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Studies on different levels and sources of nitrogen in augmenting the growth, yield and economics of fodder maize (*Zea mays* L.)

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Abstract

A field trail was conducted to determine the studies on different levels and sources of nitrogen on growth and yield of fodder maize (*Zea mays* L.) at Srinivaspur village, Amanikere, Kolar district, Eastern Dry Zone (Zone-5) of Karnataka State, India, during *Kharif* season (July to September - 2021). The experiment was laid out in randomized block design (RBD) with three replications. Among the various treatments evaluated, application of T_{10} - 180 Kg N ha^{-1} supplied through 50% as urea + 50% as poultry manure + 60:40 Kg of P_2O_5 and K_2O ha^{-1} recorded the maximum plant height (247.76 cm), number of leaves 12.06 plant^{-1}, leaf length (90.90 cm), leaf width (7 cm), leaf stem ratio (LSR) (0.69) and dry mater production (DMP) (12.38 t ha^{-1}), yield characters *viz.*, green fodder yield (GFY) (54.92 t ha^{-1}) and green fodder production efficiency (7.12 q ha^{-1} day^{-1}), and it was on par with T_{11} - 180 Kg N supplied through 50% as urea + 50% as sheep manure + 60:40 Kg of P and K ha^{-1}. Economics *viz.*, gross returns (Rs. 1,64,762 ha^{-1}), net returns (Rs. 1,07,332 ha^{-1}) and B: C ratio of 2.86 with (T_{10}). The lowest gross returns (Rs.89,559 ha^{-1}), net returns (Rs. 25,387 ha^{-1}) and B: C ratio of 1.39 with T_5 - 150 Kg N ha^{-1} as sheep manure + 60:40 Kg of P and K ha^{-1}. Results indicate that combination of inorganic and organic manure (T_{10}) have a significantly greater influence than other treatments.

Keywords: nitrogen, poultry manure, sheep manure, growth, yield and economics.

Introduction

Among the cultivated annual cereal fodder crops, maize is one of the most versatile and multi utility crops having wider adaptability in diverse ecologies. Globally it is known as Queen of cereals because of its highest genetic potential. Maize is the most important fodder crop in the world because of its high yield, high energy forage productivity than that of the other forage crops (Kumar *et al*., 2021) [13]. Maize being one of the most adaptable emerging crops having wider adaptability under varied agro-climatic conditions has been proved and preferred in terms of green fodder quality and silage making as it provides very palatable, highly succulent, digestible, and nutritionally rich fodder to livestock which is free from anti-metabolites (Kumar *et. al*., 2020) [12].

It contains 9-10 per cent crude protein, 32.52-33.49 per cent crude fibre, 60-64 per cent neutral detergent fibre, 38-41 per cent acid detergent fibre, 28-30 per cent cellulose and 23-25 per cent hemi cellulose on dry matter basis when harvested at milk to early dough stage. It can be fed as green or dry and makes excellent silage (Sunil Kumar *et al.*, 2012) [24]. Fodder maize being a C_4 plant, is very efficient in converting solar energy into dry matter. As a heavy feeder of nutrients, fodder maize productivity is largely dependent on nutrient management. In order to obtain higher crop productivity, management of nutrients through application of organic manure and inorganic fertilizers is an important consideration (Biswasi *et al*., 2020) [6]. The present availability of green fodder is 585 m.t and 494 m.t of dry fodder (Anonymous, 2013) [2]. The livestock population is increasing @ 1.23 per cent per annum, raising the livestock population approximately to 535.78 million in the country resulting in an increase of 4.6 per cent over the livestock census of 2012. Karnataka is the 9th largest state in cattle and buffalo population in the country, accounting for 29 million and it is 4.7 per cent of the total population (GOI 2019, DAHD). In Karnataka, area under cultivation of fodder crops is 3.65 lakh ha while the availability of green fodder is 85 m.t and dry fodder 15 m.t. Demand for green fodder was estimated to be 122 m.t and dry fodder 25.4 m.t per annum (Shekara *et al*., 2019) [21].

To meet the fattening livestock, India would require 855 m.t of green fodder, 526 m.t of dry fodder and 56 m.t of feed concentrates. By 2050, the demand for green and dry fodder would be 1012 and 631 m.t, respectively and at the current level of growth in forage resources, there will be 18.4 per cent shortfall deficit in green fodder and 13.2 per cent deficit in dry fodder in the year 2050 (Anonymous, 2013) [2]. The gap in demand and supply may further rise due to consistent growth of livestock population @ 1.23 per cent in the coming years and the demand of green forage supply must rise @ 1.69 per cent per annum to satisfy the deficit; however, the area under cultivated fodder accounts for only 4 per cent of the total cultivated land (8.4 m.ha) in the country, and has remained unchanged over the last few decades (Dagar *et al*., 2017; Halli *et al*., 2018; Meena *et al.*, 2018) [8, 11, 16].

