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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 4 (8): 949-952, 2001

Response of Maize (*Zea mays* L.) to NP Fertilization under Agro-climatic Conditions of Rawalakot Azad Jammu and Kashmir

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Abstract: Maize (*Zea mays* L.) yield in rainfed areas is generally low due to scanty rainfall and continuous depletion of nutrients from the soil. In Rawalakot, soils are generally deficient in nitrogen and phosphorus, therefore addition of N and P through fertilizers become inevitable for obtaining maximum yield. A field experiment was conducted to explore the response of maize to NP fertilization in terms of growth and yield. In the plots where N alone or NP together were applied, all the growth parameters i.e. height of the plant, number of leaves per plant, leaf area, fresh weight and dry weight increased significantly relative to control plots without fertilizer. The dry matter yield in control was 2933-kg ha^{-1}, which, increased to 11667 kg ha^{-1} when 120 kg N and 90 kg of P_2O_5 were applied. The difference between N alone or NP together was statistically non-significant. Yield components increased significantly when N alone or NP together was applied. The grain yield was increased from 1350 kg ha^{-1} in the control to 4200-4583-kg ha^{-1} in the treatments where either N or NP together was applied. A maximum of 4583 kg of grain ha^{-1} was obtained in the treatment where 120 kg N and 90 kg P_2O_5 ha^{-1} was applied. In the present investigation, a 4 to 5 fold increase in the yield of maize by the application of N and P proves that N & P fertilization substantially enhanced the per acre yield of maize under agro-climatic conditions of Rawalakot Azad Jammu &Kashmir.

Key words: Azad Jammu and Kashmir, fertilization, nitrogen, maize, phosphorus

Introduction

Maize (*Zea mays* L.) is an important cereal used as human food, animal feed and as a raw material for various agro-based industries throughout the world. In terms of total global production maize normally exceeds 400 million metric t/year compared with almost 500 metric tones for wheat and just under 400 metric tones for rice. Maize is an important cereal crop of Pakistan and it ranks third in cereals next to wheat and rice. It is grown on an area of 869 thousand hectares, an annual production of 1251 thousand tones with an average yield of 1440-kg ha^{-1} (Chatha *et al.*, 1986). About 60% of maize is grown under irrigation, the rest is rainfed. Maize is used as a multi-purpose crop for food, feed, fodder, manufacturing of industrial products and as a fuel (dry stalk). Its seed is an important source of carbohydrates, protein and various other mineral nutrients (Bhatti and Soomro, 1996). As a cereal, about 75% of the grain yield is consumed directly as food in the form of *chappatees*, 2.5% as seed, 11.9% starch industries and 10.6% feed and urban food grains (Chatha *et al.*, 1986). The importance of maize as a source of industrial raw material is rapidly increasing, due to its expanding industrial use in Pakistan (Chatha *et al.*, 1986).

Maize is grown on 51% of the total cultivated area in Azad Jammu and Kashmir. The average yield is 1165.6-kg ha^{-1} (Socio-economic study of Azad Jammu & Kashmir, 1992). In spite of ideal growing conditions, yield per hectare of maize in Pakistan and AJK is far below than the developing countries of the world. Among various yield limiting factors, balanced and proper fertilization is an important one. The causes of this gap in yield are injudicious use of inputs and lack of modern production technology. In addition, soil erosion and small annual additions of organic matter from plant sources are the major causes of low soil fertility resulting in low per acre yield. Use of both organic and inorganic fertilizers is still not common among farmers. According to the report presented by Socio-economic study of Azad Jammu & Kashmir (1992), only 43-45 kg N ha^{-1} is applied to maize while application of P is just 2.35 kg ha^{-1} and of the total private farms surveyed throughout AJK, only 1.6% were given optimum fertilization. Under such conditions, low fertilizer application is considered being a major constraint responsible for low maize production in the region. A detailed study of the fertility status of soils in and around Rawalakot showed that soils are severely deficient in nitrogen and phosphorus (Malik *et al.*, 2000).

