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RESPONSE OF MAIZE TO PHOSPHORUS LEVELS AND PLANT DENSITY

Mushtaq Ahmad*, Nazim Hussain*, Amanullah Jan*
Kafeel Ahmad** and Sartaj Hussain***

ABSTRACT

Two maize hybrids (Monsanto-707, Pioneer-3057) and an open-pollinated variety Kisan-90 were planted under field conditions with three levels of phosphorus (60, 90, 120 kg ha^{-1}) and three plant densities (70000, 90000, 110000 plants ha^{-1}) at NWFP Agricultural University Peshawar in 2002. The experiment was laid out in randomized complete block design with split plot arrangement with three replications. Combination of cultivars and phosphorus levels were allotted to the main plots while plant population to subplots. Maximum number of cobs $plant^{-1}$ (1.36) and number of grains cob^{-1} (556) were found in Pioneer-3057 hybrid while maximum 1000 grain weight (292 g) and grain yield (7269 kg ha^{-1}) was obtained from Monsanto-707. Phosphorus levels also significantly affected cobs $plant^{-1}$, 1000 grains weight and grain yield. Maximum cobs $plant^{-1}$ (1.41), 1000 grains weight (276 g) and grain yield (6515 kg ha^{-1}) were observed at the highest phosphorus level of 120 kg ha^{-1}. Plant density also significantly affected cobs $plant^{-1}$, grains cob^{-1}, 1000 grain weight and grain yield. Maximum cob $plant^{-1}$ (1.41) and 1000 grain weight (278 g) was noticed in plant density of 70000 plants ha^{-1}, while grain yield was highest (7269 kg ha^{-1}) at plant density of 90000 plant ha^{-1}. Significant interactions between hybrid x phosphorus were found for 1000 grain weight and grain yield. Similarly phosphorus x plant density interacted significantly for cobs $plant^{-1}$ and grain yield. It is concluded that Monsanto-707, phosphorus at the rate of 120 kg ha^{-1} and plant density of 90000-plant ha^{-1} showed best performance.

INTRODUCTION

Maize (*Zea mays* L.), one of the most important kharif crops grown in Pakistan for food and forages, has lowest production due to many factors including improved cultivars, proper nutrient management and optimum plant population. The superiority of the maize hybrids over open pollinated varieties in grain yield is well documented (Valle, 1978, Dijsbar and Gardner, 1989). The world wide experience showed that more than 50 % of the increase in crop yields is due to fertilizers (Braun and Roy, 1983). Phosphorus contributes to improve yield and quality of the crops, increases strength of cereal straw (Rashid and Memon, 2001) and thus helps to prevent cereals from lodging and increases crop resistance to diseases. Arain *et al*. (1989) reported that plant height, number of grains cob^{-1} and grain yield of all genotypes increased with increase in N and P. Hassain (1976) observed that maize plant height, cob length and 1000 grain weight were increased significantly with the application of 100 lbs N + 100 lbs P $acre^{-1}$. Phosphorus deficiency (<10 mg kg^{-1}) is wide spread in most (90%) of the soils of Pakistan and the application of phosphatic fertilizers is considered essential for crop production (Rashid and Memon, 2001). The current phosphorus fertilizer rates on average basis are approximately one third of what is actually recommended for optimal crop production (Rashid and Memon, 2001).

Plant population is an important determinant of grain yield of maize. In case of thick population, most plants bear barren cobs, smaller ears and become susceptible to lodging and pest attack. While in case of low plant density, yield per unit area is low because of less than optimum plants. Filev and Evstafef (1981) obtained maximum grain yield at 120 N + 90 kg P and also observed that the yield increase was smaller at the density of 50000 and 70000 plants ha^{-1}.Dornescus and Dornescus (1988) noticed that grain yield increased with increasing plant density and maximum grain yield of 6.33 t ha^{-1} was obtained at 80000 plants ha^{-1}. Aziz et al. (1992) found that Hybrid PSH-10 gave the highest grain yield of 6007 kg ha^{-1} with medium maturity. Khan et al. (1993) found a significant cultivar x density x fertilizer interaction for grain yield. Almeida et al. (1996) found linear decrease in grains cob^{-1} with increase in plant density of cultivars Cargill C901 and XL 370 and also observed no effect of these treatments on cobs $plant^{-1}$. Zada (1998) found that number of grains per cob,

