ROTATION AND FERTILIZATION - FACTORS IN INCREASING WHEAT PRODUCTION AND IMPROVING THE AGRO PRODUCTIVE FEATURES OF THE BROWN REDDISH SOIL FROM CENTRAL AREA OF OLTENIA

Gh. MATEI, G. PĂUNESCU, C. PĂUNESCU, F. IMBREA, Elena ROŞCULETE, C. ROŞCULETE

University of Craiova- Faculty of Agriculture
Craiova, 19 Libertăţii Street.
Corresponding author: matei.gheorghe@gmail.com

Abstract: *It is widely recognized that agriculture is an important sector which ensure the human food and the existence of life. Food production depends on numerous factors, among which the technological level achieved and soil quality that is achieved that production (M. Nicolescu et al., 2008). With increasing of world population, under continuous reduction of productive agricultural area per inhabitant, the overall capacity of food production in agriculture will be under continued pressure (Lal, 1995). In the future, expansion of agriculture in areas not covered in culture is not possible, land is presented with a reduced fertility, and technical and economic performances are almost impossible. In many cases, anthropogenic degradation is increasing, representing a real threat to terrestrial ecosystems in balance. The concept of sustainability, as an opportunity in agriculture, involving the choice for the future of those technologies to support the complex development of this area of activity (Elisabeta Dumitru et al., 2005). The introduction or removal from natural systems of additional quantities of energy and other artificial products can lead to their disruption, which requires that human activity to link with the natural ability to integrate them with beneficial effects for human and ecological balance. Concerning the above factors at SCDA Şimnic Craiova was initiated in 1965 the long-term experiments that have been pursued in addition to the influence of mineral and organic fertilization on the production and its quality but also the effects arising from the fertilization to the soil - the main means of production in agriculture - in terms of its development agro productive potential. In the present study we present results obtained in wheat production fall in the range 2005 - 2009 in the experiences with two factors (rotation x fertilization) and studied how these factors have influenced the evolution of agro productive characteristics of the brown reddish soil. The A factor - rotation – has 5 levels: monoculture, rotation of 2 years wheat-corn, rotation of 3 years pea-wheat-corn, rotation of 4 years sunflower-wheat-corn-wheat in which wheat has two prior. The B factor B - agrofond - has 5 levels: unfertilized, N_{100}, P_{60}, N_{100} P_{60}, and 20 t/ha manure. The work has generated a high degree of originality of results obtained on the evolution of wheat production achieved in different rotation, the best species are highlighted prior to this culture and also the analytical results of soil samples taken from each variant tested on agro productive changes to features of soil in the central area of Oltenia. Analyzing the bacterial micro flora (quantitative and qualitative aspects) in long-term experience on the effect of crop rotation and fertilization on wheat crops on the brown reddish soil were obtained increased total numbers of heterotrophic bacteria, indicating a strong effect at rizosphera level, with higher values in the monoculture of wheat, a situation due to large amount of plant debris left after wheat crops always heavier than the other hoeing crops.*

Key words**:** *wheat, rotation, fertilization, bacterial micro flora.*

INTRODUCTION

Modernization of agricultural structures is essential factor to global food security, with differences from area to area depending on the economic assessment and the general concept of sustainable development and implementation of production systems.

In Romania, many specialists, technologists and farmers address the complex issues of sustainable agriculture as a means of ensuring food security, conserving the natural environment in terms of recovery and efficient use of all agricultural resources.

Starting from the necessity of practicing sustainable agriculture is increasingly appreciate that achieving this goal depends on how balanced agricultural models are supported, which increases the production capacity of soils.

In natural ecosystems, the production and consumption of organic matter takes place naturally, as determined by the nature and abundance of primary resources of food and specific conditions under which it can be consumed, by the presence of water, heat and air, absolutely necessary to carry out biological processes, nutrition and breeding.

Wheat, the plant which consumes relatively small amounts of nutrients, is particularly demanding to fertilizers, because the root system explores a lower volume of soil and has less power for absorption of nutrients in forms more difficult soluble compared to other crops.

