Pak. J. Bot., 45(3): 961-965, 2013.

PROFIT MAXIMIZING LEVEL OF POTASSIUM FERTILIZER IN WHEAT PRODUCTION UNDER ARID ENVIRONMENT

GHULAM ABBAS[1], J.Z.K. KHATTAK[2], G. ABBAS[3], M. ISHAQUE[4], M. ASLAM [1], Z. ABBAS[1], M.AMER[1] AND M.B. KHOKHAR[1]

[1]*Adaptive Research zone, Karor, District Layyah, Punjab Pakistan,*
[2]*International Islamic University, Islamabad, Pakistan,*
[3]*Adaptive Research Station, Mianwali, Punjab Pakistan,*
[4]*Department of Forestry, University of Agriculture Faisalabad Pakistan.*

Abstract

A field experiment was conducted at Farmers field on adaptive research station Mianwali during Rabi 2006-07 and 2007-08, to evaluate the response of wheat variety BK-2002 to various levels of fertilizers. The experiment was laid out in Randomized Complete Block Design having three replications. Significant (p=0.05) response of potassium application on wheat was observed on tillering, number of spikelets per spike, number of grains per spike, 1000-grain weight and yield with the increase of K_2O up to 93 kg ha^{-1}. The pooled data of two year revealed that maximum 1000-grain weight (47.83 g) and yield (4533 kg ha^{-1}) were achieved by the application of 93 kg of K_2O ha^{-1}on wheat crop. All other levels of K_2O application showed a decrease in the parameters of wheat production. Regression analysis of the pooled data depicted a significant (p<0.01) parabolic trend and linear trend of increase in wheat yield in 2006-07 and 2007-08 respectively.

Introduction

Wheat (*Triticum aestivum* L.) is the most widely used staple food grain of the world. Wheat is also a very important internationally traded commodity (Wajid, 2004). The annual average volume of world wheat trade has been about 106 million tones during 1999 to 2003. By 2020, world demand for wheat is expected to be 40 percent higher than that of its level in the later half of the 1990s. But the resources available for wheat production are likely to be significantly lower. The challenge for increasing wheat supplies is much greater in the developing countries than the developed world.

An agricultural country with 130.58 x 10^7 people, and the population is increasing very rapidly. Like many other developing countries, agriculture is the most important sector of Pakistan's economy and wheat is most important agricultural commodity (Hussain *et al.,* 2012). It is grown by 80 % of the farmers. Wheat is the main staple food of Pakistan. Among the four provinces of Pakistan, Punjab has the highest population of 72.585 x 10^7 (354 people /km^2). Approximately 69.7 % of the people live in rural areas that directly or indirectly are engaged in agriculture. The growth rate of the population is 3.1% annually, and the government is facing the challenge of feeding this population. The growth rate of agricultural production is slower than the population growth rate. The population for the years 2008, 2013 and 2023 are estimated to be as high as (168, 231 and 315) x 10^7 respectively. The food-grain requirement for these populations would be 27, 37, and 51 million tons/year in 2008, 2013, and 2023, respectively. A yield gap of 72% has been reported between the potential (6.4 tons/ha) and the average yield of wheat (1.8 tons/ha) in Pakistan. Wheat was cultivated on an area of 9062 thousands hectares, showing an increase of 5.9% over last year area (Anon., 2010-11).

Potassium is unique and essential nutrient for plant metabolism processes. Activation of enzymes, acting as an osmotic to maintain tissue turgor pressure and regulating the opening and closing of stomata are physiological functions of K in plant cells. Adequate K level is essential for the efficient use of N in crop plants. Potassium could be involved with NO_3 uptake, the predominate form of soil N, through two processes.

After nitrogen and phosphorus, potassium (K) is most important nutrient element and is taken up by crops in larger amounts than any other nutrients (Brady, 1990). Despite adequate reserves of K in soils of Pakistan and sporadic crop responses to K application, intensive cultivation of high yielding varieties, use of low levels K fertilizer, the demand for K has been enhanced and its slow release from soil minerals may not meet requirement of high yielding crops (Tisdale *et al*., 1984; Iftikhar *et al*., 2010; Babar *et al*., 2011). Another factor, which may cause the deficiency of K, is trend of increased area under cereal crops (Nazir, 1994). Soil potassium uptake by cereal is approximately 2 to 3 times more than that of Legumes (Geovgeorge *et al*., 1989). Furthermore, nutrient balance sheet for soils of Pakistan shows annual deficit of 0.265 million tons of potassium (Bajwa, 1994). While, keeping in consideration the importance of potassium the study was designed to evaluate the response of wheat (*Triticum aestivum*) to potassium fertilization under field condition in arid environment.

