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COMPARISON OF MINERALISATION AND HUMIFICATION OF POSTHARVEST RESIDUES OF CEREALS IN CONVENTIONAL AND ORGANIC CROPPING PRACTICES

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Abstract

TESAŘOVÁ, M., KUDLIČKA, P., POSPÍŠILOVÁ, L., KALHOTKA, L., HRABĚ, F.: *Comparison of mineralisation and humification of postharvest residues of cereals in conventional and organic cropping*. Acta univ. agric. et silvic. Mendel. Brun., 2006, LIV, No. 1, pp. 121–126

Yearly inputs and transformations of above – and underground plant residues of winter wheat and spring barley were followed in „intensive“ (I, mineral fertilizers only) and „organic“ (0, most of nutrients applied as animal manure) crop sequences. Total amount of postharvest residues was lower in I crop system compared with that in the organic (O) one. Plant residues produced in O crop system were decomposed more rapidly both under field and laboratory conditions, than those from I crop system. Differences between Corg at the beginning and at the end of ten-weeks laboratory incubation of soils enriched by plant residues indicated that soil microflora humified more intensively a) spring barley than winter wheat residues and b) underground plant residues than straw.

postharvest residues, winter wheat, spring barley, decomposition, humification, cropping practices

One of the urgent problems of contemporary agriculture is the choice of prospective types of farming on arable soil in submontane areas. Such farming types should fulfil several conditions: they should be optimal with respect to yields, considerate with respect to natural environment, and they should observe traditional forms of farming of the respective region (Bouma, 2004; Schjonning et al., 2004). Formulation of such agri-environmental policy therefore requires knowledge about the specific relationships that exist between farm management practices, base environmental conditions and field crops structure. These relationships are studied in the region of Bohemian Moravian Upland, where the economic and ecological aspects of using different crop sequences are tested. Among the evaluated criteria are both quantitative and qualitative changes of the organic soil matter as related to the balance of organic matter in the agroecosystem. Part of the study and its goal was to characterize the amounts of postharvest remains of cereals (winter wheat and spring barley) and the processes of their transformation in different crop sequences.

MATERIAL AND METHODS

Field experiments were established in 1999 at the research station of the Faculty of Agronomy, Mendel University of Agriculture and Forestry Brno, at Vatín (Bohemian Moravian Upland, 530 m asl., average yearly air temperature 6.9 °C, average yearly precipitation 621 mm, soil type cambisol typical). There are two crop sequences each with six crops in rotation: 1) „intensive“ crop sequence (I) with exclusively cash crops (cereals, oil plants) and an optimal level of chemical inputs (mineral fertilizers, pesticides) but without organic farmyard manure, 2) „organic" crop sequence (O) with fodder and cash crops (clover, green-pea, cereals, potatoes), utilizing farmyard manure. Each experimental variant was established in four replicates, the size of individual plots was 12 m × 10 m.

Both crop sequences involve winter wheat (var. Niagara) and spring barley (var. Nordus). Nutrients are applied in the „intensive" crop sequence (I) exclusively in the mineral form at rations (kg/ha/year) 130N, 40P and 80K (winter wheat) and 60N, 35P and 80K (spring barley). Inputs of N, P, K in the „organic" system (O) involve 90N, 30P and 80K to winter wheat and 40N, 30P and 60K to spring barley, however 60% of inputs are in the organic form.

The mass of winter wheat and spring barley postharvest residues, the intensity of their decomposition and humification as well as selected parameters of the biological soil activity were recorded during the 2000 to 2002 years. The mass of postharvest residues was estimated immediately after the harvest in 2000 and 2001. Data on the mass of aboveground plant remains were obtained by both collecting from plots 20 cm × 20 cm (four replicates from each experimental variant), and by collecting from the surface of soil cylinders (see below).The mass of root remains was estimated in soil cylinders removed in 12 to 16 replicates for each experimental variant by means of a sampler 75 mm in diameter and 250 mm long. Aboveground plant remains were collected in the laboratory from the upper cylinder surfaces and then the root remains were isolated by gradual washing the cylindre on sieves with mesh sizes of 2 mm and 0.5 mm. Aboveground plant remains and root remains relieved of all adherent soil were then dried to constant weight at the temperature of 60 °C. The results were recalculated to the area of 1 ha.

Microbial transformation of plant remains and the organic soil matter were monitored under both field and laboratory conditions. The rate of straw and root remains decomposition (litter-bag method), the CO_2 output from soil and the intensity of cellulose decomposition were measured in the field by means of methods according to Tesařová (1987) and Tesařová et Gloser (1987). Soils sampled in 25 cm upper layer twice a year (spring and autumn of 2000, 2001 and 2002 years) were analyzed for Cox oxidimetrically by a Walkley-Black method (Nelson et Sommers, 1982) and numbers of cellulolytic microorganisms (plate counts method).

