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Growth Response, Content and Uptake of Nutrients by Different Forage Sorghum Varieties (*Sorghum bicolor* (L.) Moench) as Influenced by Nitrogen and Zinc Fertilization

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ABSTRACT

Forage sorghum grown on sandy loam soil responded to nitrogen and zinc application. The response for green forage yield was more to Zn application (8 to 12%) than N (6.8 to 7.0%). However, in case of dry matter yield, the response to Zn application (11 to 13%) was almost equal to N application (9 to 11%). Among different fertilizer combinations, 80 kg N/ha alongwith 2.5 kg Zn/ha produced maximum forage yield. Genotype AS-15 gave significantly higher green forage as well as dry matter yields than M. P. Chari and X-988. It also removed the highest amount of all the nutrients. Application of nitrogen to forage sorghum significantly influenced uptake of N and P as well as content and uptake of Zn and Fe. Zinc application significantly increased the uptake of K and Zn by sorghum but depressed the per cent composition as well as uptake of N and P. It also depressed the content of Fe but increased the uptake of Fe at 2.5 kg Zn/ha application.

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INTRODUCTION

Jower (*Sorghum bicolor* (L.) Moench) is known to respond extremely well to the application of 40 to 120 kg N/ha (Desai and Deore, 1980 and Patel *et al.*, 1990). It has also been reported that dry matter production of forage sorghum varieties increased due to application of zinc sulphate in the soil (Hegde and Relwani, 1974 and Patel and Patel, 1988). Dangarwala *et al.* (1983) reported Zn status of soil of Kheda district (Gujarat) as deficient in 14%, medium in 43% and sufficient in 43% of soils. Zinc deficiency not only adversely affects plant growth but also impairs health of milch animals indirectly. The use of nitrogen fertilizer alongwith Zn may play a significant role in increasing the availability of Zn (applied as well as native) by acidifying effect and thereby forage yield. In this context, a field experiment was conducted on different varieties of forage sorghum at Forage Research Farm, Gujarat Agricultural University, Anand.

MATERIALS AND METHODS

A field experiment with three different forage sorghum genotypes (M. P. Chari, Pioneer Hybrid X-988 and AS-15), three nitrogen levels (60, 80 and 100 kg N/ha as

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urea) and three zinc levels (0, 2.5 and 5.0 kg Zn/ha as $ZnSO_4$) was conducted in a split-split plot design on sandy loam soil (alluvial type) of Forage Research Project Farm, GAU, Anand during *kharif* season. The soil was low in available N (149 kg/ha), sufficient in available phosphorus (60 kg P_2O_5/ha) and medium in potassium (152 kg K_2O/ha). The DTPA extractable Fe, Mn, Cu and Zn were 14.5, 22.3, 1.5 and 0.63 ppm, respectively. A basal dose of 30 kg P_2O_5/ha, 25 kg K_2O/ha, half of the total N and whole amount of zinc as per treatments were applied at the time of sowing and remaining N as top-dressing after one month of sowing.

The crop was harvested at 50% flowering and yield attributing characters and yields were recorded. The soil and plant samples from each plot after harvest were also analysed for their nutrient contents by following the standard procedures (Jackson, 1967).

RESULTS AND DISCUSSION

Green forage and dry matter yield

The results (Table 1) indicated that genotype AS-15 produced significantly higher green forage (31 and 21%) and dry matter (19 and 9%) yields than genotypes M. P. Chari and X-988. Genotypes AS-15 produced higher forage yield due to more plant height and stem

TABLE 1

Effect of nitrogen and zinc on vegetative growth and yield of forage sorghum.

Treatments	*Plant height (cm)*	*Stem thickness (mm)*	*Yield (q/ha)*	
			Green forage	*Dry matter*
Genotype				
M. P. Chari	289.3	6.54	402	128.6
X-988	252.5	7.88	437	79.6
AS-15	367.0	12.05	528	153.2
C. D. at 5%	14.8	0.63	30	12.9
Nitrogen (kg/ha)				
60	292.9	8.36	435	113.2
80	305.2	8.98	466	125.3
100	310.0	9.12	465	122.8
C. D at 5%	12.0	0.45	26	8.0
Zinc (kg/ha)				
0	296.1	8.65	428	111.8
2.5	311.5	9.23	478	123.7
5.0	300.4	8.88	460	125.8
C. D at 5%	9.8	0.45	19	6.8

thickness as compared to that of X-988 and M. P. Chari. The genotype X-988 produced less dry matter yield due to higher moisture percentage (82) as compared to M. P. Chari (68) and AS-16 (71).