Materials and Methods

The study was conducted at farmer's field on adaptive research station Mianwali under arid environment of thal, during Rabi season of 2006-07 and 2007-8. The experiment comprised of five treatments with three replications in RCBD having plot size 7.10x14 m^2. The treatments were as under:-

Table 1. Application of various levels fertilizers on wheat crop.

Treatments	N	P	K
	(Kg ha^{-1})		
T1	128	114	0
T2	128	114	31
T3	128	114	62
T4	128	114	93
T5	128	114	124

A basal dose of Nitrogen and Phosphorus fertilizers were applied @ 128 kg N and 114 kg P_2O_5 $ha^{-1.}$ Potassium fertilizer was applied @ 0, 31, 62, 93 and 124 kg ha^1. Nitrogen, phosphorus and Potassium were applied as Urea, TSP and K_2SO_4, respectively. Nitrogen fertilizer was applied in three splits; one-third Nitrogen and whole of Potassium and phosphorus were applied at the time of seedbed preparation. The 2^{nd} (1/3) of Nitrogen was applied at the time of 1^{st} irrigation and $1/3^{rd}$ at the time of 3^{rd} irrigation. Canal water was used for irrigation. The crop was harvested at maturity and various crop parameters like tillers/plant, spikelets/spike, grains/spike, 1000-grain weight and grain yield per hectare were recorded. All other agronomic practices were adopted as per recommendation. The data were recorded and analyzed statistically. Least significant difference (LSD) at 5 percent probability level was computed to compare treatment means (Steel & Torrie, 1997). Duncan's multiple range test (Duncan, 1955) was used to see the significance of treatments means at 5% probability level. Regression analysis was done to see the parabolic and linear trends in the wheat yield increase at different levels of potassium fertilizer applications (Tables 1 & 2).

Table 2. Effect of different levels of fertilizers on grain yield of wheat during crop season 2006-07. (average of three replications)

Treatments (kg ha^{-1})	Plant height (cm)	Fertile tiller (m^{-2})	No. spike lets/ spike	No. of grains/ Spike	1000 - grain weight (g)	Yield (kg ha^{-1})
T1 NPK (128-114-0)	99.47	410.3 b	11.53 d	32.80 e	40.00 c	3750 c
T2 NPK (128-114-31)	99.53	431.3 a	12.87 d	38.33 e	43.33 bc	4167 b
T3 NPK (128-114-62)	99.93	430.0 a	13.60 b	42.07 c	45.00 ab	4450 a
T4 NPK (128-114-93)	99.73	431.0 a	14.67 a	47.27 a	49.33 a	4533 a
T5 NPK (128-114-124)	99.73	430.0 a	14.40 a	45.53 b	46.67 ab	4480 ab
LSD value	99.47	12.05	0.691	1.153	3.437	117.8

Means within the column sharing the different letters are significantly different (p=0.05) with each other

Results and Discussion

Plant height (cm): Various levels of potash produced significant effect on the plant height (cm). In Table 3, comparative study of the means of pooled data showed that, maximum plant height (100.33) were recorded where potash was applied @ 93 kg ha^{-1} followed by (99.83) where potash was applied @ 124 kg ha^{-1} keeping nitrogen and phosphorus constant.

Number of tillers per m^2: Various levels of potash produced significant effect on the number of tillers per m^2. In Table 4, comparative study of the means of pooled data showed that, maximum number of tillers (408.8 m^{-2}) were recorded where potash was applied @ 93 kg ha^{-1} followed by 404.5 m^{-2} where potash was applied @ 124 kg ha^{-1} keeping nitrogen and phosphorus constant. These results are in accordance with finding of Ali *et al*., (2013) who concluded that growth and yield was improved by adding appropriate amounts of potassium.

Number of spikelets per spike: Different levels of potash significantly affected number of spikelets per spike. In comparative study of the means (Table 3), the maximum number of spikelets per spike (14.63) was noted in treatments where potash was applied @ 93 kg ha^{-1}, which was statistically at par with plots where potash was applied @ 124 kg ha^{-1}.

