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Iffect of times of sowing and nutrient levels on growth, yield attributes :nd yield of dryland sorghum varieties

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Abstract: Field experiments conducted at Tamil Nadu Agricultural University, Coimbatore in dryland Vertisols during North-East Monsoon (NEM) seasons of 1999 and 2000 to investigate the performance of sorghum varieties under different sowing times and levels of nitrogen and phosphorus revealed that the variety CSV 15 sown before the receipt of monsoon rainfall during 1999 NEM season with 60:30:0 kg N: P_2O_5: K_2O ha^{-1} had registered enhanced growth attributes and produced earheads with higher number of grains and in turn registered higher grain yield. The resource use efficiencies were also higher with CSV 15 sown before the receipt of monsoon rainfall resulting in high B:C ratio. During 2000 NEM season, sowing of CSV 15 before the receipt of monsoon rainfall with 40:20:0 kg N: P_2O_5: K_2O ha^{-1} produced appreciable growth attributes and produced lengthier earheads with more number of grains and finally recorded higher grain yield. The resource use efficiencies and B:C ratio were also higher for this combination.

Key words : Pre-monsoon sowing, Sorghum cultivar, CSV 15.

Introduction

Sorghum is one of the most important cereal crops grown in arid and semi-arid tropics of India. The productivity of sorghum is relatively low and highly unstable as being mostly grown under dryland condition. The major constraints for higher productivity in the dryland regions are the lack of adequate soil moisture during the critical crop growth period coupled with poor fertility status of the soil. Hence it is desirable to select a suitable variety for this situation so as to accommodate within the particular length of growing period (LGP) identified. In other words, sowing the seed at appropriate time in order to utilize the rainfall and available nutrients most efficiently is the most important key management practice for dryland sorghum. Hence, the sowing date could be manipulated to increase the yield of dryland crops without any additional input cost. Dry seeding in anticipation of rain was one such advance risk free agronomic practice, which helped to establish the crop at the earliest opportunity of first seasonal rain and ensured better utilization of rainfall without any plant protection loss. Durairaj *et al.* (1993) obtained lowest grain yield of 627 kg ha^{-1} in sorghum when sowing was done one week after the onset of monsoo 1 and highest grain yield of 2033 kg ha-1 was recorded when sowing was done two weeks before the onset of monsoon in vertisols of Kovilpatti. Though productivity of dryland sorghum is mainly limited by soil moisture availability, the experiences gained so far from the dryland research had shown that under given rainfall situation, crop yields could be still enhanced with the application of nutrients. Therefore, to increase crop yields in the drylands, it is not only necessary to increase moisture availability but also to ensure the availability of required nutrients. At present, in Tamil Nadu for dryland sorghum, application of 40:20:0 kg N: P_2O_5: K_2O ha^{-1} is being recommended irrespective of varieties and rainfall amount. But sorghum crop responds differently under varying times of sowing and different cultivars have varying magnitude of response to nutrient application. This study was taken upto generate information on the response of high yielding sorghum varieties to nutrient levels under different times of sowing with varying rainfall situation which is lacking at present.

Materials and Methods

The field experiments were carried out at Agricultural College and Research Institute,

Table 1. Effect of varieties, times of sowing and nutrient levels on plant height (cm) and dry matter production (kg ha^{-1}) of sorghum

Treatments	Plant height (cm)						Dry matter production (kg ha^{-1})					
	Vegetative stage (42 DAS)		Flowering stage (70 DAS)		At harvest		Vegetative stage (42 DAS)		Flowering stage (70 DAS)		At harvest	
	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year	I year	II year
Varieties												
V_1	112.3	89.4	228	128.2	232.1	139.7	948	911	5337	3881	10093	5965
V_2	122.9	92.3	219.4	130.7	222.3	138.8	1160	960	6033	4546	11511	6395
SEd	5.52	5.63	4.48	8.2	4.01	4.96	89.5	19.4	237.0	82.4	304.3	160.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	47.4	579.9	201.7	744.6	392.1
Times of sowing												
D_1	113.8	92.2	222.2	136.8	229.1	144.5	969	965	5637	4496	11552	6381
D_2	121.4	89.4	225.1	120.1	226.3	134.0	1138	905	5733	3931	10051	5979
SEd	5.52	5.63	4.48	8.2	4.01	4.96	89.5	19.4	237.0	82.4	304.3	160.2
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	47.4	579.9	201.7	744.6	392.1
Fertilizer levels												
F_1	102.2	89.9	218.5	127.0	224.5	138.2	525	706	4137	3482	8616	5049
F_2	118.9	90.9	224.2	129.5	229.1	140.8	1132	988	5856	4631	10765	6841
F_3	131.7	91.7	228.4	129.0	230.3	138.5	1504	1111	7062	4528	13025	6650
SEd	5.50	4.90	3.47	6.35	3.59	4.00	127.1	45.5	343.5	202.2	446.8	236.8
CD (P=0.05)	11.6	NS	7.35	NS	NS	NS	269.5	96.4	728.2	428.7	947.1	502.0