Maize has been reported to respond well to nitrogenous fertilizers and N levels up to 250-kg ha^{-1} has been recommended under different soil and climatic conditions (Dathotonde and Rahate, 1972). Individual experiments have also documented an increase in crop growth rate and yield associated with increasing soil N availability (Shahzad *et al.*, 1996; Cheema *et al.*, 1997). Tasseling, silking, and maturity periods were reported to be delayed by N application while cob weight, 1000-grain weight, stalk and grain yield were increased significantly (Hussain, 1976; Shahzad *et al.*, 1996). Sabir *et al.* (1987) reported that NP application increased grain yield of maize from 1.72 t ha^{-1} with no fertilizer and 2.89 t with N alone to 4.18 t when NP were applied together.

Keeping in view the importance of maize as grain crop and the role of nitrogen and phosphorus on its productivity, a field experiment was conducted to examine the effect of different levels of N and P on the growth and yield performance of maize. The experiment will help to find the optimum dose of N and P, which, can be recommended for maximum growth, and yield of maize under agro-climatic conditions of Rawalakot Azad Jammu and Kashmir.

Materials and Methods

Field Operation: This experiment was carried out at the Experimental Farm, University College of Agriculture, Rawalakot Azad Jammu & Kashmir during 2000. The seeds of maize variety "Kashmir Gold" were collected from Agriculture Station Padhar District Bagh Azad Kashmir. From the research area, a field of 15 x 13 m^2 with uniform micro-topography was selected, ploughed thoroughly for seed bed preparation. Before sowing, composite sample in the plough layer (0-15 cm) was taken randomly for physical and chemical analysis (Table 1). The experiment was laid out in randomized complete block design with three replications, using a net plot size of 3 x 2 m^2. Following fertilizer levels were tested:

T_0: 0, 0 NP (kg ha^{-1})
T_1: 120, 0 NP (kg ha^{-1})
T_2: 150, 0 NP (kg ha^{-1})
T_3: 0, 60 NP (kg ha^{-1})
T_4: 0, 90 NP (kg ha^{-1})
T_5: 120, 60 NP (kg ha^{-1})
T_6: 120, 90 NP (kg ha^{-1})
T_7: 150, 60 NP (kg ha^{-1})
T_8: 150, 90 NP (kg ha^{-1})

A basal dose of 60 kg k_2O ha^{-1} in the form of potassium sulphate was applied to all plots including control. Nitrogen and phosphorus were applied in the form of urea and single super phosphate at the time of sowing. All the fertilizers were mixed and incorporated well into the soil before sowing to minimize any chance of loss. Maize was sown during last week of May 2000 in 50-cm apart row with a seed rate of 50-kg ha^{-1}. Germination was completed within 7-10 days. Plant population was maintained by thinning when the plants were at four leaves stage to establish a plant-to-plant distance of 22 cm. Two manual hoeing were accomplished with the help of a kasola at 20 days interval right in the early growth stage of the crop to remove weeds. All other agronomic practices were kept uniform. During or at the end of the study the observation on days taken to tasseling, silking and maturity, leaf area $plant^{-1}$ at tasseling, plant height at maturity (cm); number of leaves $plant^{-1}$; green fodder yield (kg ha^{-1}); dry matter yield (kg ha^{-1}); number of grains cob^{-1}; 1000-grain weight and total grain yield (kg ha^{-1}) were recorded.
The crop was harvested during the last week of September. Cobs were removed immediately after harvesting while from each plot all the plants were tied up into bundles. After taking their fresh weight these were allowed to sun-dry on their respective plots for about two weeks for dry weight of crop. The weight of the grains from each plot was converted into hectare basis using the formula:

$$\text{Grain yield (kg ha}^{-1}) = \frac{\text{Grain yield plot}^{-1}}{\text{Plot size (m}^2)} \times 1000$$

Harvest index of maize crop was calculated using the formula:

$$\text{Harvest Index:} \quad \frac{\text{Economic yield}}{\text{Biological Yield}} \times 100$$

For leaf area, ten plants were randomly selected from each plot and their maximum length and breadth were recorded to have estimated leaf area. Correction factor was determined with the help of graph paper using the following formula:

$$\text{C.F.} = \frac{\text{Leaf area taken by graph paper}}{\text{Estimated leaf area}}$$

The actual leaf area was estimated by multiplying estimated leaf area with correction factor and then was averaged to have leaf area per plant.

Statistical Analysis: The data collected from different treatments were statistically analyzed using analysis of variance techniques and Duncan's New Multiple Range test was employed to compare the treatment means at 0.05% probability level (Steel and Torrie, 1984).

