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Ashish Masih
Research Scholar,
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Narendra Swaroop
Associate Professor,
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Yogesh Upadhyay
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Vinod Kumar Prajapati
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Parshottam Sinha
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Dileshwar Prasad Sahu
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Correspondence
Ashish Masih
Research Scholar,
Department of Soil Science,
Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad,
Uttar Pradesh, India

Effects of integrated nutrient management on growth and yield attributes of maize (*Zea mays* L.) Var. Kirtiman Saurabh

Ashish Masih, Narendra Swaroop, Yogesh Upadhyay, Vinod Kumar Prajapati, Parshottam Sinha and Dileshwar Prasad Sahu

Abstract
The field experiment was carried out at Department of Soil Science, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, India during *kharif season* of 2015-16. The experiment was laid out in 3×3 factorial randomized block design with 9 treatments in three replications. It was observed that the best yield attributes characters in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) in respect to different day's intervals i.e. 30, 60 and 90 days after sowing (DAS). Plant height was 65.12, 165.86 and 169.55 cm found to be significant at 60 and 90 DAS but non-significant at 30 DAS,leaf length were 21.55, 52.34 and 54.90 found to be significant at 30,60 and 90 DAS, no. of leaves $plant^{-1}$ were 7.78, 11.78 and 12.89 found to be significant at 60 and 90 DAS but non-significant at 30 DAS, Highest no. of grains was found in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) which was 308.55 found to be significant. Highest cob length was found in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) which was 17.08 found to be significant. T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) found highest seed yield (q ha^{-1}) and test weight (g) which were 51.00 and 220.67 respectively found to be significant. Highest dry weight (g) found in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) which was 176.55 found to be significant. Highest C: B ratio (1: 2.43) was recorded in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed). However, since these findings are based on one year experiment and therefore, further research may be conducted to substantiate it under Allahabad agro climatic conditions.

Keywords: NPK, zinc, FYM and azotobacter growth, yield, maize

Introduction
Maize (*Zea mays* L.) is one of the most important cereal crops in the world it is a member of family graminae (poeceae) sub family panicoideae. Maize is also known as 'Queen of cereals' and kind of fodder maize has been usually considered as poor man's crops and occupying the place in the rich communities due to its multifarious uses as industrial food and feed crops. It is known as an indicator plant for evaluation of Zn deficiency of a soil. (Suke *et al.*, 2011) [10].
Maize is one of the world's leading crop cultivated over an area of 139 m ha.with a production of about 600 mt. of grain. USA leads the largest area, followed by Brazil, China, Mexico and India. Maize is grown in almost all states of India occupying an area of 6 m ha with the production and productivity of 9.7 mt. and 1.7 t ha^{-1}, respectively. (Kumar *et. al*. 2007) [3].
Maize is one of the important cereal crops in the world agricultural economy both as food grains for human and fodder and feed for cattle and poultry. Maize grain contains about 72% starch, 10% protein, 4.8% oil, 5.8% fibre, 3.0% sugar and 1.7% ash. Along with this, it is rich in vitamin A, vitamin E, nicotinic acid, riboflavin and contains fairly high phosphorus than rice and sorghum. Its fodder and hay contain 7-10% protein, 15-36% fibre, 2.09 to 2.62% ether extract, 0.42-0.70% Calcium, 0.28-0.29% phosphorus, 0.45% Magnesium, 1.34% Potassium and 56% carbohydrate, therefore, it has very nutritive fodder and hay. Besides food grain, fodder and feed, it has prime importance in textile, starch and dye industries (Rai, 2006) [7].
Maize rank third in global cereal scenario after wheat and rice, but in India it stands in fourth position following Rice, Wheat and Sorghum. The higher yield potentiality of maize cannot be manifested upto the brim due to several biotic and abiotic factors among which poor nutritional management is the prime one.

Being an exhaustive crop especially the improved and hybrids, respond positive significance to applied nutrients. Application of nitrogen upto 180 kg ha^{-1} was found to be most beneficial for grain and total biomass production of maize as well as the monetary returns (Maurya *et al.*, 2004) [4]. Maize high genetic yield potential than other cereal crops. Hence it is called as 'miracle crop' and alsoBeing a C_4 plant, it is very efficient in converting solar energy in to dry matter.

