Research Journal of Agricultural Science, 43 (1), 2011

EFFECTS OF PHYSICAL SOIL TRAITS AND ORGANO-MINERAL FERTILIZATION ON POTATO PRODUCTION IN THE APUSENI MTS. AREA

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Abstract: *Potato holds the largest spread in the Apuseni Mts area as a cultivated plant, while being an essential element for the inabitants and their livestock, as the basic food support of the population in the area. Alongside the part played as a basic food for the population in the mountain area, the importance of the potato is increased as the altitude increases, being used as fodder for animal husbandry, due to the fact that agricultural plants under crop are limited to potato, rye, oat, certain fruit trees, certain vegetables, while the rest of areas are covered with natural pastures and forests. Potato holds the largest spread, as maize hybrids- even the early ones- do not reach maturity in this high area of the Apuseni Mts. The numerous research in the area led to the conclusion that there are good and even very good pedoclimatic conditions for the potato crop, also taking into consideration the climatic anomaliies lately. The severity of the impact exerted by climatic changes varies from one region to another and has a serious effect on agriculture. In this highly important sector, climate changes will affect crop harvesting, animal husbandry and the location of production. The increasing possibility and severity of climate events will lead to the increase the risk of calamity for cultivated agricultural and horticultural plants. Climate change will also affect the soil, decreasing the organic matter content – a major contributor to soil fertility. In this context, bearing in mind the basic occupation of inhabitants in the mountain area which is animal husbandry, a certain amount of organic fertilizers is presently obtained. However, through a rational capitalization, it can represent the main potato fertilization source in the area, bringing a contribution to the recovery of physical and chemical soil traits and implicitly maintaining their fertility. The specificity of the main potato product, its tubers, as underground stalks leads to a high demand with regard to physical soil traits, as potatoes only undergo normal development in sufficiently aerated soils. Thus, the most indicated soils for potato cultivation are well aerated and dispersed soils, with a loamy or a loamy-sandy texture. The requirement for soil aeration becomes apparent even from planting, as only good aeration leads to intense breating and thus more rapid germination. Consequently, stolons, as well as tubers, grow and develop normally only in well-aerated soils that are porous and rich in nutritive elements. Assessments on soils aimed for potato cultivation in our country were conducted by Teaci, Berindei, Copony, Maxim, Canarache and other specialists who have worked in the field.The objectives of the presented research aim at the effect of physical soil traits and organo-mineral fertilization on the quantitative and qualitative production of potato tubers, as well as the increase of the organic matter content in the soils for the promotion of sustainable and evironmentally-friendly agriculture in the area.The research conducted studies the effects of the soil's physical traits and differentiated organo-mineral fertilization systems in potato, through long-term field experiments, aiming at the quantitative achievement of tuber productions per surface unit and the modification of the main agrochemical soil indices. The results obtained will be part of an agrochemical optimization model for the soil-plant system in the potato crop, by setting the domains for the preservation of soil fertility and agrochemical risk domains (insufficiency-defficiency, excess-toxicity) for superior quantitative and qualitative tuber productions in the mountain area. The paper emphasizes the effect of differentiated organo-mineral fertilization and physical soil traits in the Apuseni Mts area on a districambosol (brown acidic soil) under potato crop for the quantitative and qualitative increase of tuber production per surface unit and for the maintenance and enhancement of soil fertility. Experiments were thus set on a districanbosoil, a brown acidic soil in the high subarea of the*

Apuseni Mts. at the basis of the north-north western slope in the Ariesul Mic river basin. The importance, originality and novelty of these agrochemical experiemnts are due to yet unsolved issued regarding fertilization combinations through the implementing of an ecologically-protective soil fertilization system to maintain and enhance the organic matter content according to the climatic specificity of the mountain area and the specific and overall consumption requirements of potato varieties in the area. In this respect, the experiments and overall research conducted in the present paper are new, useful and aim at the improvement of unfortunate situations (agrochemical risk-insufficiency-defficiency; excess- toxicity for potato tuber production) and provide with alternatives in the field for the differentiation of fertilization systems in order to select practical solutions that are both agrochemically and economically accessible. These ecologically-protective soil fertilization alternatives for potato crop in the mountain area accompanied by a rigorous agrochemical control, provide for a diversity of practical solutions in achieving the agrochemical optimum of the soil-plant system and protection of mountain ecosystems.

