

Performance of post-rainy (*rabi*) sorghum production technology under FLDs for enhancing productivity and profitability

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Sorghum is mainly grown during rainy (kharif) and post-rainy (rabi) season. Post-rainy sorghum is mostly used for human consumption due to its good grain quality. Increasing productivity with improved cultivars based on soil conditions where rabi sorghum is grown on residual soils is of much importance in climate change scenario. Apart from the adoption of improved cultivation practices, adoption of soil moisture conservation practices like deep ploughing, compartmental bunding or ridge and furrow method are beneficial in reducing water stress, improve yield and net returns compared to traditional practices. Total 3699 frontline demonstrations (FLDs) on rabi sorghum were organized in major sorghum growing areas of Maharashtra, Karnataka, Telangana and Gujarat since 2012–13 to 2021–22 with improved rabi sorghum technologies which gave 49% more grain yield than the farmer's practice (FP) and resulted into 49% more net returns.

Keywords: Frontline demonstrations, Improved production technologies, Net returns, Post-rainy sorghum, Yield advantages

ONE of the major alternative for wheat and maize is a great millet commonly known as sorghum, which is vernacularly known as Saloo Jwari (Marathi), Juar (Bengali, Gujarati, Hindi), Jola (Kannada), Cholan (Malayalam, Tamil), Janha (Oriya), Jonnalalu (Telugu), Milo and Chari. It is one of the most important cereal crops grown in both *kharif* (rainy) and *rabi* (post-rainy) seasons in the semi-arid regions of the country. In India, *rabi* sorghum is grown in an area of 3.01 million hectare (mha) as compared to 1.75 mha under *kharif* sorghum. As *rabi* sorghum is consumed without polishing due to its cleanliness, the total dietary fibre and minerals are easily available for human body.

Maharashtra (1.98 mha), Karnataka (0.69 mha) and Andhra Pradesh (0.11 mha) are the major *rabi* sorghum growing states in the country. Although the productivity of *rabi* sorghum is low, it has better economic value for farmers as compared to *kharif* sorghum because of its better grain quality for food and is a major source of fodder for animals during lean summer period. The inputs required for *rabi* sorghum are lower than other cereals like wheat, rice and maize that make it more profitable.

Much of the *rabi* sorghum is grown on residual and receding soil moisture on shallow, medium and deep soils. Therefore, the progress in hybrid *rabi* sorghum breeding is limited. The variety M35-1 is a

popular landrace grown by farmers in *rabi* tracts of Maharashtra, Karnataka and Telangana since 1976. Most of the present-day improved varieties are the result of pure-line selection practiced among the local/popular varieties and their crosses. The varieties for specific soil types (shallow, medium and deep) have been released. Moreover, improved cultivation practices including crop management are also available and evaluated under farmer's fields in sorghum growing regions. The potential varieties have lustrous, bold and globular size grains which are recommended for different states (Table 1).

Table 1. Recommended *rabi* sorghum varieties and hybrids for different states

State	Hybrids	Varieties
<i>Maharashtra</i>		
Rainfed areas (Medium to deep soil)	CSH 39R, CSH 19R, CSH 15R	Phule Rohini (RPASV3), Phule Suchitra (RSV 1098), CSV 216R, CSV 29R, CSV 22R, CSV 18R, Parbhani Super Moti
Irrigated areas	CSH 39R, CSH 19R, CSH 15R	PKV Kranti, CSV 22R, Phule Vasudha
Shallow soil	-	CSV 26R, Phule Anuradha, Phule Chitra

