IMPACT OF PHOSPHORUS LEVELS AND SEED RATES ON GROWTH AND YIELD OF LATE SOWN MAIZE ON HIGH ELEVATION IN SWAT, PAKISTAN

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ABSTRACT:- After nitrogen, phosphorus (P) is required by the plants relatively in large quantity and is the second most important crop nutrient that increases productivity of maize (*Zea mays* L.). An experiment on effect of different P_2O_5 levels and seed rates on growth and yield of late sown maize cv. Baber on high elevation during *kharif* season, was conducted at Farmer Field School, Swat, Pakistan during summer 2012. The experiment was laid out in randomized complete block design having three replications. Sowing was done one month late (July 15) than the optimum time of sowing. Optimum time of sowing on high elevation in Swat, Pakistan starts from May 15 to June 15. Four levels of P_2O_5(0, 25, 50 and 75 kg ha^{-1}) and four seed rates (10, 20, 30 and 40 kg ha^{-1}) were used. A subplot size of 3m x 4.5m was used. Each subplot was consisted of six rows having 75 cm row-to-row distance with row length of 3 m. Sowing of 40 kg seed ha^{-1} treated with 75kg P_2O_5 ha^{-1}gave optimum cob length (19 cm), plant height (179.19 cm), 1000 grain weight (192.83 g) and grain yield (2712 kg ha^{-1}). While maximum grain cob^{-1}(375) was given by 30 kg seed ha^{-1} treated with 75 kg P_2O_5. On the basis of the above results, among the tested seed rate 40 kg ha^{-1}treated with 75 kg P_2O_5 is recommended for late sowing on high elevation under the agro-ecological conditions of Swat valley.

Key Words: Maize; P_2O_5; Seed Rates; Grain Yield; Yield Components; Pakistan.

INTRODUCTION

Maize (*Zea mays* L). belong to family Poaceae. Maize is one of the important cereal crops of the world (Imran, 2015). It is annual cross-pollinated crop having erect, thick, and strong culms or stalk with nodes and internodes (Imran, 2015). The corn leaf consists of blades, sheath and collar like ligule. It is normally monoecious with staminate and pistillate flowers produce on tassel and ear. In Pakistan about 60% of maize is grown in irrigated while 36% in rainfed regions. Basically it is a tropical plant but at present it is being cultivated extensively with equal success in temperate, tropical and sub-tropical regions of the world (Imran and Khan, 2015a). Maize is a dominant crop in the farming system because it is a staple food crop for much of rural population. Corn grain is valuable source of protein (10.4%), fat (4.5%), starch (71.8%), vitamins and minerals like calcium, phosphorous and sulfur (Imran and Khan, 2015b). It also provides raw materials to starch industry and is used in the preparation of many products (Tahir et al. 2009). Its grain is used for several industrial purposes such as starch, alcohol, corn sugar, corn oil, acetones and lactic acid. Besides its multipurpose uses, corn is getting

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popularity for its non-cholesterol oil content in the present day world (Martin et al., 1975). It is grown throughout Khyber Pakhtunkhwa (Shah, 2007). About two-third of the total world production of maize is used for livestock feed or for commercial starch and oil production (FAO, 2007). Tahir et al. (2009) reported that in Pakistan the average grain yield of maize crop is very low as compared to the other growing countries like Canada (6630 kg ha^{-1}), China (4570 kg ha^{-1}) and Italy (9530 kg ha^{-1}) whereas Argentina produce 5650 kg ha^{-1}. In Khyber Pakhtunkhwa maize is grown on 516.1 thousand hectares that is more than half of total maize area of Pakistan (1016.9 thousand hectares). While grain yield of Khyber Pakhtunkhwa is 583 kg ha^{-1} that is significantly low compared to our national average grain yield of 3037 kg ha^{-1} (GoP, 2009). National average grain yield of maize is low from the world average yield i.e., 4970.9 kg ha^{-1}. Some of the major causes of low maize yield are declining soil fertility and insufficient use of fertilizers. Maize crop needed fertile, well-drained soil to provide adequate supply of nutrients particularly nitrogen, phosphorus and potassium for vigorous growth and high yield. Phosphorus deficiency is invariably a common crop growth and yield-limiting factor (Imran et al., 2015). Factors that affect the availability of P to plants include soil pH, soil texture, the amount of P applied, the presence of other elements-like iron, aluminum, manganese and calcium in the soil. Yash et al. (1992) concluded that physiochemical characteristics of soil and the indigenous microbial population, its activity and the time of P application significantly influence maize crop growth, yield and yield contributing parameters. Maize grain and biomass yield, number of rows and grains ear^{-1}, plant height and P uptake efficiency (PUE) of maize increased at high P level (Okalebo and Probert, 1992; Sahoo and Panda, 2001). Imran et al. (2015) indicates that P is one of the most important factors affecting crop growth and yield of maize in Khyber Pakhtunkhwa. There are a number of factors those affecting maize yield considerably; however, it is more affected by variations in seed rates than other member of the grass family (Vega et al., 2001). Maize differs in its responses to seed rates (Luque et al., 2006). Liu et al. (2004) also reported that maize yield differs significantly under varying seed rates due to difference in genetic potential. Imran et al. (2015) reported that optimum yields result from optimum seed rates when the crop was sown lately. However, higher plant populations increase competition among individual plants for water, sunlight and nutrients. This effect may lower individual plant yield but increase yield per unit area by optimizing yield components i.e., number of ears per unit area, number of kernels per ear and weight of each kernel. Seed rates play significant role in yield performance of maize crop, therefore, present study was designed to investigate the effect of seed rates and P levels on yield and yield components of late sown maize under the agro-ecological condition of the Swat valley.

