RESPONSE OF MAIZE TO FARM YARD MANURE, NITROGEN AND ITS TIMING OF APPLICATION

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Abstract

Farm Yard Manure (FYM), Nitrogen (N) and its time of application plays an important role in crop productivity. To study its effect on maize, this experiment was conducted at Livestock Research and Development Station Surezai, Peshawar. Two levels of FYM (10 and 20 ton ha^{-1}) and three levels of N (100, 150 and 200 kg ha^{-1}) were applied at three application timings (AT), full at vegetative stage V6 (AT1), full at reproductive stage R2 (AT2) and ½ at V6 and ½ at R2 stage (AT3). Overall one control was used in the experiment. Randomized complete block design was used with three replications. The studied parameters were significantly affected by FYM, N and AT of nitrogen. Days to harvest maturity (89), ear length (17.8 cm), ear weight (115.8 g), grains ear^{-1} (390), thousand grains weight (257 g), green fodder production (kg ha^{-1}), biological yield (13647kg ha^{-1}), grain yield (5947kg ha^{-1}) and harvest index (35.5%) had significantly affected when 10 t FYM ha^{-1} was applied. Similarly, days to harvest maturity (89), ear length (17.8 cm), ear weight (115.8 g), grains ear^{-1} (390), thousand grains weight (257 g), green fodder production (kg ha^{-1}), biological yield (13647kg ha^{-1}), grain yield (5947kg ha^{-1}) and harvest Index (35.5%) were significantly affected in plots treated at the rate of 100 kg ha^{-1} with N. In case of AT, N applied full at vegetative stages significantly enhanced the ear length (17.8 cm), ear weight (115.8 g), grains ear^{-1} (390), thousand grains weight (257 g), green fodder production (kg ha^{-1}), biological yield (13647kg ha^{-1}), grain yield (5947kg ha^{-1}) and harvest Index (35.5%) . It is concluded from the experiment that, 10 ton FYM ha^{-1}, 100 kg N ha^{-1} along with its application timing full at vegetative stage significantly enhanced maize crop productivity and hence these factors are recommended for the agro climatic conditions of Peshawar.

Keywords: Application time, FYM, Maize, Nitrogen, Yield components.

Introduction

Fertilizers play an important role in crop production and also enhanced quality of crop (Amjadian *et al*., 2021). Balanced fertilizers are very important because it's improved and enhances plant development and also increases yield (Hitha *et al*., 2021). Among the essential nutrients, phosphorus (P) is the second essential nutrient. Phosphorus (P) is important nutrient in the cropping system of agriculture (Roberts and Johnston, 2015; Guignard *et al*., 2017; Khan *et al*., 2018).It plays a role in crop development and in its metabolism (Yadav *et al*., 2017). Phosphorus is the part of nucleic acids, structural proteins and of enzymes (Yao *et al*., 2018). After nitrogen, phosphorus increases yield of crop (Adeyemi*et al*., 2020). Most of the cereal and vegetable crops require phosphorus in large quantity (Ketterings *et al*., 2020). It has two different forms in soil i.e. $H_2PO_4^{-1}$ and HPO_4^{-2} and plant takes it in these two forms. The absorption of HPO_4^{-2} is very rapid and faster as compare to $H_2PO_4^{-1}$ (Alamnie *et al*., 2021). Application of phosphorus give strength to straw of cereal crop and as a result crop lodging decreases. It also increases resistance to many diseases. It plays a crucial role in cell division, nucleus formation, helps in DNA and RNA formation (Kolodiazhnyi *et al*., 2021). Deficiency of phosphorus limits development and growth of plant (Kewei *et al*., 2014). Phosphorus decreases yield in maize crop when applied in low amount (Cengiz *et al*., 2020).

