



P-ISSN: 2349-8528

E-ISSN: 2321-4902

www.chemijournal.com

IJCS 2020; 8(6): 540-545

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Received: 08-09-2020

Accepted: 20-10-2020

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Enhancing productivity and quality of fodder maize through nitrogen and zinc application levels

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DOI: <https://doi.org/10.22271/chemi.2020.v8.i6h.10831>

Abstract

Field experiment was conducted at research farm, Bihar Agricultural College, Sabour, Bhagalpur (Bihar) during *Kharif*- 2015 to study the response of fodder maize to levels of nitrogen, and zinc. The experiment was laid out in Factorial Randomized Block Design with three nitrogen levels in main plot (N_1 -90 kg ha⁻¹, N_2 -120 kg ha⁻¹ and N_3 -150 kg ha⁻¹) and three zinc levels in sub plots (Zn_1 -0 kg ha⁻¹, Zn_2 -10 kg ha⁻¹ and Zn_3 -20 kg ha⁻¹) with three replications. The results of one year study, it can be concluded that, application of 150 kg N ha⁻¹ significantly increased the leaf area index, dry matter production, and chlorophyll content plant⁻¹ at different crop growth periods of fodder maize. Stem diameter showed significant and consistent increase, with increase in nitrogen application from 90 to 150 kg ha⁻¹. Crude protein content and crude protein yield showed significant increase, whereas, crude fibre content and crude fibre yield showed significant and consistent decrease up to 150 kg N ha⁻¹. The green fodder yield of fodder maize improved significantly and consistently from 449 to 506 q ha⁻¹ with increase in nitrogen level from 90-150 kg ha⁻¹. The maximum green fodder and dry fodder yield (506 and 126 q ha⁻¹) was recorded with the application of nitrogen @ 150 kg ha⁻¹. The data further revealed that, N_2 and N_3 (nitrogen levels) marked an increase of 3.75 and 11.25 % in green fodder yield over N_1 level. It is also evident from the data that application of zinc 20 kg ha⁻¹ significantly improved the green fodder and dry fodder yield of maize over 0 kg ha⁻¹ zinc application. Highest gross return (Rs.60,668 ha⁻¹) and net return (Rs.39,190 ha⁻¹) were recorded with treatment combination N150 Zn20. However, highest benefit cost ratio (1.82) was realized with treatment combination N150 Zn10.

Keywords: Crude fiber, crude protein, fodder maize, green fodder yield, nitrogen level, zinc level

Introduction

At present, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residue and 44% concentrate feed ingredients. The demand of green and dry fodder will reach to 1012 and 631 million tones of by the year 2050. The Bihar state owns 19798.75 thousands cattle and buffalo livestock in which 12231.52 thousands are cattle's and 7567.23 thousand buffaloes (DAHDF, 2014) [9]. The acreage under green forage in state is almost negligible (0.21 % of the total cultivable area). Only large farmers (< 5 %) grow any fodder, small and a marginal farmer (90 %) depends on crop residues for feeding the livestock. Further increase in the acreage of the fodder crops is not possible due to increased competition between various land uses for cultivable land. Although, shortage of animal feed and fodder is a major issue that needs to be addressed but simultaneously quality of feed and forage cannot to be ignored. Green forage availability is very important to maintain livestock health and productivity and this is particularly essential in dairy entrepreneurship where consistent and regular supply of green fodder is imperative to sustain the milk production. Green herbage in addition to energy also provides vitamins, minerals with better dry matter digestibility.

Maize (*Zea mays* L) is the most important fodder crops in the world because of its high yield, high energy forage produced minimum per unit area and time than other forage crops. It is an ideal fodder crop due to its high production potential, wider adaptability, quick growing nature, palatability and excellent fodder quality. Maize fodder is free from toxicants and can be safely fed to animals at any stage of crop growth. It is the major source of food, feed, fodder and industrial raw material and provides enormous opportunity for crop diversification and value addition. Maize being highly exhaustive crop, it demands good nutrient management.