* Department of Agronomy, NWFP Agricultural University, Peshawar - Pakistan.
** Department of Plant Breeding and Genetics, NWFP Agricultural University, Peshawar - Pakistan.
*** Department of Agricultural Economics, NWFP Agricultural University, Peshawar - Pakistan.

thousand grains weight and grain yield were decreased at higher plant density i.e. 80000 plants ha^{-1}. Similar results were obtained by Noor-ul-Akbar (1998) while Hassan (2000) in contrary observed increase in grain yields with increasing plant density. Silva et al. (1999) observed the highest maize grain yield with a density of 90000 plants ha^{-1} when sown in October as compared to 50000 or 70000 plants population sown in August or December.

As constraints to crop growth differ in their origin, they do not operate individually but interact to lessen yield (Cooke, 1987). To study the impact of various growth factors multi factorial experiments which test the input to over come these constraints is required.

Keeping in view the importance of phosphorus, plant density and the high yielding adaptable hybrid, the present study was conducted to find out best maize hybrid, optimum plant population and appropriate level of Phosphorus for obtaining higher yield.

MATERIALS AND METHODS

The experiment was carried out at Malakandher Farm of NWFP Agricultural University Peshawar during kharif 2002 in randomized complete block (RCB) design with split plot arrangement having three replications. The maize hybrids i.e. Pioneer-3057 (three way cross), Monsanto-707 (three way cross) and an open pollinated variety (Kisan-90) were supplied with three phosphorus levels i.e. 60, 90 and 120 kg ha^{-1} having plant densities of 70000, 90000 and 110000 plants ha^{-1}. Maize cultivars and phosphorus levels were assigned to main plots and plant density to the subplots. Crop was sown in rows. The size of each subplot was 5 x 3.75 m with row to row distance of 75 cm having 5 rows per subplot. Nitrogen was applied at rate of 240 kg ha^{-1} as a basal dose (Khan *et al.* 1993).

Data were recorded on number of cobs $plant^{-1}$ by counting the number of cobs on five selected plants and averaged. Data on number of grains cob^{-1} were recorded by selecting 10 cobs from each subplot, shelled together, counted and averaged. Thousand grains weight was recorded by counting 1000 grain at random in each subplot and weighing by electric balance. Grain yield for each subplot was recorded after threshing and then converted into kg ha^{-1}.

Data recorded for each trait were individually subjected to the ANOVA technique using MSTAT-C computer software. Means were separated using LSD test to signify the treatment differences at 5% level of probability (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Number of Cobs Plant^{-1}

Data regarding number of cobs $plant^{-1}$ (Table I) revealed that cultivars, phosphorus, plant densities, hybrid x phosphorus (HxP) and phosphorus x plant density (PxD**)** interactions had significantly affected number of cobs $plant^{-1}$. While the interaction effect of hybrid x plant density (HxD) was non-significant. Mean values of the data revealed that maximum number of cobs $plant^{-1}$ (1.36) were recorded for Pioneer-3057 and was at par with Monsanto-707, whereas minimum number of cobs $plant^{-1}$ (1.13) was noticed in Kisan-90. In case of phosphorus levels, maximum number of cobs $plant^{-1}$ (1.41) were obtained at 120 kg phosphorus per hectare, while minimum number (1.15) of cobs $plant^{-1}$ were obtained at phosphorus level of 60 kg ha^{-1}, which was at par with 1.23 cobs $plant^{-1}$ produced at 90 kg ha^{-1} phosphorus applied. For densities, maximum number of cobs $plant^{-1}$ (1.41) was obtained at 70000 plants per hectare, although this difference from 90000 plants per hectare was not statistically different, while minimum number of cobs $plant^{-1}$ (1.06) was shown at 110000 plants ha^{-1}. In case of hybrid x phosphorus interaction, maximum number of cobs $plant^{-1}$ (1.61) was recorded in Pioneer-3057 at phosphorus level of 120 kg ha^{-1}. For phosphorus x density interaction, maximum number of cobs $plant^{-1}$ (1.67) was recorded at 120 kg ha^{-1} for 70000 plants $ha^{-}1$. As for as the interaction of hybrid x density is concerned, the effect was non-significant. These results are in line with Almeida *et al.* (1996) who found that number of cobs $plant^{-1}$ was not affected by treatments.

