

Maize Yield Response under Various Phosphorus Sources and their Ratios

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Abstract

Improper use of fertilizers and its ratio is one of the main reasons for low productivity; therefore balance fertilization is required to maintain crop production and improved soil fertility. Therefore the experiment was carried out at Cereal Crop Research Institute (CCRI) Pirsabak, District Nowshera KP, Pakistan during Kharif 2016. To study the effect of different phosphorus (P) sources and their ratios on maize yield and yield components, an experiment was carried out in a Randomized Complete Block Design (RCBD) with three replication. The treatments consisted of sole application of Farmyard Manure (FYM), Poultry Manure (PM) and Diammonium Phosphate (DAP), 75% FYM+25% DAP, 50% FYM+50% DAP, 75% PM+25% DAP, 50% PM+50% DAP and a control treatment with no P fertilizer. Phosphorus was applied at the rate of 100 kg ha⁻¹ from different sources in different ratios. The results indicated a significant effect of different phosphorus sources on days to tasselling, days to silking, days to maturity, plant height, grains ear⁻¹, grain yield, biological yield, and harvest index, whereas the emergence m⁻² was found non-significant with different P sources. The combined use of organic and inorganic P sources delayed tasselling, silking and maturity. Plant height, grains ear⁻¹, biological yield, grain yield, and harvest index was also higher with the addition of P from both sources as compared with the sole application of organic or inorganic fertilizer. The combined application of organic manures 50:50 (FYM or PM) and inorganic fertilizer (DAP) performed better as compared to the rest of the ratios and produced higher yield and yield components.

Keywords: Farmyard manure (FYM); Poultry manure (PM); DAP; Grain yield; Nowshera; Khyber pakhtunkhwa (KP); Pakistan

Introduction

Maize (*Zea mays L.*) is one of the important cereal crop its ranks 3rd in Pakistan after wheat and rice. The average yield of maize in Pakistan is 3983 kg ha⁻¹ which is much lower in other growing world countries [1]. C4 mode carbon fixation was found in maize due to its high biomass and its rapid growth, therefore, its need balance nutrient application. Phosphorus is one of the most important nutrients for improving yield and crop growth [2]. Due to unavailability of P crop yield is reduced up to 30% [3] and also lower P use efficiency. Inorganic phosphorus fertilizers, continuously lead phosphorus to a negative response. It could run out about 60 to 100 years if its current consumption continues and there will be no agriculture without P [4]. In Pakistan like another arid region of the world, about 80% to 90% soils are deficient in available P [5]. In Pakistani soil fertility survey reported that P after N is the most deficient nutrient [6].

P application and organic manure are very essential for P availability and as well as yield profitability [7]. Under the semiarid condition, the major limiting factor of crop production is the unavailability of P and lack of organic matter. Phosphorus is an important essential macronutrient often limiting plant growth due to fixation in soils and its low solubility. Bound P by microbial inoculants is an important factor for increasing productivity and improving soil fertility [8]. Due to low fertilizers use efficiency the crop yields in Pakistan are either stagnant or not increasing [9]. Unavailability and inadequate supply of fertilizers at the time of requirement adulteration and high cost [10]. A large amount of energy and high cost are required for the synthesis of chemical fertilizers. Moreover, the continuous use of chemical fertilizers creates an environmental problem [4]. Be that as it may, natural cultivating, with or without concoction composts is by all accounts a conceivable answer for the predominant circumstances [11]. The joining of natural supplement sources with engineered ones supply basic supplements as well as has some positive cooperation with synthetic manures to expand their proficiency in this way

decreasing ecological risks [12]. Non-customary squanders like poultry excrement and press mud from the sugar industry are of concern and should be overseen in ecological point of view.

It is apparent from various investigations, reusing and expansion of mechanical and agrarian squanders to soil may improve the productivity of connected and local supplements required by harvests. Joining of channel cake as the natural waste with Single Super Phosphate (SSP) in 2:1 proportion brought about expanded plant stature, number of tillers per plant, straw and grain yield of wheat just as P take-up by grain over control [13]. Amujoyegbe BJ et al. Found most astounding grain yield and biomass of maize and sorghum with the consolidated use of inorganic compost+poultry excrement pursued by inorganic manure [14]. In another examination, utilization of poultry excrement either alone or coordinated with synthetic changes of P for maize, performed superior to anything all alterations tried in research facility trails [15]. Hussain A et al. Prescribed that natural issue alone with manufactured manures could be useful for upgrading stale wheat grain yield, Therefore, prudent and efficient utilization of the current land, supplement composts application, budgetary assets and reusing of natural squanders under field conditions is unavoidable [16].

