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RESEARCH ARTICLE

EFFICACY OF POTASH AND NITROGEN APPLICATION ON YIELD OF MAIZE

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ABSTRACT

Potash (K) and Nitrogen (N) application play a very 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 potash (60 and 80 kg ha^{-1}) and three levels of N (80, 100 and 120 kg ha^{-1}) were applied at three application stages, 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 was used in the experiment. Randomized complete block design was used with three replications. Most of the studied parameters were significantly affected by K, N and AT. Ear length (17.7 cm), ear weight (119.1 g), grains ear^{-1} (392), thousand grains weight (257 g), biological yield (13647 kg ha^{-1}), grain yield (4638 kg ha^{-1}) and harvest index (35.6 %) were significantly affected when 80 kg K ha^{-1} was applied. Ear length (18.4 cm) , ear weight (129.6 g), grains ear^{-1} (407), thousand grains weight (258 g), biological yield (14024 kg ha^{-1}), grain yield (4638 kg ha^{-1}) and harvest index (35.5 %) were significantly affected in plots treated at the rate of 120 kg ha^{-1} with N. In case of AT, N applied half at vegetative and half at reproductive stages significantly enhanced Ear length (18.2 cm) , ear weight (127.4 g), grains ear^{-1} (391.7), thousand grains weight (255 g), biological yield (14018 kg ha^{-1}), grain yield (4488 kg ha^{-1}) and harvest index (35.8%). It can be concluded from the study that increases in the rates of K and N improved the studied parameters. Similarly, application of N, half at vegetative stage V6 and half at reproductive stage R2, significantly increased the yield and yield components in the maize crop.

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Introduction

Fertilizers play an important role in crop production and also enhanced quality of crop. Balanced fertilizers are very important because it's improved and enhances plant development and also increases yield (Hitha *et al*., 2021).

Potassium is considered as most ambient macronutrients required for proper growth, development and sustainable crop yield. It is a vital element for increasing yield of maize (Bukhsh *et al.,* 2009; Bukhsh *et al.,* 2012). Maize consumed 5.2 kg P_2O_5 ha^{-1} per day during peak flowering period (White, 2000). After sowing during 38 to 52 days, the maize plants require the total potassium up to 38% for whole growing season (Rehman *et al.,* 2008). Due to calcareous nature of Pakistani soils plants cannot uptake adequate amount of potassium (Bukhsh *et al.,* 2008). It improves the overall yield of maize (Sharma et al., 2005). It also helps plant to regulate the movement of stomata (Thomas and Thomas, 2009). Potassium plays major role in stimulation of enzymes, photosynthesis, regulation of osmotic pressure, movement of the stomata's, protein synthesis, phloem transport, transfer of the energy, cation-anion balance in soil and improves resistance against stress (Marschner, 2012). In depth of soil, potassium application in association with the other inorganic nutrients, such as phosphorus and nitrogen produce the deeper roots of plants (Kirkby et al., 2009). Therefore, due to the importance and role of potassium (K) in improving both chemical and physical properties of soil, and increasing growth, development and crop yield an experiment was planned to examine the role of different levels of potassium on maize growth, yield and quality.

Nitrogen plays an important role in plant. Nitrogen supply plays an important role in plant senescence and can greatly affect the remobilization of different nutrients from

vegetative to generative organs. The N excess or deficiency can a modifying factor of this process affecting the regulation of the synthesis of these nitrogenous chelates (Chen et al., 2016). Generally, sustaining a high yield of maize and other crops requires fertile arable land and plant fertilization, nutrition and nitrogen application (Shojaei et al., 2022), irrigation and water supply favorable weather and climatic conditions (Bojtor et al., 2021), the judicious use of agrotechnical inputs, and continuous research to develop new innovations (Semugenze et al., 2024).

MATERIALS AND METHODS

Field experiment

The experiment entitled "Potash (k) Nitrogen (N) and its time of application play 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 potash (60 and 80 kg ha^{-1}) and three levels of N (80, 100 and 120 kg ha^{-1}) were applied at three application stages, 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 was used in the experiment. Randomized complete block design was used with three replications. Plot size was 3m x 2.8m while accommodating four rows. Azam variety at the rate of 12 kg per acre was cultivated. Data were recorded from two central rows. Planting was done on flat beds in rows spaced 0.70m. First irrigation was be given 12 days after sowing while the subsequent irrigation were adjusted according to the need of the crop and avoiding the over irrigation strictly. All the other agronomic practices were kept normal and uniform for all the treatments. The mean annual rainfall of the location is 360 mm. The mean maximum summer temperature is 40 ºC and the mean minimum is 25 ºC while in winter minimum mean temperature is 4 ºC and mean maximum temperature is 18.34 ºC. The soil characteristics as evaluated in laboratory the soil as texture silty clay loam having 51.3% silt, 40% clay and 8.7% sand, 14.4% CaCO3, 8.08 pH and having low organic matter of 0.58% g kg^{-1}. The experiment was consisted of the following factors along with their respective levels