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There are many constraints for low production and productivity of fodder maize. Maize being highly exhaustive and depletes the soil of its nutrients demands good nutrient management and poor nutrient management to fodder maize is one of the most important constraints for low productivity. Among the essential nutrients, nitrogen and zinc are the most important limiting factor for plant growth and quality. Nitrogen (N) plays a very important role in crop productivity and its deficiency is one of the major yield limiting factors for cereal production (Shah *et al.* 2003) [25]. For micronutrients like- zinc there are clearly direct linkages between the occurrence of deficiencies in soils and in animal and human nutrition (Nube and Voortman, 2006) [20]. Zinc is very important trace element for the growth and development of humans, animals, and plants. Zn has vital role in stabilization of RNA, DNA, ribosome's and is involved in the immune system of animals, deficiency of which affects the health and milk production severely. About 50% of Indian soils are deficient in Zn (Singh, *et al.* 2011) [29] causing low levels of Zn and yield losses in fodder crops and hence affecting the health of the livestock. Zinc (Zn) is an essential micronutrient and has particular physiological functions in all living systems, such as the maintenance of structural and functional integrity of biological membranes and facilitation of protein synthesis and gene expression. Therefore, method and dose of

zinc application has been tested for better quality and yield of fodder maize.

Materials and Method

Field experiment under studies on nitrogen and zinc management for fodder production of maize (*Zea mays L.*) was conducted at research farm, Bihar Agriculture collage, Sabour, Bhagalpur (Bihar) during *Kharif*- 2015.

Experimental Site

Research farm of Bihar Agriculture collage, Sabour, Bhagalpur is situated at longitude 87°2' 42'' east and latitude 25°15'40'' north at an altitude of 46 m above mean sea level in the heart of vast indo-Gangetic plains of north India. The experimental site was subtropical (humid) characterized by hot summers, mild cold winters. The mean metrological data for cropping season recorded at meteorological observatory, Bihar Agricultural University, Sabour, Mean maximum relative humidity was 95.4 to 94.1 per cent and minimum relative humidity was 87.1 to 61.6 per cent. During the crop season, the total rainfall was received is 550 mm and of which 97% was received during the 33th to 38th standard meteorological week, which coincide with the initial to grand growth phase stage of the crop (Figure 1).

