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Productivity and macroelements content of cereal and legume crops

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Productivity of ecological and conventional system at two fertilization level, and average content of N, P, K and Mg in grains was evaluated in a field trial at south–western Slovakia during 1999-2005. A six-crop rotation pattern was used as follows: common pea – winter wheat and catch crop, early potato, spring barley, red clover, and winter wheat and catch crop. The designed ecological system support the productivity of cereals and legumes comparable to conventional system. No differences between two levels of fertilization and productivity expressed in Cereal Units (CU) were recognized. Negative relationship between productivity expressed in CU and total content of macroelements was confirm. Significantly higher content of potassium and magnesium was detected in ecological system with comparison to conventional system with higher input of nitrogen.

Keywords: ecological system, crop rotation, cereals, legumes, macroelements, productivity

1 Introduction

Organic farming, which does not allow the use of chemical, is regarded as one prototype to enhance the sustainability of modern agriculture while decreasing environmental impacts. Growing legumes, a major biological nitrogen source, is also a powerful option to reduce synthetic nitrogen fertilizers use and associated fossil energy consumption (Vereš and Týr, 2012; Bedoussac et al., 2015). Agricultural systems are particularly sensitive due to their co-products being used in various sectors and accounted for at several allocation steps. If the allocation procedures for different products from the same agricultural system are not aligned to one another, methodological inconsistencies might occur. As a consequence, the overall environmental burden of the agricultural system is not properly assessed. The Cereal Unit (CU) has been used as a common denominator in German agricultural statistics for decades and is mainly based on the nutritional value for livestock (Brankatschk and Finkbeiner, 2014).The content of minerals, P, K, Mg, Ca, Zn, fibre, and essential amino acids as important nutritional components of cereals is of key importance for selection of cereal grains in production of functional foods (Sidhu et al. 2007, Kowieska et al., 2011).

2 Material and Methods

The experimental site of RIPP 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:

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common pea – winter wheat and catch crop, early potato, spring barley, red clover, and winter wheat and catch crop. Farmyard 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.

The aim of our research was to evaluate the productivity and content of N, P, K and Mg in grains of pea, winter wheat after common peas and spring barley and winter wheat after red clover growing under ecological system (ES) and conventional systems (CS). Medium and low level of nitrogen was evaluated (N1, N2). The dose of mineral nitrogen in N1/N2 conventional treatments are as follows: winter wheat 40/80 kg ha^{-1}, spring barley 0/30kg ha^{-1}, and pea 10/20 kg ha^{-1}. We evaluated the productivity expressed in Cereal Units (CU) according Čvančara (1967). Term cereal units is used to express the contribution that crops make to the nutrition of monogastric animals.

3 Results and Discussion

Productivity of growing systems expressed in Cereal Units (CU) and level of macroelements of common pea, winter wheat and spring barley calculated as a part of six crop rotation system growing in ecological and conventional way is documented in Table 1. Average productivity across the whole trial was 4.81 CU.

Table 1 Productivity of crops in ecological system (ES) and conventional system (CS) expressed in crops cereal units (CU) and content of nutrient in grain during 1999–2005

Parameters	ESN1	ESN2	CSN1	CSN2
CU	4.57^{a}	4.75$^{a.b}$	4.96^{b}	4.96^{b}
N	2.10^{a}	2.13a^{b}	2.12^{a}	2.20^{b}
P	2.19^{b}	2.18^{b}	2.05^{a}	2.16$^{a.b}$
K	5.35^{b}	5.40^{b}	5.36^{b}	5.17^{a}
Mg	1.06^{b}	1.06^{b}	1.06^{b}	1.01^{a}

Means followed by the same letter are not significantly different at the $P < 0.01$ probability level separately within management systems and within crops

The productivity of ecological system with higher level of nutrition (ES-N2) reach the comparable productivity with conventional one. No differences between two levels of fertilization were noted within the system. Productivity of both treatments of CS was significantly higher by 0.26 CU with comparison to lower level of nutrition of ecological system. The CU is an appropriate unit for the description of agricultural products and can serve as the basis for an agriculture-specific allocation approach in LCA (Mönking, 2010). The Cereal Units used also Žák et al. (2012) for evaluation of productivity of energy production of arable crops.

Total average of nitrogen content of evaluated crops was significantly higher in higher level of nitrogen input in both systems. Average content of phosphorus varies in narrow interval of 2.05 %–2.19 %, but significantly lover content was in conventional treatment with lower level of nitrogen input. Significantly less content of potassium and magnesium was detected in conventional system with higher input of nitrogen. The same increasing content of potassium and magnesium in grain of wheat influence by ploughing system found Woźniak et al. (2014).

Correlation analysis (Table 2) between CU and content of macroelements revealed significantly negative relationship between productivity and average content of macroelements across the trial.

Table 2 Relationship between productivity and content of macroelements in cereals and legumes involved in crop rotation pattern

Systems	CU - N	CU - P	CU - K	CU - Mg
Growing systems	-0.7452++	-0.3926++	-0.7590++	-0.6008++
Ecological system	-0.7122++	-0.3373++	-0.7201++	-0.5866++
Conventional system	-0.7632++	-0.4559++	-0.8020++	-0.6161++

4 Conclusions

The designed ecological system support the productivity of cereals and legumes comparable to conventional system. No differences between two levels of fertilization and productivity expressed in CU were recognized.

Negative relationship between factor of productivity expressed in CU and total content of macroelements was confirm.

Significantly higher content of potassium and magnesium was detected in ecological system with comparison to conventional system with higher input of nitrogen.

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