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# Response of Wheat to Different N, P and K Rates of Applied Fertilizers under Rainfed Conditions of Pakistan

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**Abstract**: Response of dryland wheat to nitrogen, phosphorus and potash fertilizer application in different combinations was studied to assess a suitable dose for maximum economic yield. Maximum response in terms of grain yield was found to N followed by P and K application, on overall basis. On the basis of two years results, application of each kg of N (in the presence of P and K) increased 7.78 kg grain at the highest rate. In case of P and K, each kg of $P_2O_5$ and $K_2O$ (in the presence of other two nutrients) gave an average increase in yield of 6.65 and 4.36 kg, respectively. Application of 100 kg N $ha^{-1}$ along with 60 kg $P_2O_5$ and 150 kg $K_2O$ $ha^{-1}$ produced the maximum grain and straw yield.

**Key words:** Wheat, grain and straw yield, N, P and K fertilizers, rainfed conditions

## Introduction

Wheat, a staple food of the people of Pakistan is grown on about 8.23 million hectare with present production of about 20.7 million tones (Anonymous, 2000). Possibility of expanding area under wheat is rather limited. Hence, most of the increase in production should come from increased yield per unit area through better management based on modern package of production technology. This is a challenging task, especially in rainfed areas where wheat is grown on about 25 per cent of the total area and productivity per unit area is almost one half of the irrigated (Anonymous, 2000). Crop yields in barani tract are low mainly due to moisture constraint as the rains are skewed and scanty.

Fertilizers play a key role in achieving the potential of different crops, but fertilizer use in the rainfed areas is very low as compared to irrigated area, i.e., 20 kg N $ha^{-1}$ and 4 kg $P_2O_5$ $ha^{-1}$ (Raced *et al.*, 1998). Soils of Pakistan are deficient in N and P. Hence, response to N and P is common (Malik, 1976). High yielding varieties of crops have high nutritional requirements and generally give marked response to N, P and K (Sharma and Das, 1982). However not much work has been done in Potohar region under rainfed condition of Pakistan. Hence, the objective of this experiment was to investigate the response of wheat to N, P and K application and work out a suitable fertilizer dose for maximum economic yield under rainfed conditions of Potohar.

## Materials and Methods

The experiment was conducted at the research area of National Agricultural Research Centre (NARC), Islamabad during rabi 1998-2000. Treatments included application of each N, P and K at three levels in 9 different combinations. Details are as under:

| N | $P_2O_5$ | $K_2O$ |
|---|---|---|
| ---------- | (kg $ha^{-1}$) | ---------- |
| 0 | 0 | 0 |
| 0 | 60 | 75 |
| 100 | 60 | 75 |
| 150 | 60 | 75 |
| 100 | 0 | 75 |
| 100 | 120 | 75 |
| 100 | 60 | 0 |
| 100 | 60 | 150 |
| 150 | 120 | 150 |

The soil samples were taken from the experimental sites before planting at two depths i.e., 0-15 and 15-30 cm. Chemical characteristics of the soil were determined and $NO_3$-N, P and K were extracted with AB-DTPA extractant for analysis. Nitrogen and phosphorus were determined colorimetrically and K by flame photometer (Winkleman *et al.*, 1990). The $CO_3^{-2}$, $HCO_3^-$, $Cl^-$ and $Ca^{+2}$ + $Mg^{+2}$ from saturated paste extract were determined by the methods of Anonymous (1954). Sowing of wheat was done with a rabi drill, keeping 30 cm row spacing on 5 x 3 $m^2$ plot size. All N, P and K fertilizers were applied at the time of planting. All other agronomic practices were kept the same for all treatments. Experiment was laid out under RCB design using three replications. Data regarding grain and straw yield were recorded at the time of harvest, analyzed statistically by analysis of variance technique (Steel and Torrie, 1980) and treatment means were compared by the Duncan multiple range (DMR) test (Duncan, 1955).

## Results and Discussion

**Soil of experimental site**: The experimental area falls in medium to high rainfall of Potohar region. The soil belonged to Nabipur soil series, coarse loamy mixed, hyperthermic, ustochrept. Other physico-chemical characteristics of the soil are given in Table 1. The soils of experimental sites were normal with neutral to slightly alkaline in reaction and low in N, P and K. The adequate levels of N, P and K are; 20 mg $NO_3$ – N $kg^{-1}$ soil (Sultanpour *et al.*, 1987), > 10 mg P $kg^{-1}$ soil (Olsen and Somer, 1982) and 100 mg K $kg^{-1}$ soil (Sadiq, 1986). Hence, the soils of experimental sites were deficient in all the three nutrients.