Results and Discussion

Plant height (cm): The height of plant is an important growth character directly linked with the productive potential of plant in terms of fodder and grain yield. An optimum plant height is claimed to be positively correlated with productivity of plant. Results showed that different levels of N and P affected the plant height to a considerable extent (Table 2). N alone or in combination with P produced significantly taller plants as compared to the plants grown in control treatment (T_0). On the other hand, plants did not show significant response when phosphorus was applied alone. A maximum of 245.77 cm height was recorded in the plots fertilized with 120-90 kg NP ha^{-1} relative to 153.64 cm height in the control plots. Comparison between the two values indicating a 60% increase in height when 120-90 kg NP ha^{-1} was applied. Data regarding the difference within the treatments revealed that N alone or NP together was at par. However, plant height in these treatments was significantly higher than the height recorded in the treatments of P alone or in the control one. The increasing trend of plant height with N or NP together was probably because of the role of N in cell division and cell enlargement, which ultimately affect the vegetative growth particularly height of the plant. These results are supported by the findings of Khan and Gill (1992) and Shahzad *et al.* (1996).

Leaf area: Leaf area was increased significantly by the application of NP together (Table 2). A maximum leaf area of 43.90 cm^2 was recorded in the plots where 150-90 kg NP ha^{-1} was applied followed by other NP treatments. Taking the various treatments into consideration, the results disclose that a significant difference exists because of N and P fertilization. It is evident that in case of T_8 where maximum level of both N and P was applied, the leaf area matched the maximum level of 43.90 cm^2 relative to the minimum of 32.19 cm^2 in the control treatment. These observations are in agreement with the previous workers who reported increase in leaf size by the application of N and P fertilizers (Shahzad *et al.*, 1996).

No. of leaves per plant: Application of N and P alone or together increased the number of leaves per plant significantly over control but most of the fertilizer treatments were statistically at par with each other (Table 2). The maximum number of leaves (17.14) was recorded in T_5 (120-60), which is not statistically significant to the leaves found in T_7 (16.26), in the treatment where the maximum plant height was observed. The response of leaves to fertilizer observed in the present investigation was similar to those reported by Tiwary *et al.* (1970) and Khan and Gill (1992).

Green fodder yield: Results indicated a significant effect of NP fertilization on fresh fodder yield of maize (Table 2). Application of N and P alone or together increased the fodder yield substantially over control. A maximum yield of 17217-kg ha^{-1} was recorded in the plots fertilized with 120-90 kg NP ha^{-1} against the minimum of 8321 kg in the control treatment. This value showed that more than 50% increase in fresh fodder yield can be obtained if N and P together are applied @ 120-90 kg ha^{-1}. The increase in the yield of green fodder of maize by NP application can be attributed to significant increase in number of leaves/plant, leaf area, plant height. Khan and Gill (1992) also reported similar effects of NP fertilization on maize fresh fodder.

Dry matter yield: The results indicated that most of the fertilizer treatments gave significantly higher dry matter yield as compared to control. The maximum dry matter yield of 11667-kg ha^{-1} was obtained in T_6 (120-90) as compared with 4233-kg ha^{-1} in control indicating almost 3-fold increase in dry matter yield. Within the treatments the trend was almost similar to that recorded in fresh fodder yield. Arani (1975), Prusty *et al.* (1987) and Khalil *et al.* (1988) also reported the similar results.

Tasseling, silking and maturity: Tasseling is the first stage of

Table 1: Some physical and chemical characteristics of soil used during study

Depth (cm)	pH	O.M. (%)	NO_3-N (mg kg^{-1})	Avail. P (mg kg^{-1})	Available K (mg kg^{-1})	$CaCO_3$ (%)	Sand (%)	Silt (%)	Clay (%)	Texture Class
0-15	6.59	0.90	1.88	1.15	52	0.68	41.3	56.7	2.0	Silt Loam
15-30	6.69	0.85	1.92	0.95	47	0.80	31.7	63.3	5.0	Silt
mean	6.64	0.87	1.90	1.03	49.5	0.74	36.5	60.0	3.5	Silt

Table 2: Effect of nitrogen and phosphorus fertilization on vegetative growth of maize

