

## Research Article

# Impact of phosphorus and potassium levels on yield and yield components of maize

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### Abstract

Intensive cropping pattern has deprived the soil of essential plant nutrients such as nitrogen (N), phosphorus (P) and potassium (K). This has resulted in lowering maize yield. P application control plant growth behavior. P is needed for utilization of sugar and starch, photosynthesis, cell division, nucleus and fat and albumen formation. K is well documented in protein synthesis, enzyme activation, stomatal movement, water relation and photosynthesis in plants. The aim of this study was to evaluate the impact of P and K on yield and yield components of maize. The experiment was carried out in randomized complete block design during 2014-15 at Agronomy Research Farm of Agriculture University Peshawar-Pakistan. Maize hybrid "Pioneer-3025" was used as a test crop. Experiment was composed of four levels of P (0, 60, 90 and 120 kg ha<sup>-1</sup>) and four levels of K (0, 60, 90 and 120 kg ha<sup>-1</sup>). Result showed that P applied at 120 kg ha<sup>-1</sup> increased rows ear<sup>-1</sup> by 40%, grains row<sup>-1</sup> by 18%, grains ear<sup>-1</sup> by 41%, thousand grains weight by 8%, biological yield by 41%, stover yield by 34%, grain yield by 55% and harvest index by 10% over control. Similarly, K applied at 90 kg ha<sup>-1</sup> increased rows ear<sup>-1</sup> by 40%, grains row<sup>-1</sup> by 15%, grains ear<sup>-1</sup> by 36%, thousand grains weight by 8%, biological yield by 36%, stover yield by 25%, grain yield by 56% and harvest index by 15% over control. It is concluded that P at the rate of 120 kg ha<sup>-1</sup> and K at the rate of 90 kg ha<sup>-1</sup> should be applied for improved yield and yield component of maize in agro climatic conditions of Peshawar.

**Keywords:** Maize; Phosphorus; Potassium; Yield; Yield components; Levels

### Introduction

In Pakistan maize (*Zea mays* L.) is grown as an important kharif (summer) cereal [1]. Being an imperative crop following wheat

and rice it is utilized as cooking oil for human and feed for livestock. Alcoholic and non-alcohol drinks, fuel and medicines are produced from maize. It is used for the

preparation of liquid glucose, dextrin, powder glucose, crystalline dextrose and solid glucose. Maize grain has 10% protein, 77% starch, 5.8 % fiber, 4.8% oil, and 3.0% sugar. It is used for preparation of corn flakes, tanning materials, cosmetics and wax [2]. During 2013-14 in Pakistan, the total area under maize cultivation was 1169 thousand hectares with production of 5044 thousand tons and average yield of 4317 kg ha<sup>-1</sup>. Whereas, in Khyber Pakhtunkhwa the figures were 471 thousand hectares with production of 915 thousand tons and average yield of 1943 kg ha<sup>-1</sup> in the same year [3].

Maize being an exhaustive crop has high potential than other cereal crops and absorbs huge amount of nutrients during the growth stage from soil. Phosphorus is the second most crops limiting in most of soils [4]. It is essential for growth, consumption of starch and sugar, nucleus formation, photosynthesis, cell division and fat formation [4]. Phosphate compounds store energy from the metabolism of carbohydrates and photosynthesis for later growth of crop [5]. Phosphorus is mobile in plant which moves from older to younger tissues during the development of root, stem and leaves [6]. Application of P in sufficient quantity improves quality of vegetative growth and results in rapid growth and earlier maturity. About 90% of Pakistani soil is P deficient and its deficiency resulted in crooked and missing rows as kernel twist and produced small nubbies in maize [1]. P at the rate of 150 kg ha<sup>-1</sup> more gave more ears plant<sup>-1</sup> (13%), 1000 grains weight (12%) and grain yield (30%) over control plots [7].