Keeping in view the importance of phosphorus and the problem of the high price of chemical fertilizer, the present study was conducted to evaluate the effect of different phosphorus sources and their ratios on yield and yield components of maize under the climatic condition of Nowshera.

Materials and Methods

The experiment entitles "Response of Maize yield under various levels of nitrogen and zinc fertilizers" was carried out at Cereal Crop Research Institute (CCRI) Pirsabak, Distract Nowshera KP, Pakistan during Kharif 2016. The experiment factor along with their levels is as under (Table 1).

Table 1: Treatment combination.

Treatment	Organic manure	DAP	Desired P (kg ha ⁻¹)
T1	0	0	0
T2	100% FYM	0	100
T3	75% FYM	25%	100
T4	50% FYM	50%	100
T5	100% PM	0	100
T6	75% PM	25%	100
T7	50% PM	50%	100
T8	0	100%	100

The following parameters were recorded during the experiment:

- Emergence m⁻²
- Days to 75% tasseling
- Days to 75% silking

- Plant height (cm)
- Days to maturity
- Number of grains (ear⁻¹)
- Biological yield (kg ha⁻¹)
- Grain yield (kg ha⁻¹)
- Harvest index (%)

Emergence m⁻²

Data on emergence m⁻² were taken by counting the number of seedlings emerged in a one-meter long row at three random places in each plot after 80% emergence and were converted to m⁻².

Days to 75% tasseling

Days to tasseling were recorded by counting the number of days from sowing to date when 75% of plants produced tassels in each subplot.

Days to 75% silking

Data regarding days to silking were recorded by counting the number of days from sowing to date when 75% of plants produced silks in each subplot.

Plant height (cm)

Plant height was recorded at physiological maturity stage. Five representative plants from each subplot were selected randomly and were measured from base to the tip of tassel with meter rod and then their average was worked out.

Number of grains ear⁻¹

Data on a number of grains ear⁻¹ was recorded by counting the number of grains in five ears randomly selected in from each subplot and were averaged.

Biological yield (kg ha⁻¹)

Four central rows in each subplot were harvested; sun-dried and were weighed for recording biological yield data, then converted into kg ha⁻¹ by the formula.

$$\text{Biological yield (kg ha}^{-1}\text{)} = \frac{\text{Biological yield in 4 rows}}{\text{R-R (m)} \times \text{Row length (m)} \times \text{No of rows}} \times 10000 \text{ m}^2$$

Grain yield (kg ha⁻¹)

Ears from four rows harvested for biological yield were shelled and grains were weighed to determine the grain yield and then converted into kg ha⁻¹ by using the formula.

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{\text{Grain yield in 4 rows}}{\text{R-R (m)} \times \text{Row length (m)} \times \text{No of rows}} \times 10000 \text{ m}^2$$

Harvest index (%)

Harvest index (%) was calculated by using the formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Statistical analysis

The data were analyzed statistically according to the analysis of variance techniques used for randomized complete block design and Least Significant Difference (LSD) test was applied when the means were found significant by the procedure suggested by Jan MT et al. [17].

Result and Discussion

Emergence m⁻²

Data regarding emergence m⁻² of maize indicated the non-significant effect of different phosphorus (P) sources (**Table 2**). The control vs. rest comparison was also found non-significant for emergence m⁻². The insignificant effect of different P sources on emergence m⁻² might be due to the fact that at earlier stages of growth the seedlings take nutrients from stored food in seeds, that is why there was no effect of externally supplied nutrients, moreover the emergence m⁻² is also dependent on seed rate and uniform seed rate did not differ the emergence m⁻². Similar results were reported earlier by Akhtar M et al. who reported that there was no effect of externally supplied nutrients on emergence m⁻² of the crop [18,19].

Days to tasseling

Days to tasseling of maize was significantly affected by different P sources (**Table 2**). The control vs. rest comparison was also found significant. Mean values of the data showed that more days to tasseling (53 days) were taken by the plots treated with 50% poultry manure and 50% DAP, which was statistically similar with days to tasseling (52 days) taken with 100% poultry manure. Lower days to tasseling (50 days) were recorded with the addition of 75% poultry manure and 25% DAP. The planned mean comparison of control vs. fertilized plots revealed that more days to tasseling (51 days) were taken by fertilized plots as compared to unfertilized plots (49 days). The increase in days to tasseling with the application of P might be due to the reason that P enhances the growth of the crop and thus providing sufficient nutrients increased the life cycle of the plants, moreover, organic source provided nutrients throughout the life cycle and thus enhanced the growth of the crop. These results are in contrast with Khan F et al. [20] who reported a non-significant effect of P on days to tasseling of maize.

