GREEN MANURE TECHNOLOGY WITH C/N RATIO FAVORABLE FOR HUMUS ACCUMULATION AND THEIR INFLUENCE ON MAIZE YIELD

TEHNOLOGIA ÎNGRĂŞĂMINTELOR VERZI CU RAPORT C/N FAVORABIL HUMIFICĂRII ŞI INFLUENŢA ACESTORA ASUPRA CULTURII DE PORUMB

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Abstract: *The paper is based on the research carried out in the second cycle of the experiment placed in Oradea in 1999. The use of lupine mixed with oat determined the improvement of the macrostructural stability compared to lupine pure crop. The use of the mixture also determined the improvement of other physical parameters, slightly improvements of the chemical parameters of fertility of the soil, the improvement of the enzymatic activity; as a result, the soil quality enzymatic index improved, a value of 455 compared to one of 441.49. The green manure pure crop ensures a 100% rate of success; the start second crop takes risks when made after 10th of July. In average, during 2004 to 2006, the lupine + oat variant assured statistically yield gain in the maize crop, compared to the lupine pure crop variant; these yield gains were registered both in the wheat-maize crop rotation and the crop rotation which included clover; the yield gains were also registered in the backgrounds studied ($N_0P_0K_0$; $N_{90}P_{90}K_{60}$). The maize' water use efficiency had higher values in the variant fertilized with lupine + oat in both crop rotations and both background. The results obtained reveal that the use of lupine mixed with oat improves the soil's characteristics. They also lead to maize yield gains statistically assured, compared to lupine pure crop and the improvement of the maize' water use efficiency.*

Rezumat: *Lucrarea are la bază cercetări efectuate în cel de-al doilea ciclu de experimentare dintr-o experienţă amplasată la Oradea în anul 1999. Folosirea lupinului în amestec cu ovăz a determinat îmbunătăţirea hidrostabilităţii macrostructrale comparative cu lupinul în cultură pură, îmbunătăţirea altor parametri fizici, uşoare creşteri ale parametrilor chimici de fertilitate ai solului, îmbunătăţirea activităţii enzimatice; ca urmare, indicatorul enzimatic al calităţii solului a crescut, 455, faţă de 441,49. Înfiinţarea îngrăşămintelor verzi în cultură pură asigură un grad de reuşită de 100%; în cultură dublă, înfiinţarea după data de 10 iulie se face cu riscuri. În medie, pe perioada 2004-2006, în varianta cu lupin + ovăz s-au obţinut sporuri de producţie de porumb asigurate statistic faţă de varianta fertilizată cu lupin cultură pură; aceste sporuri s-au înregistrat atât în asolamentul grâu-porumb cât şi în asolamentul cu trifoi; de asemenea, sporurile s-au înregistrat în ambele agrofonduri studiate ($N_0P_0K_0$; $N_{90}P_{90}K_{60}$). Eficienţa valorificării apei de către porumb a avut valori mai mari în varianta fertilizată cu lupin + ovăz în ambele asolamente şi ambele agrofonduri. Rezultatele obţinute relevă faptul că prin folosirea lupinului în amestec cu ovăz se obţine îmbunătăţirea însuşirilor solului, sporuri de producţie de porumb asigurate statistic comparative cu lupinul cultură pură şi îmbunătăţirea eficienţei valorificări apei consumate de către porumb.*

Key words: *green manure, lupine, oat, mixture, technology*
Cuvinte cheie: *îngrăşăminte verzi, lupin, ovăz, amestec, tehnologie*

INTRODUCTION

The practice of the green manure use in the fertilization dates back in Ancient Greece and Roman Conquer. In the middle of the 20th century, many researches established that the green manure of lupine in pure crop, due to the low C/N ratio, does not improve the soil's

humus content. The Biological School solved this problem using vetch in the mixture with gramineous (rye, oat and ryegrass) (Roger, 1976 referenced by Eliade et al, 1983). The vetch is known only like fodder in Romania and to recommend it for green manure will not be successful. Starting from the premise that the lupine is known in Romania as a green manure, Domuța started the research regarding the mixture of the lupine with gramineous in 1988 on the eroded soil of Pocola, Bihor County. The results of the research evidenced the positive influence of the new green manure on the soil's properties and yield gain in comparison with lupine, pure crop; the results of the research also evidenced the best periods for the sowing datum for green manure: in spring as main crop and not earlier than 1st to 10th of July as second crop (C. Domuța, 1999, 2005, 2006; Samuel et al, 2006).

