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Sandeep Todwal
Collage of Agriculture, MGU, Sehore, Madhya Pradesh, India

UR Khandkar
Collage of Agriculture, MGU, Sehore, Madhya Pradesh, India

JK Kanaujia
Collage of Agriculture, MGU, Sehore, Madhya Pradesh, India

Corresponding Author:
Sandeep Todwal
Collage of Agriculture, MGU, Sehore, Madhya Pradesh, India

Influence of different levels of N application and foliar spray of zinc on growth and economics of hybrid maize

Sandeep Todwal, UR Khandkar and JK Kanaujia

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Abstract
A field experiment was conducted during *kharif* seasons of 2020-21and 2021-22on clayey soil at MGU, Sehore (Madhya Pradesh) to study the effect of different levels of N and foliar spray of zinc on plant height and economics. Results revealed that significantly highest plant height at 90 DAS, net return and B:C ratio was recorded with the application of Nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$ followed by application of nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$, nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$, nitrogen-120 kg/ha + 1.5% foliar spray of $ZnSO_4$, nitrogen-120 kg/ha + 1.0% foliar spray of $ZnSO_4$. The lower plant height at 90 DAS, net return and B:C ratio followed by application of nitrogen-00 kg/ha + 0.0% foliar spray of $ZnSO_4$ was recorded with the application of control.

Keywords: Maize, nitrogen, zinc and fertilizer

Introduction
Maize (*Zea mays* L.) is the third most important cereal grain worldwide after wheat and rice. Maize is a crop which belongs to the family *Poaceae*. India is the 7th largest producer of maize and ranked 4th position in area in the world. It is referred to as the cereal of the future for its valuable nutritional values in human diet. It is mainly used as feed for animals followed by food for human and industrial use as raw material in food processing, poultry, dairy and ethanol industry. In India, maize is grown in both *Kharif* and *Rabi* Season, But productivity of maize in *Kharif* is less than *Rabi* season, this is due the controlled ecosystems prevailed during the *Rabi* season, Kharif maize represents around 83% of maize area in India, while rabi maize correspond to 17% maize area (ICAR Report, 2021-22). It covers total area of 19.65 million hectares with production of 18.9 million tonnes in the world. The area under maize cultivation in India during 2021-22 was 12.56 lakh hectares with production of 31 million metric tonnes and productivity of 1970 kg ha^{-1}.

The predominant maize growing states that contributes more than 80% of the total maize production are Andhra Pradesh, Karnataka, Rajasthan, Maharashtra, Bihar, Uttar Pradesh, Madhya Pradesh and Himachal Pradesh. In *Kharif* season 2021-22, Maize is the major crop of the Chhindwara district of Madhya Pradesh. Chhindwara is known as Corn City. Corn is grown in entire district due to presence of suitable soil and climate needed for corn to grow.The area under maize cultivation in Chhindwara during 2021-22 was 2.95 lakh hectares with production of 12 lakh metric tonnes and productivity of 4126 kg ha^{-1} (AICRP on Maize, 2021).

Maize is not only used for consumption of human but it is also used for the feed and fodder of cattle and raw material for industries. The products prepared from maize are corn cooking oil, corn starch, corn syrup, products needed for distilleries and fermentation. Now days, biofuel can also be made from maize. The hybrid maize crop is highly nutrient responsive crop requires about 120 kg N, 60 kg P_2O_5, 40 kg K_20 and 5.25 kg Zinc to produce 5-6 t of grain yield. It has high nutritional value as it contains about 62.3% starch, 11.1% protein, 4.6% oil, 1.8% fibre, 4.3% sugar and 1.3% ash (Adamu*etal.*, 2015) [2]. The productivity of hybrid maize is lower than the potential productivity because of imbalanced use of plant nutrient and not using of micronutrient particularly zinc and not using fertilizer at the right time. Maize being an exhaustive crop has very high nutrient demand and its productivity mainly depend upon nutrient

managements system. Maize is becoming very popular in India as well as Punjab due to its higher market price and higher yield under irrigated conditions of Punjab state.

