Table 2). More than 48% adoption was found in practicing seed treatment (85%), use of high-yielding varieties (70%), use of nitrogen fertilizer (57%), following time of 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 labourer in peak season. Overall, significant increase in adoption of the demonstrated practices was observed than the pre-FLD stage. However, use of farm yard manure (FYM) was found to be decreasing significantly over the period of 5 years. It may be due to obvious reason of its scarcity and high cost than chemical fertilizers. 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 varieties, especially CSV 22R and Phule Vasudha, due to their high yield and bold grain size, followed by use of nitrogen fertilizer, following time of sowing and maintaining plant spacing. The similar findings were also supported by Chapke, 2014 [5].

In Marathwada region, latest national and state released varieties, namely CSV 18R, CSV 22R, Parbhani Moti, PKV Kranti (SPV 1549) and Phule Vasudha (soil type-specific, high yield potential above 3.00 t/ha and insect/pest resistant), along with recommended cultivation practices were undertaken in the trials and compared with oldest ruling variety, M 35-1 (*Maldandi*), which was low yielder below 2.0 t/ha. The overall adoption level was found significantly higher than the pre-FLD stage (Table 1). Majority of the farmers adopted practices such

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

| Practices/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 varieties | 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** |
| $P_2O_5$ (S. S.P.) | 29 | 6.75** | 3 | 2.28* | 15.5 | 6.56** |
| $K_2O$ (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 1% level; *significant at 5% level; NS = non-significant

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 time of sowing, land preparation in time, irrigation application and harvesting at proper time were found below 30%, but was highly significant than the pre-FLD stage. Similarly, the use of FYM was found decreasing significantly over the period of 5 years. The reason for this was also the same as mentioned earlier. The above findings revealed that the sorghum farmers of Marathwada region were preferred to continue with four major practices, namely weed control, maintaining plant spacing, use of high-yielding location-specific varieties, especially CSV 18R and Parbhani Moti, due to their high yield, bold grain size and pearly white colour, followed by maintaining seed rate. The lower adoption of recommended fertilizer dose was associated with lack of irrigation facilities and poor soil status of Marathwada region compared to western Maharashtra.

It was observed that the use of fertilizers (N:P:K), irrigations and high-yielding varieties was found more in western Maharashtra than Marathwada region. It may be due to adoption of moisture conservation practices by the farmers, namely compartmental bunding, better soil status and availability of better irrigation facilities in western Maharashtra, whereas adoption of the low cost and low resource-intensive cultivation practices like maintaining plant spacing, seed rate and plant protection measures was found comparatively more in Marathwada region than western Maharashtra (Table 1). It revealed that requirements of the crop production technology vary with location to location. There is a need to follow moisture conservation practices and green manuring to improve the soil moisture condition coupled with the adoption of proven production technologies which can enhance yield substantially. Adoption of the farm technology should not be regarded as an end in itself, but rather as a continuous decision-making process [20]. Individuals pass through various learning and experimenting stages from awareness of the problem and its potential solutions and finally decide 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 [19]. At each stage, there are various constraints (social, economic, physical or logistical) which are location-specific for different groups of farmers. Therefore, scientist community should not be at 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, is always supported adoption [11, 15].

### Yield and Economic Benefits Obtained from the Demonstrated Technologies

The higher adoption of the demonstrated technologies (103%) by the farmers in western Maharashtra led to produce higher grains (78%) up to 2.50 t/ha. with better quality (42%) and fodder yield by 30% over pre-FLD stage. The better grain quality was generally decided on bold grain size and its lustrous colour (pearly white) which had higher price in markets. The farmers expressed that such quality is not obtained with regularly used (check) variety and could not get high price. The increased yields were not only enabled them to obtain higher net returns (168%) and incremental increase in benefit–cost ratio (15%) but also motivated to increase in area under sorghum (27%) significantly than the pre-FLD stage, whereas very low increase in cost of production (11%) was observed over the pre-FLD stage (Table 2) which may be due to adoption of low-cost or no-cost production technologies like maintaining plant geometry, seed rate and plant protection measures. Nevertheless, effect of the FLD technologies in terms of benefit–cost ratio was not found significant. It is prompted that only increase in productivity cannot support farmers to get maximum benefit but quality of the produce also matters much. Therefore, judicious use of inputs as per the recommendations coupled with adopting timely management practices has also played vital role in achieving maximum profits per unit cost.

In Marathwada region, the farmers obtained higher net returns (170%), higher grain yield (28%) with better quality (136%) and fodder yield by 23% due to adoption of the demonstrated practices (24%). The increased yields have also enabled them to obtain incremental increase in benefit–cost ratio (28%) and increase in area under sorghum (36%) which was significantly higher than the pre-FLD stage. As mentioned earlier, little increase in cost of production (11%) 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. In support of these findings, Deb and Bantilan, 2003, also stated that for any crop, it can be difficult to interpret yield levels and changes in yield as measures of research impacts [7]. This is particularly true for crops such as sorghum that are customarily grown with few inputs under dryland conditions. Even small changes for making easy availability of quality inputs in time and type of land apportioned to sorghum can have large effects on yields.