State	Hybrids	Varieties
Karnataka		
Dry zones (Deep soil)	CSH 15R	BJV 44 (SPV 2034), SPV-2217, CSV 29R, M 351, DSV 4
Transitional zones (Medium soil)	CSH 15R	BJV 44 (SPV 2034), SPV-2217, CSV 26R, DSV 5
Irrigated zones	CSH 39R, CSH 19R, CSH 15R	BJV 44 (SPV 2034), SPV-2217, CSV 29R, CSV 22R, DSV 5
Telangana		
All areas	CSH 15R	CSV 29R, CSV 26R, CSV 22R
Normal <i>rabi</i> areas	CSH 15R	CSV 29R, CSV 26R, CSV 22R, CSV 18R
Tamil Nadu		
Entire <i>rabi</i> area	CSH 15R	CSV 29R, CSV 26R, CSV 18R, CSV 22R
Summer sorghum areas	CSH 15R	CO 26, CO 24, COFS 29, CSV 33MF, CSV 31 (Forage Sorghum)
Gujarat		
Entire <i>rabi</i> zone	CSH 15R	CSV 29R, CSV 26R, CSV 18R

Improved cultivation practices of post-rainy sorghum

Preparation of land

One deep ploughing with mold-board plough in summer followed by 3–4 harrowing is recommended to attain good seed bed and to maintain weed free conditions. To improve the water retention, compartmental bunds of 10 m × 10 m in the month of August are recommended to conserve the rain water.

Method and time of sowing

The crop is sown by bullock drawn seed drills with 2 or 3 coulters at 5–7 cm depth in the soil. The seeds are covered by one harrowing after sowing by seed drill. It is also sown by tractor drawn seed drill with 4 coulters with simultaneous covering of seeds by blade attached to the seed drill.

Time of sowing

The optimum sowing time for *rabi* sorghum is 2nd fortnight of September to 1st fortnight of October. In double cropping practice, sowing is extended up to 2nd fortnight of October.

Seed rate spacing and plant population

Seed rate of 8–10 kg/ha or 3 kg/acre is recommended. Spacing between row to row distance of 45 cm and plant to plant of 15 cm is recommended. Plant population in rainfed conditions is 1.35 lakh/ha and in irrigated conditions is 1.50–1.80 lakh/ha. High seed rate @10–12 kg/ha is recommended in case of delayed sowing.

Nutrient management

For rainfed (shallow to medium soil): Apply 40:20:00 kg of NPK per ha as basal dose.

For rainfed (deep soil): Apply 60:30:00 kg of NPK per ha as basal.

For irrigated conditions: Apply 80:40:40 kg of NPK per ha (N in two equal splits, 50% as basal and 50% at 30–35 days after sowing, full P and K at time of sowing is recommended) (Table 2).

Table 2. Recommended fertilizers dose for post-rainy sorghum

	Soil type	Inorganic fertilizer (kg/ha)		
		N	P	K
Rainfed	Shallow	25	-	-
	Medium	40	20	-
	Deep	60	30	-
Irrigated	Medium	80	40	40
	Deep	100	50	50

Nutrients can also be provided through organic sources like, bio-fertilizers and bio-agents by;

- Addition of locally available crop residues @5–10 t/ha in alternate years to build up soil organic matter.
- Regular application of FYM @5 t/ha and vermicompost @2 t/ha gives good yield.
- Seed and soil inoculation with *Azospirillum* or *Azotobacter* helps to save 25–45 kg N/ha.

Insect-pest and disease management

A few insect-pest and diseases attack on sorghum crop. These can be controlled by adopting cultural and chemical practices (Table 3).

Inter-cultivation and weed control

Inter-cultivation 2 or 3 times at 3, 5 and 7 weeks after sowing should be done to check the weed growth, which also helps to conserve soil moisture by providing



CSV 26R



CSV 18R



CSV 29R

Table 3. Pest and diseases identification symptoms and their management practices

