Agronomy Research **4**(2), 531–542, 2006

Impact of the farming systems on the content of biologically active substances and the forms of nitrogen in the soils

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Abstract. Investigations were carried out in 2000 and 2001 to assess the impact of four farming systems on the content of biologically active substances and different forms of nitrogen in the soils. The transformation of bound amino acids and the total amount of free phenolic acids, urease activity as well as the total nitrogen, concentration of ammonium, nitrate, organic carbon, and humus in the soils were related to the choice of the farming systems. The highest concentration of bound amino acids, lysine and β–alanine, the total nitrogen, organic carbon, and humus in soils was found in ecological and conventional systems. It was confirmed that the increase of free phenolic acids in the soils of continuous cropping of winter wheat was followed by the decrease of the yearly mean concentrations of urease activity, the total amount of bound amino acids, the total nitrogen and grain yields, weight of 1000 grains, and number of ears m^{-2}. The conventional system affects the increase of the yearly mean concentrations of the total amount of bound amino acids, the ammonium ions, and the grain yield, weight of 1000 grains, number of ears m^{-2} and the decrease of the total amount of free phenolic acids in the soils.

Key words: amino acids, phenolic acids, urease activity, total nitrogen, ammonium and nitrate, organic carbon, farming system

INTRODUCTION

At present, there are three different crop production systems used in agriculture: ecological, conventional and integrated. Each one of them is characterized by the direction of crop rotation, fertilization, plant protection, etc. (Kuś, 1998). Integrated production seeks to integrate economic and ecological objectives. Compared with conventional production, it is characterized by a shifting of focus from harvest maximization to cost saving and quality enhancement. This involves a reduction of fertilizer input, a preference for non-chemical rather than chemical pest control methods wherever possible, and use of adapted cultivation schemes, including more frequent crop rotation (Tamis & Brink, 1999).

Continuous cropping in comparison with crop rotations affects the physical, chemical and biological composition and biochemical properties of soil. Long-term continuous cropping results in accumulation of identical metabolites of microbes and products of plant biomass decay. These substances may develop stress conditions for many organisms including cultivated plants, leading to higher susceptibility to pathogens and pests and impairing their growth (Szajdak et al., 2004).

It has been widely acknowledged that the intensification of agricultural production leads to simplification of agroecosystem structure and loss of humus. The creation of huge uniform fields accentuates the amplitude of microclimatic factors and other phenomena such as the loosening of local cycles of matter circulation and the reduction in many structural elements. Indications of these fundamental changes in ecosystem function include enhanced chemical leaching, blow-off, volatilization, erosion, frequent floods and droughts, pest outbreaks, etc (Ryszkowski et al., 1999).

Nitrogen occupies a unique position among the elements essential for plant growth because of the rather large amounts required by most agricultural crops. The significance of nitrogen is indicated by the fact that is an important constituent of proteins, nucleic acids, porphyrins, and alkaloids. In the soil 95% and more of the total soil nitrogen is closely associated with organic matter (Schnitzer, 2001).

Phenolic compounds are characterized by a high biological activity and when present at high concentrations in the soil they have a detrimental effect on crop productivity. It was found that products formed during the decomposition of the same biochemical material leads to autointoxication of the soil. At the same time, poorly differentiated plant mass getting into the soil under continuous winter wheat cropping negatively affects soil organism communities. This negative action leads to the change in metabolism of microbes from the primary to the secondary metabolism, producing toxic metabolites (Krylov et al., 1993).

The objective of this study was to compare the impact of the farming systems on biologically active substances and the content of nitrogen forms in the soils and in winter wheat yields.