Maize is a high nutrient demanding crop, which also requires micronutrients along with major elements. Nitrogen is a vital plant nutrient and a major yield determining factor in maize production. Nitrogen is a component of protein and nucleic acids and also mediates the utilization of phosphorus, potassium, and other elements in plants (Borase *et al*., 2018) [14]. Recently developed high yielding cultivars of hybrid maize require considerable high amount of nutrient specially nitrogen and zinc. The foliar application of zinc enhances the uptake and accumulation of nitrogen and finally increased grain yield. Nitrogen is one of the important primaries non-metals nutrients which require large quantity for the plant growth and nutrition. Plant normally contains 1-5% weight of this nutrient. Furrow slice soil layer 0-15 cm depth of most soil contains nitrogen in the range of 0.02 to 0.4% by weight. It is an integral component of many compounds including chlorophyll, carbohydrate, protein, vitamins, enzymes, hormone, and nucleic acid essential for plant growth processes. It is recognized that nitrogen is one of the key element of soil fertility and plant (Amanullah *et al*., 2016) [5].

Materials and Methods

An experimental was conducted at GMU, Sehorein Madhya Pradesh during *kharif* seasons of 2020-21 and 2021-22. The climate of Sehore is warm and temperate where maximum temperature exceeds 42˚C in May and June. The winters are cool and minimum temperature reaches as low as 10˚C in December and January. Occurrence of frost is expected from the last week of December to the first week of February. The soil was sandy clay in texture and slightly alkaline in reaction (*p*H 7.8) with electric conductivity 0.30 dS/m, low in available, and medium to low in available P, high in available K and sufficient to low in available zinc. A combination of 16treatments, *viz*., Sixteen treatments comprising of nutrient management practices *viz*., Nitrogen-00 kg/ha + 0.0% foliar spray of $ZnSO_4$ (Control) (T_1), Nitrogen-00 kg/ha + 0.5% foliar spray of $ZnSO_4$ (T_2), Nitrogen-00 kg/ha + 0.1% foliar spray of $ZnSO_4$ (T_3), Nitrogen-00 kg/ha + 0.1.5% foliar spray of $ZnSO_4$ (T_4), Nitrogen-60 kg/ha + 0.0% foliar spray of $ZnSO_4$ (T_5), Nitrogen-60 kg/ha + 0.5% foliar spray of $ZnSO_4$ (T_6), Nitrogen-60 kg/ha + 1.0% foliar spray of $ZnSO_4$ (T_7), Nitrogen-60 kg/ha + 1.5% foliar spray of $ZnSO_4$ (T_8), Nitrogen-120 kg/ha + 0.0% foliar spray of $ZnSO_4$ (T_9), Nitrogen-120 kg/ha + 0.5% foliar spray of $ZnSO_4$ (T_{10}), Nitrogen-120 kg/ha + 1.0% foliar spray of $ZnSO_4$ (T_{11}), Nitrogen-120 kg/ha + 1.5% foliar spray of $ZnSO_4$ (T_{12}), Nitrogen-150 kg/ha + 0.0% foliar spray of $ZnSO_4$ (T_{13}), Nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$ (T_{14}), Nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$ (T_{15}) and Nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$ (T_{16}) were evaluated in Factorial CRD design with three replications with gross and net sizes of 5.0 m × 6.00 m and 4.0 m × 5.0 m, respectively. The experimental soil was clayey in texture, slightly alkaline in reaction and low in available N, medium in available P, high inK, and sufficient in Zn. Maize 'Hybrid Maize' was sown at 60 cm × 30 cm spacing onjuly 2020 and June 2021. The recommended dose of fertilizers is as per treatments.

Results and Discussion

Effect of nitrogen levels and foliar spray of zinc on plant height at 90 DAS

Significantly higher plant height at 90 DAS was recorded with the application of nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$, which was statistically at par with the application of nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$, nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$. The lower plant height at 90 DAS was recorded with the application of control plot.

