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Effect of different levels of nitrogen and phosphorus on the growth and yield of maize (*Zea mays* L.) and on Physico-chemical properties of post-harvest soil

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Abstract
Fertilizers played a key role in raising food production. Nutrients present in a soil govern its fertility and control the yield of crops. Soil macronutrients are essential to maintain ecosystems and high crop yields. The field experiment was conducted on sandy loam texture soil at experiment farm of Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj to assess the impact of different levels of nitrogen and phosphorus on the growth and yield of maize (Zea *mays* L.) and Physico-Chemical properties of post- harvest soil in randomized block design (RBD) with nine treatments replicated thrice. The study consisted to three levels of Nitrogen (0,100 and 120 kg ha^{-1} as Urea), Phosphorus (0, 80 and 100kg ha^{-1} as SSP) and Potassium (60 kg ha^{-1} as MOP). The parameters taken into consideration were Soil texture, EC, Organic carbon, Soil nitrogen (N), phosphorus (P), potassium (K) and plant analysis. The results revealed that the medium available nitrogen 256.32 kg ha^{-1}, high available phosphorus 28.23 kg ha^{-1} and medium available potassium 246.00 kg ha^{-1}, pH 7.6, Organic carbon 0.26%, EC 0.24 dsm^{-1} was recorded in post-harvest soil. The maximum plant height 215.99 cm, No. of leaves per plant. 12.44, No. of cobs per plant 2.22, grain yield 5.83 t ha^{-1} and stover yield 13.12 t ha^{-1} in 100 DAS was recorded with application of 120 kg N+ 100 kg P kg ha^{-1} respectively. The application of optimum doses of nitrogen, phosphorus and potassium was found highly beneficial for growth and yield of maize. There was a significantly increase in available nitrogen and phosphorus of the post- harvest soil.

Keywords: Maize, NPK, growth, yield, Physico-chemical properties of soil

Introduction
Maize is one of the most important cereal crops in the world it is a member of family Gramineae (Poaceae) and 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. (Suke *et al*., 2011) [16]. The world production of maize was 967 million metric tons (MMT) and in India its production was 23 MMT in 2013-14. (India maize summit, 2014) [6]. In the past four decades, global maize production has greatly increased (FOA, 2018) mainly due to application of nitrogen (N) fertilizers. Worldwide, N fertilizer has widely been excessively applied to achieve higher grain yield. (Meng *et al*., 2016 and Liang *et al*., 2020) [11, 9].
Nitrogen is a vitally important for plant nutrient. Nitrogen is essential constituent of protein and is present in many other compounds of great physiological important in plant metabolism. Nitrogen is called a basic constituent of life. Nitrogen also imparts 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 crops. 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 fact metabolism, in respiration of plant and early maturity of maize. Potassium plays 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 vigor and disease resistance to plant (Singh *et al*., 2010) [14]. Phosphorus (P) is one of the most limiting nutrients in agricultural cropping systems (Khan *et al*., 2018) [8]. It has been observed that the maize crop requires regulated and assured supply of nitrogen throughout its growing period right from seedling stage to grain filling stage. The response of maize of different doses of nitrogen and phosphorus performs differently.

The present studies (were undertaken with the objective to determine

1. To study the optimum doses of nitrogen and phosphorus on growth and yield of maize.
2. To study the effect on Physico-chemical properties of post-harvest soil.
3. To evaluate the best treatment for maize crop.

Materials and Methods

Study sites

The field experiment was conducted at the (Formerly Allahabad Agricultural Institute-Deemed University, Allahabad U.P.) agricultural experimental farm of Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj during the year of 2002 in Zaid Season. (25.57^0 Northern latitude,81.59^0 Eastern longitudes and altitude 98 meters above sea level).The average rainfall in this area is around 1013.4 mm annually and extremes in temperature of location reaches up to 46 ^{0}c-48 ^{0}c and seldom falls as low as 3 ^{0}c-4 ^{0}c.. The soil of experimental field was sandy loam in texture with sand 60.60%, silt 19.30%, clay 20.10%, pH 7.5, EC 0.26 dsm^{-1}, organic carbon 0.21% and soil containing Available Nitrogen 241.50 kg ha^{-1}, Phosphorus 22.60 kg ha^{-1} and Potassium 232.85 kg ha^{-1} of Pre-Harvest Soil.

