Article AR2212 DOI: HTTPS://DOI.ORG/10.23910/1.2021.2212

International Journal of Bio-resource and Stress Management

Crossref

June 2021

Print ISSN 0976-3988
Online ISSN 0976-4038

IJBSM 2021, 12(3):179-185

Research Article — *Natural Resource Management*

Effect of Nitrogen and Zinc on Growth and Yield of Maize (*Zea mays* L.)

Jagdeep Singh[1], Ram Partap[2*], Amritpal Singh[1], Naresh kumar[3] and Krity[4]

[1]Dept. of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjabi University, Patiala, Punjab (147 002), India
[2]ICAR–Indian Institute of Soil & Water Conservation Research Centre, Vasad, Dist. Anand, Gujarat (388 306), India
[3]Dept. of Agriculture, Maharaja Agarsen Agriculture College, Suratgargh, Dist. Sriganganagar, Rajasthan (335 804), India
[4]Dept. of Agriculture, Dolphin (PG) College of Science and Agriculture, Chunni Kalan, Fatehgarh Sahib, Punjab (140 406), India

Open Access

Corresponding Author

Ram Partap
e-mail: ram7728@gmail.com

Citation: Singh et al., 2021. Effect of Nitrogen and Zinc on Growth and Yield of Maize (*Zea mays* L.). International Journal of Bio-resource and Stress Management 2021, 12(3), 179-185. HTTPS://DOI.ORG/10.23910/1.2021.2212.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Abstract

The experiment was laid out on the effect of nitrogen and zinc on growth and yield of maize (*Zea mays* L.) at Research Farm of the Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, India during *kharif* (July to October) season of 2017. The experiment was laid out in randomized block design three replication with eight treatments. The soil of the experimental field was Gangetic alluvial having clay loam texture with pH 7.5. It was moderately fertile, with available nitrogen (285.24 kg ha^{-1}), available phosphorus (26.15 kg ha^{-1}), available potassium (250.84 kg ha^{-1}) and available zinc (1.42 mg kg^{-1}). The maximum growth parameter viz. plant height (cm), LAI (%), dry matter accumulation (g) and the highest yield attributes and yield parameters viz., number of cob^{-1}, length of cob (cm), test weight (g), number of grain cob^{-1}, grain yield (q ha^{-1}), stover yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%) was recorded at 30, 60, 90 DAS and at harvest stage with the application of nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} which was at par with the treatments namely; nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1} and nitrogen @150 kg ha^{-1}. All the treatments significantly influenced the growth and yield attributes as compared to control. The maximum net returns (₹ 89977 ha$^{-1)}$ and benefit:cost ratio (1.58) has been recorded with application of nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1}.

Keywords: Maize, nitrogen, zinc, growth, yield, economics

1. Introduction

Maize (*zea mays* L.) has been an important cereal crop owing to its highest production potential and adaptability to wide range of environment hence called as 'Queen of Cereals'. In India, maize is placed in 3rd position among the cereals in terms of its importance, after rice and wheat (Mahapatra et al., 2018, Anonymous, 2018 and Suganya et al., 2020). In India, area, production and productivity of maize is 9.76 mha, 26.14 mt and 26.80 kg ha^{-1} respectively (Anonymous, 2017a). Maize crop occupied 116 thousand hectares, with a production of 445 thousand tonnes and the average yield (38.35 q ha^{-1}) was in the Punjab State during 2016-17 (Anonymous, 2017b). Maize is also an important not only because of its great adaptability to widely varying conditions but also because of its high responsiveness to better management practices particularly irrigation and fertilizers. Maize is mainly grown in kharif season and to some extent, in winter and spring seasons in

Article History

RECEIVED on 24th March 2021 RECEIVED in revised form on 27th May 2021 ACCEPTED in final form on 10th June 2021

Punjab. Introduction of rice -wheat system in Punjab has also led to some severe problems among which depleting water table and deteriorating soil health are major ones. So, there is a need to interchange the high water requiring rice crop with some low water requiring crop like maize (Kaur and Vashist, 2016).

Maize is being used as staple food in many countries. With respect to the nutritive values, 100 g of maize are found to be rich in 89.1% moisture, 1.9 g protein, 0.2 g fat, 0.06 g ash, 8.2 mg carbohydrate, 28 mg calcium, 86 mg phosphorus and 11 mg ascorbic acid (Kumar et al., 2018). It shares a major contribution in farmer's economy of developing countries (Tagne et al., 2008). Apart from providing the staple diet for the population, maize is also an important crop in industrial and livestock production in the country (Anonymous, 2012). Moreover, its use as food and fodder, maize is now gaining importance on account of its potential uses in manufacturing of starch, resins, syrups, ethanol, etc. (Ayyar and Appavoo, 2016).

