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Nutrient balance of ecological and conventional cropping system

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The field trial was conducted during 1999–2005 at the RIPP in Piešťany in water protected zone. The nutrient balance of N, P, K, Mg and Ca was calculated for individual crops and for six crop rotation pattern as a whole. Incorporation of straw, catch crops and FYM was used. Crop rotation pattern of common pea – winter wheat – early potato – spring barley – red clover – winter wheat was growing under ecological system and conventional system with two level of nitrogen input. Balance of nutrients for the whole crop rotation in both systems was positive. Incorporation of fertility building crops (green manures and catch crops) in sufficient way positively influence the nutrient balance across the whole crop rotation. In ecological system balance of main nutrients in kg ha⁻¹ was as follows: N+52.5, P+1.2, K+35.8, Mg+7.3, Ca+95.9.

Keywords: ecological system, conventional system, crop rotation, nutrient balance

1 Introduction

The basic parameter predisposing positive result of nutrient balance in the soil is crop rotation pattern. Well-designed crop rotation in interaction with fertilization and soil cultivation ensures sufficient mobility of accessible nutrients, while maintaining a balanced account of the organic matter and total nutrient content in the soil (Lacko-Bartošová et al., 2005). As a consequence, tillage and crop rotation affect soil N, P and K. The inadequate fertilization regarding soil conditions and plant needs, can cause severe nutritional unbalances, which lead to a significant regression of production and quality and increased the environmental load (Ondříšek et al., 2009; Benoit et al., 2014). Incorporation of fertility building crops (green manures and catch crops) strongly reduced N leaching loss (Thorup-Kristensen, 2014).

2 Material and Methods

The field trial was carried out at the experimental station of the Research Institute of Plant Production in Piešťany (48.574 LAT 17.746 LON). The location has a continental climate with a normal annual temperature of 9.2 °C and precipitation of 595 mm. The soil type is a Luvi-Haplic Chernozem with loamy to clay-loamy texture with pH of 6.5–7.2 and medium humus content of 1.8 %–2.0 %. Soil is characterized by good content of available potassium, medium content of available phosphorus and high content of magnesium. A six-crop rotation pattern was used as follows: (1) common pea – (2) winter wheat and catch crop, (3) early potato and farm yard manure, (4) spring barley under sown with red clover, (5) first year red clover, and (6) winter wheat and catch crops. Farm yard manure was applied under potato at dose of 40 t ha⁻¹ (1999–2002) or 30 t ha⁻¹ (2003–2005) in both systems, and under winter wheat at dose of 15 t ha⁻¹ in ecological system only.

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The dose of mineral nitrogen in N1/N2 conventional treatments are as follows: winter wheat 40/80 kg ha⁻¹, spring barley 0/30 kg ha⁻¹, and common pea 10/20 kg ha⁻¹, potato and red clover zero nitrogen. Dose of nitrogen in conventional system was under restricted level allowed for protective zone of water resources. N1 maximum dosage allowed, and N2 50 % of allowed level was applied. Nitrogen levels in ecological management system make distinctions according different input of permitted form of nitrogen into N2 treatments as follows: spring barley and winter wheat via top dressing of 50 L ha⁻¹ Vermisol, red clover by higher sowing density, common pea by inoculation of rhizobin, potato by catch crops as green manure. Two weeks after harvest straw and crops residues were ploughed in by mouldboard tillage and the catch crops phacelia and mustard were sown. In conventional system level of P and K was calculated according nutrient uptake of growing forecrops (Bujnovský, 2002), also straw incorporation were taken into account when calculating doses of fertilizer phosphorus and potassium. The methodology for the nutrient balance calculation was based on Kováčik (2001).

The aim of the research was to evaluate the nutrient balance in ecological and conventional cropping system in water protective zone, calculated according input (mineral and organic fertilizers, green manure – catch crops, seeds or tuber, biological nitrogen fixation, and atmospheric wet deposition), and output (nutrient uptake of main and by-product).

3 Results and Discussion

On the base of field study, the nutrient balance of N, P, K, Mg, and Ca in six crop rotation pattern was investigated. Nitrogen balance in cultivation of common pea was active in all treatments with higher active balance in conventional system (CS) at range of 24.1 kg ha⁻¹ – 26.7 kg ha⁻¹ with comparison to 13.5 kg ha⁻¹ – 14.9 kg ha⁻¹ in ecological one.

In winter wheat growing after common pea, the higher active balance (+39.2 kg ha⁻¹) of nitrogen was in ecological system at higher level of fertilization (ES-N2) opposite to conventional system CS-N1 with negative balance of nitrogen (-17.0 kg ha⁻¹). Application of farm yard manure positively influence the active balance of potato fields in all systems and treatments with range of +132.6 kg ha⁻¹ up to 152.8 kg ha⁻¹. The negative balance of nitrogen in all spring barley treatments was in range -36.7 kg ha⁻¹ in conventional system up to -65.6 kg ha⁻¹ in ecological one. Top dressing of Vermisol only slightly influence the balance between fertilization levels. The active balance of nitrogen in red clover fields was in narrow interval from +95.2 kg ha⁻¹ to +99.2 kg ha⁻¹. Winter wheat growing after common pea as a forecrop, reached the higher active balance in ES – N2 with the same tendency for all treatments with accordance with wheat growing after red clover. The FYM application positively influence the better nitrogen balance of winter wheat growing in ecological system with comparison to conventional one. The total nutrient balance of two cropping systems and two level of nitrogen fertilization is summarize in table 1.

Table 1 Total nutrient balance of ecological and conventional cropping system, 1999–2005

System	Input level of N	N	P	K	Mg	Ca
ES	N1	+48.4	+0.1	+30.3	+6.5	+96.3
ES	N2	+56.5	+2.2	+41.2	+8.0	+95.5
CS	N1	+32.9	+13.3	+94.9	+5.8	+92.2
CS	N2	+46.1	+12.1	+95.0	+5.1	+72.2
Ecological system ES		+52.5	+1.2	+35.8	+7.3	+95.9
Conventional system CS		+39.5	+12.7	+95.0	+3.0	+82.2
Average		+46.0	+7.0	+65.4	+5.2	+89.1

Data for six crop rotation period revealed active balance of nitrogen in all treatments with average surplus in ES 52.45 kg ha⁻¹ with comparison to 39.5 kg ha⁻¹ in conventional system. Active balance of potassium ranged from 35.8 kg ha⁻¹ in ES and 95 kg ha⁻¹ in CS was also noted. Our findings contradict the results of Kajanovičová et al. (2011) who found nitrogen deficiency in the ecological system and Jakub (2009) mentioned passive balance of potassium in ecological growing system. In ecological system, the greater part of potassium returns to the land through organic fertilizers (Lacko-Bartošová, 2005). Equal balance of phosphorus and magnesium was also confirmed.

4 Conclusions

The suitable management practices and well-designed crop rotation system ensure a balanced account of phosphorus and magnesium in ecological system. Higher active balance of phosphorus and potassium was in conventional system. FYM very intensively influence the balance of all evaluated nutrients and is the main compensation tool in nutrient balance of ecological farming system. Incorporation of fertility building crops (green manures and catch crops) in sufficient way positively influence the nutrient balance across the whole crop rotation.

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