Impact of Phosphorus and Foliar Application of Zinc on Maize Yield

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Abstract

Soil applied phosphorus (P) and foliar application of zinc (Zn) on various growth stages plays significant role on maize productivity. An experiment on soil applied phosphorus and foliar zinc application on different growth stages of maize crop was conducted at Fodder and Forage crops section Harichand- Charsadda. Two levels of soil applied phosphorus (90 and 120 kg ha^{-1}) and three levels of foliar Zn (0 i.e., water spray only, 2.5 and 5 kg ha^{-1}) were applied at three (AT) i.e., full at vegetative stage V6 (AT1), full at reproductive stage R2 (AT2) and ½ at V6 and ½ at R2 stage (AT3) along with an overall control and randomized complete block design with three replications was used. The studied parameters were significantly affected by P, Zn and AT. Most of the studied parameters were significantly affected by P, Zn and AT. Shelling percentage (74.8 %), biological yield (13647 kg ha^{-1}), grain yield (5764 kg ha^{-1}) and harvest index (35.6 %) were significantly affected when 120 kg P ha^{-1} was applied. Shelling percentage (76.5 %), biological yield (14024 kg ha^{-1}), grain yield (5947 kg ha^{-1}) and harvest index (35.5 %) were significantly affected in plots treated at the rate of 5 kg ha^{-1} with Zn. In case of AT, Zn applied half at vegetative and half at reproductive stages significantly enhanced the shelling percentage (76.1 %), biological yield (14018 kg ha^{-1}), grain yield (5943 kg ha^{-1}) and harvest index

(35.8 %). It can be concluded from the study that increases in the rates of P and Zn improved the studied parameters. Similarly, application of Zn, half at vegetative stage V6 and half at reproductive stage R2 increased maize crop.

Key words: Foliar application, Maize, Phoshorus, Yied and Zinc

Introduction

Maize (*Zea mays* L.) is an important cereal crop with high commercial importance (Liaqat *et al.,* 2018). After wheat and rice, maize is the 3rd most promising crop of cereals in Pakistan (Omer *et al*., 2018). Maize contains 72% starch, 10% protein, 4.8% oil, 5.8% fiber, 3% sugar and 1.7% of ash (Murad *et al*., 2017). It is mostly grown in temperate, tropical and subtropical region (Ilyas *et al*., 2020). It is grown both in summer and spring seasons (Thomas *et al.,* 2021). It holds a top position in the high mountainous northern areas of Pakistan due to its shorter duration (Abid *et al.*, 2021). It can be grown on all types of soils, ranging from sandy to clayey with pH from 6.5 to 7.5 (Pavel *et al*., 2021). The environmental condition of Pakistan is quite suitable for maize production (Awan *et al.*, 2021).

Among macronutrient, phosphorus is very important as resistance of crop is increased to certain diseases when P is applied. It plays vital role in nucleus formation, cell division and in the development of plant (Guo *et al*., 2019). It also helps in formation of DNA and RNA (Salim *et al.,* 2020). Lodging is decreases by phosphorus because it gives strength to the straw of cereal crops. Phosphorus has a great importance in getting of high yield (Ahmad *et al*., 2019). It also affected the growth behavior of plant (Ullah *et al.,* 2018). It is required for utilization of starch and sugar, photosynthesis, fats and albumen formations, nucleus formation and cell division and growth. For later use in growth and reproduction the energy from the carbohydrates metabolism and photosynthesis is stored in phosphate compounds (Ayub *et al.*,2002). Within the plant's body, it moves from older to the younger tissues

Zinc (Zn), is fundamental micronutrient and play key role in all forms of life such as animals, human beings and plants (Alloway, 2004). As per crop plant's perspective, it is a major micronutrient constraint that throughout the world including alkaline calcareous soils of Pakistan hampers the production of crop. Highly sensitive crops like maize, rice, beans and citrus etc. about 70% of area cultivated in Pakistan is considered deficient in Zn. (Rashid and Fox, 1992). Zn is necessary for biosynthesis of chlorophyll (Ali *et al.*, 2021). In general, Zn has major role in activating enzyme, proteins synthesis, revival and oxidation reactions and carbohydrates metabolism (Shahzad *et al.,* 2021). By using fertilizers that contain other micronutrients and zinc increases crop quality. The present study was under taken to study the impact of phosphorus and foliar application of zinc on yield of maize crop.

