Original Research Article

Effect of Phosphorus and Potassium on Growth and Yield of Maize (*Zea mays* L.)

ABSTRACT

The field experiment entitled "Effect of Phosphorus and Potassium on Growth and Yield of Maize" was conducted Response of during the *rabi* season of 2022. in Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.). The experiment was laid out in a Randomized Block Design with ten treatment combinations. The soil in the experimental area was sandy loam with pH (7.6), EC (0.305 d S/m), organic carbon (0.23 %), available N (184.8 kg/ha), available P (16.45 kg/ha) and available K (187.64 kg/ha). Seeds are sown at a spacing of 60 cm × 25 cm with a seed rate of 25 kg/ha. Consisting of three Phosphorus levels (50, 70 and 90 kg P_2O_5/ha) and different Concentration of Potassium levels (35,55 and 75 kg K_2O/ha). Highest plant height (172.79 cm), maximum plant dry weight (134.14g), more number of cobs/plant (1.8), number of seeds/row (17.13), Number of rows/cobs (12.40), test weight (232.82), seed yield (6.16 t/ha) and straw yield (10.73 t/ha.) was recorded in treatments 9 Phosphorus (90 kg/ha.) + Potassium (75 kg/ha.). Maximum gross return (178395.75 INR/ha), net return (132277.78 INR/ha) and B:C ratio (2.9) were also recorded in treatment 9 Phosphorus (90 kg/ha.) + Potassium (75 kg/ha.).

Key words: *Maize, Phosphorus, Potassium, Growth, Yield, Economics*

Introduction

Maize is the most important cereal crop in the world, but maize is the most popular due to its high yielding, ease of processing, readily digested and costs less than other cereals. Maize is the most versatile crop with wider adaptability in varied agro- ecological conditions. It is an annual C_4 plant belonging to the family "Poaceae" with its origin in Central America. Maize being one of the most important cereals crops in the world agricultural economy, it is cultivated throughout the world as it has highest genetic yield potential than any other cereals crop and there are no cereals on earth which has so immense potential and hence referred to as "Queen of cereals" or miracle crop **(Ratuarary *et. al.* 2013).**

Globally, Maize is known as queen of cereals because of its highest genetic yield potential among the cereals. Every part of the maize plant has economic value (the grain, leaves, stalk, tassel, and cob) and all are used to produce a large variety of food and non-food products. It is the most versatile crop and is grown in more than 166 countries across the globe, including tropical, subtropical, and temperate regions, from sea level to 3000 m above mean sea level. It is cultivated in nearly 201 m ha with a production of 1162 m tonnes and productivity of 5754.7 kg/ha all over the world, having wider diversity of soil, climate, biodiversity, and management practices (**FAOSTAT 2020).** India produced 31.51 million tones in an area of 9.9 million hectares in 2020-21, whereas in *kharif* 2021-22, maize production was 21.24 million tones (1st advance estimates) in an area of 8.15 million hectares (sarcopenic). United States of America (USA) is the largest producer of maize contributing 30 per cent of the global production and is regarded as the driver of the US economy (Figure 1). In Andhra Pradesh, maize was cultivated in an area of 3.01 lakh ha with a production and productivity of 17.84 lakh tonnes and 5918 kg/ha respectively contributing 5.66per cent to total country's production (des.ap.gov.in, 2020-21). According to 2nd advance estimates during 2021-22, maize was grown in 3.05 lakh hectares with a production of 18.62 lakh tonnes and productivity was 6105 kg/ha.

Phosphorus is the second major nutrient after nitrogen for high crop yield especially for maize, because it is frequently deficient for crop production and is required by crops in relatively large amounts. The total P concentration in agricultural crops generally ranges from 0.1 to 0.5 percent. Phosphorus is taken up mostly as the primary orthophosphate ion ($H_2PO_4^-$), but some is also absorbed in the secondary orthophosphate form (HPO_4^{-2}). The later form increases as the soil pH increases. Phosphates are vital components of all living things. In plants, P is necessary for photosynthesis, respiration, cellular function, gene transfer and reproduction. Once aware of the critical link between P and life itself, it becomes apparent that "Without phosphorus, there is no cell, plant and grain and without adequate phosphorus, there is a lot of hunger". Phosphorus deficiency is widespread in 90% of soils and the application of phosphatic fertilizers is considered essential for a crop production **(Rashid and Memon, 2001).**