MATERIALS AND METHODS

Soils originated from the long-term arable plots at the Experimental Station of the Institute of Soil Science and Plant Cultivation in Osiny near Puławy (51°25' N, 21°58' E). This station has been carrying out experiments since 1994. Soil sub-samples were collected in 2000 and 2001 (May, August, October) from 20 locations and from the upper 20 cm, which were mixed for the purpose of preparing a "mean sample". The experiments were conducted on grey-brown podzolic soil, on a good wheat and very good rye complex with loamy sand, valuation class IIIA-IVA according to 1994 FAO. The arable plots design was a split-plot experiment with a single replicate on the fields of all plants simultaneously. Each of the arable plots was limited to 1 ha. Investigations on winter wheat were carried out throughout the crop rotations and continuous cropping. The experimental units include four types of cropping systems: ecological, conventional, integrated, and continuous cropping. Table 1 gives the main characteristics of the cropping systems for the period 2000 and 2001.

For determination of bound amino acids and free phenolic acids, urease activity, the total nitrogen, concentration of ammonium and nitrate, and organic carbon, three samples of this soil were taken. Analyses for each sample were performed in three replicates. Within the soils investigated, from 19 to 21 bound amino acids were identified and determined. For the analysis of bound amino acids, soil samples were hydrolyzed with 6 M HCl for 24 h at 105°C. Separation and determination of the bound amino acids were carried out on a T 339 amino acid analyzer (Mikrotechna-Prague) using column Ostion LGFA (0.37 x 20 cm).

Table 1. Selected elements of agrotechnics of winter wheat in the soils of four farming systems (2000, 2001).

Characteristics	Farming systems			
	ecological	**conventional**	**Integrated**	**continuous cropping**
Crop rotation	Potato Spring barley+ companion crop Red clover with grass Red clover with grass Winter wheat+ intercrop	Winter rape Winter wheat Spring barley	Potato Spring barley Horse bean Winter wheat+ Intercrop	Winter wheat
Fertilization	30 t ha^{-1} of compost under potatoes	N-140 kg ha^{-1} P_2O_5-60 kg ha^{-1} K_2O-80 kg ha^{-1} straw of winter rape and winter wheat	N-85 kg ha^{-1} P_2O_5-55 kg ha^{-1} K_2O-65 kg ha^{-1} 30 t ha^{-1} of compost under potatoes	N-140 kg ha^{-1} P_2O_5-60 kg ha^{-1} K_2O-80 kg ha^{-1} straw every third years
Fungicides	-	Sportak Alpha 1.5 l ha^{-1} Tango 1 l ha^{-1} Tilt Plus 1 l ha^{-1}	Sportak Alpha 1.5 l ha^{-1} Tilt Plus 1 l ha^{-1}	Sportak Alpha 1.5 l ha^{-1} Tango 1 l ha^{-1} Tilt Plus 1 l ha^{-1}
Herbicides	-	Glean 75 DF 20 g ha^{-1} Granstar 25 g ha^{-1} Puma Universal 1.0 l ha^{-1} Maraton 375 SC 4.0 l ha^{-1} Chwastox D 3.5 l ha^{-1}	Maraton 375 SC 4.0 l ha^{-1}	Maraton 375 SC 4.0 l ha^{-1} Puma Universal 1.0 l ha^{-1} Chwastox Turbo 2.5 l ha^{-1}

Lithium-citric buffers of the following pH were used: 2.90, 3.10, 3.35, 4.05 and 4.90 and absorbance of the eluent-ninhydrin complex were monitored at 520 nm. The mobile phase was pumped at the rate of 12 cm^3 h^{-1} and developed a pressure of 2.5 MPa. All experiments were run in triplicate and the results averaged (Szajdak & Österberg, 1996). Phenolic acids were determined according to Szajdak's & Życzyńska's method (1994).

Urease activity was estimated by the Hoffman and Teicher technique (Russel, 1972). Total nitrogen in the soils was measured by the Kjeldahl method (Lityński et al., 1976), ammonium and nitrate by the distillation method (Ostrowska et al., 1991), and the content of organic carbon with carbon analyzer TOC-5050A facilities, Solid Sample Module SSM-5000A, Shimadzu, Japan. The mean temperatures and total rainfall data during the period of vegetation of winter wheat are presented in Table 2.

Table 2. Monthly mean temperature and total of precipitation in the growing season of winter wheat (meteorological station Osiny near Puławy in Poland).