Factor A: Potash

1. 60 kg ha^{-1}
2. 80 kg ha^{-1}

Factor B: Nitrogen (N):

N1. 80 kg ha^{-1}

N2. 100 kg ha^{-1}

N3. 120 kg ha^{-1}

Factor C: Application Time of Nitrogen (AT):

AT1. Vegetative (V6)

AT2. Reproductive (R2)

AT3. ½ at V6 and ½ at R2

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

Ear length (cm)

With the increasing rate of potash the length of ear increased. In case of K, 18.7 cm ear length was noticed when more potash was applied. Similarly in case of N, maximum (18.4) ear length was observed when 120 kg N $ha^{-1}$was applied while minimum (16.1) was noticed with 60 kg N ha^{-1}only (**Table 1**). The increased cob length at greater nitrogen levels is probably caused by the take in production increasing, the efficient conversion to starches, and the optimal use of sunlight, as highlighted by (Qin et al., 2021).

Ear weight (g)

In case of K, maximum (115.8) ear weight was noticed when 120 kg P $ha^{-1}$was applied while minimum (109.4) was observed when 60 kg K $ha^{-1}$was applied. Similar in case of N, maximum (129.6) ear weight was noticed when 120 kg N ha^{-1} was applied while minimum (113.4) was noticed with 80 kg N ha^{-1} only as shown in **Table 2**. Our results are also explained by (Iqbal *et al.,* 2013).

Table 1. Ear length (cm) of maize as affected by potash, N, and its application timing

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	13.3	17.0	16.7	15.7
	100	16.3	17.1	17.2	16.9
	120	17.5	17.3	18.8	17.9
80	80	15.8	16.7	17.2	16.6
	100	17.0	17.4	19.0	17.8
	120	19.0	17.3	20.3	18.9
-	80	14.6	16.9	16.9	16.1 c
-	100	16.7	17.2	18.1	17.3 b
-	120	18.2	17.3	19.6	18.4 a
60	-	15.7	17.1	17.6	16.8 b
80	-	17.3	17.1	18.8	17.7 a
Mean		16.5 b	17.1 b	18.2 a	
Control					13.0
Rest					17.3 a

V6 = Vegetative stage leaf 6th, R2 = reproductive stage, LSD value (P≤0.05) for N = 0.81, LSD value (P≤0.05) for AT = 0.81, *Significant at 5% level of probability, NS = Non-significant at 5% level of probability, Means of the same category followed by different letters(s) reveal significant differences among mean values (P< 0.05) using LSD test

Table 2. Ear weight (g) of maize as affected by potash, N and its application timing

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	93.0	101.0	117.3	103.8
	100	110.3	96.7	110.3	105.8
	120	141.3	96.0	118.3	118.6
80	80	107.3	118.0	143.7	123.0
	100	111.3	129.0	143.3	127.9
	120	138.0	141.7	142.0	140.6
-	80	100.2	109.5	130.5	113.4 b
-	100	110.8	112.8	126.8	116.8 b
-	120	139.7	118.8	130.2	129.6 a
60	-	114.9	97.9	115.3	109.4 b
80	-	119.7	113.6	124.1	119.1 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, LSD value (p≤0.05) for N= 12.15, LSD value (p≤0.05) for AT = 12.15, *Significant at 5% level of probability, NS = Non-significant at 5% level of probability, Means of the same category followed by different letters(s) reveals significant differences among mean values (P< 0.05) using LSD test.

Grains ear^{-1}

Data concerning grains ear^{-1} are obtainable in **Table 3**. Mean values of the data showed that maximum grains ear^{-1} (379) were noted in rest plots, while the minimum was observed in control plots (341). In the case of K, a maximum of 390 grains ear^{-1} was shown when 80 kg K ha^{-1} was applied, while a minimum (369) of grains ear^{-1} was noticed when 60 kg K ha^{-1} was applied. Our study is in line with Minjian et al. (2007). Similarly, in the case of N, a maximum of 407 grains ear^{-1} was noticed when 120 kg N ha^{-1} was applied, while a minimum of 353 was shown with 80 kg N ha^{-1}.