MATERIAL AND METHOD

The research was carried out in Oradea, Western Romania, on the eroded preluvosoil with slope of 8%. On ploughing land the pH value was of 6.2, the humus content 2.1%, the mobile phosphorus 34.1 ppm and the mobile potassium content 209.2 ppm. The structure degree was of 55.8% and the field capacity (24.3%) and the wilting point (9.1%) had medium value.

The research period was 2004 – 2006 but the experiment was in the second cycle of the research. The experimental trial included three factors:

Factor A: crop rotation
- a1: wheat – maize
- a2: oat + clover – clover – wheat – maize

Factor B: organic fertilization
- b1: control
- b2: manure, 25 t/ha
- b3: manure, 50 t/ha
- b4: lupine
- b5: lupine + oat

Factor C: annual fertilization
- c1: N_0P
- c2: $N_{90}P_{60}K_{60}$

The number of repetitions used: 4. The area of the experiment plot: 300 m^2.
The total area of the experiment: 6000 m^2.

Green manure was produced in 2003, 2004 and 2005 like main crop. Sowing rate: 200 kg/ha in lupine pure crop and lupine 100 kg/ha and oat 80 kg/ha in the mixture.

The harvesting was made in the flowering stage of the lupine. After harvesting the green manure was kept like mulch on the soil surface. After 10 days the plough land of 25 cm depth was made. The maize was cropped in the first year after organic fertilization.

Water use efficiency was established dividing the wheat yield to the water consumption. Wheat water consumption was established using the soil water balance method; balance depth used was 0 – 150 cm.

RESULTS AND DISCUSSIONS

<u>The influence of the green manure on the soil's physical properties</u>

After the 2nd cycle of the experiment, a bigger structure degree was determined in the variant with lupine + oat in comparison with lupine in pure crop (60.9% vs. 55.72%). All the other physical properties (bulk density, total porosity, penetration resistance, hydraulic conductivity) were improved following the use of the mixture lupine + oat in comparison with

lupine in pure crop. In the variant with manure 50 t/ha, the values of the physical properties were more significant than the values from the variants with green manure (*table 1).*

Table 1

The green manure and manure influence on the physical properties of the preluvosoil from Oradea

Variant	Structure (p>0.25 mm) %	Bulk density g/cm^3	Total porosity %	Penetration resistance kgf/cm^2	Hydraulic conductivity
1. Control	55.8	1.44	46	25.6	13.9
2. Lupine	55.72	1.41	47	20.6	15.6
3. Lupine + oat	60.90	1.39	48	20.5	16.9
4. Manure 25 t/ha	64.40	1.36	49	17.6	18.6
5. Manure 50 t/ha	68.60	1.34	50	15.8	20.6

The influence of the green manure on the soil's chemical and biological properties

Concerning the chemical properties of the soil, a slightly decrease of the pH was registered in the variant with lupine in comparison with the control and lupine + oat. The N-NH_4 + NO_3 content increased in all the variants studied in comparison with the control; the small increase was registered in the variant with lupine. The same phenomena were discovered while studying the mobile phosphorus and potassium (*table 2*).