Application of 80 and 100 kg N/ha resulted in significantly increased the plant height and thickness of stem and thereby green forage (7 and 6.8%) and dry matter (11 and 9%) yields over 60 kg N/ha (Table 1). This can be ascribed to low availability of N (149 kg/ha) in the soil. The results are in agreement with those reported at Anand Centre (Patel *et al.*, 1990).

Application of 2.5 and 5.0 kg Zn/ha significantly increased the green forage (12 and 8%) and dry matter (11 and 13%) yields over no zinc as the soil contained available zinc just at marginal level (0.63 ppm). The vegetative growth of sorghum plant increased significantly at 2.5 kg Zn/ha level as compared to no zinc and hence resulted in higher yields. However, further increase in zinc application (5.0 kg Zn/ha) slightly reduced the yield, it might be due to imbalance in nutrition. The results are in accordance with those reported by Hegde and Relwani (1974) and Patel and Patel (1988).

Content and uptake of nutrients

Genotype X-988 was found to have significantly higher content of nutrients N, P, K, Zn and Fe than M. P. Chari and AS-15 (Table 2) while genotype AS-15 removed the highest amount of all the nutrients (Table 3). This can be ascribed to highest dry matter yield recorded with genotype AS-15.

TABLE 2

Effect of nitrogen and zinc on nutrients content in forage sorghum.

Treatments	*N (%)*	*P (%)*	*K (%)*	*Fe (ppm)*	*Zn (ppm)*
Genotype					
M. P. Chari	0.66	0.17	1.5	164.19	18.92
X-988	1.05	0.24	2.9	340.35	25.20
AS-15	0.71	0.17	2.0	236.35	22.38
C. D. at 5%	0.09	0.04	0.54	11.39	2.31
Nitrogen (kg/ha)					
60	0.77	0.19	2.15	229.45	19.89
80	0.82	0.19	2.13	247.76	24.96
100	0.82	0.19	2.19	263.69	21.66
C. D. at 5%	NS	NS	NS	17.67	2.41
Zinc (kg/ha)					
0	0.90	0.21	2.15	265.67	21.34
2.5	0.76	0.18	2.16	244.82	23.51
5.0	0.75	0.18	2.16	230.41	21.66
C. D. at 5%	0.06	0.01	NS	13.61	NS

TABLE 3

Effect of nitrogen and zinc on uptake of nutrients by forage sorghum.

Treatments	*Uptake of nutrients*				
	(kg/ha)			*(g/ha)*	
	N	*P*	*K*	*Fe*	*Zn*
Genotype					
M. P. Chari	85.0	21.7	197.7	2103.1	243.2
X-988	83.2	18.7	230.9	2702.4	200.7
AS-15	105.0	25.4	225.5	3616.1	346.8
C. D. at 5%	14.0	5.5	72.4	418.8	13.7
Nitrogen (kg/ha)					
60	83.7	20.4	231.3	2439.6	222.5
80	96.8	22.6	254.1	2958.7	311.7
100	92.5	22.8	251.8	3023.2	256.7
C. D at 5%	7.5	1.8	NS	299.8	28.3
Zinc (kg/ha)					
0	95.7	22.3	229.7	2812.6	233.3
2.5	90.7	21.7	251.6	2865.2	288.0
5.0	86.8	21.7	255.7	2743.7	269.3
C D at 5%	NS	NS	17.7	NS	31.0

The data presented in Table 2 reveal that nitrogen content in sorghum increased with increasing the level of nitrogen. Similar results were also obtained by Patel *et al.* (1990). The differences in P and K contents did not reach to the level of significance due to the application of nitrogen.

There was significant influence of nitrogen application on micronutrient concentration in sorghum (Table 2). The highest content of Fe was recorded at 100 kg N/ha, while Zn content was highest at 80 kg N/ha. This can be ascribed to acidifying effect of nitrogen fertilizer and thereby increase in the availability of soil native iron and zinc as evident by data reported in Table 4 (Giordano *et al.*, 1966; Lncas and Davis, 1961). However, with further increase in nitrogen level i.e. 100 kg N/ha, Zinc content slightly decreased as compared to 80 kg N/ha. It can be attributed to possible retention of Zn in root as Zn-protein complex (Satinder and Shukla, 1980).

