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GROWTH INDICES AND NUTRIENT UPTAKE OF FODDER MAIZE (*ZEA MAYS* L.) AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT

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SUMMARY

A field experiment was conducted at Research Farm Area of Forage Section, Department of Genetics & Plant Breeding, CCS Haryana Agricultural University, Hisar during **kharif** 2010. The experiment was carried out in randomized block design with ten treatments viz., Control, seed treatment with *Azotobacter*, 100 per cent N through FYM, 100 per cent RDF, 75 per cent RDF+*Azotobacter*, 75 per cent RDF+25 per cent N through FYM, 75 per cent RDF+25 per cent N through FYM+*Azotobacter*, 50 per cent RDF+*Azotobacter*, 50 per cent RDF+50 per cent N through FYM and 50 per cent RDF+50 per cent N through FYM+*Azotobacter*. The growth indices Leaf Area Index and crop growth rate were observed significantly higher with 100 per cent RDF followed by 75 per cent RDF+25 per cent N through FYM+*Azotobacter*. Availability of N, P and K in the soil under most of the treatments decreased after the crop harvest than before the sowing of the crop. The highest NPK status in the soil after the harvest of crop was recorded in the treatment 100 per cent N through FYM.

Key words : Maize, leaf area index (LAI), crop growth rate (CGR), *Azotobacter*, NPK uptake

INTRODUCTION

Maize or corn (*Zea mays* L.) is one of the most important cereal crops of the world used as food and feed. Although maize fodder has low protein content but it is relished by the animals due to being succulent and palatable (Ali *et al*., 2004). The maize fodder plays a vital role in increasing the productivity of the livestock and making this enterprise more profitable. The crop has an edge over cultivated fodder crops due to its adaptability and excellent fodder quality and usage in the form of silage. Since the nutrient turnover in soil-plant system is considerably high under intensive cropping system, neither the chemical fertilizer alone plays an important role in forage production nor the organic/biological sources alone can achieve production sustainability. The approach of nutrient management aims at efficient and judicious use of all the major sources of plant nutrients in an integrated manner, so as to get maximum economic yield without any deleterious effect on physico-chemical and biological properties of the soil. Even with balanced use of NPK fertilizer on long term basis, high yield level could not be maintained over the years because of deficiencies of secondary as well as micronutrients and deterioration in soil physical health. An integrated use of inorganic and biofertilizers should be opted for maximizing economic yield and to improve soil health (Syed Ismail *et al*., 2001). The chemical fertilization of crops involves high cost, whereas biofertilizers are cheaper, renewable and contribute to development of strategies which do not lead to rise in consumption of non-renewable form of energy. Now-a-days emphasis is being given to bacterial fertilization in forage crops through utilization of efficient nitrogen fixing strains of *Azotobacter chroococcum*. This non-symbiotic nitrogen fixing bacteria is also known to produce growth promoting substances which help in biomass production (Sushila and Giri, 2000). Application of organic manures is known to improve the soil fertility and productivity (David and Biswas, 1996) but their low nutrient content becomes a barrier for its use as they cannot meet the huge requirement of crop, if used alone. Application of biofertilizers like *Azotobacter* along with fertilizer nitrogen not only fixes the atmospheric nitrogen but also provided favourable environment for root growth by increasing the nutrient availability. Integrated nutrient supply involving use of organic manures can maintain the productivity of the crops. Thus, it becomes imperative to substitute nutrients requirement of maize by organic sources in order to maintain soil health as well as higher tonnage of good quality forage.

