

Effect of Phosphorus and Potassium on Growth and Yield of Maize

(*Zea mays* L.)

Comment [Ma1]: Growth, yield and Economics of Maize

ABSTRACT

The field experiment entitled “Effect of Phosphorus and Potassium on Growth and Yield of Maize” was conducted 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 P₂O₅/ha) and different Concentration of Potassium levels (35, 55 and 75 kg K₂O/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 (10.73t/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.).

Comment [Ma2]: 2022-2023

Comment [Ma3]: All letters in small letter.

Comment [Ma4]: Use full stop not comma.

Comment [Ma5]: Small letter

Comment [Ma6]: The result showed that

Comment [Ma7]: Small letter

Comment [Ma8]: T9

Comment [Ma9]: T9

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

Comment [Ma10]: Arrange the key words alphabetically

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 C₄ 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 (Ratuararyet. al. 2013).

Maize is a major source of carbohydrates which is used for food, in livestock diet and in alcohol production. Maize has immense potential in the tropics and a yield of up to 7500 kg/ha can be obtained if the crop is properly managed. Unfortunately, yields are still generally below 5000 kg/ha. and this had caused inadequacy of maize for its numerous usages. Yield differences between temperate and tropical areas have been attributed to low nutrient status of tropical soils especially nitrogen, phosphorus and potassium resulting from the practice of slash and burn farming system with excessive leaching of the soil nutrients In India, maize is grown in an area of 9.43million hectares with production of 24.35 m t and productivity of 2583 kg/ha (**Government of India, 2020**). In UP, maize is grown in an area of 0.83 m/ha with production 1.56 m t and productivity of 2376 kg/ha (**State wise 2020**).

Comment [Ma11]: Kindly give the current data of area, production and productivity.

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**).

Comment [Ma12]: Remove the word

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 is 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 into 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**

Comment [Ma13]: enzyme

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**).

Comment [Ma14]: Insert the purpose of the study at the end of the introduction.

UNDER PEER REVIEW

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° N latitude, 87.19° 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".

Comment [Ma15]: This section must be written in subsections such as area and location, treatment combinations, data collection, formula used on the economics calculation, experimental design used etc.

Result and Discussion

4.1 Growth and Growth attributes

Comment [Ma16]: Rewrite the whole discussion section.

Comment [Ma17]: Growth parameters

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 (172.79cm) 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)].

Comment [Ma18]: T₉

The result showed growth parameters *viz.* plant height (187.06 cm), **Sankadiyaet al. (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, **Noonariet 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 **tetarwalet al. (2011)**.

Comment [Ma19]: First letter always in capital letter

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 com significantly increased dry matter production. The results were in accordance with **Hirpara et al. (2017)**.

Comment [Ma20]: corn

Comment [Ma21]: with the finding of

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 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 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, M. (2020)**.

Comment [Ma22]: dose

Comment [Ma23]: potassic

Comment [Ma24]: phosphatic

Comment [Ma25]: number

Comment [Ma26]: Adnan (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)].

Comment [Ma27]: T9

Comment [Ma28]: T6

Comment [Ma29]: T9

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/ha while the root parameters showed significant response up to 120 kg K/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. **GnanaSundariet al., (2019).**

Comment [Ma30]: Somewhere use K_2O and somewhere use K. why?

Comment [Ma31]: K_2O

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 Strowyield (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)].

The result showed that growth parameters viz, plant height (187.06 cm), no. of leaves/plant (9.4), leaf area index (7.45), plant dry matter accumulation (3008 g/m²), CGR (29.8), RGR (0.0787) yield attributes like effective Cob/Plant (1.53), Cob/length (16.75 cm), Row/cob (14.89) Grains/row (26.94) Grains/cob (396.5 g), Grain yield t/ha (4.5 t/ha), stover yield t/ha (9.5 t/ha), Seed index weight (28.2 g), Harvest index (32.5) were found to be significantly highest with T9 i.e., 70 kg/ha (P) + 60 kg/ha (K). Similarly highest gross return (INR 103455 /ha), net return (INR 74095/ha) and benefit: cost ratio (2.52) were recorded superior with application T9 i.e., 70 kg/ha (P) + 60 Kg/ha (K). Sankadiyaet al., (2021).

4.2.7 Harvest index (%)

The harvest index obtained based on seed yield and strowyield 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.

Comment [Ma32]: Why these lines are repeated many times. Kindly describe the findings on the basis of particular parameter not for all.

Comment [Ma33]: Straw

Comment [Ma34]: Straw

Comment [Ma35]: Again repeated

Comment [Ma36]: Economics of the research give in the separate table and separate discussion.

Comment [Ma37]: straw

Conclusion

Comment [Ma38]: Very poorly written

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.

UNDER PEER REVIEW

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.
- Ratuary, S. K.; Ghosh, B.C., and Mitra, 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.

Comment [Ma39]: Write in proper format

- Srinivasa Sai, V., GnanaSundari, K., Gangadhara Rao, P., & 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.

UNDER PEER REVIEW