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Effect of sowing dates on growth, yield and economics of sorghum (*Sorghum bicolor* L. Moench) genotypes

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Abstract
A field experiment was conducted during *kharif* seasons of 2014, 2015 and 2016 at Main Sorghum Research Station, Navsari Agricultural University, Surat, Gujarat to investigate the appropriate sowing date for growth and yield of sorghum (*Sorghum bicolor* L. Moench) cultivars under rainfed condition. Sixteen treatment combinations were evaluated in factorial randomized block design with three replications. Treatments were comprised of four sowing dates *i.e.* D_1: Onset of monsoon, D_2: 15 days after first date of sowing, D_3: 30 days after first date of sowing, D_4: 45 days after first date of sowing. Four sorghum genotypes *i.e.* V_1: GJ 38, V_2: GJ 42, V_3: SR 2872 and V_4: SR 1904 was tested. The results showed that sowing of sorghum genotype SR 2872 at the time of onset of monsoon significantly enhanced plant growth and growth attributes. Sowing at the time of onset of monsoon gave higher grain (3253 kg/ha) and stover (11471 kg/ha) yield. Genotype SR 2872 recorded highest grain yield (2406 kg/ha) and stover yield (9299 kg/ha).

Keywords: Sowing dates, *kharif* sorghum, sorghum genotypes and grain yield

Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] is an important food crop in India and it is cultivated in tropical and subtropical climates, especially in the semi-arid tropics. It is the fifth most important cereal crop followed by rice, wheat, maize and barley in the world. In India, sorghum is extensively produced and both hybrid and improved varieties of sorghum are taken on large scale. Andhra Pradesh, Madhya Pradesh, Gujarat and Rajasthan are the sorghum producing states. India is the third largest producer in the world. Among the cereals in India, sorghum ranks third, next to rice and wheat. The area under this crop in India is about 5.79 million hectares with an annual production of 5.54 million tonnes with a productivity of 957 kg/ha. In Gujarat, it occupied an area of about 1.28 lakh hectares with an annual production of 1.75 lakh tonnes with a productivity of 1367 kg/ha during 2013-14 (Anonymous, 2015).In Gujarat Dryland farming is the backbone of Indian agriculture, as large areas of cultivated land are rainfed. The success or failure of rainfed crops depends mostly on the pattern of monsoon rains. The distribution of rainfall in monsoon decides the yield of rainfed crops. A major problem of rain-fed agriculture in semi-arid regions with short rainy seasons is how to determine the optimum sowing date. Previous work has however not evaluated the effect of planting dates on performance of these improved varieties. Date of planting directly affects the length of the growing season; varieties of different maturity groups will correspondingly be affected. The current study was therefore undertaken to determine the effect of planting date on sorghum genotypes. To mitigate these losses of *kharif* sorghum, a field experiment was conducted to find out the suitable sowing date for sustainable yield of rainfed *kharif* sorghum under erratic behavior of monsoon.

Materials and Methods
The present investigation was conducted at Main Sorghum Research Station, Navsari Agricultural University, Surat during *kharif* seasons of the year 2014, 2015 and 2016 under south Gujarat agro climatic zone - II. Main Sorghum Research Station is located on southern part of Gujarat state and geographically located 20º-12' N latitude and 72º-52' E longitude with an altitude of 12.0 meters above mean sea level. The soil of the experimental field was heavy black which represents the typical black cotton soils of South Gujarat and medium in organic matter, medium in organic carbon (0.38 to 0.45%) and available nitrogen (159 kg/ha), medium in available phosphorus (29-30 kg/ha) and high in available potash (550-650 kg/ha). The soil has flat topography and characterized by medium to poor drainage with good water holding capacity.

The soil was slightly alkaline (pH 7.7) with normal electric conductivity (0.36 dS/m). The experiment comprised with total sixteen treatment combination with four different dates of sowing *viz.* D_1: Onset of monsoon, D_2: 15 Days after D_1, D_3: 15 Days after D_2, D_4: 15 Days after D_3 and four genotypes of sorghum *viz.* V_1: GJ 38, V_2: GJ 42, V_3: SR 2872 and V_4: SR 1904. The experiment was laid out in factorial randomized block design with three replications. Dates of all operations were noted; data collected including, 50% flowering, and 50% physiological maturity. Physiological maturity was determined by the presence of the black layer at the attaching part of the grain to the heard. Number of plants per net plot before and after thinning, and at harvest were also collected as well as number of leaves per plant at 50% flowering. Weight of grain per net plot after harvest was collected for all the plots in the trial. For the height of main shoot, random selection of six representative plants from each net plot was done and their height measured from ground level to the tip of panicle or plant, the mean was recorded. The crop was harvested manually with the help of sickle when seed almost matured and stover had turned yellow. The sun dried bundles were threshed and winnowed and seed so obtained were weighed and data on seed and stover yields were recorded. The statistical analysis of data was done using analysis of variance (ANOVA) technique for split plot design at 0.05 probability level.