Thousand grains weight (g)

Data regarding thousand-grain weight are obtainable in **Table 4**. Mean values of the data showed that the maximum thousand-grain weight (240) was noted in the treated plots, while the minimum (206) was noticed in the control plots. In the case of K, maximum (257) and minimum (223) thousand-grain weights were seen at 80 kg Pha^{-1}and 60 kg K ha^{-1} application (**Table 4**). These findings are similar to the research of Gozubenli et al. (2001). Similarly in the case of N, the highest (258) thousand-grain weight was noticed when 120 kg N ha^{-1} was applied, while the minimum (220) was noticed with 80 kg N ha^{-1}.

Table 3. Grains ear^{-1} of maize as affected by potash, N and its application timing

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	313.3	343.0	386.7	347.7
	100	356.7	351.3	390.0	366.0
	120	416.7	381.3	382.7	393.6
80	80	360.0	356.7	359.7	358.8
	100	386.7	388.7	400.7	392.0
	120	414.7	416.7	430.3	420.6
-	80	336.7	349.8	373.2	353.2 c
-	100	371.7	370.0	395.3	379.0 b
-	120	415.7	399.0	406.5	407.1 a
60	-	362.2	358.6	386.4	369.1 b
80	-	388.1	392.3	396.9	392.4 a
Mean		374.7 b	372.9 b	391.7 a	
Control					341.0 b
Rest					379.8 a

V6 = Vegetative stage leaf 6th, R2 = reproductive stage, LSD value (P≤0.05) for N= 15.88, LSD value (P≤0.05) for AT = 15.88, *Significant at 5% level of probability, NS = Non-significant at 5% level of probability, Means of the same category followed by different letters(s) reveals significant differences among mean values (p< 0.05) using LSD test

Table 4. Thousand-grain weight (g) of maize as affected by potash, N, and its application timing

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	195	208	203	202
	100	200	220	253	224
	120	240	233	260	244
80	80	206	250	260	238
	100	250	266	263	260
	120	280	243	293	272
-	80	200	229	231	220 b
-	100	225	243	258	242 a
-	120	260	238	276	258 a
60	-	211	220	238	223 b
80	-	245	259	272	257 a
Mean		228 b	239 b	255 a	
Control					206 b
Rest					240 a

V6 = Vegetative stage leaf 6th, R2 = reproductive stage. LSD value ($p \leq 0.05$) for N = 17.90, LSD value ($p \leq 0.05$) for AT = 17.90, Means of the same category followed by different letters(s) reveals significant differences among mean values ($P < 0.05$) using LSD test

Biological yield (kg ha^{-1})

Data as regards on biological yield are shown in **Table 5**. Data revealed that control vs rest, K, N and AT had significantly affected biological yield. Mean value of the data revealed that maximum (13194) biological yield was observed in fertilized plots while minimum (10718) was noticed in unfertilized plots. In case of K, highest (13647) biological yield was noticed when 80 kg K ha^{-1} applied while the lowest (12740) was noticed in plots that were fertilized with 60 kg K ha^{-1}. More biological yield was noticed when more K applied. Reason behind the increase in grain yield and biological yield might be increase in potash level increased the rate of CO2 assimilation, stabilized the osmosis regulation, improved stomata closure and enzyme activity as a result of which more carbohydrates might have produced which might have increased grain yield and biological yield as observed by (Tabatabaii *et al.,* 2011).

In case of N, highest (14024) biological yield was noticed by the application 120 kg N ha^{-1} and the lowest (12532) biological yield was recorded in 80 kg N ha^{-1}. While in case of N application timing, maximum biological yield (14018) was noticed in plots when N was applied half at vegetative and half at reproductive stage and the lowest (12590) was noticed in plots when N was applied at a reproductive stage.

Grain yield (kg ha^{-1})

Data as regards on grain yield are shown in **Table 6**. Statistical analysis of the data revealed that control vs rest, K, N and AT had significantly affected grain yield. Mean value of the data revealed that highest grain yield (4382) was noticed in fertilized plots while lowest (2957) was noticed in unfertilized plots. In case of K, highest (4638) grain yield was noticed when K was applied at the rate of 80 kg ha^{-1} while the lowest (4125) was noticed in plots that are fertilized with 60 kg k ha^{-1}. Grain yield of maize crop increases with the application of potash. This might be due to that potassium plays an imperative role in the photosynthesis process and the subsequent carbohydrate translocation and metabolism, which eventually increase the grain yield (Pettigrew. 2008). In case of N, highest grain yield (4763) was observed when 120 kg N ha^{-1}was applied and the lowest (4007) grain yield was shown when 80 kg N ha^{-1}. Increasing rate of N increased grain yield as explained by (Abayomi *et al*., 2006).