Nitrogen is a major fertilizer which is constituent of protein and protoplasm of chlorophyll and enzymes. Nitrogen is the essential constituent of chlorophyll, protoplasm and enzymes. (Yeshiwas, 2017 and Kaur et al., 2020). Higher nitrogen levels are reported to increase plant height, stem thickness, leaf area, leaf area index, dry matter accumulation; net assimilates ratio and yield per hectares (Cheema et al., 2010). In maize the amount of maize grain produced per unit of fertilizer N applied depends upon the uptake from fertilizer and soil N and its utilization in producing grains. As such, nitrogen being the most limiting nutrient its supply along with other nutrients becomes a matter of paramount concern to maintain fertility of the soils for sustained high crop production (Scharf et al. 2002). Maize grain yield potential is twice as high as compared to other cereal crops (Potarzycki and Grzebisz, 2009). Nitrogen management in maize production system is one of the main concerns since it is the most important and primary nutrient for growth and development of the crop (Blumenthal et al., 2008).

Zinc is one of the essential micronutrient elements and is required by crop plants in very small amounts. It plays a significant role in various enzymatic and physiological activities and performs many catalytic functions in plant system besides transformation of carbohydrates, chlorophyll and protein synthesis (Singh, 2009). Zinc is an essential element for plants, animals and human beings. Its nutritive value is similar to those of non-leguminous vegetables such as cauliflower, tomato, cucumber and cabbage (Palai et al., 2017). Zinc element is essential for normal, healthy growth and reproduction of plants. The interaction resulting from the effects of N application helps to promote plant growth and it is possible to find positive interactions between increasing levels of Zn and N fertilizers (Hafeez et al., 2013). Maize being a high nutrient mining crop it needs a higher amount of NPK for its economic production (Adhikari et al., 2021). Considering the above facts, the present experiment was planned and undertaken with the objective to study the effect of Nitrogen and Zinc on growth, yield and compute the economic feasibility of maize.

2. Materials and Methods

A field experiment was conducted at Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib (Punjab), India during July–November month of 2017. The research farm lies between 76^{o} 22' and 76^{o} 46' longitude and 30^{o} 36' and 30^{o} 39' latitude. The total rainfall received during crop-growing season of 2017 was 256.10 mm. The soil of the experimental field was clay loam in texture, neutral to slightly alkaline in reaction and medium in organic carbon, available N, K, P and high in Zn. The experiment laid out in randomized block design with three replicates. the total treatment combinations were eight. the treatments details are as treatment$_1$- control, treatment $_2$- zinc @15 kg ha^{-1}, treatment $_3$- zinc @ 30 kg ha^{-1}, treatment $_4$- nitrogen @80 kg ha^{-1}, treatment $_5$- nitrogen @80 kg ha^{-1}++zinc @15 kg ha^{-1}, treatment $_6$- nitrogen @80 kg ha^{-1}++zinc @30 kg ha^{-1}, treatment $_7$- nitrogen @120 kg ha^{-1},treatment $_8$- nitrogen @120 kg ha^{-1}++zinc @15 kg ha^{-1}, treatment$_9$- nitrogen @120 kg ha^{-1}++zinc @30 kg ha^{-1}, treatment $_{10}$- nitrogen @150 kg ha^{-1}, treatment $_{11}$- nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1}, treatment $_{12}$- nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1}. The field was ploughed and given pre-sowing irritation. After the preparatory tillage, the field was divided into 36 different plots of 3×3 m^2 size. The pretreated seed of variety Pioner-3401 was sown by the dibbling method in between the rows by using maize seed at the rate of 8 kg ha^{-1} with a spacing of 45×20 cm^2 on 20 July, 2017. RDF (Recommended dose of fertilizer) of P and K for Maize is 60, 40 kg ha^{-1}. Full of dose P_2O_5, K_2O, and Zn as basal dose in form of $ZnSo_4$ and remaining dose of nitrogen was applied as urea in 1/3 was applied as topdressing in two splits at knee high stage and at pre-tasseling stage. The field was kept free from weeds by manual hoeing. The plant protection measures and irrigations whenever required were provided in the same manner for all the treatments. Observations were recorded from selected plants with different characters of growth attributes viz., plant height (cm), dry matter accumulation (g plant^{-1}), leaf area index and yield attributes viz., number of cob plant^{-1}, length of cob (cm), test weight (g), number of grain cob^{-1}, grain yield (q ha^{-1}), stover yield (q ha^{-1}), biological yield (q ha^{-1}) and harvest index (%). Regular biometric observations were recorded at periodic intervals of 30, 60, and 90 days after sowing and at the harvest stage. Yield attributes parameters were recorded just before harvesting the crop. The crop was harvested on 30 October 2017 when about 80% of the cobs turned yellowish and grains became hard and then tied in the labeled bundles. The sun dried weight of bundles was recorded. The cobs were removed from the plants, dried and threshed with hand operated maize sheller. Thus grain yield of each plot was recorded. Economic analysis was carried out by calculating the amount of material needed for one hectare, calculating annual cost of production by considering the present market rate, depreciation, life of the material, and annual interest. The raw data were subjected to appropriate statistical procedure as suggested by Gomez and Gomez (1984).

