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Research Paper

Production potential of improved grain sorghum cultivars (*Sorghum bicolor*) under staggered plantings in non-traditional areas of Eastern India

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ABSTRACT

Performance of 10 grain sorghum [*Sorghum bicolor* (L.) Moench] cultivars, viz. (5 hybrids, ('CSH 13', 'CSH 14', 'CSH 16', 'CSH 25' and 'CSH 30') and 5 varieties, viz. ('CSV 15', 'CSV 20', 'CSV 23', 'CSV 27' and 'SPV 462') was evaluated under 2 sowing dates (16 February and 3 March) at the ICAR Research Complex for Eastern Region, Patna during summer seasons of 2015 and 2016, to find out the possibility of grain sorghum cultivation in non-traditional area of Eastern India. The crop sown on 3 March gave significantly higher grain (4.30 t/ha) and stover (21.23 t/ha) yields, net returns (₹ 38.4 × 10^3/ha), benefit: cost ratio (2.22) and economic efficiency (₹376/ha/day) than that sown on 16 February sowing. Sorghum hybrids gave 22% higher grain yield than varieties. Among the hybrids, 'CSH 16' recorded significantly higher grain yield (5.51 t/ha) and profits followed by 'CSH 13' (4.93 t/ha) and 'CSH 14' (4.45 t/ha); and among the varieties, 'SPV 462' (3.89 t/ha) and 'CSV 27' (3.82 t/ha) were found promising. Sorghum hybrid 'CSH 13' sown on 3 March gave the maximum grain yield (5.86 t/ha), whereas 'CSH 14' yielded higher (5.04 t/ha) when sown on 16 February. However, the grain yield of 'CSH 16' (5.43–5.59 t/ha) was not much affected by variation in sowing dates.

Key words: Economics, Grain yield, Sorghum cultivars, Sowing dates, Yield attributes

Sorghum is the 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 pearlmillet, and majority of population in the central India depends on sorghum for their dietary and energy requirements (Parthasarathy Rao *et al*., 2006). Because of its drought adaptation capability, sorghum is a preferred crop in tropical, warmer and semi-arid regions of the world with high temperature and water-stress conditions. In India, the crop is grown in both rainy (June–October) and post-rainy (November–February) seasons. In spite of its multiple uses as food, feed, fodder and bio-fuel, the area under grain sorghum has drastically declined from 18.5 m ha during early 1970s to 5.82 m ha in 2013–14 (ASG, 2014). The area under the rainy (*kharif*) sorghum declined much faster than the winter (*rabi*) due to changing food habits, competition from other commercial crops like cotton and soybean, and poor grain quality due to grain mold disease, etc. Hence there is a need to search for new niches for sorghum cultivation.

In recent years, sorghum cultivation in rice-fallows during late-*rabi* has gained popularity in non-traditional area of Andhra Pradesh due to insufficient water for second crop of rice, and the area under sorghum has increased from 2000 ha in 2005–06 to >21,000 ha, with an average productivity of 6.5 t/ha (Mishra *et al*., 2012). 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 potential for expansion. With limited irrigation facilities, it can be a potential alternative to summer mungbean, which suffers badly due to infestation of yellow mosaic virus (YMVs). The average productivity of some of the sorghum hybrids, viz. 'CSH 16' in rice-fallows is very high (>7.0 t/ha) (Mishra *et al.,* 2013). Being a C_4 crop, it utilizes high temperature and solar radiation more efficiently. It can be very well fitted in cropping system with limited irrigation facilities. Under changing climate scenario, sorghum being a drought-hardy crop will play an important role in food, feed and fodder security of the eastern India.

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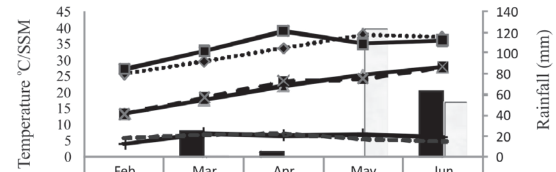
Sowing time is one of the major inputs affecting growth and crop yield. It affects duration of vegetative, reproductive and maturity period of crop. Optimum planting time of sorghum may vary from one variety to another and from a region to another because of variation of agro-ecological conditions. Sowing date ensures complete harmony between vegetative and reproductive phase, on 1 hand, and climatic rhythm, on the other, and helps in realizing potential yield. However, cultivation of short-duration sorghum genotypes during summer is more rewarding owing to congenial conditions, i.e. free from natural vagaries, incidence of insect-pest and diseases. Sorghum genotypes vary significantly for various root characteristics, which may affect production potential (Seetharama *et al*., 1990). Hence there is need to find out an optimum sowing time and varieties that can fit well during summer, so that it could be safely harvested before onset of monsoon.