Materials and Methods

The experiment entitled "Impact of phosphorus and foliar application of zinc on yield of maize crop" was performed at Fodder section Harichand, District Charsadda-Pakistan. The experiment comprised of three factors. The experiment comprised two levels of phosphorus (90 and 120 kg ha^{-1}) and three levels of zinc (0, 2.5 and 5 kg ha^{-1}) were applied at three growth stages (i.e. foliar application at vegetative (V6), reproductive (R2) and ½ at vegetative (V6) and ½ at reproductive (R2) stage along with one unsprayed check were used in the experiment. The experiment was conducted in randomized complete block design with three replications. Treatment combinations of all the three factors along with a control were randomly allotted to the experimental plots in each block. Plot size was 4.9 x 4.0 m. Jalal variety was used for sowing. Planting was made on flat beds in rows spaced of 0.70 m. Phosphorus was applied in the form of SSP at the time of sowing. For application of Zn, 0.5% solution of $ZnSO_4.7H_2O$ was prepared. Keeping in view the treatments and volume to wet the subplot area completely, the solution was further diluted with water. Control plots were sprayed with equivalent quantity of water. Plots were sprayed as per levels of factor-C. First irrigation was given12 days after sowing and subsequent irrigation was adjusted according to the need of crop. For all the treatments, other agronomic practices were kept uniform.

Results and Discussion

Shelling percentage

Data regarding shelling percentage are shown in table 01. Maximum shelling (74.8 %) was seen when 120 kg P $ha^{-1}$was applied while minimum (74.1 %) was noticed at 90 kg p ha^{-1}. Shelling percentage increased with increased P levels (Manzoor *et al*., (2019). The increased in maize shelling percentage increased with P levels probably may be due to increased in ears length, number of grains per ears as well as heaviest grain weight (EL-Sobky *et al.*, 2021). Similarly in case of Zn, maximum shelling (76.5 %) was recorded when 5 kg Zn ha^{-1}was applied while minimum (73.8 %) was noticed when no Zn was applied and plot sprayed with water only. In case of Zn application timing, maximum shelling (76 %) was noticed when Zn was applied half at V6 and half at R2 stage while minimum (74.60 %) was observed when all applied at R2 stage.

Table 01. Shelling percentage (%) of maize as affected by phosphorus, foliar Zn and its application timing.

Phosphorus (kg ha^{-1})	Zn (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
90	0	72.77	72.40	72.90	72.69
	2.5	74.87	71.47	75.17	73.83
	5.0	74.63	75.87	76.40	75.63
120	0	75.00	74.43	75.17	74.87
	2.5	75.73	76.50	77.27	76.50
	5.0	75.73	76.93	79.30	77.32
-	0	73.88	73.42	74.03	73.78 c
-	2.5	75.30	73.98	76.22	75.17 b
-	5.0	75.18	76.40	77.85	76.48 a
90	-	74.09	73.24	74.82	74.05 b
120	-	74.83	73.92	75.58	74.78 a
Mean		74.79 b	74.60 b	76.03 a	
Control					72.50 b
Rest					75.14 a

V6 = Vegetative stage leaf 6th, R2 = reproductive stage

Table 02. Biological yield (kg ha^{-1}) of maize as affected by phosphorus, foliar Zn and its application timing.

Phosphorus (kg ha^{-1})	Zn (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
90	0	10714	11820	12443	11659
	2.5	12283	11333	14383	12667
	5.0	13216	14350	14117	13894
120	0	14586	12487	13140	13404
	2.5	13430	11890	14833	13384
	5.0	13610	13660	15190	14153
-	0	12650	12153	12792	12532 b
-	2.5	12856	11612	14608	13026 ab
-	5.0	13413	14005	14653	14024 a
90	-	12071	12501	13648	12740 b
120	-	13875	12679	14388	13647 a
Mean		12973 ab	12590 b	14018 a	
Control					10718
Rest					13194

V6 = Vegetative stage leaf 6th, R2 = reproductive stage

Biological yield (kg ha^{-1})

Data as regards on biological yield are shown in table 02. Data revealed that highest (13647) biological yield was noticed when 120 kg P ha^{-1} applied while the lowest (12740) was noticed in plots that were fertilized with 90 kg P ha^{-1}. Biological yield increased with the increasing rates of P. Phosphorus fertilization treatment increased the root development which result increased plant height, stalk diameter and total biomass in maize crop (Pereira *et al*., 2020). In case of Zn, highest (14024) biological yield was noticed by the application 5 kg Zn ha^{-1} and the lowest (12532) biological yield was recorded in unfertilized plots of Zn. Biological yield of maize crop increased with foliar application of zinc because, Zn play a key role in processing of photosynthesis, respiration, physiological and biochemical activities (Zeidan *et al*., 2010). Harris *et al*. (2007) also reported that soil application Zn significantly increased mean total dry matter, Stover yield, cob yield and thousand grain weight in maize crop. While in case of Zn application timing, maximum biological yield

(14018) was noticed in plots when Zn was applied half at vegetative and half at reproductive stage and the lowest (12590) were noticed in plots when Zn was applied at a reproductive stage.