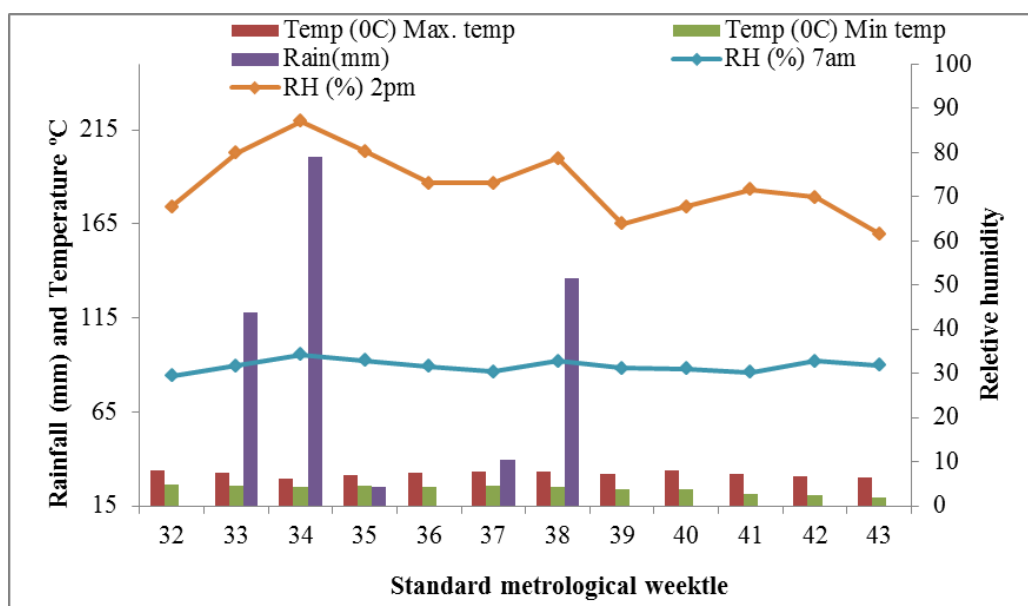


Fig. 1: Mean weekly metrological data during crop growth season of kharif-2015

Experimental details and field operations

The composite soil samples were drawn at depth of 0-15 cm before the start of experiment and collect from experimental site. The experiment was laid out in factorial randomized block design with three nitrogen levels (N_1 -90 kg ha⁻¹, N_2 -120 kg ha⁻¹ and N_3 - 150 kg ha⁻¹) and three zinc levels (Zn_1 -0 kg ha⁻¹, Zn_2 -10 kg ha⁻¹ and Zn_3 -20 kg ha⁻¹), replication thrice. The field was disc ploughed followed by two turns with tiller and one turn with rotavator to bring the soil to a fine tilth. Replication boards, path and irrigation channels were made manually. Proper leveling of plots was done before sowing of fodder maize. The plots were given uniform recommended dose of phosphorus and potassium @ of 60 and 40 kg P₂O₅ and K₂O ha⁻¹ respectively. Half dose of nitrogen, full dose of zinc sulphate as per treatment and full dose of phosphorus and potassium as per recommended package and practice was applied as basal before sowing. Remaining half dose of

nitrogen was top dressed to each plot as per treatment at knee high stage. Nitrogen, phosphorus, potassium and zinc were applied through urea, di-ammonium phosphate, muriate of potash and zinc sulphate heptahydrated (ZnSO₄. 7H₂O-22% zinc), respectively. Fodder maize variety African tall was used as test variety in this experiment. Seed was sown at a row spacing of 45 cm in each plot @ 40 kg seed ha⁻¹. Harvesting of fodder maize was done at 50 % silking of maize (leaving two crop rows from all sides of each plot). The harvested crop from each net plot was weighed separately for fresh fodder yield.

Observations recoded

Pre harvest studies

The various plant growth studies were carried out at 15, 30, 45 days after sowing and finally at harvest. Plant height of five randomly tagged plants in the penultimate rows of each

plot was recorded at 15, 30, 45 DAS and at harvest and averaged to height in cm. The height was taken from soil surface to fully opened top leaf before tasseling, whereas after tasseling height was measured up to base of tassel. Leaf area index was recorded with canopy analyzer (Accu PAR Model LP-80) at 15, 30, 45 DAS and at harvest from each plot. Chlorophyll content was determined with chlorophyll meter (SPAD-520) from five randomly selected plants in each plot at 15, 30, 45 DAS and at harvest. SPAD-chlorophyll meter readings were recorded and presented which correspond to chlorophyll content. Five plants were selected randomly from each plot to measure stem diameter. It was measured with the help of vernier caliper from top, middle and bottom portions of the stem and then their averages were worked out and expressed in cm.

Post harvest studies

The crop from each net plot (leaving border and penultimate rows) was harvested and immediately weighed in kg plot⁻¹ and then converted into q ha⁻¹. The fresh fodder yield of each net plot was allowed to sundry for about a week and weight was recorded in kg and converted to q ha⁻¹ to give the dry weight ha⁻¹. The samples were ground and subsequently used for chemical analysis. Nitrogen content of ground samples was estimated by "Modified Kjeldahl's Method" (Jackson, 1967) [13]. Nitrogen uptake was determined by multiplying dry fodder yield with respective percentage of nitrogen content and recorded in kg ha⁻¹. Zinc content of ground samples of fodder maize was determined by "Wet Digestion Method" through digestion in di-acid mixture using (Atomic absorption Spectrophotometer, Piper, 1950) [22] and subsequently zinc uptake was calculated by multiplying zinc content with respective dry fodder yield and recorded in g ha⁻¹.

