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RESPONSE OF CANDIDATE WHEAT VARIETY 'NIA-8/7' TO DIFFERENT LEVELS/RATIOS OF NITROGEN AND PHOSPHORUS

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Abstract

Field experiments were conducted for two consecutive years (2007-08 and 2008-09) to evaluate the response of a candidate wheat variety NIA-8/7 to different ratios of nitrogen and phosphorus. Four levels of N (0, 120, 150 and 180 kg ha^{-1}) and nine levels of P_2O_5 (0, 30, 40, 45, 60, 75, 90, 110 and 135 kg ha^{-1}) along with 60 kg K_2O ha^{-1} in 10 combinations were employed in 4:1, 4:2 and 4:3 N:P_2O_5 ratios. The results showed that the grain yield increased significantly ($P < 0.05$) with fertilizer levels up to 150 kg N, and 110 kg P_2O_5 ha^{-1}. The differences in grain yield at 150:110 and 180:135 levels of N: P_2O_5 were not significantly different with each other during both years. Yield traits viz., spike length, number of grains per spike and 100-grain weight were higher at 150:110 kg N and P_2O_5 ha^{-1} as compared with other treatments. The test genotype NIA-8/7, produced significantly highest yield (5417 kg ha^{-1}) at 150 kg N and 110 kg P_2O_5 ha^{-1}, therefore, it is observed that it could be adopted as the most economical dose for obtaining the maximum yield from this wheat genotype under the agro-climatic conditions of Sindh.

Introduction

Plant nutrition is the science that studies the effect of element on plant growth and development, determines the forms and conditions of availability and uptake, and establishes the ranges of beneficial and detrimental effects (Jones, 2003). Optimization of the mineral nutrition is one of the factors that limit plant growth and production. Among the mineral elements, nitrogen (N) is one of the major plant nutrients applied in the form of chemical fertilizers. It is essential for the formation of amino acids, the building blocks of proteins (Ma, 2004). Phosphorus is another essential plant mineral involved in the formation of nucleic acids, phospholipids and ATPs (Schachtman *et al.*, 1998). Phosphorus counter balances the effect of excessive nitrogen by hastening plant maturity, improving grain quality and retarding excessive vegetative growth (Theodorou & Plaxton, 1993). When the soil is deficient in phosphorous, the response of crop to nitrogen would also be reduced (Senigagliesi *et al.*, 1983; Tahir, 1980). However, the judicious use of these elements in the form of fertilizers can increase yield from 30-47 % (Maseh, 1994).

Increasing population, waterlogging and salinity are converting the arable land into non-agricultural uses (Alam & Khan, 1999) and these are considered as main obstacles to modern agriculture and ultimately affecting crop productivity. Moreover, population is increasing in the geometric ratio while crop productivity increases in arithmetic ratio (Khan *et al.*, 2010). Therefore, there is a dire need to improve vertical crop productivity rather than longitudinal increase. The vertical increase can be obtained by cultivating high yielding genotypes endowed with better agronomic practices and adequate package of production technology. Crop genetic contributes only 20-30% in the enhancing the crop productivity (Khan *et al.*, 2002), whereas, agronomic practices share 70-80% in the discipline of crop productivity.

Wheat (*Triticum aestivum* L.) is amongst the major cereal crops in Pakistan and contributes 14.4% to agriculture sector and 3.1% to the GDP. It is being grown on 9.05 million hectares, with an average yield of 2639 kg ha^{-1} in Pakistan (Anon., 2010), which is very low as compared to other wheat producing countries of the world. Improper use of fertilizer is one of the major dilemma to achieve high crop productivity. Balanced fertilization not only accelerates nutrient uptake and maintains soil nutrient balance, but also increases grain yield and farmers income. The importance of balanced fertilization in maintaining soil fertility for sustainable production is highly evident. Genotype response always depends on the environment whereas, rhizosphare environment depends on the soil and application of fertilizer. Different nutritional requirements are needed by different genotypes which need to be investigated for obtaining high crop productivity. The self sufficiency in wheat can only be obtained by applying balance fertilizer to each genotype. The present study was therefore, planned to investigate the optimum and balanced doses of nitrogen and phosphorus for exploiting maximum potential of new candidate wheat variety NIA-8/7 developed by NIA, Tando Jam, Sindh.