Grain yield (kg ha^{-1})

Data as regards on grain yield are shown in table 03. Statistical analysis of the data revealed highest (4638) grain yield was noticed when p was applied at the rate of 120 kg ha^{-1} while the lowest (4125) was noticed in plots that are fertilized with 90 kg P ha^{-1}. Grain yield increased with higher rate of P. The increased in maize grain yield with increase in P levels probably may be due to increased in ear length, number of rows and number of grain per ear as well as heaviest grain weight (Amanullah *et al.,* 2009). In case of Zn, highest grain yield (4763) was observed when 5 kg Zn ha^{-1}was applied and the lowest (4007) grain yield was shown when no Zn was applied Zn. Application of Zn at higher levels increased grain yield (Hussain *et al.,* 2018).Higher levels of Zn increased grain yield on account of higher leaf area duration and leaf area index that lead to more radiation interception, photosynthetic efficiency, growth rate and therefore grain number and grain weight per ear increased (de Mattos *et al*., 2020). While in case of Zn application timing, maximum grain yield (4488) was observed when Zn was applied half at vegetative and half at reproductive stage and the lowest (4278) were noticed in plots when all Zn was applied at the vegetative stage only.

Harvest index (%)

Data as regards on harvest index are shown in table 04. Statistical analysis of the data revealed that control vs rest, P, Zn and AT had significantly affected harvest index. Mean value of the data revealed that highest harvest index (33.4) was noticed in fertilized plots while lowest (28.1) was noticed in unfertilized plots. In case of P, highest (35.6) harvest index was noticed when 120 kg P ha^{-1} was applied while the lowest (31.3) was observed in plots when 90 kg P ha^{-1} was applied. Higher rate of P improve maize harvest index, it might be due P contribution in yield and yield components (Amanullah *et al.,* 2021).In case of Zn, highest harvest index (35.5) was recorded when Zn was applied at the rate of 5 kg ha^{-1} and the lowest (31.6) harvest index was observed in unfertilized plots of Zn. While in case of Zn application timing, maximum harvest index (35.8) was shown when Zn was applied half at vegetative and half at reproductive stage and the lowest (32) were noticed in plots when Zn was applied at a reproductive stage.

Table 03. Grain yield (kg ha^{-1}) of maize as affected by phosphorus, foliar Zn and its application timing.

Phosphorus (kg ha^{-1})	Zn (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
90	0	3740	3831	3860	3810
	2.5	4037	4096	4240	4124
	5.0	4349	4439	4538	4442
120	0	4162	4183	4265	4203
	2.5	4430	4664	4787	4627
	5.0	4949	5061	5239	5083
	0	3951	4007	4063	4007 c
	2.5	4234	4380	4513	4376 b
	5.0	4649	4750	4888	4763 a
	90	4042	4122	4213	4125 b
	120	4514	4636	4763	4638 a
	Mean	4278 c	4379 b	4488 a	
	Control				2957 b
	Rest				4382 a

V6 = Vegetative stage leaf 6th, R2 = reproductive stage

Table 04. Harvest index of maize as affected by phosphorus, foliar Zn and its application timing.

Phosphorus (kg ha^{-1})	Zn (kg ha^{-1}) Application	Application Timing (AT)			Mean
		V6	R2	50% at V6 + 50% at R2	
90	0	29.0	26.7	34.1	29.9
	2.5	31.3	26.6	35.5	31.1
	5.0	31.4	32.6	34.3	32.8
120	0	31.2	33.4	35.6	33.4
	2.5	35.4	35.1	34.9	35.1
	5.0	36.7	37.7	40.2	38.2
-	0	30.1	30.0	34.8	31.6 b
-	2.5	33.3	30.8	35.2	33.1 b
-	5.0	34.0	35.2	37.3	35.5 a
90	-	30.5	28.6	34.6	31.3 b
120	-	34.4	35.4	36.9	35.6 a
Mean		32.5 b	32.0 b	35.8 a	
Control					28.1b
Rest					33.4 a

V6 = Vegetative stage leaf 6^{th}, R2 = reproductive stage

Conclusions and Recommendations

Application of 120 kg P ha^{-1} significantly improved shelling%, biological yield, grain yield and harvest index of maize crop. In case of foliar application of zinc, 5 kg Zn ha^{-1} improved shelling%, biological yield, grain yield and harvest index. Similarly in case of application timing of zinc, when applied ½ at vegetative & ½ reproductive stage improved shelling%, biological yield, grain yield and harvest index improved productivity of maize crop. Therefore, phosphorus and zinc with its various application stages is recommended for the agro climatic conditions of Peshawar. Hence it is recommended that 120 kg P ha^{-1} and 5 kg Zn ha^{-1} along with its application timing ½ at vegetative & ½ reproductive stage will improve maize crop. Therefore, it is recommended for the agro climatic conditions of Peshawar.

Author's Contribution

Sajid Ali: Assistant Botanist, who did research, collect data, analysis and wrote draft of the manuscript.

Shahen Shah and Muhammad Amin helped in technical guidelines.

Conflict of interest

The authors have declared no conflict of interest.

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