Relative economic

Economics of all treatment combinations was worked on the basis of green fodder yield. The cost of input and output was estimated as per prevailing market rates at the time of experimentation. The benefit cost ratio was determined as the data obtained in respect of various observations were statistically analysed as described by Cochran and Cox (1963) [8]. The significance of "F" test was tested at 5% level of significance. The critical difference value was determined when "F" test was significant. The benefit cost ratio was determined as:

$$\text{Benefit Cost Ratio} = \frac{\text{Net returns}}{\text{Total cost of cultivation}}$$

Qualitative studies

The N content of the ground samples determined was multiplied by a factor 6.25 to give the crude protein content. The crude protein yield was determined by multiplying crude protein content with respective dry matter yield at harvest and expressed in kg ha⁻¹. The crude fibre content of ground samples was determined by "Acid Alkali Method" and subsequently it was multiplied by respective dry matter yield at harvest to crude fibre yield and was expressed in kg ha⁻¹.

Results and Discussion

Crop growth studies

Data regarding plant height (cm.) is given in table 1 indicated that, application of nitrogen from 90 to 150 kg ha⁻¹ caused significant and consistent increase in the plant height of fodder maize at all growth periods except at 15 days interval during the experimentation. It was also found that application of zinc at 20 kg ha⁻¹ has significantly increased the plant height of fodder maize at all the growth periods except at 15 DAS over no zinc application. These results may be attributed to the positive effect of nitrogen on the plant vegetative growth that led to progressive increase in the inter node length. These results validate with the finding of Eltelib *et al.* (2006) [11]. Earlier Patel *et al.* (2007) [24] also reported a significant increase in the plant height of fodder maize with soil application of zinc over the control. Data regarding leaf area index is presented in table 1 indicated that, the application of nitrogen from 90 to 150 kg ha⁻¹ significantly and consistently improved the leaf area index of fodder maize at various growth stages viz. 15, 30, 45 DAS and at harvest. Maximum LAI value of 6.12 was recorded with application of N @ 150 kg ha⁻¹. Leaf area index, a vital photosynthetic character recorded discernible increase with increase in ZnSO₄ level up to 20 kg ha⁻¹ which is significant with 0 kg ha⁻¹ but at par with 10 kg ha⁻¹ moreover, leaf area index went on increasing up to harvest, however, the magnitude of increase was more pronounced from 30 to 45 DAS. Infact, increase in leaf area index with nitrogen fertilization could be attributed to a mere fact that more protein synthesis at higher nitrogen rates induced vegetative growth which resulted in increase of photosynthetic surface that stimulated more leaf length, width and leaf blade size. Earlier Osman *et al.* (2010) [21] also reported similar findings.

Data on chlorophyll content (SPAD readings) of fodder maize at various growth periods are individually presented in table 1. The results revealed that the chlorophyll content of maize increased significantly and consistently with increase in nitrogen dose from 90 to 150 kg ha⁻¹ at various crop growth periods except 15 DAS. As regards the effect of zinc levels, it was found that, Zn application of 10 and 20 kg ha⁻¹ at par with each other has remarkably increased the chlorophyll content of maize crop over no Zn application. Earlier, Verma *et al.* (1994) and Verma and Joshi (1997) [30, 31] also reported similar findings. Arya and Singh (2000) [4] also reported that zinc is involved in the synthesis of proteins, Indole 3-actin acid, chlorophyll formation and carbohydrate metabolism. Data on stem diameter of maize at harvest is also presented in table 2. Results revealed that the stem diameter of maize plant was discernibly influenced by manipulating the N rates and was significantly improved with increase in nitrogen dose from 90 to 150 kg ha⁻¹. These results could be attributed to more cell division and protein synthesis at higher rates of nitrogen. As zinc is involved in auxin synthesis which in turn induces cell division and as such higher cell division with zinc application would lead to increase in stem diameter. Similar, results have been reported earlier by Eltelib *et al.* (2006) and Ayub *et al.* (2007) [11, 5]. In case of Zn application, it was found that Zn application at 10 and 20 kg ha⁻¹ has markedly improved the stem diameter over no Zn application.