From mineral fertilizers, the nitrogen occupies a primarily place determining the crop growth rate (KANAME T., J. TAMAK 1979, AYOUB M. et al. 1994). Besides nitrogen, other nutrients balanced their role in nutrition of wheat, especially the phosphorus which must give the due weight (M. NICOLESCU et al., 2005). Highest yields are obtained when the fertilization is made using two types of fertilizers – nitrogen and phosphorus (LAUREY PI et al. 1980, ALTMAN DW et al., 1983).

MATERIAL AND METHODS

On the brown reddish soil from SCDA Şimnic Craiova we organize an experience with two factors (rotation x fertilization) and studied how these two factors have influenced in long terms the evolution of productions and agro productive characteristics of the soil from tested area.

The **A factor** - *rotation* – has 5 levels: monoculture, rotation of 2 years wheat-corn, rotation of 3 years pea-wheat-corn, rotation of 4 years sunflower-wheat-corn-wheat in which wheat has two previous plant: sunflower and corn.

The **B factor** - *agro fond* - has 5 levels: unfertilized, $N_{100,}$ $P_{60,}$ N_{100} $P_{60,}$ and 20 t/ha manure.

As varieties we use in 2005 – 2007 period the Boema variety and in cycle 2008 – 2009 the Briana variety. The density used was 550 germinable seeds/m^2.

As witness was used the average production of the most prevalent rotation in Romania now: wheat – corn.

RESULTS AND DISCUSSIONS

During the experimentation cycle 2005 – 2009 the climate conditions for winter wheat culture were different as favorability, especially from the precipitations point of view, which were unevenly distributed in the vegetation period of wheat. This aspect has a high influence to leverage of chemical fertilizers and finally to the yields obtained in each year (*tables 1 and 2*).

Production data analysis for each type of rotation showed the effect of chemical and organic fertilizations on wheat crop. It is obvious to obtain lower production for wheat in year 2007 due the severe drought from the 2007 spring.

In **wheat monoculture** the plus production registered were generated only by the fertilizers applied in doses of $N_{100}P_{60}$ and organic fertilization with 20 t/ha manure in comparison with the witness – the average yield of wheat – corn rotation (*table 2*).

In the **rotation of the two years – wheat – corn** – the level of production was higher than the previous rotation, the average yields registered in 2005 – 2009 was 33.7 q/ha (witness). In comparison with this value, higher yields were observed at the variant with both

macro elements $N_{100}P_{60}$ with a plus production of 8.0 q/ha and the variant with organic fertilization with a plus production of 5.3 q/ha. If we take into consideration the results obtained with the unfertilized variant from this rotation it can be observed that the all variants realized very significant increases in production from the statistically point of view (tables 1 and 2).

Table 1

The combined influence of rotation and fertilization to the wheat yields in non irrigated conditions at SCDA Şimnic Craiova (2005 – 2007)