Days to silking

Statistical analysis of the data indicated that different P sources significantly affected days to silking of maize (**Table 2**). The planned mean comparison of control vs. rest was also found significant. Mean values of the data revealed that number of days to silking (57 days) were taken with the addition of applied

50% from poultry manure and 50% DAP, which was statistically at par with P from poultry manure. Lower days to silking (55 days) were recorded with the addition of DAP alone or in combination with 50% from FYM (54 days). The fertilized plots took more days to silking (55 days) as compared to control plots (53 days). The reason for delayed silking due to P might be that P enhanced the root development and thus facilitated the nutrients uptake and increased the growth and development. These results are in line with Amanullah et al. [21] who reported delayed silking with the addition of poultry manure and P.

Table 2: Emergence m⁻², days to tasseling and days to silking of maize as affected by different P sources.

P Sources	Emergence m ⁻²	Days to tasseling	Days to silking
100% FYM	6.57	51.67 ab	56.00 ab
75% FYM	6.43	50.67 b	55.67 ab
50% FYM	6.77	50.33 b	54.33b
100% PM	6.73	52.00 a	56.00 a
75% PM	6.73	50.00 b	53.33 b
50% PM	6.67	53.00 a	57.33 a
100% DAP	6.63	51.00 b	55.00 b
LSD (0.05)	NS	1.6	2.27
Control vs rest	NS	**	*
Control	6.7	49.33	53.33
Rest	6.65	51.24	55.38

Means followed by different letters are statistically different from each other at 5% or 1% level of probability
 NS=no significant at 5% level of probability
 *,**=significant at 5% and 1% level of probability respectively

Plant height (cm)

Plant height of maize was significantly affected by different P sources (**Table 3**). The control vs. rest comparison was also found significant. Data regarding P sources revealed that taller plants (195.1 cm) were produced when P was applied 50% from FYM and 50% from DAP, which was statistically at par with plant height (196.9 cm) attained with the addition of 75% P from poultry manure and 25% from DAP, plant height was lower (179.6 cm) with addition of 100% poultry manure. Moreover taller plants (188.1 cm) were produced in fertilized plots as compared to unfertilized plots (170.3 cm). The probable reason for the increase in plant height due to P might be that it improved the root development and nutrient absorption which had a great effect on overall plant growth performance which resulted in taller plants, moreover P availability from organic manures is very slow, therefore application of organic P in combination with inorganic increased the availability of P which enhanced plant growth. Similar results were reported earlier by Liu Z et al. [22,27] who reported that combine application of organic and inorganic P increased the plant height.

Days to maturity

Data regarding days to maturity revealed the profound effect of different P sources (**Table 3**). The control vs. rest comparison was also found significant for days to maturity of maize. Mean values of the data showed that more days to maturity (99) were taken with the addition of P 50% from FYM and 50% from DAP, statistically similar days to maturity (98.8) were taken when P was applied in 50:50 ratio of poultry manure and DAP, while early maturity was observed with the addition of organic or inorganic P alone. The reason for delayed maturity due to P might be the better growth and development with the application of P which enhanced the lifecycle of the crop and delayed the maturity. These results are in line with Ali W et al. [12,28] who reported a significant effect of P on days to maturity of maize.

Grains ear⁻¹

The number of grains ear⁻¹ was considerably affected by different P sources (**Table 3**). The control vs. rest comparison was also found significant. The number of grains ear⁻¹ was higher (442 and 435) with the addition of organic and inorganic P in 50:50 ratio regardless of manure types, statistically similar number of grains ear⁻¹ (432) were recorded when P was applied from poultry manure and DAP in 75:25 ratio, while the number of grains ear⁻¹ were lower when P was applied from organic or inorganic source alone. Similarly, the fertilized plots produced a number of grains ear⁻¹ (407) as compared with unfertilized plots (354). The increase in number of grains ear⁻¹ might be due to the fact that P is an essential nutrient and involved in many physiological processes which are necessary for better growth and development which resulted in more number of grains, moreover the organic manure applied alone released nutrient slowly and timely availability of nutrients are not ensured which reduced the growth comparatively and resulted in low seed set. These results are similar with the results of Liu Z et al. [22,23].