MATERIALS AND METHODS

The field experiment was conducted at Research Farm Area of Forage Section, Department of Genetics & Plant Breeding at CCS Haryana Agricultural University, Hisar during **kharif** 2010 in randomized block design with 10 treatments viz., Control, *Azotobacter*, 100 per cent N through FYM, 100 per cent RDF, 75 per cent RDF+*Azotobacter*, 75 per cent RDF+25 per cent N through FYM, 75 per cent RDF+25 per cent N through FYM+*Azotobacter*, 50 per cent RDF+*Azotobacter*, 50 per cent RDF+50 per cent N through FYM and 50 per cent RDF+50 per cent N through FYM+*Azotobacter*. The soil of experimental field was sandy loam in texture, slightly alkaline in reaction (8.3), low in organic carbon (0.38%) and available nitrogen (156.2 kg/ha), medium in available phosphorus (11.1 kg/ha) and available potassium (210.5 kg/ha). The whole quantity of well decomposed FYM was mixed in the soil one month before sowing of the crop. Full dose of phosphorus (Single super phosphate) and half dose of nitrogen through urea were applied as a basal dose at the time of sowing and remaining half dose was top dressed at 28 days after sowing as per the treatments. The seed of the plots having biofertilizers treatment were inoculated with *Azotobacter chroococcum* culture (HT-54) using 10 per cent sugar syrup so that the cultures may adhere well on the seeds. Maize variety African Tall was sown by *'pora'* method with hand plough in rows 30 cm apart using a seed rate of 75 kg seed/ha. Leaf and stem weights were recorded per plant separately at the time of harvesting and their ratio was calculated. The leaf area index (LAI) is the ratio between leaf area to ground area.. The mean leaf area per plant from the freshly harvested three plants was taken and divided by ground area per plant to determine the leaf area index .Crop growth rate (g/m^2/day**)** represents the dry weight gained by plant material per unit of time. It is calculated by the formula i. e. crop growth rate (CGR) = W_2-W_1 / T_2-$T_{1,}$ Where, W_1 and W_2 are dry weight of plant (g) from a given land at time T_1 and T_2, respectively, where, T_2 and T_1 are interval of observation (days).

The composite soil samples from 0-15 cm depth were analyzed before sowing and after harvesting for determining the available nitrogen, phosphorus and potassium. Available N in soil was determined according to alkaline permanganate method described by Subbiah and Asija (1956). Available P in soil was determined by Olsen's method (Jackson, 1973). Available K in soil was extracted by neutral normal ammonium acetate and estimated by flame photometer (Piper, 1966).

RESULTS AND DISCUSSION

The perusal of the data in Table 1 reveals that the leaf : stem at successive stages of crop growth declined with the advancement in the age of crop up to harvest. The maximum leaf : stem was observed in the treatments 100 per cent RDF and 75 per cent RDF+25% N through FYM+*Azotobacter* which were statistically at par but remained significantly superior to all the other treatments. The minimum leaf : stem was observed in the control and *Azotobacter* alone treatments which remained at par during all the periods of observations. With the advancement of crop age, there was a corresponding increase in leaf area index (LAI) upto harvest. The LAI was maximum in 100% RDF through inorganic fertilizer (1.86, 3.77, 5.63 and 6.44 at 30 DAS, 45 DAS, 60 DAS and at harvest, respectively) and it was follwed by 75% RDF + 25% N through FYM+ *Azotobacter* treatments. LAI was statistically at par in 50% RDF + 50% N through FYM+ *Azotobacter*, 50% RDF + 50% N through FYM, 75% RDF + *Azotobacter* and 100% N through FYM treatments at various stages of crop growth except at 30 DAS. LAI was statistically at par in Control and *Azotobacter* treatments at 45 DAS, 60 DAS and at harvest . The magnitude of increase in LAI was higher between 45 and 60 DAS as compared to other periods of observation (Table 1). Crop growth rate (CGR) increased up to 30-45 DAS and declined thereafter irrespective of the treatments. All the fertility treatments produced significantly superior CGR over the control. The crop growth rate enhanced significantly with the use of 100 per cent RDF through inorganic fertilizer over other treatments and it was follwed by 75 per cent RDF+25 per cent N through FYM+*Azotobacter* treatment at all the stages of crop growth. The treatments 50 per cent RDF+50% N through FYM+*Azotobacter*, 50 per cent RDF+50 per cent N through FYM, 75 per cent RDF+*Azotobacter* and 100 per cent N through FYM