3. Results and Discussion

3.1. Growth attributes

The observations on plant height of maize recorded at 30, 60, 90 DAS and at harvest stage were affected by different treatments of nitrogen and zinc are presented in Table 1. At 30, 60, 90 DAS and at harvest the maximum plant height was recorded with the nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} which was found at par with the treatments namely; nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1} followed by the nitrogen @150 kg ha^{-1} and nitrogen @120 kg ha^{-1}++zinc @30 kg ha^{-1} it was significantly superior over rest of the treatments. The maximum plant height was recorded at harvest stage with the nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} was noted 217.1 cm. The enhanced vegetative growth in terms of plant height due to nitrogen application was reported by Kumar et al. (2002), Patel et al. (2006), Ravi et al. (2012), Ali et al. (2013) and Imran et al. (2015). Jangir et al. (2015) reported that the significant response to zinc in terms of improvement in plant height is further supported by the fact that soil of the experimental field was low in zinc status and its early supply corrected the deficiency and considerably improved the crop growth. The maximum dry weight accumulation have been recorded 27.6, 104.6, 216.0 and 240.9 gm at 30, 60, 90 DAS and harvesting stage respectively under the application of with the nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} Followed by the nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1} and the nitrogen @150 kg ha^{-1}. Ghodpage et al. (2008) reported that the increase in yield could be attributed to the proper supply of Zn up to harvesting stages in soil and which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby finally increased dry-matter accumulation. The maximum leaf area index was recorded at 30, 60 and 90 DAS with the nitrogen @ 150 kg ha^{-1}++zinc @30 kg ha^{-1} which were found at par with the nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1} and the nitrogen @150 kg ha^{-1}. Similar findings were also obtained by Amanullah et al. (2014), who reported that the increase in growth and

Table 1: Effect of nitrogen and zinc on growth attributes parameters of maize

Treatment details	Plant height (cm)				Dry matter accumulation (g plant^{-1})				Leaf area index		
	30 DAS	60 DAS	90 DAS	At Harvest stage	30 DAS	60 DAS	90 DAS	At Harvest stage	30 DAS	60 DAS	90 DAS
T_1=Control	31.0	144.0	147.7	148.7	14.2	70.6	149.7	152.9	0.8	1.6	2.5
T_2=Zinc @15 kg ha^{-1}	32.1	148.4	153.2	154.4	14.5	73.7	155.3	168.3	0.8	1.6	2.6
T_3=Zinc @30 kg ha^{-1}	35.2	156.7	160.0	161.3	16.6	77.9	160.7	184.2	1.1	1.7	2.9
T_4=Nitrogen @80 kg ha^{-1}	37.7	159.1	166.3	168.1	17.4	79.5	174.8	192.2	1.1	1.7	3.0
T_5=Nitrogen @80 kg ha^{-1}++Zinc @15 kg ha^{-1}	39.0	162.6	168.7	170.1	17.9	81.4	176.1	200.7	1.2	2.0	3.0
T_6=Nitrogen @80 kg ha^{-1}++Zinc @30 kg ha^{-1}	40.3	166.8	174.2	176.4	18.5	87.6	181.8	207.1	1.3	2.0	3.3
T_7=Nitrogen @120 kg ha^{-1}	42.2	171.9	178.3	179.4	20.1	87.1	186.1	214.2	1.6	2.1	3.4
T_8=Nitrogen @120 kg ha^{-1}++Zinc @15 kg ha^{-1}	47.0	178.7	188.0	190.2	22.7	90.6	195.7	218.5	1.7	2.2	3.6
T_9=Nitrogen @120 kg ha-1++Zinc @30 kg ha^{-1}	52.1	187.3	196.8	198.2	23.5	94.1	197.6	225.2	2.3	2.5	3.7
T_{10}=Nitrogen @150 kg ha^{-1}	52.5	190.5	197.4	199.3	25.4	97.3	208.0	228.4	2.5	2.7	3.9
T_{11}=Nitrogen @150 kg ha^{-1}++Zinc @15 kg ha^{-1}	54.9	197.8	207.1	210.2	26.9	100.5	213.0	231.0	2.6	2.7	4.1
T_{12}=Nitrogen @150 kg ha^{-1}++Zinc @30 kg ha^{-1}	56.3	204.9	214.4	217.1	27.6	104.6	216.0	240.9	2.7	2.9	4.3
SEm±	1.7	6.0	6.3	6.6	0.8	3.2	5.9	7.4	0.1	0.1	0.1
CD (p=0.05)	5.2	18.3	19.1	20.1	2.4	9.7	17.8	22.3	0.2	0.2	0.4

