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ASSESSING THE SOIL PHYSIOLOGICAL POTENTIAL USING PEDO-BIOLOGICAL DIAGNOSIS UNDER MINIMUM-TILLAGE SYSTEM AND MINERAL FERTILIZATION

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Abstract

The main objective of sustainable agriculture is the protection of environment and natural vegetal and soil resources. Accordingly, the objective of this research was to assess the impact of technological systems by minimum tillage on soil biological activity, using the Pedo-Biological Diagnosis of Soil Resources. Our research was conducted on haplic chernozem from Experimental Station of University of Agricultural Sciences and Veterinary Medicine of Iasi, Romania, during the seasonal dinamic, to the soybean crop, on unfertilized and fertilized agrofond, using moderate mineral doses ($N_{80}P_{80}$) as average of 2009 – 2010 period, under minimum tillage (2x disk, paraplow, chisel) compared to conventional (plugging at 20cm and 30cm). In the case of soil works with chisel and paraplow without return of furrow, the Pedo-Biological Diagnosis highlights an increase of soil physiological potential, in the both variants (unfertilized and fertilized), unlike the method of alternating the depth of plugging that proved to be ineffective.
Key words: *minimum-tillage, soil biological activity, Pedo-Biological Diagnosis.*

Introduction

Sustainable agriculture has, like the main objective, the protection of environment and natural vegetal and soil resources. Technological system of conservative works are increasingly used because of the enlargement processes of soil degradation through conventional farming systems based on the intensive practices of the soil. Soil is a significant gene reservoir, so, an essential element in the functioning of the biosphere (Várallyay, 2010). Soil management practices influence soil physical and chemical characteristics and bring about changes in the soil microbial community structure and function (Reji et al., 2012). Alteration of soil conditions by tillage practices has complex effects on soil characteristics thereby affecting environmental conditions, the growth and activity of soil microorganisms and consequently, the nutrient dynamics. Other studies (Farahbakhshazad et al., 2008) highlighted that, the complex interrelationships, established between the soil management and biogeochemical cycles offer opportunities for the identifying and establishing the best management practices for agro-ecosystems because the crop production must be in harmony with soil conservation (Pagliai, 2008). For this reasons, in a sustainable agriculture, the cropping methods and technologies must

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be scientifically proved, in order to achieve high yields and sustainable management of the soil resources. This research aimed to assess the impact of soil conservation works by minimum tillage on soil biological activity, compared to conventional tillage, using the Pedo-Biological Diagnosis of Soil Resources.

Material and methods

This research was conducted at Experimental Station of University of Agricultural Sciences and Veterinary Medicine of Iasi, Romania, under specific ecological conditions of forest steppe from North Eastern Romania. The soil samples were collected from haplic chernozem, non-irrigated, unfertilized and fertilized with moderate chemical doses of nitrogen and phosphorus ($N_{80}P_{80}$). The sampling was accomplished on 0-15 cm and 15-30 cm depth, during seasonal dynamic, respectively in the autumnal period of 2009 and vernal and aestival period of 2010, to the soybean crop, under conservative soil works (2x disk, paraplow, chisel, plugging at 20cm and plugging at 30cm).

Pedo-Biological Diagnosis of Soil Resources (DIPEBIOS) is the synthetic matrix representation of the soil biological activity, having the role to quantify its physiological potential. For this reason we considered that the assessment file of the soil biological activity must contain the most important 10 pedo-biological indicators: soil respiration, celulosolyse, catalase, invertase, urease, total phosphatase Indicator of Vital Activity Potential, Indicator of Enzymatic Activity Potential, Biological Synthetic Indicator and dehydrogenase activity. Pedo-Biological Diagnosis of Soil Resources is expressed by value/points and is obtain by summing of the scores for each of the 10 analyzed pedo-biological indicators, after formula:

$$DIPEBIOS = \sum_{1}^{10}(R, C, K, I, U, P, IVAP, IEAP, BSI, DA) \text{ where:}$$

R- soil respiration; C- celulozolysae; K- catalase; I- invertase; U- urease; P- total phosphatase; IVAP- Indicator of Vital Activity Potential; IEAP- Indicator of Enzymatic Activity Potential; BSI- Biological Synthetic Indicator; DA - Dehydrogenase Activity.

For comparision of the results has done an assessment scale with five steps: 0-20 points - score 2–low biological activity; 21-40 points – score 4-sub-medium biological activity; 41-60 points – score 6–medium biological activity; 61-80 points–score 8 - good biological activity; 81-100 points – score 10–very good biological activity.