Table 1: Periodic plant height (cm), LAI and Chlorophyll content of fodder maize as affect by nitrogen and zinc levels

Treatments	Plant height (cm)				Leaf Area Index				Chlorophyll content (SPAD reading)			
	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest	15 DAS	30 DAS	45 DAS	At harvest
Level of Nitrogen (kg ha⁻¹)												
90	28.80	88.44	232.90	238.46	0.99	2.34	5.16	5.38	30.24	31.07	32.11	33.18

120	28.98	94.78	246.44	253.33	1.03	2.68	5.90	6.06	30.39	32.55	33.54	34.64
150	29.32	99.67	255.14	262.26	1.04	2.97	6.00	6.12	31.46	33.60	34.66	35.79
SEm(±)	0.67	1.54	1.08	0.91	0.02	0.01	0.03	0.02	0.43	0.29	0.30	0.31
CD (0.05)	NS	4.62	3.24	2.73	NS	0.04	0.09	0.05	NS	0.86	0.90	0.93
Level of ZnSO₄ (kg ha⁻¹)												
0	28.46	90.67	241.14	249.03	0.99	2.57	5.53	5.71	30.24	31.22	32.25	33.31
10	29.06	95.22	245.77	251.99	1.02	2.70	5.73	5.91	30.91	32.59	33.62	34.76
20	29.49	97.00	247.58	253.02	1.04	2.73	5.81	5.95	30.94	33.42	34.44	35.54
SEm(±)	0.67	1.54	1.08	0.91	0.02	0.01	0.03	0.02	0.43	0.29	0.30	0.31
CD (0.05)	NS	4.62	3.24	2.73	NS	0.04	0.09	0.05	NS	0.86	0.90	0.93
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

DAS = Days after sowing, SEm = Standard error of mean, CD = Critical difference, NS = Non-significant

Table 2: Periodic Stem diameter (cm), green fodder, dry fodder yield (q ha⁻¹), N%, N uptake, Zn (ppm), Zn uptake, CP%, CPY (q ha⁻¹), CF% and CFY (q ha⁻¹) at harvest of fodder maize as affected by nitrogen and zinc levels

Treatments	Stem diameter (cm)	GFY (q ha ⁻¹)	DFY (q ha ⁻¹)	N %	N uptake (kg ha ⁻¹)	Zn (ppm)	Zn uptake (g kg ⁻¹)	CP %	CPY (q ha ⁻¹)	CF %	CFY (q ha ⁻¹)
Level of Nitrogen (kg ha⁻¹)											
90	1.83	449	113	1.37	155	20.9	237.6	8.56	9.42	34.57	39.10
120	2.03	487	122	1.48	180	22.9	279.2	9.24	10.93	30.40	37.50
150	2.15	506	126	1.54	194	24.5	309.6	9.62	11.74	28.02	36.19
SEm(±)	0.01	2.59	0.75	0.01	1.46	0.5	6.62	0.06	0.09	0.61	0.37
CD (0.05)	0.03	7.76	2.25	0.03	4.39	1.57	19.84	0.18	0.27	1.84	1.11
Level of ZnSO₄ (kg ha⁻¹)											
0	1.96	445	111	1.38	155	20.5	229.6	8.65	9.38	33.03	39.02
10	2.00	495	124	1.47	182	22.9	283.8	9.17	11.02	31.02	37.51
20	2.04	501	125	1.54	193	24.9	313.0	9.60	11.70	28.93	36.26
SEm(±)	0.01	2.59	0.75	0.01	1.46	0.52	6.62	0.06	0.09	0.61	0.37
CD (0.05)	0.03	7.76	2.25	0.03	4.39	1.57	19.84	0.18	0.27	1.84	1.11
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