**Grain and straw yield**: The grains and biological yield (grain + straw) of wheat as affected by various fertilizer treatments are given in Table 2. The application of P and K led to a significant increase in the yield compared to control. The N, P and K combination of 100:60:150 kg $ha^{-1}$ produced a grain yield of 2,837 kg $ha^{-1}$, the maximum mean grain yield. The average response of different rates of N, P and K is summarized in Tables 3 and 4. Straw yield significantly increased with the application of nitrogen as compared to that of control treatment. Sixty four per cent increase in straw yield was obtained with 100 kg N $ha^{-1}$ while N, P and K treatment increased 84 per cent straw yield as compared to alone PK treatment. Straw yield was further increased by 13 per cent with an additional application of 50 kg N $ha^{-1}$. Phosphorus increased straw yield significantly over control (0-0-0) and NK treatment, which were 125 and 16 per cent respectively. Phosphorus application @ 120 kg $ha^{-1}$ gave 19 percent higher yield over P applied @ 60 kg $ha^{-1}$. Response of wheat to K application in terms of straw yield was less in case of its lower rate, while at higher rate i.e., application @ kg 150 $ha^{-1}$, gave an increase of 177 per cent over control, whereas @ 75 kg $ha^{-1}$ it was 125 per cent. Application of 75 kg $K_2O$ $ha^{-1}$ increased straw yield by 10 per cent and the increase was 35% with 150 kg $K_2O$ $ha^{-1}$ over NP treatment. In short, one kg addition of each nutrient fertilizer (in the presence of other two nutrients) gave an increased straw yield by 23.9, 18.6 and 14.8 kg, respectively (Table 3).

Grain yield was similarly affected with N application and response to N was more or less similar to that of straw yield (Table 4). The application of N @ 100 kg $ha^{-1}$ resulted in more increase in yield as compared to 150 kg $ha^{-1}$ application. A gradual increase in

Table 1: Chemical characteristics of the experimental site at NARC 1998-99 and 1999-2000

| Depth (cm) | pH | ECe ($dSm^{-1}$) | N | P | K | Ca+Mg | $HCO_3$ | Cl | Zn | Cu | Fe | Mn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ------ ($mg\ kg^{-1}$)------ | | | --------- (m eq. $L^{-1}$)--------- | | | ---------- ($mg\ kg^{-1}$)---------- | | | |
| 1998-1999 | | | | | | | | | | | | |
| 0-15 | 7.7 | 0.44 | 0.85 | 1.87 | 60 | 25 | 5.0 | 5.50 | 0.38 | 0.28 | 7.0 | 7.0 |
| 15-30 | 7.9 | 0.43 | 0.62 | 4.67 | 42 | 22 | 5.0 | 6.00 | 0.32 | 0.28 | 4.2 | 3.2 |
| 1999-2000 | | | | | | | | | | | | |
| 0-15 | 7.6 | 0.57 | 6.40 | 0.18 | 58 | 5.0 | 0.65 | 2.25 | 0.34 | 0.50 | 8.2 | 9.6 |
| 15-30 | 7.7 | 0.60 | 8.70 | 1.25 | 62 | 5.5 | 0.08 | 2.25 | 0.30 | 0.36 | 5.6 | 6.8 |

Table 2: Effect of applied N, P and K fertilizers on grain and straw yield of wheat at NARC 1998-99 and 1999-2000

| Treatments | | | Grain yield ($kg\ ha^{-1}$) | | | Straw yield ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|
| N | $P_2O_5$ | $K_2O$ | 1998-99 | 1999-2000 | Means | 1998-99 | 1999-2000 | Means |
| 0 | 0 | 0 | 900f | 1103e | 1002 | 2780g | 3410g | 3085 |
| 0 | 60 | 75 | 1420e | 1538d | 1479 | 3849f | 4639f | 4244 |
| 100 | 60 | 75 | 2350e | 2627b | 2439 | 6704d | 7181d | 6943 |
| 150 | 60 | 75 | 2548b | 2743b | 2646 | 8419a | 8230b | 7823 |
| 100 | 0 | 75 | 1800d | 2136c | 1968 | 5300e | 6701e | 6001 |
| 100 | 120 | 75 | 2709b | 2746b | 2728 | 7827c | 8639a | 8233 |
| 100 | 60 | 0 | 2231c | 2133c | 2182 | 5153e | 7459c | 6326 |
| 100 | 60 | 150 | 2723b | 2950a | 2837 | 8348b | 8750a | 8549 |
| 150 | 120 | 150 | 2921a | 3060a | 2991 | 8567a | 8875a | 8721 |
| LSD (0.05) | | | 185.6 | 141.5 | | 316.6 | 316 | - |
| CV | | | 004.92 | 003.48 | | 001.68 | 2.56 | - |

LSD at Probability 0.05 Means followed by different letters in columns are significantly different from each other at $P < 0.05$