Previous plant	Rotation A factor	Agro fond B factor	Productions q/ha		
			2005	2006	2007
a1 – wheat	monoculture	b1 - unfertilized	16.4	10.3	10,1
		b2 – N100	30.7	29.8	25,3
		b3 – P60	27.5	23.1	12,7
		b4 – N100 P60	43.1	41.7	27,2
		b5 – 20 t manure	40.7	36.1	26,2
Rotation average			**31,7**	**28.2**	**20.3**
a2 - corn	wheat - corn	b1 - unfertilized	19.2	12.3	13,2
		b2 – N100	38.9	34.4	25,6
		b3 – P60	30.1	25.8	18,4
		b4 – N100 P60	49.3	44.4	29,1
		b5 – 20 t manure	48.1	39.2	27,6
Rotation average – St.			**37,1**	**31.2**	**22.7**
a3 - pea	pea-wheat-com	b1 - unfertilized	21.3	18.3	16,2
		b2 – N100	41.0	47.2	29,6
		b3 – P60	36.3	39.2	23,3
		b4 – N100 P60	58.2	58. 9	31,1
		b5 – 20 t manure	56.3	55.5	30,2
Rotation average			**42,6**	**43.8**	**26.1**
a4 - sunflower	sunflower-wheat-corn-wheat	b1 - unfertilized	21.1	19.8	17,3
		b2 – N100	45.8	50.3	31,6
		b3 – P60	38.0	40.1	25,6
		b4 – N100 P60	55.8	62.7	33,4
		b5 – 20 t manure	53.5	58.6	32,2
Rotation average			**42,8**	**46.3**	**28.0**
a5 - corn	sunflower-wheat-corn-wheat	b1 - unfertilized	20.8	18.8	17,6
		b2 – N100	44.6	48.7	27,6
		b3 – P60	37.3	38.5	24,7
		b4 – N100 P60	54.1	61.1	31,7
		b5 – 20 t manure	52.5	56.9	31,2
Rotation average			**41,9**	**44.8**	**26.7**
A Factor – Rotation					
DL 5%			2.4	3.7	4.4
DL 1%			2.9	5.3	6.4
DL 0.1%			3.3	8.0	9.6
B Factor – Agro fond					
DL 5%			1.9	3.2	3.8
DL 1%			2.5	4.3	5.1
DL 0.1%			3.0	5.6	6.7

Under **the rotation of 3 years**, where the wheat follows in culture after pea, those chemical and organic applied fertilizers conduct to significantly increases in production related to the monoculture and two years rotations. The best variant on this rotation proved to be the mineral fertilization of $N_{100}P_{60}$, with a production of 47.7 q/ha, as average per experimented period. The increase on this kind of rotation was 6.3 q/ha comparative with the 2 year rotation and 10.9 q/ha related to the monoculture (table 2).

The **4 years rotation - sunflower-wheat-corn-wheat** – has generate different yields on winter wheat, depends of the previous plant in rotation: sunflower or corn.

In the first situation when wheat followed in rotation after sunflower, the yield registered as average per rotation was 41.1 q/ha. The increases in productions related to the witness were statistically point of view considered as very significant.

In the same type of rotation, but with corn as previous plant, the level of yields obtained at wheat was a little bit smaller than the other 4 years rotation. The differences between those rotations were of 0.6 q/ha. However, the levels of production on each variant of

fertilization are very closely to those registered in the first situation. We explain that situation thru the different water consumption of the sunflower and corn and the possibility that the sunflower to leave the soil with a high moisture that the corn.

Table 2

The combined influence of rotation and fertilization to the wheat yields in non irrigated conditions at SCDA Şimnic Craiova (2005 – 2009)

Previous plant	Rotation A factor	Agro fond B factor	Productions				
			2008	2009	Average 2005 - 2009		
			q/ha	q/ha	q/ha	differences	%
a1 – wheat	monoculture	b1 - unfertilized	11,7	11,3	12,0	-21,7	35
		b2 – N100	26,8	28,0	28,1	-5,6	83
		b3 – P60	22,4	23,6	21,9	-11,8	65
		b4 – N100 P60	34,9	40,4	37,5	3,8	111
		b5 – 20 t manure	32,4	38,8	34,8	1,1	103
Rotation average			**25,6**	**28,4**	**29,1**	**-4,6**	**86**
a2 - corn	wheat - corn	b1 - unfertilized	15,3	17,3	15, 5	-18,2	46
		b2 – N100	30,2	36,8	33,2	-0, 5	98
		b3 – P60	25,0	26,5	25,2	-8,5	75
		b4 – N100 P60	41,8	43,7	41,7	8,0	124
		b5 – 20 t manure	38,4	41,5	39,0	5,3	116
Rotation average			**30,1**	**33,2**	**33,7**	**St.**	**100**
a3 - pea	pea-wheat-com	b1 - unfertilized	19,0	26,1	20,2	-13,5	60
		b2 – N100	34,7	41,1	38,7	5,0	115
		b3 – P60	27,0	32,8	31,7	-2,0	94
		b4 – N100 P60	44,1	46,0	47,7	14,0	141
		b5 – 20 t manure	41,8	43,5	45,5	11,8	135
Rotation average			**33,3**	**37,9**	**40,0**	**6,3**	**119**
a4 - sunflower	sunflower-wheat-com-wheat	b1 - unfertilized	22,4	18,8	19,9	-13,8	59
		b2 – N100	36,9	39,7	40, 9	7,2	121
		b3 – P60	31,8	32,0	33,5	-0,2	99
		b4 – N100 P60	50,9	44,4	49,4	15,7	147
		b5 – 20 t manure	48,6	42,4	47, 1	13,4	140
Rotation average			**38,1**	**35,5**	**41,1**	**7,4**	**122**
a5 - corn	sunflower-wheat-com-wheat	b1 - unfertilized	21,3	19,6	19, 6	-14, 1	58
		b2 – N100	36,4	40,6	39, 6	5,9	117
		b3 – P60	32,0	33,1	33, 1	-0,6	98
		b4 – N100 P60	50,6	45,0	48,5	14,8	144
		b5 – 20 t manure	48,0	42,7	46, 3	12, 6	137
Rotation average			**37,7**	**36,2**	**40,5**	**6,8**	**120**