Treat.	Fertilizer applied (kg ha^{-1})			Plant height (cm)	No. of Leaves (per plant)	Leaf area (cm^2)	Fresh fodder weight (kg ha^{-1})	Dry matter yield (kg ha^{-1})
	N	P	K					
T_0	0	0	60	153.64c	12.35c	32.19f	8321g	2933i
T_1	120	0	60	221.20ab	16.21ab	40.32c	13333e	7217f
T_2	150	0	60	216.97ab	16.58a	41.67b	16667c	10000c
T_3	0	60	60	201.10b	13.80b	35.20e	10540f	5550g
T_4	0	90	60	177.14bc	14.01b	36.98d	10210f	5000h
T_5	120	60	60	220.89ab	17.14a	41.72ab	15000d	8883e
T_6	120	90	60	245.77a	15.67ab	42.82a	17217a	11667a
T_7	150	60	60	226.63a	16.26a	43.76a	17209a	11100b
T_8	150	90	60	241.27a	15.64b	43.90a	16117b	9433d

* Any two values not sharing a letter in common differ significantly (P< 0.05)

Table 3: Time taken to maize crop from emergence to maturity following the application of N and P fertilizer

Treat	Fertilizer applied (kg ha^{-1})			Days taken to		
	N	P	K	Tasseling	Silking	Maturity
T_0	0	0	60	48.70f	54.15f	101.19f
T_1	120	0	60	54.22d	59.70b	116.42c
T_2	150	0	60	56.46b	60.47ab	121.42ab
T_3	0	60	60	50.00b	57.20c	110.32e
T_4	0	90	60	50.40e	57.60c	114.17d
T_5	120	60	60	55.70c	59.62b	117.12c
T_6	120	90	60	55.10c	59.12b	118.0bc
T_7	150	60	60	57.00a	61.22a	121.60ab
T_8	150	90	60	57.32a	61.52a	123.62a

* Any two values not sharing a letter in common differ significantly (P< 0.05)

Table 4: Effect of NP fertilization on the yield and yield components of maize

Treat.	Fertilizer applied (kg ha^{-1})			No. of grains/cob	1000-grain weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
	N	P	K					
T_0	0	0	60	288.63c	188.43c	1350d	2933i	46.03
T_1	120	0	60	494.00ab	263.08b	4217b	7217f	58.43
T_2	150	0	60	498.95a	283.84b	4333b	10,000d	43.33
T_3	0	60	60	496.66a	201.64c	1600c	5550g	28.83
T_4	0	90	60	495.71a	227.61c	1621c	5000h	32.00
T_5	120	60	60	484.00ab	326.97a	4250b	8883e	47.84
T_6	120	90	60	510.33a	354.53a	4583a	11667a	39.28
T_7	150	60	60	511.66a	313.82a	4336b	11100b	39.06
T_8	150	90	60	490.33ab	295.02b	4256b	9433c	45.11

* Any two values not sharing a letter in common differ significantly (P< 0.05)

Table 5: Economic analysis of maize production following the addition of nitrogen and phosphorus fertilizer

Treat.	Fertilizer applied			Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Fertilizer cost (Rs)	Income (Rs)			Net return (Rs)	Net return over control (Rs)
	N	P	K				Grain	Straw	Total		
T_0	0	0	60	1350	2933	720	12150	3666	15816	15096	--------
T_1	120	0	60	4217	7217	2280	37953	9021	46974	44694	29598
T_2	150	0	60	4333	10,000	2670	38997	12500	51497	48827	33731
T_3	0	60	60	1600	5550	1716	14400	6937	21337	19621	4525
T_4	0	90	60	1621	5000	2214	14400	6250	20650	18436	3340
T_5	120	60	60	4250	8883	3276	38250	11104	49354	46078	30981
T_6	120	90	60	4583	11667	3774	41247	14584	55831	52057	36960
T_7	150	60	60	4336	11100	3666	39024	13875	52899	49233	34137
T_8	150	90	60	4256	9433	4164	38304	11791	50095	45931	30835

