



Asian Journal of Plant Sciences

ISSN 1682-3974

science
alert

ANSI*net*
an open access publisher
<http://ansinet.com>

Wheat Response to Nitrogen and Phosphorus Fertilizers as Affected by Cropping Sequence in Rainfed Areas of Pakistan

¹M. E. Akhtar, ²W. A. Rice and ¹Rohul Amin

¹Potash Development Institute, National Agricultural Research Center (NARC), Islamabad, Pakistan

²Agriculture Canada, Beveridge Research Station, Canada

Abstract: Four levels of N (0, 40, 80, 120 kg ha⁻¹) and P (0, 30, 60, 120 kg ha⁻¹) in all possible combinations as urea and single super phosphate were applied to wheat crop sown after millet, millet green manuring and fallow at two sites in the rainfed areas of Pakistan. The grain yield increased significantly with combined application of N and P fertilizers. A marked interaction of fertilizer N and P on grain yield was observed after fallow and millet. Wheat grain and straw yield responded positively to fertilizers N and P, however all the variations observed in wheat yield are not correlated with extractable values of N and P. The polynomial correlation coefficient between NaHCO₃-extractable soil P values and grain yield was fairly high. Out of four experiments response surface model predicting crop yield proved good at two sites only.

Key words: Rainfed, N and P fertilizers, NaHCO₃-extractable, polynomial correlation, grain yield, crop yield

Introduction

Food production in Pakistan is not keeping pace with population growth. The yield of the major crops is stagnated. The farmers of rainfed areas practice low input agriculture because of high risk due to climatic uncertainties (Razzaq *et al.*, 1990). However judicious use is necessary not only for increasing agricultural output but also for realizing maximum return from the investment of fertilizer. Advice to the farming community for levels of fertilizer application is generated from field trials, using different rates of fertilizer nutrients and deriving mean optimum rates from these trials for various agro-climatic zones.

Soil organic matter content or total N is used as a soil test for predicting fertilizer N requirement in Pakistan (Malik *et al.*, 1984). However, the reliability of this method for any crop has not been established. It has been shown that correlation between total soil N, NH₄-N and NO₃-N is very poor in soils of rainfed areas of Pakistan and that the crop response to fertilizer N is greatly affected by the initial levels of soil NH₄-N plus NO₃-N (Rice *et al.*, 1986). Use of N in rainfed wheat is 32 kg ha⁻¹ against the optimum use of 71 kg ha⁻¹ and the use of P₂O₅ is only 9 kg ha⁻¹ against the optimum use of 48 kg ha⁻¹ (Anonymous, 1993). The study was conducted with the objective of developing fertilizer recommendations for wheat under various cropping sequence of barani conditions in Potohar area, Pakistan.

Materials and Methods

The study consisted of four field experiments at two different sites. Three experiments were conducted on Gujranwala soil series, at the National Agricultural Research Centre (NARC), Islamabad and the fourth experiment on Rajar series, in a farmer's field at Mandra, Rawalpindi. Some physical and chemical characteristics of these soils are given in Table 1. The methods used for soil analysis have been described by Winkelman *et al.* (1986).

Table 1: Chemical and physical properties of the experimental soils

Parameters	Gujranwala soil series	Rajar soil series
Texture	Silty clay loam	Sandy clay loam
pH	7.6	7.8
EC (dS m ⁻¹)	1.2	2.1
Organic matter (%)	0.72	0.65
NH ₄ OAc extractable K (mg kg ⁻¹)	79	164
USDA-Classification	Typic ustorthent	Typic torriorthent

Nitrogen @ 0, 40, 80, 120 and P @ 0, 30, 60, 120 kg ha⁻¹ in single as well as in all possible combinations were tested using urea and single super phosphate fertilizers. The experiment was laid out with factorial arrangements in a randomized complete block design

having four replications. The fertilizers were broadcast and disked into plots of 1.2 x 10 m² prior to seeding of wheat.

Sodium bicarbonate extractable P was found 20.7, 10.0, 6.8 and 12.9 mg kg⁻¹ at these sites, respectively. While NH₄-N and NO₃-N were 16.0 and 11.2 mg kg⁻¹ at site-I, 6.6 and 35.6 at site-II, 5.2 and 10.7 at site-III, and 17.1 and 21.4 at site-IV, respectively.

There were six rows in each plot and only the central four rows with a plot size of 8 m² were harvested at maturity. Weeding was done manually during the growing season. The grain and straw samples were collected, air-dried and weighed.

The data obtained were analyzed using ANOVA (Steel and Torrie, 1980). Response surface curve methodology (multiple regressions using a quadratic model) was adopted to predict the fertilizer response with the equation given below:

$$Y = a + b_1N + b_2N^2 + b_3P + b_4P^2 + b_5NP$$

Where N and P stand for nitrogen and phosphorus fertilizers, Y for yield of the crop, a and b unknown constants (Khan *et al.*, 1987).