Month	Temperature (°C)		Precipitation (mm)	
	1999/2000	2000/2001	1999/2000	2000/2001
IX	15.0	11.7	29	60.8
X	8.1	11.1	39	12.4
XI	1.5	6.6	42	32.7
XII	0.3	1.5	21	44.6
I	-1.8	-0.4	22	32.6
II	2.2	-0.7	32	24.4
III	3.3	2.7	65	41.9
IV	11.9	8.8	49	88.9
V	15.1	14.9	59	15.3
VI	17.4	15.5	30	58.4
VII	17.0	21.0	174	139.5
VIII	18.0	19.3	62	84.4

RESULTS AND DISCUSSION

Enzymes are central to microbial activity and nitrogen transformations. Urease activities have been shown to be responsive to environmental conditions and agricultural management. Urease catalyzes the hydrolysis of urea to CO_2 and NH_3, which can be adsorbed by soil particles; in this way it is easily accessible to plants (Nannipieri et al., 2002). Tillage, residue management, fertilization and cropping practices have significant effects on urease activity in soils. It was shown that the yearly mean of the urease activity was higher in 2000 (7.4 μmol h^{-1} g^{-1}) for the ecological system than for the conventional, integrated and continuous cropping systems (Table 3). Different phenomena appeared in 2001, where the yearly mean activity of this enzyme was the lowest in the ecological system (4.0 μmol h^{-1} g^{-1}) and the highest in the integrated system (5.1 μmol h^{-1} g^{-1}). According to Pancholy & Rice (1973) soil enzyme activity is dependent on seasonal variation, with the highest activity of urease in summer; the lowest, in winter. Furthermore, soils under crop rotations with a high input and diversity of organic materials generally contain high concentrations of microbial biomass and enzymes compared with continuous cropping systems (Burket & Dick, 1998; Klose & Tabatabai, 2000). Inorganic nitrogen fertilization can have significant effect on soil microorganisms and enzymes through higher plant yields and thus, crop residues, and through its impact on soil pH, depending on the amount and type of fertilizer. Studies have documented an increase in microbial biomass and activity as well as a decrease of these parameters with increasing nitrogen fertilizer application (Burket & Dick, 1998). Dick et al. (1998) showed that urease activity was suppressed by long-term nitrogen fertilizer application. This outcome was not in accordance with our results (Table 1).

It is well known that active microbial biomass is strongly associated with the pH values of the soil. An increase of ureolytic bacteria biomass is more favorable at neutral pH.

The present study showed that farming systems of soil were not correlated to pH. It was found that the optimum pH for the soils ranged from 5.0 to 7.7 (Table 3). Szajdak and Matuszewska (2000) observed that enzyme activity increased together with the increasing pH values.

Table 3. Yearly mean urease activity (µmol h^{-1} g^{-1}), pH (H_2O**)**, total nitrogen (N-tot.), concentration of ammonium (N-NH_4) and nitrate (N-NO_3) (mg kg^{-1}), organic carbon (C-org.) humus (g kg^{-1}) and C/N (± 95% confidence interval) in the soils of four farming systems (2000, 2001).

Parameters	**Farming systems**							
	Ecological		**conventional**		**integrated**		**continuous cropping**	
	2000	**2001**	**2000**	**2001**	**2000**	**2001**	**2000**	**2001**
Urease activity	7.4 ± 0.52	4.0 ± 0.28	5.8 ± 0.41	4.5 ± 0.32	5.8 ± 0.41	5.1 ± 0.52	5.5 ± 0.39	4.8 ± 0.34
pH	5.8 –6.0	5.5 –6.1	6.5 –7.7	5.4 –5.7	5.4 –6.0	5.0 –5.3	5.2 –5.8	5.5 –5.9
N-tot.	899 ± 62.93	1269 ± 88.83	874 ± 61.18	1120 ± 78.40	720 ± 50.40	779 ± 54.53	630 ± 44.10	950 ± 66.5
N-NH_4	8.6 ± 0.60	27.7 ± 1.94	21.3 ± 1.49	23.4 ± 1.64	6.7 ± 0.47	43.9 ± 3.07	12.3 ± 0.86	45.5 ± 3.19
N-NO_3	4.8 ± 0.34	16.8 ± 1.18	3.0 ± 0.21	20.8 ± 1.46	9.0 ± 0.63	19.1 ± 1.34	6.0 ± 0.42	41.0 ± 2.87
C-org.	-	15 ± 1.05	-	16 ± 1.12	-	16 ±1.12	-	9 ± 0.63
Humus	-	26 ± 1.82	-	28 ± 1.96	-	28 ± 1.96	-	16 ± 1.12
C/N	-	12 ± 0.84	-	14 ± 0.98	-	14 ± 0.98	-	10 ± 0.7