Maize (*Zea mays* L.) has becoming very popular cereal crop in India because of the increasing market price and high production potential of hybrid varieties in both irrigated as well as rain fed conditions. More ever in irrigated areas farmers produce the income equal to the cash crops such as sugarcane, onion, cotton, etc. in comparatively short time period of 120-130 days by cultivating hybrid maize varieties. Hence the trend of replacing some cash crops with maize in intensive cultivation is observed in present condition. (Kimdu *et al.,* 2009) [2] Nitrogen is a vitally important for plant nutrient. Nitrogen is essential constituent of protein and is present in many other compound of great physiological importance in plant metabolism. Nitrogen is called a basic constituent of life. Nitrogen also impart vigorous vegetative growth dark green colour to plant and it produce early growth of maize. Nitrogen governs the utilization of potassium, phosphorus and other elements in maize crop. (Singh *et al.* 2010) [8]. Phosphorus has a great role in energy storage and transfer and closely related to cell division and development of maize. Phosphorus is a constituent of nucleic acid, phytin and phospho-lipid. Phosphorus compound act as "energy currency" within plants. Phosphorus is essential for transformation of energy, in carbohydrate metabolism, in fat metabolism, in respiration of plant and early maturity of maize. (Singh *et al.*, 2010) [8]. Potassium play important role in formation of protein and chlorophyll and it provide much of osmotic "pull" that draw water into plant roots. Potassium produces strong stiff straw in maize and reduce lodging in maize. Potassium imparts increase vigour and disease resistance to plant. (Singh *et al.* 2010) [8]. Zinc play important role in the correct functioning of manyenzyme systems, the synthesis of nucleic acids and auxins (plant hormones) metabolisms, protein analysis andnormal crop development and growth. Phosphorus and zinc, though essential for plant growth, are antagonistic to eachother in certain circumstances, such as when P is suppliedin high levels and Zn uptake becomes slower orinadequate. This may be as aresult of slower rate of translocation of Zn from roots totops, i.e. zinc accumulation in the roots and lower Znuptake. Plants absorb Zn in the form of Zn^{2+}. The functional role of Zn includes auxins metabolism, nitrogen metabolism, influence on the activitiesof enzymes, cytochrome c synthesis and stabilization of ribosomal fractions andprotection of cells against oxidative stress. Poor growth, interveinalchlorosis and necrosis of lower leaves are thecommon symptoms of Zn deficiency in field crops. (Paramasivan *et al.* 2011) [6]. FYM (Farm Yard Manure) helps to improve and conserve the fertility of soil. FYM imparts dark color of the soil and thereby help to maintain the temperature of soil. The activity and population of beneficial soil organisms increased on application of FYM in soil. FYM is one of the oldest manure used by the farmer is growing crops because of its early availability and presence of almost all the nutrient required by plant. The composition of FYM is 0.50 % N, 0.25 % P and 0.50 % K. (Nair 2000) [5]. Azotobactorcan be used as a Biofertilizers for most non leguminous annual and perennial crops for the nutrition of nitrogen rice, cotton, sugarcane are some examples. *Azotobactor* act in temperate zone soils having pH 6.5-8.0. It fixes the nitrogen @ 5-20 kg N ha^{-1}/year in the soil. Seed treatment, seedling dipping and soil application methods are use for *Azotobactor* application. For seed treatment 200 g *Azotobactor* used for 10 kg seed. For seedling dipping prepare the suspension of required amount of inoculants in water in the ratio of 1: 10 and applied 3- 5 kg *Azotobactor* inoculums mix with 5 t FYM for one hectare soil application. (Balyan *et al.*, 2008).