MATERIALS AND METHODS

The field experiment was conducted at the ICAR Research Complex for Eastern Region, Patna (25°30‘N, 85°15‘E, 52 m above mean sea-level) during the summer seasons of 2015 and 2016. The soil of experimental field (0–15 cm) was clay loam (23.36% sand, 39.64% silt and 37% clay), low in organic carbon (0.47%), nitrogen (213 kg N/ha) and medium in available phosphorus (19.7 kg P/ha) and high in available potassium (436 kg K/ha) and neutral in soil reaction (*p*H 7.43). The bulk density of experimental field was 1.46 g/cm³. The total precipitation recorded during the crop-growing season was 92.2 and 181.6 mm in 2015 and 2016, respectively. Mean annual rainfall (February to June) during 2015 and 2016 was 136.9 mm, which was 71.2 mm less than the long-term normal rainfall (208.1 mm). In the first year, the amount of precipitation was unequally distributed and fluctuated variably high during crop-growing period as compared to the second year, where equal distribution of precipitation occurred. Mean monthly maximum and minimum temperature varied from 39.01 to 22.75°C and 27.86 to 13.29°C, respectively (Fig. 1). Treatments consisting of 2 sowing dates (16 February and 3 March) in main plot and 10 grain sorghum cultivars including 5 hybrids and 5 inbred (open-pollinated varieties) (Table 1) as subplot were replicated thrice in a splitplot design. The sowing was done manually in rows (45 cm × 15 cm) at 4–6 cm depth. To control the initial flushes of weeds, atrazine @ 0.50 kg/ha was applied as pre-emergence with 500 *l*/ha water with the help of knap-sack sprayer fitted with flat-fan nozzle. Hand-hoeing was done at 25 days after sowing (DAS) and intra-row weeds were removed by hand-weeding. Detillering was done manually at 35 DAS by removing extra shoots from the mother plants. Fertilizer dose of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha was applied as recommended for grain sorghum. Phosphorus as diammonium phosphate (DAP) and potassium as muriate of potash (MoP) were applied basal on day of planting. Nitrogen as urea was applied in 2 splits, 50% at sowing as basal application and remaining at 35 DAS. Three irrigations were given during cropping period as per critical stages of crops. Furadan 3G (@ 20 kg/ha was applied in furrows at the planting to control shootfly (*Atherigona soccata*). Five randomly selected plants from each plot was taken at harvesting for growth and yield attributes such as plant height, green leaves/plant, nodes/plant, stem girth, leaf area and leaf area-index (LAI), leaf dry weight, shoot dry weight, total dry-matter production, panicle length, panicle/m², panicle weight, grains/panicle (no.) and 1,000-grain weight with following standards procedures. Total root mass of 3 plants at flowering stages was dipped in water kept in a measuring cylinder for recording root volume by displacement of water method with help of thin thread. The displaced water (cc) was recorded to represent the volume of root. Gross returns were calculated on the basis of the minimum support price (MSP) declared by the Government of India for the rainy-season grain sorghum (₹16,250/Mg). Net income was calculated as difference between gross returns and total cost of cultivation. Benefit: cost ratio was worked out by dividing gross returns with a total cost of cultivation. Data were analyzed with analysis of variance (ANOVA) as suggested by Gomez and Gomez (1984). Treatments were compared by computing the F-test. The significant differences between treatments were compared by critical difference at the 5% level of probability.



