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Growth, Yield and Nutrient Content of Sorghum [*Sorghum bicolor* (L.) Moench] Cultivars as Influenced by Different Scheduling of Nitrogen Application

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Abstract A field experiment was conducted during rainy season *kharif* of 2013 to study the effect of nitrogen scheduling on growth, yield and nutrient content in sorghum cultivars. Two cultivars (V_1 : CSH 16 and V_2 : CSV 20) and five nitrogen schedules (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 4 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) were assigned in a factorial randomized block design. The results revealed that the cultivar CSH 16 recorded significantly higher grain yield (1,521 kg/ha) and nutrient content by grain and stover, while significantly higher dry matter accumulation at 40 and 60 DAS, higher stover and biological yield were recorded in CSV 20. Application of N as 50% at sowing as basal+ 25% at 30 DAS + 25% at boot-leaf stage doses had marked influence on growth parameter, yield and nutrient content when compared to other treatments.

Keywords Nitrogen scheduling, Sorghum, Cultivars, Yield, Nutrient content.

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Introduction

Sorghum [*Sorghum bicolor* (L.) Moench], the fifth most important cereal crop on the globe, is traditionally grown for grain both as food and as animal feed and stalks as animal fodder. 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. 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 respectively [1].

The reason for low productivity of this crop is seems to be non-adoption of proper agrotechniques. Amongst 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. The complexities of N management occur due to its solubility, mobility and vulnerability to denitrification. The efficiency of fertilizer N is only 30—40% in rice and 50—60% in other cereals. The efficiency of fertilizer can be increased and losses reduced by matching supply with crop demand, optimizing split application schemes, changing the form to suit the conditions, and use of slow-release fertilizers and inhibitors. 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 [2]. 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 meager. Keeping this in view, the experiment was laid out to assess the most suitable cultivar and best schedule of nitrogen application for higher yield.

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), available phosphorus (20.80 kg/ha) and high in available potassium (355.60 kg/ha) in the plough layer. The well distributed rainfall of 736.0 mm was recorded during crop growth period.

The experiment consisting of 10 treatment combinations comprising 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) were tested in a factorial randomized block design having three replications. Sorghum cultivars were sown manually on 6 July 2013 at 45 × 15 cm row to row and plant to plant spacing with a seed rate of about 10 kg/ha. Full dose of P_2O_5 and K_2O was applied as basal at time of sowing through DAP and MOP. For supplying nitrogen, urea fertilizer was applied to each plot as per treatment schedule after deducting the nitrogen applied through DAP. 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. The numbers of plants in net plot area in each experimental unit were counted at crop maturity. These were averaged and expressed in thousand plants/ha. When the crop turned yellow and more than 90% panicle turned brown, this was recorded for each plot and number of days to maturity was calculated. The crop was harvested during second fortnight of October. For grain yield, earheads from each net plot were picked up and kept in gunny bags. After sun drying these was threshed, winnowed and cleaned and final yield was expressed in kg/ha, while after detaching the earheads the fodder was left in the field for sun drying for few days. After drying, the bundles of each plot were weight and noted dry fodder yield per unit area.

Results and Discussion

Growth parameters

The plant population at harvest was not affected significantly due to the cultivars during the experimentation. The cultivars show significant influence on days to maturity and dry matter accumulation at 40 DAS, 60 DAS and at harvest (Table 1). Minimum days to maturity (100.1) were observed in cultivar CSH 16 which was significantly earlier as compare to cultivar CSV 20. Between the cultivars, higher dry matter accumulation at 40 DAS and 60 DAS was observed in cultivar CSV 20 which was significantly superior over CSH 16, but hybrid CSH 16 was significantly higher over CSV 20 in dry matter accumulation at harvest by 2.93%. The magnitudes of increase in dry matter accumulation with cultivar CSV 20 were 6.92 and 8.81% per plant over CSH 16 at 40 and 60 DAS, respectively. 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 differential behavior of these cultivars in respect to growth parameters could also be explained solely by the variation in their genetic makeup [3, 4].

A further reference to the same Table 1 reveals that plant population was also not affected significantly due to various nitrogen schedules at harvest. Application of N_2 schedule viz., 50% at sowing as

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

Treatments		Plant popula-tion at harvest ('000/ha)	Days to matu-rity	Dry matter accumulation (g/plant) 40 DAS	60 DAS	80 DAS	At har-vest
Cultivars							
V_1 :	CSH 16	147.0	100.1	9.54	25.88	76.24	94.83
V_2 :	CSV 20	146.5	105.0	10.20	28.16	76.78	92.13
	SEm±	1.01	0.3	0.13	0.45	1.15	0.87
	CD (p = 0.05)	NS	0.8	0.37	1.31	NS	2.54
Nitrogen sScheduling							
N_1 :	50% at sowing as basal+50% at 30 DAS	146.8	103.7	8.56	25.18	65.20	84.08
N_2 :	50% at sowing as basal+25% at 30 DAS + 25% at boot leaf stage	147.0	101.5	10.33	30.04	81.17	98.15
N_3 :	25% at sowing as basal+50% at 30 DAS + 25% at boot leaf stage	146.9	102.2	10.24	26.84	79.04	94.74
N_4 :	25% at sowing as basal+50% at 30 DAS + 15% at boot leaf stage+10% at grain filling stage	146.3	102.5	10.21	26.98	79.36	95.49
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	146.8	103.0	10.00	26.06	77.76	94.93
	SEm±	1.59	0.4	0.20	0.71	1.82	1.38
	CD (p = 0.05)	NS	1.2	0.59	2.07	5.28	4.02

basal+25% at 30 DAS+25% at boot leaf stage recorded significantly minimum days to maturity and higher dry matter accumulation per plant at 40 DAS, 60 DAS, 80 DAS and at harvest compared to other schedules of nitrogen application. The corresponding increase in dry matter accumulation were to the tune of 19.30, 11.92, 11.34 and 15.27% at 40 DAS, 19.30, 11.92, 11.34 and 15.27% at 60 DAS, 24.49, 2.70, 2.28 and 4.39% at 80 DAS and 16.73, 3.60, 2.79 and 3.39% at harvest over N_1, N_3, N_4 and N_5 schedules, respectively. In present experiment urea was used as source of fertilizer, which hydrolyses in presence of urease enzyme in ammonium carbonate which is an unstable compound and 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 [5, 6].

