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Response of nitrogen and phosphorus levels on the yield of maize (*Zea mays* L.)

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Abstract
A field experiment entitled "Response of nitrogen and phosphorus levels on the yield of maize (*Zea mays* L.)" was conducted at the Research Farm, School of Agriculture, ITM University, Gwalior, (M.P.) during the *kharif* season of 2019-20. A set of 12 treatment combinations including four nitrogen levels *viz.*, 0 kg/ha (N_0), 110 kg/ha (N_1), 120 kg/ha (N_2) and 130 kg/ha (N_3) with three phosphorus levels *viz.*, 60 kg/ha (P_1), 70 kg/ha (P_2) and 80 kg/ha (P_3) were evaluated. Treatments were replicated thrice as per Randomized Block design with Factorial concept. Crop sown with application of nitrogen @ 130 kg/ha combined application with phosphorus@ 80 kg/ha attained significantly higher plant growth and yield at all the growth stages of plant.
The significantly higher plant height, number of leaves per plant, number of days taken to 50 per cent tasseling, number of cobs per plant, number of grains per cob, grain and stalk yield per hectare of maize at maximum crop growth stage was recorded under the application of nitrogen @ 130 kg/ha combined application with phosphorus @ 80 kg/ha with the respective values of 212.75 cm, 15.49, 56.64,2.50,317.36,47.12q/ha and65.12q/ha, respectively proved significantly superior to rest of the treatments. Result showed that maize variety when sown the application of nitrogen @ 130 kg/ha combined application with phosphorus @ 80 kg/ha recorded the maximum and significantly higher values of these parameters.

Keywords: Maize, phosphorus, growth stage, cobs, tasseling, stalk yield

Introduction
Maize (*Zea mays* L.) also called corn, is one of the most crucial and strategic crops in the world. Corn means literally "that which sustains life". Maize is emerging as an important world cereal crop after wheat and rice, which is "Queen of Cereals", due to the high productiveness, easy to process, low cost than other cereals (Jaliya *et al*., 2008), provides nutrients for humans and animals, serves as basic raw materials for production of starch, oil, protein, alcoholic beverages, food sweetness and more recently fuel.
The nutritional composition of maize (per 100 g) is as follows protein 4 g, 30 g carbohydrate, 3.5 g dietary fiber, 1.5 g fat, 3.6 g sugar, 310iu vit A, 4 mg calcium, 0.72 mg zinc etc. fwww.seedgufdes.info/maize L. It has an important role in the industry as more than 35 products of daily use are derived from maize. It is raw material for a number of products via. Starch, lactic acid, glucose, acetic acid, dextrose, sorbitol, dextrin, high fructose syrup, maltodextrin, germ oil, germ application in industries such as alcohol, textile, paper, pharmaceutical, organ chemical, cosmetics and edible oil.
In India, it is grown on 8.67 m ha area with the production and productivity of 21.75 mt and 2566 kg /ha, respectively (Anonymous, 2014) [1]. In Madhya Pradesh it covers an area of 1098 thousand ha with a production of 2580.3 thousand tones at an average productivity of 2350 kg/ha. Area covered under maize crop in Gwalior district of 200 ha, production of 300 tones with productivity of 1830 kg/ha.
It is well known that maize is a heavy feeder crop and it well responded to fertilization, especially where soils are generally low in native fertility. It is generally observed that maize fails to produce worthwhile grain yield in plots without fertilizer application. Soil fertility is a major constraint to it productivity, low organic matter content coupled with low and imbalance application of nutrients limits its full potential yield and is the main yield barrier. Nitrogen is universally deficient in majority of Indian soil and experiment conducted at various places in different agroclimatic zones of India indicated that nitrogen has beneficial effect on growth, yield attributing characters and yield of maize. Most of the varieties of maize are single cross hybrids in which nitrogen stress before flowering reduces leaf area and photosynthesis. Nitrogen stress during flowering stage results in kernel and ear abortion, whereas stress during grain filling accelerates leaf sencence, reduces photosynthesis and kernel weight.

Thus, for enhancing grain yield of single cross hybrids of maize, nitrogen fertilization has emerged as a serious matter of concern for maize growing farmers.

Moreover, the availability of phosphorus is influenced by many factors of which pH is predominant, particularly in black cotton soil of Madhya Pradesh. Next to nitrogen, phosphorus is of paramount importance for energy transfer in living cells by mean of high energy phosphate bonds of ATP. It plays pivotal role in formation, translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. It also affects protein content of the grain as well as fodder. Nitrogen and phosphorus have been reported as the third most important limiting nutrient elements in crop production. As maize is more exhausting in its demand for growth promoting factors, it is very crucial to determine the optimum rate of nitrogen fertilizer application as exceeding dosage may result in crop lodging, delayed silking, enhanced number of barren ears, poor grain quality and subsequently, lower grain productivity.

The interaction of these nutrient elements may affect the critical levels of available nitrogen and phosphorus below which response to their application could be observed. Information on effect of combined application of nitrogen and phosphorus on growth, yield, and quality of each nutrient in maizeis rather limited in the sub-tropical zone of M.P. Keeping these points in view, the present investigations were under taken.

Materials and Methods

The experiment was carried out at the Research Farm, School of Agriculture, ITM University, Gwalior, (M.P.) during the *kharif* season of 2018-19. The experiment was conducted in randomize complete block design having Factorial concept with three replications. Different rates of nitrogen and phosphorus allocated to the plots as per treatments. The treatments were four levels of nitrogen levels *viz*., 0 kg/ha (N_0), 110 kg/ha (N_1), 120 kg/ha (N_2) and 130 kg/ha (N_3) with three phosphorus levels *viz.*, 60 kg/ha (P_1), 70 kg/ha (P_2) and 80 kg/ha (P_3). The gross and net plot size was 7.5 m x 6.25 m and 6.0 m x 5.0 m, respectively. The fertilizers grades were applied as per treatments. The recommended dose of potassium was applied @ 60 kg K_2O/ hawhile, nitrogen (N) and phosphorus (P_2O_5) was applied as per the treatments. All the other agronomic practices were applied uniformly to all the treatments.

Results and Discussion

The result shows that plant height, number of leaves per plant, number of days taken to 50 per cent tasseling, number of cobs per plant, number of grains per cob, grain and stalk yield per hectare was influenced significantly due to different concentrations of nitrogen and phosphorus.

Data regarding these characters are reported in (Table- 1). Statistical analysis of the data revealed that maximum plant height and number of leaves per plant (195.68 cm and 14.14, respectively) were recorded in plots treated with the application of nitrogen @ 130 kg/ha (N_3) while, lowest values were observed in plot that received no nitrogen. Similarly, application of phosphorus@ 80 kg/ha gave maximum plant height and number of leaves per plant with the respective of 192.52 cm and 13.71, respectively.

Statistical analysis of data revealed that interaction effect of nitrogen and Sulphur significantly affected plant growth was found significant. Similarly, in interaction the maximum plant height and number of leaves per plant was recorded from plot receiving nitrogen @ 130 kg/ha combined application with phosphorus @ 80 kg/ha, value of 212.75cm and 15.49, respectively while minimum was recorded from plot receiving 0 kg/ha nitrogen with application of phosphorus of 60 kg/ha.

Nitrogen levels significantly influenced growth attributes. Growth attributes responded to increasing dose of nitrogen. Maize has shown almost all universal response to nitrogen as it plays an important role in improving growth and yield attributes and final grain yield. Nitrogen constitutes 40 to 50 per cent of dry matter of protoplasm in plant cell and is essential element for its proper growth and development. It is also essential for building of protein unit and early establishment of leaf area capable of synthesizing the food through photosynthesis and ultimately resulting in higher economic yield. The improvement in growth parameter with application of 130 kg N/ha might have resulted in better and timely availability of N for their utilization by plant as judged from nitrogen content of straw. Nitrogen is considered a vitally important plant nutrient. In addition to its role in the formation of proteins, nitrogen is an integral part of chlorophyll which is the primary absorber of light energy needed for photosynthesis. Besides these, it is also a constituent of certain organic compounds of physiological importance. Under the present investigation, profound influence of N as component of fertility management, on crop growth seen to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media.

Increase in plant height with increasing levels of N could be attributed to the fact that nitrogen helps in higher photosynthetic activity, cell and internodal elongation and maintenance of higher auxin levels, which might have resulted in the plants of taller stature. Similar results of increase in plant height with increasing levels of N application were reported by Singh and Nepalia (2009) [15]; Mukhtar *et al*. (2011) [10]; Jeet *et al.* (2012a) [8]; Ravi *et al*. (2012) [13] and Chaudhary *et al.* (2013) [3].