	Feb	Mar	Apr	May	Jun
2015 Rainfall	0.00	24.50	5.00	0.00	62.70
2016 Rainfall	0.00	3.10	0.00	124.80	53.70
2015 Tmax	25.75	29.59	33.60	37.88	37.04
2016 Tmax	27.26	32.69	39.06	35.10	36.13
2015 Tmin	13.29	17.59	21.96	25.54	27.81
2016 Tmin	13.36	18.31	23.45	24.21	27.86
2015 SSH	3.94	7.30	6.56	7.06	6.01
2016 SSH	5.61	6.86	7.05	5.32	4.66

Fig. 1. Weather data during crop season 2015 and 2016

RESULTS AND DISCUSSION

Growth attributes

All the growth attributes of sorghum genotypes were markedly influenced with sowing date (Table 2). Initial plant stand of sorghum cultivars recorded at 15 DAS did

Table 1. Characteristics of the grain sorghum cultivars used for the trials during 2015 and 2016

Cultivar	Pedigree	Year of release and place	Plant height (cm)	Days to 50% flowering	Maturity duration (days)	Average grain yield (t/ha)	Season
Hybrid							
'CSH 13'	296A × RS 29	1991, IIMR, Hyderabad	165–185 (medium)	70-75	110-115	3.5–4.0	Both *Kharif* and *Rabi*
'CSH 14'	AKMS 14A × AKR 150	1992, PDKV, Akola	180–200 (medium)	65-67	100–105	3.8–4.0	*Kharif*
'CSH 16'	27 A × C 43	1997, IIMR, Hyderabad	190–210 (medium)	68-72	110–115	4.0–4.5	*Kharif*
'CSH 25'	PMS 28A × C 43	2007, VNMAU, Parbhani	170–190 (medium)	68-75	110–115	4.0–4.5	*Kharif*
'CSH 30'	415A × CB 33	2013, IIMR , Hyderabad	170–180 (medium)	65-72	100–105	4.0–4.5	*Kharif*
Inbred (Variety)							
'CSV 15'	SPV475 × SPV462	1996, IIMR , Hyderabad	240–260 (tall)	69-70	110–115	3.5–3.8	*Kharif*
'CSV 20'	SPV946 × Kh 89-246	2006, IIMR , Hyderabad	250–270 (tall)	70-72	105–110	3.1–3.2	*Kharif*
'CSV 23'	SPV 861 × SU 248	2007, MPUAT, Udaipur	230–250 (tall)	70-72	110–115	2.5–3.0	*Kharif*
'CSV 27'	(GJ 38 × INDORE 12)-2-1-2-1	2012, IIMR , Hyderabad	230–250 (tall)	70-75	115–120	2.8–3.0	*Kharif*
'SPV 462'	(IS 2947 × SPV 232) × 1022	1986, RARS, Palem	235–250 (tall)	70-73	112–115	3.0–3.2	*Kharif*

IIMR, Indian Institute of Millets Research; PDKV, Panjabrao Deshmukh Krishi Vidyapeeth; MPUAT, Maharana Pratap University of Agriculture and Technology; VNMAU, Vasantrao Naik *Marathwada Agricultural University*

not differ significantly with respect of sowing date. However, it was found in the order of 3 March >16 February sowings. The growth characters, viz. plant height, number of green leaves, nodes/plant, stem girth, leaf area, leaf-area index (LAI), leaf dry weight, shoot dry weight and total dry matter production were found to be significantly higher with 3 March sown crop compared to 16 February sowing. The crop sown on 3 March recorded 39% higher dry-matter production than that sown on 16 February (Fig. 2). This might be owing to better growing conditions such as temperature, light, humidity and rainfall to fully exploit genetic potentiality of crop (Bahar *et al*., 2015). Sowing date determines time available for vegetative phase before onset of flowering, which is mainly influenced by photoperiod. The growth duration although has not affected elongation but was reflected in other attributes like green leaves/plant (Kumar *et al.*, 2009). However, root parameters like root length, root dry weight and root volume were significantly influenced with different date of sowing (Table 3). All these attributes were recorded markedly higher with 3 March sown crop as compared to 16 February sown crop. This was probably owing to better growth environment caused by moderate temperature and better soil-moisture regimes with the respective treatment. The 16 February sown crop significantly reduced the number of days required for 50% flowering (64) as compared to 3 March sown crop (72.8), but reverse trend was observed in case of days to maturity. This might be due to fact that sowing time determines time available for vegetative phase before onset of flowering, which is mainly influenced by the photoperiod.

Plant population was markedly influenced with sorghum genotypes (Table 2). Initial plant stand was noted markedly higher with varieties as compared to hybrids.