Potassium (K) being an important macronutrient is a primary osmoticum in maintaining low water potential in plant tissues. It plays a vital role in protein synthesis, enzyme activation, photosynthesis, regulation of plant stomata, translocation of photosynthates and many

other processes [8]. It improves the soil physical properties known as soil aggregating agent. K cations are present in plants in large amount and play an essential role in several biochemical and physiological processes. K has a vital role to withstand the plant during water shortage [9]. Keeping in view the importance of P and K and their synergistic effect the present study was aimed at evaluating the impact of phosphorus and potash level on yield and yield component of maize in agro climatic conditions of Peshawar valley.

### Materials and methods

A field trail was conducted to evaluate the impact of phosphorus and potassium levels on yield and yield components of maize at Agronomy Research Farm, Agriculture University Peshawar-Pakistan during 2014-15. The experiment was carried out in randomized complete block design having four replications. A plot size of 10.5 m<sup>2</sup> having 3.5 m width and 3 m length was used. Each plot had five rows. Row to row distance was 70 cm and plant to plant distance was 20 cm. The experiment was composed of four levels of phosphorus (0, 60, 90 and 120 kg ha<sup>-1</sup>) and four level of potassium (0, 60, 90 and 120 kg ha<sup>-1</sup>). Phosphorus as single super phosphate and potassium as sulphate of potash was applied at sowing time. Nitrogen at the rate of 150 kg ha<sup>-1</sup> was treated in split doses half at sowing time and half at second irrigation at V3 (third leaf) stage. Maize hybrid "Pioneer-3025" was use as test crop. The crop was cultivated on 19<sup>th</sup> June, 2014 and harvested on 10<sup>th</sup> October, 2015. All recommended agronomic practices (weeding, hoeing, pesticides, irrigation etc.) were kept uniform for all the treatment and were carried out throughout the growing season, when required.

### Data Measurements

During the experiment data were recorded using the standard procedure for each

parameter. Data on rows ear<sup>-1</sup> was calculated by selecting ears randomly from each plot after harvesting. Rows were counted in each ear and then were averaged. Three ears rows were selected at random for grains row<sup>-1</sup> data from each plot after harvesting, and the number of grains row<sup>-1</sup> were counted and then averaged. Data regarding grains number ear<sup>-1</sup> was recorded by selecting five ears at random from each experimental unit.

Ears were dried and shelled. Grains were counted in each ear and then averaged. 1000 grains were counted at random from each experimental unit and weighed with electronic weighing scale. Biological yield was recorded by collecting dried harvested plants of three center rows from each plots and weighed with spring balance. Biological yield in kg ha<sup>-1</sup> was recorded using the given equation.

$$\text{Biological yield (kg ha}^{-1}\text{)} = \frac{\text{Central three rows biomass yield (kg)}}{\text{No of Rows} \times \text{Row length} \times \text{Row to row distance}} \times 10000$$

After shelling sun dried ears of three central rows was weighed from each experimental

unit. Grain yield in kg ha<sup>-1</sup> was recorded using the given equation.

$$\text{Grain yield (kg ha}^{-1}\text{)} = \frac{\text{Central three rows grain yield (kg)}}{\text{No of Rows} \times \text{Row length} \times \text{Row to row distance}} \times 10000$$

After harvesting stover yield was measured on the following formula:

Stover yield = Biological yield – Grain yield  
Harvest index (H.I) in percentage was determined as under.

$$\text{H.I} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

### Statistical analysis

Analysis of variance was carried out to verify the significance influence of the treatments under RCBD using LSD (least significant difference) test for the mean comparison where treatment and its interaction found significant [10].