Laboratory experiments were focussed on the processes of mineralization and humification of plant remains. Freshly collected soil samples were sieved (2mm mesh) and enriched by plant remains (100 g soil, 2 g of finely cutted straw or roots) and incubated for 10 weeks under optimal temperature (25 °C ± 1 °C) and moisture conditions (60% WHC). The output of CO_2. was recorded during the whole time of incubation using soda-lime as absorbent (see Tesařová et Gloser, 1987). Soil samples taken at the beginning and on the end of incubation were dried in the air, sieved at mesh size of 0.5mm and analyzed for the Corg. The data were statistically evaluated (Statgraphic, ANOVA P=0.05).

RESULTS AND DISCUSSION

The overall amount of postharvest remains passing every year into the soil i.e sum of stubble, straw and root residues, has reached 5.8 to 7.5t per ha^{-1} for winter wheat and 2.9 to 3.6t per ha^{-1} for spring barley (Tab. I). Similar values were published by Jurčová et Bielek (1997): 5.6 and 3.97 $t.ha^{-1}$ for winter wheat and spring barley respectively. The postharvest residua of both crops involved about 20 to 30% of the roots (Tab. I). This is evidently the reason why no relationship was found between the total amount of postharvest remains and the yields. The yields of above – ground plant biomass, i.e. sum of grain and straw attained with winter wheat in the I (intensive) and O (organic) crop sequences 10.05 $t.ha^{-1}$ and 9.29 $t.ha^{-1}$ respectively, corresponding data for spring barley were 7.01 $t.ha^{-1}$, and 6.49 $t.ha^{-1}$.

Root remains of cereals in soil were decomposed under field conditions substantially more slowly than the straw (Tab. II). Whitmore et Matus (1996) clearly showed that the representation of fibre carbon (hemicellulose plus cellulose plus lignin) is more higher in root than in shoot residues of cereals. As easily decomposable parts of residues break down, the fibrous part become more concentrated in the remainder and retard decomposition to a greater and greater extent. The decomposition rate of both root remains and straw was always higher (statistically significant in most cases) in the O than in the I crop sequence. Same differences in the decomposition rate of root remains (evaluated according to the CO_2 output) were found between cereals grown in both O and I crop rotations under laboratory conditions (Fig. 1). One reason of the more intensive decomposition rate of postharvest cereal remains from the O crop rotation can be the more favourable C/N ratio. The values of C/N ratio for wheat straw from the O crop rotation attained 66 and from the I crop rotation 72. Similar relations were found for the barley straw (C/N = 55 for I and 50 for O crop sequence).

I: *Average mass of postharvest cereal remains ($t.ha^{-1}$ per year)*

	Crop sequence	
	Intensive (I)	Organic (0)
Postharvest residua ($t.ha^{-1}$)		
Stubble, straw		
winter wheat	4.25[a]	5.85[b]
spring barley	2.30[a]	2.84[a]
Root remains		
winter wheat	1.51[a]	1.62[a]
spring barley	0.62[a]	0.73[a]
Sum		
winter wheat	5.76[a]	7.47[b]
spring barley	2.92[a]	3.57[a]

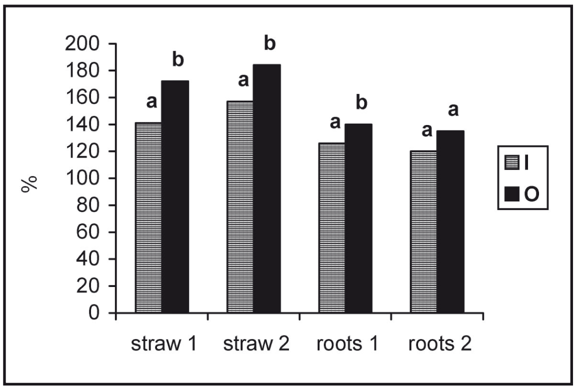
Values in lines designated by different letters are significantly different (P = 0.05)

II: *Decomposition rate of postharvest residua under field conditions ($mg.g^{-1}$ per day)*

