FERTILISER RESPONSES OF MAIZE AND WINTER WHEAT AS A FUNCTION OF YEAR AND FORECROP

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The N, P and K effects of mineral fertilisers were examined in a long-term fertilisation experiment set up on chernozem soil with forest residues. The data from 20 experiments on winter wheat and 24 on maize were evaluated as a function of the year, the forecrop and the soil nutrient supplies.

Of the two plant species, N effects were found to be greater for winter wheat. When sown after maize, the N responses of both wheat and maize were almost 1 t ha^{-1} greater than when winter wheat was the forecrop. The positive effect of phosphorus was only significant in winter wheat, while that of potassium was not significant for either species.

In a wheat–wheat sequence, N fertiliser alone was only effective in wet years. In winter wheat, no phosphorus effects could be detected in any year without N fertilisation. In years with extreme weather conditions, P effects were only significant when wheat was grown after cereals.

In dry years nitrogen only had a significant effect on the yield of maize after wheat if it was combined with phosphorus and potassium. In years with average or above-average rainfall maize was able to extract sufficient phosphorus for its development even from soils with poor P supplies; yield increases were limited by other factors.

Key words: maize, winter wheat, year, mineral fertiliser, yield surplus

Introduction

Weather conditions, which differ considerably from one place to the other and are gradually becoming increasingly variable, always exert a great influence on the results of field experiments. The joint manifestation of these factors is known as the year effect. Meteorological factors have a strong effect on plant productivity and on the utilisation of fertiliser by the crop as they alter the quantity of nutrients available in the root zone. The analysis of correlations between the year, including the rainfall supplies that determine its character, and the nutritional status and productivity of the plants makes up an important part of research on crop production and agricultural chemistry in Hungary (Ruzsányi, 1992; Berzsenyi, 1993; Nagy and Huzsvai, 1995; Márton, 2002). Numerous authors have demonstrated that the optimum quantity of nutrients may vary over a very wide interval due to weather extremes (Debreczeni and Debreczeniné, 1983; Csathó et al., 1991; Árendás, 1995).

In scientific publications on factors influencing the soil–plant system, increasing emphasis is being placed on papers that summarise the results of long time-series of data and analyse the ecological and economic aspects of fertiliser utilisation in terms of the effects and interactions of crop composition or crop rotation (Berzsenyi and Győrffy, 1997; Tóth, 2001).

Materials and methods

A long-term fertilisation experiment set up by Mihály Krámer on chernozem soil with forest residues in Martonvásár in 1960 is still being used to examine the effect of combinations of 160, 80 and 80 kg ha^{-1} of N, P and K fertilisers, respectively, on a maize–wheat diculture.

At the beginning of the experiment the ploughed layer had the following agrochemical properties: pH_{H2O} = 7.2; humus % = 3.0; $CaCO_3$ % = 0.8; AL-soluble P_2O_5 = 30–40 mg kg^{-1}; AL-soluble K_2O = 150–200 mg kg^{-1}.

The results of 12 crop production cycles (48 years) between 1960 and 2007 were processed. In two of these cycles spring cereals were grown, so the data of 20 winter wheat and 24 maize experiments were available for evaluation. Within each cycle the genetic background of the individual species was never changed, i.e. with respect to the two different forecrops the ratio of identical varieties was the same. The macroelement effects were analysed as the difference between the grain yields (t ha–1) in the various treatments (0, N, P, NP, NK, NPK). The years were grouped according to the quantity of rainfall during the vegetation period, using the limit values given by Harnos (1993).

The data were statistically processed using analysis of variance, following the guidelines given by Sváb (1981).

Results and discussion

Evaluation of fertiliser responses in terms of forecrop (wheat or maize)

On csernozem soil with forest residues, containing 3% humus, the mean yield-increasing effect of 160 kg ha^{-1} N active agents was statistically significant, regardless of the crop and forecrop, and ranged from 0.73–2.08 t ha^{-1} (Fig. 1: N effects). Of the two species examined wheat responded with a greater yield surplus to each N rate than maize when grown after both maize and wheat. The difference between the forecrops was significant for both crops, being 0.88 t ha^{-1} for wheat and 0.91 t ha^{-1} for maize in favour of maize as forecrop.