MATERIALS AND METHOD

To study the impact of various P levels and seed rates on late sown maize in term of growth and yield in high elevation area (Meramai, Swat), field experiment was conducted at Farmer Field School (FFS) Swat, Pakistan during *kharif* 2012. The experiment was laid out in randomized complete block (RCB) design having three replications. Four levels (0, 25, 50, and 75 kg P ha^{-1}) and four seed rates (10, 20, 30 and 40 kg ha^{-1}) were used on hybrid cultivar Baber. Sowing was done one month late than optimum time of sowing. A plot size of 3.0m x 4.5m was used. Each sub plot comprised 6 rows having 75 cm row-to-row distance with row length of 3 m. All the recommended agronomic practices were followed. Data were recorded during Agronomic ecosystem analysis (AESA) on days to tasseling, days to silking, cob length, plant height (cm), number of grain cob^{-1}, 1000-grain weight and grain yield. Days to tasseling and silking were counted from the date of sowing to 50% tasseling and silking. Plant height was measured at harvesting stage. Plant height from ground level to the last node of the five randomly selected plants in each subplot was measured with measuring tape and averaged. After harvesting, grains cob^{-1} was recorded by counting grains in three cobs randomly selected in each subplot and then averaged. After shelling the ears, thousand grains were selected randomly to record thousand grain-weights with the help of electronic balance from the produce of each subplot. Grain yield was recorded with the help of a spring balance after shelling all the ears harvested from the central four rows in each subplot. Grain yield thus obtained was then converted into kg ha^{-1}.

Data were statistically analyzed according to the relevant procedure of the RCBD. Least significant difference (LSD) value was used (0.05) for mean comparison to identify the significant components of the treatment means (Jan et al., 2009).

RESULTS AND DISCUSSION

Days to Tasseling

Significant differences were observed in days to tasseling. Early tasseling was observed (52 days) in plots treated with 75 kg P ha^{-1} whereas tasseling was delayed to 55.5 days in control plots (Table 1). Late sown maize responded positively to P levels and seed rates. P_2O_5 application enhanced days to tasseling. Enhancement in the phonological development of maize with higher rate of P may probably have proliferated root system, developed deep and dense root system and thus helped the plants to obtain more P for the growth, maintenance, survival and reproduction to complete its life cycle earlier. Similar findings were also reported by Imran et al. (2015) and Imran and Khan (2015). Rapid plant growth and development with the highest rate of P was also earlier reported by Singaram and Kothandaraman (1994). Early tasseling was observed in 10 kg and 30 kg seed ha^{-1} (52 days) while maximum days taken to tasseling was observed in 40 kg seed ha^{-1} applied plots. Imran (2015) reported that most of the terrestrial plants struggle for their survival and reproduction in critical period and complete early their vegetative growth and soon start their reproductive phase. Another possible reason could be that the minimum seed rate and optimum seed rate have more nutrients availability and P uptake

Table 1. Effect of phosphorus levels and seed rates on days to tasseling, days to silking, cob length, plant height, number of grains cob^{-1}, 1000 grain weight and grain yield of maize

