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RESEARCH PAPER

Effect of nitrogen and zinc fertilization on growth and productivity of maize

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Abstract : The experiment consisted of 12 treatments combinations comprising 4 nitrogen levels (60, 80, 100 and 120kg ha^{-1}) and 3 zinc levels (2.5, 5.0 and 7.5kg ha^{-1}). The experiment was laid out in Factorial Randomized Block Design with four replications. The experimental soil was clay loam in texture, slightly alkaline in reaction, medium in available nitrogen (275.0 kg ha^{-1}) and phosphorus (20.21kg ha^{-1}) and potassium (280.5kg ha^{-1}) and low in available zinc (0.49ppm). The crop was shown on 9.7.2011 using variety PEHM-2 with recommended seed rate of 25kg ha^{-1}. The results revealed that application of N upto 100kg ha^{-1} recorded significantly higher plant height (50, 75DAS and at harvest), dry matter accumulation and leaf area index at all the growth stages over 60 and 80kg N ha^{-1}. Likewise, application of N upto 100kg ha^{-1} was found significantly superior in increasing RGR and NAR between 25 and 50 days compared to 60kg N ha^{-1}. Application of 100 and 120kg N ha^{-1} statistically at par were found significantly superior in increasing cob plant^{-1}, grain cob^{-1}, grain weight cob^{-1}, 100 grains weight and shelling per cent over 60 and 80kg N ha^{-1}. Application of 80 and 100kg N ha^{-1} significantly increased grain; stover, biological yield and harvest index over 60kg N ha^{-1}. The per cent increase in grain, stover and biological yields due to 100kg N ha^{-1} was 39.03, 23.43 and 28.89, respectively compared to 60kg N ha^{-1}. A significant increase in N, P and Zn content and their uptake was recorded under the application of 80, 100 and 120kg N ha^{-1} compared to 60kg N ha^{-1} but 120kg N ha^{-1} was found statistically at par with 100kg N ha^{-1}. Protein content in grain and chlorophyll in leaves increased significantly with successive increase in nitrogen doses upto 100kg ha^{-1}.

Key Words : RGR, NAR, DAS,LAI, Maize

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INTRODUCTION

The continual increase in food grain production, nutritional security, maintenance of soil health and sustainability are the main focus of agricultural development. To feed its escalating population, India will have to produce more and better quality food from available and limited land resource. The cultivated area from past few decades is almost constant (140±2m ha). Since opportunities are limited for horizontal expansion of area, increases in food grain supply will have to be achieved through the intensification of current production system. The food grain requirement in 2025 is estimated to be around 300 million tonnes which has to be elevated from the current estimated production of 250.42 million

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tonnes. To achieve this future target, food grain production must increase at an annual rate of 3.54m t $year^{-1}$ in coming years. In India maize is cultivated over an area of 8.49 million hectares with the production of 21.28 million tonnes and productivity of 2507kg ha^{-1} (Directorate of Economics and Statistics, 2011). Rajasthan has the highest area of maize in the country occupying an area of 1.05 million hectares with the production and productivity of 1.95 million tonnes and 1860 kg ha^{-1}, respectively. In Rajasthan, Udaipur district contributes maximum area (1.74 lakh ha) with production of 2.39 lakh tonnes and productivity of 1376kg ha^{-1} (Rajasthan Krishi, 2010). Maize is the third most important cereal crop of world as well as India after wheat and rice and it is a principal staple food crop in many countries particularly in the tropics and subtropics. Maize is regarded as the "Queen of Cereals". Being a C_4 plant, it utilizes solar radiation more efficiently even at higher radiation intensity. In general, it has greater worldwide significance as human food, animal feed and a source of large number of industrial products. Maize is cultivated in diverse production environments ranging from temperate hill zone of Himachal Pradesh to the semiarid region of Rajasthan. Maize is predominantly cultivated under rainfed condition in *Kharif* season at Mewar, Wagad and Hadoti regions of the Rajasthan. In recent years, cultivation of hybrid maize has been found to be more remunerative than other *Kharif* crops in South Eastern part of Rajasthan. It is the versatile crop that adapt easily to a wide range of production environments and fits well in the existing cropping systems of India. Being a source of diversified products obtained from industrial inputs such as starch, corn oil, glucose etc., the demand of maize crop has been constantly mounting. Maize grain has elevated nutritive value as it contains about 72 per cent starch, 10 per cent protein, 4.8 per cent oil, 5.8 per cent fibre and 3.0 per cent sugar (Rafiq *et al.,* 2010). Present day maize hybrids have high yield potential but their average yield do not appear to be satisfactory in the India as compared to other maize growing countries of the world. Among the various agro-techniques, fertilizer is the single most important input in modern agriculture to raise the crop productivity. Both major and micronutrients are essential for growth and development of plants. Among the 17 essential plant nutrients, nitrogen plays the most important role in augmenting agricultural production which is required in the greatest quantity of all mineral nutrient absorbed by plant roots. It plays a vital role by participating in different metabolic activities in plant system. The improved genotypes of cereals require large quantities of nitrogen for the expression of their production potential especially under low and medium soil nitrogen fertility. Fertilizer nitrogen is the major source of nitrogen supply for crop. Maize is an exhaustive crop and requires high quantities of nitrogen during the period of its growth. Being an essential element it plays an important role in crop development and yield. The deficiency of this element has been found as one of the major yield limiting factors for maize production. Applications of nitrogen at low rate adversely affect growth and grain yield of maize.Yield and protein content in maize seed increase with increase in nitrogen rate which is indispensable for increasing crop production. It is an important constituent of molecules, enzymes, co-enzymes, nucleic acid and cytochromes. It is also an important constituent of protoplasm, chlorophyll and is associated with the activity of living cells. With the intensification of agriculture by use of high yielding short duration varieties and high analysis fertilizer, the deficiency of micronutrients, especially zinc has turned out to be a limiting factor in Indian agriculture. In the entire alkaline calcareous belt of the country, zinc has assumed considerable importance in balance fertilization for improving crop productivity. Wide spread deficiency of zinc leads to low productivity of dry land crops. Zinc plays a significant role in various enzymatic and physiological activities in the plant system. It performs many catalytic function in the plant besides transformation of carbohydrates, chlorophyll and protein synthesis. Under conditions where there is a lack of zinc, a decrease of carbonic anhydrase enzyme can lead to a diminished rate of net photosynthesis. The use of zinc serves to increase the density of zinc and protein in seeds, pneumatic organs and the overall quality of seed production. Zinc deficiency is rated as the most wide spread micronutrient problem in Indian soils as it is deficient in 50 per cent soils of 14 Indian states (Katyal and Rattan, 1990) and crop like maize has been found to respond to zinc application. Currently millions of hectare of crop plants are affected by zinc deficiency and approximately one third of the human population suffer from an inadequate intake of zinc. Low zinc content in grains and straw results in poor zinc nutrition of human beings and animals, which has received considerable attention (Cakmak, 2008). It is an established fact that among field crops, maize is most susceptible to zinc deficiency and is considered an indicator plant for zinc deficiency. Zinc fertilization is therefore, considered necessary for increasing maize production in most of the parts of country (Katyal, 1985). Several workers have reported beneficial effect of zinc fertilization on maize (Dwivedi *et al*., 2002 and Hosseini *et al.,* 2007).Considering the above facts, the present investigation was conducted to study with the following objectives: To work out suitable dose of nitrogen to enhance growth and productivity of maize, to evaluate the response of maize to zinc application and to workout economically viable treatment.