The positive effect of 80 kg ha^{-1} phosphorus active agents was only significant in winter wheat, based on the yield differences between plots with or without P fertiliser (Fig. 1: P effects). The annual yield surplus was 0.63 t ha^{-1} for wheat grown after maize and 1.04 t ha^{-1} for wheat grown after wheat. The difference between the forecrops was only significant at the 5% level.

Regular supplies of potassium at a rate of 80 kg ha^{-1} improved the K supplies of the ploughed layer to “very good”. However, the differences between the yields recorded on these plots and in the control treatments, which exhibited a moderate supply level, did not justify the need for K application on chernozem soil with forest residues (Fig. 1: K effects). The non-significant effects were greater for maize, which has a higher K requirement.

Evaluation of the fertiliser responses of wheat and maize in terms of the year effect

In years with average rainfall supplies, the yield surplus of winter wheat in response to N fertiliser on plots with at least moderate supplies of P and K (NP and NPK) ranged from 1.68–2.76 t ha^{-1} (Table 1). The N effect was greater when maize was the forecrop, due to the greater depletion of the soil N reserves and to the shorter mineralisation phase, when no nutrient uptake occurs, as the result of later harvesting. This difference as a consequence of the forecrop was also perceptible, though to a lesser extent, in dry and wet years. The positive effect of 160 kg ha^{-1} N active agents was not significant in average and dry years when wheat was grown after wheat on soils with very poor P supplies. N fertiliser applied alone to a wheat–wheat rotation only had a significant effect when the availability of the poor P supplies was improved by wetter than average weather conditions.

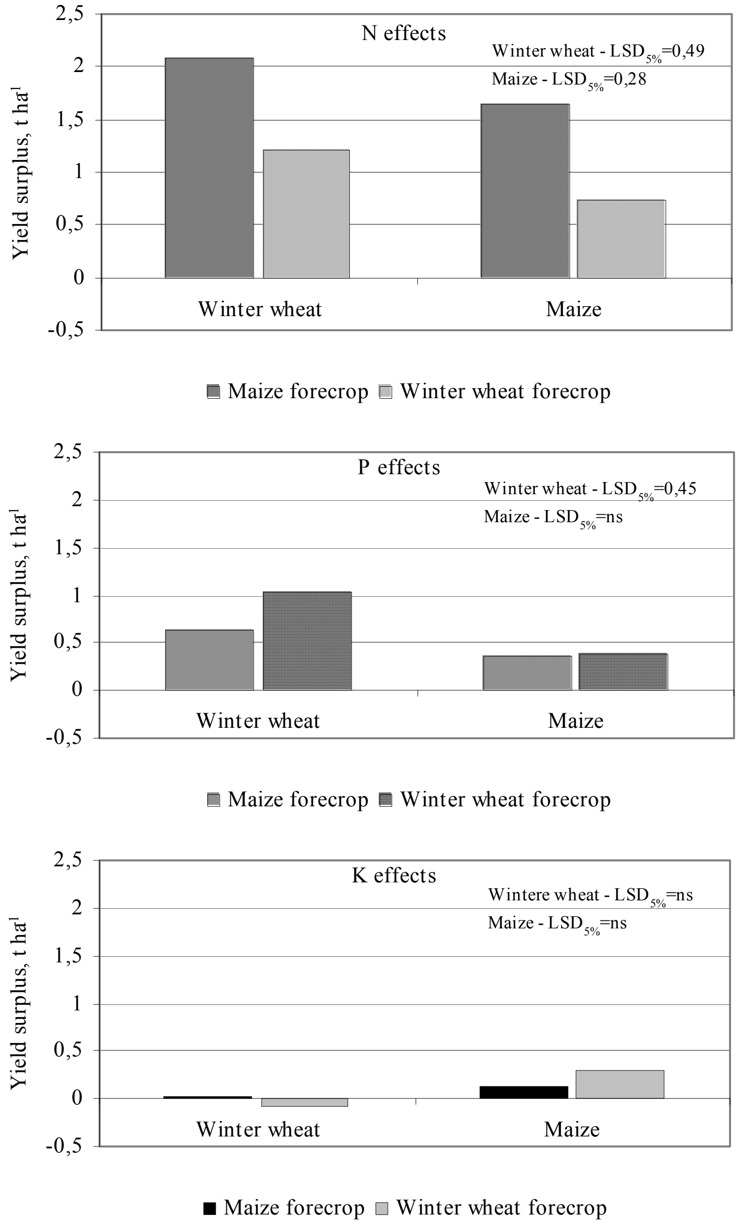
In terms of yield surpluses, P effects could not be achieved without N fertilisation in any of the years for the P-demanding winter wheat crop. Irrespective of the forecrop, applying P in combination with N was the most effective in average years (1.16–2.20 t ha^{-1} yield surplus).