Key words: *soil, fertiliztion, mineral elements, potato*

INTRODUCTION

The paper highlights the effect of physical soil traits of the districambosol (brown acidic) soil in the Apuseni Mts. area and differentiated organo-mineral fertilization in potato crop to maintain and enhance the organic matter content in accordance with the climate specificity of the mountain area and the specific and overall consumption requirements of potato varieties in the area.

The varied relief, the damp climate and low fertility of soils in the area limits the variety of agricultural plants under crop on these soils, providing suitable developement conditions solely to non-termophilous plants with a short vegetation period. Potato is the crop with the largest spread, as it is an essential food for inhabitants and their livestock.

Agriculture is practised in the area of the Apuseni Mts. and plays and essential part as the basic activity of population in the area and the source of their existance. In this respect, the paper present the main physico-chemical traits of the districambosol, which is characteristic to the mountain area and certain differentiated organo-mineral fertilization systems that determine an optimum agrochemical environment for potato crops and the protection of mountain agriecosystems.

The paper was supported throgh the Programme 4 of CNMP „Partnerships in priority fields” 2nd Competition of 2008, PN II no. 52128/01.10.2008.

MATERIAL AND METHODS

The experiment was conducted in conditions similar to those employed to obtain the potato production in a mountai area, being placed during three experimental years on a brown acidic soil (Distrocambosoil) located in the high subrea of the Apuseni Mounntains, between the Găina Cruce (altitudes 1465 m) and Curcubăta Mare (altitude 1848 m) peaks, at the basis of the north-north western slope of the Arieşul Mic river basin. The experimental field was placed in the lower part of the mountain climate area (under the beech and mixed forest area). In these areas, soils underwent solification processes, dealkalinization and decarbonatation phenomena, as well as clayfication and acidic humus accumulation in „acidic mull” and „moder” forms, from a geomorphological and geologic point of view. The geolithologic substratum is formed of metamorphic rocks, crystalline schists, conglomerates, clay and ferruginous sandstone.

The experiment was polyfactorial with two factors, placed according to the subdivised lot method wih the following graduations:

Factor A: potato variety with graduations: a_1 – Semenic, a_2- Desiree

Factor B: level of fertilization with graduations:

b_0 – 0N + 0 P_2O_5 + 0 K_2O (kg s.a./ha)+ 0 t/ha manure (C. unfertilized);
b_1 – 40N + 40 P_2O_5 + 40 K_2O (kg s.a./ha)+ 0 t/ha manure;
b_2 – 60N + 60 P_2O_5 + 60 K_2O (kg s.a./ha)+ 0 t/ha manure;
b_3 – 80N + 80 P_2O_5 + 80 K_2O (kg s.a./ha)+ 0 t/ha manure;
b_4 – 0N + 0 P_2O_5 + 0 K_2O (kg s.a./ha)+ 10 t/ha manure;
b_5 – 0N + 0 P_2O_5 + 0 K_2O (kg s.a./ha)+ 20 t/ha manure;
b_6 – 0N + 0 P_2O_5 + 0 K_2O (kg s.a./ha)+ 30 t/ha manure;
b_7 – 40N + 40 P_2O_5 + 40 K_2O (kg s.a./ha)+ 20 t/ha manure;
b_8 – 60N + 60 P_2O_5 + 60 K_2O (kg s.a./ha)+ 20 t/ha manure;
b_9 – 80N + 80 P_2O_5 + 80 K_2O (kg s.a./ha)+ 20 t/ha manure;

In the case of polyfactorial experiments with two factors, the first with a graduation and the second with two graduations, a number of 20 variants resulted (table 2).

The biologic material employed for the experimentation was the elite Ostara and Desiree category, sorted before planting and employing only healthy tubers, with a 40-70 g weigth.

The potato variety under experiment is part of the precocious group of semiealry varieties, beig one of the most widespread varieties cultivated in the mountain region under study, due to its suitability for the less favourable conditions of growth and devlopment for the majority of agricultural plants under crop. In choosing the cropping system for potato cultivation, its biologic traits were considered, as well as the high requirements for the preparation and structuring of the soil. As such, during the three experimental years, the previous crop was rye, which was early removed from the land, thus providing the opportunity for potato cultivation through summer ploughing at a 15-20 cm depth.