Table 2

The green manure and manure influence on the chemical and biological properties of the preluvosoil from Oradea

Variant	pH	N-NH_4+NO_3	P_{AL}	K_{AL}	Enzymatic indicator of the soil quality
		ppm			
1. Control	6.34	3.18	34.1	209.2	347.29
2. Lupine	6.25	5.02	37.4	208.2	441.49
3. Lupine + oat	6.32	5.90	39.0	214.0	455.90
4. Manure 25 t/ha	6.40	6.27	39.8	218.9	560.2
5. Manure 50 t/ha	6.46	8.60	42.5	226.2	630.6

The enzymatic activity of the soil, registered the smallest value in the control, 347.29. The smallest increase in comparison with the control was registered in the variant with lupine, 27.1%; in the variant with lupine + oat an increase of 31.2% was registered; in the variant with manure increases of 61.3% and 81.5% were registered.

The green manure influence on maize yield

Both in the crop rotation wheat-maize and in the crop rotation oat + clover-clover-wheat + maize, the lowest maize yields values were determined in the variant with lupine; the differences in comparison with the control were of 13.7% ($N_0P_0K_0$) and of 9.5% ($N_{90}P_{60}K_{60}$) in the crop rotation wheat-maize and of 11.1% ($N_0P_0K_0$) and of 8.8% ($N_{90}P_{60}K_{60}$) in the crop rotation with clover (*table 3*).

Table 3

Maize yield obtained under the influence of fertilization and crop rotation, Oradea 2004 – 2006

Organic fertilization	Chemical fertilization							
	N_0P_0				$N_{90}P_{60}K_{60}$			
	2004	2005	2006	Average	2004	2005	2006	Average
Wheat - maize								
1. Control	5170	5020	4860	5020	6420	6340	6110	6290
2. Manure 25 t/ha	5990	5620	5520	5710	7030	6830	6820	6890
3. Manure 50 t/ha	6710	6100	6130	6310	7620	7320	7200	7380
4. Lupine	6820	6140	6100	6350	7710	7300	7240	7416
5. Lupine + oat	8010	7320	7930	7750	8760	8520	8410	8560
Oat + clover – clover – wheat – maize								
1. Control	5990	5880	5710	5860	7230	6820	7010	7020
2. Manure 25 t/ha	6810	6400	6320	6510	8010	7350	7560	7640
3. Manure 50 t/ha	7520	6820	6860	7067	8780	7810	7900	8163
4. Lupine	7500	6900	6990	7130	8790	7900	7960	8220
5. Lupine + oat	8410	8020	7910	8113	9220	9000	9020	9080

	Organic fertilization		Chemical fertilization		Chemical fertilization x Organic fertilization		Organic fertilization x Chemical fertilization	
	a1	a2	a1	a2	a1	a2	a1	a2
DL 5%	180	150	120	110	230	210	208	190
DL 1%	310	290	240	208	410	420	310	360
DL 0.1%	520	470	410	390	710	730	530	580

In the variant with lupine + oat, the maize yields registered were bigger than in the variants with lupine, pure crop; overall on the studied period the differences registered were of 600 kg/ha ($N_{90}P_{60}K_{60}$) and of 490 kg/ha ($N_{90}P_{60}K_{60}$) in the crop rotation wheat-maize; in the crop rotation with clover the differences were of 557 kg/ha ($N_0P_0K_0$) and of 523 kg/ha ($N_{90}P_{60}K_{60}$)).

Generally, in the variant with manure, 25 t/ha the yield registered in the variant with lupine; the biggest yield was registered in the variant with manure 50 t/ha in all cases.

Green manure influence on maize water consumption

In the variants with green manure and manure bigger quantities of rainfall were stored during the cold period leading to values of the maize' water consumption higher than the control. In the variant with lupine + oat the values of the maize' water consumption were bigger than in maize' water consumption in the variant with lupine pure crop. The highest value of the maize' water consumption was registered in the variant with manure 50 t/ha. In the crop rotation with clover bigger quantities of rainfall were stored in the cold period determining values of the water consumption higher than the values registered in the wheat-maize crop rotation (*table 4*).