Materials and Methods

Field studies were carried out on a fixed layout during two growing seasons (2007-08 and 2008-09) at Nuclear Institute of Agriculture (NIA), Tando Jam to study the response of wheat crop to N and P fertilizer application. The experimental site was silty clay in texture, non-saline in nature (ECe, 0.63 and 0.59 dS m^{-1}), low in organic matter (7.8 and 8.5 g kg^{-1}), Kjeldahl N (0.05 and 0.045 %) and Olsen's P (6.4 and 6.9 mg kg^{-1}). Four levels of N (0, 120, 150 and 180 kg ha^{-1}), nine levels of P_2O_5 (0, 30, 40, 45, 60, 75, 90, 110 and 135 kg ha^{-1}) along with 60 kg K_2O ha^{-1} in ten combinations were employed in 4:1, 4:2 and 4:3 N: P_2O_5 ratios. The experiment was laid out in a randomized complete block design with four replications. The net plot size was 4m x 4m in both the years. Phosphorus in the form of triple super phosphate (TSP) was applied at the time of sowing according to the quantity required for each treatment. The required quantity of N in the form of urea was applied in two splits; half at sowing and the remaining half at the time of second irrigation. Pre-sowing soil samples upto 30 cm depth were collected and analyzed for their physico-chemical properties such as soil texture (Koehler *et al*., 1984), soil $pH_{(1:5)}$ (Mclean, 1982) using 105 Ion Analyzer pH Meter, soil organic matter (Nelson & Sommers, 1982) and P by Spectrophotometer "Spectronic 21" using required standard solutions. Total nitrogen in soil and plants was determined using Kjeldahl distillation procedure as described by Bremner, 1996. Seed of the candidate wheat variety NIA-8/7 was sown with single row hand drill at inter-row spacing of 30 cm with the seed rate of 150 kg ha^{-1}. The requisite agronomic measure was adopted during the entire growth period. At maturity the data were recorded for biological yield after harvesting the crop. The plant samples were then collected randomly from each treatment and threshed for grain and straw. Both of the plant parts were dried at 70 ^{o}C in an oven at a constant weight for determination of N and total P. A uniform sub portion of the dried material was ground in Wiley's mill and a known quantity of the ground material was digested by modified Kjeldahl's method in which N is converted in NH_4^+ form by digestion with H_2SO_4. The NH_3 was distilled into boric acid and determined by titration with standard H_2SO_4 (Jackson, 1962). Total P was also determined by digesting the plant material in HNO_3: $HClO_4$ mixture prepared in 5:1 ratio. The digested material was analysed to determine total P by metavanadate yellow colour method as described by Jackson (1962). The data obtained were subjected to statistical analysis by computer software (Anon., 1982).

Results and Discussion

Plant height, number of grains spike^{-1} and spike length (cm): The overall results showed that plant height was significantly influenced by various combinations of fertilizer (Table 1). The treatment receiving 180 kg N and 135 kg P_2O_5 ha^{-1} produced the maximum plant height (102.3 cm) while the treatment 150 kg N and 110 kg P_2O_5 ha^{-1} produced plant height of 98.8 cm. Minimum plant height of 77.1 cm was recorded in control. All the fertilizer treatments were significantly different from control. The treatment 120 kg N+ 30 kg P_2O_5 and 120 kg N + 60 kg P_2O_5 ha^{-1} gave 89.4 and 91.3 cm plant heights respectively which was significantly lower than the other fertilizer treatments.

Data pertaining to number of grains per spike given in Table 1 revealed that various nitrogen and phosphorus rates significantly affect the number of grains per spike. The highest number of grains per spike (66.8) was recorded in case of 150 kg N with110 kg P_2O_5 ha^{-1} followed by 120 kg N & 90 kg P_2O_5 ha^{-1} (62.1) grains per spike. The lowest number of grains per spike (33.5) was recorded in control treatment. These results are in accordance with those of Kadry *et al*., (1984) and Dilbaugh *et al*., (1988).

Significant ($p<0.05$) differences were observed for spike length among various fertilizer treatments (Table 2). Treatment 150 kg N & 110 kg P_2O_5 ha^{-1} produced the longest spikes (13.6 cm). This was followed by treatment 180 kg N & 135 kg P_2O_5 ha^{-1} produced 12.9 cm long spikes. The shortest spike length (8.6 cm) was noted in control. Our findings are in agreement with those reported by Ahmad & Rashid (2003).