growth attributes with respect to increased nitrogen and zinc application rate indicates maximum vegetative growth of plant under higher nitrogen availability. Arshewar et al. (2018), observed that the significantly increase the growth attributes with the increase level of nitrogen and zinc. Wasaya et al. (2017), stated that application of zinc gave significant increase in growth parameters such as plant height and leaf area index in maize. Assefa and Mekonnen (2019) showed that the plant height, Leaf area index (LAI) and dry matter accumulation was significantly affected by level of nitrogen application. Similarly result founded by Rasheed et al. (2004) and Inamullah et al. (2011). Panneerselvam and Palaniyandi (2014) was also noted the favorable effect of plant height and other growth attributes may be ascribed to its stimulatory effect on most of the physiological and metabolic processes of plant.

3.2. Yield attributes

Yield attributing characters like number of cobs plant^{-1}, length of cobs, number of grain cob^{-1}, and test weight, grain yield (q ha^{-1}), stover yield (q ha^{-1}), biological yield (q ha^{-1}), and harvest index (%) showed positive correlation with yield. The increase in the value of yield attributes could be attributed to the increase in plant dry matter. The data from the Table 2 revealed with the nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} shows the maximum number of cobs plant^{-1} followed by the nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1}. While the lowest number of cobs plant^{-1} found under control treatment among all the applied treatments. However, treatments of nitrogen and zinc were non-significant to each other. Prodhan et al. (2007), who found the higher cob yield realization with application of higher nitrogen, could be ascribed to its profound influence on vegetative and reproductive growth of the crop. Kumar et al. (2018) observed that the application of increasing doses of Zn increases the yields of maize cob. The maximum length of cobs was recorded in the nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} which was first at par with the nitrogen @ 150 kg ha^{-1}++zinc @ 15 kg ha^{-1} and second at par with nitrogen @150 kg ha^{-1} and significantly superior rest of the treatments. The minimum length of cobs was showed by under control treatments. Thakur and Sharma (2009) observed that the maximum cob length with application of nitrogen @200 kg ha^{-1} as compared to nitrogen @100 kg ha^{-1}. Similarly Ahmad et al. (2018) also reported a positive correlation between the level of Nitrogen and length of cob. The maximum test weight recorded with nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} gave the highest test weight which was at par with nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1}, nitrogen @150 kg ha^{-1} and nitrogen @ 120 kg ha^{-1}++zinc @30 kg ha^{-1} recorded significantly superior over rest of treatments. However, all the other treatments recorded higher test weight better than untreated control. Application of nitrogen @ 150 kg ha^{-1}++zinc @ 30 kg ha^{-1} gave the highest number of grain cob^{-1} which was at par with the nitrogen @150 kg ha^{-1}++zinc @15 kg ha^{-1} and nitrogen @ 150 kg ha^{-1} it recorded significantly superior over rest of treatments. Ehsanullah et al. (2015) noted that the increase in number of grains cob^{-1} was significantly enhanced by the application of Zn. Pandey et al. (2010) observed the optimum grains cob^{-1} was observed with application of nitrogen @120 kg ha^{-1} than that of with nitrogen @60 kg ha^{-1} and nitrogen @ 90 kg ha^{-1} in baby corn. A faster

Table 2: Effect of nitrogen and zinc on yield attributes and yield parameters of maize