Results and Discussion

Grain and straw yield: The statistical analysis indicated that treatments effects were significant for straw and biomass (grain plus straw) at all the four sites (Table 2). However, the effect of fertilizers on grain yield was significant only at site-IV. Relatively higher, but non-significant, grain yield was obtained with N₆₀:P₃₀ treatment at sites-I, II and III. In case of site-IV, N₄₀:P₆₀ produced higher grain weight. The highest rate of combined N and P, i.e. N₁₂₀:P₁₂₀ produced relatively more grain weight, though differences were non-significant compared to other treatments.

Application of N fertilizer alone tended to depress the grain yield in summer fallow-wheat sequence at sites-II and IV (Fig 1). Application of P fertilizer at lower rates showed a positive trend on grain yield at all sites except at site-I (Table 2), where native extractable P level was very high (Table 1). Hobbs *et al.* (1986) observed that on the mera land (soils where sufficient organic manures are not added) N or P fertilizer applied alone had no significant effect on crop yield. Moreover, combined application of N and P was needed for higher yields under rainfed conditions. Arif *et al.* (1993) observed maximum economic and biological yield of three wheat cultivars with combined application of N and P @ 140: 60 kg ha⁻¹. Similarly, Akhtar *et al.* (2002) showed that combined application of NP and K was required for the maximum economic yield of wheat in rainfed areas of Pakistan.

Nitrogen fertilizer application did not affect grain and straw yields at site-II, i.e fallow-wheat sequence on Gujranwala soil series (Table 3). Whereas, on sites-I and III of the same soil series but with different cropping sequence at NARC, i.e. wheat after millet

Table 2: Wheat grain yield response to different N and P fertilizer rates at different sites

Fertilizer (kg ha ⁻¹)		Wheat yield (kg plot ⁻¹)*			
N	P	Site-I	Site-II	Site-III	Site-IV
0	0	1.49	1.17	0.55	0.88
0	30	1.00	1.51	1.04	1.12
0	60	1.12	1.36	0.67	0.89
0	120	1.07	1.40	1.06	1.25
40	0	1.14	1.15	1.34	0.43
40	30	1.24	1.38	1.15	1.91
40	60	1.74	1.41	1.47	2.68
40	120	1.73	1.32	1.20	2.57
80	0	1.62	0.95	1.25	0.48
80	30	1.80	1.48	1.75	0.57
80	60	1.78	1.22	1.54	2.68
80	120	1.79	1.28	1.39	2.83
120	0	1.53	1.06	1.30	0.45
120	30	1.59	1.34	1.48	2.26
120	60	1.71	1.24	1.19	2.90
120	120	1.30	1.31	1.53	2.95
LSD (0.1) value		NS	NS	0.51	0.89

* Plot size = Eight square meter NS: Non-significant

Table 3: Significance of N and P treatment responses on growth parameters of wheat

Parameters	Site-I	Site-II	Site-III	Site-IV
Grain weight				
N	4.49**	1.05	18.70	19.30
P	0.49	5.98**	2.51	53.52
N X P	1.07	0.28	2.15*	04.82**
Straw weight				
N	13.55**	0.26	25.66**	15.31
P	0.25	7.65**	1.23	47.93
N X P	1.71	1.27	0.53	03.31**

*: P < 0.1

**: P < 0.05

green manuring and after millet harvest, had a marked response to N fertilizer. Response to N fertilizer on the site-IV with fallow-wheat sequence, i.e., Rajar series at Mandra was significant despite mineral N contents of this site being almost equal to that of site-II, where no response to fertilizer N was observed. Rice *et al.* (1986) also observed high build-up applied levels of NO₃-N + NH₄-N in fallow field of the rainfed area and wheat response to N fertilizer N was greatly affected by the initial levels of NO₃-N + NH₄-N. The grain and straw yield response to P fertilizer was observed at two sites, i.e. site-II and IV (Table 4). At sites-II and III non-significant treatment effects were observed. At site-IV all P levels tested produced similar results but higher than the control. It indicates that the requirements for vegetative growth and grain production were met with lower rates of P fertilizer application.

The levels of extractable P at site-I were quite high and these levels are generally considered adequate for wheat (Olsen and Somers, 1982; Pala and Matat, 1987), hence no response was observed to the applied P fertilizer. Soil extractable P levels at sites-II and III were low and a marked response to P fertilizer was observed only at site-II, however a little response at site-III. This indicates that large heterogeneity occurred in the soil and profile characteristics other than NP levels that affected the crop response to applied fertilizers. A marked interaction of fertilizers N and P was observed at sites-III and IV for grain yield and for straw weight only at site-IV.