The green manure influence on the water use efficiency in maize

In comparison with the control, in the variant with lupine pure crop the lowest values of the water use efficiency were determined both in the crop rotation wheat-maize (1.08 kg/m^3 in the $N_0P_0K_0$ background and 1.36 kg/m^3 in the $N_{90}P_{60}K_{60}$ background) and in the crop rotation with clover (1.3 kg/m^3 in the $N_0P_0K_0$ and 1.45 kg/m^3 in the $N_{90}P_{60}K_{60}$ background). In the variants with lupine, the water use efficiency was better than in the variant with lupine pure crop.

Table 4

Maize water consumption obtained under the influence of the organic fertilization and crop rotation, Oradea 2004 – 2006

Variant of organic fertilization	Crop rotation					
	Wheat - maize			Oat + clover – clover – wheat - maize		
	2004	2005	2006	2004	2005	2006
1. Control	4910	4760	5370	5360	5110	5620
2. Manure 25 t/ha	4970	4820	5460	5420	5200	5710
3. Manure 50 t/ha	5100	4830	5510	5510	5320	5790
4. Lupine	5120	4900	5500	5560	5300	5600
5. Lupine + oat	5320	5020	5610	5720	5420	5810
Average	5084	4866	5490	5514	5270	5706

The values registered in the variants with manure 25 t/ha were the same or a little bigger than the values obtained in the variant with lupine + oat; the highest value of the water use efficiency was registered in the variant with manure 50 t/ha (*table 5*)

Table 5

Water use efficiency (kg/m^3) in maize under the influence of the organic fertilization and crop rotation, Oradea 2004 – 2006

Variant of organic fertilization	Crop rotation							
	Wheat - maize				Oat + clover – clover – wheat – maize			
	2004	2005	2006	Average	2004	2005	2006	Average
N_0P_0								
1. Control	1.05	1.05	0.91	1.00	1.31	1.33	1.14	1.26
2. Manure 25 t/ha	1.12	1.17	0.96	1.08	1.41	1.42	1.25	1.36
3. Manure 50 t/ha	1.32	1.26	1.11	1.23	1.49	1.52	1.31	1.44
4. Lupine	1.33	1.25	1.11	1.23	1.51	1.49	1.32	1.44
5. Lupine + oat	1.51	1.46	1.41	1.46	1.65	1.75	1.50	1.63
Average	1.27	1.24	1.10	1.20	1.47	1.50	1.30	1.42
$N_{90}P_{60}K_{60}$								
1. Control	1.31	1.33	1.14	1.26	1.35	1.33	1.37	1.35
2. Manure 25 t/ha	1.41	1.42	1.25	1.36	1.48	1.41	1.45	1.45
3. Manure 50 t/ha	1.49	1.52	1.31	1.44	1.59	1.47	1.48	1.51
4. Lupine	1.51	1.49	1.32	1.44	1.58	1.49	1.50	1.52
5. Lupine + oat	1.65	1.70	1.50	1.62	1.61	1.66	1.66	1.64
Average	1.47	1.49	1.53	1.42	1.52	1.47	1.45	1.49

CONCLUSIONS

The use of the mixture lupine + oat determined the improvement of the soil's properties (structure, bulk density, total porosity, penetration resistance, hydraulic conductivity, pH, N + NH_4 + NO_3, mobile phosphorus and potassium, enzymatic indicator of soil quality) in comparison with lupine pure crop.

In the variant with lupine + oat, the maize yield obtained was bigger than the maize yield obtained in the wheat-maize crop rotation and in the crop rotation with clover both in the $N_0P_0K_0$ background and in the $N_{90}P_{60}K_{60}$ background.

All of the organic variants of fertilization determined the increase of the rainfall stored in the soil in the cold season. The same phenomena was registered in the crop rotation with clover in comparison with wheat – maize crop rotation (the values of the maize water consumption increased in comparison with the control).

In the maize crop the values of the water use efficiency in the variant lupine + oat were bigger than the ones registered in the variant with lupine in all the cases. The water use

efficiency in maize from crop rotation with clover had higher values than the ones registered in the wheat-maize crop rotation.

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