Potassium plays a vital role in enhancing the yield and quality of maize grain. Potassium is an important nutrient for improving the crop yield per unit area. Potassium 15 vital for physiological processes, water availability, photosynthesis, assimilate transport and enzyme activation with a direct effect on crop production Potassium deficiency significantly reduces the leaves number and size of individual leaf and as a result photosynthetic activity of the plant was affected **(William, 2008)**. Potassium limits the crop water requirement during drought conditions because K has a dominant role in the opening and closing of stomata, through which transpiration occurs from the leaves and CO_2 enters leaf tissues. If K is inadequate, the stomatal activity decreases and transpiration loss increases. Grain yield increases by enhancing the uptake of potassium under the arid condition **(Damon and Rengel, 2008).** Many physiological processes of plants, affecting plant growth and yield such as photosynthesis, activation of enzymes, plant water relation and assimilation are affected by potassium application. Potassium is an important nutrient as nitrogen and phosphorus for grain crops. It significantly affects protein synthesis, enzyme activation, osmoregulation, photosynthesis, stomatal movement, phloem transport, Energy transfer, cation-anion balance, and stress resistance **(Marschner, 2012).**

Materials and Methods

The experiment was conducted during the *Rabi season* of 2022 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Science (SHUATS), Prayagraj (UP). The Crop Research Farm is situated at 25.57^{o} N latitude, 87.19^{o} E longitude and at an altitude of 98 m above mean sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Prayagraj City. All the facilities for crop cultivation were available. The experiment was laid out in Randomized Block Design and comprised of Nitrogen and Boron with ten treatments, and each was replicated thrice *viz*., T1- Phosphorus (50 kg/ha.) + Potassium (35 kg/ha.), T2- Phosphorus (50 kg/ha.) + Potassium (55 kg/ha.), T3- Phosphorus (50 kg/ha.) + Potassium (75 kg/ha.), T4- Phosphorus (70 kg/ha.) + Potassium (35 kg/ha.), T5- Phosphorus (70 kg/ha.) + Potassium (55 kg/ha.), T6- Phosphorus (70 kg/ha.) + Potassium (75 kg/ha.), T7- Phosphorus (90 kg/ha.) + Potassium (35 kg/ha.), T8- Phosphorus (90 kg/ha.) + Potassium (55 kg/ha.), T9- Phosphorus (90 kg/ha.) + Potassium (75 kg/ha.), T10- Control (NPK 120-60-40 kg/ha). At harvesting maturity, the maize crop was harvested at 100 DAS, Seeds were harvested from each plot, dried under the sun for three days, winnowed and the seed yield per hectare was calculated and expressed in t/hectare. The straw production from each plot was measured and expressed in t/hectare after ten days of drying in the sun. The data was analysed using statistical analysis. All agronomic practices were followed during the crop period. "Experimental data collected were treated using Fisher's method of analysis of variance (ANOVA) as outlined by **(Gomez and Gomez, 1984)**. Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level".

Result and Discussion

4.1 Growth and Growth attributes

4.1.1 Plant height

The plant Height recorded at different intervals *i.e.*, 20, 40, 60 and 80 differed significantly as effect by phosphorus and potassium of maize. (Table.1)

At 80 DAS, significantly highest plant height (172.79 cm) was recorded with the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)]. However, the treatments 6 (172.67 cm) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], treatments 8 (161.32 cm) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], treatments 7 (157.31 cm) [Phosphorous (90 kg/ha) + Potassium (35 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

The result showed growth parameters *viz*, plant height (187.06 cm), **Sankadiya and Sanodiya. 2021.** Phosphorus encourages formation of new cells, promotes plant vigour and hastens leaf development, which helps in harvesting more solar energy and better utilization of nitrogen, which help towards higher growth attributes, **Noonari *et al.* (2016)**. The increase in plant height might be due to the Potassium in that application plays a crucial role in meristematic growth through its effect on the synthesis of phyto hormones. Among various plant hormones, cytokinin plays an important role in growth of the plant. Beneficial effect of K on growth reported by **tetarwal *et al.* (2011)**.

4.1.2 Plant Dry Weight (g)

At 80 DAS, the highest dry weight (134.14g) was recorded in treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)]. However, treatment 6 (124.78g) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

The plants attained more vigor with phosphorus, due to adequate supply and availability of NPK & spacing in balanced combination, resulting in increased dry weight of the plant. The application of Phosphorus 70 kg/ha to baby corn significantly increased dry matter production. The results were in accordance with **Hirpara *et al.* (2017).**

4.2 Yield and Yield attributes

4.2.1 Number of cobs/plants

From the observations significantly highest cobs/plant (1.80) was observed in the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], However, treatment 6 (1.8) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], treatment 8 (1.6) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], treatment 7 (1.6) [Phosphorous (90 kg/ha) + Potassium (35 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

The results indicated that higher rates of both potassic and phosphatic fertilizers have significantly enhanced the weight per ear, no of grains per ear and the 1000-grains weight. The sole effect of potassium was found to be non-significant for grain yield but in interaction with phosphorus levels and maize varieties potassium produced the better yield. But alone the phosphorus levels and its interaction with potassium levels and maize hybrids showed significant effect on grain yield. **(Adnan & Anwar, 2020)**