Number of grains spike: Data concerning number of grains per spike was collected, analyzed statistically and showed significant results and is presented in the Table 3. Number of grains differed significantly at various levels of potash. Comparative study of the means showed that, maximum numbers of grains/spike (47) were recorded at 93 kg ha^{-1} followed by (45.13) grains per spike where potash was applied @ 124 kg ha^{-1}. It is again interesting to conclude that application of potassium increased the number of grains $spike^{-1}$ significantly. The treatment 93 kg K_2O ha^{-1} in the present study was found an optimum dose to increase the number of grains $spike^{-1}$. These results are in close agreement with the findings of Ahmad (1975), Ashraf (1986) and Khaliqui (1988) and Jan *et al*., (2012). Regression analysis of the pooled data depicted a significant (p<0.01) parabolic trend and linear trend of increase in wheat yield in 2006-07 and 2007-08 respectively.

1000–grain weight: Various levels of potash had also a significant effect on 1000–grain weight that increased with the addition of potash up to 93 kg ha^{-1}. Maximum 1000-grain weight (47.83) was noted at 93 kg ha^{-1} showing a negative effect on thousand-grain weight by more addition of K to wheat crop. It was concluded that potassium application helped to increase 1000-grain weight in wheat. These results are in accordance with the findings Kalikinskii & Tverezovskaya (1981) and Jan *et al*., (2012).

Table 3. Effect of different levels of fertilizers on grain yield of wheat during crop season 2007-08. (average of three replications)

Treatments (kg ha^{-1})	Plant height (cm)	Fertile tiller (m^{-2})	No. spike lets/ spike	No. of grains/ Spike	1000 - grain weight (g)	Yield (kg ha^{-1})
T1 NPK (128-114-0)	97.40	352.3 b	11.33 d	32.60 e	38.75 c	3500 d
T2 NPK (128-114-31)	99.20	370.3 a	12.67 c	38.40 d	43.39 b	3900 c
T3 NPK (128-114-62)	100.40	373.3 a	13.40 b	41.87 b	44.88 ab	4100 bc
T4 NPK (128-114-93)	100.93	386.7 a	14.16 a	46.43 a	47.33 a	4535 a
T5 NPK (128-114-124)	99.93	378.7 a	14.07 ab	44.73 b	45.52 ab	4367 ab
LSD value	97.40	17.80	0.6815	1.721	2.679	391.2

Means within the column sharing the different letters are significantly different (p=0.05) with each other

Table 4. Effect of different levels of fertilizers on grain yield of wheat. (Pooled data of two years)

Treatments (kg ha^{-1})	Plant height (cm)	Fertile tiller (m^{-2})	No. spike lets/ spike	No. of grains/ Spike	1000 - grain weight (g)	Yield (kg ha^{-1})
T1 NPK (128-114-0)	98.43	381.3 e	11.43 d	32.70 e	39.38 d	3625 d
T2 NPK (128-114-31)	99.37	400.8 d	12.77 c	38.37 d	43.33 c	4033 c
T3 NPK (128-114-62)	100.17	401.7 c	13.50 b	41.97 c	44.94 bc	4275 b
T4 NPK (128-114-93)	100.33	408.8 a	14.63 a	47.00 a	47.83 a	4533 a
T5 NPK (128-114-124)	99.83	404.5 b	14.23 a	45.13 b	46.09 ab	4430 ab
LSD Value	98.43	0.4202	0.4202	0.9150	1.922	187.9

Means within the column sharing the different letters are significantly different (p=0.05) with each other

Yield (kg ha^{-1}): Comparative study of the means showed that, maximum grain yield (4533 kg ha^{-1}) was recorded in plots where K was applied @ 93 kg ha^{-1}. It was statistically at par with plots where K was applied @ 124 kg ha^{-1} having yield 4433 kg ha^{-1}. It was evident from the results that potassium application significantly increased the grain yield of wheat. These results were in accordance with the findings of Bhatti *et al*., (1976), Vengiell (1982), Malik *et al*., (1989) and Hamayun *et al*., (2011). Regression analysis of the pooled data depicted a significant (p<0.01) parabolic trend and linear trend of increase in wheat yield in 2006-07 and 2007-08 respectively (Fig. 1). Such analysis also indicated significant increase (p<0.01) in yield beside the economic return at 93 kg level of K_2O ha^{-1} application on wheat crop (Fig. 2).