Tamil Nadu Agricultural University, Coimbatore during Northeast monsoon season of 1999 and 2000. The soil was low in available nitrogen (120 and 131 kg ha^{-1} for I and II year, respectively), medium in available phosphorus (13 and 11.5 kg ha^{-1} for I and II year, respectively) and high in available potassium (37(and 395 kg ha^{-1} for I anc II year, respectively). Spli plot design was adopted anc the treatments were replicatec thrice in both the years. Th main plot treatments consistec of two sowing times (sowin; before the receipt of monsoo rainfall (D_1) and sowing afte the receipt of monsoo rainfall (D_2)) and tw varieties (CO 26 (V_1) an CSV 15 (V_2)). Three nutrien levels viz. No nutrien application (F_1), 40:20:0 k N: P_2O_5: K_2O ha^{-1} (F_2) an 60:30:0 kg N: P_2O_5: K_2(ha^{-1} (F_3) were allotted t subplots. During both th years of experimentatio farmyard manure at the rat of 12.5 t ha^{-1} was incorporate uniformly over the fiel before last ploughing. Ju before sowing, N and fertilizers were applied basall in fertilizer lines as per th treatment schedule. Nitroge was applied as urea (46 pe cent N), while P_2O_5 was give through single super phosphat (16 per cent P_2O_5). In th years of experimentation, th rainfall received during th cropping season was follows: During I year, 427. mm distributed in 27 rain days for D_1 and 391 m distributed in 23 rainy day for D_2 sowing. Th

ble 2. Effect of varieties, times of sowing and nutrient levels on yield attributes of sorghum

eatments	Ear head length (cm)		No. of grains earhead^{-1}		100 grain weight (g)	
	I year	II year	I year	II year	I year	II year
rieties						
	22.8	14.5	906	304	26.4	23.3
	23.0	16.7	1120	389	26.1	23.2
:d	0.47	0.26	29.6	19.1	0.57	0.53
) (P=0.05)	NS	0.63	72.4	46.6	NS	NS
nes of sowing						
	23.3	15.3	1102	369	26.2	23.3
	22.4	14.9	924	324	26.3	23.3
:d	0.47	0.26	29.6	19.1	0.57	0.53
) (P=0.05)	NS	NS	72.4	NS	NS	NS
rtilizer levels						
	21.6	13.7	895	281	26.0	23.1
	22.6	14.1	1028	388	26.2	23.2
	24.4	17.6	1116	371	26.5	23.6
:d	0.59	0.57	51.4	27.4	0.51	0.49
) (P=0.05)	1.24	1.21	109.0	58.2	NS	NS

ble 3. Effect of varieties, times of sowing and nutrient levels on grain and straw yield (kg ha^{-1}) and harvest index of sorghum

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Harvest index	
	I year	II year	I year	II year	I year	II year
Varieties						
V_1	1910	614	8560	5359	18.43	10.29
V_2	3021	750	9512	5595	26.39	11.64
SEd	165.6	41.7	591.2	600.8	1.897	0.855
CD (P=0.05)	374.7	102.1	NS	NS	4.643	NS
Times of sowing						
D_1	2691	712	9591	5574	23.29	11.06
D_2	2240	652	8481	5379	21.53	10.87
SEd	165.6	41.7	591.2	600.8	1.897	0.855
CD (P=0.05)	374.7	NS	NS	NS	NS	NS
Fertilizer levels						
F_1	1862	503	8794	4973	21.10	9.97
F_2	2502	796	8729	5863	22.97	11.67
F_3	3033	746	9586	5594	23.16	11.25
SEd	114.4	43.9	478.3	407.6	1.434	0.920
CD (P=0.05)	236.1	93.1	NS	NS	NS	NS