The significant improvement in nutrient status of plant parts might have resulted in greater synthesis of amino acids, proteins and growth promoting hormones, which leads to enhanced the meristematic activity and increased cell division and their elongation. Further increased chlorophyll content accompanied with more functional leaves and leaf area under the application of 130 kg N/ha might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and thereby increase plant height, number of leaves per plant and finally results in better growth. The results are in close conformity with the findings of Bindhani *et al*., (2007) [2]; Sepat and Kumar (2007) [14]; Jeet *et al*., (2012) [6]; Giang *et al*., (2015) [4] and Tadesse and Kim (2015) [16].

The improvement in growth parameter with application of 80 kg P_2O_5/ ha might have resulted in better and timely availability of P for utilization by plant as judged from phosphorus content of straw. Phosphorus fertilization improves the various metabolic and physiological processes and thus known as “energy currency” which is subsequently used for vegetative and reproductive growth through photo-phosphorylation. In addition to its vital metabolic role, P is an important structural component of nucleic acid, phytein, phospholipids and enzymes which might have accumulated in grain and helped in grain formation and its development. An adequate supply of phosphorus early in the life cycle of plant is important in laying down the primordia of its reproductive part. It also increases the initiation of both first and second

order rootlets and their development. The extensive root system helps in exploiting the maximum nutrients and water from the soil.

Statistical analysis of the data revealed that maximum number of days taken to 50 per cent tasseling, number of cobs per plant and number of grains per cob(54.92, 2.07and 277.45, respectively) were recorded in plots treated with the application of nitrogen @ 130 kg/ha (N_3) while, lowest values were observed in plot that received no nitrogen. Similarly, application of phosphorus @ 80 kg/ha gave maximum number of days taken to 50 per cent tasseling, number of cobs per plant and number of grains per cob with the respective of 53.31, 1.92and 269.02, respectively.

Statistical analysis of data revealed that interaction effect of nitrogen and phosphorus significantly affected yield attributes was found significant. Similarly, in interaction the maximum number of days taken to 50 per cent tasseling and number of grains per cobwas recorded from plot receiving nitrogen @ 130 kg/ha combined application with phosphorus @ 80 kg/ha, value of 56.64 and 317.36, respectively. While, minimum was recorded from plot receiving 0 kg/ha nitrogen with application of phosphorus of 60 kg/ha. Interaction effect of nitrogen and phosphorus for number of cobs per plant was found non-significant.

Data regarding highest grain and stalk yield are reported in (Table- 1). Statistical analysis of the data revealed that maximum grain and stalk yield (14.12 q/ha and 35.42 q/ha, respectively) were recorded in plots treated with the application of nitrogen @ 130 kg/ha (N_3) while, lowest values were observed in plot that received no nitrogen. However, application of phosphorus@ 80 kg/ha gave highest grain and Stover yield value of 12.55 q/ha and 31.85 q/ha, respectively.

Statistical analysis of data revealed that interaction effect of nitrogen and phosphorus significantly affected grain and Stover yield were found significant. Similarly, in interaction the maximum values of these parameters were recorded from plot receiving nitrogen @ 130 kg/ha combined application with phosphorus @ 30 kg/ha, value of 15.12 q/ha and 37.72 q/ha, respectively.While, minimum values were recorded from plot receiving 0 kg/ha nitrogen with combined application of phosphorus of 60 kg/ha.

It was emphasized that nitrogen level of 130 kg N/ha did cause a significant improvement in overall growth of the crop expressed in terms of plant height, leaf area index, functional leaves, chlorophyll content, stem diameter and dry matter accumulation by virtue of increased photosynthetic efficiency. Thus, greater availability of photosynthates, metabolites and nutrients to develop reproductive structures seems to have resulted in increased productive plants, number of grains per cob, number of cobs per plant, cob length, cob girth, test weigh with nitrogen levels of 130 kg ha-1. The result of the present investigation is in close accordance with the findings of Kar *et al*., (2006) [9]; Jeet *et al*., (2012) [6] and Om *et al*., (2014) [12].