TABLE 1

Periodic leaf: stem ratio and leaf area index of forage maize as influenced by integrated nutrient management

Treatments	Leaf : stem				Leaf area index			
	Days after sowing				Days after sowing			
	30	45	60	At harvest	30	45	60	At harvest
Control	0.64	0.54	0.37	0.29	1.52	2.78	4.20	4.56
Azotobacter	0.65	0.56	0.39	0.31	1.57	2.82	4.36	4.81
100% N through FYM	0.77	0.68	0.46	0.35	1.73	3.31	5.03	5.68
100% RDF through inorganic fertilizer	0.88	0.81	0.55	0.41	1.86	3.77	5.63	6.44
75% RDF+*Azotobacter*	0.78	0.70	0.47	0.36	1.75	3.37	5.05	5.74
75% RDF+25% N through FYM	0.83	0.78	0.50	0.38	1.79	3.51	5.24	5.96
75% RDF+25% N through FYM+*Azotobacter*	0.86	0.79	0.53	0.40	1.84	3.70	5.45	6.34
50% RDF+*Azotobacter*	0.68	0.62	0.41	0.33	1.64	3.01	4.63	5.08
50% RDF+50% N through FYM	0.81	0.70	0.48	0.36	1.75	3.41	5.07	5.83
50% RDF+50% N through FYM+*Azotobacter*	0.82	0.71	0.49	0.37	1.77	3.44	5.13	5.86
C. D. (P=0.05)	0.04	0.15	0.03	0.02	0.07	0.22	0.38	0.46

TABLE 2

Periodical changes in crop growth rate, green fodder and dry matter yield of forage maize as influenced by integrated nutrient management

Treatment	CGR ($g/m^2/day$)				Green fodder yield (q/ha)	Dry matter yield (q/ha)
	0-30 DAS	30-45 DAS	45-60 DAS	60-At harvest		
Control	0.85	4.97	3.48	2.11	238.0	63.1
Azotobacter	0.86	4.99	3.50	2.19	253.0	67.3
100% N through FYM	1.08	5.56	3.84	2.61	380.0	95.1
100% RDF through inorganic fertilizer	1.33	6.18	4.36	2.80	460.0	114.2
75% RDF+*Azotobacter*	1.10	5.60	3.97	2.63	387.0	96.0
75% RDF+25% N through FYM	1.23	5.89	4.09	2.71	426.0	105.1
75% RDF+25% N through FYM+*Azotobacter*	1.27	6.11	4.29	2.76	443.0	109.8
50% RDF+*Azotobacter*	0.97	5.27	3.60	2.45	300.0	77.2
50% RDF+50% N through FYM	1.14	5.66	4.01	2.66	398.0	97.5
50% RDF+50% N through FYM+*Azotobacter*	1.16	5.72	4.05	2.67	408.0	100.8
C. D. (P=0.05)	-	-	-	-	10.4	2.7
					31.2	8.1

were statistically at par but significantly superior in CGR than the rest of the treatments. The least CGR was recorded in control followed by *Azotobacter* inoculation. The increase in LAI and CGR with the increase in fertility levels was also reported by Jayaparkash *et al.* (2005).

The green fodder and dry matter yields of maize were significantly higher with the use of 100 per cent RDF (T_4) than the other treatment except treatment, T_7 where 75 per cent RDF+25 per cent N through FYM+*Azotobacter* (Table 2). Maximum fodder yield (460 q/ha) was recorded with the application of 100 per cent RDF (T_4) followed by 75 per cent RDF+25 per cent N through FYM+*Azotobacter* having yield (443 q/ha) and it was 93.2 and 86.1 per cent higher over the control (238 q/ha). The corresponding values for dry matter were 80.9 and 74.0 per cent higher over the control. The beneficial response of 100 per cent RDF to various yield studies could be ascribed due to favourable effect of growth characters, namely, plant height and dry matter accumulation and physiological parameters (LAI and CGR). The significant increase in fodder yield with increase in fertility levels could be attributed to conducive effect on root and shoot growth of plant which in turn accrued from increased morphological parameters viz., plant height and LAI. The results of present investigation are in close agreement with the findings of Sheoran and Rana (2005).