Nitrogen in soils occurs as both organic and inorganic forms. Essentially, all nitrogen in the plough layer occurs mostly in organic combinations, ranging between 93 to 97%. The assumption is often made that from 1 to 3% of the organic nitrogen in soil is mineralized during the course of the growing season, presumably available to plants. These studies indicate that differentiae of quantitative composition of total nitrogen were influenced by the types of the farming systems. The ecological and conventional systems resulted in a greater increase (874–1269 mg kg^{-1} in 2000 and 2001) in the yearly mean content of the total nitrogen than the integrated and continuous cropping systems (Table 3). Winter wheat was sown after the red clover, with grass mixture, in the ecological system, but after the winter rape in the conventional system. However Koper & Piotrowska (1999) showed that the total nitrogen concentration was higher in the soil under rotation than under continuous cropping. Our research in 2000 and 2001 in the ecological and the conventional systems confirmed their results. More accurate inorganic fertilizer application in the soil under continuous cropping might be an influence to increased concentration of the total nitrogen in 2001 as compared to the integrated system (Tables 1, 3). According to Janowiak & Murawska (1999) applied mineral fertilization as well as complex mineral–organic fertilization essentially influenced the content of total nitrogen in the examined soils.

Ammonium and nitrate are mobile, that is, subject to leaching and movement into water supplies. The magnitude of the leaching of inorganic forms of nitrogen- depends on a number of variables: amount and time of rainfall, infiltration and percolation rates, evapo-transpiration, the water-retention capacity of the soil, and the presence of growing plants. The economic and environmental attributes of various farm-types vary significantly; the variations in nitrogen leaching between farm-types are therefore the result of differences in the production mix within farm-types (Skop & Schou, 1999). Our results indicate mean values of determined amounts of these nitrogen forms. An especially high yearly mean concentration of ammonium (45.5 mg kg^{-1}) and nitrate (41.0 mg kg^{-1}) occurred in the continuous cropping system in 2001. Higher yearly mean concentration of these ions was observed in 2001 rather than in 2000 in the soils of all four farming systems (Table 3).

The results of Skjemstad et al. (1998) indicated that the organic carbon status in soil was improved by balanced application of chemical fertilizer nutrients and manure. Climate seems to be the most important factor regulating organic carbon content of soil, as it determines to a great extent the vegetation type and the amount and nature of the organic residues that enter the soil. Additional factors such as topography, lithologic substrate, clay content, mineralogy, pH, redox potential and soil structure, as well as land use, also influence soil organic carbon levels. Our results showed that the yearly mean content of organic carbon was formed equally throughout the farming systems (15–16 g kg^{-1}) except in continuous cropping (9 g kg^{-1}) (Table 3). The study by Sokołowska's et al. (1998) confirmed that the amounts of organic carbon were higher in the ecological rather than in the conventional system.

The nitrogen content of organic residues, as reflected through the C/N ratio, is of primary importance in regulating the magnitude of the two opposing processes of mineralization and immobilization. The ratio of carbon mineralized to nitrogen mineralized increased with the application of different ratios of fertilizer nutrients and manure (Goyal et al., 1993). The C/N ratio in the ecological, conventional and continuous cropping systems ranged from 10 to 14 (Table 3). These values indicate that there are processes permitting retention of the balance in the decomposition and formation of humus in soil.