Nitrogen helps in maintaining higher auxin levels which in turn have favourable effect on cell enlargement, resulting in higher plant height and LAI resulting in better interception and utilization of radiant energy, leading to higher photosynthetic rate, which ultimately resulted in higher accumulation of dry matter. In addition to this, nitrogen is a major constituent of chlorophyll, whose intensity is known to increase with added N supply, which results in more efficient photosynthesis, accumulating higher level of biomass. Enhanced dry matter production with adequate supply of nitrogen, as evidenced in this investigation corroborates the findings of Chaudhary *et al*. (2013) [3] and Jeet *et al*. (2014) [7].

The increase in maize yield at higher phosphorus level probably, may be ascribed to the increase in cob number, number of grains row and number of grains/cob as well as heaviest grain weight. A good and optimum supply of phosphorus is associated with increase root growth due to which the plants explore more soil nutrients and water. Choudhary *et al*. (2012) observed that increasing phosphorus level enhance maize yield. Similarly, these findings are in accordance to those revealed by Nsanzabaganwa *et al*. (2014) [11].

Nitrogen and Phosphorus are essential nutrients required for the promotion of the meristematic and physiological activities such as leaf spread, root development, plant dry matter production, leading to efficient absorption and translocation of water and nutrients and interception of solar radiation. These activities promote higher photosynthetic activities leading to the production of enough assimilates for subsequent translocation to various sink and there by leading to production of higher sink components like cob length, cob girth, 1000- grain weight, number of cobs/ plant and number of grains/cob. The results are also in conformity with the findings of Singh and Nepalia (2009) [15] and Ravi *et al* (2012) [13].

Table 1: Effect of nitrogen and phosphorus on growth and yield of maize

Treatment	Plant height (cm)	Number of leaves per plant	Number of days taken to 50 per cent tasseling	Number of cobs per plant	Number of grains per cob	Grain yield per hectare (q/ha)	Straw yield per hectare (q/ha)
		Effect of nitrogen levels					
N_0	9.71	11.61	47.99	1.49	219.16	28.01	41.08
N_1	10.15	12.63	51.54	1.63	231.54	36.44	52.66
N_2	10.95	13.66	53.67	1.88	262.56	42.98	60.53
N_3	11.35	14.14	54.92	2.07	277.45	44.32	62.31
S.Em±	2.47	0.16	0.12	0.08	4.37	0.56	0.91
CD	7.23	0.47	0.35	0.24	12.82	1.64	2.66
		Effect of phosphorus levels					
P_1	10.61	12.56	51	1.67	232.79	33.95	48.96
P_2	10.54	12.76	51.79	1.72	241.23	38.58	55.22
P_3	10.47	13.71	53.31	1.92	269.02	41.28	58.25
S.Em±	2.13	0.14	0.10	0.07	3.79	0.49	0.79
CD	6.26	0.41	0.31	0.21	11.10	1.42	2.31
		Interactive effect of nitrogen and phosphorus levels					
N_0P_1	9.76	11.49	47.32	1.45	215.78	20.24	29.87
N_1P_1	9.70	11.52	47.74	1.49	218.55	29.72	43.54
N_2P_1	9.67	11.83	48.92	1.54	223.15	34.07	49.83

N_3P_1	10.21	12.51	50.59	1.59	228.17	34.68	50.34
N_0P_2	10.17	12.59	51.71	1.62	229.45	36.95	53.62
N_1P_2	10.07	12.79	52.31	1.68	237.00	37.68	54.02
N_2P_2	11.02	12.90	52.71	1.79	239.73	39.45	56.42
N_3P_2	10.97	13.35	52.95	1.87	249.37	43.24	61.14
N_0P_3	10.87	14.73	55.35	1.97	298.57	46.25	64.03
N_1P_3	11.46	13.32	53.38	1.83	247.47	41.43	59.23
N_2P_3	11.32	13.60	54.75	1.88	267.53	44.41	62.58
N_3P_3	11.28	15.49	56.64	2.50	317.36	47.12	65.12
S.Em±	4.27	0.28	0.21	0.14	7.57	0.97	1.57
CD	12.52	0.82	0.61	NS	22.20	2.85	4.62

Conclusion

Based upon this experiment it is concluded that application of higher level of nitrogen at the rate of 130 kg/ ha combined application with phosphorus at the rate of 80 kg/ ha recorded the maximum growth and grain yield of maize.

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