Materials and Methods

The experiment was conducted during *kharif season* of 2015-16 at Crop research farm Department of Soil Science Allahabad School of Agriculture SHIATS-DU Allahabad. The experimental site is located in the sub – tropical region with 25^0 27^1 N *latitude* 81^0 51^1 E longitudes and 98 meter the sea level *altitudes.* The experiment was laid out in a 3^2 RBD factorial design with three levels of NPK, Zinc and FYM, Azotobacter with nine treatments, each consisting of three replicates. The total number of plots was 27. Maize (*Zea mays* L.) Var. Kirtiman Saurabh' were sown in kharif season plots of size 2 x 2 m with row spacing 50 cm and plant to plant distance 20 cm. The Soil of experimental area falls in order of Inceptisols and is alluvial in nature, both the mechanical and chemical analysis of soil was done before starting of the experiment to as certain the initial fertility status. The soil samples were randomly collected from 0-15cm depths prior to tillage operations. The treatment consisted of nine combination of T_0 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed), T_1 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 5 t ha^{-1}: Azotobacter 100 gm/10kg seed), T_2 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed), T_3 (N:P:K:Zn 60:30:30:10 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed), T_4 (N:P:K:Zn 60:30:30:10 kg ha^{-1} + FYM 5 t ha^{-1}: Azotobacter 100gm/10kg seed), T_5 (N:P:K:Zn 60:30:30:10 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed), T_6 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed), T_7 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 5 t ha^{-1}: Azotobacter 100 gm/10kg seed), T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed). The source of NPK, Zinc and FYM, Azotobacter as Urea, SSP, MOP, Zinc Sulphate respectively.

Physical and chemical analysis of soil samples (pre-sowing)

Table 1: Physical analysis of soil

Ingredient	Percentage	Method employed
Sand (%)	60	Bouyoucous Hydrometer method Bouyoucous (1927)
Silt (%)	25	
Clay (%)	15	
Textural class	Sandy loam	
Bulk density (Mgm^{-3})	1.32	Graduated measuring cylinder Black (1965)
Particle density (Mgm^{-3})	2.62	Graduated measuring cylinder Black (1965)
Pore space (%)	48.33	Graduated measuring cylinder Black (1965)

Table 2: Chemical analysis of soil

Particulars	Method employed	Results
Soil pH (1:2)	Glass electrode, pH meter (Jackson, 1958)	7.16
Soil EC (dS m^{-1})	EC meter (Digital Conductivity Meter) (Wilcox, 1950)	0.18
Organic Carbon (%)	(Walkley and Black's method 1947)	0.58
Available Nitrogen (kg ha^{-1})	Alkaline potassium permanganate method (Subbiah and Asija (1956)	280.26
Available Phosphorus (kg ha^{-1})	Colorimetric method (Olsen *et al.*, 1954)	24.05
Available Potassium (kg ha^{-1})	Flame photometric method (Toth and Prince, 1949)	156.62
Available Zn (mg kg^{-1})	(Shaw and Dean 1952)	0.31

Results and Discussion

Table 3: Plant growth parameter

Treatment	Plant height (cm)			Leaf length(cm)			Number of leaves/plant		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_0	47.32	65.12	104.62	16.36	42.05	43.87	4.66	7.44	7.55
T_1	50.65	122.03	125.19	17.12	43.18	44.81	4.89	7.55	7.66
T_2	50.92	122.99	127.12	17.66	43.49	45.15	5.11	7.78	8.00
T_3	52.29	126.32	129.25	17.49	45.41	47.12	4.78	8.55	8.78
T_4	52.75	128.12	133.85	17.88	45.94	47.66	6.11	8.99	9.66
T_5	56.01	156.36	161.56	18.66	46.12	48.54	7.00	9.55	10.00
T_6	57.05	158.14	163.45	19.39	47.59	50.32	7.11	10.44	10.78
T_7	61.63	161.45	165.16	20.45	50.61	53.18	7.66	10.89	11.22
T_8	65.12	165.86	169.55	21.55	52.34	54.90	7.78	11.78	12.89
F-test	NS	S	S	S	S	S	NS	S	S
S.Ed. (±)	2.176	2.141	2.351	0.195	0.595	0.530	0.480	0.202	0.346
C.D. (at 05%)	4.613	4.538	4.983	0.413	1.261	1.125	1.018	0.429	0.734

Table 4: Plant yield attributes parameter

Treatment	No. of Grains	Dry Weight (g)	Cob length (cm)	Test Weight (g/ 1000 seed)	Total Seed yield (t ha^{-1})	C:B Ratio
T_0	220.22	136.52	11.47	199.33	25.66	1.87
T_1	225.99	143.70	11.93	205.00	28.43	1.71
T_2	237.11	152.20	12.61	207.33	31.25	1.59
T_3	262.44	158.82	13.07	209.00	35.22	2.31
T_4	271.22	160.74	14.35	213.67	40.94	2.29
T_5	278.11	163.88	15.07	215.67	43.36	2.09
T_6	291.67	167.68	16.02	216.00	45.87	2.85
T_7	301.88	172.25	16.40	218.00	49.00	2.61
T_8	308.55	176.55	17.08	220.67	51.00	2.43
F-test	S	S	S	S	S	-
S.Ed. (±)	0.493	1.869	0.025	1.987	0.448	-
C.D. (at 5%)	1.045	3.962	0.054	4.213	0.950	-

Growth parameters

Table 3. shows the interaction effect of NPK, Zinc and FYM, Azotobacter the important growth parameters of Maize.