Effect of nitrogen levels and foliar spray of zinc on economics

Nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$ resulted in the highest net return followed by application of nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$, nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$, nitrogen-120 kg/ha + 1.5% foliar spray of $ZnSO_4$, nitrogen-120 kg/ha + 1.0% foliar spray of $ZnSO_4$. The lower net return followed by application of nitrogen-00 kg/ha + 0.0% foliar spray of $ZnSO_4$was recorded with the application of control.

Highest B:C ratio was recorded with the application of Nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$ followed by application of nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$, nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$, nitrogen-120 kg/ha + 1.5% foliar spray of $ZnSO_4$, nitrogen-120 kg/ha + 1.0% foliar spray of $ZnSO_4$. The lower B:C ratio followed by application of nitrogen-00 kg/ha + 0.0% foliar spray of $ZnSO_4$ was recorded with the application of control.

Table 1: Effect of different levels of N and foliar spray of Z on plant height at 90 DAS of maize

Levels of N (kg ha^{-1})	Foliar spray of Z (%)				
	Z 0	**Z 0.5**	**Z 1.0**	**Z 1.5**	**Mean**
Plant height at 90 DAS at 2020-21					
N 00	128.73	163.03	165.86	168.04	156.42
N 60	172.52	174.02	176.59	179.29	175.61
N 120	182.42	186.97	188.98	191.08	187.36
N 150	195.76	202.07	210.75	214.34	205.73
Mean	169.86	181.52	185.55	188.19	
	N		**Z**		**N × Z**
SEm±	0.78		0.78		1.56
CD at 5%	2.24		2.24		4.48
Plant height at 90 DAS at 2021-22					
(kg ha^{-1})	Z 0	Z 0.5	Z 1.0	Z 1.5	Mean
Plant height at 90 DAS					
N 00	130.09	164.32	167.81	170.40	158.15
N 60	173.52	175.35	176.02	181.03	176.48
N 120	183.08	185.70	187.68	189.41	186.47
N 150	197.71	203.10	209.42	213.68	205.98
Mean	171.10	182.12	185.23	188.63	
	N		**Z**		**N × Z**
SEm±	0.82		0.82		1.64
CD at 5%	2.36		2.36		4.72
Plant height at 90 DAS at Pooled data					
(kg ha^{-1})	**Z 0**	**Z 0.5**	**Z 1.0**	**Z 1.5**	**Mean**
N 00	129.41	163.67	166.84	169.22	157.28
N 60	173.02	174.68	176.31	180.16	176.04
N 120	182.75	186.34	188.33	190.25	186.92
N 150	196.74	202.59	210.08	214.01	205.85
Mean	170.48	181.82	185.39	188.41	
	N		**Z**		**N × Z**
SEm±	0.56		0.56		1.13
CD at 5%	1.58		1.58		3.17

Table 2: Effect of different levels of N and foliar spray of Z on gross return and cost of cultivation