The experimental results were treated statistically by ANOVA (± 95% confidence interval, $\alpha = 0.05$) between urease activity, total nitrogen, ammonium, nitrate, organic carbon, humus, and C/N, among others, in the soil samples of the four farming systems (2000, 2001). Results indicated a significant relationship between nitrate and the ecological, conventional, integrated, continuous cropping systems, and ammonium, total nitrogen, organic carbon, humus, C/N in the ecological and continuous cropping systems. However, no significant relationship was found for urease activity and the ecological, conventional, integrated, continuous cropping systems, or in ammonium, total nitrogen, organic carbon, humus, C/N and conventional or integrated systems.

The main identifiable organic compounds of nitrogen in the soil are amino acids, which exceed concentration of ammonium and nitrate. Amino acids are incorporated into soils from root exudates. They are also created in the process of post-harvest residue decomposition and can result from transamination of certain keto acids, compounds that are a source of nutrients for plants and other soil organisms. Considerable quantities of amino acids occur in soil in the protein fraction bound to humus, mostly to humic acids. Amino acids, which account for the majority of organic nitrogen in soils and humic substances, impact plant growth and serve to explain how organic matter promotes soil productivity (Schnitzer, 2001). Our investigations have shown that the highest concentration of the total amount of amino acids were found in the soil under the conventional system (509.94 g kg^{-1}) and the lowest in the soil under the continuous cropping system (249.92 g kg^{-1}) (Table 4).

Table 4. Bound amino acids (g kg^{-1}, ± 95% confidence interval) and the total amount of free phenolic acids (mg kg^{-1}, ± 95% confidence interval) in the soils of four farming systems (year 2000).

Amino acids	**Farming systems**			
	ecological	**conventional**	**integrated**	**continuous cropping**
Cysteic acid	13.82 ± 0.5	17.92 ± 0.7	1.12 ± 0.1	9.80 ± 0.4
Taurine	4.49 ± 0.2	5.52 ± 0.2	2.46 ± 0.1	1.20 ± 0.1
Proline	5.09 ± 0.2	2.25 ± 0.1	10.68 ± 0.4	3.20 ± 0.1
Glycine	1.79 ± 0.1	3.71 ± 0.1	38.11 ± 1.5	0.90 ± 0.1
Alanine	71.03 ± 2.7	77.84 ± 2.9	67.27 ± 2.6	34.52 ± 1.3
Cytruline	114.20 ± 4.3	111.55 ± 4.2	94.16 ± 3.6	34.52 ± 1.3
Methionine	2.72 ± 0.1	1.66 ± 0.1	1.25 ± 0.1	0.76 ± 0.1
Valine	16.86 ± 0.6	19.49 ± 0.7	14.45 ± 0.6	10.75 ± 0.1
Phenyloalanine	7.54 ± 0.3	4.63 ± 0.2	5.72 ± 0.2	4.72 ± 0.2
Cysteine	33.69 ± 1.3	41.42 ± 1.6	28.26 ± 1.1	24.38 ± 0.9
β–alanine	12.24 ± 0.5	21.42 ± 0.8	3.94 ± 1.2	2.28 ± 0.1
Cystathionine	13.03 ± 0.5	6.20 ± 0.2	7.06 ± 0.3	8.69 ± 0.3
β–aminobutyric acid	7.88 ± 0.3	7.72 ± 0.3	4.99 ± 0.2	–
Leucine	69.05 ± 2.6	67.92 ± 2.6	60.04 ± 2.3	33.31 ± 1.3
γ–aminobutyric acid	5.89 ± 0.2	7.84 ± 0.3	6.30 ± 0.3	4.15 ± 0.2
Ornithine	13.69 ± 0.5	19.51 ± 0.8	11.01 ± 0.4	10.60 ± 0.4
Lysine	39.84 ± 1.5	49.65 ± 1.9	33.82 ± 1.3	30.58 ± 1.2
Histidine	20.41 ± 0.8	21.41 ± 0.8	15.05 ± 0.6	14.25 ± 0.5
1–methylhistidine	5.27 ± 0.2	14.29 ± 0.5	6.18 ± 0.3	6.25 ± 0.2
3–methylhistidine	3.19 ± 0.1	3.87 ± 0.2	8.21 ± 0.3	–
Arginine	21.48 ± 0.8	4.12 ± 0.2	18.84 ± 0.3	15.06 ±0.6
Total amount of bound amino acids	483.20 ± 19	509.94 ± 20	438.91 ± 17	249.92 ± 9
Total amount of free phenolic acids	10.5 ± 0.74	9.9 ± 0.69	15.7 ± 1.10	35.2 ± 2.46