Micro-nutrients though are as important as macro-nutrients (Jake *et al*., 2022). However, as compared to macronutrients, micronutrients are required in very small amount. Generally in most cases, both the plants and soils have very small amounts of micro-nutrients (Chakraborty *et al*., 2021). Micro-nutrients play a key role in plant growth and its development, improve crop phenology and also involve in various physiological processes (Hassan *et al*., 2019). Similarly, in case of micro-nutrients, Zinc (Zn) is an important micro-nutrient and plays a key role in plants (Natasha *et al.*, 2022). 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 (Ali *et al*., 2021). The deficiency of Zn may lead to photosynthesis decline and destruction of RNA, decreased protein synthesis, carbohydrates solution and thus affecting performance and quality of crop (Kadyampakeni *et al.*, 2021). Foliar application of both Zn and Fe also enhances the phenological development and yield component of wheat crop (Ali *et al*., 2021). Application of Zn enhances height of maize crop when applied at split doses (Sonal *et al*., 2021). Foliar Zn also significantly enhances size of maize leaf (Raheela *et al*., 2021).

MATERIALS AND METHODS

Field experiment

The experiment entitled ''Farm Yard Manure (FYM), Nitrogen (N) and its time of application plays an important role in crop productivity''. To study its effect on maize, this experiment was conducted at Livestock Research and Development Station Surezai, Peshawar. Two levels of FYM (10 and 20 t ha^{-1}) and three levels of N (100, 150 and 200 kg ha^{-1}) were applied at three application timings (AT), 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 one control were used in the experiment. Randomized complete block design was used with three replications. Plot size will be 3m x 2.8m while accommodating four rows. Azam variety at the rate of 12 kg per acre will be cultivated. Data will be recorded from two central rows. Planting will be done on flat beds in rows spaced 0.70m. Phosphorus will be applied in the form of SSP/TSP at the time of sowing. First irrigation will be given 12 days after sowing while the subsequent irrigation will be adjusted according to the need of the crop and avoiding the over irrigation strictly. All the other agronomic practices will be kept normal and uniform for all the treatments.

Statistical analysis

The data noticed on different parameters was analyzed statistically according to the procedure relevant to randomized complete block design as described by little and Hills, (1978). Least significant difference (LSD) test were used for mean separation when the F test was significant.

Results and Discussion

Days to harvest maturity

Data on days to harvest maturity shown in table 1. More days to harvest maturity (91) was noticed when 90 kg P ha^{-1}was applied while minimum (89) was noticed when 120 kg P ha^{-1}was applied. Days to harvest maturity decrease with increasing rate of P. The possible reason may be due to the development of maize phenology, also might be due to the higher rate of P that increased the development of root and thus the root obtained more P to complete the life cycle earlier as soon as possible. These results are in line with (Ali *et al*., 2019) who reported a significant effect of P on days to maturity of maize. Similarly in case of Zn, maximum (92) days to harvest maturity was noted in unfertilized plots while minimum (88) was shown when 5 kg Zn ha^{-1}was applied. Zinc application brings early maturity because zinc accelerates various physiological processes in plant (Nabat *et al*., 2022). In case of Zn application timing, maximum (91) days to harvest maturity was noticed when Zn was applied at AT2 stage while minimum (89) was recorded at AT1 stage.

Ear length (cm)

Data of ear length showed in table 2. Maximum ear length (17.8 cm) was noticed when 120 kg P ha^{-1} was applied while minimum (16.8 cm) was noticed when 90 kg P ha^{-1} was applied. The reason for increased of ear length of maize might be that phosphorus could translocate assimilation to ears has accrued and have been resulted in to increased ear length (Juan *et al*., 2021). Similarly in case of Zn, maximum ear length (18.4 cm) was observed when 5 kg Zn ha^{-1} was applied while minimum (16.1 cm) was noticed with water spray only. Ear length and weight increased with higher rate of Zn (Hisham *et al*., 2021). In case of Zn application timing, maximum ear length (18.2 cm) was recorded when Zn was applied all at AT3 stage while minimum (16.5 cm) was noticed when applied all at AT1 stage.

Ear weight (g)

Data concerning ear weight are accessible in table 3. Maximum ear weight (115.8 g) was noticed when 120 kg P ha^{-1} was applied while minimum (109.4 g) was observed when 90 kg P ha^{-1} was applied. Ear weight of maize crop increased with higher rate of phosphorus because phosphorus increases the amount of endosperm in grain (Perkins *et al.*, 2021). Similar in case of Zn, maximum ear weight (129.6 g) was noticed when 5 kg Zn ha^{-1} was applied while minimum (113.4 g) was noticed with water spray only. Increase of ear weight is due to the heavier grain weight, because zinc provided adequate amount of carbohydrates to source. Therefore ear weight increases with the application of Zn (Liu *et al.*, 2020). In case of Zn application timing, maximum ear weight (127.4g) was shown when all Zn was applied at AT3 stage while minimum (111.4 g) was noticed with all at AT2 stage. In such away in case of P x AT interaction, the maximum ear weight (124.1 g) was noticed in plots when 120 kg P ha^{-1} and Zn applied half at V6 and half at R2 stage while minimum (97.9 g) was noticed in plot that received 90 kg P ha^{-1} and all Zn at AT2 stage.