Nitrogen is a primary nutrient required by crop plants for their growth and development. It plays a key role in vegetative growth of maize plants. The application of nitrogen not only affects the forage yield of maize, but also improves its quality, mostly its protein content. Application of nitrogen to maize increased growth characters, yield characters and quality characters by increasing nitrogen levels (Aziz Khan *et al.*, 2014; Manjunatha *et al*., 2017) [5, 15]. Integrating chemical fertilizer and organic manure is advantageous in enhancing the availability of nitrogen, phosphorus and potassium in plants, improving soil fertility and productivity on a sustainable basis. These improved soil properties and nutrient availability enhanced the fresh and dry biomass production and improved the crop growth (Rajashekhara Rao *et al*., 2010) [18].

Materials and Methods

A field experiment entitled 'studies on different levels and sources of nitrogen in augmenting the growth and yield of fodder maize *(Zea mays* L.)' was conducted at Srinivaspur village, Amanikere, Kolar district, Eastern Dry Zone (Zone - 5) of Karnataka State, India, during *Kharif* season (July to September - 2021). Geographically this site is situated at 13^0 33′ N latitude and 78^0 21′ E longitude with an altitude of +819 m above mean sea level. The soil of experimental field was sandy loam in texture and neutral pH of 7.7. Electrical conductivity was 0.20 dSm^{-1} with an organic carbon content of 0.37%. Available nitrogen was low (110 kg N ha^{-1}), phosphorus was medium (20.5 P_2O_5 ha^{-1}) and potassium was medium (202.5 K_2O ha^{-1}). The fodder maize (cv. African Tall) was used as test crop and dibbled by adopting a spacing of 60 × 10 cm. The organic nutrient sources used were poultry manure (PM) and sheep manure (SM) whereas the inorganic sources were urea, single super phosphate (SSP) and muriate of potash (MOP). The experiment was laid out in Randomized Block Design (RBD) with three replications and eleven treatments. Treatments involving a combination of various nutrients from different sources (organic and inorganic) were used which include: T_1 - 120:60:40 kg of NPK ha^{-1} (RDF), T_2 - 150:60:40 kg of NPK ha^{-1}, T_3 - 180:60:40 kg of NPK ha^{-1}, T_4 - 150 kg N ha^{-1} as poultry manure + 60:40 kg of P and K ha^{-1}, T_5 - 150 kg N ha^{-1} as sheep manure + 60:40 kg of P and K ha^{-1}, T_6 - 180 kg N ha^{-1} as poultry manure + 60:40 kg of P and K ha^{-1}, T_7 - 180 kg N ha^{-1} as sheep manure + 60:40 kg of P and K ha^{-1}, T_8 - 150 kg N ha^{-1} supplied through 50% as urea + 50% as poultry manure + 60:40 kg of P and K ha^{-1}, T_9 - 150 kg N ha^{-1} supplied through 50% as urea + 50% as sheep manure + 60:40 kg of P and K ha^{-1}, T_{10} - 180 kg N ha^{-1} supplied through 50% as urea + 50% as poultry manure + 60:40 kg of P and K ha^{-1} and T_{11} -180 kg N ha^{-1} supplied through 50% as urea + 50% as sheep manure + 60:40 kg of P and K ha^{-1}. The total treatment combinations were 33, each treatment combination was laid out on plot area of 5.4 m × 4 m = 21.6 m^2 and net plot area 4.2 m × 3.8 m.

Observations on growth characters *viz*., plant height (cm), number of leaves $plant^{-1}$, leaf length (cm), leaf width (cm), leaf stem ratio (LSR) and dry matter production (DMP) (t ha^{-1}) were observed from randomly selected five tagged plants in each treatment and the average values of each treatment was calculated and tabulated. Yield characters *viz*., green fodder yield (GFY) (t ha^{-1}) and green fodder production efficiency (q ha^{-1} day^{-1}). The green fodder yield was computed from the net plot and expressed in t ha^{-1}. Green fodder production efficiency was computed as green fodder yield divided by number of days to harvest. Economics *viz*., cost of cultivation, gross return, net return and benefit cost ratio were also worked out to evaluate the economic benefits of each treatment, based on the existing market prices of inputs and output. The statistical analysis of the field data was carried out as per the methodology given by Gomez and Gomez (1984) [10]. The critical difference were worked out at 5 per cent probability level, wherever the results were significant.