A Factor – Rotation			
DL 5%	1.9	3.8	3.1
DL 1%	2.7	5.5	4.3
DL 0.1%	4.0	8.3	6.4
B Factor – Agro fond			
DL 5%	1.6	3.3	2.5
DL 1%	2.2	4.4	3.7
DL 0.1%	2.8	5.8	4.8

Compared with the conventional wheat-corn rotation, used as witness, the rotation of three years of wheat after pea and four years rotation with wheat after sunflower and corn, generated an increase in production of 6.3 – 7.4 q/ha on the rotation's average. If we take into consideration the differences registered between witness and monoculture we can say that kind of rotation has generated a less production of 21.7 q/ha in non fertilized conditions.

As a partial conclusion regarding the data presented in tables 1 and 2, we can say that the most valuable rotation in the central area of Oltenia favorable for winter wheat proved to be the 4 year rotation: **sunflower-wheat-corn-wheat**, with sunflower as previous plant. This kind of rotation was greater than 3 years, when wheat follow after the pea.

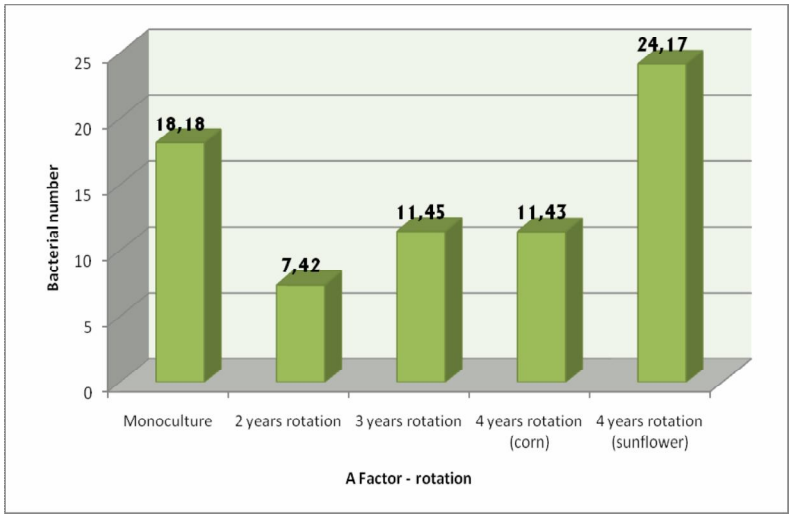
Analyzing the bacterial micro flora (quantitative and qualitative aspects) in long-term experience under the effect of crop rotation and fertilization on wheat on the brown soil from Şimnic, were separated a few special items.