This study revealed that the total amount of bound amino acids in the soil were 51% higher in the conventional system than in continuous winter wheat cropping. Życzyńska-Bałoniak & Szajdak (1993) also confirmed much higher concentrations of the total amount of bound amino acids in the soil under crop rotation than under continuous cropping.

Furthermore our investigations showed that when the highest rate of inorganic fertilizer was applied, there was decreased accumulation of the total amount of bound amino acids in the soil under continuous cropping; simultaneously, they exhibited increased concentration in the conventional system (Tables 1, 4).

Particular attention was paid to those amino acids having significant importance in soil transformation, i.e. proline, β–alanine, lysine, 1–methylhistidine and 3–methylhistidine. In the soil samples, concentrations of proline were from 52 to 79% higher in the integrated system than in other farming systems (Table 4). In addition, the results of other authors showed a much higher concentration of proline in the soil under continuous cropping than under crop rotation (Życzyńska-Bałoniak & Szajdak, 1993). The high percentage of this amino acid is dangerous because proline is a heterocyclic amino acid that undergoes slow decomposition in soil. In acid soils, and in the presence of nitrous acid, this compound creates N-nitroso derivatives that are toxic and show cancer–, muta– and teratogenic activity (Larsson et al., 1990).

It is worth noticing that the highest concentration of β–alanine and lysine (12.24–49.65 g kg^{-1}) were in the soils of the conventional and ecological systems. Lysine is formed in the soil due to decarboxylation of α, ε–diaminopimmelinic acid. It is commonly known that this acid, as well as β–alanine, are typical constituents of bacterial cell walls. Higher concentration of β–alanine and lysine found in the soils under the conventional and ecological systems than under integrated and continuous cropping systems may indicate a higher microbial biomass and the increase in the rate of transformation of the organic matter in these soils. Earlier investigations by Szajdak et al (2004) confirmed the increase of the density of both amino acids in soils under crop rotation. Particular attention should be given to the concentrations of 1–methylhistidine and 3–methylhistidine, which are products of the decomposition of lower plants (mosses, lichens and algae). High amounts of these compounds in the examined samples indicate higher biomass of these plants in those soils (Parsons & Tinsley, 1975). The highest amounts of 1–methylhistidine (14.29 g kg^{-1}) were found in the soils of the conventional system, and 3–methylhistidine (8.21 g kg^{-1}) in the integrated system (Table 4).

Intensive cropping systems based on cereal growing and mineral fertilizers often lead to a decreased level of soil organic matter, which significantly influences physical properties of the soil. At the same time, poorly differentiated plant mass getting into the soil negatively affects soil organism communities, leading to the change of microbes from the primary to the secondary metabolism. This, in turn produces toxic metabolites, namely: phenolic compounds and combinations of amino acids with purine bases and sugars. It is often considered that the important factors regulating the content of biologically active substances in the soils are fertilization, the cropping system, plant pesticides and precipitation (Ryszkowski et al., 1998; Szajdak et al., 2006). Our investigations have shown that the changes of phenol compound levels in the soil are influenced by farming systems (Table 4). The highest concentration of the total amount of free phenolic acids was found in soil under continuous cropping (35.2 mg kg^{-1}), in agreement with Szajdak (2003). The results have shown that a very long period of continuous cropping system in comparison with crop rotation may result in an increase of accumulation of free phenolic acids. We would also observe an increase of these compounds with the highest decrease of the total amount of bound amino acids and yearly mean urease activity and total nitrogen in soil under continuous cropping rather than in the other cropping systems (Tables 3, 4). Furthermore our tests showed that application of the highest inorganic fertilizer rate resulted in the highest accumulation of the total amount of free phenolic acids in the soil under continuous cropping and, simultaneously, their lowest concentration in the conventional system (Tables 1, 4).

