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Response of common wheat to intensifying soil fertility levels

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ABSTRACT Efficient use of adequate level of nitrogen (N), phosphorus (P), and potassium (K) is essential and important part of the sustainable agricultural production. P deficiency is one of the most important yield-limiting issue in many parts of the world including large areas of the Carpathian basin area. Bread wheat is the largest crop in Hungary and its yield is significantly affected by nutrient status of the soil. This study was conducted to determine the optimum fertilizer levels of bread wheat in a low-P level, Calcisols, rich in organic matter content and N-supply.
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KEY WORDS

common (bread) wheat
nutrient management
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yield
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P deficiency has been identified as one of the main limiting factors of crop production in various soils all over the world (Haynes 1984; Fageria and Baligar 1997). Nearly one out of every two soil samples analyzed in North America testing medium or below in P or K; however, in many sites more P is contained in manure alone than is removed in crops leading to water quality problems in those sites. In Hungary, in the last ten-fifteen years, the yearly fertilization dramatically dropped if compare to the level of the eighties. As a result, the estimated P and K nutrient status of Hungarian soils tend to be on poor or medium level. (Kádár 1997). At present, in Hungary, common wheat (*Triticum aestivum* L.) is grown in 1.2 million ha-s including areas where P and K poorly available for plants. Little information is available concerning fertilizer requirements of common wheat on these areas. Our aim was to evaluate the yield response of common wheat varieties to various N-, P- and K-rates on a typical soil type of the Carpathian basin area.

Materials and Methods

As part of a long-term (15-yr) field experiment, a one-year test was conducted in Fulopszallas, Hungary to study the response of three wheat varieties to various N P K treatments. Sunflower was the fore crop on the area. The soil at the experimental site was a low, very compact, humic, meadow calcisols, rich in organic matter content and N-supply. In the last five years, there was no phosphorus fertilization to achieve P-deficiency at the experimental site. The initial soil properties at 0-20 cm soil depth were: pH 6.5, humus: 4.5%, P 90 mg/kg, K 260mg/kg. Treatments consisted of combinations of four soil fertility N rates and also four of P+K rates: N_0, N_{80}, N_{160}, N_{240}; P_0K_0, $P_{30}K_{30}$, $P_{60}K_{60}$, $P_{90}K_{90}$. Thus, sixteen soil fertility treatments were applied in the study. Half quantity of N was applied at sowing (October) and the remaining part was top-dressed during spring. P+K treatments were applied at sowing. The experimental design was a split-plot design with four replicates. Wheat cultivars (GK Elet, GK Garaboly, GK Petur) developed at our institution

Table 1. Fertilizer-levels effects on wheat yield (Fülöpszállás, Hungary 1999).

P+K	N	cv. GK Élet			cv. GK Garaboly			cv. GK Petur			Cultivar Average		
kg/ha		t/ha	D_N	D_{PK}	t/ha	D_N	D_{PK}	t/ha	D_N	D_{PK}	t/ha	D_N	D_{PK}
	0	3.41			3.13			3.56			3.37		
	80	3.97	0.56		3.76	0.63		4.19	0.63		3.97	0.61	
0+0	160	3.40	-0.01		3.42	0.29		3.54	-0.02		3.45	0.09	
	240	3.14	-0.27		3.08	-0.05		3.14	-0.42		3.12	-0.25	
	0	5.93		2.52	5.33		2.20	5.11		1.55	5.46		2.09
	80	7.08	1.15	3.11	6.82	1.49	3.06	7.17	2.06	2.98	7.02	1.57	3.05
30+30	160	6.90	0.97	3.50	6.70	1.37	3.28	7.08	1.97	3.54	6.89	1.44	3.44
	240	6.83	0.90	3.69	6.56	1.23	3.43	6.75	1.64	3.61	6.71	1.26	3.59
	0	7.57		4.46	6.82		3.69	7.30		3.74	7.23		3.86
	80	8.66	1.09	4.69	8.51	1.69	4.75	8.66	1.36	4.47	8.61	1.38	4.64
60+60	160	9.34	1.77	5.94	9.37	2.55	5.95	9.06	1.76	5.52	9.26	2.03	5.80
	240	9.72	2.15	6.58	9.82	3.00	6.74	9.29	1.99	6.15	9.61	2.38	6.49
	0	8.72		5.31	7.69		4.56	8.55		4.99	8.32		4.95
	80	9.64	0.92	5.67	9.19	1.50	5.43	9.42	0.87	5.23	9.42	1.10	5.44
90+90	160	9.91	1.19	6.51	9.90	2.21	6.48	9.75	1.20	6.21	9.85	1.53	6.40
	240	9.85	1.13	6.71	10.31	2.62	7.23	9.83	1.28	6.69	10.00	1.68	6.88
	$SzD_{5\%}$	0.42			0.37			0.58			0.46		

D_N = Yield differences on various N levels if compar to 0-level of N
D_{PK} = Yield differences on various P+K levels if compar to 0-level of P+K

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were planted in 12 cm rows with the density of 550 germ/m^2.

Results and Discussion

In general, grain yield increased with increasing fertilization intensity at all cultivars. (Table 1). At high NPK rates, wheat cultivars produced extremely high (9-10 t/ha) yield. N itself can affect yield considerably: raising N rate from zero to 80 or 160 at $P_{60}K_{60}$, resulted a ca. 2 t/ha grain yield benefit. Even, at variety GK Garaboly, the N-response was much higher (Table 1). Productivity of all genotypes was significantly affected by P+K levels in most of the combinations. At 160 kg/ha N-rate, yield increase reached more than 2 t/ha due to moving from $P_{30}K_{30}$, to $P_{60}K_{60}$. Two varieties (GK :Elet, GK Petur) reached the plateau on a mid fertilizer level (N_{240} + $P_{60}K_{60}$ or N_{160} + $P_{90}K_{90}$) - did not response significantly for higher rates. The exception was cultivar GK Garaboly: this cultivar did not reach the plateau in this experiment. Due to the highest fertilizer-level N_{240} + $P_{90}K_{90}$, its yield still significantly moved up. Considering the cost of the fertilizers and striving for sustainable agricultural production, we can conclude that N_{80} + $P_{90}K_{90}$ may be the optimum and economic fertilization level for the wheat in the area. More intensive cultivars (*i.e.* GK Garaboly) may need a higher rate (N_{160} + $P_{90}K_{90}$) to reach optimum production level. Among the three main elements, P was in deficiency in the soil. In a previous study on this experimental area, the optimum soil P-level proved to be 200-220 mg/kg (Harmati 1989. The present level of 90 mg/kg is far deep; thus in this study, the dramatic yield- increase achieved among various P+K levels occurred due to added P.

The yield response to P is considered close to its maximum a critical soil P level beyond which there would be no response to P fertilizer (George 2000). Wheat cultivars responded significantly to the highest P+K rate indicating that the soil P was under the critical level even at the highest fertilizer rate in this study.

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