In monoculture wheat were produced elevated numbers of total heterotrophic bacteria, which indicates a rizosphera strong effect. This is possible due to the large amount of

plant debris left after wheat crops always heavier than hoes (eg. maize), although low in humus content and nutrient supply condition is satisfactory.

Quality spectrum was composed of bacteria belonging to rizospheric unsporogens bacteria, mainly *Pseudomonas* and *Arthrobacter*, followed in smaller proportion of sporogens bacteria belonging to the genus *Bacillus*.

Related to the influences of rotation to the quantitative features of the useful micro flora from the tested soil, in *figure 1* we present the situation resulting than the analysis made.



DL 5% = 6.57, DL 1% = 9.55, DL 0.1% = 14.33

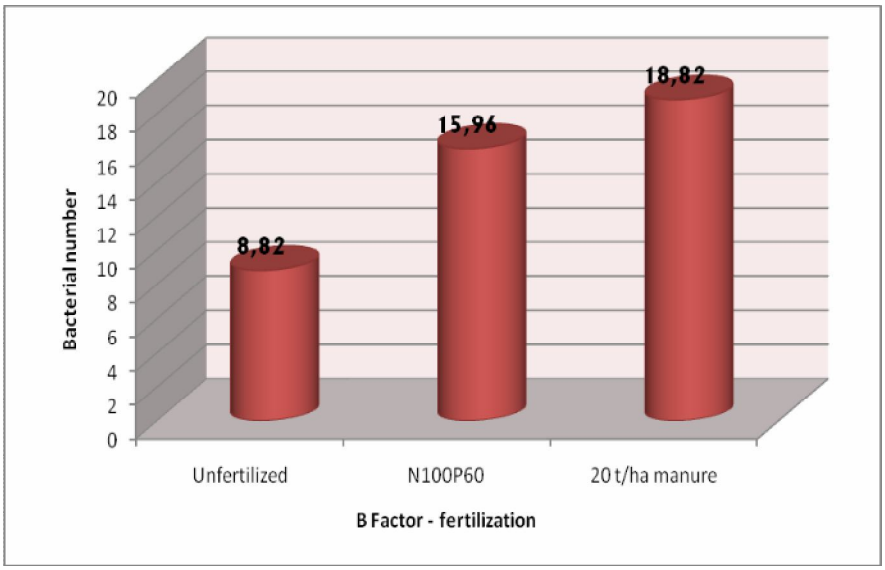
Figure 1: The influence of A factor – rotation - to the bacterial number in soil * 10^6/gram dry soil

Related to the witness – the monoculture – only in the 4 years rotation we registered more bacteria in soil samples with 5.99 * 10^6/ gram dry soil, but this increase was not enough to determine a statistically increase of bacteria number.

When we analyzed the influence of the second factor – fertilization – we take into consideration only the following variants: unfertilized, the mineral fertilized level of $N_{100}P_{60}$ and the organic fertilized variant 20 t/ha manure (*figure 2*). As it can be observed the influence of the applied fertilizers to the number of bacteria is high, with significant increase of number on mineral fertilization at $N_{100}P_{60}$ variant of 7.14 * 10^6/g dry soil and distinct significant increase on the organic fertilization of 20 t/ha manure of 10.0 * 10^6/g dry soil, in comparison with the witness – unfertilized variant.

In table 3 is presented the influence of the rotation to the number of bacteria in tested variants. Related to this aspect it can be observed that if we take as witness on each rotation the unfertilized variant were registered increases in all experimented variants for each rotation. The applied fertilizers conduct to the multiplication of useful bacteria, but in different way, related to the level of fertilization. The highest number of bacteria was observed in the 4 year rotation with corn as previous plant at unfertilized variant. The fertilization with manure in monoculture has stimulated the growth of the number of bacteria (36.88 * 10^6/g dry soil) compared with unfertilized and mineral fertilized variants where bacterial population presented was low, of 7.21 and 10.46 10^6/g dry soil.

Significant increases in number of useful bacteria were registered on $N_{100}P_{60}$ and organic level of fertilization from the 4 year rotation with sunflower as previous plant for wheat.