In autumn, more precisely October, organic fertilizers were applied, as well as chemical fertilizers with phosphorus and potassium, in the doses required for experimental variants.

Fertilizer soil incorporation was conducted through autumn ploughing at a 25-30 cm depth, with the plough.

Land fertilization employing chemical nitrogen fertilizers was conducted in spring, namely March, using urea for the production of each experimental year, in the doses required for the exprimental variants.

The soil incorporation of these ferilizers was performed immediately after application, at a 17-18 cm depth.

For an increasingly aerated soil, which is both well structured and sufficiently aerated, the lasnd was prepared by cultivator, in order to achieve a 17-18 cm planting.

Tuber plating for the three experimental years was conducted manually, at the end of March, the beginning April, thus following the fertilization pattern .

Maintenace works during the vegetation period aimed at soil aeration, weed cotrol and the control of diseases and pests.

Disease and pest control was conducted over time, according to the moment of occurence and crop year, applying three treatments each experimental year to control the Colorado beetle, blight, both in a mixture with an insecticide, as well as by themselves, according to the attack severity, starting with the month of June, up to the physiologic maturation of potato plants.

Before harvesting, frontal and vaccial removals were conducted, as required by experimental tecique rules.

Harvesting was conducted manually, 10-15 days from the physiologic maturation of each variety, sufficiently enough for tuber periderma (peel) to suber.

Production determination was conducted by weighing for each variant, referencing tuber production to the surface unit (hectare), the production was transported, stored and capitalized in raffia sacks.

The physico-chemical analysis of the soil samples collected was conducted according to the ICPA method for agrochemistry laboratories (ICPA, 1981).

RESULTS AND DISCUSSIONS

a. The morphologic description of the SOIL PROFILE –Districambosol in the locality of Avram Iancu

The districambosol soil under study is located in the heart of the Apuseni Mts. at the basis of the north-north western slope of the Ariesul Mic river basin. From a morphologic point of view, as a consequence of natural solification processes, as well as human intervention, the soil exhibits along the depth of the profile the specific genetic horizons for mountain acidic soils.

Soil type: Districambosol (brown acidic), weak-moderat-gleyed:

Class: Cambisoils

Location: Loc. Avram Iancu, Târsa village;

Relief: wavy slope, slight terrace;

Slope: 10-15 ^{0}

Altitude: 1200

Usage: arable, potato crop

Rock : Green sericite schists, mica schists, conglomerates, loams;

Horizon succession: Ao-A/B-Bv_1-Bv_2(G)-R

Horizon Ao

- ✓ depth 0–23 cm;
- ✓ average loam;
- ✓ dark greyish brown (10YR4/1 when damp) and brown grey (10YR5/1 when dry);
- ✓ small-average gritty structure, poorly-stable;
- ✓ frequent average slender roots;
- ✓ moderate-aerated compact;
- ✓ rare earthworm galleries, coprolites;
- ✓ devoid of effervescence;
- ✓ pH 5

Horizon A/B

- ✓ thickness 24-41 cm;
- ✓ transition horizon with a gradual transition between A and B;

Horizon Bv_1

- ✓ depth 41-87cm;
- ✓ average dusty loam;
- ✓ dark yellowish brown (10YR5/4 when damp) and brown yellow (10YR6/3 when dry);
- ✓ large gritty structure, poor subangular polyhedron;
- ✓ moderate compact, moderate skeleton (15%);
- ✓ rare roots;
- ✓ no effervescence;

Horizon Bv_2

- ✓ depth 87 – 120;
- ✓ dusty loam;
- ✓ dark yellowish brown with rusty-red spots (10YR5/3 when damp) and marmorate brown-yellow (10YR6/1 when dry);
- ✓ polyhedron structure with lumps;
- ✓ weak-moderate compact;
- ✓ very rare roots;
- ✓ frequent skeleton phragments;
- ✓ devoid of effervescence
- ✓ pH 5-5,5

Horizon R

- Dislocated metamorphic rocks (green sericite schists, cloritous schists, mica schists, conglomerates, quartzites with loam famps)

b. Physico-chemical characterisation of the DISTRICAMBOSOL (brown acidic soil) under study

The districambosol soil, under potato cultivation during the experimental period in the locality of Avram Iancu is representative for the Apuseni Mts. area. It exhibits the physical and chemical traits of the soil class it belongs to and the acidic soil type (table 1). It reacts at the limit of the strong acidic state (aound the value of pH 5.0) in the supeficial horizon, with tendencies of slight increase in depth, according to the essential processes involved in the solification-dealkalinization and acidification processes.