	Key identification symptoms	Control measures
<i>Insect pest</i>		
Shoot fly	Occurs in seedling stage, wilting and drying of central leaf appearing as 'dead heart'	Sowing at the end of September to 1 st week October, seed treatment with thiamethoxam 30 FS @3 g/kg and spray of cypermethrin 20 EC (200 ml/ha) or quinalphos 25 EC (400 g a.i./ha) or carbofuran granules (5–7 granules/plant) in leaf whorls during severe damage
Stem borer	Scratches on upper whorl leaving lower surface as transparent windows, dead heart symptoms in young plants due to early attack, peduncle tunnelling forming complete or partial chaffy panicles	Uproot or burn the stubbles and remove stems/stalks to prevent carryover and apply carbofuran 3 G @8–12 kg a.i./ha at 20–35 DAE* in whorls
Shoot bug	Heavy infestation during <i>rabi</i> , when it rains in seedling stage, nymphs and adults suck sap causing yellowing and reduced plant vigour, young leaves start drying extending to older leaves in severe cases or sometimes plant death occurs	Remove alternate host grasses, soil application of dimethoate 0.03% and neem seed kernel suspension 0.04%+soap
Aphids	Adults and nymphs feed leaves and suck the sap at boot stage causing poor panicle exertion, yellowish blotches and necrosis appears during heavy infestation	Application of dimethoate 0.03% and neem seed kernel suspension 0.04%+soap
Fall army worm (FAW)	1 st and 2 nd instar larvae scrape the leaves by skeletonizing upper epidermis, 3 rd instar make ragged edged holes on whorl, 5 th instar larvae starts feeding voraciously with 1–2 larvae in each whorl	Deep ploughing exposes larvae and pupae to sunlight and natural enemies, collect and destroy egg masses/ larvae, deploy pheromone traps @15 traps/acre and erect bird perches @25/ha soon after emergence
<i>Diseases</i>		
Charcoal rot	Softening of stalk at base, premature lodging affecting seed size, grain yield, quality or quantity of fodder	Apply minimal dose of nitrogen, maintain low plant density and mulching with wheat straw as check for disease, and seed treatment with <i>Pseudomonas chlororaphis</i> @10 g/kg seed
Strip virus	Appearance of continuous chlorotic stripes/bands between veins, stunted growth, early infected plants die sooner or later without emergence of ear head, dwarf plant with short internodes and partial exertion of ear head with few or no seeds during late incidence	Avoid sowing in early September and late October, for vector control spray metasystox 35 EC or methyl –S–demeton 35 EC @5 ml/10 litre water at 15 days interval from 20 DAE

top soil mulch. Weed control by application of atrazine @0.5 kg a.i./ha by spraying on the soil as pre-emergence application immediately within 48 hours after sowing is found effective.

Water management

Although sorghum is a drought tolerant crop, it responds well to irrigations and is well suited for limited irrigations. It is also known as water sipping crop as it uses water very efficiently. Water availability to plant largely depends on soil texture. To increase productivity, sorghum crops need between 425 and 610 mm of water. The mature sorghum plant roots can draw moisture from the soil up to a depth of 2 m, although yields are greatest when moisture is present in the top 76 cm of the soil. It can also be grown on residual soil moisture with limited irrigation facilities.

Critical stages for irrigation in sorghum

The period of 40–85 days after sowing during flowering and grain formation stages is very sensitive to moisture stress. The critical growth stages of sorghum in relation to water requirement are mentioned in Table 4. In case, water is available for providing irrigation at all four stages, it would be advantageous. Under irrigated conditions in medium–deep to deep soils, three irrigations first at germination, second at panicle

initiation and third at grain filling stage are desirable. Optimum irrigation schedule consists of five irrigations each at 35, 55, 75, 85 and 105 days after sowing which coincides with physiological stages of panicle, primordial initiation, boot leaf, flowering, milky and dough stages, respectively. In case of limited availability of irrigation water, it can be restricted to one irrigation and should be at flower primordial stage or boot leaf stage depending on the soil moisture situation.