### Results and discussion

#### Rows ear<sup>-1</sup>

Phosphorus (P) and potassium (K) levels significantly influenced row ear<sup>-1</sup> of maize, whereas P x K interaction was non-significant (Table 1). Mean values for P showed that more rows ear<sup>-1</sup> (14) were recorded with 120 kg P ha<sup>-1</sup>, whereas less rows ear<sup>-1</sup> (10) were noted in control plots. More rows ear<sup>-1</sup> with higher rate of P might be due to the positive response of P for rapid growth. Our results are in line with [6, 11] who reported more rows ear<sup>-1</sup> with increase in P rate. Mean values for K showed that

more rows ear<sup>-1</sup> (14) were noted when K was applied with 120 kg ha<sup>-1</sup> which was statistically at par with K applied with 90 kg ha<sup>-1</sup> resulting in 13 rows ear<sup>-1</sup>, whereas control plots gave less rows ear<sup>-1</sup> (10). Increase in rows ear<sup>-1</sup> with increase in K level might be due to more translocation of photosynthates to ear which resulted in more rows ear<sup>-1</sup> [12]. Similar results were noted by [13-15] who reported that K application increased the number of grain rows cob<sup>-1</sup>.

#### Grains row<sup>-1</sup>

P and K levels significantly influenced grains row<sup>-1</sup> of maize, whereas P x K interaction was non-significant (Table 1). P mean values showed that P applied at the rate of 120 kg ha<sup>-1</sup> gave higher grains row<sup>-1</sup> (39), whereas lower grains row<sup>-1</sup> were recorded in control plots. These results are confirmed by [16-17] who reported more grains row<sup>-1</sup> with higher level of P. Mean values for K showed that higher grains row<sup>-1</sup> (38) were resulted with those plots where 120 kg K ha<sup>-1</sup> was applied, which was statistically at part when 90 kg K ha<sup>-1</sup> was applied, which resulted in (37) grains row<sup>-1</sup>

of maize, whereas lower grains row<sup>-1</sup> (33) were noted in control plots.

**Table 1. Mean values for rows ear<sup>-1</sup>, grains row<sup>-1</sup>, grains ear<sup>-1</sup>, thousand grain weight (TGW), biological yield (BY), grain yield (GY), stover yield (SY) and harvest index (HI) of maize as influenced by phosphorus and potassium levels.**

Treatment	Rows ear <sup>-1</sup>	Grains row <sup>-1</sup>	Grains ear <sup>-1</sup>	TGW (g)	BY (kg ha <sup>-1</sup> )	GY (kg ha <sup>-1</sup> )	SY (kg ha <sup>-1</sup> )	HI (%)
<b>Phosphorus level (kg ha<sup>-1</sup>)</b>								
0	10 c	33 c	357 c	294 c	9241 d	3160 d	6081 d	34.0 b
60	12 b	36 b	420 b	305 b	11034 c	4164 c	6869 c	37.6 a
90	12 b	36 b	438 b	307 b	12041 b	4532 b	7508 b	37.4 a
120	14 a	39 a	503 a	317 a	13006 a	4883 a	8124 a	37.4 a
LSD <sub>(0.05)</sub>	0.8	2.0	41.4	9.1	118.4	132.1	171.0	1.2
<b>Potassium levels (kg ha<sup>-1</sup>)</b>								
0	10 c	33 c	353 c	293 c	9151 c	3046 c	6105 c	33.1 b
60	12 b	35 b	417 b	303 b	11427 b	4278 b	7149 b	37.4 a
90	12 b	37 ab	469 a	311ab	12322 a	4654 a	7668 a	37.6 a
120	14 c	38 a	479 a	315 a	12422 a	4762 a	7660 a	38.2 a
LSD <sub>(0.05)</sub>	0.8	2.0	41.4	9.1	118.4	132.1	171.0	1.2
<b>Interactions</b>								
P x K	NS	NS	NS	NS	**	**	**	NS

Means of the same category followed by different letter (s) are significantly different at  $P \leq 0.05$  level using LSD test. NS = Non-Significant, \*\*Significant at  $P \leq 0.01$  level using LSD test