DL 5% = 5.94, DL 1% = 8.08, DL 0.1% = 10.95

Figure 2: The influence of B factor - fertilization - to the bacterial number in soil * 10^6/gram dry soil

Table 3

The influence of interaction rotation x fertilization to the bacterial number in soil

A Factor rotation	B Factor fertilization	Bacterial number * 10^6/g dry soil	Differences	Signification
monoculture	**unfertilized**	**7.21**	**st.**	-
	$N_{100}P_{60}$	10.46	+3.25	-
	20 t/ha manure	36.88	+29.67	***
wheat - corn	**unfertilized**	**6.44**	**st.**	-
	$N_{100}P_{60}$	6.95	+0.51	-
	20 t/ha manure	8.88	+2.44	-
pea-wheat-corn	**unfertilized**	**7.93**	**st.**	-
	$N_{100}P_{60}$	19.00	+11.07	-
	20 t/ha manure	7.43	+0.50	-
sunflower-wheat-corn-wheat	**unfertilized**	**9.24**	**st.**	-
	$N_{100}P_{60}$	14.80	+5.56	-
	20 t/ha manure	10.26	+1.02	-
sunflower-wheat-corn-wheat	**unfertilized**	**13.26**	**st.**	-
	$N_{100}P_{60}$	28.58	+15.32	*
	20 t/ha manure	30.67	+17.41	*

DL 5% = 13.41; DL 1% = 18.23; DL 0.1% = 24.71

Analyzing the influence of the fertilization to the heterotrophic bacteria density in table 4 it can be establish the importance of the organic fertilization to the improve of natural fertility of the soils and the increase of number of useful bacteria.

Table 4

The influence of interaction fertilization x rotation to the bacterial number in soil

B Factor fertilization	A Factor rotation	Bacterial number * 10^6/g dry soil	Differences	Signification
unfertilized	**monoculture**	**7.21**	**st.**	-
	wheat - corn	6.44	-0.77	-
	pea-wheat-corn	7.93	+0.72	-
	sunflower-wheat-corn-wheat	9.24	+2.03	-
	sunflower-wheat-corn-wheat	13.26	+6.05	-
$N_{100}P_{60}$	**monoculture**	**10.46**	**st.**	-
	wheat - corn	6.95	-3.51	-
	pea-wheat-corn	19	-8.54	-
	sunflower-wheat-corn-wheat	14.8	+4.34	-
	sunflower-wheat-corn-wheat	28.58	+18.12	**
20 t/ha manure	**monoculture**	**36.88**	**st.**	-
	wheat - corn	8.88	-28	-
	pea-wheat-corn	7.43	-29.45	000
	sunflower-wheat-corn-wheat	10.26	-26.62	000
	sunflower-wheat-corn-wheat	30.67	-6.21	-

DL 5% = 12.76; DL 1% = 17.64; DL 0.1% = 24.57

The levels of bacteria were high in case of organic fertilization on all experimented rotations, with the highest number registered in wheat monoculture of 36.88 * 10^6/g dry soil followed by the 4 years rotation in the same conditions of organic fertilization of 30.67 * 10^6/g dry soil.

Distinct significant increase of heterotrophic bacteria number was observed to the same 4 year rotation in the mineral conditions of $N_{100}P_{60}$ level. This statistically ensuring was possible due the small differences between the witness and other experimented variants.

Another important observation related to the influences of the fertilizers to the soil micro flora is that the number of heterotrophic bacteria is smaller in the classic rotation wheat – corn than the monoculture and that result reconfirm the importance of the rotation more than 3 years for winter wheat,.