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 K, highest (35.6) harvest index

was noticed when 120 kg K ha^{-1} was applied while the lowest (31.3) was observed in plots when 60 kg P ha^{-1} was applied. In case of N, highest harvest index (35.5) was recorded when N was applied at the rate of 120 kg ha^{-1} and the lowest (31.6) harvest index was observed in 80 kg N ha^{-1} (**Table 7**). This might be due to as the greater fertilizer dosages lead to a better harvest index, according to (Anwar *et al.,* 2017).

Table 5. Biological yield (kg ha^{-1}) of maize as affected by potash, N and its application timing.1030.

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	10714	11820	12443	11659
	100	12283	11333	14383	12667
	120	13216	14350	14117	13894
80	80	14586	12487	13140	13404
	100	13430	11890	14833	13384
	120	13610	13660	15190	14153
-	80	12650	12153	12792	12532 b
-	100	12856	11612	14608	13026 ab
-	120	13413	14005	14653	14024 a
60	-	12071	12501	13648	12740 b
80	-	13875	12679	14388	13647 a
Mean		12973 ab	12590 b	14018 a	
Control					10718
Rest					13194

V6 = Vegetative stage leaf 6th, R2 = reproductive stage, LSD value ($p \leq 0.05$) for N = 1158, LSD value ($p \leq 0.05$) for AT = 1158, Means of the same category followed by different letters(s) reveals significant differences among mean values ($P < 0.05$) using LSD test.

Table 6. Grain yield (kg ha^{-1}) of maize as affected by potash, N and its application timing

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	3740	3831	3860	3810
	100	4037	4096	4240	4124
	120	4349	4439	4538	4442
80	80	4162	4183	4265	4203
	100	4430	4664	4787	4627
	120	4949	5061	5239	5083
-	80	3951	4007	4063	4007 c
-	100	4234	4380	4513	4376 b
-	120	4649	4750	4888	4763 a
60	-	4042	4122	4213	4125 b
80	-	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, LSD value ($p \leq 0.05$) for N = 83.40, LSD value ($p \leq 0.05$) for AT = 83.40, means of the same category followed by different letters(s) reveal significant differences among mean values ($P < 0.05$) using the LSD test

Table 7. Harvest index of maize as affected by potash, N and its application timing

Potash (kg ha^{-1})	N (kg ha^{-1}) Application	Application Timing (AT)			Mean
		AT1	AT2	50% at AT1 + 50% at AT2	
60	80	29.0	26.7	34.1	29.9
	100	31.3	26.6	35.5	31.1
	120	31.4	32.6	34.3	32.8
80	80	31.2	33.4	35.6	33.4
	100	35.4	35.1	34.9	35.1
	120	36.7	37.7	40.2	38.2
-	80	30.1	30.0	34.8	31.6 b
-	100	33.3	30.8	35.2	33.1 b
-	120	34.0	35.2	37.3	35.5 a
60	-	30.5	28.6	34.6	31.3 b
80	-	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, LSD value ($p \leq 0.05$) for N= 2.06, LSD value ($p \leq 0.05$) for AT = 2.06, means of the same category followed by different letters(s) reveal significant differences among mean values ($P < 0.05$) using LSD test

Conclusions and Recommendations

Application of nitrogen at the rate of 120 kg ha^{-1} significantly improved ear length, ear weight, grains per ear, thousand-grain weight, biological yield, grain yield, and harvest index. In the case of application of potash at the rate of 80 kg ha^{-1}, improved ear length, ear weight, grains per ear, thousand-grain weight, biological yield, grain yield and harvest index. Similarly, in the case of application stages of nitrogen, all parameters were improved when nitrogen was applied at AT3 stages. Therefore, it is recommended that application of N at the rate of 120 kg ha^{-1}, K at the rate of 80 kg ha^{-1} and N application at AT3 stages be performed best at the agroclimatic condition of Peshawar.

Novelty Statement

The novelty of this study is to find out the impact of K and N and their application stages, which improved maize yield.

Author's Contribution

SA performed experiments, data collection and wrote a draft of the manuscript. AS analysis the data. SA and ZH data reviewing final draft.

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