Results

Table 1a,b highlights the assessing soil physiological potential through the Pedo-Biological Diagnosis of Soil Resources (DIPEBIOS) under conservative soil works to the soy bean crop, on 0-15 cm and 15-30 cm depths, during seasonal dinamic, on unfertilized and fertilized agrofond. Biological activity pointed out higher values in

all experimental variants compared to disk x2 variant on 0-15 cm because in this variant the loosening is superficial, on 5-7 cm from the 15 cm taken into study.

Table 1a. *Matrix of Pedo-Biological Diagnosis of Soil Resouces (DIPEBIOS) to the soy-bean crop – spring season - flowering stage*

Indicators of soil biological activity	Depth (cm)	Conservative soil works *(values / notes)*									
		Disk x 2		Paraplow		Chisel		Ploughed 20 cm (Control)		Ploughed 30 cm	
		N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$
Soil respiration (mg CO_2)	0-15	32.88 **4**	34.16 **4**	47.41 **8**	49.72 **8**	50.81 **8**	53.65 **8**	35.16 **6**	38.24 **6**	33.51 **4**	35.32 **6**
	15-30	15.31 **2**	16.85 **2**	23.73 **4**	26.91 **4**	25.62 **4**	27.88 **4**	17.38 **2**	18.85 **2**	16.74 **2**	17.16 **2**
Celuloso-lysae *(% cellulose)*	0-15	33.56 **4**	35.61 **6**	48.32 **8**	50.91 **8**	51.54 **8**	54.41 **8**	36.51 **6**	39.78 **6**	34.42 **4**	36.61 **6**
	15-30	16.74 **2**	17.07 **2**	26.14 **4**	27.42 **4**	27.08 **4**	28.12 **4**	18.14 **2**	19.24 **2**	17.16 **2**	18.55 **2**
Catalase *(cmc O_2)*	0-15	201 **4**	222 **4**	256 **4**	276 **4**	288 **4**	296 **4**	245 **4**	251 **4**	212 **4**	235 **4**
	15-30	98 **2**	105 **2**	137 **2**	148 **2**	155 **2**	168 **2**	116 **2**	128 **2**	103 **2**	111 **2**
Invertase *(mg glucose)*	0-15	1342 **8**	1586 **10**	1653 **10**	1686 **10**	1771 **10**	1821 **10**	1515 **10**	1624 **10**	1404 **8**	1615 **10**
	15-30	705 **6**	788 **6**	801 **6**	832 **6**	815 **6**	861 **6**	788 **6**	853 **6**	722 **6**	816 **6**
Urease *(mg NH_4)*	0-15	19.16 **8**	23.56 **10**	24.61 **10**	25.81 **10**	25.16 **10**	26.73 **10**	21.41 **10**	25.26 **10**	20.22 **10**	24.01 **10**
	15-30	8.04 **6**	10.43 **8**	12.81 **8**	13.36 **8**	13.62 **8**	14.11 **8**	12.16 **8**	13.07 **8**	11.07 **8**	12.13 **8**
Total phospha-tase *(mgP)*	0-15	6.18 **8**	7.01 **8**	8.88 **10**	10.11 **10**	9.26 **10**	10.78 **10**	7.89 **8**	8.42 **8**	6.51 **6**	7.32 **6**
	15-30	3.01 **6**	3.45 **6**	4.23 **6**	5.01 **6**	4.58 **6**	5.21 **6**	3.95 **6**	4.35 **6**	3.24 **6**	3.56 **6**
Indicator of Vital Activity Potential- *%*	0-15	27.74 **6**	29.19 **6**	39.96 **8**	42.03 **8**	42.71 **8**	45.09 **10**	29.97 **6**	32.64 **6**	28.38 **6**	30.08 **6**
	15-30	13.47 **2**	14.15 **2**	20.98 **4**	22.68 **4**	22.08 **4**	23.35 **4**	14.86 **2**	15.90 **4**	14.16 **2**	14.99 **2**
Indicator of Enzimatic Activity Potential- *%*	0-15	16.83 **6**	19.78 **6**	21.33 **8**	22.32 **8**	22.76 **8**	23.86 **8**	19.42 **6**	20.03 **8**	17.67 **6**	20.30 **8**
	15-30	8.35 **4**	9.54 **4**	10.62 **6**	11.27 **6**	11.17 **6**	11.90 **6**	10.09 **6**	10.96 **6**	9.11 **4**	10.13 **6**
Biological Synthetic Indicator- *%*	0-15	22.29 **6**	24.48 **6**	30.64 **8**	32.18 **8**	32.73 **8**	34,47 **8**	24.70 **6**	26.34 **6**	23.02 **6**	25.19 **6**
	15-30	10.91 **4**	11.84 **4**	15.06 **4**	16.98 **4**	16.63 **4**	17.63 **4**	12.47 **4**	13.43 **4**	11.63 **4**	12.56 **4**
Dehydroge-nase *(mg TPF)*	0-15	18.17 **6**	19.21 **6**	25.81 **8**	27.11 **8**	31.61 **10**	33.44 **10**	19.66 **6**	20.45 **8**	20.06 **8**	20.11 **8**
	15-30	8.78 **4**	9.68 **4**	18.47 **6**	19.59 **6**	20.18 **8**	22.56 **8**	8.56 **4**	9.13 **4**	10.11 **6**	10.76 **6**
DIPEBIOS *Value/ Points*	0-15	**60** ***good***	**66** ***good***	**82** ***very good***	**82** ***very good***	**84** ***very good***	**86** ***very good***	**68** ***good***	**72** ***good***	**62** ***good***	**70** ***good***
	15-30	**38** ***sub-med.***	**40** ***sub-med.***	**50** ***med.***	**50** ***med.***	**52** ***med.***	**52** ***med.***	**42** ***med.***	**44** ***med.***	**42** ***med.***	**44** ***med.***