CONCLUSIONS

In conclusions we can say that:

- analyzing on long terms the influence of the applied fertilizers to the yields obtained on wheat cultivated in central area of Oltenia has conduct to very significant increase in productions on all experimented variants;
- the unilateral applied of phosphorus or nitrogen has generate smaller increase in production than the situation when we applied both macro elements in the same time, with very significant plus productions;
- the production level varied depending on the climate conditions, but in each year the most valuable variant proved to be the mineral fertilization of $N_{100}P_{60}$ no matter in what rotation was applied;

- from the point of view of rotation the best one was the 4 years rotation when wheat has as a previous plant the sunflower;
- the rotation and fertilization has a powerful influences on soil level thru the heterotrophic micro flora as well as number but as type determinate in samples of soil;
- the number of bacteria has increase under the organic fertilization with the highest value registered in monoculture of 36.88 * 10^6/g dry soil;
- equally, in terms of taxonomic variety in monoculture wheat fertilized with 20 t / ha manure were isolated bacterial species and genus exist in soil and the manure applied [Pseudomonas, Arthrobacter (A. globiformis) Bacillus (B. circulans, B. polymyxa, B. megaterium, B. cereus) and Mycobacterium (M. roseum)].

BIBLIOGRAPHY

1. AILINCĂI DESPINA ŞI COLAB., 2005. Cercetări privind influenţa îngrăşămintelor asupra producţiei de grâu şi a fertilităţii solului, în Câmpia Moldovei. Cercetări agronomice în Moldova. Anuar XXXVII, vol 1-4
2. BORCEAN I., MOISUC AL., BORCEAN A., DAVID GH., NIŢĂ SIMONA, 2001. Cercetări privind influenţa principalelor verigi tehnologice asupra recoltei şi calităţii grâului în Banat. Cercetarea ştiinţifică şi agricultura durabilă. Editura Agris Bucureşti.
3. BUDOI GH., 1982. Efectul rotaţiei, monoculturii şi îngrăşămintelor asupra unor indicatori ai fertilităţii solului. Probleme Agricole nr. 9.
4. BUDOI GH., 2001. Agrochimie, îngrăşăminte, tehnologii, eficienţă. Editura Didactică şi Pedagogică Bucureşti.
5. DUMITRU ELISABETA ŞI COLAB., 2005. Lucrarea conservativă a solului între tradiţie şi perspectivă în agricultura durabilă. Ed. Estfalia, Bucureşti.
6. MATEI GH. şi colab., 2004, Research regarding the influence of applied potassium to pea crop, cultivated on brown-reddish soil in non irrigated conditions, Analele Universităţii din Craiova, Agricultură, Montanologie, Cadastru, vol. XXXIV, Editura Universitaria Craiova,
7. NEDELCIUC C., ŞI COLAB., 1989. Influenţa îngrăşămintelor chimice asupra calităţii unor soiuri de grâu de toamnă cultivate în condiţii de irigare în zona cernoziomurilor Olteniei. Probleme de agrofitotehnie teoretică şi aplicată, vol. XI nr. 4.
8. NICOLESCU M. şi colab. 2005. Grâul în Oltenia. Aspecte agrotehnice. Ed. Alma, Craiova.
9. NICOLESCU M. şi colab. 2007. Manualul fermierilor pentru producţia vegetală. Ed. Universitaria, Craiova.
10. NICOLESCU M ŞI COLAB., 2008 – Particularităţi ale sistemului de agricultură durabilă din Oltenia. Ed. Sitech, Craiova
11. PETRESCU E., MATEI GH., ROSCULETE C., 2008. Irrigation implication on the soybean crop in the pedoclimatic conditions of the Caracal Plain. Simpozionul internaţional „Tendinţe de dezvoltare în agricultura europeană. Ediţia a II a", Lucrări ştiinţifice USAMV Timişoara, vol XL.
12. SALAZAR G.M., MORENO R.O., Wheat production as affected seedling rate – fertilization interaction. Cer. Res. Commun 24, p. 231-237.
13. SIN GH., 1981. Asolamentul în condiţiile agriculturii intensive. Producţia vegetală. Cereale şi plante tehnice, nr. 1.
14. SIN GH., 1987. Cercetări privind asolamentele, lucrările solului şi tehnologia de semănat. Analele ICCPT Fundulea LV.