In vegetation periods with extreme weather conditions the P effects were much smaller than average, but were always significant when wheat was grown after wheat; this was only true of one year when the forecrop was maize (Table 1: dry year, NPK-NK).

On chernozem soil with forest residues, no K effects could be detected based on differences between treatment pairs in the grain yields of winter wheat, irrespective of the year or the forecrop.

The positive effect of N nutrition on maize was significant in years with average rainfall, regardless of the P and K supplies or the forecrop (Table 2). By contrast, the response of maize grown after maize to N fertiliser was similar in seasons with either rainfall deficiency or above-average rainfall. In dry years, when maize was grown after wheat N fertiliser was only effective on soils fertilised with P and K.

The advantage of good soil P supplies for maize production was clear in dry or droughty years. The results indicated that in years with average or above-average rainfall, maize was able to extract the P required for its development even from soils poorly supplied with phosphorus; yield increments were limited by other factors.



ns: Non-significant

Fig. 1. N, P and K fertiliser responses (t ha^{-1}) as a function of the forecrop (winter wheat or maize) in a long-term fertilisation experiment on chernozem soil with forest residues in Martonvásár

Table 1. N, P and K fertiliser responses (t ha^{-1}) of winter wheat as a function of year, forecrop and macroelement supplies in a long-term fertilisation experiment on chernozem soil with forest residues in Martonvásár

Mineral fertilizer effect	Treatments compared	Average year		Dry year		Wet year	
		W	M	W	M	W	M
N effect	N-0	0.33	1.72	0.18	0.74	0.95	2.24
	NP-P	1.76	2.71	0.96	1.22	2.01	2.22
	NPK-PK	1.68	2.76	1.11	1.27	1.83	2.00
P effect	P-0	0.39	0.18	0.17	-0.03	-0.02	0.21
	NP-N	1.82	1.17	0.95	0.45	1.04	0.19
	NPK-NK	2.20	1.16	1.47	0.69	0.88	0.32
K effect	PK-P	0.08	-0.05	-0.03	0.09	0.04	0.26
	NK-N	-0.38	0.01	-0.29	-0.10	0.02	-0.09
	NPK-NP	-0.01	0.00	0.13	0.14	-0.14	0.04
$LSD_{5\%}$		0.40	0.52	0.32	0.59	0.38	0.41

W: Forecrop – winter wheat
M: Forecrop - maize

Table 2. N. P and K fertiliser responses (t ha^{-1}) of maize as a function of year. forecrop and macroelement supplies in a long-term fertilisation experiment on chernozem soil with forest residues in Martonvásár

Mineral fertilizer effect	Treatments compared	Average year		Dry year		Wet year	
		W	M	W	W	M	W
N effect	N-0	0.87	1.64	0.45	1.37	0.31	1.73
	NP-P	0.75	1.60	0.27	1.71	0.67	1.45
	NPK-PK	1.09	1.91	0.79	1.67	1.47	2.01
P effect	P-0	0.31	-0.03	0.79	0.40	-0.37	0.00
	NP-N	0.18	-0.07	0.61	0.73	0.00	-0.28
	NPK-NK	0.32	0.38	0.73	0.65	0.88	0.10
K effect	PK-P	0.06	-0.04	-0.14	0.17	0.20	-0.03
	NK-N	0.26	-0.19	0.26	0.21	0.12	0.15
	NPK-NP	0.40	0.27	0.38	0.13	1.00	0.53
$LSD_{5\%}$		0.73	0.88	0.57	0.59	0.44	1.20

W: Forecrop – winter wheat
M: Forecrop - maize

Based on the yield differences between plots with "very good" and "moderate" K supplies. a significant positive K effect could only be detected in one of 18 years. In the majority of cases. however. there was a tendency for the joint application of all three macroelements to result in the most pronounced K effects.

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