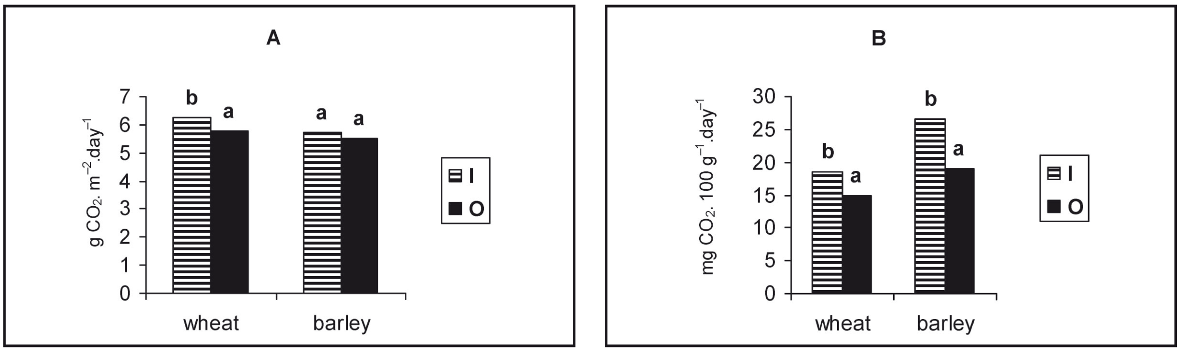
	Crop rotation	
	Intensive (I)	Organic (0)
Straw		
winter wheat	2.85[a]	3.68[b]
spring barley	2.88[a]	3.71[b]
Root remains		
winter wheat	1.03[a]	1.51[b]
spring barley	1.45[a]	1.77[a]

Values in lines designated by different letters are significantly different (P = 0.05)

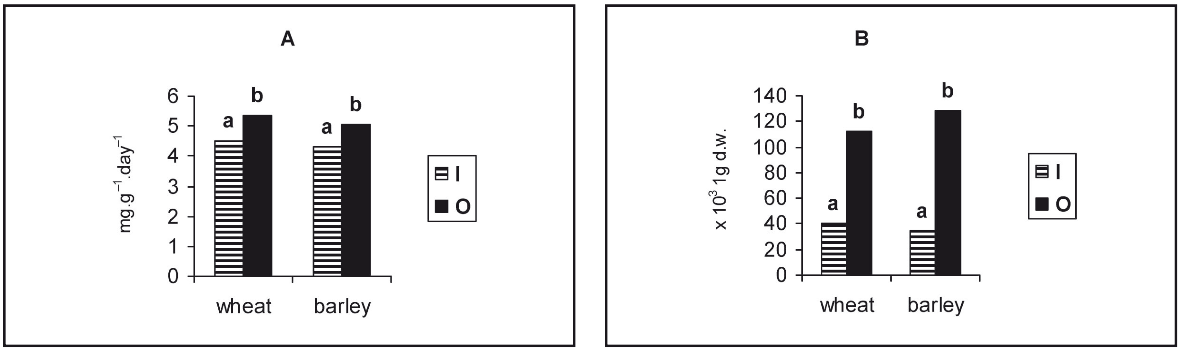
The results of measuring CO_2 output from soil under both field and laboratory conditions indicate a comparable or even higher biological activity of soil in the intensive crop sequence (I), i.e. in variants with mineral fertilization (Fig 2). This is seemingly in contradiction with measurement results on the decomposition of postharvest remains (Tab. II, Fig 1) giving evidence on their more intensive course in the soil of the organic crop sequence (O). Nevertheless, it is necessary to take in account that the soil respiration data include the CO_2 released by microbial decomposition of both easily as well as more difficultly decomposed organic substances. Data on the decomposition of cellulose in soil indicate that the worse available organic substances of the cellulose type were faster decomposed in the soil of organic crop sequence (Fig 3). This conclusion is supported by significantly higher numbers of cellulolytic microorganisms in soils of organically fertilized variants (Fig 3).