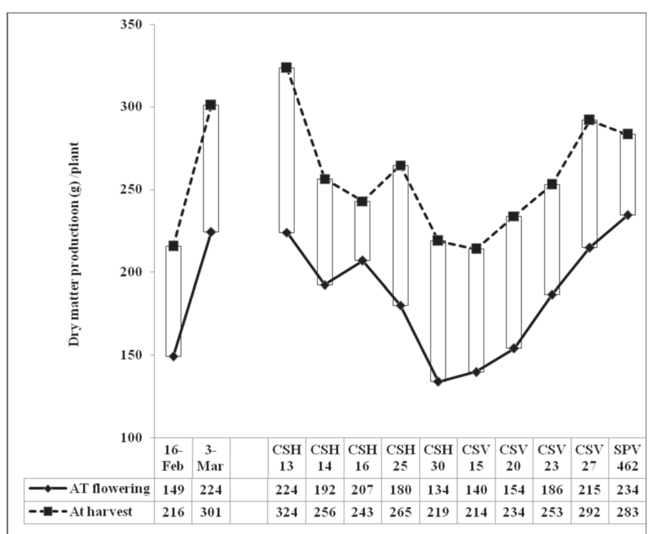


Fig. 2. Dry-matter production of sorghum cultivars as influenced by staggered planting (pooled data of 2 years)

Table 2. Growth attributes of sorghum cultivars as influenced by staggered planting (pooled data of 2 years)

Treatment	Initial plant population (×10³/ha)at	Plant height (cm)		Green leaves/ plant* (no.)	Nodes/ plant* (no.)	Stem girth/ plant* (cm)	Leaf area/ plant* (cm²)	Leaf area index*	Leaf dry weight (g)/ plant at		Shoot dry weight (g)/ plant at	
		Flowering	Harvest						Flowering	Harvesting	Flowering	Harvesting
Sowing date												
16 February	176.6	174.5	185.3	7.5	9.7	7.9	4,918	5.1	28.1	33.4	120.9	182.1
03 March	177.6	203.9	215.1	10.6	11.2	9.1	6,857	7.1	38.3	43.7	86.0	257.1
SEm±	0.58	2.1	1.4	0.1	0.1	0.1	177	0.2	0.5	0.59	7.9	3.6
CD (P=0.05)	NS	6.1	3.9	0.4	0.4	0.4	507	0.5	1.3	1.69	22.7	10.4
Cultivar												
'CSH 13'	156.6	235.2	230.1	10.2	11.9	8.8	7,587	7.9	35.4	39.7	188.6	283.8
'CSH 14'	171.6	179.3	207.8	8.5	9.8	8.8	5,790	6.0	30.1	33.7	162.2	222.7
'CSH 16'	171.6	178.6	193.2	9.8	9.9	9.3	5,945	6.2	34.5	37.1	172.3	205.6
'CSH 25'	176.6	176.8	194.7	9.8	12.1	8.5	6,549	6.8	35.8	38.2	144.2	226.4
'CSH 30'	166.6	170.2	177.1	7.0	8.3	7.0	3,947	4.1	25.8	28.8	108.1	190.1
'CSV 15'	181.6	186.4	198.7	9.0	10.4	8.9	6,331	6.6	26.4	29.7	113.3	184.1
'CSV 20'	178.3	192.3	198.3	9.3	11.2	8.8	6,522	6.8	27.9	29.6	126.1	204.2
'CSV 23'	188.3	196.4	208.8	9.4	10.2	8.5	5,783	6.0	32.7	43.4	153.8	209.4
'CSV 27'	190.0	195.8	185.6	8.8	10.2	8.0	5,177	5.4	39.3	51.0	175.5	240.9
'SPV 462'	195.0	180.8	217.7	8.7	10.4	8.4	5,241	5.4	44.5	54.7	190.0	228.6
SEm±	0.89	3.2	2.1	0.2	0.2	0.2	271	0.3	0.7	0.90	12.1	5.5
CD (P=0.05)	2.57	9.3	6.0	0.6	0.6	0.6	775	0.8	2.1	2.58	34.6	15.8