During the vernal season, DIPEBIOS highlights the lowest values, on unfertilized agrofond, in the disk x 2 variant, both, on 0-15 cm depth (60 points – medium biological activity), as well as, especially, on 15-30cm depth (38 points – sub-medium biological activity). The highest values, which reflect a very good biological activity appear in the paraplow and chisel variants, on unfertilized and

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fertilized agrofond, on the both depths. Thus, on unfertilized agrofond, DIPEBIOS highlights 82 points in case of soil worked with paraplow, on 0-15 cm depth and 84 points in case of soil worked with chisel.

Table 1b. *Matrix of Pedo-Biological Diagnosis of Soil Resouces (DIPEBIOS) to the soy-bean crop – summer season – after flowering*

Indicators of soil biological activity	Depth (cm)	Conservative soil works *(values / notes)*									
		Disk x 2		Paraplow		Chisel		Ploughed 20 cm (Control)		Ploughed 30 cm	
		N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$	N_0P_0	$N_{80}P_{80}$
Soil respiration (mg CO_2)	0-15	36.16 **6**	39.04 **6**	41.56 **8**	43.84 **8**	44.71 **8**	47.56 **8**	38.51 **6**	41.84 **8**	37.01 **6**	40.16 **8**
	15-30	16.24 **2**	18.75 **2**	20.17 **4**	22.11 **4**	22.52 **4**	24.92 **4**	17.48 **2**	17.06 **2**	17.11 **2**	16.12 **2**
Celuloso-lysae *(% cellulose)*	0-15	39.56 **6**	41.23 **6**	42.17 **6**	44.56 **6**	45.86 **8**	46.47 **8**	39.32 **6**	42.76 **6**	38.21 **6**	41.04 **6**
	15-30	17.61 **2**	19.84 **2**	21.41 **2**	23.13 **2**	24.91 **2**	25.02 **4**	20.08 **2**	19.21 **2**	18.72 **2**	18.32 **2**
Catalase *(cmc O_2)*	0-15	228 **4**	251 **4**	401 **8**	432 **8**	448 **8**	486 **8**	256 **4**	272 **4**	246 **4**	261 **4**
	15-30	107 **2**	118 **2**	186 **2**	196 **2**	206 **4**	225 **4**	152 **2**	128 **2**	131 **2**	122 **2**
Invertase *(mg glucose)*	0-15	1452 **8**	1516 **10**	1634 **10**	1788 **10**	1751 **10**	1801 **10**	1583 **10**	1601 **10**	1501 **10**	1588 **10**
	15-30	768 **6**	805 **6**	901 **6**	965 **6**	962 **6**	988 **6**	801 **6**	858 **6**	795 **6**	825 **6**
Urease *(mg NH_4)*	0-15	21.24 **10**	25.42 **10**	24.15 **10**	28.28 **10**	26.51 **10**	30.14 **10**	23.81 **10**	27.06 **10**	22.16 **10**	25.88 **10**
	15-30	10.06 **6**	13.57 **8**	13.81 **8**	14.36 **8**	14.17 **8**	15.02 **8**	12.33 **8**	16.04 **8**	12.05 **8**	15.41 **8**
Total phospha-tase *(mgP)*	0-15	6.81 **8**	8.12 **10**	8.15 **10**	9.06 **10**	8.95 **10**	9.32 **10**	7.45 **8**	8.58 **10**	7.01 **8**	8.42 **10**
	15-30	3.02 **6**	4.03 **6**	4.01 **6**	4.27 **6**	4.43 **6**	4.51 **6**	3.51 **6**	4.43 **6**	3.31 **6**	4.11 **6**
Indicator of Vital Activity Potential- *%*	0-15	31.83 **6**	33.63 **6**	34.94 **6**	36.89 ***8***	37.83 **8**	39.09 **8**	32.50 **6**	35.33 **8**	31.44 **6**	33.91 **6**
	15-30	14.21 **2**	16.17 **4**	17.43 **4**	18.93 **4**	19.96 **4**	20.81 **4**	15.87 **4**	15.29 **4**	15.06 **4**	14.53 **2**
Indicator of Enzimatic Activity Potential- *%*	0-15	18.46 **6**	20.95 **8**	22.74 **8**	24.31 **8**	24.76 **8**	26.29 **8**	20.34 **8**	21.28 **8**	19.24 **6**	21.74 **8**
	15-30	10.10 **6**	10.49 **6**	12.06 **6**	12.59 **6**	12.91 **6**	13.50 **6**	11.46 **6**	11.01 **6**	10.70 **6**	10.76 **6**
Biological Synthetic Indicator- *%*	0-15	25.15 **6**	27.29 **6**	28.84 **6**	30.60 **8**	31.29 **8**	30.19 **8**	26.42 **6**	28.80 **6**	25.34 **6**	27.82 **6**
	15-30	12.16 **4**	13.33 **4**	14.75 **4**	15.76 **4**	16.44 **4**	17.15 **4**	13.66 **4**	13.90 **4**	12.88 **4**	13.15 **4**
Dehydroge-nase *(mg TPF)*	0-15	22.41 **8**	23.81 **8**	27.34 **8**	30.44 **10**	32.11 **10**	34.16 **10**	19.81 **6**	20.45 **8**	20.14 **8**	21.36 **8**
	15-30	10.83 **6**	11.81 **6**	16.21 **6**	18.91 **6**	21.07 **8**	23.27 **8**	14.21 **6**	15.18 **6**	12.11 **6**	13.15 **6**
DIPEBIOS *Value/ Points*	0-15	**68** ***good***	**74** ***good***	**80** ***good***	**86** ***very good***	**88** ***very good***	**88** ***very good***	**70** ***good***	**78** ***good***	**70** ***good***	**76** ***good***
	15-30	**42** ***med.***	**46** ***med.***	**46** ***med.***	**46** ***med.***	**52** ***med.***	**54** ***med.***	**46** ***med.***	**46** ***med.***	**46** ***med.***	**44** ***med.***