Results and Discussion

Growth attributes of sorghum

Sowing of grain sorghum on set of monsoon registered significantly higher plant height (238, 219, 226 and 228 cm) and highest panicle length (28.1, 31.0, 18.0 and 27.0 cm) during 2014, 2015, 2016 and pooled basis, respectively. Delayed sowing of sorghum noted lower plant height and panicle length in descending order. Two months delayed sowing of sorghum (treatment D_4) recorded (53%, 9% and 13%) lower plant height and (54%, 13% and 17%) lower panicle length compared to sowing at onset of monsoon (treatment D_1). Changing planting date could effluence on growth process with changing environment temperature (Dehghan, 2007) [3]. The significant increase in these attributes under early sown crop might be due to favourable environmental condition and better translocation of photosynthates during the reproductive phase of the crop.

Significantly higher plant height recorded with genotype GJ 42 (174 cm) during 2014 and GJ 38 (219, 219 and 205 cm) during 2015, 2016 and pooled basis, respectively. On the basis of pooled analysis, panicle length remained statistically non significant but it was higher with genotypes GJ 38 and SR 2872 (*i.e.* 24 cm). This could be attributed to genetic factors. The variation in the plant height and panicle length could be explained by the variation in their genotype make-up (Panwar *et.al*, 2015) [6].

Interactions of different sowing dates and genotypes failed to exert any significant effect on plant height and panicle length of sorghum in pooled analysis.

Phonological periodicity of sorghum

Days to 50% flowering and maturity

The different date of sowing didn't influenced statistically days to 50% flowering and days taken to maturity in pooled results whereas less days for 50% flowering were taken by sorghum crop under treatment with treatment D_1 (79 days) in 2014, treatment D_3 (79 days) in 2015 and D_4 (76 days) in 2016. Significant effect of date of sowing on maturity days was observed only during 2014 and 2015. Minimum number of days to maturity was recorded under treatment D_1 (117 days) in 2014, treatment D_3 and D_4 (123 days) in 2015.

In case of genotype, pooled analysis and first year (2014) data were found non significant for days to 50% flowering but genotype GJ 38 (Treatment V_1) recoded significantly lower number of days to 50% flowering (79 days) during 2015. Genotype GJ 38 (Treatment V_1) and GJ 42 (Treatment V_2) took 75 days to flowering in 2016 which was lower than other genotypes.

Physiological maturity days

Effects of different genotypes was non significant in pooled as well as in 2014 and 2015 for number of days to physiological maturity while it was found significant during 2016 where minimum days to maturity observed with genotypes GJ 38 and GJ 42 (*i.e.* 112 day).

Grain and stover Yield

Sowing of grain sorghum on set of monsoon (treatment D_1) registered significantly higher grain yield (3508, 2701, 3549 and 3253 kg/ha) and stover yield (7798, 12212, 14403 and 11471kg/ha) during 2014, 2015, 2016 and pooled basis, respectively. Delayed sowing of sorghum noted lower grain and stover yields in descending order. On the basis of pooled data, it was calculated that treatment D_2, D_3 and D_4 recorded 11.65, 48.38 and 54.47% lower grain yield and 5.54, 33.96 and 42.08% lower stover yield over treatment D_1. Two months delayed sowing of sorghum (treatment D_4) recorded lowest grain and stover yield compared to sowing at onset of monsoon (treatment D_1). More favorable climatic conditions created at grain filling stage of sorghum in treatment D_1 caused a better sink-source relationship and higher seed yield. It seems that in D_1 planting date there was enough time for seed filling before winter cold arrival. These results are in line with results obtained by Bandiougou (2012) [2] who reported that Grain yield and yield components were influenced by planting date, the effects of planting dates on growth, development, and yield of grain sorghum hybrids were found to be variable among hybrid maturity groups and locations, whereas Ismail and Ali (1996) [4] found that planting dates had significant effects on plant height, head weight and final grain yield.

Data presented in table 2 illustrated that in pooled analysis grain and stover yield didn't affected significantly by various genotypes, however genotype SR 2872 (treatment V_3) recorded highest grain yield (2406 kg/ha) and stover yield (9299 kg/ha) on pooled basis. This could be attributed to genetic factors. The variation in the plant height and panicle length could be explained by the variation in their genotype make-up (Panwar *et.al*, 2015) [6].