The NPK content in forage maize was significantly improved with the application of fertilizers in any from over the control. The maximum NPK content was observed in the treatment 100 per cent RDF, followed by treatment T_3 (100% N through FYM). The improvement of plant nutrient status of plant under FYM application might have increased absorption of nutrients and efficient translocation towards the plant system during vegetative growth. The increased concentration of mentioned nutrients at harvest of the crop was expected due to translocation of nutrients present in vegetative parts to the storage organs. It is generally believed that in plant extracted nutrients are used for maintaining their critical concentration that can be used for plant growth or developing structures (Kumar and Thakur, 2004).

The higher uptake of NPK under treatment 100 per cent RDF was mainly due to good nutrient concentration (Table 3) and higher dry matter yield (Table 2). The increase in NPK uptake with fertilizer application was also reported by Harikrishan *et al.* (2005). The residual status of nitrogen, phosphorus and potassium in soil decreased under most of the treatments except 100 per cent N through FYM, 100 per cent RDF through inorganic fertilizer and 75% RDF+25% N through FYM+*Azotobacter* after the crop harvest than before the sowing of the crop (Table 4). The extent of decrease was less when nutrient supply was made practically through inorganic sources in combination with organic sources as compared to chemical fertilizers alone.

TABLE 3

Effect of integrated nutrient management on NPK content (%) and its uptake in forage maize

Treatment	N (%)	N uptake (kg/ha)	P (%)	P uptake (kg/ha)	K (%)	K uptake (kg/ha)
T_1–Control	0.74	46.7	0.10	6.3	1.06	66.8
T_2–*Azotobacter*	0.78	52.4	0.11	7.4	1.07	72.0
T_3–100% N through FYM	1.08	102.7	0.14	13.3	1.15	109.3
T_4–100% RDF through inorganic fertilizer	1.10	125.6	0.16	18.2	1.09	125.4
T_5–75% RDF+*Azotobacter*	0.92	88.3	0.13	12.4	1.08	103.6
T_6–75% RDF+25% N through FYM	0.97	101.9	0.14	14.7	1.11	116.6
T_7–75% RDF+25% N through FYM+*Azotobacter*	1.05	115.3	0.15	16.4	1.12	122.9
T_8–50% RDF+*Azotobacter*	0.80	61.7	0.11	8.5	1.07	82.6
T_9–50% RDF+50% N through FYM	0.95	92.6	0.13	12.6	1.12	109.2
T_{10}–50% RDF+50% N through FYM+*Azotobacter*	1.03	103.8	0.14	14.1	1.13	113.9
S. Em±	0.02	3.4	0.01	0.33	0.02	2.5
C. D. (P=0.05)	0.07	10.7	0.03	0.97	0.06	7.1

TABLE 4

Available N, P and K (kg/ha) in soil after harvest of maize as influenced by integrated nutrient management

Treatment	Available N	Available P	Available K
Control	151.3	10.2	206.0
Azotobacter	152.2	10..4	206.5
100% N through FYM	158.2	11.9	212.0
100% RDF through inorganic fertilizer	155.0	11.6	208.2
75% RDF+*Azotobacter*	153.7	11.2	207.3
75% RDF+25% N through FYM	155.3	11.3	210.4
75% RDF+25% N through FYM+*Azotobacter*	156.3	11.5	210.6
50% RDF+*Azotobacter*	153.1	10.8	206.7
50% RDF+50% N through FYM	156.6	11.5	211.4
50% RDF+50% N through FYM+*Azotobacter*	157.6	11.7	210.5

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