The results are in accordance with the findings of Khan *et al*., (2009) who reported that the plant height increased significantly with increasing the application of N and P_2O_5. Nitrogen is a part of many critical plant components including chlorophyll, which is considered to be the heart of photosynthesis. The increased level of N may have increased the rate of photosynthesis which increased the growth and plant height. At the same time adequate phosphorous enhances many physiological processes including seed production (both number of seed and weight) and the fundamental processes of photosynthesis thus helping in plant growth. The ratio of N P @ 4:3 reflects the balance adequacy of these nutrients for plant which cause maximum plant height and gave higher numbers of grain (Brady & Weil, 2002).

100-grain weight (g): A similar impact of balanced fertilization was observed in 100-grain weight (Table 2) as noted in case of spike length. Similarly, lowest 100-grain weight (3.09 g) was recorded in the control. The highest grain weight of 4.56 gm was recorded with the application as N and P_2O_5 at 150 and 110 kg ha^{-1} respectively and which was significantly different from other treatments. The 100-grain weight was enhanced significantly with the successive increments in the application rates of N and P_2O_5, which may have been due to the effect of these nutrients on growth, seed formation and seed development (Imtiaz *et al*., 2003). These results are similar to those of Kirrilov & Pavlov (1989), who reported that application of nitrogen markedly increased the 100-grain weight.

Straw and grain yield: Straw and grain yield increased with increasing levels of N and P_2O_5 but the effect of different ratios of N and P_2O_5 was more significant (Table 3), the highest straw yield (6608 kg ha^{-1}) was recorded with 180 kg N and 135 kg P_2O_5 ha^{-1} and the lowest was observed in control. The better growth and higher straw yield with increase in N levels might be due to the role of N, in enhancing the vegetative growth (Ma *et al*., 2004). Phosphorus seems to have an additive effect on crop growth in a balanced proportion to that of applied N (Bhatti *et al*., 1988; Brink, 2001; Imtiaz *et al.,* 2003; Khan *et al.,* 2008). Our findings are in line to those reported by Ahmad *et al*., (1992).

In the present study, different fertilizer treatments significantly affected the grain yield of wheat genotype NIA-8/7 (Table 3). Treatment of 150 kg N and 110 Kg P_2O_5 kg ha^{-1} gave the highest grain yield of 5417 kg ha^{-1} which was statistically at par with the treatment 180 kg N and 135 kg P_2O_5 ha^{-1} (5260 kg ha^{-1}). The lowest grain yield of 2630 kg ha^{-l} was recorded in control. Khan *et al*., (2008) also reported that grain yield increased significantly with the application of nitrogen and phosphorus at ratio of 4:3. The increase in grain yield might be due to the driving behaviour of other yield attributes (Maqsood, *et al.,* 1999; Das & Yaduraju, 1999) viz., spike length, number of grains per spike and 100-grain weight which were higher at 150 N + 110 P_2O_5 kg ha^{-1} than other treatments. Also the supply of adequate nitrogen increases the plumpness of cereal grains protein contents of both seed and foliage (Villar-Mir *et al*., 2002). It can dramatically stimulate plant productivity whether measured in tons of grain or other plant parts. On other hand addition of P in balance with N may have additional effect on root development and seed formation (Brady & Weil, 2002). A similar study on the yield trend clearly indicated that application of N and P_2O_5 at 4:3 ratios improved grain yield (*Khan et al*., 2009). Thus, it has been observed from the present studies that application of N and P_2O_5 at 4:3 ratios may be considered as a balanced and economical dose for the test cultivar NIA-8/7 and it can be revealed that this ratio will be enough to satisfy its nutrient requirements.

Value cost ratio (VCR) and net income: Value cost ratio is an important criterion which is related to the economics of commodity produced and determines the net profit for the farmers (Khan *et al.*, 2009). On the basis of economic analysis, net income and benefit-cost ratio was calculated as indicated in Table 4. The maximum net income of Rs. 61433 per hectare was obtained when the crop was fertilized with 150 kg N and 110 P_2O_5 kg ha^{-1} and minimum net income of Rs. 28128 per hectare recorded with 120 kg N and 30 kg P_2O_5 ha^{-1}. The maximum cost-benefit ratio (6.29) was observed in case of 150 kg N and 40 kg P_2O_5 ha^{-1} while the minimum cost-benefit ratio (4.47) was obtained when fertilized with 180 kg N and 135 kg P_2O_5 ha^{-1}. It is evident from the results that the unnecessary application of higher fertilizer doses with marginal yield increases; are neither economical nor profitable. It is thus necessary to use the costly inputs judiciously for greater profitability.