*At flowering stage

Among the hybrids 'CSH 25' (176.6×10³/ha) recorded significantly higher plant population as compared to rest of the hybrids. In varieties, significantly maximum number of plants were associated with 'SPV 462' (195 × 10³/ha), which was found to be significantly superior to rest of the verities and hybrids. This might be owing to better germination and withstanding ability of the respective genotypes, which further helps them for better survival in existing conditions. Plant height recorded at harvesting differed significantly among the genotypes and ranged from 177.1 cm with 'CSH 30' to 230.1cm with 'CSH 13'. The mean plant height of hybrids (200 cm) was lower than that of varieties (202 cm). Among the sorghum cultivars, green leaves/plant differed significantly and ranged from 7.04 with 'CSH 30' to 10.2 with 'CSH 13' among the hybrids, and 8.6 to 9.4 among varieties. Significantly maximum number of nodes/plant was recorded with 'CSH 25', which was found to be at par with 'CSH 13'. In case of varieties, 'CSV 20' recorded significantly higher nodes/plant. The stem girth was found to be significantly higher with 'CSH 16' amongst all the hybrids and varieties but it was at par with 'CSH 13', 'CSH 14', 'CSV 15' and 'CSV 20'. Significantly higher leaf area/plant was noted with 'CSH 13'. The lowest values of leaf area was associated with 'CSH 30' because of the lowest number of green leaves/plant. Similar trend was followed in case of LAI, where 'CSH 13' had significantly higher LAI. Differences in growth of sorghum genotypes might be attributed to variations in their genetic constitutions. These results corroborate the findings of Rana *et al*. (2009). Significantly higher leaf dry weight/plant and shoot dry weight/plant at harvesting were associated with 'CSH 13'. The lowest values of these parameters were recorded with 'CSV 15'. Salunke *et al.* (2003) reported that genotypes those were drought tolerant produced higher dry matter in medium black soils of Parbhani, Maharashtra, India. Significantly longer roots (45.5 cm) were produced by 'CSH 13' which was on a par with 'CSV 27'. Days to 50% flowering and days to maturity differed significantly among the sorghum cultivars. In general, varieties flowered earlier than hybrids. The reverse trend was followed in case of maturity where, hybrids took lesser duration (100–102 days) as compared to varieties (100–109 days). Rao *et al*. (2013) also reported variation in phonology of sorghum cultivars.

Yield attributes and yield

The yield attributes of sorghum genotypes markedly influenced with sowing time (Table 3). Panicle length, panicle weight and grains/panicle were significantly higher with 3 March sowing as compared to 16 February sown crop. However, different sowing dates did not influence panicle/m^2 and 1,000-seed weight. Grain, stover and biological yields were significantly higher with 3 March sown crop and the respective increase was 16.53, 23.22 and 20.2% over 16 February sowing. Higher seed yield realized in case of 3 March sown crop because of higher growth and yield attributes (Table 4). Yield attributes like dry-matter production, panicle length, panicle weight and grains/panicle were associated with stronger sink. Under early-sown conditions of 16 February, however plants could not accumulate sufficient photosynthates due to poor vegetative growth. Azrag and Dagash (2015) reported that sowing date had greater effect on yield than the cultivar. This might be owing to increase of leaf area, better growth period, length of head, greater head and increase weight of seeds/plant. It is quite evident from data (Table 3) that 3 March sown crop elucidated a mark improvement in crop productivity, green fodder yield, green-fodder productivity and dry-fodder yield as compared to 16 February sown crop. Sowing on 3 March significantly increased crop productivity, green fodder yield, green-fodder productivity and dry-fodder yield to the tune of 17.9, 31.1, 37.1 and 18.3%, respectively, over 16 February sowing. The higher yields obtained from 3 March sowing might be owing to suitable temperature prevailing accompanied by higher soil-moisture content due to sufficient rainfall in April, which enhanced vegetative and reproductive growth of crop. Similarly, higher values of LAI in 3 March sown crop resulted in increased production of photosynthates, contributing to higher total dry-matter production and its partitioning to reproductive parts (Bahar *et al*., 2015).

Yield attributes, viz. panicle length, grains/panicle, panicles/m^2 and 1,000-grain weight, differed significantly among the sorghum cultivars. Among the sorghum hybrids 'CSH 25', and among the varieties 'SPV 462' produced the longest panicles. Hybrids produced more grains/panicle (2,946–3,156) and bolder seeds (1,000-grain weight 23.0–27.8 g) than the varieties (2,815–3,033 and 20.5–26.2 g respectively). On mean basis, hybrids produced 4.3% more grains and 8.87% higher 1,000-grain weight over the varieties. Sorghum hybrid 'CSH 16' recorded significantly higher grain yield followed by 'CSH 13' and 'CSH 14' (Table 5). Among the varieties, 'SPV 462' followed by 'CSV 27' was promising. On mean basis, hybrids produced 21.7% higher grain yield over the varieties. The similar trend was followed in case of grain productivity also. However, mean stover yield was higher with varieties as compared to hybrids. On mean basis,