### Grains ear<sup>-1</sup>

P and potash K levels significantly influenced grains ear<sup>-1</sup> of maize, whereas P x K interaction was non significant (Table 1). Mean value for P showed that more grains ear<sup>-1</sup> (503) were recorded when P levels was applied at the rate of 120 kg ha<sup>-1</sup> whereas, less grains ear<sup>-1</sup> (436) were noted in control plots. Our results are in line with [18-20] who reported that grains ear<sup>-1</sup> were enhanced with increased in P level. Mean values for K levels indicated that maximum grains ear<sup>-1</sup> (497) was recorded in plots where potash was applied at the rate of 120 kg ha<sup>-1</sup> though statistically similar to plots where potash was applied at the rate of 90 kg ha<sup>-1</sup> (497) while minimum grains ear<sup>-1</sup> (431) was obtained in control plots. The reasons for maximum grain ear<sup>-1</sup> could be attributed to the maximum availability of potash which resulted in increased photosynthetic activities, which resulted in more

translocation of food materials to the grain [21-22] also reported that maize produced maximum number of grains ear<sup>-1</sup> with increased in K level.

### Thousand grains weight (g)

P and K levels significantly influenced thousand grains weight of maize, whereas P x K interaction was non significant (Table 1). Thousand grains weight increased with increase in P and K levels. Mean values for P showed that more thousand grains weight (317 g) was recorded in plots where P was applied at the rate of 120 kg ha<sup>-1</sup> whereas, minimum thousand grains weight (294 g) was recorded in those plots where no P was applied. Increase in thousand grains weight may be due to more assimilates transferred to grains. Similar results were reported by [23]. Mean value for K levels showed that increased thousand grains weight (315 g) was recorded in plots where K was applied at the rate of 120 kg ha<sup>-1</sup> whereas, minimum

thousand grains weight (293 g) was recorded in control plots. This might be due to the increased translocation of assimilates from leaf to grain [24] who recorded that K increase enzymes activities in the plant which is important for accumulation and translocation of assimilates from leaf to grain that resulted increased grain weight.

#### **Biological yield (kg ha<sup>-1</sup>)**

P and K levels and P x K interaction significantly influenced biological yield of maize (Table 1). Biological yield increased with increase in P and K levels. Mean values for P showed that maximum biological yield (13006 kg ha<sup>-1</sup>) was recorded in plots where P was applied at the rate of 120 kg ha<sup>-1</sup>, while minimum biological yield (9241 kg ha<sup>-1</sup>) was recorded in control plots. The possible reason for increased in biological yield with high P level could be that adequate supply of P to plants increase root growth which explore the plant most soil moisture and nutrients. Another possible reason could be the well photosynthesis and other physiological functions of the plant [25]. Mean values for K showed that K application at the rate of 120 kg ha<sup>-1</sup> produced more biological yield (12422 kg ha<sup>-1</sup>), whereas control plots resulted minimum biological yield (9151 kg ha<sup>-1</sup>). P and K interaction indicated that more biological yield was resulted when P and K were applied at the rate of 120 kg ha<sup>-1</sup> each. It may be due to the increase of potash increased CO<sub>2</sub> assimilation rate, enzyme activity, stomata closure and stabilized osmosis regulation which produced more carbohydrates which improved grain yield and biological yield, as recorded by [26-27].

#### **Grain yield (kg ha<sup>-1</sup>)**

P and K levels and P x K interaction significantly influenced grain yield of maize (Table 1). Mean values for P showed that more grain yield (4883 kg ha<sup>-1</sup>) was noted in those plots where 120 kg P ha<sup>-1</sup> was applied whereas, minimum grain yield (3160 kg ha<sup>-1</sup>)

was recorded in control plots. Our results are in line with those of [28] who reported more grain yield with higher rate of P applied. Mean values for K indicated that higher grain yield (4762 kg ha<sup>-1</sup>) was recorded in those plots where K was applied at the rate of 120 kg ha<sup>-1</sup> though statistically similar with 90 kg K ha<sup>-1</sup> (4654) while minimum grain yield (3046) was recorded in control plots. The increase in grain yield might be due to maximum utilization of K by maize that increased grains ear<sup>-1</sup>, grains weight and hence grain yield. Our results are in line with [29-31] who reported that grain yield increased with the increase in K level. P x K interaction significantly affected grain yield. Increasing the level of both nutrients resulted in increase grain yield. Our findings are similar with those of [6, 20, 32- 33] who reported more grain yield with P and K application.