Table 1. Effect of different fertilizer levels and ratios on agronomic parameters of wheat genotype NIA- 8/7.

Treatments	Plant height (cm)			Number of grains spike^{-1}		
(N- P_2O_5 kg ha^{-1})	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Control	73.0 f	81.3 f	77.13 e	35.7 d	31.2 d	33.5 d
120-30 (4:1)	80.7 e	98.0 e	89.38 d	49.5 c	47.0 c	48.3 c
120-60 (4:2)	82.2 de	100.3 d	91.25 d	51.5 c	50.2 c	50.9 c
120-90 (4:3)	85.5 cd	102.6 bc	94.04 c	61.7 ab	62.5 a	62.1 b
150-40 (4:1)	86.2 cd	101.8 c	94.05 c	49.7 c	51.5 c	50.5 c
150-75 (4:2)	88.2 c	102.5 bc	95.38 c	58.0 b	61.2 ab	59.6 b
150-110 (4:3)	94.5 b	103.1 ab	98.79 b	67.7 a	65.7 a	66.8 a
180-45 (4:1)	95.0 b	103.0 abc	98.99 b	63.5 b	57.2 b	60.4 b
180-90 (4:2)	99.7 a	103.5 ab	101.6 a	60.7 b	62.5 a	61.8 b
180-135 (4:3)	100.5 a	104.0 a	102.3 a	60.5 b	62 ab	61.3 b
LSD	**4.739**	**1.216**	**2.487**	**6.099**	**4.967**	**3.823**

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 2. Effect of different fertilizer levels and ratios on agronomic parameters of wheat genotype NIA- 8/7.

Treatments	Spike length (cm)			100-grain weight (g)		
(N- P_2O_5 kg ha^{-1})	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Control	8.3 e	8.8 g	8.6 g	3.7 d	2.53 e	3.09 e
120-30 (4:1)	11.2 d	9.3 fg	10.3 f	3.9 c	3.69 d	3.79 d
120-60 (4:2)	12.3 c	9.9 ef	11.1 e	4.2 b	4.17 bc	4.21 b
120-90 (4:3)	13.3 ab	10.5 de	11.9 d	4.4 b	4.29 ab	4.34 b
150-40 (4:1)	12.9 bc	10.5 d	11.7 d	4.0 c	3.95 cd	3.97 c
150-75 (4:2)	13.3 ab	11.9 bc	12.6 bc	4.3 b	4.26 abc	4.29 b
150-110 (4:3)	13.9 a	13.4 a	13.6 a	4.6 a	4.53 a	4.56 a
180-45 (4:1)	13.3 ab	11.6 c	12.4 c	4.4 b	4.33 ab	4.35 b
180-90 (4:2)	13.4 ab	12.0 bc	12.7 bc	4.4 b	4.28 ab	4.32 b
180-135 (4:3)	13.5 ab	12.4 b	12.9 b	4.3 b	4.20 bc	4.22 b
LSD	**0.7813**	**0.5947**	**0.4696**	**0.1947**	**0.3078**	**0.1734**

Table 3. Effect of different fertilizer levels and ratios on the yield of candidate wheat variety NIA-8/7.

Treatments (N-P_2O_5 kg ha^{-1})	Yield (Kg ha^{-1})					
	Straw			Grain		
	2007-08	2008-09	Mean	2007-08	2008-09	Mean
Control	3610 g	3397 g	3503 h	2485 f	2775 g	2630 f
120-30 (4:1)	4985 f	4430 f	4707 g	4438 e	3695 f	4066 e
120-60 (4:2)	5047 f	4946 e	4996 f	4656 de	3961 ef	4309 e
120-90 (4:3)	5500 e	5202 de	5351 e	5031 bc	4158 de	4595 d
150-40 (4:1)	5657 de	5330 d	5493 de	4938 cd	4342 cde	4640 cd
150-75 (4:2)	5875 cd	5388 d	5631 d	5111 bc	4769 b	4940 b
150-110 (4:3)	6375ab	6525 a	6450 ab	5485 a	5350 a	5417 a
180-45 (4:1)	6110 bc	5825 c	4967 c	5313ab	4409 bcd	4861 bc
180-90 (4:2)	6375 ab	6141 b	6258 b	5297 ab	4594 bc	4946 b
180-135 (4:3)	6610 a	6607 a	6608 a	5282 ab	5238 a	5260 a
LSD	**371.8**	**310.1**	**249.9**	**329.0**	**425.8**	**264.3**

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table. 4. Value cost ratios (VCR) at different levels and ratios of N and P for wheat genotype NIA-8/7.

