

Sorghum cultivation under non-traditional areas of eastern Indo-Gangetic plains

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Sorghum is a major staple food of millions of rural poor in arid and semi-arid regions of the world. It is the second cheapest source of energy and micronutrients after pearl millet and the majority of the population in central India depends on sorghum for their dietary and energy requirements. Despite its multiple uses as food, feed, fodder and biofuel, area under grain sorghum has drastically declined from 18.5 mha during early 1970s to 4.48 mha in 2019–20. Area under kharif sorghum declined much faster than rabi due to changing food habits, competition from other commercial crops like cotton and soybean, and poor grain quality due to grain mold disease. Under changing climate scenarios, sorghum being a drought-hardy crop will play an important role in food, feed and fodder security of eastern India.

Keywords: Non-traditional areas, Planting window, Sorghum cultivars

GLOBALLY, sorghum production was 62 million tonnes during 2020. USA stands first in total production with 9.4 million tonnes (15%) and India ranks 5th in total sorghum production with 4.7 million tonnes. Global demand for sorghum increased drastically between 2013 and 2015 when China began purchasing US sorghum to use as livestock feed, as a substitute for corn. It helps to meet the needs of their animal feed and fodder, and will continue to be grown by dryland farmers in the foreseeable future. Hence, there is a need to search for new niches for sorghum cultivation. Sorghum is primarily introduced in non-traditional areas of Bihar as an alternative to summer mungbean, as crop diversification approaches during February-March and to utilize the land and water resources, which otherwise will remain unused. In recent years, sorghum cultivation in rice-fallows during the late *rabi* has gained popularity in non-traditional area of Andhra Pradesh due to insufficient water for second crop of rice and the acreage under sorghum

increased from 2000 ha in 2005–06 to >21,000 ha, with an average productivity of 6.5 t/ha. In eastern India, especially in south Bihar, Jharkhand, Chhattisgarh and parts of Odisha, large area remains fallow after *kharif* paddy due to non-availability of sufficient water for second crop. In such areas, sorghum has a great potential for wider expansion. With limited irrigation facilities, it can be a potential alternative to summer mungbean, which suffers badly due to infestation of yellow mosaic virus (YMV). Average productivity of sorghum hybrids, viz. CSH 16 in rice-fallows is very high (>7.0 t/ha). Being a C4 crop, it utilizes high temperature and solar radiation more efficiently. It can be very well fitted in a cropping system with limited irrigation facilities. In the changing climate scenario, sorghum being a drought-hardy crop will play an important role in food, feed and fodder security of eastern India.

Planting window for sorghum cultivation

Sowing date determines the time available for vegetative phase before

onset of flowering, which is mainly influenced by photoperiod. Yield attributes of sorghum cultivars are markedly influenced by sowing environment. Grain and biological yields are significantly higher with timely (3 March) sown crop and respective increase is 16.53%, 23.22% and 20.2% over early (16 February) sowing. Higher seed yield is realized in case of timely sown crop as higher growth and yield attributes. In early sown conditions, plants could not accumulate sufficient photosynthates due to poor vegetative growth. Timely sown crop elucidates a marked improvement in crop productivity and green fodder yield compared to early sown crop (Table 1). Higher yield from timely sowing might be owing to prevailing suitable temperature accompanied by higher soil-moisture content due to sufficient rainfall during April, which enhanced vegetative and reproductive growth. Higher Leaf Area Index (LAI) in timely sown crop resulted in increased production of photosynthates, contributing to higher total dry matter production



Sorghum cultivated under summer condition under non-traditional areas

and its partitioning to reproductive parts. Sorghum hybrid CSH 16 recorded higher grain yield followed by CSH 13 and CSH 14. Among varieties, SPV 462 followed by CSV 27 are promising cultivars for the regions. On a mean basis, hybrids have produced 21.7% higher grain yield over varieties.

Quality of sorghum cultivars under varying planting window

Sorghum is an important crop that can be grown successfully in the summer season during hot and dry environment. Zn and Fe deficiencies are rising public health and socio-economic issues particularly in developing countries like India. Around 5 lakhs children under 5 year die annually due to Zn and Fe deficiency. Sorghum is the second cheapest source of energy after pearl millet and the mass population in central India depends on it for their dietary energy and micronutrient

requirement. Few studies indicate that mineral concentration and bioavailability are limited in cooked grains. Most sorghum growing soils of semi-tropic regions of India are deficient in Zn, Fe and Cu content. Sorghum cultivars vary in nutrient-use efficiency, hence differ in Zn, Fe and Cu contents in grain. Integrating the nutrient enriched cultivars along with optimum sowing time is an economical approach that would increase nutrient utilization by crop.

Sorghum cultivars varied significantly in nutrient contents and uptake (N, P, K, S, Zn, Fe and Cu) in grain except K content. Among 10 tested cultivars of sorghum, viz. 5 hybrids (CSH 13, CSH 14, CSH 16, CSH 25, CSH 30) and 5 varieties (CSV 15, CSV 20, CSV 23, CSV 27, SPV 462), total uptake of N was higher with CSH 13, while total P uptake was the maximum with CSV 27 and K with CSV 23. Total uptake of Zn and Fe is higher with