Results and Discussion

Growth characters

The results of the study clearly expressed the influence of various sources and levels of nitrogen on the growth of fodder maize, as transparent from the data on plant height, number of leaves, leaf length, leaf width, leaf stem ratio (LSR) and dry matter production (DMP), and all of the growth parameters at harvest stage of observation in Table 1.

Regarding the different levels of N tried, the remarkable response was noticed up to 180 kg N ha^{-1}; the increase in plant height compared to the 120 kg N ha^{-1} (T_1) was 17 per cent, while it was 61.4 and 39.1 per cent for LSR and DMP respectively. N is a major nutrient involved in active cell division and cell elongation, thus enhancing meristematic activity and enhanced uptake of N is likely due to better synthesis of amino acids and protein (Singh *et al*., 2015) [22]. The notable rise in growth components and vigorous vegetative growth of fodder maize may be explained by the abundant supply of N, and our finding is well validated by earlier findings of Malik and Paynter (2010) [14].

However, the maximum achievement in growth parameters was registered with INM (T_{10} and T_{11}) where 50% N of 180 kg ha^{-1} was supplied through urea and the remaining N was supplied through poultry manure or sheep manure; the increase in plant height was for a length of 247.76 cm; number of leaves 12.06 $plant^{-1}$, leaf length (90.90 cm), leaf width (7 cm), 0.69 (LSR) and 12.38 t ha^{-1} (DMP). The increase in DMP with INM (T_{10} / T_{11}) compared with organic manure application alone (sheep and poultry manure) at the same level of 180 kg N ha^{-1} (T_6 and T_7) was 36.91 per cent, while it was 11.79 per cent compared to inorganic N alone @ 180 kg N ha^{-1} as urea (T_3), thus showing the influence and benefit of integrating organic and inorganic in augmenting the growth of fodder maize. It is striking to note that the inorganic source of N alone was better than that of the organic source alone demonstrating the immediate availability of N from inorganic sources, and it is evident from the significant growth parameters with T_{10} / T_{11}, where part of N was supplied as urea. As N was readily and continuously available from both inorganic and organic sources *viz*., urea, poultry and sheep manure, the enhanced performance of growth characters in INM treatments is quite understood. Adeniyan and Ojeniyi (2003) [1] earlier reported the advantage of INM in fodder maize and endorsed our present findings.

There was a consistent increase in all the growth parameters (Sharma *et al.*, 2016) [20] with the LSR of 0.69. Rasool *et al.* (2015) [19] and Nirmal *et al.* (2016) [17] earlier showed the priming effect of organics on the release of N with higher meristematic activity, with a favourable effect on cell division and enlargement. Ayeni and Adetunji (2010) [4] also proved that sheep manure provides macro and micronutrients to the root zone, which in turn improves the soil's physical and chemical properties, respectively, in better photosynthetic efficiency. Valadabadi and Farhani (2010) [26] showed that N was an integral part of chlorophyll and enhanced photosynthesis, and it is the fulfilment of our current findings of higher growth characters with treatments having INM at 180 kg N ha^{-1}. So many workers reported the advantage of harmonizing organics and inorganics in enhancing the various growth characteristics of fodder maize (Cheema *et al.*, 2010 on plant height; Sharma *et al.*, 2016 on LSR; Asif Iqbal *et al.*, 2014 on DMP) [7, 20, 3] and thus contribute confidence to our present findings.

Yield characters

As the yield of any crop is normally the manifestation of all growth components, the same is true, with our present finding also Table 2. The highest green fodder production efficiency of 7.12 q ha^{-1} day^{-1} was noticed with T_{10} however, on par with T_{11}, which was higher by 42 per cent compared with T_1 (120 kg N ha^{-1}). Similarly, T_{10} / T_{11} achieved the highest green fodder yield (54.92 t ha^{-1}) which was higher by 11.7 per cent compared to T_3 indicating the effectiveness of integration and response to higher levels of N. Likewise, at 150 kg N ha^{-1} (T_2), the increase with T_8 / T_9 (150 kg N ha^{-1} supplied through 50% as urea + 50% as sheep manure + 60:40 kg of P and K ha^{-1}) over T_2 was 10.5 per cent, again demonstrating the advantage of an organic source integrated with an inorganic source of N at any level. An increase of 23.2 per cent green fodder yield was noticed with T_2 over T_1 and 18.8 per cent with T_3 over T_2, thus indicating the response to incremental N. As observed in our present study, a similar growth and yield pattern was earlier reported by many authors (Adeniyan and Ojeniyi, 2003; Vasanthi and Kumaraswamy, 2000) [1, 27]. As N is a constituent of chlorophyll and an essential functionary of the growth of plants, its continuous availability during the entire duration of the crop results in higher leaf and stem growth (Subrahmanaya *et al*., 2019) [23]. In our present study, N was continuously available from an inorganic and organic source (vide Table 2), and hence a significant increase in T_{10} and T_{11} was noticed. Similar findings of the response of fodder maize were earlier demonstrated by Asif Iqbal *et al.* (2014) [3] and Sunitha Yadav *et al*. (2019) [25].