Soil test values and crop response: An attempt was made to relate soil test values with relative crop yield. The extractable P levels and grain yield response to P fertilizer followed a typical response pattern; with low levels of soil test values a high response and vice versa (Fig. 1A). However, the response patterns were markedly influenced by the application of varying levels of N fertilizer (Fig. 1B). In contrast to P response, it was difficult to correlate

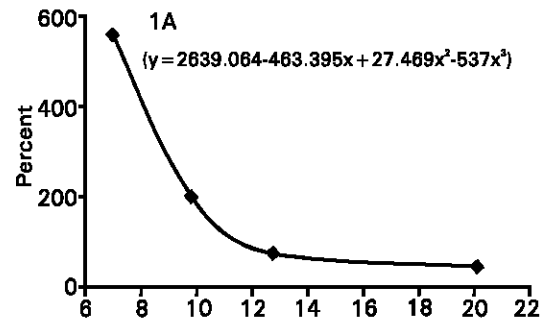


Fig. 1A: Wheat grain yield response (%) as related to extractable P in soil

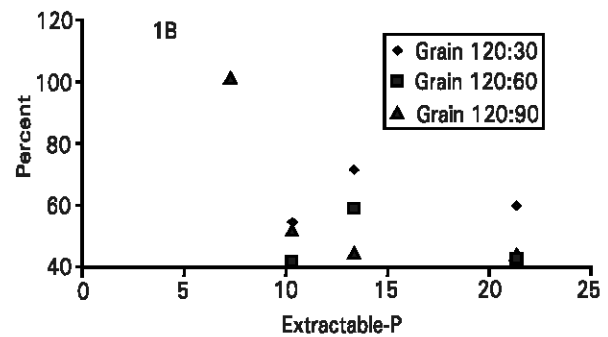


Fig. 1B: Wheat grain yield response (%) in relation to extractable-P in soil at various levels of N fertilizer

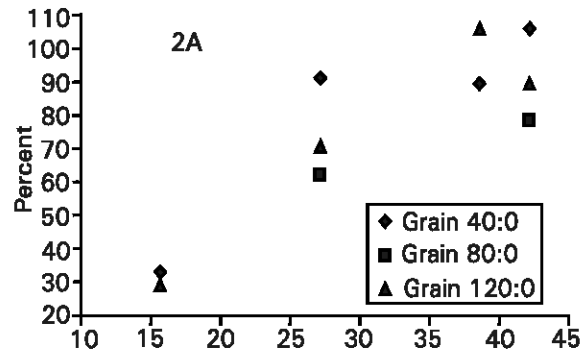


Fig. 2A: Wheat grain yield response (%) as related to mineral N in soil

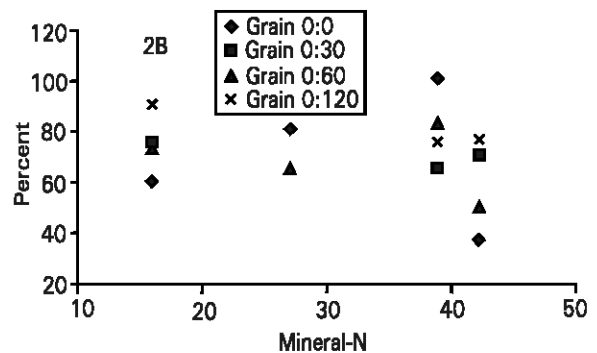


Fig. 2B: Wheat grain yield response (%) as related to mineral-N in soils with addition of graded levels of P fertilizer

Akhtar *et al.*: Wheat response to N and P fertilizers in rainfed areas

Table 4: Response equations for grain and straw yield at different sites

Sites	Parameters	Constant	N	P	N ²	P ²	NP	R ²	Multiple R
I	Grain	1322.99	1660.00	4.61	-0.0999	-0.028	-0.009	0.187	0.432
	Straw	3981.58	23.79	1.581	-0.0153	-0.035	0.040	0.354	
II	Grain	1523.13	-2.87	8.98	0.0103	-0.061	0.0049	0.162	0.402
	Straw	3512.95	6.275	2.327	-0.053	-0.12	0.017	0.163	0.439
III	Grain	872.96	19.77	5.65	-0.118	-0.028	-0.028	-0.473	0.661
	Straw	3508.8	52.77	67.65	-0.276	-0.042	0.061	0.545	0.789
IV	Grain	345.56	22.68	48.46	-0.164	-0.239	-0.15	0.736	0.859
	Straw	1145.25	36.90	70.151	-0.275	-0.451	-0.19	0.732	0.709

clearly soil test values of mineral N (NH₄-N + NO₃-N) with grain yield (Fig. 2A); addition of graded levels of fertilizer P rendered these relationships more intricate (Fig. 2B). Similarly, Pala and Matar (1987) could not develop relationship between soil test values of mineral N with wheat grain yield.