Table 4. Critical growth stages of sorghum

Critical stages	Days after sowing
Initiation of grand growth stage	20–25
Flag-leaf stage or boot stage	50–55
Flowering stage	70–75
Grain-filling stage	90–100

Soil-moisture conservation practices for *rabi* sorghum

- Deep ploughing with mould board plough followed by 3–4 harrowing during summer (May–June) helps to conserve rainwater in deeper soil layers for a longer period.
- Compartmental bunding involves making square or rectangular compartments on the field to retain rain water and to arrest soil erosion in medium deep black soils. After receipt of early rains in June and



Preparation of compartment bunding to conserve monsoon rains



Rainwater stored in compartments



Rainwater stored in ridges

July, land is harrowed to remove the germinating weeds. Then the compartmental bunds (0.15–0.25 m height) are formed using bullock or tractor-drawn bund former. The size of bunds varies from 3 m × 3 m to 4.5 m × 4.5 m depending on the slope. The cost of constructing these bunds is between ₹1500–3000/ha. These bunds are retained till the sowing of *rabi* crop during second fortnight of September to first fortnight of October. Compartmental bunds provide more time for water to infiltrate into the soil and help in conserving soil moisture.

- Ridge and furrow method; in this system, ridges and furrows are formed across the slope by bullock-drawn plough before monsoon. The height of ridges is around 20 cm and width of furrows is 45 cm. The rainwater is stored in furrows and infiltrates into the soil, and help in conserving soil moisture. Besides, opening of furrows in preceding (*kharif*) legumes (cowpea, mungbean, urdbean, soybean) after every 3rd or 4th row by baliram plough conserves soil and moisture, improves drainage, and increases the productivity of *rabi* sorghum.

Comparative to the flat-bed method, *in situ* moisture conservation techniques such as tied ridges and compartment bunding were found to be more effective at preserving higher soil moisture, grain yield and net returns. Application of organic mulch (straw of preceding legume crops) in between rows after 3 weeks of sowing helps in conserving soil moisture by reducing evaporation. Spraying 2% urea at the times of soil moisture stress experienced by crop also helps to overcome moisture stress.

Crop-based cropping system

Rabi sorghum is sown after a fallow period of rainy season (*kharif*) in medium to deep soil where the rainfall frequency is high. However, double cropping of blackgram/greengram/cowpea (fodder) and *rabi* sorghum is recommended wherever found operationally feasible as legumes save about 10–20 kg N/ha. Soybean + *rabi* sorghum sequence cropping is found feasible and profitable in irrigated conditions. Intercropping of sorghum with safflower with 4:2 or 6:3 ratio is recommended on deep soils. As the moisture is a limiting factor during post-rainy sorghum production, intercropping is feasible only in deep soils. Sorghum + chickpea and sorghum + safflower are the important intercropping systems in *rabi* sorghum growing regions of Maharashtra and Karnataka.

Harvesting and threshing

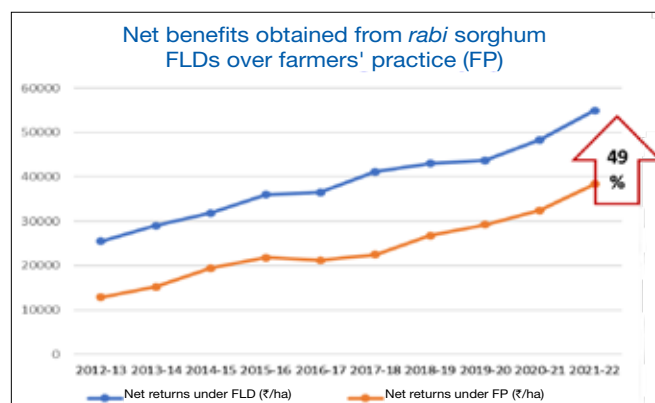
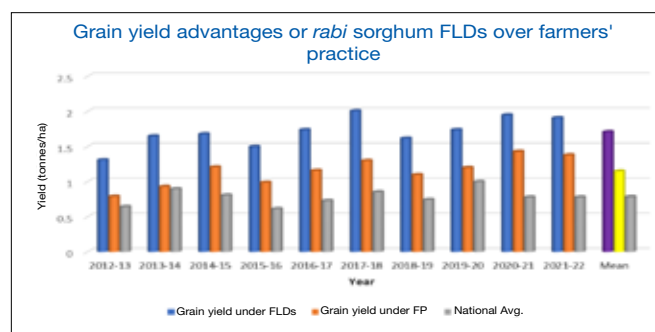
Crop should be harvested at physiological maturity (110–120 days after sowing) depending upon the genotypes duration. The harvested panicles are left in the field for about a week for drying and thereafter the grains are separated from panicles by threshing or manually. The panicles are harvested first and remaining plants later.