GFY = Green fodder yield, DFY = Dry fodder yield, N = Nitrogen, CP = Crude protein, CPY = Crude protein yield, CF = Crude fiber, CFY = Crude fiber yield, SEm = Standard error of mean, CD = Critical difference, NS = Non-significant

Green fodder and dry fodder yield

Data on green fodder and dry fodder yield of fodder maize at harvest are presented in table 2. The results showed that, the green fodder yield of fodder maize improved significantly and consistently from 449 to 506 q ha⁻¹ with increase in nitrogen level from 90-150 kg ha⁻¹. The maximum green fodder yield of 506 q ha⁻¹ was recorded with the application N @ 150 kg ha⁻¹. The data further revealed that N₂ and N₃ level marked an increase of 3.75 and 11.25 % in green fodder yield over N₁ level. It is also evident from the data that application of zinc 20 kg ha⁻¹ significantly improved the green fodder yield of maize over 0 kg ha⁻¹ zinc application. The dry fodder yield of maize improved significantly and consistently from 113 to 126 q ha⁻¹ with increase in nitrogen level from 90 to 150 kg ha⁻¹. The maximum dry fodder yield of 126 q ha⁻¹ was recorded with the application N @ 150 kg ha⁻¹. The data further revealed that N₂ and N₃ level marked an increase of 3.17 and 10.31 % in dry fodder yield over N₁ level. It is also evident from the data that application of zinc 20 kg ha⁻¹ significantly improved the dry fodder yield of maize over 0 kg ha⁻¹ zinc application. Since nitrogen is an essential constituent of plant tissue and is involved in cell division and cell elongation, its beneficial effect on the growth characters viz., plant height, leaf area index and stem diameter might have contributed to higher yield. Earlier Eltelib *et al.* (2006) [11] also reported similar findings. They found that fresh fodder yield recorded discernible improvement with increase in nitrogen application from 90 to 150 kg ha⁻¹. Keskin *et al.* (2005) [16] also reported significant increase in green forage yield of corn with increase in nitrogen rate up to 160 kg ha⁻¹.

Interaction effect of nitrogen and zinc levels on fodder maize

The data on interaction effect on green fodder yield between N and Zn level is presented in table 3. The data revealed that,

application of no Zn, green fodder yield increased significantly and consistently with increase in N rate from 90-150 kg ha⁻¹ similar trend was also noticed with different level of nitrogen application at 10 kg Zn ha⁻¹. Regarding zinc application, the green fodder yield increased significantly by increasing Zn application from 0 to 10 kg ha⁻¹ at every three level of nitrogen application. However, Zn application at the rate of 20 kg ha⁻¹ could not influence the green fodder yield significantly at different level of nitrogen application. Highest green fodder yield of maize (523 q/ha) was received with the treatment combination of 150 kg N and 20 kg Zn ha⁻¹. However N₁₅₀ + Zn₂₀ kg ha⁻¹ was at par with N₁₅₀ + Zn₁₀ kg ha⁻¹. Palled *et al.* (1991) [23] observed that application of nitrogen from 100-200 kg ha⁻¹ caused significant and consistent increase in the fresh fodder yield of maize. Whereas, Karwasra and Dahiya (1997) [15] reported that N application @ 120 kg ha⁻¹ produced maximum green and dry matter yield.