Table 3. Root parameters and yield attributes of sorghum cultivars as influenced by staggered planting (pooled data of 2 years)

Treatment	Root length/ plant* (cm)	Root dry weight/ plant* (g)	Root volume/ plant*(cc)	Days to 50% flowering	Days to maturity	Panicle length/ plant (cm)	Panicle (no./m^2)	Panicle weight/plant (g)	Grains/ panicle (no.)	1,000-grain weight (g)
Sowing date										
16 February	35.8	19.4	55.2	64.0	103.3	32.2	16.0	88	2,912	24.4
03 March	37.7	23.8	58.9	72.8	102.3	34.5	16.3	101	3,103	25.3
SEm±	0.4	0.3	0.59	0.4	0.43	0.4	0.3	3	66	0.6
CD (P=0.05)	1.2	0.7	1.7	1.1	NS	1.0	NS	10	189	NS
Cultivar										
'CSH 13'	45.5	18.7	54.3	74.3	102.5	33.9	17.3	113	3,156	27.5
'CSH 14'	34.8	14.0	55.5	71.7	100.8	30.1	16.7	86	3,052	25.4
'CSH 16'	24.3	10.2	55.6	71.0	102.5	38.1	16.0	108	3,084	24.2
'CSH 25'	32.8	25.4	56.2	68.8	101.7	40.8	16.5	103	2,946	27.8
'CSH 30'	39.0	12.7	57.5	70.5	100.3	38.6	18.2	82	3,114	23.1
'CSV 15'	34.5	19.1	57.8	64.8	100.3	29.8	15.7	82	2,815	24.2
'CSV 20'	36.8	19.1	58.0	60.7	101.5	29.8	15.8	90	3,033	24.5
'CSV 23'	32.0	22.6	58.3	62.8	102.3	30.2	16.8	70	2,881	25.2
'CSV 27'	45.3	39.9	58.5	70.5	109.5	29.7	14.8	107	2,977	20.5
'SPV 462'	42.5	34.2	58.8	69.0	106.5	32.7	13.8	98	3,013	26.2
SEm±	0.6	0.4	0.9	0.6	0.7	0.5	0.4	6	101	0.9
CD (P=0.05)	1.8	1.1	2.6	1.7	1.9	1.6	1.3	16	NS	2.7

*At flowering stage

varieties produced 21.61% higher stover yield than the hybrids. The similar trend was followed in case of biological yield. The mean harvest index (HI) was recorded significantly higher in hybrids than the varieties. The higher HI in sorghum hybrid 'CSH 16' showed that this genotype was more efficient in converting biological yield into economic yield (Kusalkar *et al*. 2003).With respect to crop productivity; sorghum genotypes 'CSH 16' recorded significantly higher grain productivity. Significantly higher green-fodder yield was recorded with 'CSV 27' as compared to rest of the genotypes. Further, higher green fodder productivity and dry-fodder yield was recorded with 'CSV 23'. This might be owing to more growth attributes like more plant population, number of green leaves, dry matter and leaf area were recorded more with the respective treatments (Kumar *et al*., 2015).

Economics

The economic parameters for sorghum were calculated and presented in Table 4. The maximum gross returns, net returns and benefit: cost ratio were obtained when the crop was sown on 3 March. Consequently, 3 March sown crop gave significantly higher economic efficiency. This was because of the higher productivity with favourable environmental conditions was associated with the respective treatments. Among the sorghum cultivars, hybrids were more economical than the varieties except 'CSH 30'. Sorghum hybrids 'CSH 16' recorded significantly higher gross returns, net returns, benefit: cost ratio and economic efficiency over rest of the genotypes. Similar findings were reported by Mishra *et al.* (2015) in grain sorghum cultivars.