Treatments	Cob plant^{-1}	Length of cob (cm)	Test weight (g)	No. of grain cob^{-1}	Grain yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_1=Control	0.9	12.0	210.7	176.0	3.1	7.8	10.4	27.2
T_2=Zinc @15 kg ha^{-1}	1.2	13.7	215.0	201.0	3.4	8.8	12.2	27.6
T_3=Zinc @30 kg ha^{-1}	1.6	14.9	221.0	217.0	3.9	10.1	14.0	28.0
T_4=Nitrogen @80 kg ha^{-1}	1.7	15.7	221.0	250.2	4.1	11.1	15.2	28.0
T_5=Nitrogen @80 kg ha^{-1}++Zinc @15 kg ha^{-1}	1.7	16.7	223.3	265.0	4.4	11.4	15.9	28.6
T_6=Nitrogen @80 kg ha^{-1}++Zinc @30 kg ha^{-1}	1.8	17.9	227.3	274.6	4.8	12.0	16.8	28.8
T_7=Nitrogen @120 kg ha^{-1}	1.8	18.2	229.3	325.2	5.0	12.9	17.9	29.1
T_8=Nitrogen @120 kg ha^{-1}++Zinc @15 kg ha^{-1}	1.9	18.5	232.3	331.5	5.4	13.2	18.5	29.3
T_9=Nitrogen @120 kg ha-1++Zinc @30 kg ha^{-1}	2.0	19.9	235.7	356.8	5.9	13.4	19.3	30.5
T_{10}=Nitrogen @150 kg ha^{-1}	2.4	20.0	238.0	383.3	6.1	14.2	20.3	30.6
T_{11}=Nitrogen @150 kg ha^{-1}++Zinc @15 kg ha^{-1}	2.4	21.7	243.7	410.1	6.5	14.4	20.9	30.9
T_{12}=Nitrogen @150 kg ha^{-1}++Zinc @30 kg ha^{-1}	2.6	22.0	245.7	415.0	6.6	14.8	21.7	31.5
SEm±	0.1	0.7	4.2	10.6	0.2	0.4	0.6	1.1
CD (p=0.05)	0.2	2.0	12.7	32.1	0.7	1.3	1.7	NS

growth under influence of higher level of nitrogen fertilization might have played a significant role in reducing competition for photosynthates and nutrients with other plants resulting in healthy plants. Sandya et al. (2016) who noted the indicating significantly higher value of yield attributes with the higher level of nitrogen. The increased availability of photosynthates might have enhanced number of flowers and their fertilization resulting in higher number of yield attributes. Wasaya et al. (2017) observed significant increase in yield parameters and yield of maize with the application of zinc.

The maximum grain yield was recorded with the application of nitrogen @ 150 kg ha^{-1}++zinc @ 30 kg ha^{-1} and it was found at par with the nitrogen @ 150 kg ha^{-1}++zinc @ 15 kg ha^{-1} and nitrogen @150 kg ha^{-1}. All these might have cumulatively produced higher grain yield under the higher level of nitrogen. Singh et al. (2010) reported that the application of N through fertilizer alone recorded significantly higher yield over 50% fertilizer N+50% N through FYM. The results are also supported by those of Asif et al. (2013), who reported the positive effect of combined use of nitrogen and zinc on yield and yield contributing parameters. Matusso and Materusse (2016), reported that the yield characters and grain yield increased significantly with increase in nitrogen level. Ruffo et al. (2016) documented that application of zinc at higher level gave higher yield than control treatment in maize. Adhikari et al. (2021) reported that the different levels of nitrogen had a significant effect on grain yield. The highest stover yield, biological yield and maximum harvest index was recorded under the application of nitrogen @ 150 kg ha^{-1}++zinc @ 30 kg ha^{-1} and it was found at par with the nitrogen @ 150 kg ha^{-1}++zinc @ 15 kg ha^{-1} and nitrogen @ 150 kg ha^{-1}. Chauhan et al. (2014) reported that the interaction effect of nitrogen and zinc was significant for grain and stover yield. All the levels of zinc increased the grain yield significantly at each level of nitrogen and vice versa. Arya and Singh (2000), who found the grain yield and biological yield increased owing to zinc application which takes part in metabolism of plant as an activator of several enzymes and in turn may directly or indirectly affect the synthesis of carbohydrate and protein.

3.3. Economics

Data on economics of various nitrogen and zinc treatments was presented in Table 3 revealed that the plot treated with application of the nitrogen @ 150 kg ha^{-1}++zinc @ 30 kg ha^{-1} gave the maximum net returns and maximum benefit: cost ratio followed by the nitrogen @ 150 kg ha^{-1}++zinc 15 @ kg ha^{-1}. Application of the nitrogen @ 150 kg ha^{-1}++zinc @ 30 kg ha^{-1} gave maximum net return and maximum benefit: cost ratio was 1.58. Swati (2014) reported that the application of nitrogen and zinc readily and more nutrients available to crop which result in increased the growth and yield attributes of crop which ultimately increase the productivity of crop. High grain and Stubble yield results in high gross income. Pandey et al. (2010) reported that the application of nitrogen @120 kg ha^{-1} gave significantly higher yield (21.9 and 7.9) and more net return compared with nitrogen @60 and @90 kg ha^{-1} respectively. Benefit: cost ratio was also the highest nitrogen @120 kg ha^{-1}. Different nitrogen schedules also influenced the maize yield, yield attributes and economic returns. Sandya et al. (2016) noted that the enhancement in nitrogen application increased the gross, net returns and B:C ratio. All the treatments significantly influenced the growth, yield attributes, yield, gross return, net return and B:C ratio as compared to control. So the higher B: C was obtained in these treatments due to higher yield obtained over control which in turn increased the net returns.