With regard to soil evolution, the high mobile-Al concentration at soil-surface and in depth is apparent, which fits this soil within the limits for correction requirements through amendments and protective fertilization.

The content of exchangeable hydrogen (E_H) represents ove 60% of the total cationic exchange ability (T), which supports dealkalinization. Thus, there is a stringent requirement for ecologically-protective fertilization measures for agricultural and horticultural plants in the mountain area.

Suprinsingly, the soil exhibits a high humus content, but in a rough, unevolved form, expressed through a sufficiently high C/N ratio. This proves an average pace of humification, as well as mineralization determined by the specific mountain environmental conditions. This humic stability relies on the C-rich components and is relevantly supported by soil acidity, the representation of fulvic acids in the soil complex, as well as Al and Fe hydrate oxides. The expression of R_2O_3 representation may forecast a tendency towards the fixation-immobilization of certain nutritive ions (such as the phosphate ones), which increases the practical interest for the sufficient and correct application of organo-mineral fetilizers, in accodance to a rigorous agrochemical study.

From an agrochemical point of view, the soil has an average nitrogen supply in the superficial horizon and weak supply of this element in depth on the profile. It has a poor phosphorus supply and an everage potassium one.

Regarding the physical characteristics of the soil, there is a highlight on the soil profile of a loamy to a loamy-dusty one, but also a certain level of compaction- compression in the superior horizon (A_o) determined by a shallow processing.

The soil subscribes a category of acidic and poorly fertile soils that require special soil fertilization measures that allow for ecologic protection, as well. This is applied for the main nutritive elements according to the specificity of the mountain area where this soil is predominant and according to specific and overall plant consumption requirement.

Table 1

The main physico-chemical traits of the districambosoil (brown acidic soil) under study on the N-NW slope of the Ariesul Mic river in the Apuseni Mts. (Experimental years 2008-2010)

Properties	Horizons (thickness - cm)				
	Ao 0 – 20 cm	A/B 20 – 30 cm	Bv_1 30 – 45 cm	Bv_2 45 – 60 cm	R 60 – 80 cm
Chemical					
pH in (H_2O)	5,00	5,10	5,25	5,30	-
Mobile- Al (me)	2,68	2,36	1,20	1,10	-
Exchangeable H (S_H, me)	10,20	9,15	9,00	8,20	-
Exchange bases (S_B, me for 10g soil)	9,02	8,30	9,20	9,25	-
Cationic exchange capacity (T, me)	19,22	17,45	18,20	17,45	-
Humus (%)	5,20	3,78	1,21	1,08	-
Alkali saturation degree (V%)	47	48	51	53	-
Nitrogen index (I_N)	2,44	1,81	0,61	0,57	-
Mobile P (ppm)	7,80	5,15	4,20	3,15	-
Mobile K (ppm)	120	105	89	74	-
Carbon/nitrogen ratio (C/N)	24	17	16	15	-
Ca (me)	7,02	7,15	7,45	7,78	-
Mg (me)	2,10	1,14	0,80	0,44	-
K (me)	3,20	3,00	2,45	1,70	-
Na (me)	0,15	0,12	0,10	0,10	-
Concentration of humic acids/of fulvic acids (CAH/CAF)	0,65	0,54	0,28	0,20	-
Hydrate iron and aluminum oxides (R_2O_3%)	4,00	3,25	2,80	2,00	-
Physical					
Skeleton (%)	3	5	15	20	45
Coarse sand (2,0-0,2mm) %	24,4	28,6	18,8	25,4	-
Fine sand (0,2-0,02 mm) %	14,2	13,0	22,2	27,2	-
Dust (0,02-0,002 mm) %	36,5	33,9	41,2	36,2	-
Clay (%)	24,9	24,5	17,8	11,2	-
Apparent density (DA g/cm^3)	1,09	1,25	1,30	1,32	-
Texture	L	L	L	L	-

c. Average tuber productions achieved in the potato crop for the period under study