Phosphorus (kg ha^{-1})	Days to tasselling	Days to silking	Cob length (cm)	Plant height (cm)	Grains cob^{-1}	1000 G wt (g)	Grain yield (kg ha^{-1})
0	55.50^{c}	60.00^{c}	16.41^{c}	167.58^{d}	346.00^{d}	171.58^{d}	1855^{d}
25	53.83^{b}	58.41^{b}	17.40^{b}	174.00^{c}	363.00^{c}	179.67^{c}	1936^{c}
50	52.83^{a}	58.00^{b}	17.73^{b}	182.00^{b}	377.00^{b}	190.25^{b}	2068^{b}
75	52.00^{a}	56.75^{a}	19.10^{a}	190.83^{a}	381.50^{a}	203.42^{a}	2318^{a}
LSD(0.05)	0.84	0.60	0.89	1.95	4.59	5.47	100.28
Seed rates (kg ha^{-1})							
10	52.00^{a}	58.33^{b}	16.83^{b}	179.50^{a}	358.00^{d}	184.42^{b}	1334^{d}
20	53.33^{a}	58.83^{b}	17.51^{b}	176.83^{b}	369.00^{b}	186.00^{b}	1956^{c}
30	52.00^{a}	57.50^{a}	17.48^{b}	178.92^{a}	375.42^{a}	181.67^{b}	2174^{b}
40	54.25^{b}	58.33^{b}	19.00^{a}	179.17^{a}	365.00^{c}	192.83^{a}	2712^{a}
LSD(0.05)	0.84	0.60	0.89	1.95	4.59	5.47	100.28
Interaction P X S	1.68	ns	ns	3.91	9.19	ns	200.55

Means followed by same letters do not differ significantly at P ≤0.05 level; ns= non-significant

that might have enhanced days to tasseling while maximum seed rates have compatibility.

Days to Silking

Data regarding days to silking revealed that earlier silking (57 days) was observed in plots treated with highest level (75 kg P ha^{-1}) whereas silking was delayed to 60 days in control plots (Table 1). The possible reason could be that with application of P_2O_5 chlorophyll contents enhances which absorb more light and produce optimum dry matter and assimilation. Seed rates significantly affected days to silking and earlier silking was observed in 30 kg ha^{-1} seed treated plots while the other seed rates were at par. The reason of variation in phonological traits and development of maize with higher rate of P may probably have proliferated root system which take more mineral nutrients and leads to develop deep and dense root system and thus helped the plants to obtain more P and other essential nutrients for the growth, maintenance, survival and reproduction to complete its life cycle earlier. These results are closely associated with those of Imran et al. (2015) and Amanullah et al. (2009) who reported that P enhance days to silking at highest dose. Rapid plant growth and development with the highest rate of P was also earlier reported by Singaram and Kothandaraman (1994).

Another possible reason of the variation in days to phonological traits might be due to late sowing of the crop. Plants struggle for their survival and reproduction in critical period and complete early their vegetative growth and start their reproductive phase soon.

Cob Length (cm)

Data regarding cob length showed that plots treated with P at 75 kg ha^{-1} produced maximum cob length (19.10 cm) while minimum cob length was observed in control plots (16.41 cm). Phenological and morphological traits positively responded to P application and seed rates (Table 1). Cob length increased with P application and optimum cob length was observed as the level of P reached to highest rate (75 kg ha^{-1}) while plots treated with 25 and 50 kg P were at par, respectively. The optimum cob length might be due to more dry matter portioning, more photosynthesis production and its assimilation which results by frequent supply of the nutrients (Imran, 2015). Similarly seed rates significantly affected cob length and maximum cob length was observed in 40 kg seed ha^{-1} treated plots. While the other sowed seed rates were at par in this order. The reason for increased length of maize cob due to higher level of P and seed rates could be that higher translocation of assimilates in to sink as well as no photo respiration in maize crop due to four carbon compound formation. Sahoo and Panda (2001) also reported that length of cob increased with increasing level of P.

Plant Height (cm)

The analysis of the data showed that plant height, seed rates and interaction between seed rates and phosphorous levels (S x P) significantly affected plant height. Plant height was drastically increased with increase in P level. Fluctuation in plant height was recorded during growth period as well as at maturity stage. Optimum plant height (190.83 cm) was observed in plots treated with 75 kg P ha^{-1} followed by 50 kg P ha^{-1} treated plots which produce 182 cm plant height whereas minimum plant height (167.58 cm) was observed in control plots (Table 1). Linear increase was observed in plant height as P level increased from 0 to 75 kg ha^{-1}. These results are supported by those of Imran et al. (2015) and Amin et al. (1989) that various P levels enhanced phonological and morphological characteristics of maize crop under cold climatic region condition. Possible reason of fluctuation in plant height might be due to frequent supply of nutrients and more water uptake by the plants as there was more rainfall at vegetative stage. Seed rates also influenced plant height and maximum plant height was observed in 10, 30, and 40 kg seed ha^{-1} applied plots but statistically at par having 179.5, 178.92 and 179.17 cm, res-pectively. Interaction showed that short plants were observed in 10 kg seed ha^{-1} treated plots (170.67) with no application of P. As the level of P increased up to 75 kg ha^{-1} tallest plants (195 cm) were observed in plots treated with 40 kg ha^{-1} seed rate. The results conform with those of Amin et al. (1989) who reported that plant height of maize plants increased with increasing phosphorus levels.