Biological activity decreases on unloosening depth by the conservative works, correlated with reduction of soil aeration, even if is apply moderate doses of mineral fertilizers to the soil.

In case of conventional tillage (plugging 20 and 30 cm), DIPEBIOS pointed out a reduction of biological activity, compared with minimum tillage.

During the summer season, biological activity and so the DIPEBIOS shows an ascending trend compared with vernal season, on the both depth, in all variants of soil work on unfertilized and fertilized agrofond. The explanation is due, on the one hand, of wetter summer season of 2010 year and, one the other hand, of the special contribution of the rizosphere of soybean, as it known that, between the plant roots and microbial communities are establish dynamic and complex feed-back mecanisms. However, DIPEBIOS highlights the lowest values, on unfertilized agrofond, in the disk x 2 variant, both, on 0-15 cm depth (68 points – good biological activity), as well as, especially, on 15-30cm depth (42 points –medium biological activity). The highest values, which reflect a very good biological activity appear in the chisel variants (88 points – very good biological activity), on unfertilized and fertilized agrofond, on 0-15 cm depth. Also, an increase of biological activity highlights in case of soil worked with paraplow, particularly in the fertilized variant, on 0-15 cm (86 points). Referring to conventional tillage (plugging 20 and 30 cm), DIPEBIOS also pointed out a reduction of biological activity, compared with minimum tillage even if is apply the mineral fertilizers.