Statistic data processing of average tuber productions obtained during the experimental period (2008-2010) allow for a correct assessment of the effects of differentiated organo-mineral fertilization in Ostara and Desiree potati varieties under cultivation in the pedoclimatic area of the Apuseni Mts. (table 2)

Table 2

Effect of organo-mineral fertilization on average tuber productions for the Ostara and Desiree potato varities in the Apuseni Mts area (2008-2010 period)

No.	Variety	Fertilization variant	Average production (t/ha)	%	Difference	Significance
1	2	3	4	5	6	7
1	Ostara	b0 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha)+ 0t/ha stable manure (control)	17,65	100,0	0,00	Mt.
2		b1 –40N+$40P_2O_5$+ $40K_2O$ (kg s.a./ha)+ 0t/ha stable manure	19,59	111,0	1,94	***
3		b2 – 60N+ $60P_2O_5$+ $60K_2O$ (kg s.a./ha)+ 0t/ha stable manure	22,95	130,1	5,31	***
4		b3 – 80N+ $80P_2O_5$+ $80K_2O$ (kg s.a./ha)+ 0t/ha stable manure	24,10	136,6	6,45	***
5		b4 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha)+ 10t/ha stable manure	17,75	96,03	0,10	-
6		b5 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha) +20t/ha stable manure	17,95	96,60	0,30	-

1	2	3	4	5	6	7
7	Ostara	b6 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha) +30t/ha stable manure	18,16	97,80	0,51	-
8		b7 –40N+$40P_2O_5$+ $40K_2O$ (kg s.a./ha)+ 20t/ha stable manure	19,98	113,2	2,34	***
9		b8 – 60N+ $60P_2O_5$+ $60K_2O$ (kg s.a./ha)+ 20t/ha stable manure	24,96	141,4	7,31	***
10		b9 – 80N+ $80P_2O_5$+ $80K_2O$ (kg s.a./ha)+ 20t/ha stable manure	25,54	144,7	7,89	***
1	Desirée	b0 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha)+ 0t/ha stable manure (Control)	18,28	100,0	0,00	Mt.
2		b1 –40N+$40P_2O_5$+ $40K_2O$ (kg s.a./ha)+ 0t/ha stable manure	20,80	113,8	2,52	**
3		b2 – 60N+ $60P_2O_5$+ $60K_2O$ (kg s.a./ha)+ 0t/ha stable manure	25,23	138,0	6,95	***
4		b3 – 80N+ $80P_2O_5$+ $80K_2O$ (kg s.a./ha)+ 0t/ha stable manure	26,69	146,0	8,41	***
5		b4 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha)+ 10t/ha stable manure	18,35	100,4	0,07	-
6		b5 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha) +20t/ha stable manure	18,68	102,1	0,40	-
7		b6 – 0N+ $0P_2O_5$+ $0K_2O$ (kg s.a./ha) +30t/ha stable manure	18,89	103,3	0,60	*
8		b7 –40N+$40P_2O_5$+ $40K_2O$ (kg s.a./ha)+ 20t/ha stable manure	21,34	116,7	3,06	***
9		b8 – 60N+ $60P_2O_5$+ $60K_2O$ (kg s.a./ha)+ 20t/ha stable manure	26,67	145,9	8,39	***
10		b9 – 80N+ $80P_2O_5$+ $80K_2O$ (kg s.a./ha)+ 20t/ha stable manure	27,69	151,4	9,40	***

Ostara	DL (p 5%)	0,76
	DL (p 1%)	0,03
	DL (p 0,1%)	0,39
Desiree	DL (p 5%)	0,50
	DL (p 1%)	0,69
	DL (p 0,1%)	0,92

The data presented (table 1) regarding average tuber productions for the two potato varieties under testing in the experimental conditions of the Apuseni Mts. area, there can be observed a certain eveness of production obtained due to negative climate phenomena during the growth period.

Average production resultsfor the three experimental years in varieties under experiment were inferior to the were inferior to the variety's genetic potential, which mostly expresses the negative effect of climate imbalances lately and the low soil fertility in the mountain area, which hindered the expression the variety's productivity traits. The analysis of the differentiated effect of fertilization (organic, organo-mineral, complex-mineral) the experimental results obtained on a multiannual basis, shed light on the positive significance of increased fertilizer doses, as well as relevant differentiations determined by the nature and structure of fertilizing assortments applied and the biologic potential of assortments.