MATERIAL AND METHODS

A field study on effect of nitrogen and zinc fertilization on growth and productivity of maize was conducted during *Kharif,* 2011 under M.Sc. research work at Bhagwant University, Ajmer. The details of experimental techniques, materials used and criteria adopted for treatment evaluation during the course of investigation are presented in this chapter.

Treatment details :

(A) Nitrogen levels (kg ha^{-1}) (i) 60 (ii) 80 (iii) 100 (iv) 120 (B) Zinc levels (kg ha^{-1}) (i) 2.5 (ii) 5.0 (iii) 7.5.

Treatment application:

Full dose of phosphorus and zinc and 1/3 nitrogen was applied at sowing by drilling in the crop rows. The remaining dose of nitrogen was top dressed in two splits at knee high and tasseling stages depending upon the occurrence of rains.

Seed and sowing:

Maize variety PEHM-2 was sown at seed rate of 25 kg ha^{-1} at inter row of 60 and plant to plant spacing of 25cm. Furrows were opened through bullock drawn desi plough and seeds were sown manually at the depth of 5 cm. Before sowing seeds were treated with 3.0 g thiram kg^{-1} seed to protect it from fungal diseases.

Weed management:

Atrazine 0.5kg ha^{-1} as pre emergence was applied one day after sowing through knap sack sprayer using 600 litres water ha^{-1}. One manual hoeing and weeding was also done 30 DAS to control late flush of weeds.

Irrigation:

During the crop growth period it was not felt necessary to irrigate the crop because there was a well distributed rainfall during this period.

Plant protection:

2-3 granules of phorate 10 G were applied in leaf whorls against stem borer 35DAS.

Harvesting:

The crop was harvested along with cobs when plant turned golden yellow with the help of sickle. The net plot crop was harvested close to ground and plants were tied in bundles and kept for sun drying on threshing floor for few days.

Threshing:

After sun drying of harvested plants of net plot area, cobs were separated from individual plant. After separation of the cobs from plants, they were dehusked and shelled through thresher and produce of each plot was winnowed and weighed.

Treatment evolution:

In order to evaluate the effect of treatments on growth, yield attributes, yield, nutrient uptake and other aspects of maize crop, observations were recorded for each parameter as per the procedures mentioned below:

Plant population:

The number of plants per metre row length were counted 25DAS and at harvest in 5 different rows of each net plot area, then averaged and was converted into thousands ha^{-1}.

Growth parameters:

Plant height 25, 50 and 75 DAS and at harvest:

Five plants were randomly selected from each plot and height of tagged plants was measured from ground level to the top of shoot 25, 50 and 75DAS and at harvest .The mean height was calculated and expressed in cm.

Dry matter accumulation 25, 50, 75DAS and at harvest :

Five randomly selected plants from each plot were removed 25, 50, 75DAS and at harvest. These plants were chopped to smaller size and dried in oven at 65º C till a constant weight is obtained. These were weighed to estimate dry matter plant^{-1} at respective stages.

Leaf area index 25, 50 and 75DAS:

For maize, the length and maximum width of every viable leaf of five tagged plants were measured 25, 50 and 75 DAS with the help of meter scale and then leaf area was worked out by following formulae as proposed by Montgomery (1911). Leaf area = Length × Maximum width × 0.75. The average was worked out and values of leaf area were expressed in cm^2 plant^{-1} and used for computing the leaf area index. From the leaf area plant^{-1}, the leaf area index (LAI) was worked out for maize crop by multiplying the leaf area per plant with the number of plants in the net plot area and dividing it by net plot area.

Growth indices (RGR and NAR):

Relative growth rate and net assimilation rate were computed between 25-50 and 50 -75DAS by the following formulae as given by Redford (1967).

$$\mathbf{RGR\ (g\ g^{-1}\ day^{-1}) = \frac{Log_e W_2 - Log_e W_1}{t_2 - t_1}}$$

where, W_1, W_2 are dry matter at time t_1, t_2, respectively.

$$\mathbf{NAR\ (g\ m^{-2}\ day^{-1}) = \frac{(W_2\text{-}W_1)(Log_e L_2 - Log_e L_1)}{(t_2\text{-}t_1)(L_2\text{-}L_1)}}$$

where, L_1 and W_1 are leaf area and dry weight of plants at time t_1, and L_2 and W_2 are leaf area and dry weight of plants at time t_2.

Yield attributes:

Number of cobs plant^{-1}:

Number of cobs of five tagged plants was counted at harvest and the mean value plant^{-1} under each experimental unit was worked out.

Number of grains cob^{-1}:

Number of grains of five cobs was counted at harvest and the mean value per cob under each experiment unit was worked out.

Weight of grains cob^{-1}:

The randomly selected five cobs of net plot area taken for the weight of the individual cob were shelled with hand sheller. The grains were weighed and average weight of grains cob^{-1} was computed and expressed as weight of grains cob^{-1} in (g).

100-grain weight:

The sun dried 100-grains were counted from produce of each plot for recording 100-grain weight in (g).

Shelling percentage:

Shelling percentage was calculated by the following formula:

$$\mathbf{Shelling\ (\%) = \frac{Weight\ of\ grains\ of\ net\ plot\ area}{Weight\ of\ cobs\ of\ net\ plot\ area} x100}$$

Yield and harvest index:

Grain yield:

Cobs of harvested plants of net plot area after proper sun drying were separated from plants, dehusked and shelled with the help of cob sheller. The produce was cleaned, weighed and expressed in terms of grain yield kg ha^{-1}.

Stover yield:

Stover yield was obtained by subtracting the grain yield per plot from the respective biological yield per plot and finally expressed in terms of stover yield kg ha^{-1}.

Biological yield:

The weight of thoroughly sun-dried plants of net plot along with cobs were recorded and expressed as biological yield in kg ha^{-1}.

Harvest index :

The harvest index was obtained by dividing the economic yield (grain yield) by total biological yield and expressed as percentage.

$$\mathbf{Harvest\ index\ (\%) = \frac{Economic\ yield\ (kg\ ha^{-1})}{Biological\ yield\ (kg\ ha^{-1})} x\ 100}$$

Biochemical analysis:

Nutrient content:

The maize grain and stover samples collected from each plot at harvest were oven dried at 65^{0}C till a constant weight was obtained. The dried samples were finely ground and used for determination of N, P, Zn and protein content as per method furnished in Table A.

Table A : Methods employed for plant analysis

Sr. No.	Character under analysis	Reference
1.	Nitrogen	Snell and Snell (1949)
2.	Phosphorus	Richards (1968)
3.	Zinc	Lindsay and Narvell (1978)

Nutrient uptake:

N, P and Zn uptake at harvest was calculated using the following formulae:

$$\text{Nutrient uptake by seed / stover (kg ha}^{-1}) = \frac{\text{\% Nutrient content in seed / stover x Yield of seed / stover (kg ha}^{-1})}{100}$$

$$\text{Zinc uptake by seed /stover (kg ha}^{-1}) = \frac{\text{Nutrient content (ppm) in seed / stover x Yield of seed / stover (kg ha}^{-1})}{1000}$$

Chlorophyll content 50 and 75DAS (mg g^{-1}):

Fresh leaf samples were collected 50 and 75DAS from crop and these samples were immediately taken to laboratory, washed with distilled water and dried with blotting paper. A sample of 100mg was taken from each experimental unit in mortar and pestle. The sample was ground well with 80 per cent acetone and filtered through Whatman filter paper No. 1 and volume was made to 25ml. The absorbance was recorded on spectronic-20 at 645 and 663 wave lengths. The chlorophyll content was estimated as per standard procedure.

$$\text{Total chlorophyll content (mg g}^{-1}) = \frac{20.2\,(A_{645}) + 8.02\,(A_{663})}{a \times 1000 \times W} \times V$$

a =Length of light path in the cell, v = Volume of extract (ml).

Protein content:

Crude protein content in the maize grain was calculated by multiplying the nitrogen content of grain with a factor 6.25 as proposed by Tsen and Martin (1971). It was expressed in terms of per cent protein content.

Economics of treatments:

The economics of different treatments was estimated in terms of net profit ha^{-1}. The cost of cultivation for each treatment was subtracted from gross returns and net profit was worked out. Further, to ascertain economic viability of the treatments, benefit cost ratio was also calculated as: Benefit/ Cost= Value of the produce / cost of cultivation.

RESULTS AND DISCUSSION

Results of the field experiment on effect of nitrogen and zinc fertilization on growth and productivity of *Zea mays* L." conducted at Instructional Farm of Bhagwant University, Ajmer *Kharif* season, 2016 are being presented in this chapter. The data pertaining to the effect of different treatments on various parameters used for treatment evaluation were statistically analysed in order to test their significance.

Plant population:

A perusal of data revealed that varying nitrogen and zinc levels did not significantly influence plant population both 25DAS and at harvest.

Table 1 : Effect of nitrogen and zinc fertilization on plant population of maize

Treatments	25 DAS	At harvest
Nitrogen (kg ha^{-1})		
60	65545	65088
80	66189	65806
100	65083	64834
120	65143	64794
S.E.±	975	986
C.D. (P=0.05)	NS	NS
Zinc (kg ha^{-1})		
2.5	64886	64512
5.0	65835	65504
7.5	65750	65375
S.E.±	845	854
C.D. (P=0.05)	NS	NS

NS= Non-significant

Growth parameters:

Plant height 25, 50, 75DAS and at harvest:

Nitrogen:

It is apparent from data presented in Table 2 that each successive increase in nitrogen level upto 100 kg

Table 2 : Effect of nitrogen and zinc fertilization on plant height of maize (cm)

Treatments	25 DAS	50 DAS	75 DAS	At harvest*
Nitrogen (kg ha^{-1})				
60	95.6	180.7	204.3	218.5
80	100.8	197.0	220.9	234.9
100	104.9	212.8	237.5	251.5
120	106.6	216.8	246.8	262.8
S.E.±	2.2	5.4	5.5	5.6
C.D. (P=0.05)	6.3	15.4	15.7	16.1
Zinc (kg ha^{-1})				
2.5	97.6	190.6	215.1	229.9
5.0	102.9	204.5	230.2	244.7
7.5	105.3	210.3	236.8	251.2
S.E.±	1.9	4.6	4.7	4.9
C.D. (P=0.05)	5.4	13.3	13.6	14.0

ha^{-1} significantly increased plant height at all the stages of crop growth except non-significant difference between 80 and 100kg N ha^{-1} 25DAS. The per cent increase in the plant height 25DAS due to 80 and 100kg N ha^{-1} was 5.44 and 9.72, respectively compared to 60kg N ha^{-1} and corresponding increase in plant height 50 and 75DAS was to the extent of 9.02, 17.76 and 8.13, 16.25 per cent whereas, at harvest the magnitude of increase in plant height due to both of these treatments was 7.51 and 15.10 per cent, respectively.

Zinc:

A reference to data presented in Table 2 revealed that except 25DAS, application of zinc upto 5.0kg ha^{-1} significantly enhanced plant height at all the stages of observation. The per cent increase in plant height 25 DAS due to 7.5kg Zn ha^{-1} was 7.88 compared to 2.5kg Zn ha^{-1}, whereas increase in plant height 50 and 75DAS owing to 5.0kg zinc ha^{-1} was 7.30 and 7.0 per cent, respectively while at harvest the increase in plant height due to 5.0kg zinc ha^{-1} was to the tune of 6.43 per cent compared to 2.5kg Zn ha^{-1}.

Dry matter accumulation 25, 50, 75DAS and at harvest:

Nitrogen:

A perusal of data pertaining to dry matter accumulation in maize presented in Table 3 revealed that nitrogen levels upto 100 kg ha^{-1} significantly increased dry matter accumulation at all the stages of crop growth. Application of 100kg N ha^{-1} was found statistically at par with 120kg N ha^{-1} at all the stages in this regard. The per cent increase in the plant dry matter 25DAS due to 80 and 100kg N ha^{-1} was 13.75 and 24.27, respectively compared to 60kg N ha^{-1}. Likewise the corresponding increase in plant dry matter under these treatments 50 and 75DAS was to the extent of 13.16, 24.34 and 10.79, 22.10 per cent whereas, at harvest the increase in plant dry matter under both these treatments was to the extent of 11.38 and 23.54 per cent, respectively.

Zinc:

A reference to data presented in Table 3 indicated that application of zinc upto 5.0kg ha^{-1} significantly enhanced plant dry matter 25, 50 and 75DAS and at harvest and thereafter, it did not increase significantly. Increase in plant dry matter 25, 50 and 75DAS and at harvest due to application of 5.0kg Zn ha^{-1} was 8.45, 8.80, 8.85 and 8.96 per cent, respectively compared to 2.5kg Zn ha^{-1}.

Leaf area index 25, 50 and 75DAS:

Nitrogen:

A critical examination of data presented in Table 4 showed that progressive increase in nitrogen levels upto 100 kg ha^{-1} significantly enhanced LAI of maize at all the stages of observation. The per cent increase in LAI due to 80 and 100 kg N ha^{-1} 25DAS was 25.55 and 38.88, respectively compared to 60 kg N ha^{-1}. The corresponding per cent increase in LAI under both these treatments 50DAS was 17.78 and 30.76 over 60kg N

Table 3 : Effect of nitrogen and zinc fertilization on dry matter accumulation by maize (g plant^{-1})

Treatments	25 DAS	50 DAS	75 DAS	At harvest
Nitrogen (kg ha^{-1})				
60	12.65	37.76	122.43	127.43
80	14.39	42.73	135.64	141.93
100	15.72	46.95	149.43	157.43
120	15.80	49.44	159.05	167.72
S.E.±	0.42	1.38	4.53	4.29
C.D.(P=0.05)	1.22	3.96	13.04	12.35
Zinc (kg ha^{-1})				
2.5	13.71	40.84	131.60	138.32
5.0	14.87	44.43	143.25	150.61
7.5	15.33	47.39	150.06	156.95
S.E.±	0.37	1.19	3.92	3.72
C.D. (P=0.05)	1.06	3.43	11.29	10.70

Table 4 : Effect of nitrogen and zinc fertilization on leaf area index of maize

Treatments	25 DAS	50 DAS	75 DAS
Nitrogen (kg ha^{-1})			
60	0.90	2.08	1.74
80	1.13	2.45	2.15
100	1.25	2.72	2.59
120	1.30	2.91	2.78
S.E.±	0.03	0.09	0.09
C.D.(P=0.05)	0.08	0.25	0.26
Zinc (kg ha^{-1})			
2.5	1.07	2.22	1.94
5.0	1.17	2.62	2.43
7.5	1.20	2.78	2.58
S.E.±	0.02	0.08	0.08
C.D. (P=0.05)	0.07	0.22	0.23

ha^{-1} whereas, 75DAS the increase in LAI was 23.55 and 48.85 per cent, respectively compared to 60kg N ha^{-1}.

Zinc:

The experimental finding presented in Table 4 showed that application of zinc fertilization upto 5.0kg ha^{-1} resulted in significant increase in LAI 25, 50 and 75DAS compared to 2.5kg Zn ha^{-1} but was found statistically at par with 7.5kg Zn ha^{-1}. The increase in LAI 25 and 50DAS due to 5kg Zn ha^{-1} was 9.34 and 18.0 per cent, respectively over 2.5kg Zn ha^{-1}. The corresponding increase in LAI 75DAS under the influence of 5.0kg Zn ha^{-1} was 25.25 per cent compared to 2.5kg Zn ha^{-1}.

RGR between 25 and 50 and 50 and 75 days:

Nitrogen:

Data presented in Table 5 showed that ever increase in nitrogen fertilization upto 100kg ha^{-1} significantly increased RGR between 25 and 50 days growth stage of crop. The magnitude of increase in RGR due to application of 100kg N ha^{-1} was 14.28 and 9.09 per cent over 60 and 80kg N ha^{-1}, respectively. Data also indicated that between 50 and 75 days period of crop growth application of nitrogen could not significantly affect RGR.

Zinc:

Data presented in Table 5 showed that successive increase in zinc doses failed to show any perceptible variation on RGR between 25 and 50 and 50 and 75 days growth stage of crop.

Table 5 : Effect of nitrogen and zinc fertilization on relative growth rate

Treatments	Between 25 and 50 DAS	Between 50 and 75 DAS
Nitrogen (kg ha^{-1})		
60	0.042	0.048
80	0.044	0.046
100	0.048	0.046
120	0.050	0.047
S.E.±	0.001	0.002
C.D.(P=0.05)	0.004	NS
Zinc (kg ha^{-1})		
2.5	0.044	0.047
5.0	0.046	0.047
7.5	0.047	0.046
S.E.±	0.001	0.001
C.D. (P=0.05)	NS	NS

NS= Non-significant

NAR between 25 and 50 and 50 and 75 day's stage:

Nitrogen:

Table 6: Effect of nitrogen and zinc fertilization on net assimilation rate (g m^{-2} day^{-1})

Treatments	Between 25 and 50 DAS	Between 50 and 75 DAS
Nitrogen (kg ha^{-1})		
60	4.08	11.84
80	4.25	10.88
100	4.90	10.43
120	5.10	10.32
S.E.±	0.15	0.48
C.D.(P=0.05)	0.43	NS
Zinc (kg ha^{-1})		
2.5	4.44	11.67
5.0	4.59	10.63
7.5	4.71	10.29
S.E.±	0.13	0.42
C.D. (P=0.05)	NS	NS

NS= Non-significant

A reference to data presented in Table 6 revealed that application of N levels upto 100kg N ha^{-1} significantly enhanced NAR between 25 and 50 days growth stage of crop.

When compared with NAR of 4.08g m^{-2} day^{-1} recorded less than 60kg N ha^{-1}, application of 80 and 100kg N ha^{-1} increased it by 4.17 and 20.09 per cent, respectively. Data also showed that application of nitrogen could not bring significant variations in NAR during 50 to 75 days growth stage of crop.

Zinc:

A perusal of data presented in Table 6 showed that successive increase in zinc doses could not bring significant variation in NAR during 25 to 50 and 50 to 75DAS.

Yield attributes:

Cobs plant^{-1}:

Nitrogen:

It is evident from data presented in Table 7 that increasing levels of nitrogen upto 100kg ha^{-1} resulted in significant increase in number of cob $plant^{-1}$ and thereafter, it could not increase the parameter significantly. The per cent increase in cobs plant^{-1} due to 100kg N ha^{-1} was 18.69 and 6.72 over 60 and 80kg N ha^{-1}, respectively.