As mentioned earlier, western Maharashtra had better irrigation facilities and more adoption of moisture conservation practices by the farmers unlike in Marathwada region. It was resulted into higher productivity. When, the increased area during post-FLD period was compared between these two regions, it was found that little bit low sorghum area was increased in western Maharashtra (27%) compared to Marathwada region (36%) (Table 2). It is interesting to note that sorghum area had been reduced where irrigation facilities were developed which led to competition of high remunerative cash crops, namely sugarcane, vegetable and oilseed crops.

### 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 5 years before ratio of hired

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

| Sl. no. | Indicators | 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 |
| 1 | Area of sorghum (ha) | 27 | 3.97** | 36 | 4.63** | 29 | 5.24** |
| 2 | Adoption level | 103 | 31.94** | 24 | 41.12** | 27 | 45.4** |
| 3 | Cost of production (Rs./ha) | 11 | 2.68** | 11 | 38.30** | 11 | 5.63** |
| 4 | Grain yield (q/ha) | 78 | 13.58** | 28 | 3.36** | 58 | 10.63** |
| 5 | Fodder yield (q/ha) | 30 | 6.60** | 23 | 7.76** | 26 | 9.36** |
| 6 | Net returns (Rs./ha) | 168 | 2.24** | 170 | 9.95** | 170 | 5.46** |
| 7 | Benefit–cost ratio | 15 | $1.15^{NS}$ | 28 | 7.96** | 22 | 3.2** |
| 8 | Quality of grain | 42 | 10.09** | 136 | 26.53** | 78 | 20.92** |
| 9 | Labourer used | 133 | 10.56** | 43 | 13.35** | 19 | 7.87** |
| 10 | Hired labourer | 122 | 7.49** | 64 | 12.82** | 39 | 11.08** |
| 11 | Family labourer | 167 | 5.53** | 20 | 7.03** | − 25 | 7.86** |

**Significant at 1% level; *significant at 5% level; NS = non-significant 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, and the increasing trend is also depicted in Table 2. While sorghum cultivation could provide small employment in the form of family labour (19%), however, it depended more on hired labourer up to 81%. This draws attention to the need of introduction of mechanization, wherever possible, especially for harvesting operation which takes major toll in sorghum cultivation.

## Income Utilization Pattern of Sorghum Farmers

As mentioned earlier, the farmers of these rainfed areas had very limited crop options in post-rainy season except sorghum. Hence, monetary returns obtained from sorghum had major influence and important role in their livelihood, which was realized by the farmers. Utilization of additional returns obtained from the improved sorghum cultivation by the FLD farmers in western Maharashtra revealed (Table 4) that farmers could spend double on attending more social functions like marriage and birthday functions (100%) than earlier, followed by on purchase of household items like television and mobile set (62%), health of all family members (54%), for next crop cultivation (53%), education of their children (49%) and food for their family (39%) which was significantly higher than the pre-FLD period. A little increase in investment in farm development activities (13%) was also found, whereas 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 was indicated that the additional returns only helped them in spending significantly higher on attending more social functions (116%) than before demonstration period, followed by on purchase of household items (111%), purchase of animals (90%), start of new business (86%), education of their children (57%), health of all family members (49%) and for next crop cultivation (45%), whereas increased expenditure on investment in farm development activities like field levelling, pond construction and well repair work (63%), food for their family (39%) and making bank deposit (77%) was not significant.

As discussed earlier, high productivity in western Maharashtra attributed to better irrigation facilities and better soil status. In Marathwada region, due to scanty rainfall coupled with non-adoption of moisture conservation practices and poor soil status, the farmers tend to shift on subsidiary occupations like dairy and other small enterprises, namely grocery shop and tea stall. For this, they were spending more on purchase of animals and to

**Table 3** Labour use pattern in sorghum cultivation

| 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 |

Figure in parentheses indicates percentage

**Table 4** Utilization of additional returns obtained from sorghum cultivation

| Sl. no. | Items (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 |
| 1 | Education | 49 | 13.6*** | 57 | 9.98** | 52 | 16.26** |
| 2 | Health | 54 | 18.22** | 49 | 6.75** | 52 | 15.31** |
| 3 | Food | 39 | 10.58** | 39 | 1.89$^{NS}$ | 39 | 3.76** |
| 4 | Purchase of animals | 01 | 1.00$^{NS}$ | 90 | 2.35* | 91 | 2.32* |
| 5 | Next crop cultivation | 53 | 6.11** | 45 | 4.63** | 52 | 6.81** |
| 6 | New business | 02 | 1.42$^{NS}$ | 86 | 3.86** | 86 | 3.73** |
| 7 | Bank deposit | 00 | 00$^{NS}$ | 77 | 1.84$^{NS}$ | 77 | 1.83$^{NS}$ |
| 8 | Purchase of household items | 62 | 12.04** | 111 | 3.65** | 111 | 10.44** |
| 9 | Investment in farm development | 13 | 19.32** | 63 | 1.89$^{NS}$ | 62 | 1.93$^{NS}$ |
| 10 | Attending social functions | 100 | 16.62** | 116 | 3.50** | 109 | 11.7** |

**Significant at 1% level; *significant at 5% level; NS = non-significant start new business compared to western Maharashtra region as reflected in Table 4. There is scope to promote entrepreneurship development programme on value addition of sorghum.