Number of Grains Cob^{-1}

Statistical analysis of the data (Table I) revealed that cultivars and plant density had significantly affected number of grains cob^{-1}, whereas the effects of phosphorus levels and all interactions were non-significant. Maximum number of grains cob^{-1} (556)

was recorded for Pioneer-3057, whereas minimum number of grains cob^{-1} (381) was seen in Kisan-90. The effect of phosphorus levels was non-significant. Do not agree with Arain et al (1989) who reported that plant height, number of grains cob^{-1} and yield of all genotypes increased with increase in N and P doses. In case of plant density, maximum number of grains cob^{-1} (498) was obtained at 70000 plants ha^{-1} and was at par statistically with 90000 plant ha^{-1}, while minimum number of grains cob^{-1} (458) was shown at 110000 plants ha^{-1}. It might be due nutrients deficiency occurred in case of higher plant density which resulted in short size cobs with less number of grains. These results are in line with Almeida et al. (1996) who reported that increase in plant density decreases grains cob^{-1}.

1000 Grain Weight

Data (Table I) showed that hybrids, plant density, phosphorus levels and hybrid x phosphorus (HxP) interaction had significantly affected 1000 grain weight, whereas the effect of HxD and PxD interactions were non significant. Maximum 1000 grains weight (292 g) was recorded for Monsanto-707, whereas minimum 1000 grain weight (246 g) was seen in Kisan-90. In case of phosphorus levels, maximum 1000 grain weight (276 g) was obtained with phosphorus at the rate of 120 kg ha^{-1}; however, it was at par with 60 kg P ha^{-1}, while minimum 1000 grain weight (269 g) was observed with 90 kg P ha^{-1}. It is clear from the data, when the rate of phosphorus increases, 1000-grains weight increases. These results are in line with Hassain (1976) who reported that plant height and 1000 grain weight increased significantly with the increased application of nitrogen and phosphorus. In case of hybrid x phosphorus interaction, significant results were found. Maximum 1000-grains weight (297 g) was recorded in Monsanto-707 at phosphorus level of 120 kg ha^{-1}. For plant density, maximum 1000 grains weight (278 g) was obtained at 70000 plants ha^{-1}, while minimum 1000 grain weight (267 g) was noted at 110000 plants ha^{-1}. As plant population increases competition for essential nutrients also increases. So whole plant growth is adversely affected and ultimately 1000 grain weight reduced. These results are in line with Hassan (2000) who observed that number of grains row^{-1} and 1000 grain weight decreased with increasing plant density.