Table 3: Effect of nitrogen and zinc on economics

Treatments	Cost of cultivation (₹ ha^{-1})	Gross Return (₹ ha^{-1})	Net Return (₹ ha^{-1})	B:C Ratio
T_1=Control	49927	67950	18023	0.36
T_2=Zinc @15 kg ha^{-1}	52297	77858	25561	0.48
T_3=Zinc @30 kg ha^{-1}	54667	89413	34745	0.63
T_4=Nitrogen @80 kg ha^{-1}	51987	95358	43371	0.83
T_5=Nitrogen @80 kg ha^{-1}++Zinc @15 kg ha^{-1}	53654	101175	47521	0.88
T_6=Nitrogen @80 kg ha^{-1}++Zinc @30 kg ha^{-1}	55924	107892	51968	0.92
T_7=Nitrogen @120 kg ha^{-1}	52268	114449	62181	1.18
T_8=Nitrogen @120 kg ha^{-1}++Zinc @15 kg ha^{-1}	54368	120280	65912	1.21
T_9=Nitrogen @120 kg ha-1++Zinc @30 kg ha^{-1}	56408	128642	72234	1.28
T_{10}=Nitrogen @150 kg ha^{-1}	52625	134225	81600	1.55
T_{11}=Nitrogen @150 kg ha^{-1}++Zinc @15 kg ha^{-1}	54695	140117	85422	1.56
T_{12}=Nitrogen @150 kg ha^{-1}++Zinc @30 kg ha^{-1}	56765	146742	89977	1.58

1 USD=INR 65.06691 average rate for harvesting month of October 2017

4. Conclusion

The integrated application of nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1} give maximum growth, yield attributes and yield of maize at 30, 60, 90 DAS, and at harvest stage. The maximum net returns (89977 Rs. ha^{-1}) and benefit: cost ratio (1.58) has been recorded with application of nitrogen @150 kg ha^{-1}++zinc @30 kg ha^{-1}. Results showed that increased nitrogen doses favorably affected the yield attributes, yield and monetary returns.

5. References

Adhikari, K., Bhandari, S., Aryal, K., Mahato, M., Shrestha, J., 2021. Effect of different levels of nitrogen on growth and yield of hybrid maize (*Zea mays* L.) varieties. Journal of Agriculture and Natural Resources 4(2), 48–62.

Ahmad, S., Khan, A.A., Kamran, M., Ahmad, I., Ali, S., Fahad, S., 2018. Response of maize cultivars to various nitrogen levels. European Experimental Biology 8(1), 1–4

Ali, A., Iqbal, Z., Hassan, S.W., Yasin, M., Khaliq, T., Ahmad, S., 2013. Effect of nitrogen and Sulphur on phenology, growth and yield parameters of maize (*Zea mays* L.). International Journal of Agricultural Sciences 25(2), 363–366.

Amanullah, K.M., Khan, A., Khan, I., Shah, Z., Hussain, Z., 2014. Growth and yield response of maize (*Zea mays* L.) to foliar NPK-fertilizers under moisture stress condition. Soil and Environment 33(2), 116–123.

Anonymous, 2012. Statistical Database. Food and Agriculture Organization of the United Nations, Statistics Division. www.faostat.fao.org.

Anonymous, 2017a. Agriculture Statistics Division Directorate of Economics & Statistics Department of Agriculture, cooperation and Farmer Welfare. https://eands.dacnet.nic.in

Anonymous, 2018 . Part-3: Feeding the World, Statistical Year Book of FAO of United Nation, Retrieved on December 21, 2019 from http://www.fao.org.

Anonymous, 2017b. Package of Practices for *Kharif* Crops. Punjab Agricultural University, Ludhiana, India, 24.

Arshewar, S.P., Karanjikar, P.N., Dambale, A. S., Kawde, M.B., 2018. Effect of Nitrogen and Zinc Levels on Growth, Yield and Economics of Pearl Millet (*Pennisetum glaucum* L.). International Journal of Bio-resource and Stress Management 9(6), 729–732.