Treatments	Gross returns (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1- Nitrogen-00 kg/ha + 0.0% foliar spray of $ZnSO_4$ (Control)	55044	56164	55604	25200	25300	25250
T_2- Nitrogen-00 kg/ha + 0.5% foliar spray of $ZnSO_4$	64135	64623	64379	25200	25300	25250
T_3- Nitrogen-00 kg/ha + 0.1% foliar spray of $ZnSO_4$	65873	66768	66320	25200	25300	25250
T_4- Nitrogen-00 kg/ha + 0.1.5% foliar spray of $ZnSO_4$	68972	69802	69387	25800	25900	25850
T_5- Nitrogen-60 kg/ha + 0.0% foliar spray of $ZnSO_4$	73077	80156	76617	26100	26200	26150
T_6- Nitrogen-60 kg/ha + 0.5% foliar spray of $ZnSO_4$	87041	84213	85627	26832	26932	26882
T_7- Nitrogen-60 kg/ha + 1.0% foliar spray of $ZnSO_4$	91296	91487	91392	27142	27242	27192
T_8- Nitrogen-60 kg/ha + 1.5% foliar spray of $ZnSO_4$	93235	96589	94912	27202	27302	27252
T_9- Nitrogen-120 kg/ha + 0.0% foliar spray of$ZnSO_4$	102726	102048	102387	27132	27232	27182
T_{10}- Nitrogen-120 kg/ha + 0.5% foliar spray of $ZnSO_4$	107170	104693	105932	26110	26210	26160
T_{11}- Nitrogen-120 kg/ha + 1.0% foliar spray of $ZnSO_4$	110795	106470	108633	26420	26520	26470
T_{12}- Nitrogen-120 kg/ha + 1.5% foliar spray of $ZnSO_4$	112215	110840	111528	27812	27912	27862
T_{13}- Nitrogen-150 kg/ha + 0.0% foliar spray of $ZnSO_4$	114826	112968	113897	27312	27412	27362
T_{14}- Nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$	116138	114694	115416	27622	27722	27672
T_{15}- Nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$	120213	118906	119559	27932	28032	27982
T_{16}- Nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$	122664	120597	121630	27992	28092	28042

Table 3: Effect of different levels of N and foliar spray of Z on net return and B: C ratio

Treatments	Net return (Rs. ha^{-1})			B:C ratio		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1- Nitrogen-00 kg/ha + 0.0% foliar spray of $ZnSO_4$ (Control)	29844	30864	30354	2.18	2.22	2.20
T_2- Nitrogen-00 kg/ha + 0.5% foliar spray of $ZnSO_4$	38935	39323	39129	2.55	2.55	2.55
T_3- Nitrogen-00 kg/ha + 0.1% foliar spray of $ZnSO_4$	40673	41468	41070	2.61	2.64	2.63
T_4- Nitrogen-00 kg/ha + 0.1.5% foliar spray of $ZnSO_4$	43172	43902	43537	2.67	2.70	2.68
T_5- Nitrogen-60 kg/ha + 0.0% foliar spray of $ZnSO_4$	46977	53956	50467	2.80	3.06	2.93
T_6- Nitrogen-60 kg/ha + 0.5% foliar spray of $ZnSO_4$	60209	57281	58745	3.24	3.13	3.19
T_7- Nitrogen-60 kg/ha + 1.0% foliar spray of $ZnSO_4$	64154	64245	64200	3.36	3.36	3.36
T_8- Nitrogen-60 kg/ha + 1.5% foliar spray of $ZnSO_4$	66033	69287	67660	3.43	3.54	3.48
T_9- Nitrogen-120 kg/ha + 0.0% foliar spray of $ZnSO_4$	75594	74816	75205	3.79	3.75	3.77
T_{10}- Nitrogen-120 kg/ha + 0.5% foliar spray of $ZnSO_4$	81060	78483	79772	4.10	3.99	4.05
T_{11}- Nitrogen-120 kg/ha + 1.0% foliar spray of $ZnSO_4$	84375	79950	82163	4.19	4.01	4.10
T_{12}- Nitrogen-120 kg/ha + 1.5% foliar spray of $ZnSO_4$	84403	82928	83666	4.03	3.97	4.00
T_{13}- Nitrogen-150 kg/ha + 0.0% foliar spray of $ZnSO_4$	87514	85556	86535	4.20	4.12	4.16
T_{14}- Nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$	88516	86972	87744	4.20	4.14	4.17
T_{15}- Nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$	92281	90874	91577	4.30	4.24	4.27
T_{16}- Nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$	94672	92505	93588	4.38	4.29	4.34

Conclusion

Based on the pooled results of two-year experimentation, it is concluded that higher and economical production along with efficient nutrient management in kharif maize under Bhopal region can be achieved by either nitrogen-150 kg/ha + 1.5% foliar spray of $ZnSO_4$ or nitrogen-150 kg/ha + 1.0% foliar spray of $ZnSO_4$ or nitrogen-150 kg/ha + 0.5% foliar spray of $ZnSO_4$ according to availability of labourers.

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