4.2.2 Number of seeds/rows

From the observations significantly highest seeds/rows (17.13) was observed in the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], However, treatment 6 (16.87) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], treatment 8 (16.33) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], treatment 7 (16.00) [Phosphorous (90 kg/ha) + Potassium (35 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

4.2.3 Number of rows/cobs

From the observations significantly highest rows/cobs (12.40) was observed in the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], However, treatment 6 (12.73) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], treatment 8 (12.67) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], treatment 7 (12.60) [Phosphorous (90 kg/ha) + Potassium (35 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

The results indicated that plant height showed a significant response up to 40 kg K_2O/ha, whereas SPAD values and Leaf area index were higher up to 80 kg K_2O/ha while the root parameters showed significant response up to 120 kg K_2O/ha. Yield parameters *viz.*, cob length and 100 grain weight were significantly influenced up to 120 kg K_2O/ha. Whereas cob girth and rows per cob responded only up to 80 kg K_2O/ha. Grain and stover yield of hybrid maize showed significant response up to 120 kg K_2O /ha. **Gnana Sundari *et al.*, (2019).**

4.2.4 Test weight (g)

From the observations significantly highest test weight (232.82) was observed in the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], However, treatment 6 (230.30) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], treatment 8 (224.57) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], treatment 7 (216.74) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

4.2.5 Seed Yield (t/ha)

From the observations significantly highest seed yield (6.16 t/ha) was observed in the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], However, treatment 6 (6.51t/ha) [Phosphorous (70 kg/ha) + Potassium (75 kg/ha)], treatment 8 (5.95 t/ha) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], treatment 7 (5.52 t/ha) [Phosphorous (90 kg/ha) + Potassium (55 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

The results indicated that higher rates of both potassium and phosphorus fertilizers have significantly enhanced the weight per ear, no of grains per ear and the 1000 grains weight. The sole effect of potassium was found non-significant for grain yield but in interaction with phosphorus levels and maize varieties potassium produced the better yield. But alone the phosphorus levels and its interaction with potassium levels and maize hybrids showed significant effect on grain yield. **Adnan, M. (2020).**

4.2.6 Strow yield (t/ha)

From the observations significantly highest strow yield (10.73 t) was observed in the treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], were found to be statistically at par with treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)].

4.2.7 Harvest index (%)

The harvest index obtained based on seed yield and strow yield is given in table 2 The that shown that there was non-significant difference among treatments combinations. However, the highest harvest index (26.06 %) was noticed in treatment 9 [Phosphorous (90 kg/ha) + Potassium (75 kg/ha)], and last was in treatment 10 (18.42) [Phosphorous (70 kg/ha) + Potassium (55 kg/ha)], respectively.

Conclusion

It is concluded Maize application of Phosphorus 90 kg/ha. along with the application of Potassium 75 kg/ha. observed highest seed yield, stover yield and benefit cost ratio.

Table 1. Effect of Phosphorus and Potassium on Growth Attributes of Maize.

S.No.	Treatment combinations	At 80 DAS	
		Plant height (cm)	**Plant dry weight (g)**
1.	Phosphorus (50 kg/ha.) + Potassium (35 kg/ha.)	146.97	89.45
2.	Phosphorus (50 kg/ha.) + Potassium (55 kg/ha.)	150.93	95.12
3.	Phosphorus (50 kg/ha.) + Potassium (75 kg/ha.)	152.99	101.99
4.	Phosphorus (70 kg/ha.) + Potassium (35 kg/ha.)	154.51	110.08
5.	Phosphorus (70 kg/ha.) + Potassium (55 kg/ha.)	155.78	120.65
6.	Phosphorus (70 kg/ha.) + Potassium (75 kg/ha.)	172.34	124.78
7.	Phosphorus (90 kg/ha.) + Potassium (35 kg/ha.)	157.31	118.63
8.	Phosphorus (90 kg/ha.) + Potassium (55 kg/ha.)	161.32	119.82
9.	Phosphorus (90 kg/ha.) + Potassium (75 kg/ha.)	172.79	134.14
10.	Control – 120-60-40 kg/ha	157.85	100.98
	F test	S	S
	SEm(±)	5.40	4.25
	CD (p=0.05)	16.05	12.63

Table 2. Effect of Phosphorus and Potassium on Yield and Yield Attributes of Maize.