Table 1: Effect of different dates of sowing on plant height and panicle length of various sorghum genotypes

Treatments	Plant height (cm)				Panicle length (cm)			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled
(A) Sowing dates								
D_1: Onset of monsoon	238	219	226	228	28.1	31.0	18.0	27.0
D_2: 15 Days after D_1	192	210	215	206	27.3	27.0	17.0	25.0
D_3: 15 Days after D_2	123	215	206	181	13.5	27.0	17.0	20.0
D_4: 15 Days after D_3	112	199	197	170	13.0	27.0	15.0	20.0
S.Em.±	3.8	4.8	4.79	17.01	0.31	0.6	0.7	2.43
CD @ 5%	11.1	13.8	13.83	NS	0.89	1.9	NS	NS
(B) Genotype (Varieties/Promising lines)								
V_1: GJ 38	164	219	219	201	21.3	28	21	24
V_2: GJ 42	174	206	206	195	22.4	26	21	23
V_3: SR 2872	156	201	201	186	19.6	30	23	24
V_4 : SR 1904	171	218	218	202	18.6	27	19	22
S.Em.±	3.8	4.8	4.79	2.64	0.31	0.6	0.7	0.83
CD @ 5%	11.1	13.8	13.83	7.4	0.86	1.9	NS	NS
Interaction (A x B)								
S.Em.±	7.7	9.6	9.58	5.07	0.61	1.3	1.5	0.7
CD @ 5%	NS	NS	NS	NS	1.77	NS	4.3	NS
CV%	8	7.9	7.87	7.94	5.2	8.0	12.1	8.85

Table 2: Effect of different dates of sowing on flowering and days to maturity of various sorghum genotypes

Treatments	Days to 50% flowering				Days to maturity			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled
(A) Sowing dates								
D_1: Onset of monsoon	79	83	80	80	117	125	93	120
D_2: 15 Days after D_1	81	84	79	81	118	128	93	121
D_3: 15 Days after D_2	87	79	78	82	128	123	92	122
D_4: 15 Days after D_3	92	80	76	83	131	123	91	122
S.Em.±	1.00	0.98	0.76	2.57	3	1.21	0.73	2.94
CD @ 5%	3.00	2.82	2.2	NS	8.0	3.5	NS	NS
(B) Genotype (Varieties/Promising lines)								
V_1: GJ 38	85	79	75	80	123	125	112	120
V_2: GJ 42	86	80	75	80.41	123	123	112	120
V_3: SR 2872	84	85	87	85	123	123	124	123
V_4 : SR 1904	84	82	76	81	124	127	113	121
S.Em.±	1	0.98	0.76	1.67	3	1.21	0.82	2.02
CD @ 5%	NS	2.82	2.2	NS	NS	NS	2.37	NS
Interaction (A x B)								
S.Em.±	2	1.95	1.52	1.13	5	2.42	1.64	1.91
CD @ 5%	NS	NS	NS	NS	NS	NS	4.74	NS
CV%	4.4	4.15	3.36	4.04	7.5	3.37	2.46	5.02

Table-3: Effect of different dates of sowing on grain and stover yield (kg/ha) of various sorghum genotypes

Treatments	Grain yield				Stover yield			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled
(A) Sowing dates								
D_1: Onset of monsoon	3508	2701	3549	3253	7798	12212	14403	11471
D_2: 15 Days after D_1	3297	2150	3174	2874	7623	11955	12927	10835
D_3: 15 Days after D_2	1039	1559	2433	1679	3601	9239	9887	7575
D_4: 15 Days after D_3	1044	1224	2176	1481	3503	7536	8889	6643
S.Em.±	144	37	34	260	192	263	152	276
CD @ 5%	416	106	97	899	554	759	438	954
(B) Genotype (Varieties/Promising lines)								
V_1: GJ 38	2253	1821	2752	2275	5761	10190	11291	9081
V_2: GJ 42	2253	1898	2845	2332	5607	10350	11425	9127
V_3: SR 2872	2197	2047	2973	2406	5561	10190	12145	9299
V_4 : SR 1904	2186	1867	2762	2272	5597	10211	11245	9018
S.Em.±	144	37	34	50	192	263	152	122
CD @ 5%	NS	106	97	NS	NS	NS	438	NS
Interaction (A x B)								
S.Em.±	288	74	67	95	384	525	303	223
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV%	22.46	6.67	4.09	13.13	11.8	8.8	4.5	7.9

Conclusion

The farmers of South Gujarat Agro-climatic Zone II (AES-II) growing *kharif* sorghum are advised to sow sorghum during onset of monsoon or within 15 days after onset of monsoon for getting higher grain yield, stover yield as well as net profit and to escape from shoot fly and stem borer attack. Late sowing of sorghum significantly reduces the grain yield, stover yield and net return.

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