#### **Stover yield (kg ha<sup>-1</sup>)**

P and K levels and P x K interaction significantly influenced stover yield of maize (Table 1). Mean values for P showed that 120 kg P ha<sup>-1</sup> application gave more stover yield (8124 kg ha<sup>-1</sup>) whereas, control plots resulted in lower stover yield (6081 kg ha<sup>-1</sup>). Increased in stover yield at higher P level indicated that applying more P increased availability of P. Khyber Pakhtunkhwa soil have high fixation capacity with higher demand for P fertilizer [34]. Among K levels increased stover yield (7660 kg ha<sup>-1</sup>) was recorded where K was applied at the rate of 120 kg ha<sup>-1</sup> though statistically at par with 90 kg ha<sup>-1</sup> (7667 kg ha<sup>-1</sup>), while minimum stover yield (6105 kg ha<sup>-1</sup>) was observed in control plots. Enhancement in stover yield with the increased K level might be attributed to the increase in the height of maize plants. The same results were reported by [30] that considerable increased in stover yield of maize with K application was recorded over the control plots. The interaction of P and K

each applied at 120 kg ha<sup>-1</sup> resulted in higher stover yield of maize.

#### Harvest index (%)

P and K levels significantly influenced harvest index of maize, whereas P x K interaction was non-significant (Table 1). In case of phosphorus levels increased harvest index (37.6 %) was recorded in plots where phosphorus was applied at the rate of 60 kg ha<sup>-1</sup> which is statistical at par with 120 kg P ha<sup>-1</sup> (37.4 %) and 90 kg P ha<sup>-1</sup> (37.4 %) while, minimum harvest index (34.0 %) was recorded in control plots. The enhancement in harvest index with application of phosphorus levels might be due to the increased in yield and yield components of maize as found by [35] whereas, increase in harvest index (38.2 %) was recorded in those experimental units where potash was applied at the rate of 120 kg ha<sup>-1</sup> were statistically at par with those plots where potash was applied at the rate of 90 kg ha<sup>-1</sup> (37.6 %) and 60 kg ha<sup>-1</sup> (37.4 %) whereas minimum harvest index (33.1 %) was recorded in control experimental units. The increase in harvest index with the increase in potash level might be due to more partitioning of assimilates toward sink. More harvest index was noted with higher potash applied [36]. In case of interaction between P and K increased harvest index was found with application of 60 kg P ha<sup>-1</sup> and 120 kg K ha<sup>-1</sup> and no further increase in harvest index beyond the 60 kg P ha<sup>-1</sup> was recorded. The same results were also reported by [20] who recorded that harvest index was significantly affected by PK fertilizer in different levels.

#### Conclusion

It is concluded that P at the rate of 120 kg ha<sup>-1</sup> and K at the rate of 90 kg ha<sup>-1</sup> resulted in more rows ear<sup>-1</sup>, more grain row<sup>-1</sup>, more grains ear<sup>-1</sup>, maximum 1000 grains weight, more biological and grain yield. Therefore, 120 kg P ha<sup>-1</sup> and 90 kg K ha<sup>-1</sup> is recommended for obtaining higher yield and

yield component of maize under agro ecological conditions of Peshawar valley.

#### Authors' contributions

Conceived and designed the experiments: AA Khan, Inamullah, G Sadiq, A Rab & H Fayyaz, Performed the experiments: G Sadiq, A Rab, H Nawaz & WA Khattak, Analyzed the data: G Sadiq, AA Khan, H Raza, G Naz & AA Khan, Contributed reagents/ materials/ analysis tools: J Amin, HA Khan, I Ali & S Ali, Wrote the paper: G SA Ali Khan, A Rab, Inamullah & H Raza.

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