reproductive growth in which male organs (tassels) are developed. Tasseling is necessary for cob formation and final maturity of the crop. Silking on the other hand is the process of formation of thread like silks, which after pollination leads to the development of grains in cob. In the present study, time taken to tasseling, silking and maturity was significantly influenced by NP fertilization (Table 3). It was generally observed that NP fertilizers increased the duration of the crop to mature. In other words these fertilizers delayed the maturity and reproductive stage of the crop. The maturity of crop was delayed up to three weeks while tasseling and silking delayed for 7-10 days period. Comparisons among different treatments revealed that in most of the cases N alone or NP together extended the growth and maturity period as compared to control. Application of P with N did not play its role to reduce the growth period and hasten the maturity of a crop. The reason being not understood. Our results are in line with the findings of Roy and Singh (1986), Bangarwa *et al.* (1988), Shahzad *et al.* (1996).

Number of grains per cob: Number of grains per cob is an important yield component that contributes directly to the final grain yield of the crop. More the number of grains per cob, more will be the yield. Data presented in Table 4 evinced that application of different levels of N and P alone or in combination affected the number of grains significantly. All fertilizer treatments differ significantly from control but the difference within the fertilizer treatments was non-significant. A maximum of 511.66 grains/cob was recorded in T_7 followed by 510.33 grains in T_6 and the difference between the two was non-significant. This showed that combined application of N and P yielded more than 70% grain of maize relative to the control. These results are supported by the findings of Manuel *et al.* (1985) and Shahzad *et al.* (1996).

1000-grain weight: 1000-grain weight is an important indicator, which directly affect the ultimate grain yield because the plumpness of the grain is positively correlated with grain yield. The data in Table 4 revealed a significant increase in 1000-grain weight with the application of N alone and NP together. Comparison of individual treatment means indicated that maximum 1000-grain weight (354.53 g) was observed in T_7. The difference between all the treatments of N and NP together was non-significant. However, the yield was significantly higher than the control and P treatments. Prusty *et al.* (1987) reported similar results.

Grain yield: Statistical analysis indicated a highly significant effect of NP fertilizer on grain yield (Table 4). The comparison of individual treatment means revealed that N alone and NP together produced significantly higher grain yield as compared to the control and P treatments. A maximum of 4583-kg ha^{-1} grain yield was produced in T_6 and it was significantly higher than the grain yield obtained from rest of the treatments. These results showed the justification of fertilizer application for maximum crop production. Samad (1992), Alvi (1994), Shahzad *et al.* (1996) and Chaudhry (1997) also reported a significant difference in grain yield of maize by NPK application.

Harvest Index: The Physiological efficiency of maize in converting the photosynthesis into grain yield is measured in the form of harvest index. The maximum harvest index, i.e. 58.43% was given by T_1 followed by T_5 (Table 4). Control and the treatments where only P was applied gave a minimum harvest index indicating that N played a major role in this parameter of crop development.

Economic Evaluation: Table 5 depicts that a maximum rate of return (Rs. 36960 ha^{-1}) was obtained by T_6. The total income without considering the net return (Rs. 52057) is also maximum in this treatment while the fertilizer cost was Rs. 3774, which can be easily afford by a farmer. The net return obtained in the treatment T_2 was Rs. 48827 and the fertilizer cost in this case is Rs. 2670. This treatment can also be recommended for a farmer having no access to apply phosphatic fertilizer.

From the result of this study, it was concluded that deficiency of two major nutrients in our soil, i.e. nitrogen and phosphorus is a major constraint of low agriculture production. Application of balanced fertilization substantially enhanced the per acre yield of maize. At the moment the overall yield of maize under Azad Jammu and Kashmir is around 1200-kg ha^{-1}. By applying NP at the rate of 120-90 kg ha^{-1}, the maximum yield obtained was 4500-kg which, is 4 times higher than the soil without added fertilizers. This yield is almost equivalent to per hectare yield obtained in Turkey. The level of yield can be increased up to the level of yield obtained in USA or Italy by considering factors other than fertilizer application. In areas like Azad Jammu & Kashmir supply of water/moisture to crops at proper time is a major problem, which also affect the fertilizer use efficiency.

Application of phosphorus alone did not give any significant response to the vegetative growth and grain yield of maize although the soil under study was deficient in P. It may be because of the poor growth during early crop development due to absence of N, the maize plants were unable to utilize the P application properly. Other possibility is that broadcasting of P may not be as effective as the other methods of its application

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