Treatments ($N-P_2O_5$ kg ha^{-1})	Production value (wheat grain + bhoosa) (Rs)	Fertilizer cost (Rs)	Profit (Rs)	VCR
Control	-	-		-
120-30 (4:1)	34650	6522	28128	5.31
120-60 (4:2)	41633	8870	32763	4.69
120-90 (4:3)	50046	11217	38828	4.69
150-40 (4:1)	52500	8348	44152	6.29
150-75 (4:2)	58249	11087	47162	5.25
150-110 (4:3)	75259	13826	61433	5.44
180-45 (4:1)	48497	9783	38714	4.96
180-90 (4:2)	66557	13304	53253	5.00
180-135 (4:3)	75272	16826	58446	4.47

Nitrogen and phosphorus uptake: The uptake of both nutrients was significantly affected by their respective fertilizer application rates (Tables 5 and 6). Nitrogen uptake by wheat genotype was enhanced varying from 36.5 to 139.8 kg ha^{-1} as N application rate increased from 120 to 180 kg ha^{-1}. Our findings are in close agreement to those reported by Van Keulen & Stol (1991). Successive increments in P_2O_5 fertilization at each N dose significantly improved the efficiency of N usage, which reflects strong synergism between both elements. Phosphorus harvest also increased linearly with the corresponding increase in P_2O_5 application rates. The highest P uptake (27.35 kg ha^{-1}) was recorded with 110 kg P_2O_5 ha^{-1} and the lowest (2.82 kg ha^{-1}) in the control. The results of the present study are similar to those recorded by Brink *et al*., (2001), who reported that appropriate proportion of nutrients in the soil facilitate their uptake by plants.

Table 5. Nitrogen uptake as influenced by different N and P application.

Treatments ($N-P_2O_5$, kgha^{-1})	N uptake (kg ha^{-1})						
	2007-08		Total	2008-09		Total	Mean
	Grain	Straw		Grain	Straw		
Control	29.97 f	7.14 e	37.1e	31.29 e	4.52 f	35.82 e	36.47 f
120-30 (4:1)	78.48 e	15.81 d	94.3 d	79.50 d	13.77 e	93.27 d	93.78 e
120-60 (4:2)	81.58 de	16.51d	98.1 cd	88.78 cd	15.07 e	103.85 cd	101.0 de
120-90 (4:3)	88.97 cd	18.80 d	107.8 c	89.72 c	17.03 e	106.75 c	107.3 cd
150-40 (4:1)	83.92 cde	23.88 c	107.8 c	90.56 c	24.67 d	115.23 bc	111.5 c
150-75 (4:2)	92.49 bc	28.28 b	120.8 b	94.38 bc	27.00 d	121.38 b	121.1 b
150-110 (4:3)	102.84 a	34.23 a	137.1 a	109.49 a	31.52 c	141.01 a	139.0 a
180-45 (4:1)	98.90 ab	32.96 a	131.9 ab	103.59 ab	35.38 ab	138.96 a	135.4 a
180-90 (4:2)	99.75 ab	33.74 a	133.5 a	101.25 ab	33.07 bc	134.32 a	133.9 a
180-135 (4:3)	100.60 ab	34.69 a	135.3 a	106.35 a	38.05 a	144.40 a	139.8 a
LSD	**9.713**	**3.987**	**7.113**	**10.13**	**3.655**	**2.622**	**8.256**

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Table 6. Phosphorus uptake as influenced by different N and P application rates and ratios.