Economic analysis: The marginal and total analysis was carried out to find the profit-maximizing level of use of different fertilizers. To estimate the total cost of fertilizers, the information given in the Table 1 was used. The average prices of fertilizers (urea, ssp and sop) during 2006-07 and 2007-08 were used (Anon., 2010-11). Similarly to calculate the total revenue, the information given in Table 4 was used. The average retail price of wheat was used during 2006-07 and 2007-08 (Anon., 2010-11). Finally marginal revenue (MR) and marginal cost (MC) were estimated as shown in Table 5. The marginal analysis reveals that the optimal combination of different fertilizers under T4 provides the highest profit of wheat production in the arid environment. Hence, by adopting the application of different fertilizer that is 128, 114, 93 of N, P, K respectively, of wheat production, profits can be maximized. Similarly, the economic analysis on the basis of total revenue and total cost also indicated that the highest profit (Rs. 57301) can be achieved at 93 kg level of K_2O ha^{-1} application on wheat crop.

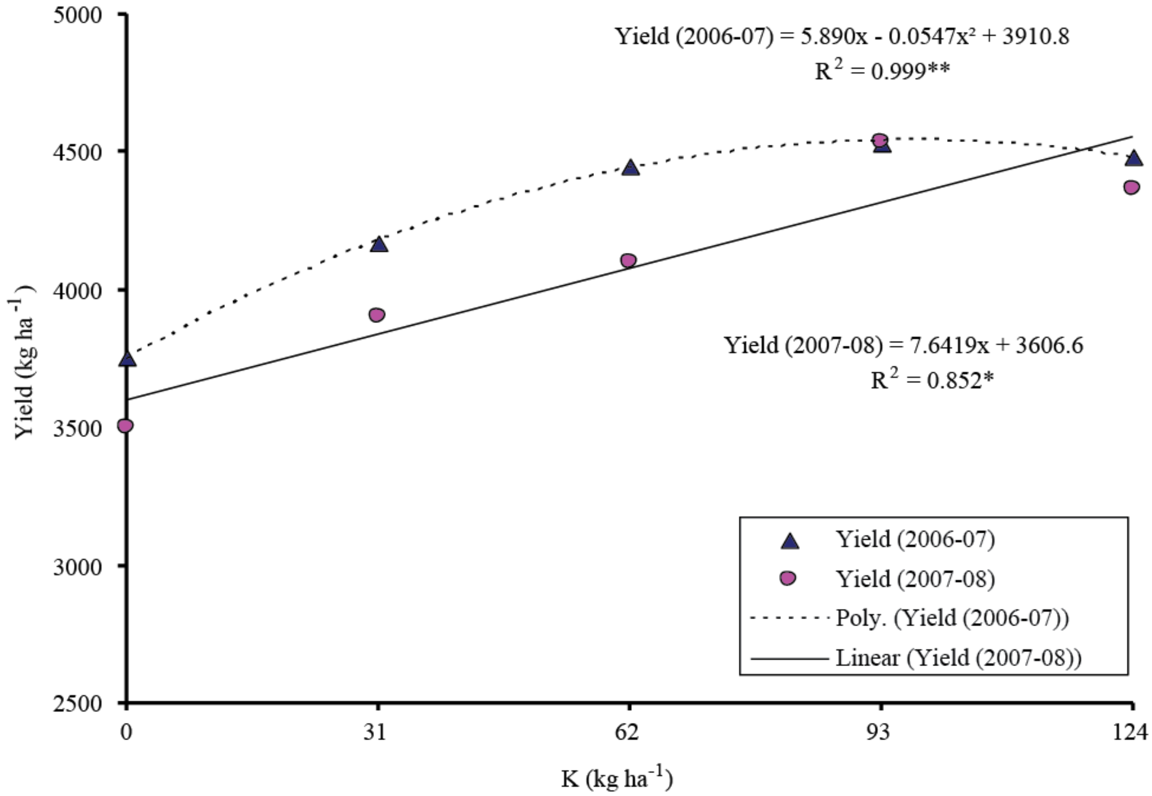

Fig. 1. Regression analysis of the pooled data indicating a significant (p<0.01) parabolic trend and linear trend of increase in wheat yield in 2006-07 and 2007-08 respectively.