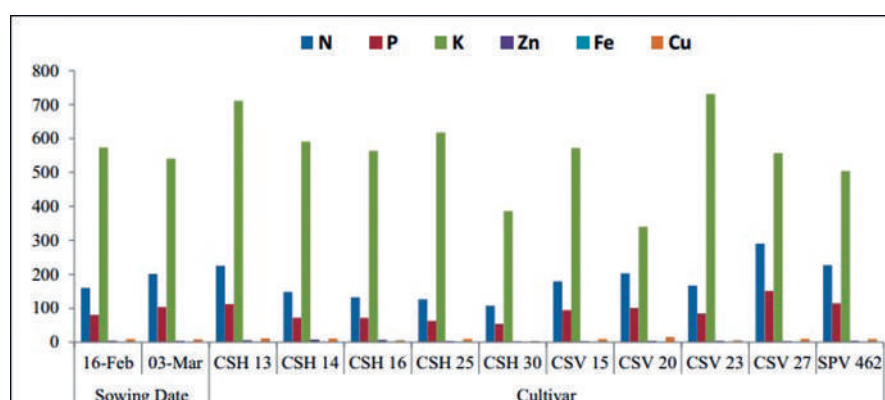
CSH 13, while total uptake of Cu was highest with CSV 20. Thus, use of nutrient efficient cultivars i.e. CSH 13, CSH 16, CSV 27 and SPV 462 with optimum sowing time are necessary to improve nutrient-use efficiency of sorghum. Micronutrient deficiency in human food and animal feed and fodder in rural areas could be addressed by selecting appropriate sorghum cultivars rich in micronutrient (Fe, Zn, Cu) contents in grain as well as in stover.

Thermal response of sorghum cultivars towards planting window

Basically sorghum is a tropical crop and is recommended for dry regions. Sorghum follows a predictable pattern of growth from planting to physiological maturity. Temperature is one of the primary microclimatic factors driving rates of growth. Rate of plant growth and development is dependent upon temperature

Table 1. Agronomical, meteorological and physiological use efficiency of sorghum cultivars under the non-traditional areas

Treatment	Plant height (cm)	LAI	Photosynthetic rate ($\mu\text{mol (CO}_2\text{)}/\text{m}^2/\text{s}$)	Transpiration rate [$\text{mmol (H}_2\text{O)}/\text{m}^2/\text{s}$]	Stomatal conductance [$\text{mol (H}_2\text{O)}/\text{m}^2/\text{s}$]	GDD at maturity ($^{\circ}\text{C days}$)	HUE ($\text{kg/ha } ^{\circ}\text{C day}$)		Grain yield	Biological yield (t/ha)
							Grain yield	Biological yield (t/ha)		
<i>Sowing date</i>										
16 Feb.	185.3	5.1	25.27	2.08	0.31	1934.6	1.93	11.60	3.69	20.93
03 March	215.1	7.1	29.98	2.78	0.53	1980.5	2.29	12.67	4.30	25.15
<i>Cultivars</i>										
CSH 13	230.1	7.9	28.07	2.98	0.264	1962.5	2.55	14.27	4.93	27.59
CSH 14	207.8	6.0	27.07	2.22	0.249	1940.3	2.31	12.48	4.45	23.01
CSH 16	193.2	6.2	28.78	2.14	0.552	1911.1	2.86	11.11	5.51	21.35
CSH 25	194.7	6.8	27.73	3.11	0.189	1890.8	2.19	11.68	4.13	21.30
CSH 30	177.1	4.1	26.18	1.63	0.475	1857.1	1.54	8.21	2.91	15.47
CSV 15	198.7	6.6	27.02	2.27	0.572	1901.3	1.91	10.97	3.57	22.54
CSV 20	198.3	6.8	27.18	2.52	0.579	1830.5	1.81	10.34	3.53	18.19
CSV 23	208.5	6.0	29.65	2.02	0.621	1881.8	1.68	15.82	3.25	30.33
CSV 27	185.6	5.4	25.43	2.81	0.181	2009.6	2.11	13.79	3.82	27.82
CSV 462	217.7	5.4	29.12	2.60	0.539	2175.1	1.94	12.16	3.89	22.77



Nutrient uptake (kg/ha) by sorghum cultivars under non-traditional areas

surrounding the plant and each species has a specific temperature range. Days required for sorghum cultivars to reach its maturity depend primarily upon the location, date of planting and temperature. Due to variations in daily minimum and maximum temperature from year to year and between locations, number of days from planting to physiological maturity vary accordingly. Meteorological indices, viz. growing degree days (GDD), heliothermal unit (HTU), and photo-thermal unit (PTU) based on air temperature are used to describe changes in phenological behavior and growth. Temperature based indices provide a reliable prediction for better crop yield. Changes in temperature during phenophases of

crops adversely affect economic yield. It is thus indispensable to have knowledge of exact duration of phenophases in a particular environment and their association with yield attributes for achieving higher yield.

Growing degree days (GDDs) and heliothermal unit (HTU) reduced significantly in early sowing. Sorghum cultivars SPV 462 and CSH 13 accumulated markedly higher GDDs and HTUs. Sorghum hybrid CSH 16 showed better performance of heat use efficiency (HUE) and helio-thermal use efficiency followed by CSH 13 and SPV 462. Varieties giving higher yield and HUE are identified in varying growing environments, so as to suggest appropriate sowing time

of sorghum cultivars in middle IGP.

SUMMARY

Traditionally, sorghum is a staple diet for rural and lower-income, semi-urban households in India. However, with Green Revolution production gains and food security programs subsidized rice and wheat, other coarse grains are being replaced in food baskets. However, there is increased consumption of sorghum among a small population of health conscious, urban consumers seeking to incorporate high-fiber and nutrient rich grains into their diets. Sorghum in eastern India could be grown successfully during summer i.e. second fortnight of February to first week of March. Grain sorghum hybrid CSH 13 (timely sown) gave maximum grain yield, whereas CSH 14 yielded higher when sown on 16 February. Hence, selections of micro-nutrient enriched genotypes (CSH 16, CSV15, SPV 462) with proper sowing time not only helps in improving nutrient use efficiency, but would also help in addressing the problem of hidden hunger in rural areas.

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