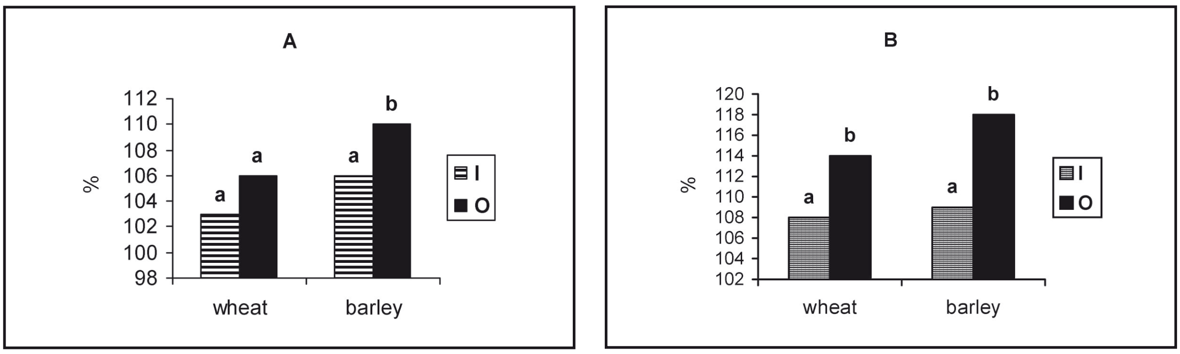
1: *The CO_2 output from soil enriched by the postharvest remains of cereals under laboratory conditions. Data expressed as percentage of control (CO_2 released by soil alone). Intensive (I) and organic (O) crop sequence, 1 – winter wheat, 2 – spring barley. Data for I and O crops sequences designated by different letters are significantly different (P = 0.05).*



2: *The* CO_2 *output by soil in the field (A) and laboratory conditions (B) Intensive (I) and organic (O) crop sequence. For details see Fig 1.*



3: *The decomposition rate of cellulose in soil under field conditions in mg.g*$^{-1}$ *per day (A) and counts of cellulolytic microorganisms (×* 10^3 *per g of dry soil-B). Intensive (I) and organic (O) crop sequence. For details see Fig 1.*



4: *Changes in Corg contents in the course of ten week´s incubation of soil samples enriched by straw (A) or root remains (B) in % of the control (soil without plant material). Crop sequence intensive (I), organic (O). For details see Fig 1.*

Amount of plant residues, incorporated in arable soils into soil organic matter by microbial activities, strongly depend on management practice (Beyer et al., 1999; Filip et Kubát, 2004). Our results confirm these findings. Intensity of humification processes was evaluated on the basis of differences between Corg soil contents on the beginning and at the end of ten weeks lasting incubation of soil samples enriched by postharvest remains. The contents of Corg in the soil were in all studied cases higher at the end of incubation than on its beginning, and this particularly in soil samples enriched by postharvest residua from the organically fertilized variants (Fig 4). An overall faster humification process was shown (a) by the postharvest remains of spring barley than by those of winter wheat and (b) by root remains than by straw. These data agree on the whole with data of Corg estimated in soil of the field experiment (Pospíšilová et Tesařová, in preparation), with relatively higher Corg contents in soil below spring barley (1.48%) than below winter wheat (1.32%), as well as with higher Corg values (1.50%) in the organic crop rotation (O) than in the intensive one (1.30 %).

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SOUHRN

Srovnání mineralizace a humifikace posklizňových zbytků obilnin při konvenčním a organickém způsobu hospodaření

Na výzkumné stanici Agronomické fakulty MZLU v Brně ve Vatíně (Českomoravská vysočina, nadm. výška 530 m) byly v r. 1999 založeny polní pokusy zaměřené na perspektivní způsoby hospodaření na orné půdě v podhorských oblastech. Objektem studia byla pšenice ozimá (*Triticum aestivum*, odr. Niagara) a ječmen jarní (*Hordeum vulgare*, odr. Nordus) zařazené do tzv. intenzivního osevního postupu (I, výhradně tržní plodiny a optimální úroveň minerálního hnojení) nebo postupu tzv. organického (O, pícniny a tržní plodiny, statková hnojiva). V průběhu let 2000–2002 byla zjišťována hmotnost nadzemních i podzemních rostlinných zbytků, intenzita jejich rozkladu v půdě v polních (metoda litter-bag) i laboratorních podmínkách (na základě výdeje CO_2) a stupeň humifikace (desetitýdenní modelové laboratorní pokusy). Celková hmotnost posklizňových zbytků, v nichž 20–30 % tvořily kořeny, byla vyšší v organickém osevním postupu (O), a to jak u pšenice ozimé, (O–7,47 t.ha^{-1}, I–5,76 t.ha^{-1} ročně), tak ječmene jarního (O–3,57 t.ha^{-1}, I–2,92 t.ha^{-1}). Posklizňové zbytky osevního postupu O byly – ve srovnání s osevním postupem I – rozkládány v půdě rychleji v polních i laboratorních pokusech. V modelových pokusech v laboratoři bylo zjištěno, že půdní mikroflóra humifikuje intenzivněji posklizňové zbytky a) ječmene jarního než pšenice ozimé, b) kořenové zbytky ve srovnání se slámou.

posklizňové zbytky, pšenice ozimá, ječmen jarní, mineralizace, humifikace, osevní postupy, konvenční a organický způsob hospodaření

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