Yield

A critical examination of data reveals that cultivar CSH 16 recorded significantly higher grain yield (1,521 kg/ha) over cultivar CSV 20 by 19.20%. However, cultivar CSV 20 provided significantly higher stover (10,070 kg/ha) and biological yield (11,590 kg/ha) resulting in 10.63 and 7.13% increase in stover and biological yield, respectively over CSH 16 (Table 2). The higher grain yield by CSH 16 and fodder and biological yield registered by CSV 20 appear to be a resultant of remarkable improvement in different yield components, which was brought about due to adoption of cultivars. It was further, confirmed by the fact that grain yield was found strongly correlated with different yield components [7, 8].

Among the N scheduling treatments, N_2 schedule viz, 50% at sowing as basal, 25% at 30 DAS and 25% at boot leaf stage had produced significantly maximum grain (1,613 kg/ha), stover (11,811 kg/ha)

Table 2. Effect of nitrogen scheduling on yield and nutrient content of sorghum cultivars.

Treatments	Yield (kg/ha) Grain	Stover	Biological	Nitrogen Grain	Nitrogen Stover	Phosphorus Grain	Phosphorus Stover	Potassium Grain	Potassium Stover
Cultivars									
V_1 : CSH 16	1521	10070	11590	1.642	0.502	0.282	0.176	0.492	1.623
V_2 : CSV 20	1276	11141	12416	1.585	0.452	0.273	0.167	0.468	1.575
SEm±	34	159	170	0.005	0.001	0.001	0.001	0.001	0.006
CD (p = 0.05)	99	462	392	0.016	0.003	0.003	0.003	0.003	0.018
Nitrogen scheduling									
N_1 : 50% at sowing as basal + 50% at 30 DAS	1459	9715	11174	1.574	0.474	0.273	0.168	0.477	1.570
N_2 : 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage	1613	11811	13424	1.630	0.482	0.279	0.176	0.493	1.609
N_3 : 25% at sowing as basal + 50% at 30 DAS + 25% at boot leaf stage	1230	10370	11601	1.618	0.476	0.279	0.171	0.476	1.602
N_4 : 25% at sowing as basal + 50% at 30 DAS + 15% at boot leaf stage+10% at grain filling stage	1338	10963	12301	1.621	0.477	0.278	0.170	0.478	1.608
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	1.624	0.476	0.278	0.173	0.476	1.605
SEm±	54	252	269	0.009	0.002	0.002	0.002	0.002	0.010
CD (p = 0.05)	157	730	778	0.025	0.005	0.005	0.005	0.005	0.028

and biological yield (13,424 kg/ha) which was recorded 31.14, 20.55 and 19.48% higher grain yield over N_3, N_4 and N_5 schedules, 21.57, 13.90, 7.74 and 16.17% in stover yield and 20.14, 15.71, 9.13 and 16.56% in biological yield over N_1, N_3, N_4 and N_5 schedules, respectively (Table 2). Applications of N_2 schedule must have helped in vigorus growth of plant as reflected by higher plant height, chlorophyll content and dry matter accumulation and contribute much to the developing sink and thereby increased the yield. 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 other nitrogen scheduling treatments [6, 9].

Nutrient content

Comparing both the cultivars for N, P and K nutrients, CSH 16 recorded significantly higher N, P and K content in grain and stover at harvest (Table 2). The increase in nitrogen, phosphorus and potassium content were by 3.60, 3.30 and 5.13% in grain and 11.06, 5.39 and 3.05% in stover, respectively over CSV 20. The improvement in nutrient status of plant under different cultivars might be due to their genetic makeup. It is generally believed that the plant extracted nutrients are responsible for maintaining their critical concentration that can be used for plant growth or development structures. Thus, the greater availability of nutrient with CSH 16 seems to have critical concentration at cellular level and fulfilled their requirements for profuse plant growth and their efficient translocation towards sink. The significant increase in N, P and K content of grain and stover at harvest seems to be on account of capabilities of cultivar for efficient absorption, translocation and utilization of mineral nutrients more over the increased dry matter accumulation, subscribe to the view that there was adequate supply of metabolites from root to shoot. This might have facilitated better root growth thus higher extraction of nutrients from soil environment [3, 10].

Similarly, application of nitrogen as 50% at sowing as basal + 25% at 30 DAS + 25% at boot leaf stage significantly enhanced N, P and K uptake in grain and stover compared to rest of the nitrogen scheduling treatments (Table 2). It is generally believed that in plant system extracted nutrients are used for maintaining their critical concentration, which can be used for growth of developing structures. Thus greater availability of nitrogen seems to have synergistic interactions between these nutrients particularly primary nutrients (NPK) for maintained critical concentration at cellular level, fulfilled their requirements for profuse plant growth and their efficient translocation towards sink components [11, 12].

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