Application of 2.5 or 5.0 kg Zn/ha significantly decreased the nitrogen content of sorghum as compared to no zinc. This can be attributed to dillution effect of increased dry

TABLE 4

Effect of nitrogen and zinc application on availability of Zn and Fe (ppm) in post harvest soil.

Available nutrient	Nitrogen level (kg/ha)			Zinc level (kg/ha)			C. D. (5%) N or Zn levels
	60	80	100	0	2.5	5.0	
Zn	0.69	0.75	0.78	0.46	0.82	0.95	0.07
Fe	8.30	8.67	8.93	8.91	8.50	8.50	0.33

matter yield (Rajagopal and Mehta, 1971). The phosphorus content was reduced significantly from 0.21 to 0.18 per cent due to application of zinc. This can be ascribed to antagonism between phosphorus and zinc in plants (Boawn and Brown, 1968). The differences in content of K and Zn did not reach to the level of significance due to the application of zinc. The Fe content of sorghum reduced significantly with the increased rate of zinc. This might be due to antagonism between Zn and Fe. The results are in accordance with those observed by Rajagopal and Mehta (1971) in corn.

The removal of N and P by the crop were 16 and 11 per cent higher with the application of 80 kg N/ha than 60 kg N/ha (Table 3). This can be attributed to higher dry matter production at higher levels of nitrogen. The uptake of K was not altered significantly with applied N. Sorghum crop removed 21 and 24 per cent higher Fe and 40 and 15 per cent higher Zn, respectively at 80 and 100 kg N/ha as compared to 60 kg N/ha. The increase in Fe and Zn uptake were mainly because of additive effects of both increase in dry matter yield and content of Fe and Zn in forage sorghum with the increase in the rate of nitrogen application.

Application of 2.5 and 5.0 kg Zn/ha increase dry matter yield significantly over no zinc. However, the removal of N and P were not influenced significantly due to zinc application as the concentration of both the nutrients were reduced significantly (Table 2). The application of 2.5 or 5.0 kg Zn/ha significantlyincreased the potash uptake over no zinc as dry matter production was increased by zinc application. The increase in Zn uptake by the crop was mainly because of additive effects of both increase in dry matter yield as well as Zn content with the application of zinc (Rajagopal and Mehta, 1971). Uptake of Fe was not altered significantly by the application of zinc as Fe content was reduced significantly by the application of zinc.

The interaction effect of genotype and nitrogen on content and uptake of N and Zn by sorghum was significant (Table 5). Application of 100 kg N/ha to sorghum genotype X-988 showed significantly higher N content than other interactions except X - 988 x 80 kg N/ha.

TABLE 5

Interaction effect of genotype and nitrogen on content and uptake of nitrogen and zinc by forage sorghum.

Nitrogen level (kg/ha)	Nitrogen (%)			Zinc (ppm)		
	M. P. Chari	X-988	AS-15	M. P. Chari	X-988	AS-15
60	0.60 (71.9)	0.95 74.7	0.76 (104.4)	18.4 (220.6)	22.0 (173.1)	19.3 (273.7)
80	0.67 (87.0)	1.08 (88.1)	0.71 (115.6)	18.6 (241.9)	28.0 (228.4)	28.3 (464.6)
100	0.71 (963)	1.10 (86.6)	0.65 (94.7)	19.8 (267.1)	25.6 (200.3)	19.6 (302.4)
C D (5%)		0.11 (13.00)			4.20 (49.20)	

Figures in parentheses indicate uptake of N (kg/ha) and Zn (q/ha).

Application of 80 kg N/ha to sorghum genotype AS-15 removed maximum nitrogen than other interactions. Similarly same genotype recorded the maximum Zn content (28.3 ppm) and Zn uptake (464.6 q/ha) at 80 kg N/ha.

This study indicated that genotype AS-15 with the application of 80 kg N/ha alongwith 2.5 kg Zn/ha increased green forage, dry matter among the three varieties of forage sorghum which ultimately resulted in larger removals of nutrients from the soil.

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