Nutrients content & uptake

Data on nutrients contents like nitrogen and zinc content in fodder maize and their uptake are presented in table 2. Data exposed that nitrogen content in fodder maize increased significantly and consistently with increase in nitrogen rates from 90 to 150 kg ha⁻¹. The results also signposted that zinc application 0 to 20 kg ha⁻¹ significantly increased the nitrogen content in fodder maize over no zinc application. These results could be attributed to more leaves and higher leaf area index at higher levels of nitrogen because leafy portion contains more nitrogen than other plant parts. Similar, findings have also been reported by Verma *et al.* (1999) [32]. Regarding nitrogen uptake, the results revealed that with increase in nitrogen levels from 90 to 150 kg ha⁻¹, nitrogen uptake by fodder maize showed significant and consistent

increase during the research study. Data also revealed that zinc application @ 0-20 kg ha⁻¹ significantly increased the nitrogen uptake by fodder maize over no zinc application. In-fact, nitrogen uptake at harvest is the product of dry fodder yield and respective nitrogen content. Since both dry fodder yield and nitrogen content showed significant improvement with increase in nitrogen rates and hence the increase in nitrogen uptake the results are in conformity with those of Verma *et al.* (1999) [32].

The results revealed that zinc content in fodder maize increased significantly and consistently with increase in nitrogen levels from 90 to 150 kg ha⁻¹. Data also revealed that zinc application @ 0 to 20 kg ha⁻¹ significantly increased the zinc content in fodder maize. In case of zinc uptake, the data indicated that zinc uptake by fodder maize increased significantly and consistently with increase in nitrogen level from 90 to 150 kg ha⁻¹. With regards to Zn application, the Zn uptake significantly improved with application of Zn from 10 to 20 kg ha⁻¹. Improvement in the zinc content with increased levels of nitrogen could be attributed to the synergistic effect between nitrogen and zinc, as increased protein formation following nitrogen fertilizer additions can lead to zinc being retained in the roots as zinc-protein complex and zinc absorption by plants is more protein mediated. Nitrogen application at 150 kg ha⁻¹ also caused significant increase in the zinc uptake over 120 and 90 kg ha⁻¹. This could be due to higher dry fodder yield and higher zinc content recorded at higher nitrogen levels as nutrient uptake at harvest is the product of dry fodder yield and respective nutrient content. Singh and Singh (1998) [28] also reported similar findings.

Fodder qualitative studies

Data on crude protein content, crude fibre and yield of fodder maize are presented in table 2. Data revealed that crude protein content of fodder maize recorded a significant and consistent increase with increase in nitrogen rates from 90 to 150 kg ha⁻¹. Crude protein yield was also significantly influenced with the application of N from 90 to 150 kg N ha⁻¹. This could be attributed to higher nitrogen concentration in the plant at higher nitrogen levels thus emphasizes the fact that nitrogen plays great role in the protein synthesis. Eltelib *et al.* (2006) [11] also reported similar findings. Earlier Singh *et al.* (2008) [27] have also reported significant increase in crude protein yield of maize with increase in levels of nitrogen up to 150 kg ha⁻¹. It was also revealed that both crude protein content and yield of fodder maize recorded significant improvement with zinc application over the control. In-fact, apart from other essential contributions, zinc is involved in enhancing the number of ribosomes in cells thereby increased protein synthesis as such both protein content and yield increased with its application.

Crude fiber content of fodder maize recorded a significant and consistent decrease with increase in nitrogen doses from 90 to 150 kg ha⁻¹. Crude fiber yield also showed substantial decrease with increase in N rate from 90 to 150 kg ha⁻¹. Crude fiber content of fodder maize recorded a significant and consistent decreased with increased in zinc dose from 0 to 20 kg ha⁻¹. Crude fiber yield also showed substantial decrease with increase in Zn rate from 0 to 20 kg ha⁻¹. The results are in conformity with the findings of Almodares *et al.* (2009) [2]. Decrease in crude fiber yield with increase in nitrogen levels could be attributed to decrease in crude fiber content at higher nitrogen levels as crude fiber yield is the product of crude fiber content and respective dry matter. The decrease in crude fiber content with increase in might be due to higher plant

population per unit area resulting in the production of soft stemmed plants with soft leaves.