Interaction effects

Significant interaction effect was observed between sowing dates and sorghum cultivars for grain yield (Table 5). On pooled basis, the highest grain yield (5.86 t/ha) was recorded with 'CSH 13' sown on 3 March. Sorghum hybrids, viz. 'CSH 13', 'CSH 25', 'CSH 30', and varieties,

Table 5. Interaction effect of sowing date with cultivar on grain yield of sorghum (t/ha)

Cultivar	Sowing date		
	16 February	3 March	Mean
'CSH 13'	4.00	5.86	4.93
'CSH 14'	5.04	3.87	4.45
'CSH 16'	5.43	5.59	5.51
'CSH 25'	3.67	4.59	4.13
'CSH 30'	2.14	3.68	2.91
'CSV 15'	3.54	3.61	3.57
'CSV 20'	2.85	4.15	3.50
'CSV 23'	2.33	4.16	3.25
'CSV 27'	3.80	3.84	3.82
'SPV 462'	3.80	3.98	3.89
Mean	3.69	4.30	4.00
	Sowing date (D)	Cultivar (C)	D x C
SEm±	0.11	0.17	0.29
CD (P=0.05)	0.31	0.47	0.82

Table 4. Yields and economics of sorghum cultivars as influenced by staggered planting (pooled data of 2 years)

Treatment	Yield (t/ha)			Harvest index (%)	Grain productivity (kg/ha/day)	Green-fodder yield (t/ha)	Green-fodder productivity (kg/ha/day)	Gross returns (×10³ ₹/ha)	Net returns (×10³ ₹/ha)	Benefit: cost ratio	Economic efficiency (₹/ha/day)
	Grain	Stover	Biological								
Sowing date											
16 February	3.69	17.23	20.93	18.10	35.7	53.3	515.2	60.1	28.6	1.91	276
03 March	4.30	21.23	25.15	17.57	42.1	72.5	706.4	69.9	38.4	2.22	376
SEm±	0.11	0.27	0.30	0.45	1.1	0.7	7.60	1.8	1.4	0.06	14
CD (P=0.05)	0.31	0.77	0.86	NS	3.1	2.1	21.75	5.1	4.0	0.16	40
Cultivar											
'CSH 13'	4.93	22.66	27.59	17.75	48.2	73.8	722.7	80.1	48.6	2.55	476
'CSH 14'	4.45	18.56	23.01	20.15	44.1	60.1	597.6	72.4	40.9	2.30	405
'CSH 16'	5.51	15.84	21.35	25.83	53.8	53.5	521.8	89.6	58.1	2.85	568
'CSH 25'	4.13	17.17	21.30	19.54	40.6	57.3	564.5	67.1	35.7	2.13	351
'CSH 30'	2.91	12.56	15.47	18.52	29.0	49.7	495.4	47.3	15.9	1.51	158
'CSV 15'	3.57	18.97	22.54	16.75	35.5	58.8	586.3	58.1	26.7	1.85	265
'CSV 20'	3.50	14.69	18.19	18.99	34.6	48.3	476.2	56.9	25.4	1.81	251
'CSV 23'	3.25	27.09	30.33	10.56	31.7	74.5	729.9	52.8	21.3	1.68	209
'CSV 27'	3.82	24.00	27.82	13.75	34.8	78.2	714.7	62.0	30.6	1.97	279
'SPV 462'	3.89	20.79	22.77	16.49	36.6	74.8	698.9	63.2	31.8	2.01	298
SEm±	0.17	0.41	0.46	0.68	1.7	1.1	11.6	2.7	2.1	0.09	21
CD (P=0.05)	0.47	1.17	1.31	1.96	4.8	3.2	33.22	7.7	6.1	0.25	60

viz. 'CSV 20' and 'CSV 23' gave significantly higher yield when sown on 3 March as compared to the crop sown on 16 February. However, 'CSH 14' gave significantly higher yield when sown on 16 February as compared to 3 March. Some of the cultivars, viz. 'CSH 16', 'CSV 27', 'CSV 15' and 'SPV 462' were least affected due to variation in sowing dates. Sorghum hybrid 'CSH 16' gave the higher grain yield (5.43–5.59 t/ha) under both the sowing dates.

It may be concluded that sorghum in Eastern India could be grown successfully during summer. It may be sown during the second fortnight of February to the first week of March depending on the cultivars. Grain sorghum hybrid 'CSH 13' sown on 3 March gave the maximum grain yield (5.86 t/ha), whereas 'CSH 14' yielded higher (5.04 t/ha) when sown on 16 February. However, 'CSH 16' (5.43–5.59 t/ha) was not much affected by variation in sowing dates.

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