Economics

The economics for various treatments was drawn using the cost involved and market price of green fodder showed in Table 2. The total cost of cultivation varies between Rs. 59, 261 ha^{-1} to Rs. 50, 196 ha^{-1}. Among the different treatments, INM plot recorded the highest green fodder yield at 54.92 t ha^{-1} (T_{10}) registered highest gross return of Rs. 1, 64, 762 ha^{-1}, net return of Rs. 1, 07, 332 ha^{-1} and B: C ratio of 2.86. This was followed by T_{11} and in turn by T_3 which gave a gross return of Rs. 1, 64, 738 and 1, 45, 384 ha^{-1} respectively. The lowest gross returns (Rs. 89, 559 ha^{-1}) were registered with T_5. Net return from different treatments followed a similar trend as that of gross return. The highest net return of Rs. 1, 07, 332 ha^{-1} was obtained due to application of T_{10}. This was followed by T_{11} and T_3 which gave a net return of Rs. 1, 05, 476 and 94, 390 ha^{-1} respectively. The lowest net return of Rs. 25, 387 and 28, 932 ha^{-1} was registered with T_5 and T_4, respectively.

Table 1: Effect of different levels and sources of N on growth characters at harvest stage of fodder maize

Treatments	Plant height (cm)	Number of leaves (plant^{-1})	Leaf Length (cm)	Leaf width (cm)	LSR	DMP (t ha^{-1})
T_1	197.26	10.30	80.66	5.80	0.22	6.65
T_2	217.16	10.96	84.73	6.30	0.37	8.81
T_3	237.06	11.73	88.76	6.73	0.57	10.92
T_4	196.70	10.20	79.96	5.80	0.21	6.71
T_5	196.53	10.13	79.86	5.80	0.20	6.84
T_6	207.26	10.63	82.83	6.0	0.31	7.81
T_7	207.10	10.60	82.76	6.0	0.30	7.70
T_8	227.30	11.43	87.00	6.53	0.49	9.87
T_9	227.16	11.33	86.96	6.50	0.48	9.80
T_{10}	247.76	12.06	90.90	7.0	0.69	12.38
T_{11}	247.26	12.03	90.86	6.96	0.68	12.29
S.Em±	3.29	0.09	0.58	0.04	0.01	0.29
CD at 5%	9.72	0.27	1.73	0.14	0.05	0.85

Table 2: Effect of different levels and sources of N on yield characters and economics of fodder maize

Treatments	GFY (t ha^{-1})	Green fodder production efficiency (q ha^{-1} day^{-1})	Cost of cultivation (Rs.ha^{-1})	Gross returns (Rs.ha^{-1})	Net returns (Rs.ha^{-1})	B : C ratio
T_1	30.20	4.02	50196	90628	40432	1.80
T_2	39.33	5.27	50595	118008	67412	2.33
T_3	48.46	6.44	50993	145384	94390	2.85
T_4	30.08	4.02	61323	90255	28932	1.47
T_5	29.85	3.95	64172	89559	25387	1.39
T_6	34.77	4.65	63866	104329	40462	1.63
T_7	34.66	4.60	67529	104000	36470	1.54
T_8	44.13	5.77	55959	132413	76453	2.36

T_9	43.98	5.75	57475	131958	74482	2.29
T_{10}	54.92	7.12	57430	164762	107332	2.86
T_{11}	54.91	7.03	59261	164738	105476	2.77
S.Em±	1.47	0.15	-	-	-	-
CD at 5%	4.36	0.46	-	-	-	-

Green fodder cost per kg – 3 rupees

Conclusion

From the results obtained in the experiment conducted in the Eastern dry zone of Srinivaspur, Karnataka State, it may be concluded that fodder maize cv. African Tall responsed well up to 180 kg N ha^{-1} applied as 50% through urea and 50% through either poultry manure or sheep manure along with 60 kg P_2O_5 and 40 kg K_2O as SSP and MOP respectively that gave the maximum green fodder yield of 54.92 t ha^{-1} and net returns of Rs. 1, 07, 332 ha^{-1} and B: C ratio of 2.86. (T_{10}) showed best performance than all the other treatments in increasing the growth and yield characters of fodder maize.

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