Treatments ($N-P_2O_5$, kgha^{-1})	P uptake (kg ha^{-1})						
	2007-08		Total	2008-09		Total	Mean
	Grain	Straw		Grain	Straw		
Control	1.78 h	2.55 f	4.34 h	0.8 f	0.51 e	1.31 g	2.82 h
120-30 (4:1)	4.53 g	4.36 e	8.89 g	11.8 e	7.20 cd	18.98 f	13.93 g
120-60 (4:2)	7.80 e	5.70 cd	13.51 e	12.9 e	7.32 cd	20.26 ef	16.89 f
120-90 (4:3)	12.22 c	6.27 bc	18.49 c	16.1 bc	6.70 d	22.78 de	20.64 de
150-40 (4:1)	5.53 f	5.50 d	11.03 f	13.7 de	9.13 b	22.80 de	16.92 f
150-75 (4:2)	10.18 d	6.80 b	16.97 d	16.8 bc	7.96 c	24.72 cd	20.85 d
150-110 (4:3)	15.65 a	8.14 a	23.80 a	21.6 a	9.25 b	30.90 a	27.35 a
180-45 (4:1)	5.77 f	6.10 c	11.87 f	15.3 cd	11.38 a	26.65 bc	19.26 e
180-90 (4:2)	11.36 c	7.57 a	18.93 c	17.6 b	9.36 b	26.96 bc	22.95 c
180-135 (4:3)	14.06 b	8.09 a	22.15 b	17.5 b	10.62 a	28.11b	25.13 b
LSD	**0.9851**	**0.5730**	**1.138**	**2.056**	**0.8583**	**0.5066**	**1.463**

Means followed by different letters in the same column are significantly different from each other at 5% level of significance

Conclusion

The genotype NIA-8/7 performed well with the increasing N and P_2O_5 levels and ratios. The maximum yield was produced with optimum inputs of 150 N + 110 P_2O_5 kg ha^{-1}. Hence, it can be considered as the most economical dose for this genotype when grown on silty clay soil.

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References

Ahmad, N. and M. Rashid. 2003. *Fertilizer and their Uses in Pakistan*. NFDC. Planning and Development Div. Islamabad. p. 17.

Ahmad, N., M. W. Thakar, N. A. Malik, M. L. Shah and S. Ahmad. 1992. Effect of NPK on growth, yield and yield components of Sunflower. *J. Agri. Res*., 30(1):20-24.

Alam, S. M. and M. A Khan. 1999. Major Agricultural Problems. In: Targeting Agriculture and Economics Growth. *Pak. & Gulf Econ*., 18(9): 13-14.

Anonymous, 2010. *Economic Survey*, Government of Pakistan, Finanace Division, Islamabad, Pakistan. pp. 19-20.

Anonymous. 1982. User's Guide MSTATC, A Micro Computer Statistical Programme. MSU. Crop land Soil Science, Agri. Economics. Inst. of international Agric, Michigan State University, USA.

Bhatti, H. M., M. Rashid, M. Y. Nadeem and M. T. Siddique. 1988. Micronutrient fertilization and wheat yield in Punjab. In: *Micronutrients in Soils and crops in Pakistan. Proc. Natl. Sem.*, Agri. Univ. Peshawar, December 13-15, 1987, pp. 208-217.

Brady, N.C. and R.R. Weil, 2002. *The Nature and Properties of Soils*. 13th Edition, Prentice Hall, New Jersey. Pp. 543-596.

Bremner, J.M. 1996. Nitrogen-Total. P. 1085-1122. In: *Methods of Soil Analysis*. Part 3 Chemical methods. (Ed.): D.L. Sparks. SSSA and ASA., Madison, WI. USA.

Brink, G.E., G.A. Peterson, K.R. Sistani and T.E. Fairbrother. 2001. Uptake of selected nutrients by temperate grasses and legumes. *Agron. J.*, 93: 887-890.

Das, T. K. and N. T. Yaduraju. 1999. Effect of weed competition on the growth, nutrient uptake and yield of wheat as affected by irrigation and fertilizers. *J. Agric. Sci*., 133(1): 45-51.

Dilbaugh, M., G.A. Chaudhry, M.I. Makhdum and U.D. Shabab. 1988. Influence of phosphorus application in different proportion with nitrogen and potassium on wheat yield under irrigated conditions. *Pak. J. Sci. Indus. Res*., 32: 206-211.

Imtiaz, M., K.H. Shah, P. Khan, S. H. Siddiqui, M. Y. Memon and M. Aslam. 2003. Response of wheat genotype 'SI-91195' to increasing N and P levels and their ratios under agro-climatic conditions of Sindh. *Pak. J. Soil Sci*., 22: 58-63.

Jackson, M. L. 1962. *Soil Chemical Analysis*. Prentice Hall Inc., Englewood Cliffs, N. J. pp. 151-185.