Experimental design and treatment

There were 9 treatments and 3 replications. The experiment was laid out in randomized block design. Maize variety Ganga safed-2 was sown. The plot size was 2.4 x 1.9 and the spacing adopted was 60x25 cm between rows and plants. The treatment included: To: control, T_1: 0 kg N ha^{-1} and 80 kg P ha^{-1}, T_2: 0 kg N ha^{-1} and 100 kg P ha^{-1}, T_3: 100 kg N ha^{-1} and 0 kg P ha^{-1}, T_4: 100 kg N ha^{-1} and 80 kg P ha^{-1}, T_5:100 kg N ha^{-1} and 100 kg P ha^{-1}, T_6: 120 kg N ha^{-1} and 0 kg P ha^{-1}, T_7: 120 kg N ha^{-1} and 80 kg P ha^{-1}, T_8: 120 kg N ha^{-1} and 100 kg P ha^{-1}. The doses of K 60 kg ha^{-1} in each plot. The field was ploughed by one disc harrow and cultivator operations before the sowing of crop. Crops were managed according to the recommended agronomic practices including irrigation water management.

Treatment description

Fertilizer N levels (0,100 and 120 kg ha^{-1}) and Fertilizer P levels (0, 80 and 100 kg ha^{-1}).

Treatment combination

S. No	Treatments	Dose(ha^{-1})	Symbol
1	T0	0kgN+0kgP	NOP0
2	T1	0kgN+80kgP	NOP1
3	T2	0kgN+100kgP	NOP2
4	T3	100kgN+0kgP	N1P0
5	T4	100kgN+80kgP	N1P1
6	T5	100kgN+100kgP	N1P2
7	T6	120kgN+0kgP	N2P0
8	T7	120kgN+80kgP	N2P1
9	T8	120kgN+100kgP	N2P2

Fertilizer application

Urea as a source of nitrogen of 0,100 and 120 kg ha^{-1}, SSP as a source of phosphorus of 0,80 and 100 kg ha^{-1} and MOP as a source of potassium of 60 kg ha^{-1}. The dose of nitrogen was applied in two split doses at knee height stage and tasseling stage respectively. The dose of phosphorus and potassium were applied in basal dose to plot. (Aliyas *et al*., 2003) [1] observed that when 150 kg N ha^{-1} & 125 kg P_2O_5 ha^{-1} were applied then plant height 195.9 cm, grain yield 5.32 t ha^{-1} and stover yield 12.84 t ha^{-1} was achieved.

Method of data collection

Soil sample were collected from different plots at 0-15 cm soil depth after harvest of maize crops. The soil sample were collected from four spots in each plot and were mixed thoroughly to obtain a representative sample. The soil samples were air dried, ground to pass through 2.0 mm sieve and store in the laboratory for physical and chemical parameters namely soil texture, electrical conductivity (EC), pH, organic carbon and available NPK in soil were estimated by standard laboratory procedures. Particle size distribution (Sand, silt and clay) was determined by Bouyoucous hydrometer method (1962). Soil pH was determined by universal indicator solution, electrical conductivity was determined by Jackson (1973), The organic carbon content was determined by Walkley and Black method (1934). Available nitrogen was determined by alkaline permanganate method Subbiah and Asija (1956). Available phosphorus was determined by Olsen's method (1954). Available potassium was determined by Flame photometer method.

Statistical analysis

The data recorded during the course of investigation was subjected to statistical analysis by Analysis of Variance (ANOVA) technique (Fisher, 1960).

Result and Discussion

Character attributes (Soil texture, pH, OC, EC)

Mechanical analysis of soil texture shows that experimental area had sandy loam in status. Sand% varied from 60.60-60.92, silt varied from19.30-19.36% and clay varied from 20.10-20.19%. Soil pH was scaled that there was a very slight increase in soil pH after the harvest of the crop. The pH ranged from 7.5-7.6. EC was decrease in all the treatment after the harvest of the crop. It was revealed that there was a slight increase in the organic carbon content of the soil after the harvest of the crop. The OC ranged from 0.21- 0.25. The details of treatments are presented below in (Table1). (Garki *et al*., 2004) [3] also reported that maize can be grown on soils with pH values ranging from 5.5-8.0 and does best at neutral pH. (Sheeba and Chellamuthu, 2000) [3] also reported that the application of 100% NPK+FYM improved the soil chemical properties (Soil pH 8.3, EC<1dSm^{-1} respectively) of maize. (Kalhapure *et al*., 2013) [7] found that effect of Integrated Nutrient Management in maize (*Zea mays* L.) and after experiment soil fertility status result showed that different fertility level had significant effect of physico-chemical properties of soil.

Effect of different levels of nitrogen and phosphorus on growth & yield of maize

Character attributes (Growth and Yield of maize)

Studies showed that there are non-significant effect on plant height, no. of leaves $plant^{-1}$, no. of cobs $plant^{-1}$, grain yield and stover yield at 100DAS. The maximum plant height 215.99 cm, no. of leaves $plant^{-1}$. 12.44, no. of cobs $plant^{-1}$ 2.22, grain yield 5.83 t ha^{-1} in 100 DAS was recorded with application of 120kg N+ 100kgP kg ha^{-1}. The details of treatments are presented below in (Table 2) and stover yield 13.12 t ha^{-1} in 100 DAS was recorded in treatment T8 at

higher dose of 120kgN+100kgP ha^{-1}. The details of stover yield are presented below in (Figure 1). (Sheeba and Chellamuthu, 2000) [13] also reported that the application of 100% NPK+FYM improved the grain yield (3875 kg ha^{-1}) of maize. (Subedi and Ma, 2005) [15] also reported that no significant increase in plant height due to nitrogen application. (Rasheed *et al.*, 2004) [12] who reported that increasing nitrogen application was non -significant on plant height & No. of leaves $plant^{-1}$ of maize. (Halvorson *et al.*, 2006) [5] also reported that corn grain yields increased each year with increasing nitrogen fertilizer rates. (Mandoloi,1999) also reported that 150 kg N increased the grain yield of hybrid by 7 to 9 q ha^{-1}.The response from 60 kg P_2O_5 was not found no significant but response from 50 kg K_2O ha^{-1} was found significant and yield increased to the extent of 60 kg ha^{-1}. (Gauri *et al.*, 1991) [4] also reported that the highest maize grain yield was 53.3 q ha^{-1} and stover yield 102.2q ha^{-1} and maximum uptake by grain and stover was at harvest by applying 120 kg nitrogen in these splits.1/$_2$ at sowing,1/$_4$ at knee height stage and1/$_4$ at tasseling stage, which was significantly high over rest of the nitrogen application treatments.

Character attributes (Available NPK of Post-harvest soil)

The result obtained from the analysis show that there was significant difference in available nitrogen, phosphorus and potassium in the soils. Available N status varied from 241.56-256.32 kg ha^{-1}, available phosphorus content 22.65-28.23 kg ha^{-1} and status of available K in the soils ranged between 232.96-246.00 kg ha^{-1} respectively. Since the plots were treated with basal dose of nitrogen and phosphorus. Available potassium content was a little much higher in the plots receiving doses of potassium fertilizer application. This could be due to different doses potassium fertilizer application in these plots, as presented below in (Table 3).

Table 1: Following character attributes recorded

Treatment combination	Sand %	Silt %	Clay %	pH (1:2)	OC (%)	EC (dSm^{-1})	Available N($kgha^{-1}$)	Available P($kgha^{-1}$)	Available K($kgha^{-1}$)
Pre-sowing	60.60	19.30	20.10	7.5	0.21	0.26	241.50	22.60	232.85
Post-harvest									
T_0	60.60	19.30	20.10	7.5	0.21	0.20	241.56	22.65	232.96
T_1	60.90	19.06	20.00	7.6	0.21	0.21	242.44	24.25	234.13
T_2	60.64	19.36	20.00	7.6	0.22	0.22	242.62	24.66	236.10
T_3	60.75	19.06	20.10	7.6	0.22	0.20	240.00	23.81	242.37
T_4	60.72	19.22	20.06	7.5	0.24	0.21	242.55	25.40	244.86
T_5	60.84	19.12	20.04	7.6	0.25	0.23	244.39	25.28	245.84
T_6	60.86	19.08	20.06	7.5	0.24	0.22	251.87	26.24	243.96
T_7	60.87	19.09	20.04	7.5	0.25	0.24	254.93	27.26	245.73
T_8	60.92	19.00	20.08	7.6	0.25	0.24	256.32	28.23	246.00

Table 2: Following character attributes recorded (growth and yield) on maize

Character treatment	Plant height(cm) at 100DAS	No. of leaves $Plant^{-1}$ at 100 DAS	No. of cobs $plant^{-1}$	No. of grain cob^{-1}	Grain Yield (tha^{-1})
T_0	195.20	11.44	1.22	94.05	3.76
T_1	201.57	11.55	1.33	125.22	4.83
T_2	207.66	11.77	1.33	127.28	4.90
T_3	202.33	11.88	1.66	128.51	4.72
T_4	208.66	11.99	1.77	155.24	5.50
T_5	211.33	11.99	1.88	157.40	5.65
T_6	212.66	11.83	1.88	152.18	4.95
T_7	214.33	12.22	2.21	161.28	5.75
T_8	215.99	12.44	2.22	162.11	5.83
F-test	NS	NS	NS	S	NS
CD (5%)	5.73	0.46	0.76	1.18	0.53

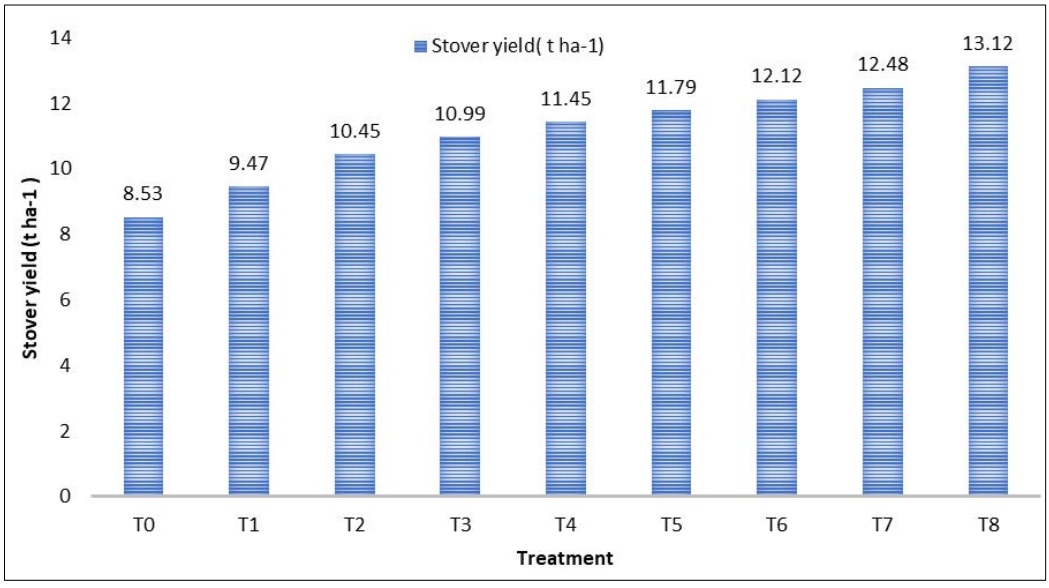

Fig 1: Effect of interaction between different levels of N and P on stover yield (t ha^{-1})

Table 3: Following character attributes recorded (Available NPK of Post-harvest soil)

Character treatment	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T0	241.56	22.65	232.96
T1	242.44	24.25	234.13
T2	242.62	24.66	236.10
T3	240.00	23.81	242.37
T4	242.55	25.40	244.86
T5	244.39	25.28	245.84
T6	251.87	26.24	243.96
T7	254.93	27.26	245.73
T8	256.32	28.23	246.00
F-test	S	S	S
CD (5%)	1.38	0.59	0.90

Conclusion

Based on the results of research, it is concluded that the application of 120 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1} along with 60 kg K_2O ha^{-1} supplied through inorganic fertilizers (Urea, SSP and MOP) gave the best results on the growth, seed yield and productivity of maize. Nitrogen and Phosphorus application significantly increased in available nitrogen and phosphorus of the post-harvest soil.

Further Research

After soil testing, chemical fertilizers and other (Bio-fertilizer and organic manures) should be used in balanced quantity according to the requirement of crops to be sown. In addition, carry out long term soil fertility status can be met by choosing green manures and crop residue should be mixed in soil with bio-fertilizers.

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