Table 3: Effect of applied N, P and K fertilizers on wheat straw yield

| Treatments | | | Straw wt. | Increase over control | | Response to individual nutrient: N | | Increase over N1 | |
|---|---|---|---|---|---|---|---|---|---|
| N | $P_2O_5$ | $K_2O$ | ($kg\ ha^{-1}$) | ($kg\ ha^{-1}$) | % | ($kg\ ha^{-1}$) | % | ($kg\ ha^{-1}$) | % |
| 0 | 0 | 0 | 3085 | - | - | - | - | - | - |
| 0 | 60 | 75 | 4244 | 1129 | 38 | - | - | - | - |
| 100 | 60 | 75 | 6943 | 3858 | 125 | 2699 | 64 | - | - |
| 100 | 60 | 150 | 7823 | 4338 | 153 | 3579 | 84 | 880 | 13 |
| | | | | | | $P_2O_5$ | | Increase over P1 | |
| 0 | 0 | 0 | 3085 | - | - | - | - | - | - |
| 100 | 0 | 75 | 6001 | 2916 | 94 | - | - | - | - |
| 100 | 60 | 75 | 6943 | 3858 | 125 | 942 | 16 | - | - |
| 100 | 120 | 75 | 8233 | 5148 | 167 | 2232 | 37 | 1290 | 19 |
| | | | | | | $K_2O$ | | Increase over K1 | |
| 0 | 0 | 0 | 3085 | - | - | - | - | - | - |
| 100 | 60 | 0 | 6326 | 3241 | 105 | - | - | - | - |
| 100 | 60 | 75 | 6943 | 3858 | 125 | 617 | 10 | - | - |
| 100 | 60 | 150 | 8549 | 5464 | 177 | 2223 | 35 | 1606 | 23 |

Table 4: Effect of applied N, P and K fertilizers on wheat grain yield

| Treatments | | | Grain yield | Increase over control | | Response to individual nutrient: N | | Increase over N1 | |
|---|---|---|---|---|---|---|---|---|---|
| N | $P_2O_5$ | $K_2O$ | ($kg\ ha^{-1}$) | ($kg\ ha^{-1}$) | % | ($kg\ ha^{-1}$) | % | ($kg\ ha^{-1}$) | % |
| 0 | 0 | 0 | 1002 | - | - | - | - | - | - |
| 0 | 60 | 75 | 1479 | 477 | 47 | - | - | - | - |
| 100 | 60 | 75 | 2439 | 1437 | 143 | 960 | 65 | - | - |
| 100 | 60 | 150 | 2646 | 1644 | 164 | 1167 | 79 | 207 | 8 |
| | | | | | | $P_2O_5$ | | Increase over P1 | |
| 0 | 0 | 0 | 1002 | - | - | - | - | - | - |
| 100 | 0 | 75 | 1968 | 966 | 96 | - | - | - | - |
| 100 | 60 | 75 | 2439 | 1437 | 143 | 471 | 24 | - | - |
| 100 | 120 | 75 | 2728 | 1726 | 172 | 760 | 38 | 289 | 12 |
| | | | | | | $K_2O$ | | Increase over K1 | |
| 0 | 0 | 0 | 1002 | - | - | - | - | - | - |
| 100 | 60 | 0 | 2182 | 1180 | 118 | - | - | - | - |
| 100 | 60 | 75 | 2439 | 1437 | 143 | 257 | 12 | - | - |
| 100 | 60 | 150 | 2837 | 1835 | 183 | 655 | 30 | 398 | 16 |

biomass was observed in both N rates when compared with control. Grain yield increased significantly with N, P and K application. An increase of 143 per cent in grain yield with N, P and K @ 100, 60, 75 was obtained over control. An increase in yield by 65 and 79 per cent with N @ 100 kg $ha^{-1}$ and 150 kg $ha^{-1}$ over constant PK treatment were obtained, respectively. Eight per cent more grain yield was obtained with higher level of N compared to lower level of its application. Phosphorus application increased grain yield significantly. A gradual increase in yield was observed with increasing P rates over constant N and K treatment and no fertilizer application. Response of wheat to P in terms of grain was 24 and 38 per cent @ 60 and 120 kg $ha^{-1}$ in the presence of N and K application, respectively. Similarly, Rice *et al.* (1988) showed a significant response of wheat to combined application of N and P at four sites in the rainfed areas of Potohar, Pakistan, Although wheat grain and straw yield responded positively to fertilizers N and P however, all the variations observed were not related to soil test values. They also observed much less response to applied P fertilizers on sites with P soil test values > 10 mg P $kg^{-1}$ soil.

As far as potash is concerned the trend of response was similar to that of phosphatic fertilizer. However, the response of wheat to lower level of potash (75 kg $ha^{-1}$) application was lesser as compared to higher level (150 kg $ha^{-1}$). Application of 75 and 150 kg $K_2O$ $ha^{-1}$ resulted in an increase grain yield of 12 and 30 per cent respectively over N, P treatment. The reason is that these soils contain vermiculite minerals in clay fractions (Krauss *et al.*, 1996) and the small amounts of added fertilizer K is not always available to plants, it is taken by the clay particles of soil, fixed in clay lattices (Bajwa, 1985). This is the reason that application of K at its higher level gave more response as compared to that of lower rate of application.

Response of wheat in terms of grain yield can be summarized that each kg of N, P and K (in the presence of other two elements at constant rate) resulted in increase of 7.78 kg, 6.33 and 4.36 kg grain, respectively. These results are in line with those of Gill *et al.* (1995). They also reported a significant improvement in wheat yield with N, P and K application in different combinations. Similarly Saleem (1983) reported the response of rainfed wheat to N, P and K fertilization, which confirms these findings.

Application of balanced fertilizers is needed for maximum economic yield under rainfed conditions. Yield response pattern showed that the N application increased the yield maximum followed by P and K fertilizers.

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