Zinc:

A perusal of data presented in Table 7 showed that application of zinc could not influence number of cobs plant^{-1} significantly.

Grains cob^{-1}:

Nitrogen :

A critical examination of data showed that application of nitrogen doses upto 100kg ha^{-1} significantly increased number of grains cob^{-1}. The per cent increase in number of grains cob^{-1} due to 100kg N ha^{-1} was 18.10 and 7.38 compared to 60 and 80kg N ha^{-1}, respectively.

Zinc:

A reference to data presented in Table 7 indicated that application of zinc in maize upto 5.0kg ha^{-1} was found significant in enhancing number of grains cob^{-1} compared to 2.5kg Zn ha^{-1}. The magnitude of increase in number of grains cob^{-1} due to 5.0kg Zn ha^{-1} was 6.56 per cent over 2.5kg Zn ha^{-1}.

Grains weight cob^{-1}:

Nitrogen:

It is explicit from the data presented in Table 7 that increasing levels of nitrogen upto 100kg ha^{-1} significantly responded grain weight cob^{-1}. Application of 120kg N ha^{-1} was found statistically at par with 100kg N ha^{-1} in this regard. The increase in grain weight cob^{-1} due to 100kg N ha^{-1} was 22.28 and 8.01g compared to 60 and 80kg N ha^{-1}, respectively.

Zinc:

A critical examination of data showed that of zinc fertilization upto 5.0kg ha^{-1} significantly increased grain weight cob^{-1}. The per cent increase in grain weight cob^{-1} due to 5.0kg Zn ha^{-1} was 9.01 over 2.5kg Zn ha^{-1}.

100 grains weight:

Nitrogen:

100 grains weight of maize increased significantly with each successive increment in nitrogen levels upto 100 kg ha^{-1} and thereafter, failed to increase it significantly. The increase in 100 grains weight due to 100kg N ha^{-1} was 20.79 and 6.57 per cent compared to 60 and 80kg N ha^{-1}, respectively.

Zinc:

Data presented in Table 4 showed that application of zinc could not bring significant variation in 100 grains weight of maize.

Shelling per cent:

Nitrogen :

Data in Table 7 showed that application of nitrogen upto 100kg ha^{-1} significantly increased shelling per cent of maize over its both the lower doses. The per cent increase in shelling per cent due to 80 and 100kg N ha^{-1}

Table 7 : Effect of nitrogen and zinc fertilization on yield attributes of maize

Treatments	Cobs plant^{-1}	Grains cob^{-1}	Grain weight cob^{-1} (g)	100 grain weight (g)	Shelling (%)
Nitrogen (kg ha^{-1})					
60	1.07	309.04	58.12	18.81	71.62
80	1.19	339.88	72.39	21.32	74.69
100	1.27	364.96	80.40	22.72	76.82
120	1.30	373.69	85.91	23.27	77.60
S.E.±	0.03	8.63	1.98	0.46	0.92
C.D.(P=0.05)	0.08	24.82	5.71	1.32	2.64
Zinc (kg ha^{-1})					
2.5	1.17	330.67	68.85	20.78	73.51
5.0	1.21	352.38	75.05	21.69	75.89
7.5	1.24	357.63	78.72	22.10	76.16
S.E.±	0.02	7.47	1.72	0.40	0.79
C.D. (P=0.05)	NS	21.49	4.95	NS	2.28

NS= Non-significant

was 4.28, 7.26, respectively compared to 60kg N ha^{-1}.

Zinc:

Significant increase in shelling per cent with zinc application upto 5.0kg ha^{-1}. The per cent increase in shelling per cent under the influence of 5.0kg Zn ha^{-1} was 3.23 over 2.5kg Zn ha^{-1}.

Yield and harvest index:

Grain yield:

Nitrogen:

A perusal of data pertaining to maize grain yield presented in Table 8 revealed that increasing levels of nitrogen upto 100kg ha^{-1} significantly increased grain yield of maize and thereafter, it did not increased significantly. When compared with grain yield of 2112.11kg ha^{-1} recorded less than 60kg N ha^{-1}, application of 80 and 100kg N ha^{-1} increased it by 18.76 and 39.03 per cent, respectively.

Zinc:

A significant improvement in grain yield of maize was observed with zinc fertilization upto 5.0kg ha^{-1}. Further, application of zinc upto 7.5 kg ha^{-1} did not increase it significantly. When compared with grain yield of 2382.44 kg ha^{-1} recorded less than 2.5kg zinc ha^{-1}, application of 5.0kg zinc ha^{-1} increased it by 14.38 per cent.

Stover yield:

Nitrogen:

An examination of data presented in Table 8 showed that progressive increase in nitrogen levels upto 100kg ha^{-1} significantly increased stover yield of maize over its lower doses and 120kg N ha^{-1} could not significantly increase the stover yield over 100kg N ha^{-1}. Increase in stover yield due to 80 and 100kg N ha^{-1} was 463.85 and 919.77kg ha^{-1}, compared to 3924.85kg ha^{-1} recorded less than 60kg N ha^{-1}.

Zinc:

A perusal of data presented in Table 8 showed that application of zinc in maize upto 5.0kg ha^{-1} significantly increased stover yield. Increase in stover yield due to 5.0 kg Zn ha^{-1} was 396.63 kg ha^{-1} compared to 4232.42 kg ha^{-1} recorded less than 2.5 kg Zn ha^{-1}.

Biological yield:

Nitrogen:

A perusal of data pertaining to biological yield of maize presented in Table 8 showed that application of nitrogen significantly increased biological yield upto 100 kg ha^{-1}. Critical examination of data also revealed that except 120 kg N ha^{-1} all the doses of N were found significantly superior over its preceding lower doses in enhancing biological yield. The per cent increase in biological yield due to 80 and 100 kg N ha^{-1} was 14.24 and 28.89, respectively compared to 60 kg N ha^{-1}.

Zinc:

Application of zinc upto 5.0kg ha^{-1} significantly increased biological yield. The extent of increase in biological yield due to 5.0kg zinc ha^{-1} was 11.17 per cent

Table 8 : Effect of nitrogen and zinc fertilization on yield and harvest index of maize

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Grain	Stover	Biological	
Nitrogen (kg ha^{-1})				
60	2112.11	3924.85	6036.96	35.05
80	2508.28	4388.70	6896.98	36.35
100	2936.54	4844.62	7781.15	37.72
120	3084.33	5082.85	8167.18	37.80
S.E.±	73.91	158.03	224.23	0.43
C.D. (P=0.05)	212.64	454.68	645.16	1.24
Zinc (kg ha^{-1})				
2.5	2382.44	4232.42	6614.86	35.91
5.0	2725.26	4629.05	7354.31	36.99
7.5	2873.25	4819.29	7692.54	37.28
S.E.±	64.00	136.85	194.19	0.37
C.D. (P=0.05)	184.15	393.76	558.73	1.07

compared to 2.5 kg zinc ha^{-1}.