Gross returns, net returns and benefit cost ratio

The economics of green fodder yield of maize crop such as gross returns, net returns and benefit cost ratio (B: C ratio) were found to be significantly influenced by different nitrogen and zinc levels. The data pertaining to gross returns and net returns of fodder maize are presented in table 4. The data indicated that gross return was significantly influenced by different nitrogen and zinc levels of maize crop. The significantly maximum gross return (Rs. 60,668 ha⁻¹) was recorded from nitrogen application level of 150 kg ha⁻¹, whereas, 20 kg ha⁻¹ of zinc sulfate application gave the maximum gross return (Rs. 60,150 ha⁻¹), which was statistically comparable with the zinc application level of 10 kg ha⁻¹ with a gross return of Rs.59,364 ha⁻¹. The highest net return (Rs. 39,190 ha⁻¹) was recorded with the nitrogen application level of 150 kg ha⁻¹ among other nitrogen levels. Likewise, zinc level of 20 kg ha⁻¹ provided highest net return (Rs. 38,615 ha⁻¹) among other zinc application rates. However, that was statistically at par with zinc application level of 10 kg ha⁻¹ with a net return of Rs.38, 279 ha⁻¹. Further, highest benefit cost ratio (1.82) was realized with the nitrogen application level of 150 kg ha⁻¹ among other nitrogen rates. Interestingly, highest benefit cost ratio (1.81) was obtained with the low cost treatment i.e. zinc level of 10 kg ha⁻¹ which was statistically at par with the zinc level of 20 kg ha⁻¹ (1.79).

Conclusion

After one year of experimentation it could be revealed that the treatment combinations N₃Zn₃ recorded significantly higher green fodder yield and that at par with N₃Zn₂ in this regard. The crude protein content and crude protein yield were recorded maximum (9.62% and 11.74 q ha⁻¹) under 150 kg N ha⁻¹ and significantly superior than rest of the treatments. The data further revealed that N₂ and N₃ level marked an increase of 3.75 and 11.25 % in green fodder yield over N₁ level. Similarly, 120 kg N ha⁻¹ and 150 kg N ha⁻¹ level produced an increase of 3.17 and 10.31 % in dry fodder yield over 90 kg N ha⁻¹ level. Besides, highest benefit cost ratio (1.82) was realized with the nitrogen application level of 150 kg ha⁻¹ among other nitrogen rates. Hence, highest benefit cost ratio (1.81) was obtained with the zinc level of 10 kg ha⁻¹ which was statistically at par with the zinc level of 20 kg ha⁻¹ (1.79). Thus the study lead to conclusion, that for realizing the highest yield and quality fodder maize the nutrient management must center a rounded of 150 kg Nitrogen with 10 kg ha⁻¹ Zn application along with recommended dose of phosphorus and potassium. Thus, it can be recommended from the study that maize fodder productivity and quality can be enhanced with nitrogen and zinc fertilization as soil application, which will further strengthen and sustain the performance of green fodder yield of maize as well as livestock in terms of health and milk production.

Table 3: Interaction affected of nitrogen and zinc for green fodder yield during cropping season

N dose Zn dose	N ₁	N ₂	N ₃
Zn ₁	407	456	473
	464	500	521
Zn ₂	477	504	523
SEm (±)	4.55		
CD (0.05)	13.63		

Table 4: Relative economics of fodder maize as affected by nitrogen, and zinc levels

Treatment	Cost of cultivation (Rs ha ⁻¹)	Gross return (Rs ha ⁻¹)	Net return (Rs ha ⁻¹)	B:C ratio
Level of Nitrogen (kg ha⁻¹)				
90	20689	53879	33190	1.60
120	21087	58406	37319	1.77
150	21478	60668	39190	1.82
SEm (±)	-	310.50	310.50	0.01
CD (0.05)	-	930.89	930.89	0.04
Level of ZnSO₄ (kg ha⁻¹)				
0	20635	53439	32804	1.59
10	21085	59364	38279	1.81
20	21535	60150	38615	1.79
SEm (±)	-	310.50	310.50	0.01
CD (0.05)	-	930.89	930.89	0.04
Interaction	NS	NS	NS	NS

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