Grain Yield

Data (Table I) revealed that maize hybrids/variety, phosphorus levels, plant density, hybrid x phosphorus (HxP) and phosphorus x plant density (PxD) interactions significantly affected grain yield. Mean value of the data inferred that Monsanto-707 produced significantly higher grain yield of 7269 kg ha^{-1} followed by Pioneer-3057 with 6703 kg ha^{-1} while lowest grain yield of 4830 kg ha^{-1} was recorded for Kisan-90. The possible reason could be of the genetic potential for grain yield of the hybrids and variety Kisan-90. The potential yield of a hybrid is greater than the synthetic variety (Aziz et al. 1992). In case of phosphorus levels, maximum grain yield (6515 kg ha^{-1}) was obtained with application of phosphorus at the rate of 120 kg ha^{-1}, while minimum grain yield (6038 kg ha^{-1}) was produced by phosphorus level of 90 kg ha^{-1}. These results are in line with Filev and Evstafef (1981) who reported that application of 60 kg N + 90 kg P ha^{-1} to maize hybrids increased the average yield by 1.7-3.01 t ha^{-1}. Among the plant densities, maximum grain yield (7269 kg ha^{-1}) was produced by density of 90000 plants ha^{-1}, while minimum grain yield (4830 kg ha^{-1}) was obtained at 110000 plants ha^{-1}. This is because in 90000 density level, number of grains per cob as well as 1000 grains weight was greater than density level of 110000 plants ha^{-1}. These results are also in agreement with Dornescus and Dornescus (1988), Noorul-Akbar (1998) and Silva *et al.* (1999) who reported highest grain yield at density of 90000 plants ha^{-1} compared with 70000 and 110000 plants ha^{-1}. Interaction between hybrid x phosphorus showed that P (120 kg ha^{-1}) significantly increased yield (7911 kg ha^{-1}) of Monsanto-707. Phosphorus rather significantly decreased yield of Pioneer-3057. The yield of Kisan-90 with 60 and 120 kg P ha^{-1} was about the same; however, the yield of Kisan-90 fertilized with 90 kg ha^{-1} P was lower than 60 and 120 kg P ha^{-1}(Data not shown). For phosphorus x density interaction, maximum grain yield (7536 kg ha^{-1}) was recorded at 120 kg P ha^{-1} in plots having 90000 plants ha^{-1} and was at par with 60 kg P ha^{-1}. The possible reason could be that the maximum phosphorus requirement at reproductive stage might be fulfilled by both these two levels of phosphorus for the stated plant density as compared to other densities. These results are supported by Khan *et al.* (1993) who found a significant cultivar x density x fertilizer interaction for grain yield.

CONCLUSION AND RECOMMENDATIONS

Maize hybrid Monsanto-707 with plant density of 90000 plants ha^{-1} and 120 kg P ha^{-1} is recommended for higher grain yield in agro-climatic condition of Peshawar.

Table I ***Cobs plant^{-1}, No. of grain cob^{-1}, 1000 grain weight (g), grain yield (kg ha^{-1}) of two maize hybrids and a variety as affected by different phosphorus levels and plant density***

Factors	Cobs Plant^{-1}	Grain Cob^{-1}	1000 Grain weight (g)	Grain yield (kg ha^{-1})
Hybrids				
Pioneer-3057	1.36 a	556 a	279 b	6703 b
Monsanto-707	1.30 a	491 b	292 a	7269 a
Kisan-90	1.13 b	381 c	246 c	4830 c
LSD	0.12	40.0	4.82	95
Phosphorus				
60	1.15 b	462	272 ab	6249 b
90	1.23 b	480	269 b	6038 c
120	1.41 a	486	276 a	6515 a
LSD	0.12	ns	4.82	95
Plant Densities				
70,000	1.41 a	498 a	278 a	6703 b
90,000	1.32 a	472 ab	273 b	7269 a
110,000	1.06 b	458 b	267 c	4830 c
LSD	0.09	30	2.20	309
Interactions (Only maximum values presented)				
H x P	Pioneer-3057 x 120 (1.61) *****	ns	Monsanto-707 x 120 (297) *****	Monsanto-707 x 120 (7911) *****
H x D	ns	ns	ns	ns
P x D	120 x 70,000 (1.67) *****	ns	ns	120 x 90,000 (7536) *****

Means in the same category followed by similar letters are not significantly different at 5% level of probability.

***** = Significant at $P \leq 0.05$
H = Hybrid
P = Phosphorus
D = Plant Density
LSD = Least Significant Difference
ns = Non-significant

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