Drying and Bagging

After threshing, the grains are sundried for 1–2 days to reduce the moisture content up to 10–12%. Bagging of the grains is done in plastic or gunny bags for immediate marketing.

Performance of the demonstrated technologies in farmer's fields under FLDs

The area under *rabi* sorghum reduced with little extent recently in last decade. However, due to concerted efforts made by the scientists, extension workers, developmental agencies and farmers, average productivity has now increased to 989 kg/ha in 2019–20 from 894 kg/ha in 2007–08 under rainfed conditions. Total 3699 FLDs were organized since last nine years,



Net benefits obtained from *rabi* sorghum FLDs over farmer's practice



Field view of FLDs on *rabi* sorghum at Parbhani

(2012–13 to 2021–22) with improved *rabi* sorghum cultivars, viz. CSV 26R, CSV 29R, CSV 18R, CSV 22R, PKV Kranti, Phule Vasuda, Phule Yashodha, Phule Revati, Phule Chitra and Parbhani Moti, and recommended package of practices in major sorghum growing states Maharashtra, Karnataka and Telangana. They gave 49% more grain yield than the farmer's practice (FP) which was 2–3 times higher than the state average productivity.

The higher yield of the FLDs resulted into same 49% more net returns than the FP.

SUMMARY

At all the locations, the demonstrated improved sorghum production technologies took over the yields and profits of the local varieties. The yield gap of 49% was bridged in grain and obtained same 49% of additional returns by adopting the improved sorghum production technologies, which indicated that sorghum farmers could increase yields and profits by adopting these technologies in their fields. Therefore, the sorghum farmers in different regions should be exposed to latest sorghum technologies to realize its impact by following the improved cultivation practices and timely crop management. Non-trial farmers also need to be exposed to the proven technologies by organizing extension programmes like field day programmes, farmers' day for wide adoption. There is more demand for seeds of the demonstrated varieties from the farmers across the regions.

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HANDBOOK OF INTEGRATED PEST MANAGEMENT

To reverse the loss of environmental resources and also to reduce biodiversity loss, the Government of India has Integrated Pest Management (IPM) as part of the National Agricultural Policy. Integrated Pest Management emphasizes the growth of a health crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM is not new – mechanical, cultural and biological tactics were used by farmers for hundreds of years before chemical pesticides became available. Besides, there are IPM techniques that have been developed more recently and are effective in suppressing pests without adversely affecting the environment.



The task of spreading the message of IPM across is tough due to poor awareness about the subject among people in line-departments as also among the farmers. The information on integrated pest management as a whole is scattered. This *Handbook* comprehensively deals with all the aspects of integrated pest management in field crops, horticultural crops under traditional, protected systems. Information on basic strategies and tactics of different methods of management including mass production of biocontrol agents, IPM policy and pesticide registration is provided in comprehensive form.

The *Handbook of Integrated Pest Management* comprises 82 chapters which are well written in lucid language with crispy sentences by the renowned scientists. The role of IPM is elucidated with different pests like *Trichogramma*, *Bacillus thuringiensis*, *Nomuraea rileyi* etc. and agricultural crops like rice, wheat, maize, sorghum, pearl millet, pulses, soybean, rapeseed mustard, groundnut, minor-oilseed crops, sugarcane, cotton, jute and mesta, potato, vegetable crops, fruits, grapes, citrus, banana, pomegranate, coconut etc. This *Handbook* will provide information of available useful technologies to educate on how to reduce or judiciously use chemical pesticides, safeguard ourselves from chronic poisoning, save the National environment while also reducing input costs and raise farmers' income. This compilation will be useful to teachers, students, trainers, line-department personnel and policy makers.

TECHNICAL SPECIFICATIONS

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