Harvest index:

Nitrogen:

It is evident from data presented in Table 8 that progressive increment in nitrogen upto 100kg ha^{-1} increased harvest index of maize significantly. The harvest index recorded under 80, 100 and 120kg N ha^{-1} was 36.35, 37.72 and 37.80, respectively as against the lowest of 35.05 recorded under 60 kg N ha^{-1}.

Zinc:

Data presented in Table 8 revealed that application of zinc upto 5.0 kg ha^{-1} in maize significantly increased harvest index. The harvest index recorded fewer than 5.0 and 7.5 kg zinc ha^{-1} was 36.99 and 37.28, respectively as against 35.91 observed under 2.5 kg zinc ha^{-1}.

Biochemical parameters: Nitrogen, phosphorus and zinc content at harvest:

Nitrogen content in grain:

Nitrogen:

Critical examination of data presented in Table 9 revealed that application of nitrogen upto 100kg ha^{-1} significantly increased nitrogen content in grain and thereafter, it did not increase significantly. The increase in nitrogen content due to 80 and 100kg N ha^{-1} was 5.09 and 9.72 per cent respectively compared to 60kg N ha^{-1}.

Zinc:

It is apparent from the data that application of zinc upto 5.0kg ha^{-1} significantly enhanced nitrogen content in grain. The per cent increase in nitrogen content due to application of 5.0 kg zinc ha^{-1} was 4.30 compared to 2.5kg zinc ha^{-1}.

Nitrogen content in stover:

Nitrogen:

Data pertaining to nitrogen concentration in maize stover presented in Table 9 revealed that each successive increment in nitrogen level upto 100kg ha^{-1} significantly increased nitrogen concentration in maize stover and it was found statistically at par with 120kg N ha^{-1} in this regard. Increase in nitrogen content of stover due to 100kg N ha^{-1} was to the tune of 15.92 and 6.97 per cent compared to 60 and 80kg N ha^{-1}, respectively.

Zinc:

Data revealed that application of increasing level of zinc upto 5.0kg ha^{-1} significantly increased nitrogen concentration in maize stover and the magnitude of increase was 4.3 per cent compared to 2.5kg ha^{-1}.

Phosphorus content in grain:

Nitrogen:

A perusal of data pertaining to phosphorus content in maize grain presented in Table 9 indicated that application of nitrogen upto 100 kg ha^{-1} significantly enhanced phosphorus content in maize grain and thereafter, did not increase significantly. The per cent increase in phosphorus content due to 80 and 100 kg N ha^{-1} was 11.45 and 21.14, respectively compared to 60

Table 9 : Effect of nitrogen and zinc fertilization on N, P and Zn content of maize at harvest

Treatments	Nitrogen content (%)		Phosphorus content (%)		Zinc content (ppm)	
	Grain	Stover	Grain	Stover	Grain	Stover
Nitrogen (kg ha^{-1})						
60	1.491	0.490	0.227	0.113	43.150	19.575
80	1.567	0.531	0.253	0.125	45.523	20.959
100	1.636	0.568	0.275	0.135	47.948	22.121
120	1.676	0.580	0.280	0.140	48.953	22.383
S.E.±	0.022	0.008	0.005	0.002	0.695	0.390
C.D. (P=0.05)	0.063	0.023	0.014	0.007	2.001	1.122
Zinc (kg ha^{-1})						
2.5	1.536	0.523	0.250	0.125	43.921	19.653
5.0	1.602	0.545	0.265	0.133	46.608	21.299
7.5	1.639	0.558	0.261	0.128	48.652	22.826
S.E.±	0.019	0.007	0.004	0.002	0.602	0.338
C.D. (P=0.05)	0.055	0.020	0.012	0.006	1.733	0.972

kg N ha^{-1}.

Zinc:

Phosphorus content in maize grain increased significantly upto 5.0kg Zn ha^{-1} and thereafter, it decreased non-significantly. The magnitude of increase in phosphorus content due to application of 5.0kg Zn ha^{-1} was 6.0 per cent compared to 2.5kg Zn ha^{-1}.

Phosphorus content in stover:

Nitrogen:

Data presented in Table 9 explicit that progressive increase in nitrogen level upto 100 kg ha^{-1} significantly increased phosphorus content in maize stover. Compared to 60 kg N ha^{-1} the increase in phosphorus content due to 80 and 100 kg N ha^{-1} was 10.60 and 19.47 per cent, respectively.

Zinc:

Phosphorus content in maize stover increased significantly upto 5.0kg Zn ha^{-1} and thereafter, it decreased non-significantly. The increase in phosphorus content due to application of 5.0kg Zn ha^{-1} was to the tune of 6.40 per cent compared to 2.5kg Zn ha^{-1}.

Zinc content in grain:

Nitrogen:

Data presented in Table 9 indicated that application of nitrogen in maize upto the extent of 100 kg ha^{-1} significantly increased zinc concentration in grain. Application of 120 kg N ha^{-1} was found statistically at par with 100kg N ha^{-1} in this regard. Increase in zinc concentration due to 100kg N ha^{-1} was 11.11 and 5.33 per cent over to 60 and 80 kg N ha^{-1}, respectively.

Zinc:

It is evident from the data presented in Table 9 that each successive increase in zinc level significantly enhanced zinc concentration in maize grain. The per cent increase in zinc concentration in grain due to application of 5.0 and 7.5kg Zn ha^{-1} was 6.11 and 10.77, respectively compared to 2.5kg Zn ha^{-1}.

Zinc content in stover:

Nitrogen:

It is apparent from the data presented in Table 9 that application of nitrogen in maize significantly increased zinc concentration in stover. Data clearly indicated that 120kg N ha^{-1} was found statistically at par with 100kg N ha^{-1} in this respect. Increase in zinc concentration due to 80 and 100kg N ha^{-1} was 7.07 and 13.0 per cent, respectively compared to 60kg N ha^{-1}.

Zinc:

An examination of data presented in Table 9 revealed that application of zinc upto 7.5kg ha^{-1} significantly enhanced zinc concentration in maize stover. The per cent increase in zinc concentration in stover due to application of 5.0 and 7.5 kg Zn ha^{-1} was 8.37 and 16.14, respectively compared to 2.5kg Zn ha^{-1}.

Nitrogen uptake by grain:

Nitrogen:

A reference to data presented in Table 10 revealed that nitrogen application upto 100kg ha^{-1} in maize significantly increased uptake of nitrogen by grain and further increase in nitrogen level was found at par with 100kg N ha^{-1}. The magnitude of increase in nitrogen uptake by grain due to 100kg N ha^{-1} was 16.35 and 8.65kg ha^{-1} compared to 60 and 80kg N ha^{-1}, respectively.

Table 10 : Effect of nitrogen and zinc fertilization on nitrogen uptake (kg ha^{-1}) by maize at harvest

Treatments	Grain	Stover	Total
Nitrogen (kg ha^{-1})			
60	31.76	19.32	51.08
80	39.46	23.37	62.83
100	48.11	27.53	75.64
120	51.67	29.49	81.16
S.E.±	1.36	0.940	2.16
C.D. (P=0.05)	3.91	2.71	6.21
Zinc (kg ha^{-1})			
2.5	36.99	22.46	59.45
5.0	43.92	25.38	69.30
7.5	47.35	26.94	74.29
S.E.±	1.18	0.814	1.87
C.D. (P=0.05)	3.39	2.34	5.37

Zinc:

It is evident from the data presented in Table 10 that application of zinc upto 5.0kg ha^{-1} significantly enhanced nitrogen uptake by grain by 6.93 per cent compared to 2.5kg Zn ha^{-1}.

Nitrogen uptake by stover :

Nitrogen:

Application of 100kg N ha^{-1}, being at par with 120kg

N ha^{-1} significantly increased nitrogen uptake by stover over 60 and 80kg N ha^{-1} by 42.29 and 17.80 per cent, respectively.

Zinc:

Maize fertilized with 5.0 kg zinc ha^{-1} significantly increased nitrogen uptake by stover and thereafter, the increase was marginal due to 7.5kg ha^{-1}. The increase in nitrogen uptake by stover due to 5.0 and 7.5kg Zn ha^{-1} was 2.92 and 4.48kg ha^{-1}, respectively as against 22.46kg ha^{-1} observed less than 2.5kg Zn ha^{-1}.

Total nitrogen uptake by crop:

Nitrogen:

A critical examination of data presented in Table 10 showed that application of nitrogen upto 100kg ha^{-1} significantly increased total nitrogen uptake by the crop and further increase could not increase it significantly. The per cent increase in total N uptake by the crop due to 80 and 100kg N ha^{-1} was 23.0 and 48.08, respectively compared to 60kg N ha^{-1}.

Zinc:

It is evident from the data presented in Table 10 that application of zinc upto 5.0kg ha^{-1} being statistically at par with 7.5kg Zn ha^{-1} was found significant in increasing total nitrogen uptake by crop compared to 2.5kg Zn ha^{-1}. The magnitude of increase was 16.56 per cent compared to 2.5kg Zn ha^{-1}.

Phosphorus uptake by grain:

Nitrogen:

Application of 100kg N ha^{-1} significantly increased phosphorus uptake by grain and further increase in nitrogen failed to record significant increase in phosphorus uptake by grain. The per cent increase in phosphorus uptake by grain due to 80 and 100 kg N ha^{-1} was 31.60 and 66.73, respectively compared to 60kg N ha^{-1}.

Zinc:

It is evident from the data presented in Table 11 that application of zinc upto 5.0kg ha^{-1} significantly enhanced phosphorus uptake by maize grain and it was found statistically at par with 7.5kg Zn ha^{-1} in this regard. Phosphorus uptake by maize grain increased by 19.90 per cent due to application of 5.0kg Zn ha^{-1} compared to 2.5kg Zn ha^{-1}.

Table 11: Effect of nitrogen and zinc fertilization on phosphorus uptake (kg ha^{-1}) by maize at harvest

Treatments	Grain	Stover	Total
Nitrogen (kg ha^{-1})			
60	4.84	4.47	9.30
80	6.37	5.51	11.88
100	8.07	6.56	14.63
120	8.66	7.10	15.76
S.E.±	0.25	0.25	0.46
C.D.(P=0.05)	0.72	0.71	1.31
Zinc (kg ha^{-1})			
2.5	6.08	5.36	11.44
5.0	7.29	6.18	13.47
7.5	7.59	6.18	13.77
S.E.±	0.22	0.21	0.39
C.D. (P=0.05)	0.62	0.61	1.13

Phosphorus uptake by stover:

Nitrogen:

A reference to data revealed that application of nitrogen upto 100kg ha^{-1} significantly increased phosphorus uptake by maize stover, beyond which the increase was not found significant. Application of 100kg N ha^{-1} increased total N uptake by 46.75 and 23.15 per cent over 60 and 80kg N ha^{-1}, respectively.

Zinc:

A reference to data presented in Table 11 further revealed that application of zinc beyond 5.0kg ha^{-1} could not enhance phosphorus uptake by maize stover. Data further indicated that application of both 5.0 and 7.5kg Zn ha^{-1} significantly increased phosphorus uptake by stover by 15.30 per cent compared to 2.5kg Zn ha^{-1}.

Total phosphorus uptake by crop:

Nitrogen:

A perusal of data pertaining to total phosphorus uptake by the crop presented in Table 11 revealed that application of nitrogen beyond 100kg ha^{-1} failed to record significant increase in total phosphorus uptake by crop. The per cent increase in total phosphorus uptake by crop under the influence of 80 and 100kg N ha^{-1} was 27.74 and 57.31, respectively compared to 60kg N ha^{-1}.

Zinc:

Data presented in Table 11 illustrated that application of zinc upto 5.0kg ha^{-1} significantly increased total phosphorus uptake by the crop and further increase in zinc level did not increase the parameter significantly. The magnitude of percent increase in total phosphorus uptake by the crop due to 5.0kg Zn ha^{-1} was 17.75 over 2.5kg Zn ha^{-1}.

Zinc uptake by grain:

Nitrogen:

Application of successive increase in nitrogen level upto 100kg ha^{-1} significantly increased zinc uptake by maize grain and the per cent increase in Zn uptake by grain due to 100kg N ha^{-1} was 54.29 and 23.16 compared to 60 and 80kg N ha^{-1}, respectively.

Zinc:

Application of zinc upto 7.5kg ha^{-1} in maize significantly increased its uptake by grain. The per cent increase in zinc uptake by grain due to 5.0 and 7.5kg Zn ha^{-1} was 21.10 and 33.38, respectively over 2.5kg Zn ha^{-1}.

Zinc uptake by stover:

Nitrogen:

Its is revealed that application of 80 and 100kg N ha^{-1} significantly increased Zn uptake by stover over its lower levels. Data also indicated that application of 120 kg N ha^{-1} was found at par with 100 kg N ha^{-1} in this regard. The per cent increase in Zn uptake by stover with application of 100 kg N ha^{-1} was 37.37 and 12.51 over 60 and 80 kg N ha^{-1}, respectively.

Zinc:

Data presented in Table 12 indicated that each successive increase in zinc level upto 7.5 kg ha^{-1} significantly increased total Zn uptake by crop. The per cent increase in total Zn uptake by crop due to 5.0 and 7.5 kg Zn ha^{-1} was 19.86 and 32.64, respectively over 2.5 kg Zn ha^{-1}.

Total zinc uptake by crop:

Nitrogen:

Application of nitrogen upto 100kg ha^{-1} significantly increased total zinc uptake by crop and the per cent increase in total Zn uptake by crop due to 80 and 100 kg N ha^{-1} was 23.81and 46.53, respectively compared to 60kg N ha^{-1}.

Zinc:

An examination of data presented in Table 12 indicated that application of Zn upto 7.5kg ha^{-1} significantly increased its total uptake and the per cent increase in total zinc uptake by crop due to 5.0 and 7.5 kg Zn ha^{-1} was 19.86 and 32.65, respectively over 2.5 kg Zn ha^{-1}.

Chlorophyll content:

Nitrogen:

Data presented in Table 13 revealed that successive increase in nitrogen upto 100kg ha^{-1} significantly increased chlorophyll content of leaves 50 and 75DAS and beyond this it did not increased significantly. The per cent increase in chlorophyll content 50 and 75DAS due to 80 and 100kg N ha^{-1} was 14.47, 25.0 and 28.57, 44.44, respectively compared to 60kg N ha^{-1}.

Table 12 : Effect of nitrogen and zinc fertilization on zinc uptake (kg ha^{-1}) by maize at harvest

Treatments	Grain	Stover	Total
Nitrogen (kg ha^{-1})			
60	91.58	77.70	169.28
80	114.73	94.87	209.60
100	141.30	106.74	248.04
120	151.79	113.45	265.24
S.E.±	3.70	3.29	6.66
C.D. (P=0.05)	10.64	9.47	19.18
Zinc (kg ha^{-1})			
2.5	105.66	84.15	189.81
5.0	127.96	99.57	227.52
7.5	140.93	110.85	251.78
S.E.±	3.20	2.85	5.77
C.D. (P=0.05)	9.21	8.20	16.61

Table 13: Effect of nitrogen and zinc fertilization on chlorophyll (mg kg^{-1}) and protein content (%) in maize

Treatments	Chlorophyll content in leaves (mg kg^{-1})		Protein content in grain (%)
	50 DAS	75 DAS	
Nitrogen (kg ha^{-1})			
60	1.52	1.26	9.32
80	1.74	1.62	9.79
100	1.91	1.82	10.22
120	1.99	1.91	10.47
S.E.±	0.04	0.04	0.14
C.D.(P=0.05)	0.11	0.12	0.40
Zinc (kg ha^{-1})			
2.5	1.69	1.56	9.60
5.0	1.81	1.68	10.01
7.5	1.88	1.72	10.24
S.E.±	0.03	0.04	0.12
C.D. (P=0.05)	0.10	0.10	0.34

Zinc:

Data presented in Table 13 revealed that zinc fertilization upto 5.0kg ha^{-1} significantly increased chlorophyll content of leaves 50 and 75 DAS and was found statistically at par with 7.5kg Zn ha^{-1}. The magnitude of increase in chlorophyll content 50 and 75DAS due to 5.0kg Zn ha^{-1} was 7.10 and 7.69 per cent, respectively compared to 2.5kg Zn ha^{-1}.

Protein content in grain:

Nitrogen:

It is evident from the data presented in Table 13 that application of nitrogen upto 100kg ha^{-1} significantly increased protein content in maize grain. However, it was found statistically at par with 120kg N ha^{-1} in this regard. The increase in protein content of maize grain due to 100kg N ha^{-1} was 9.65 and 4.39 per cent compared to 60 and 80kg N ha^{-1}, respectively.

Zinc:

A perusal of data presented in Table 13 showed that application of 5.0 kg zinc ha^{-1} in maize significantly increased protein content of maize grain and thereafter, not responded significantly. The per cent increase in protein content owing to 5.0kg Zn ha^{-1} was 4.27 over 2.5kg Zn ha^{-1}

Economic evaluation:

Net returns and benefit cost ratio:

Nitrogen:

A perusal of data presented in Table 14 indicated that nitrogen fertilization to maize had significant effect on net returns and benefit cost ratio. Net returns and benefit cost ratio increased significantly with every unit increase in nitrogen level upto 100kg ha^{-1} and thereafter, it did not increase significantly. Application of 100kg N ha^{-1} increased the net returns Rs. 9499 and Rs. 4922 over 60 and 80kg N ha^{-1}, respectively. The highest benefit cost ratio of 2.26 was recorded with 120kg N ha^{-1} but it was statistically found at par with 100kg N ha^{-1} having benefit cost ratio of 2.18.

Zinc:

Data presented in Table 14 revealed that application of zinc upto 5.0kg ha^{-1} significantly increased net returns and benefit cost ratio and found statistically at par with 7.5kg Zn ha^{-1} in this regard. The magnitude of increase in net returns due to 5.0 and 7.5kg zinc ha^{-1} was Rs. 3750 and Rs. 5152, respectively, compared to 2.5kg Zn ha^{-1}. The highest benefit cost ratio of 2.10 was recorded due to 7.5kg Zn ha^{-1} however, it found statistically at par with 5.0kg Zn ha^{-1} having benefit cost ratio of 2.04.

Table 14 : Effects of nitrogen and zinc fertilization on economics of maize

Treatments	Net returns (Rs. ha^{-1})	Benefit cost ratio
Nitrogen (kg ha^{-1})		
60	10618	1.64
80	15195	1.90
100	20117	2.18
120	21735	2.26
S.E.±	951	0.06
C.D.(P=0.05)	2736	0.16
Zinc (kg ha^{-1})		
2.5	13949	1.84
5.0	17699	2.04
7.5	19101	2.10
S.E.±	823	0.05
C.D. (P=0.05)	2369	0.14

Conclusion

On the basis of the results emanated from present investigation conducted during *Kharif* 2016, it could be concluded that application of 100kg N and 5.0 kg Zn ha^{-1} may be applied in maize to achieve higher grain yield, net returns and B:C in clay loam soil of agro-climatic zone Ajmer Rajasthan. Since these experimental findings are based on one year's data, hence, needs further confirmation.

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