S.No.	Treatment combination	Number of cobs/ Plant	Number of seeds /rows	Number of rows /cobs	Test weight (g)	Seed Yield (t/ha)	Stover Yield (t/ha)	Harvest Index (%)
1.	Phosphorus (50 kg/ha.) + Potassium (35 kg/ha.)	1.00	13.40	9.87	209.88	3.04	7.16	20.70
2.	Phosphorus (50 kg/ha.) + Potassium (55 kg/ha.)	1.20	13.67	11.07	206.52	3.01	7.61	19.91
3.	Phosphorus (50 kg/ha.) + Potassium (75 kg/ha.)	1.20	14.33	11.33	206.75	3.21	8.16	20.18
4.	Phosphorus (70 kg/ha.) + Potassium (35 kg/ha.)	1.47	14.80	11.80	207.66	4.26	8.81	23.00
5.	Phosphorus (70 kg/ha.) + Potassium (55 kg/ha.)	1.53	15.33	12.53	220.08	5.15	9.65	24.56
6.	Phosphorus (70 kg/ha.) + Potassium (75 kg/ha.)	1.80	16.87	11.73	230.30	6.51	9.98	27.52
7.	Phosphorus (90 kg/ha.) + Potassium (35 kg/ha.)	1.60	16.00	12.60	216.74	5.52	9.49	25.83
8.	Phosphorus (90 kg/ha.) + Potassium (55 kg/ha.)	1.60	16.33	12.67	224.57	5.95	9.59	26.71
9.	Phosphorus (90 kg/ha.) + Potassium (75 kg/ha.)	1.80	17.13	12.40	232.82	6.16	10.73	26.06
10.	Control – 120-60-40 kg/ha	1.20	12.93	10.93	202.50	2.74	8.08	18.42
	F-test	S	S	S	S	S	S	NS
	SEm(±)	0.07	0.93	0.57	6.79	0.38	0.34	1.78
	CD (p=0.05)	0.21	2.77	1.70	20.18	1.13	1.01	-

Reference

Adnan, M., & Anwar, K. (2020). Online Learning amid the COVID-19 Pandemic: Students' Perspectives. *Online Submission*, ***2***(1), 45-51.

Damon, P.M., and Z., Rangel. (2008). Crops and genotypes differ in efficiency of potassium uptake and use. *Physiology Plantarum*, **133**(4): 624-36.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John wiley & sons.

Krishnan, R., Sanjay, J., Gnanaseelan, C., Mujumdar, M., Kulkarni, A., and Chakraborty, S. (2020). *Assessment of climate change over the Indian region: a report of the ministry of earth sciences (MOES), government of India* (p. 226). Springer Nature.

Marcher, P. (2012). Marcher's Mineral Nutrition of Higher Plants, 3rd edition, pp: 178-189. *Academic Press: London, UK.*

Noonari, S., Kalhoro, S. A., Ali, A., Mahar, A., Raza, S., Ahmed, M., ... & Baloch, S. U. (2016). Effect of different levels of phosphorus and method of application on the growth and yield of wheat. *Natural Science*, **8**(7), 305-314.

Patriarca, C., Macchi, R. M., Marschner, A. K., and Mellstedt, H. (2012). Epithelial cell adhesion molecule expression (CD326) in cancer: a short review. *Cancer treatment reviews*, ***38***(1), 68-75.

Rashid, A., and K.S. Memon. (2001). Soil and Fertilizer Phosphorus. Soil Science. Elena, B., and R. Bentel (Eds.) *National Book Foundation, Islamabad*. pp. 300-302.

Ratuarary, S. K.; Ghosh, B.C., and Mittra, B.N. (2013). Effect of fly ash, organic wastes and chemical fertilizers on yield, nutrient uptake, heavy metal content and residual fertility in rice mustard cropping sequence under acid lateritic soils. Bioresource Technology, **90**: 275-283.

Rengel, Z., & Damon, P. M. (2008). Crops and genotypes differ in efficiency of potassium uptake and use. *Physiologia Plantarum*, **133**(4), 624-636.

Sankadiya, S., and Sanodiya L., (2021) "Effect of phosphorus and potassium levels on growth and yield of maize (*Zea mays* L.)." *The Pharma Innovation*, **10**: 1347-1350.

Srinivasa Sai, V., Gnana Sundari, K., Gangadhara Rao, P., and Surekha, B. (2019). Improvement of machining characteristics by EDM with graphite powder-mixed dielectric medium. In *Advances in Manufacturing Technology: Select Proceedings of ICAMT 2018* (pp. 41-48). Springer Singapore.

Tetarwal, J. P., Ram, B., & Meena, D. S. (2011). Effect of integrated nutrient management on productivity, profitability, nutrient uptake and soil fertility in rainfed maize (Zea mays). *Indian journal of Agronomy*, **56**(4), 373-376.

William, T.P., (2008). Potassium influences on yield and quality production for maize Acta *Physiologies Plantarum,* **133:** 670– 681.

Wong, A. L., Hirpara, J. L., Pervaiz, S., Eu, J. Q., Sethi, G., and Goh, B. C. (2017). Do STAT3 inhibitors have potential in the future for cancer therapy. Expert opinion on investigational drugs, 26(8), 883-887.