Table 1. Days to harvest maturity of maize as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	93	93	92	92
	150	91	91	91	91
	200	89	90	90	90
20	100	90	92	92	91
	150	88	92	87	89
	200	87	87	87	87
-	100	91	92	92	92 a
-	150	89	91	89	90 b
-	200	88	89	89	88 b
10	-	91	91	91	91 a
20	-	88	90	89	89 b
Mean		89 b	91 a	90 b	

Control	94.33
Rest	90.50

Table 2. Ear length (cm) of maize as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	13.3	17.0	16.7	15.7
	150	16.3	17.1	17.2	16.9
	200	17.5	17.3	18.8	17.9
20	100	15.8	16.7	17.2	16.6
	150	17.0	17.4	19.0	17.8
	200	19.0	17.3	20.3	18.9
-	100	14.6	16.9	16.9	16.1 c
-	150	16.7	17.2	18.1	17.3 b
-	200	18.2	17.3	19.6	18.4 a
10	-	15.7	17.1	17.6	16.8 b
20	-	17.3	17.1	18.8	17.8 a
Mean		16.5 b	17.1 b	18.2 a	
Control					13.0 b
Rest					17.3 a

Table 3. Ear weight (g) of maize as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	93.0	101.0	117.3	103.8
	150	110.3	96.7	110.3	105.8
	200	141.3	96.0	118.3	118.6
20	100	107.3	118.0	143.7	123.0
	150	111.3	129.0	143.3	127.9

	200	138.0	141.7	142.0	140.6
-	100	100.2	109.5	130.5	113.4 b
-	150	110.8	112.8	126.8	116.8 b
-	200	139.7	118.8	130.2	129.6 a
10	-	114.9	97.9	115.3	109.4 b
20	-	119.7	103.6	124.1	115.8 a
Mean		117.0 ab	111.4 b	127.4 a	
Control					94.3 b
Rest					119.9 a

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

Grains ear^{-1}

Data concerning grains ear^{-1} are obtainable in table 4. In case of P, maximum grains ear^{-1} (390) was shown when 120 kg P ha^{-1} was applied while minimum (369) grains ear^{-1} was noticed when 90 kg P ha^{-1} was applied. Phosphorus is responsible for the growth of root which directly affects the overall plant performance (Bing *et al*., 2022). It has also reported that grains per ear also increase with phosphorus fertilization (El-Sobky *et al.*, 2021). Similarly in case of Zn, maximum grains ear^{-1} (407) was noticed when 5 kg Zn ha^{-1} was applied while minimum (353) was shown with water spray only. This is because that Zn is essential for pollen grain development and pollen viability; as a result number of grains increases in ear (Sonal *et al*., 2022). In case of Zn application timing, maximum (391) was noticed when Zn was applied half at V6 and half at R2 stage while minimum (372) was noticed when all applied at AT2 stage.

Thousand grains weight (g)

Data regarding thousand grains weight are obtainable in table 5. Statistical analysis of the data show that maximum thousand grains weight (257 g) was seen at 120 kg P ha^{-1} and minimum (233.7 g) thousand grains weight were seen at 90 kg p ha^{-1} application. Heaviest grain weight with higher P level probably may be due to higher P translocation in to the fruiting area which results in highest grain weight. Increasing in P levels increased grain weight (Hamza *et al*., 2022). Similarly, in case of Zn, highest (258.3 g) thousands grain weight was noticed when 5 kg Zn $ha^{-1}$was applied while minimum (220.5 g) was noticed with water spray only. When the supply of carbohydrates to grain is high then the filling of grain

Will be high and as a result weight of kernels will be more (Wenxin *et al*., 2017).In case of Zn using timing, maximum thousands grain weight (255.5 g) was shown when Zn was applied half at V6 and half at R2 stage while minimum (228.6 g) was noticed when applied all at V6 stage.