First and foremost, a positive effect resides i the nutritive fertilizing value of organo-mineral combinations with an organic substratum (20 t/ha stable manure), as well as a mineral support of nitrogen, phosphorus and potassium, systems that reveal the summing up and synergic effect of these combinations for tuber production. This combined positive effect is due to the initial level of precarious soil fertility, which is representative for the area, as well as the potato crop capacity that can positively capitalize organo-mineral interactions.

Compared to the highly significant effects of differentiated fertilization systems based o the organo-mineral interaction of nutrients, single fertilizations, either mineral nitrogen, phosphorus or potassium based ones or solely organic ones with manure prove the limiting factor of these interventions and their inability to meet with normal specific and overall consumption levels multi-annually for normal tuber productions.

Solely mineral fertilization, as well as the single character of the organic one prove to be partial in terms of their fertilizing effects and a limiting of the approach on these solutions for the potato cultivation technology in the Apuseni Mts. Area where this crop is relevant in obtaining basic food for the population in the area.

Despite this limitation, the population in the mountain area is too poor to afford the purchase of mineral fertilizers, thus being forced to practise subsistence agriculture, with limited natural resources from household animal husbandry. Natural organic fertilizers employed in the area are highly diversified assortments, from plant residues to animal residues, composts or natural elements that first exhibit an input of organic matters and substances that are incorporated into the soil and have complex positive results on low-quality soils that are specific to the area, as well as the quality of agricultural and horticultural products.

A through study of the complex approach on the efficiency of differentiated fertilization systems in potato crop for representative soils in the Apuseni Mts. Area, with limited levels of fertility and productive capacity, requires for a rigorous control and study on the evolution of these basic soil traits, from a qualitative point of view, as well as establishing certain risk domains. Solutions of single fertilization, be it mineral or organic, can determine impact states of acidification and limited nutrient supply compared to the organo-mineral fertilization system, able to improve the soil's traits, its buffering capacity. In these conditions, an important agrochemical aspect is highlighted with reference to the application of complementary mineral fertilization, for potato crop in the mountain area, on a suitable organic substratum provided through systematic organic fertilization to the soil achieved through the employment of organic fertilizers from personal households.

The organic support provided through the systematic application of manure in 20t/ha doses, offers the favourable and meliorating environment of soil physical and chemical traits. In this context, the complementary application of mineral fertilizers determines a higher bioavailability of nutrients and their better capitalization by potato plants and implicitly superior qualitative and quantitative productions.

CONCLUSIONS

In terms of the physical soil traits, the brown acidic soil (districambosoil) characteristic for the Apuseni Mts. area exhibits a profile where a preponderance of the loamy state is encountered and a certain level of compaction-compression in the superior horizon (A_o) determined by a superior processin, due to the presence of hard rocks and a high skeleton content;

Systematic organic fertilization for mountain area plants modifies positively and sustainably the acidic reaction (specific to mountain soils) through its neutralization, the coarse humus content, the nutritive element regime, the alkalinization of the adsorptive complex of the soil and implicitly its physico-chemical traits;

Organo-mineral fertilization, which is the most compatible with the biologic and nutrition requirements of the potato, enhances the bioavailability regime of soil nutritive elements on a organic support background, meliorates the acidic reaction of the soil, maintains and enhances soil fertility in the mountain area;

In the mountain area, animals are bred in a household system, and the quantity of natural fertilizers obtained alongside mineral fertilizers, through a positive organo-mineral fertilization can provide the fetilization of important land surfaces in order to obtain ecologic agricultural productions, on the one hand ad maintain and enhance the fertility of soils in the area, on the other;

At present, there is an increasing requirement and a special interest for conservative agriculture, which involves a more efficient management of vegetal residues and natural resources, providing the long-term sustainable employing of the land, preventing soil and agroecosystem degradation and obtaining qualitatively superior plant products for consumption that comply with food safety and security standards.

The paper was supported throgh the Programme 4 of CNMP „Partnerships in priority fields" 2nd Competition of 2008, PN II no. 52128/01.10.2008.

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