Table 3: Plant height (cm), days to maturity and grains ear⁻¹ of maize as affected by different P sources.

P Sources	Plant height (cm)	Days to maturity	Grains ear ⁻¹
100% FYM	185.42 b	94.33 b	384.4 b
75% FYM	185.28 b	96.67 ab	372.3 b
50% FYM	195.51 a	99.00 a	442.5 a
100% PM	179.58 b	95.33 b	405.3 ab
75% PM	196.93 a	94.67 b	432.3 a
50% PM	191.63 ab	98.67 a	434.0 a
100% DAP	182.37 b	95.00 b	380.1 b
LSD (0.05)	9.97	3.27	39.8
Control vs. rest	**	**	**
Control	170.33	92.67	353.5
Rest	188.1	96.24	407.3

Means followed by different letters are statistically different from each other at 5% or 1% level of probability

NS=non-significant at 5% level of probability

*,**=significant at 5% and 1% level of probability respectively

Biological yield (kg ha⁻¹)

The biological yield of maize was significantly affected by different P sources (**Table 4**). The control vs. rest comparison was also found significant. Mean values of the data indicated that biological yield was higher with the addition of combine P form organic and inorganic sources, however, the application of P from organic or inorganic source alone produced lower biological yield. The control plots produced lower biological yield as compared with fertilized plots. The increased in biological yield due to combining application of P form organic and inorganic source might be that organic manures improved soil health and timely supplied nutrients by inorganic fertilizer which resulted in better growth and development and thus increased the biological yield of maize. Similar results were earlier reported by Ali M et al. [23,24].

Grain yield (kg ha⁻¹)

Grain yield of maize was significantly affected by different P sources (**Table 4**). The control vs. rest comparison was also found significant. Mean values of the data indicated that grain yield was higher with the addition of combine P form organic and inorganic sources, however, application of P from organic or inorganic source alone produced lower grain yield. The control plots produced lower grain yield as compared with fertilized plots. The increase in grain yield due to combining application of P form organic and inorganic source might be due to the higher yield components like grains ear⁻¹ and higher growth with the addition of P from combining organic and inorganic sources. These results are in agreement of those reported by Ali W et al. [12,25] who reported higher grain yield with the combined application of P from organic and inorganic sources.

Harvest index (%)

Harvest index of maize was significantly affected by different P sources (**Table 4**). The control vs. rest comparison was also found significant. Higher harvest index (31.8% and 31.2%) was calculated for the combined application of P in 50:50 of FYM or poultry manure and DAP, whereas lower harvest index (26.5) was calculated for FYM applied alone. The fertilized plots had higher harvest index (28.9%) as compared to unfertilized plots (24.9%). The harvest index is the ratio of grain yield to biological yield which increased with higher grain ratio, the probable reason for higher harvest index might be that higher grain to Stover ratio due to combining application of organic and inorganic P similar results were reported earlier by Luo B et al. [26,29].

Table 4: Biological, grain yield (kg ha⁻¹) and harvest index (%) of maize as affected by different P sources.

P Sources	Biological yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Harvest index (%)
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100% FYM	10144 b	2661 b	26.5 b
75% FYM	12399 a	3428 a	27.6 b
50% FYM	11861 ab	3767 a	31.8 a
100% PM	9772 b	2843 b	29.1 ab
75% PM	12082 a	3540 a	29.4 ab
50% PM	12027 a	3742 a	31.2 a
100% DAP	9940 b	2688 b	27.0 b
LSD (0.05)	1787	401	3.2
Control vs. rest	**	**	**
Control	8269	2040	24.9
Rest	11175	3238	28.9

Means followed by different letters are statistically different from each other at 5% or 1% level of probability
 NS=non-significant at 5% level of probability
 *,**=significant at 5% and 1% level of probability respectively

Conclusion

It is concluded from the results that combined application of organic and inorganic P sources produced 29.3%, 28.64% and 24.5% more yield as compared to the sole application of farmyard manure, DAP, and poultry manure respectively.

Application of P in 50:50 ratio of organic and inorganic fertilizer produced 45.8% more grain yield as compared to control plots.

Recommendation

Combined use of organic and inorganic fertilizer in 50:50 is recommended for higher maize yield in Peshawar region.

Further studies are required to identify and integration of other organic with inorganic fertilizers on different crops under the different ecological zone of KPK.

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