Response surface equations for grain yield: In order to obtain fertilizer response relationship, the quadratic response surface (multiple regressions) model was used. The characteristic of the multiple regression equations suggested that the predictability of this model is reliable only in the case of site-IV experiment (high R² value), followed by site-III (Table 4). In case of sites-I and II, the R² values were too low and thus of the limited use for fertilizer response predication. Bhatti and Khan (1999) also tested regression models for predicting the response of wheat to N fertilizer and developed site-specific N requirements both for irrigated and rainfed conditions. These models successfully predicted the fertilizer requirements. The trials conducted by Bhatti and Khan (1999) were simple as the studied a single variable i.e., nitrogen fertilizer as compared to results of the present set of experiments where two variable (N&P) and their different levels were tested.

The cropping sequence and crop management practices affect soil N and P levels and the crop response to applied N and P fertilizer. The relationship between soil P test values and grain yield was predictable to a large extent, whereas it was difficult to correlate mineral N values with grain yield.

Acknowledgments

Authors gratefully acknowledge Dr. M. I. Khan and Mr. N. A. Khan, Computer and Statistical Section and Mr. M. Zameer Khan and Mr. Sagheer Ahmad, Potash Research Programme, National Agricultural Research Centre, Islamabad, for their technical assistance.

References

Akhtar, M.E., M.Z. Khan, S. Ahmed and M. Akhtar, 2002. Response of wheat to different N, P and K rates of applied fertilizers under rainfed condition of Pakistan. *Asian J. Pl. Sci.*, 1: 337-339.

Arif, H.A., A. Sajid and N. Ahmed, 1993. Physiological effects of N and P application on wheat yield components of three cultivars. *Pak. J. Soil Sci.*, 8: 47-50

Bhatti, A.U. and M. Khan, 1999. Validation of regression models in the field for estimate of N requirements of wheat. *Pak. J. Soil Sci.*, 17: 9-4

Hobbs, P.R., B.R. Khan, A. Razzaq, B.M. Khan, M. Aslam, N.I. Hashmi and A. Majid, 1986. Results from agronomic on-farm *barrani* wheat in the high and medium rainfall areas of the northern Punjab for 1983 to 1985. PARC/ CIMMYT Wheat Paper No. 86-8. Pakistan Agricultural Research Council, Islamabad, Pakistan.

Khan, M.I., M.M.I. Nizami and N.A. Khan, 1987. Response of surface approach to derive economically optimal fertilizer doses for wheat production on two soil families. Occasional Paper; Pakistan Agricultural Research Council, Islamabad, Pakistan.

Malik, D.M., M.A. Khan and T. A. Chaudhary, 1984. Analysis manual for soils plants and waters. Soil Fertility Survey and Soil Testing Institute, Department of Agriculture, Punjab, Lahore, Pakistan.

Anonymous, 1993. Opportunities of expanding crop production in Pakistan. Economic and foreign exchange impacts. Economic Wing Monograph No. 4. Ministry of Food Agriculture and Cooperative, Government of Pakistan, Islamabad.

Olsen, S.R. and L.E. Somers, 1982. Phosphorus: *In* A. L. Page (ed.) *Methods Soil Analysis, Agronomy 9. Part 2* (2nd ed.) Am. Soc. Argon. Madison, Wisconsin, USA.

Pala, M. and A. Matar, 1987. Soil test calibration with N and P for wheat under dryland conditions in Syria. *In* A. Mattar (ed.). *Proc. Second Regional Soil Test Calibration Workshop*. Ankara, Turkey, Sept. 1-6. ICARDA, Aleppo, Syria.

Razzaq, A., N.I. Hashmi, B. Khan, B.R. Khan and P.R. Hobbs, 1990. Wheat in Barani Areas of Northern Punjab: A Synthesis of On-farm Research Results, 1982-88. PARC/CCIMMYTpaper 90-2, Islamabad, Pakistan.

Rice, W.A., M.B. Tahin, R. Amin and G.E. Winkleman, 1986. Soil test methods for determining the nitrogen fertilizer requirements of rainfed crops in Pakistan, pp: 67-85. *In* P. N. Soltanpour (ed.). *First Regional Soil Test Calibration Workshop*, ICARDA, Aleppo, Syria.

Steel, R.G.D. and J.H. Torrie, 1980. Principles and procedures of statistics. McGraw Hill Book Co., New York, USA.

Winkleman, G.E., R. Amin, W.A. Rice and M.B. Tahir, 1986. Methods manual: soil laboratory. Pakistan Agricultural Research Council, Islamabad, Pakistan.