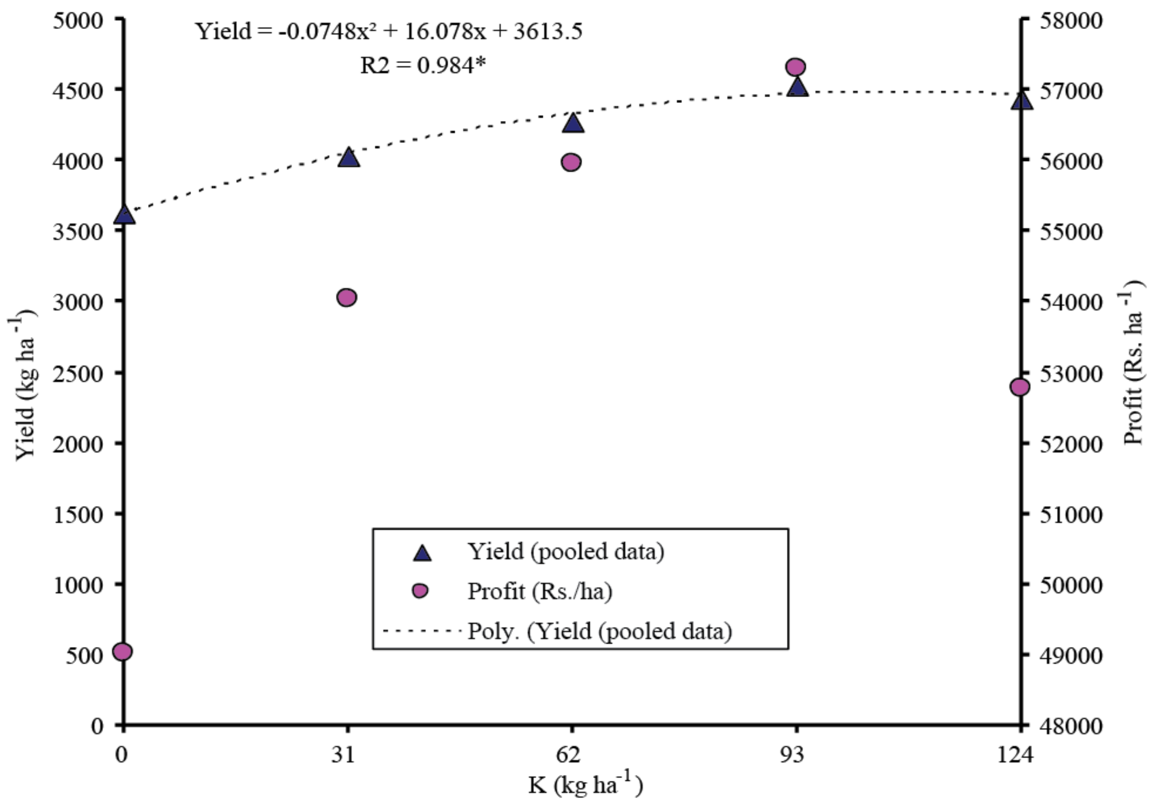

Fig. 2. Regression analysis of pooled data indicating significant increase (p<0.01) in yield beside the economic return at 93 kg level of K_2O ha-1 application on wheat crop.

Table 5. Economic analysis of wheat production on a marginal and total basis.

Treatments	Cost of fertilizers (Rs.)				Yield (kg ha^{-1})	Total revenue (TR) Rs.	MR* (Rs.)	MC* (Rs.)	Profit Rs./ha
	N	P	K	Total cost					
T1 NPK (128-114-0)	1418	1033	0	2451	3625	51475			49024
T2 NPK (128-114-31)	1418	1033	769	3221	4033	57269	5794	770	54048
T3 NPK (128-114-62)	1418	1033	1539	4759	4275	60705	3436	1538	55946
T4 NPK (128-114-93)	1418	1033	2308	7068	4533	64369	3664	2309	57301
T5 NPK (128-114-124)	1418	1033	3078	10145	4430	62906	-1463	3077	52761

* MR= Marginal revenue, * MC= Marginal cost

References

Ahmad, M. 1975. Effect of different rates of NPK on the growth and grain yield of new wheat variety, D-13.M.Sc. *Thesis, Agron. Dept, Univ. Agri*., Faisalabad.

Ali, L., M. Ashraf, M. Maqbool, R. Ahmad and A. Aziz. 2013.Optimization of soil K: Na ratio for cotton (*Gossypium hirsutum* L.) nutrition under field conditions. *Pak. J. Bot*., 45(1): 127-134.