Discussions

According to Reji et al. (2012), the tillage practice and soil depth were two important factors affecting soil microbial communities. Disk x2 variant is inferior to the other experimental variants, due to the low depth of loosening and incorporation of plant remains. Fertilization with moderate doses of N and P improving the biological activity, particularly enzymatic activity. Inorganic fertilization, primarily with nitrogen, not only increases soil fertility but also influences its chemical, physical and biological properties (Mikanova et al., 2009). Our results correspond to those from literature that the soil loosening with chisel and paraplow pointed out the highest biotic and enzymatic levels. Several authors (Erbach et al., 1992; Pierce et al., 1992; Sojka et al., 1997; Franzluebbers, 2002) reported benefits associated with the use of paraplows, including increased infiltration rates, reduced soil strength and increased water availability to plants (López-Fando and Pardo, 2008). In general, minimum tillage like disk, paraplow and chisel, maintained greater biological activity than conventional tillage like ploughing at 20 and 30cm, especially in the layer of 0-15 cm (Gajda et al., 2013). By disk, like minimum tillage, the depth of loosening being low (5-7 cm), the effects of this soil work are unsatisfactorily for the depth taken into study (0-15 cm and 15-30). Plugging of 20 and 30 cm with return of furrow gradually leads to excessive mineralization and diminishing the content of humus (Mermut, 2010), like esential factor to soil fertility. Soil microflora use the humus for its existence and has no way to synthesize another humus if not introduce organic matter in the soil. Thus, in the chisel variant, without return of furrow, the organic remains on the soil after harvesting induce a higher activity of microorganisms, compared to plugging at 20 and 30 cm. Also, Baker et al. (2007) consider that minimum tillage and particularly no-tillage could contribute to storage of important amounts of

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organic carbon in the soil. Method of alternating depth of plugging, in our case, plugging at 20 cm and 30 cm, is not efficient, because is continued removing the humus to surface, at the same time contributing also to the formation of hard soil in greater depth.

Conclusions

Minimum tillage improve the soil biological activity compared with conventional tillage. Biological activity pointed out higher values in all experimental variants compared to disk x2, on 0-15 cm, because in this variant the loosening is superficial, on 5-7 cm from the 15 cm taken into study. The best values of pedo-biological diagnosis, superior in all experimental variants, pointed out in the wetter summer season of 2010 year. Under conditions of wetter summer of 2010 year, ascending trend of biological activity of the vernal season continues.

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ÉVALUER LE POTENTIEL PHYSIOLOGIQUE DU SOL EN UTILISANT LE DIAGNOSTIC PEDO-BIOLOGIQUE EN TERMES DE SYSTEMES DU TRAVAIL DU SOL ET DE L'ENGRAIS MINERAL

Résumé

L'objectif de cette recherche est d'évaluer l'impact des systèmes technologiques pour la conservation des sols sur l'activité biologique des sols en utilisant Diagnostic Pedo-Biologique. Notre recherche a été menée sur un certain type de tchernoziom au cadre de la Station Didactique et Expérimentale de l'USAMV de Iasi. La dynamique saisonnière, dans la culture de soja, dans un agro fond non fertilisé et fertilisé a utilise des doses chimiques modérées de l'azote et du phosphore ($N_{80}P_{80}$) dans la période 2009-2010, sous l'influence des travaux de protection du sol. Au cas des travaux du sol avec le burin et le paraplow , sans le labour du sillon, Diagnostic Pedo-Biologique révèle une croissance du potentiel physiologique du sol, dans les deux variantes contrairement à la méthode de l`alternance de profondeur de labour qui s' est avérée inefficace.

Mots-clés: *systèmes technologiques pour la conservation des sols, l'activité biologique du sol, Diagnostics Pedo-Biologique*

VALUTAZIONE DEL POTENZIALE FISIOLOGICO DEL SUOLO MEDIANTE DIAGNOSI PEDO-BIOLOGICA, IN UN SISTEMA DI GESTIONE CON MINIMA LAVORAZIONE E CONCIMAZIONE MINERALE

Riassunto

Per agricoltura sostenibile si intende il rispetto dei criteri di sostenibilità nella produzione agricola e agroalimentare privilegiando tutti quei processi naturali che consentono di preservare la "risorsa ambiente". L'obiettivo di questa ricerca è stato quello di valutare in modo concreto, mediante analisi pedo-biologica, l'impatto sull' attività biologica del suolo dei sistemi tecnologici di minima lavorazione. La ricerca è stata condotta presso la stazione sperimentale dell'Università di Scienze Agrarie e Medicina Veterinaria di Iasi (Romania), su soia seminata su suoli classificati come Haplic Chernozem. Lo schema applicato ha riguardato suoli fertilizzati e non fertilizzati. Le dosi utilizzate di concime minerale ($N_{80}P_{80}$) sono state moderate come nella media del 2009 - 2010. In aggiunta e' stato valutato uno scenario di minima lavorazione rispetto ad uno convenzionale (aratura 20-30 cm). Una prima analisi mette in evidenza che nei sistemi con lavorazione minima si e' avuto un aumento evidente della potenzialità fisiologia.

Parole chiave: *minima lavorazione, attività biologica, diagnosi pedo-biologica*

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