### Association Between Socio-economic Traits of the Farmers and Impact of Demonstrated Technologies

Correlation between different variables with impact of the demonstrated technologies was analysed. Since sorghum is labour intensive, family size refers to the total number of family members involved in the farming activities which was found to be positive and significantly correlated with impact of improved production technologies (Table 5). This implies that the size of family with more members had more contribution in farm work and therefore had influence on the adoption and impact of the technologies. It was also supported by the findings of Tiwari et al. [21]. Furthermore, adoption period of the farmers under FLDs was impacted as highly significant and positive. It was hypothesized too. It is obvious that parameters of impact index, namely increase in grain and fodder yield, net returns and benefit–cost (B/C) ratio, had high correlation with impact at 1% level of probability. These apart, out of nine different socio-economic and yield-related variables, namely family size and adoption period of the farmers under FLD programme, were found highly correlated at 1% level of probability with impact of the FLDs, while the adoption level was found correlated at 5% level of probability, whereas variables like increase in cost of production was found negatively correlated. It implies that more number of family members and number of years of adoption under FLD had high correlation with effect of the technologies in terms of additional grain yield, net returns and B/C ratio.

**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 as 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 | 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 to the area in the pre-FLD period | 44.23 | 76.68 | 0.115 |
| $X_8$ | Percentage increase in adoption level | Percentage change in adoption level of demonstrated technologies was calculated as a ratio of the increase in the adoption level at post- FLD period to the adoption level at pre-FLD stage | 68.34 | 65.51 | 0.169* |
| $X_9$ | Percentage change in cost of production | 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 to the operational cost of production incurred in the pre-FLD period | 16.36 | 32.61 | − 0.096 |
| $X_{10}$ | Percentage change in grain yield | Percentage change in grain yield of sorghum was calculated as a ratio of the increase in the grain yield in post- FLD to the grain yield obtained in the pre-FLD period | 57.74 | 48.32 | 0.279** |
| $X_{11}$ | Percentage change in fodder yield | Percentage change in fodder yield of sorghum was calculated as a ratio of the increase in the fodder yield in post- FLD to the fodder yield obtained in the pre-FLD period | 23.11 | 34.59 | 0.177* |
| $X_{12}$ | Percentage change in net returns | Percentage change in net returns obtained from sorghum was calculated as a ratio of the increase in net returns in post- FLD to the net returns obtained in the pre-FLD period | − 23.90 | 2066.30 | 0.833** |
| $X_{13}$ | Percentage change in benefit–cost ratio | Percentage change in benefit–cost ratio obtained from sorghum was calculated as a ratio of the increase in net returns in post- FLD to the benefit–cost ratio obtained in the pre-FLD period | 97.99 | 275.34 | 0.471** |

**Significant at 1% level; *significant at 5% level

In this study, personal profile of the farmer like caste classification, age, education and dominated community had no relevance as significant impact was observed except who had the adequate working members in the family and the dependency on farming occupation only. The similar observations were also recorded by Tiwari et al. [21].

## Conclusions

Out of fifteen demonstrated practices, only five practices, namely use of high-yielding varieties, 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. Effect in terms of impact of the demonstrated technologies increased in adoption level which resulted in higher grain yield with better quality and fodder yield, and ultimately net returns. This impact enabled the farmers to be motivated for expanding the area under sorghum. The farmers continued with the technologies after FLD period too. It is also revealed that more number of family members and years of adoption under FLD programme resulted into high impact. The improved sorghum cultivation could provide small employment in the form of family labour; however, the shifting trend towards more hired labourer was observed. The findings aptly indicated that the impact of the production technologies was very vital in meeting out their social, educational, health, financial needs apart from food and fodder. Moreover, even small changes in using low-cost recommended practices and timely management had large effects on yields and monetary benefits, which supports their livelihood.

Although 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 input support mechanism in convergence mode needs to be developed at grassroot level and marketing facilities. Since it is a labour-intensive crop, suitable mechanization wherever possible should be introduced, especially for harvesting operations to overcome labour problems which take major share of input cost. These were the limiting factors in the adoption process. To make this crop more remunerative, value addition would be a viable option which could provide income generation opportunity to farmers in dryland and resource-poor areas. 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 5 years should be considered.

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**Compliance with Ethical Standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

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