The highest mean grain yield of winter wheat (5.6–7.3 t ha^{-1}) in 2000 and 2001 was obtained with conventional and integrated systems (Table 5). This suggested that there wasn't a significant relationship between loss of grain yield of winter wheat and weed biomass. Our investigations indicated a higher number of ears m^{-2} (471–586) and weight of 1000 grains (45.0–49.6 g) in both those management systems than in continuous cropping and ecological system. Additionally, our results revealed that the highest concentration of ammonium (21.3 mg kg^{-1}) corresponds to the total amount of bound amino acids (509.94 g kg^{-1}), which represent the character of building material in the soils of conventional systems (the year 2000) (Tables 3, 4, 5). The above relationships have been connected with low concentrations of phenolic acids, substances inhibiting seed germination and growth of root cells, in comparison with continuous cropping (Table 4).

Table 5. Grain yields of winter wheat and property of structure for four farming systems (Osiny).

Characteristics	Year	Farming systems			
		ecological	conventional	integrated	continuous cropping
Grain yields* (t ha^{-1})	**2000**	3.8	6.2	7.3	5.5
	2001	4.8	5.6	5.7	4.2
Number of Ears m^{-2}	**2000**	422	497	471	455
	2001	506	531	586	441
Weight of 1000 grains (g)	**2000**	41.2	48.5	49.6	44.3
	2001	42.9	45.8	45.0	40.9

*/ mean grain yields for four varieties of winter wheat (Kobra, Roma, Juma, Elena) which were cultivated in every farming system.

Our experiments indicate the effects of continuous cropping, namely the decrease of biological equilibrium of the agro-ecosystems and lower yields, as compared with a crop rotation. One of the indices of these changes is the significant accumulation of phenolic compounds and the decrease of amino acids, progressive degradation of humus, as well as increased phytotoxic compounds content. It is related to a lower number of ears m^{-2}, weight of 1000 grains and yield of winter wheat.

The interrelation between yields of winter wheat and chemical composition of soils has been discussed in different crop production systems. However, the experiments with applications of generically different organic fertilizers, crop rotations, tillage, kinds and doses of plant pesticides made it difficult for us to analyze the results. In the conventional, integrated and continuous cropping systems a positive relationship was found between yield of winter wheat and chemical parameters of the soil. Our results showed the impact on the crop yields of biologically active substances in soils under different farming systems.

CONCLUSIONS

1. It follows from our experiments that the ecological and conventional farming systems increased the content of the total amount of bound amino acids, lysine and β–alanine, representing the microbial biomass in the soils and the total nitrogen, higher than the integrated and continuous cropping systems. However, the ecological and conventional systems lowered concentrations of the total amount of free phenolic acids, which inhibited seed germination and growth of root cells.
2. Application of the highest inorganic fertilizer rate led to a decrease in accumulation of the total amount of bound amino acids in the soil under continuous cropping, but simultaneously, to their increased concentration in the conventional system. However, different phenomena related to the changes of the content of the total amount of free phenolic acids appeared in these cropping systems.
3. Compared to the other farming systems, continuous cropping of winter wheat resulted in the following: increased total amount of free phenolic acids, and a decrease in the total amount of bound amino acids, urease activity, and total nitrogen concentration. It was related to a lower grain yield of winter wheat, number of ears m^{-2} and weight of 1000 grains.
4. The conventional farming system acts to increase the total amount of bound amino acids and yearly mean concentration of ammonium, and to a decreased content of the total amount of free phenolic acids in the soils. It was related to a larger grain yield of winter wheat, number of ears m^{-2} and weight of 1000 grains.
5. A distinct relationship was observed between the grain yield of winter wheat and the index of soil chemicals represented by the total amount of bound amino acids and free phenolic acids, and the yearly mean concentration of ammonium in the conventional, integrated and continuous cropping systems.

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