Alik, D.M., R.A. Chaudhary and G. Hussain. 1989. Crop response to K application in the Punjab. pp. 71-93. Proc. workshop on "role of potassium in improving fertilizer use efficiency". March 21-22, 1987, NFDC/PARC, Islamabad, Pakistan.

Anonymous. 2010-11. Economic Survey of Pakistan. Finance division, Economic Advisor's Wing, Islamabad, Pakistan.

Ashraf, A.H. 1986. Studies on the interactive relationship of two wheat genotypes and NPK application under late sown conditions. M.Sc . *Thesis, Agron. Dept., Univ. Agri*., Faisalabad.

Babar, L.K., T. Iftikhar, H.N. Khan and M.A. Hameed. 2011. Agronomic trials on sugarcane crop under Faisalabad conditions, Pakistan. *Pak. J. Bot*., 43(2): 929-935.

Bajwa, M.I. 1994. Soil potassium status, potassium fertilizers usage and recommendation in Pakistan. Potash Review, 20th Suit, No. 3:1-8.

Bhatti, A., A.A. Qureshi and S. Rehman. 1976. Effect of nitrogen alone and in combinations with phosphorus and potash on the yield of wheat. *Pak. J. Agri. Res*., 6: 88-92.

Brady, N.C. 1990. The Nature and properties of soils. *MacMillan Company*, New York. USA.

Dowdy, S. and S. Wearden. 1991. Statistics for research. *John Wiley and Sons*, New York, pp. 629.

Duncan, D.B. 1955. Multiple range and multiple F-test. *Biometrics*, 11: 1-42.

Geovgeorge, M. and P. Rajanedra. 1989. Potassium removal by rice based cereal and cereal- legume intensive cropping system and their effect on exchangeable potassium in soil. *J. Potassium Res*., 5: 89-103.

Hamayun, M., S.A. Khan, A.L. Khan, Z.K. Shinwari, N. Ahmad, Y.H. Kim and I.J. Lee. 2011. Effect of foliar and soil application of nitrogen, Phosphorus and potassium on yield Components of lentil. *Pak. J. Bot*., 43(1): 391-396.

Hussain, M., M. Niaz, M. Iqbal, T. Iftikhar and J. Ahmad. 2012. Emasculation techniques and detached tiller culture in wheat X maize crosses. *J. Agric. Res*., 50(1): 1-19.

Iftikhar, T., L.K. Babar, S. Zahoor and N.G. Khan. 2010. Impact of land pattern and hydrological properties of soil on cotton yield. *Pak. J. Bot*., 42(5): 3023-3028.

Jan, M.T., M.J. Khan, F. Ullah, M. Arif, M. Z. Afridi, A. Khan and H. Akbar. 2012. Integrated management of crop residue and N fertilizer for wheat production. *Pak. J. Bot*., 44(6): 2015-2019.

Kalikinskii, A.A. and M.N. Tverezavskaya. 1981. Effect of rates and methods of basal fertilizer application on grain yield and quality of winter wheat cv. Micronovskaya 808. Referativnyi Zhurnal 2: 105. *Field Crop Absts*., 35: 9469; 1982.

Khaliqui, C.K.M. 1988. To study the relationship between soils K, applies K and plant K under different soil textures. M.Sc. *Thesis, Dept. Soil Sci., Univ. Agri*., Faisalabad.

Nazir. S. 1994. Introduction to crop production. p. 3-11. In: (Ed.): E. Bashir. Crop Production. *National Book Foundation*, Islamabad, Pakistan.

Steel, R., J.H. Torrie and D.A. Dickey. 1997. *Principles and Procedures of Statistics*. A Biometrical Approach, 3rd Ed. McGraw Hill Book Co., New York, 172-177.

Tisdale, S., W.L. Nelson and J.D. Beaton. 1984. Soil fertility and fertilizer. *MecMillan Company*, New York, USA.

Vengiell, A. 1982. The use of chemical fertilizer on wheat during the systematic use of varying Bletitutim a Larte Bujqesor Tirane, Albania 21: 5-13. *Field Crop Absts*., 36: 2924.

Wajid, S.A. 2004. Modeling development, growth and yield of wheat under different sowing dates, plant populations and irrigation levels . Ph.D. Thesis, Dept.of Agron. University of Agriculture, Faisalabad, Pakistan.

(Received for publication 15 December 2011)