distribution was 367.6 mm (21 rainy days), 41.6 mm (3 rainy days) and 18.4 mm (3 rainy days) for D_1 sowing and it was 331.0 mm (17 rainy days), 45.6 mm (4 rainy days) and 14.4 mm (2 rainy days) for D_2 sowing in respect of vegetative, flowering and maturity stages, respectively of first crop. The initial soil moisture during I year for 0-15 cm depth was 21.5mm and for 15-30 cm depth was 22.6 mm. In II year, a quantum of 284 mm (18 rainy days) and 123.3 mm (13 rainy days) of rainfall were recorded under D_1 and D_2 sowings, respectively and the rainfall received at vegetative, flowering and maturity stages was 207.7 mm (11 rain days), 63.5 mm (5 rainy days) and 12.8 mm (2 rainy days) for D_1 sowing and 47.6 mm (6 rainy days), 62.9 mm (5 rainy days) and 12.8 mm (2 rainy days) under D_2 sowing. The initial soil moisture during II year for 0-15 cm depth was 26 mm and for 15-30 cm depth was 26.3 mm. Biometric observations like plant height, dry matter production, leaf area index, yield components and yield were recorded at harvest in all the experimental plots and statistically analysed.

Results and Discussion

Varietal performance on the growth and yield parameters and yield of sorghum

Varieties did not exert any significant difference in plant height throughout the crop growth period (vegetative, flowering and maturity stages) in both the years. With regard to dry matter production (DMP), the variety CSV 15 produced significantly higher DMP than CO 26 at all stages of both the years (Table 1) except at vegetative stage of first year. The DMP is a function of numerous interactios between environment and genetic factors. The optimum LAI coupled with well developed root system enabled the variety CSV 15 to produce more drymatter than CO 26.

The varieties did not differ in terms of earhead length during I year (Table 2). This might be due to the efficient utilization of resources by both the varieties evaluated. During II year, the variety CSV 15 produced lengthier panicles than CO 26. This might be due to the well developed root system of CSV 15 which enabled the crop to obtain more soil moisture during panicle initiation to flowering stage as compared to CO 26. The variety CSV 15 contained significantly higher number of grains earhead-1 as compared to CO 26 in both the years. The variation in this character between CSV 15 and CO 26 might be due to the difference in assimilate partitioning and assimilate redistribution capacity. Similar results were also reported earlier by Somasundaram (2000) in maize. In respect of test weight there was no difference between CSV 15 and CO 26 and this was because the size and weight of grains were essentially varietal characters which were not influenced by any of the treatment imposed. However, if soil moisture became limited especially after heading, development of grain size and weight were adversely affected and resulted in reduced test weight. This was the reason for the lowest test weight in II year as compared to I year. Similar result was also reported by Pushpanathan (1987).

In respect of grain yield, the variety CSV 15 outyielded CO 26 in both the years and the increase in grain yield was 58 and 22 per cent, respectively during I and II year (Table 3). The straw yield also showed similar trend as that of grain yield though the difference was not significant during both the years. Higher grain and straw yields in CSV 15 over CO 26 was due to higher level of growth contributing characters viz. drymatter production (Table 1) and yield contributing characters (Table 2) in both the years. This also corroborated with the findings of Thombre *et al.* (1982) who concluded that panicle length, panicle girth, number of primaries and secondaries, panicle weight, number of grains panicle and 1000 seed weight did influence either directly or indirectly the per plant grain yield of a particular genotype. Results of the advanced varietal trial conducted under All India *kharif* 1996 also revealed that CSV 15 recorded higher grain yield (3016 kg ha^{-1}) than CO 26 (2896 kg ha^{-1}) though not significant and produced significantly higher fodder yield (13 t ha^{-1}) as compared to CO 26 (10.7 t ha^{-1}) (Annual Report, 1997-98). During I year, the variety CSV 15 registered significantly higher harvest index than CO 26 and this might be due to considerable increase in DMP in CSV 15 after anthesis.

ffect of times of sowing on the growth and ield parameters and yield of sorghum

Times of sowing did not alter the plant eight significantly throughout the crop growth eriod in both the years. In respect of DMP, D_1 sown crop produced higher DMP than D_2 own crop in both the years. During I year, D_1 sown crop produced significantly higher DMP than D_2 sown crop at most of the crop rowth stages. This was due to higher and ptimum distribution of rainfall for the crops own under D_1 date of sowing. During II year, n all the stages D_1 sown crop produced higher DMP than D_2 sown crop.

The times of sowing had no significant nfluence on earhead length in both the years. The crop sown under D_1 sowing recorded ignificantly higher number of grains earead^{-1} than crop sown under D_2 sowing during year. This was because, in D1 sowing, there vas no soil moisture stress observed upto 77 DAS, whereas it was only upto 70 DAS in D_2 sowing. But such significance was absent luring II year. The existence of moisture stress ondition during panicle development and grain illing stages would be the reason for such non significance results.

In respect of grain yield, D_1 sown crop had recorded significantly higher grain yield over D_2 sown crop during I year whereas the lifference in yield was not significant during I year. During I year, both grain and straw yields were higher to an extent of 20 and 13 per cent, respectively under D_1 sown crop over D2. With sowing before the cost of the nonsoon, by nature the crop had been given in opportunity to utilize all the environmental esources effectively. This finding was in agreement with the findings of Balasubramanian *et al.* (1993) who reported 33 and 8 per cent increase n grain and straw yields due to sowing before he onset of monsoon (during 38th-39th MSW) over sowing after the monsoon rain under Coimbatore condition. During II year, irrespective of treatments, the crop growth and yield were affected because of the prolonged moisture stress as experienced by the crop. During II year also, D_1 sown crop performed better than D_2 and D1 recorded 9 and 4 per cent higher grain and straw yields over D_2. This was due to lesser moisture stress experienced by D_1 sown crop than D_2 sown crop. This result is in accordance with the findings of Das *et al.* (1993) who reported that sorghum yield was inversely proportional to the stress period and the larger the stress duration, the lower was the grain yield.

Effect of nutrient levels on the growth and yield parameters and yield of sorghum

Nutrient application positively influenced the sorghum plant height during I year and application of 60:30:0 kg N: P_2O_5: K_2O ha^{-1} had produced taller plants over control (no nutrient application) at vegetative and flowering stages. The increased plant height with NP fertilization was because of increase in cell division (Levitt, 1972).

In respect of Dry Matter Production (DMP), during I year, higher level of nutrient application (F_3) resulted in higher DMP as compared to F_2 and F_1 levels at all the stages of crop growth. During II year, F_3 level of nutrient application produced higher dry matter at vegetative stage and thereafter F_2 and F_3 levels were at par and produced higher DMP than F_1 level. This indicated that F3 level was not so efficient as observed in the first year because of reduced soil moisture noted in the second year. The results were in agreement with the findings of Myers and Asher (1982) who reported lower response of sorghum crop to fertilizer application under lower rainfall amount. In both the years, higher level of nutrient application improved earhead length and number of grains earhead^{-1}. The result was in agreement with the findigns of Rama Mohan Rao *et al.* (1995).

During I year, the grain and straw yields increased significantly with increasing NP fertilization (Table 3). The nutrient level F3 (60:30:0 kg N: P_2O_5: K_2O ha^{-1}) gave the highest grain yield followed by F_2 (40:20:0 kg N: P_2O_5: K_2O ha^{-1}) and the increase was 63 and 34 per cent over F_1 (control). F_3 also recorded the highest straw yield, though the difference was not significant. The higher yield of grain under higher nutrient level (F_3) was due to higher growth and yield attributes obtained. F_3 recorded an average of 21,8,15 and 51,13,25 per cent higher total DMP, panicle length and number of grains per panicle over F_2 and F_1, respectively. Porwal and Pushpendra Singh (1992) also gave similar findings from their experimentation.

During II year, F_2 registered the highest grain yield (796 kg ha^{-1}) which was at par with F_3 (746 kg ha^{-1}) and significantly higher than F_1 (503 kg ha^{-1}). Higher grain yield at F_2 was through obtaining higher values in the growth and yield components, especially number of grains per panicle. Similarly, highest straw yield was also recorded with F_2, though the difference was not significant. The insufficient soil moisture condition during the crop growth period had resulted reduction in grain and straw yields under increased nutrient levels beyond F_2. This was because soil moisture had a pronounced effect on the uptake of plant nutrients. The results are in agreement with the findings of Rama Mohan Rao *et al.* (1995).

Economics

The B:C ratio was higher (2.68) when V_1 (CO 26) entry was sown at D_1 under F3 nutrient level (60:30:0 kg of $N:P_2O_5:K_2O$ ha^{-1}) and still higher performance was observed for V2 (3.17) in the I year. While in the II year, it was D_2 sowing with a nutrient level of 40:20:0 kg of N: P_2O_5: K_2O ha^{-1} (F_2) for the variety CO 26 (1.27) and it was D_1 sowing with 40:20:0 kg of $N:P_2O_5$: K_2O ha^{-1} (F_2) for the variety CSV 15 (1.43) which had recorded higher B:C ratio.

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