Jones, J.B. (Jr). 2003. Plant Mineral Nutrition. In: *Agronomic Handbook*: Management of Crops, Soils and their Fertility. pp. 291-334. CRC, USA.

Kadry, W., E. El-Gharib and A.H. Said. 1984. Effect of urea fertilizer as foliar application on Egyptian wheat production. *Annual Agri. Sci*., 29: 237-99; Caiso, Egypt (Wheat, Barley and Triticale Absts; 2: 1748; 1985).

Khan, I.A., A. Khatri, M. A. Javed, M. A. Siddiqui, M. H. Khanzada, N. A. Dahar and R. Khan. 2002. Performance of somaclones under field conditions at NIA, Tandojam. *Pak. J. Bot*., 34 (1): 65-71.

Khan, I.A., S. Bibi, S. Yasmin, A. Khatri, N. Seema and S. Afghan. 2010. Study of genetic variability in mutated population of sugarcane clone NIA-98 through molecular markers (RAPD and TRAP) *Pak. J. Bot*., 42(2): 605-614.

Khan, P., M. Imtiaz, M. Aslam, K. H. Shah, Nizamuddin, M. Y. Memon and S. H. Siddiqui. 2008. Effect of different nitrogen and phosphorus ratios on the performance of wheat cultivar 'Khirman'. *Sarhad J. Agri*., 24(2): 233-239.

Khan, P., M. Imtiaz, M.Y. Memon and M. Aslam. 2009. Response of wheat genotype 'MSH-14' to different levels/ratios of nitrogen and phosphorus. *Sarhad J. Agri.*, 25(1): 59-64.

Kirrilov, Y. A.I. and V.D. Pavlov. 1989. Effect of fertilizer on yield and protein contents in wheat grain. *Agrochimiya,* 1: 49-51

Koehler, F.E., C.D. Moudre and B.L. Mcneal. 1984. *Laboratory Manual for Soil Fertility*. Washington State Univ. Pullman, USA.

Ma, B.L., W. Yan, L.M. Dwyer, J. Fregeau-Reid, H.D. Voldeng, Y. Dion and H. Nass. 2004. Graphic analysis of genotypes, Environment, Nitrogen Fertilizer and their interaction on spring wheat yield. *Agron. J*., 96: 169-180.

Maqsood, M., M. Akbar, N. Yousuf, M.T. Mehmood and S. Ahmad. 1999. Effect of different rate of N, P and K Combinations on yield and Components of yield of wheat. *Int. J. Agri. Biol*., 1(4): 359-361.

Maseh, I. 1994. Effect of different N and P levels on growth and yield of two varieties of wheat *(Triticum aestivum* L.*).* M.Sc. Thesis, Univ. Agri., Faisalabad.

Mclean, E.O. 1982. Soil pH and lime requirement. P 199-208. In: *Methods of soil analysis*. Part 2: 2nd Edition. (Eds.): A.L. Page, R.H. Miller and D.R. Keeney. American Society of Agronomy, Madison, WI. USA.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon and organic matter. P. 574-577. In: *Methods of soil analysis*. Part 2: 2nd edition (Eds.): A.L. Page, R.H. Miller and D.R. Keeney. American Society of Agronomy, Madison, WI. USA.

Schachtman, D.P., R.J. Reid and S.M. Ayling. 1998. Phosphorus uptake by plants: from soil to cell. *Plant Physiol*., 116:447-453.

Senigagliesi, C.A., R. Garcia, S. Meria, M.L.R. Galetto, E. de Frusos and R. Teves. 1983. Fertilizer application to wheat in the north of province of Bunenos Aires and South of Santa Fe. Agropecuaria Pergammo, 191:28 Argentina (*Field Crop Absts*: 37:51).

Tahir, M. 1980. *Wheat Production Manual*. Pak Agri. Res. Council, Islamabad, pp. 77-80.

Theodorou, M.E. and W.C**.** Plaxto. 1993. Metabolic adaptations of plant respiration to nutritional phosphate deprivation. *Plant Physiol*., 101:339-344 .

Van Keulen, H. and W. Stol. 1991. Quantitative aspects of nitrogen nutrition in crops. *Fert. Res*., 27: 151-160.

Villar-Mir, J.M., P.V. Claudio-Stocckle, F. Ferrer and M. Aran. 2002. On farm monitoring of soil nitrate-nitrogen in irrigated cornfields in the Ebro Valley (Northeast Spain). *Agron. J*., 94: 373-380.

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