Plant height (cm)

Increase in plant height due to increasing of NPK, Zinc and FYM, Azotobacter may be due to adequate nutrients which is turns help in vigorous vegetative growth of plants and subsequently increase the plant height through cell elongation cell division photosynthesis and turbidity of plant cell. The maximum height recorded as 65.12, 165.86 and 169.55 respectively at 30, 60 and 90 DAS in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed). Similar results have also been recorded by Singh *et al.,* (2003) [9].

Number of leaves per plant

The effect of NPK, Zinc and FYM, Azotobacter on no. of leaves $plant^{-1}$ was found significant at 60 and 90 DAS, where as found non-significant at 30 DAS. The maximum no. of leaves $plant^{-1}$ was recorded as 7.78, 11.78 and 12.89 respectively at 30, 60 and 90 DAS in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed). Similar results have also been recorded by Singh *et al.,* (2003) [9].

Leaf length (cm)

The effect of NPK, Zinc and FYM, Azotobacter on Leaf length was found to be significant. The maximum leaf length was recorded as 21.55, 52.34 and 54.90 in treatment T_8 where as maximum no. of secondary branches $plant^{-1}$ was recorded as 16.77 in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed). Similar results have also been recorded by Singh *et al.,* (2003) [9].

Table 4. shows the interaction effect of NPK, Zinc and FYM, Azotobacter the important plant yield attributes parameters of Maize.

Higher yield response in comparison of NPK, Zinc and FYM, Azotobacter was recorded with balanced application of NPK, Zinc, FYM and Azotobacter. The maximum no. of grains was recorded as 308.55 in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed). and minimum no. of grains was recorded as 220.22 in treatment T_0 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed) and were found to be significant. The maximum dry weight of plant was recorded as 176.55 in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) and minimum dry weight of plant was recorded as 136.52 in treatment T_0 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed) and were found to be significant. The maximum cob length was recorded as 17.08 in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) and mimimum cob length of plant was recorded as 11.47 in treatment T_0 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed) and were found to be significant. The maximum test weight of seeds 220.67g was recorded in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) and minimum test weight of seeds was 199.33g recorded in T_0 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed) and were found to be significant. The maximum seed yield 51.00 t ha^{-1} was recorded in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) and minimum seed yield 25.66 t ha^{-1} was recorded in T_0 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 0 t ha^{-1}: Azotobacter 0 gm/10kg seed) and were found to be significant. Among the different treatments studied with respect of maximum C:B ratio, The maximum C:B ratio was recorded in T_8 followed by T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) and the minimum was recorded T_2 (N:P:K:Zn 0:0:0:0 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed).

Conclusion

It is concluded that the best yield attributes characters in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) in respect to different days intervals i.e. 30, 60 and 90 days after sowing (DAS). Plant height was 65.12, 165.86 and 169.55 cm found to be significant at 60 and 90 DAS but non-significant at 30 DAS, leaf length were 21.55, 52.34 and 54.90 found to be significant at 30,60 and 90 DAS, no. of leaves plant^{-1} were 7.78, 11.78 and 12.89 found to be significant at 60 and 90 DAS but non-significant at 30 DAS, Highest no. of grains was found in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) which was 308.55 found to be significant. Highest cob length was found in treatment T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) which was 17.08 found to be significant. T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) found highest seed yield (t ha^{-1}) and test weight (g) which were 51.00 and 220.67 respectively found to be significant. Highest dry weight (g) found in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed) which was 176.55 found to be significant. Highest C:B ratio (1:2.43) was recorded in T_8 (N:P:K:Zn 120:60:60:20 kg ha^{-1} + FYM 10 t ha^{-1}: Azotobacter 200 gm/10kg seed).

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