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EFFECT OF NITROGEN SCHEDULING ON GROWTH, YIELD AND NUTRIENT UPTAKE IN SORGHUM [*SORGHUM BICOLOR* (L.) MEONCH] CULTIVARS

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ABSTRACT

A field experiment was carried out during rainy season (*kharif*) of 2013 at Udaipur (Rajasthan) to find out the effect of nitrogen scheduling on growth, yield and nutrient uptake in sorghum cultivars. The experiment comprised two cultivars and five nitrogen schedules with three replications were assigned in factorial randomized block design. The results revealed that the cultivar V_2 (CSV 20) recorded significantly higher plant height (221 cm) and dry matter accumulation of leaves and stem (8.01 and 2.19 g plant^{-1}) at 40 DAS and (21.63 and 23.30 g plant^{-1}, respectively) at 80 DAS, consequently higher stover (11141 kg ha^{-1}) and biological yield (12416 kg ha^{-1}), while significantly higher chlorophyll content (2.64 mg g^{-1}), grain yield (1521 kg ha^{-1}), N (24.95 kg ha^{-1}), P (4.29 kg ha^{-1}) and K uptake (7.53 kg ha^{-1}) by grain was recorded in cultivar V_1 (CSH 16). On the other hand application of nitrogen in N_2 schedule (50% at sowing as basal + 25% at 30 DAS + 25% at boot-leaf stage) registered significant influence on plant height (223 cm), dry matter accumulation of leaves, stem and panicle, grain (1613 kg ha^{-1}), stover (11811 kg ha^{-1}) and biological yield (13424 kg ha^{-1}), N, P and K uptake (26.31, 4.51, 7.95 kg ha^{-1}) by grain and (56.83, 20.73, 189.52 kg ha^{-1}, respectively) by stover compared to remaining nitrogen schedules. Therefore, it was concluded that significantly higher grain yield was recorded in cultivar CSH 16 and N_2 schedule of nitrogen application from sorghum.

INTRODUCTION

Sorghum is one of the important cereal crops globally after wheat, maize, rice and barley. It is a unique crop among the major cereals and the staple food and fodder crop of the world's poor and most food insecure populations in the semi-arid tropics. In India, the area under sorghum is approximately 5.82 million ha with an annual production of about 5.39 million tonnes and an average productivity of 926 kg ha^{-1}. The major sorghum growing states are Maharashtra, Karnataka, Rajasthan, Tamil Nadu and Andhra Pradesh. In Rajasthan, it is cultivated over an area of 0.58 million ha with a production and productivity of 0.36 million tonnes and 615 kg ha^{-1} respectively (DAC, 2013).

The reason for low productivity of this crop is seems to be non-adoption of proper agrotechniques. Among the growth factors adequate supply of chemical fertilizer, especially nitrogen is considered to be of prime importance due to its profound impact on various aspects of growth and development, hence productivity of the crop. Nitrogen use and demand is continuously increasing day by day. Since it is highly mobile, it is subject to greater losses from the soil-plant system (Abd El-Lattief, 2011). Even under best management practices, 30 to 50 per cent of applied nitrogen is lost through different agencies and hence, the farmer is compelled to apply more than the actual need of the crop to compensate the loss. The loss of nitrogen not only troubles the farmer, but it has also hazardous impacts on environment. Scheduling of fertilizer application is low cost strategy to reduce nutrient leaching, so that nutrient supply is synchronized with plant demand and increases nitrogen use efficiency (Gehl *et al*., 2005).

Sinare *et al*. (2005) reported that the sweet sorghum genotype "RSSV-9" produced the highest plant height, dry matter accumulation, grain yield and nutrient uptake when nitrogen was applied as 30 per cent at sowing + 35 per cent at 25 DAS + 35 per cent at 50 DAS. Bindhani *et al*. (2008) studied the effect of nitrogen scheduling in three equal splits as 1/3 as basal, at knee high and at pre tasseling stages which significantly increased plant height and dry matter accumulation over application of nitrogen in two splits at basal and at knee high stages in baby corn. Choudhary *et al*. (2013) observed that application of nitrogen in four equal splits (25:25:25:25) at basal, 4 to 6 leaf stage, knee high and 50 per cent tasseling stages, respectively recorded significantly higher grain yield over recommended three splits of nitrogen application at basal, knee high and 50 per cent tasseling stages in quality protein maize.

During the last few years a number of high yielding genotypes of grain sorghum have been evolved. Genotype of a crop plays an important role in increasing crop production but information on the response of newly evolved genotypes to split application of nitrogen is meagre. Sumeriya *et al.* (2007) reported that that genotype CSV 15 proved superior in producing higher plant height and dry matter accumulation than SPV 1430 and CSH 14. Dhaker (2010) found that genotype CSH 16 proved significantly superior in grain yield and nutrient uptake by grain while genotype CSV 20 recorded highest nutrient uptake by stover.

There is little information available in the current literature on growth, yield and nutrient uptake in sorghum cultivars to different nitrogen scheduling and their interactions. But these data are insufficient to provide a basis for evolving a strategy of nitrogen application with sorghum cultivars to optimize nitrogen utilization and yield. Therefore, an attempt was made to study the effect of nitrogen scheduling on growth, yield and nutrient uptake in sorghum cultivars under rainfed condition.

The objectives of this study were to observe the effects of nitrogen scheduling on growth, yield and nutrient uptake in sorghum [*Sorghum bicolor* (L.) Meonch] cultivars and their interactions.

MATERIALS AND METHODS

A field experiment was carried out during *kharif* 2013 at the Instructional Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur which is situated at 23°34′N latitude and 73°42′E longitude at an altitude of 582.17 meter above the mean sea level. The soil of experimental site was clay loam in texture having slightly alkaline pH (8.0) in reaction, organic carbon (0.65%), medium with respect to available nitrogen (257.06 kg ha^{-1}), available phosphorus (20.80 kg ha^{-1}) and high in available potassium (355.60 kg ha^{-1}) in the plough layer. The well distributed rainfall of 736.0 mm was recorded during crop growth period.

The experiment was laid out in factorial randomized block design with two sorghum cultivars (V_1: CSH 16 and V_2: CSV 20) and five nitrogen scheduling (N_1: 50% at sowing as basal + 50% at 30 DAS, N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot-leaf stage, N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot-leaf stage, N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage, N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage) having three replications. Sorghum cultivars were sown manually with a seed rate of 10 kg ha^{-1} in line and intercultural operations were done as and when necessary. Full dose of P_2O_5 and K_2O was applied as basal at time of sowing through Diammonium phosphate and Muriate of potash. For supplying nitrogen, urea fertilizer was applied to each plot as per treatment schedule. The five plants from sampling rows of each plot were uprooted for recording dry matter accumulation, washed with water and roots were separated. The plant parts were dried under shade for few days, oven dried at 65°C till a constant weight was obtained and expressed in g $plant^{-1}$. The chlorophyll content was estimated as per standard procedure (Arnon, 1949). Days to 50% flowering was observed visually and recorded on total plant basis. For grain yield, earheads from each net plot were picked up and after detaching the earheads the dry fodder yield per unit area was noted. The nutrient uptake was calculated by multiplying the concentration of N, P and K with yield. The nitrogen concentration in the plant was determined by Nessler's reagent colorimetric method (Lindner, 1944), Phosphorus by Ammonium vanadomolybdate yellow colour method (Richards, 1968) and Potassium by Flame photometer (Jackson, 1973). The results were analyzed using standard statistical procedure given by Panse and Sukhatme (2000).

RESULTS AND DISCUSSION

Growth characters

The plant height, chlorophyll content, days to 50 % flowering and dry matter accumulation in leaf, stem and panicle was significantly influenced by the sorghum cultivars (Table 1). Minimum days to 50 % flowering (58.1) was observed in cultivar V_1 (CSH 16) which was significantly earlier as compare to cultivar V_2 (CSV 20). The plant height (221 cm) and dry matter accumulation of leaf and stem (8.01 g $plant^{-1}$ and 2.19 g $plant^{-1}$) at 40 DAS and (21.63 g $plant^{-1}$ and 23.30 g $plant^{-1}$ respectively) at 80 DAS was higher in cultivar V_2 (CSV 20) which was significantly superior over V_1 (CSH 16), but cultivar V_1 (CSH 16) was registered significantly higher over V_2 (CSV 20) in chlorophyll content (2.64 mg g^{-1}) at 30 DAS and dry matter accumulation of panicle (34.18 g $plant^{-1}$) at 80 DAS. Since both the cultivar were grown under identical agronomical and external climate conditions, the marked variation in growth could be ascribed on account of their genetic capabilities to exploit available resources for their growth and development. The variation in plant height of the cultivar might be related to inherent variations and higher vigor. These results are already in agreement with the reported of Dixit *et. al*., (2005), Sumeriya and Singh (2008) and Dhaker (2010) for growth character of the sorghum in different cultivars.

Application of N_2 schedule (50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage) recorded significantly minimum days to 50 % flowering (61.0) and increased plant height (223 cm) at harvest, chlorophyll content (2.64 mg g^{-1}) at 30 DAS, dry matter accumulation of leaves (8.15 g $plant^{-1}$) and stem (2.17 g $plant^{-1}$) at 40 DAS and leaves (21.73 g $plant^{-1}$), stem (24.28 g $plant^{-1}$) and panicle (35.16 g $plant^{-1}$) at 80 DAS compared to other schedules of nitrogen application (Table 1). The urea hydrolyses in presence of urease enzyme in ammonium carbonate which is decompose to ammonia and nitrate and in these form nitrogen is absorbed by plants within a week period of time. Some of ammonia may be lost through leaching and denitrification and cause low recovery of nitrogen. Thus under N_2 schedule these losses may be negligible and it becomes available for longer period, in higher amount and increased its use efficiency and efficient uptake. Similar finding were also reported elsewhere by Bindhani *et al*. (2008), Singh (2010) and Choudhary *et al*. (2013).

Yield

The data in Table 2 revealed that cultivar V_1 (CSH 16) produced significantly higher grain yield (1521 kg ha^{-1}) over cultivar V_2 (CSV 20). However, cultivar V_2 (CSV 20) was provided significantly higher stover (10070 kg ha^{-1}) and biological yield (11590 kg ha^{-1}) over V_1 (CSH 16). The higher grain yield by V_1 (CSH 16) and stover and biological yield registered by V_2 (CSV

Table 1: Effect of nitrogen scheduling on growth parameters of sorghum cultivars

Treatments	Plant height at harvest (cm.)	Chlorophyll content at 30 DAS (mg g^{-1})	Days to 50 % Flowering	Dry matter accumulation(g $plant^{-1}$) 40 DAS Leaves	Stem	80 DAS Leaves	Stem	Panicle
Cultivars								
V_1: CSH 16	200	2.64	58.1	7.53	2.01	20.14	21.91	34.18
V_2: CSV 20	221	2.55	66.1	8.01	2.19	21.63	23.30	31.84
SEm+	1.9	0.01	0.2	0.13	0.02	0.40	0.38	0.75
CD (P=0.05)	5.5	0.03	0.5	0.38	0.07	1.15	1.11	2.17
Nitrogen Scheduling								
N_1: 50% at sowing as basal + 50% at 30 DAS	200	2.62	61.8	6.61	1.96	17.94	17.93	29.32
N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	223	2.64	61.0	8.15	2.17	21.73	24.28	35.16
N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	209	2.59	62.0	8.09	2.15	21.51	24.21	33.32
N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage	216	2.56	62.8	8.10	2.12	21.70	23.43	34.23
N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage	205	2.58	62.7	7.90	2.10	21.54	23.20	33.02
SEm+	2.9	0.02	0.3	0.21	0.03	0.63	0.60	1.18
CD (P=0.05)	9.0	0.05	0.8	0.60	0.10	1.83	1.76	3.43

Table 2: Effect of nitrogen scheduling on yield and nutrient uptake by sorghum cultivars.

Treatments	Yield (kg ha^{-1})			Nutrient uptake (kg ha^{-1})					
				Nitrogen		Phosphorus		Potassium	
	Grain	Stover	Biological	Grain	Stover	Grain	Stover	Grain	Stover
Cultivars									
V_1: CSH 16	1521	10070	11590	24.95	50.59	4.29	17.72	7.53	163.47
V_2: CSV 20	1276	11141	12416	20.25	50.39	3.47	18.69	5.96	175.49
SEm+	34	159	170	0.55	0.77	0.09	0.33	1.17	2.63
CD (P=0.05)	99	462	392	1.59	NS	0.27	NS	0.50	7.63
Nitrogen Scheduling									
N_1: 50% at sowing as basal + 50% at 30 DAS	1459	9715	11174	22.88	46.01	4.00	16.39	6.98	152.05
N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	1613	11811	13424	26.31	56.83	4.51	20.73	7.95	189.52
N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	1230	10370	11601	20.16	49.18	3.45	17.72	5.94	166.43
N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage	1338	10963	12301	21.70	52.29	3.70	18.61	6.41	176.34
N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage	1350	10167	11517	21.94	48.13	3.75	17.59	6.43	163.06
SEm+	54	252	269	0.87	1.22	0.15	0.52	0.27	4.16
CD (P=0.05)	157	730	778	2.52	3.53	0.44	1.53	0.79	12.07

Table 3: Interaction effect of nitrogen scheduling and cultivars on grain yield, nitrogen, phosphorus and potassium uptake by grain

Treatments	Cultivars	
Nitrogen Scheduling	V_1: CSH 16	V_2: CSV 20
Grain yield (kg ha^{-1})		
N_1: 50% at sowing as basal + 50% at 30 DAS	1600	1319
N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	1641	1585
N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	1447	1013
N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage	1556	1120
N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage	1360	1341
SEm±	76.62	
CD (P= 0.05)	221.96	
Nitrogen uptake by grain (kg ha^{-1})		
N_1: 50% at sowing as basal + 50% at 30 DAS	24.17	21.59
N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	27.63	25.00
N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	25.10	15.22
N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage	25.37	18.04
N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage	22.47	21.41
SEm±	1.23	
CD (P= 0.05)	3.58	
Phosphorus uptake by grain (kg ha^{-1})		
N_1: 50% at sowing as basal + 50% at 30 DAS	4.61	3.39
N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	4.74	4.28
N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	4.14	2.76
N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage	4.19	3.21
N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage	3.78	3.73
SEm±	0.21	
CD (P= 0.05)	0.62	
Potassium uptake by grain (kg ha^{-1})		
N_1: 50% at sowing as basal + 50% at 30 DAS	7.85	6.11
N_2: 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	8.15	7.76
N_3: 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	7.42	4.46
N_4: 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage + 10% at grain filling stage	7.52	5.30
N_5: 25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage	6.70	6.16
SEm±	0.39	
CD (P= 0.05)	1.12	

20) appear to be a resultant of remarkable improvement in different yield components, which was brought about due to adoption of cultivars. These observations are also in agreement with that of Kushwaha and Thakur (2006) Kumar *et al*. (2008), Dhaker (2010) and Prasad *et al*. (2014) who also reported that yield of crop was influenced significantly by cultivars.

Among the different nitrogen scheduling (Table-2), N_2 schedule (50 per cent at sowing as basal, 25 per cent at 30 DAS and 25 per cent at boot leaf stage) produced significantly highest grain (1613 kg ha^{-1}), stover (11811 kg ha^{-1}) and biological yield (13424 kg ha^{-1}). It was remained at par with N_1 schedule (50% at sowing as basal + 50% at 30 DAS) for grain yield (1459 kg ha^{-1}). Under N_2 schedule of nitrogen application, higher availability of nitrogen coincided with active growth phase of the plant. This eventually observed longer available period of nitrogen in soil accentuating greater content and uptake of N, P and K thus increasing yield attributes and yield compared to remaining nitrogen schedules. These findings are in agreement with those by Harikrishna *et al*. (2005), Singh (2010) and Choudhary *et al*. (2013).

Nutrient uptake

Comparing both the cultivars for N, P and K nutrient uptake (Table 2), V_1 (CSH 16) recorded significantly higher N (24.95 kg ha^{-1}), P (4.29 kg ha^{-1}) and K (7.53 kg ha^{-1}) uptake in grain, while V_2 (CSV 20) recorded maximum K (175.49 kg ha^{-1}) uptake in stover. N and P uptake in stover was not significantly influenced by the cultivars. As the nutrient uptake of plant depends on the yield and nutrient concentration, considerable increase in either of components may increase the uptake. Genotypic variation in uptake of nutrient by crop was significantly affected due to cultivars. Genetic variability in cultivars with respect to N, P and K uptake were also observed by Dixit *et al*., (2005), Sumeriya (2010), Mawliya (2012) and Binjola and Kumar (2013).

The application of nitrogen in N_2 schedule (50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage) recorded significantly highest N (26.31 and 56.83 kg ha^{-1}), P (4.51and 20.73 kg ha^{-1}) and K uptake (7.95 and 189.52 kg ha^{-1}) in grain and stover, respectively compared to remaining nitrogen scheduling (Table 2). It is an established fact that nutrient accumulation depends upon total biomass and concentration of nutrients at cellular level. Therefore, considerable increase in N, P and K uptake was attributed to significantly higher grain and stover yield with N_2 schedule. The results are in close conformity with the findings of Mahajan *et al.* (2010) and Kharub and Chander (2010).

Interaction effect of cultivars and nitrogen scheduling

The data (Table 3) on combined effect of cultivars and nitrogen scheduling was found non-significant in terms of plant height, chlorophyll content, days to 50 % flowering, dry matter accumulation of leaves, stem, panicle, stover yield, biological yield, N, P and K uptake by stover. But, the grain yield, N, P and K uptake by grain was significantly influent by interaction effect of cultivars and nitrogen scheduling. The grain yield, N, P and K uptake in grain was highest in N_2 schedule (50 per cent at sowing as basal, 25 per cent at 30 DAS and 25 per cent at boot leaf stage) with cultivar V_1 (CSH 16) and significantly higher over same nitrogen schedule with cultivar V_2 (CSV 20) and N_5 schedule (25% at sowing as basal + 45% at 30 DAS + 5% foliar spray at 45 DAS + 15 % at boot leaf stage + 10% at grain filling stage) with cultivar V_1 (CSH 16) and remained statistically at par with remaining treatment combinations. These findings are in agreement with those by Bindhani *et al.*, (2007) and Mawliya (2012).

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2. **The senior scientists award** : It is awarded to the academicians above the age of 35 years.
3. **The best paper award**: It is awarded to the contributor of the Journal **The Bioscan** during the year.
4. **The best paper presentation award** : It is awarded to the scholar whose presentation is the best other than the young scientist category.
5. **The best oration award** : It is awarded to the scholar who delivered invited speech.
6. **The recognition award** : It is awarded to those senior scholars who have contributed to the subject through their continued research .
7. **The environmental awareness award** : It is awarded to those who, apart from their research contribution, have done commendable extension work for environmental betterment.

The number of recipients of award in each category will vary depending upon the recommendation of the panel of judges and the executive committee. The association has the provision to institute awards in the name of persons for whom a with desired sum is donated in consultation with the executive body.

PUBLICATION OF THE ASSOCIATION

In order to provide a platform to a vast group of researchers to express their views and finding of research as well as to promote the attitude of quality research among the scholars of younger generation the association publishes an international quarterly journal – **THE BIOSCAN (ISSN:0973-7049).** For the benefit of the potential contributors **instructions to authors** is given separately in this journal. However, the details regarding the journal and also the association can be seen on our website *www.thebioscan.in.*

Cont. .... P. 264