Grain Cob^{-1}

Phosphorous levels, seed rates and interaction between seed rates and phosphorous levels (S x P) significantly affected number of grain cob^{-1}. Significant difference was observed in P treated plots as compared with control plots. Linear increase was occurred in grain cob^{-1}. Maximum number of grains cob^{-1}

(381.5 grains cob^{-1}) was noted in highest level of P (75 kg ha^{-1}) treated plots followed by 50 and 25 kg P applied plots (377, 363 grains cob^{-1}). Minimum (346 grains cob^{-1}) were observed in control plots. The reason of fluctuation in grains cob^{-1} might be due to frequent supply of nutrients and more water uptake by the plants with optimum photosynthesis assimilation, translocation into the sink and more dry matter partitioning due to optimum moisture contents in soil as there was more rain fall at vegetative stage. Seed rates significantly affected number of grain cob^{-1}. Maximum grain cob^{-1} was noted in plots treated with 30 kg ha^{-1} (375.42 grain cob^{-1}) seed rate followed by 20 kg (369 grain cob^{-1}) and 40 kg ha^{-1} (365 grain cob^{-1}). While minimum grains cob^{-1} was observed in 10 kg seed ha^{-1} treated plots (358 grains cob^{-1}). Interaction showed that minimum grains cob^{-1} was observed in 10 kg seed ha^{-1} treated plots while maximum grain cob^{-1} observed in 30 kg seed ha^{-1} treated plots with 50 kg P application. The results are in accordance with those of Sharma and Sharma (1989) who reported that Phosphorous fertilizer application significantly affected the grains per cob.

Thousand Grain Weight (g)

Statistical analysis of the data showed that 1000-grains weight responded positively to phosphorus levels and seed rates. Maximum thousand grain weight (203 g) was recorded in P treated with 75 kg ha^{-1} applied plots followed by 50 and 25 kg P ha^{-1} treated plots (190.25 and 179.67 g). Whereas minimum thousand grain weights was recorded in control plots (171.58 g). Heaviest grain weight with higher P level probably may be due to the higher P translocation into the fruiting areas which resulted in highest grain weight (Amanullah et al., 2009b). Sahoo and Panda (2001) also suggested that increase in P levels increased grain weight in maize. Similarly seed rates significantly affected 1000-grain weight and maximum weight was recorded in 40 kg ha^{-1} seed treated plots (192.83g) while the other seed rates were at par respectively. The reason for increase in 1000-grain weight in seed rates might be due to more nutrients uptake with high mass flow and diffusion to root deflation zone due to maximum seed rates.

Grain Yield (kg ha^{-1})

Phosphorous levels, seed rates and interaction between P x S significantly affected grain yield. Highest grain yield was obtained from plots treated with highest level of P as compared to lowest level of P receiving plot. The effect of all the P levels on grain yield was significantly different from one another. The highest grain yield (2318 kg ha^{-1}) was recorded in plots treated with 75 kg P ha^{-1} followed by 50 kg P ha^{-1} (2068 kg ha^{-1}) while minimum grain yield was recorded in control plots (1855 kg ha^{-1}). The increase in grain yield with increase in P level probably may be due to the increase in cob length, number of rows and number of grains cob^{-1} as well as heaviest grain weight (Amanullah et al. 2009). The lower grain yield in the absence of P (control) indicating higher demand for P fertilizer (Hussain and Haq, 2000). Ibrikci et al. (2005) suggested that P deficiency was invariably a common crop growth and yield limiting factor. Seed rates also significantly affected grain yield and maximum grains yield 2712 kg ha^{-1} was recorded in plots received seed at the rate of 40 kg ha^{-1} followed by 30 kg and 20 kg seed ha^{-1} treated plots which produced grain yield 2174 and 1956 kg ha^{-1}, respectively. Minimum grains yield 1334 kg ha^{-1} was recorded in 10 kg seed ha^{-1} treated plots. The reason for low grain yield probably may be due to insufficient seed rates which reduces number of plants per unit area which causes weed emergence and competing with economic crop. Higher grain yield can be achieved with proper seed rates and proper agronomic practices. Interaction showed significant difference in grain yield. Minimum grain yield was recorded in plots received 10 kg seed ha^{-1} and linearly increase was observed with seed rates optimization. A sharp increase was noted in plots received 40 kg seed ha^{-1} with application of 75 kg P ha^{-1}, and produced optimum grain yield ha^{-1} followed by 30 kg seed treated with 75 kg P ha^{-1}.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Mr. Imran	Design the experiment, Data collection, Analysis and interpretation of the data
2.	Dr. Shaheeda Naveed	Revised the paper
3.	Dr. Asad Ali Khan	Supervised and overall management of the experiment, Data analysis
4.	Mr. Inayat Khattak	Review of literature, Data collection and analysis

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