Table 4. Grains ear^{-1} of maize as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	313.3	343.0	386.7	347.7
	150	356.7	351.3	390.0	366.0
	200	416.7	381.3	382.7	393.6
20	100	360.0	356.7	359.7	358.8
	150	386.7	388.7	400.7	392.0
	200	414.7	416.7	430.3	420.6
-	100	336.7	349.8	373.2	353.2 c
-	150	371.7	370.0	395.3	379.0 b
-	200	415.7	399.0	406.5	407.1 a
10	-	362.2	358.6	386.4	369.1 b
20	-	387.1	387.3	396.9	390.4 a
Mean		374.7 b	372.9 b	391.7 a	
Control					341.0 b
Rest					379.8 a

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

Table 5. 1000 grains weight (g) of as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	195	208	203	202
	150	200	220	253	224
	200	240	233	260	244
20	100	206	250	260	238
	150	250	266	263	260
	200	280	243	293	272
-	100	200	229	231	220 b
-	150	225	243	258	242 a
-	200	260	238	276	258 a
10	-	211	220	238	223 b
20	-	245	253	272	257 a
Mean		228 b	236 b	255 a	
Control					206 b
Rest					240 a

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

Biological yield (kg ha^{-1})

Data as regards on biological yield are shown in table 6. 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 7. 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 8. 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 6. Biological yield (kg ha^{-1}) of maize as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	10714	11820	12443	11659
	150	12283	11333	14383	12667
	200	13216	14350	14117	13894
20	100	14586	12487	13140	13404
	150	13430	11890	14833	13384
	200	13610	13660	15190	14153
-	100	12650	12153	12792	12532 b
-	150	12856	11612	14608	13026 ab
-	200	13413	14005	14653	14024 a
10	-	12071	12501	13648	12740 b
20	-	13875	12679	14388	13647 a
Mean		12973 ab	12590 b	14018 a	
Control					10718
Rest					13194

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

Table 7. Grain yield (kg ha^{-1}) of maize as affected by FYM, N and its application timing.

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	3740	3831	3860	3810
	150	4037	4096	4240	4124
	200	4349	4439	4538	4442
20	100	4162	4183	4265	4203
	150	4430	4664	4787	4627

	200	4949	5061	5239	5083
-	100	3951	4007	4063	4007 c
-	150	4234	4380	4513	4376 b
-	200	4649	4750	4888	4763 a
10	-	4042	4122	4213	4125 b
20	-	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 8. ***Harvest Index of Maize Affected by FYM, N and its Application Timing.***

FYM (ton ha^{-1})	N (kg ha^{-1}) Application	Application Timing (AT)			Mean
		V6	R2	50% at V6 + 50% at R2	
10	100	29.0	26.7	34.1	29.9
	150	31.3	26.6	35.5	31.1
	200	31.4	32.6	34.3	32.8
20	100	31.2	33.4	35.6	33.4
	150	35.4	35.1	34.9	35.1
	200	36.7	37.7	40.2	38.2
-	100	30.1	30.0	34.8	31.6 b
-	150	33.3	30.8	35.2	33.1 b
-	200	34.0	35.2	37.3	35.5 a
10	-	30.5	28.6	34.6	31.3 b
20	-	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 6th, R2 = reproductive stage

Conclusions and Recommendations

It is concluded from the experiment that application of 120 kg P ha^{-1} significantly improved ear length, ear weight, grains per ear and thousand grain weight. Similarly, foliar application of 5 kg Zn ha^{-1} improved ear length, ear weight, grains per ear and thousand grain weight of cob. In case of application timing of zinc, when applied ½ at vegetative & ½ reproductive stage will improve productivity of maize crop. Therefore, 120 kg P ha^{-1}, 5 kg Zn ha^{-1} along with its application timing ½ at vegetative & ½ reproductive stage is recommended for the agro climatic conditions of Peshawar.

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Novelty Statement:

This study conducted to find out the impact of phosphorus, Zinc and its application stages to improve maize yield.

Author's Contribution

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Conflict of interest

The authors have declared no conflict of interest.