Arya, K.C., Singh, S.N., 2000. Effect of different levels of phosphorus and zinc on yield and nutrient uptake of maize (*Zea mays*) with and without irrigation. Indian Journal of Agronomy 45(4), 717–721.

Asif, M., Saleem, M.F., Anjum, S.A., Wahid, M.A., Bilal, M.F., 2013. Effect of nitrogen and zinc sulphate on growth and yield of maize. Journal Agriculture Research 51(4), 162–178.

Assefa, K., Mekonnen., Z., 2019. Effect of level and time of nitrogen fertilizer application on growth, yield and yield components of maize (*Zea mays* L.) at Arba Minch, Southern Ethiopia. African Journal of Agricultural Research 14(33), 1785–1794.

Ayyar, S., Appavoo, S., 2016. Effect of graded levels of Zn and microbial inoculation on NPK availability and their uptake for maize in black soil. Madras Agricultural Journal 103, 207–212.

Blumenthal, J., Baltensperger, D., Cassman, K.G., Mason, S., Pavlista, A., 2008. Importance and effect of nitrogen on crop quality and health, Nitrogen in the Environment: Sources, Problems, and Management, Elsevier, Oxford, 2nd edition.

Chauhan, T.M., Ali, J., Singh, S.P., Singh, S.B., 2014. Effect of nitrogen and zinc nutrition on yield, quality and uptake of nutrients by wheat. Annals Plant Soil Research 16(2), 98–101.

Cheema, M.A., Farhad, M.F., Saleem, H.Z., Khan, A., Munir, M.A., Wahid, F., Rahul, H.M., 2010. Nitrogen management strategies for sustainable maize production. Crop Environment 1, 49–52.

Ehsanullah, A., Tariq, M.A., Randhawa, A.S., Anjum, M., Nadeem, M., Naeem, M., 2015. Exploring the Role of Zinc in Maize (*Zea mays* L.) through Soil and Foliar Application. Universal Journal of Agricultural Research. 3(3), 69–75.

Ghodpage, R.M., Balpanda, S.S., Babhulkar, V.P., Pongade, S., 2008. Effect of phosphorus and zinc fertilization on nutrient content in root, yield and nutritional quality of maize. Journal of Soils and Crops 18, 458–461.

Gomez, K.A., Gomez, A.A., 1984. Statistical procedure for agricultural research. 2nd ed. John Wiley and Sons. New York, 64.

Hafeez, B., Khanif, Y.M., Saleem, M., 2013. Role of zinc in plant nutrition- a review. American Journal of Experimental Agriculture 3(2), 374–91.

Imran, S., Arif, M., Khan, A., Khan, M.A., Shah, W., Latif, A., 2015. Effect of Nitrogen Levels and Plant Population on Yield and Yield Components of Maize. Advance Crop Science Technology 3(6), 170–182.

Inamullah, R.N., Shah, N.H., Arif, M., Siddiq, M., Mian, I.A., 2011. Correlations among grain yield and yield attributes in maize hybrids at various nitrogen levels. Sarhad Journal of Agriculture 27(7), 531–538.

Jangir, A., Singh, V., Srivastava, P.C., Ram, S., Bhatnagar, A., 2015. Phosphorus and zinc uptake and protein, lysine and tryptophan contents in quality protein maize in relation to phosphorus and zinc fertilization in mollisol. Annals of Agricultural Research New Series 36(1), 50–57.

Kaur, M., Vashist, K.K., 2016. Effect of sowing method, mulch and irrigation regimes on yield and yield components of August sown maize (*Zea mays* L.). Journal of Crop and Weed 12(2), 150–154.

Kaur, P., Singh, S.K., Kaur, R., Sidhu M.K., 2020. Response of Different Levels of Nitrogen and Spacing on Growth and Yield of Cauliflower Grown under Central Region of Punjab. International Journal of Bio-resource and Stress Management 11(4), 320–326.

Kumar, M., Singh, M., Ahmed, P., 2002. Effect of different level of nitrogen and phosphorus on growth and yield of maize. In: 2nd International Agronomy congress, New Delhi, 202–203.

Kumar, R., Bohra, J.S., Kumawat, N.P., Upadhyay, K., Singh, A.K., 2018. Effect of balanced fertilization on production, quality, energy use efficiency of baby corn (*Zea mays*) and soil health. Indian Journal of Agricultural Sciences 88(1), 28–34.

Mahapatra, A., Barik, A.K., Mishra, G.C., 2018. Integrated nutrient management on babycorn (*Zea mays* L.). International Journal of Bio-resource and Stress Management 9(1), 044–048.

Matusso, Materusse, J.M., 2016. Growth and yield response of maize (*Zea mays* L.) to different nitrogen levels in acid soils. Academic Research Journal of Agricultural Science and Research 4(2), 35–44.

Palai, J.B., Sarkar, N.C., Jena, J., 2017. Effect of Zinc on Growth, Plant Yield, NPK Uptake and Economics. International Journal of Bio-resource and Stress Management 8(5), 698–702.

Pandey, A.K., Prakash, V., Mani, V.P., Singh, R.D., 2010. Effect of rate of nitrogen and time of application on yield and economics of baby corn (*Zea mays* L.). Indian Journal of Agronomy 45, 338– 343.

Panneerselvam, S.P., Palaniyandi, S., 2014. Response of maize to soil applied zinc fertilizer under varying available zinc status of soil. Indian Journal of Science and Technology 7(7), 939–944.

Patel, J.B., Patel, V.J., Patel, J.R., 2006. Influence of different methods of irrigation and nitrogen levels on crop growth rate and yield of maize (*Zea mays* L.). Indian Journal of Crop Science 1(2), 175–177.

Potarzycki, J., Grzebisz, W., 2009. Effect of zinc foliar application on grain yield of maize and its yielding components. Plant, soil and environment, 55, 519–527.

Prodhan, H.S., Bala, S., Khoyumthem, P., 2007. Response to rate of nitrogen and effect of plant density on yield of baby corn. Journal of Interacademy 11(3), 265–269

Rasheed, M., Ali, H., Mahmood, T., 2004 Impact of nitrogen and sulphur application on growth and yield of maize (*Zea mays* L.) crop. Journal of Research Science 15(2), 153–157.

Ravi, N., Basavarajappa, A., Chandrashekar, C., Pharlapur, S.I., Hosamani, M.H., Manjunatha, M.V., 2012. Effect of integrated nutrient management on growth and yield of quality protein maize. Journal of Agriculture Science 25, 395–396.

Ruffo, M., Olson, R., Daverede, I., 2016. Maize yield response to zinc sources and effectiveness of diagnostic indicators. Communications in Soil Science and Plant Analysis. 47(2), 137–141.

Sandya, N.R., Subbaiah, G., Pulla, R.C., 2016. Yield potential, economics and nutrient uptake of rabi sweet corn (*Zea mays saccharata*) as influenced by varying plant densities and nitrogen rates. International Journal of Bio-resource and Stress Management 7(2), 315–319.

Scharf, P.C., William, J. W., John, A. L., 2002. Corn yield response to nitrogen fertilizer timing and deficiency level. Indian Journal of Agronomy 94, 435-41.

Singh, M.K., Singh, R.N., Singh, S.P., Yadav, M.K., Singh, V.K., 2010. Integrated nutrient management for higher yield, quality and profitability of baby corn (*Zea mays*). Indian Journal of Agronomy 55, 100–104.

Singh, M.V., 2009. Micronutrient nutritional problems in soils of India and improvement for human and animal's health. Indian Journal of Fertilizers 5(4), 11–26.

Suganya, A., Saravanan, A., Manivannan, N., 2020. Role of zinc nutrition for increasing zinc availability, uptake, yield, and quality of maize (*Zea Mays* L.) Grains: An Overview. Communications in Soil science and Plant analysis 51(15), 2001–2021.

Swati, P., Kaushik, M.K., Sharma, S.K., Kumawat, P., 2014. Impact of integrated nutrient management on growth and productivity of hybrid maize (*Zea mays* L.). Annals of Biology 30, 106-108.

Tagne, A., Feujio, T.P., Sonna, C., 2008. Essential oil and plant extracts as potential substitutes to synthetic fungicides in the control of fungi. International conference diversifying crop protection, La Grande-Motte, France.

Thakur, D.R., Sharma, V., 2009. Effect of varying rates of nitrogen and its schedule of split application in baby corn (*Zea mays*). Indian Journal Agricultural Science 69, 93–95.

Wasaya, A., Shabir, M.S., Hussain, M., Ansar, M., Aziz, A., Hassan, W., Ahmad, I., 2017. Foliar application of Zinc and Boron improved the productivity and net returns of maize grown under rainfed conditions of Pothwar plateau. Journal of Soil Science and Plant Nutrition 17(1), 33–45.

Yeshiwas, Y., 2017. Effect of different rate of nitrogen fertilizer on the growth and yield of cabbage (*Brassica oleraceae*) at Debre Markos, North West Ethiopia. African Journal of Plant Science 11(7), 276–281.

Zeb, T., Arif, M., 2008. Effect of zinc application methods on yield and yield components of maize [Abstract]. Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan.