GREEN MANURE INFLUENCE ON MAIZE YIELD AND WATER USE EFFICIENCY IN MAIZE FROM NORTH WESTERN ROMANIA

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Abstract

The research was carried out during 2010-2012 on the preluvosoil from Agricultural Research and Development Station Oradea. Two factors were studied: organic fertilization and annual fertilization. Organic fertilization included the variants: control, Lupinus angustifolius; vetch + oat + ryegrass; Lupinus angustifolius + oat; Lupinus angustifolius + oat + rape; rape; rape + oat; manure 25 t/hectare and manure 50 t/hectare. Annual fertilization included the graduations: N_0P_0, $N_{120}P_{90}$. Green manure were seeded in the 15th July, 3rd and 20th August like second crop. The biggest green manure yields were obtained seeding in 15th July. Both in the first year of the green manure effect, the biggest yields maize were obtained in the mixture of the Lupinus sp.: 5510 kg/ha and 3990 kg/ha in Lupinus sp. +oat+rape without chemical fertilizers, 6868 kg/ha and 5110 kg/ha in the variant with $N_{120}P_{90}$; in the variant with Lupinus sp.+oat the yields were very close. The yield maize obtained in the Lupinus sp. mixtures were bigger than the yield maize obtained using the mixture vetch+oat+ryegrass recomanded by biological school. In the all mixture of green manure the yields maize obtained were bigger than the yields obtained in the variant with Lupinus sp. pure crop. The manure determined to obtain the yields maize bigger than the yields obtained using the mixture of green manure.

Keywords: green manure, organic fertilization, yield, water use efficiency, maize

INTRODUCTION

The quantities of the manure produced in the Romanian farms don't provide an optimum organic fertilization. As consequence, the use of the green manure is very important. Theoretical, *Lupinus* sp. is the most known green manure from Romania, but not only. This plant fixed the atmospheric nitrogen (80-100 kg/ha). (Borlan et al., 1994; Budoi, Penescu, 1996; Domuţa, 2003, 2004, 2005, 2006, 2007; Ciobanu, 2003, 2007) due the symbiosis with bacteria *Rhyzobium lupini*; the results is a small quantity of nitrogen fixed in the soil from enormous quantity of nitrogen (200.000 - 300.000 t) situated in the atmosphere over 1 hectare, but the leguminous only can fixe the atmospheric nitrogen in the soil. But, the most promoted green manure both in Romania and in the European Union. (Berca, 2011; Bogdan et al., 2003; Domuţa, 2011; Neamţu, 1996) The paper presents the

results research regarding the use of the lupin pure crop and in mixture with oat and and with oat+ rape in comparison with the rape pure crop and in mixture with oat, in comparison with an mixture recomanded by biological school (vetch+oat+ ryegrass) and in comparison with manure (25 t/hectare, 50 t/hectare).

During 1999-2013 the researches regarding the green manure technology was the components of the following project obtained in competition regime: **Relansin Project Nb. 159/1999** *"Research for elaboration a sustainable agriculture system on the erosioned soil from Bihor", Value: 22900 lei; Period 1999 – 2003. Project manager: Prof.Cornel Domuţa, PhD*; **CNCSIS Project Nb. 27648/14.03.2005** *„Research regarding the improvment of the soil management on the land with slope from North-Western Romania for realising an agricultural sustainable system"*. Period 2004–2007. Value 36.000 lei; Project manager: Prof. Cornel Domuţa, PhD; **CEEX Project Nb. 35/20.07.2006** *"Study of the risk factors, quantification of their impact on the agriculture systems, the creation of the new genotype and technologies for a sustainable development"* Value 1490000 lei. Period 2006-2008. Project manager Prof. Gheorghe Cioban, PhD, Scientifical manager: Prof. Cornel Domuţa, PhD; **HURO Project 0901/135/2.2.3:** *„Elaboration of Soil Strategy for the Nyírség Region and Bihor Mountains Based EU Soil Directives,* Value: 191.000 EUR. Period 2010-2011 Project Manager Csep Nicolae, PhD, PA:8 Prof. Domuţa Cornel, PhD.

MATERIAL AND METHOD

The research field from Agricultural Research and Development Station Oradea was placed on the preluvosoil characterized by a humus content of 2.1% în Ap (0-20 cm) horizon, pH of 6.3, phosphorus of 31.5, bulk density of 1.44 g/cm^3 and total porosity is of 47%. Field capacity (24.3%) and wilting point (9.1%) have the median values. (Domuţa, Brejea, 2010, 2011)

The experiments was placed in 2010 had two factors: organic fertilization and annual fertilization. Organic fertilization included the variants: control, *Lupinus angustifolius*; vetch + oat + ryegrass; *Lupinus angustifolius* + oat; *Lupinus angustifolius* + oat + rape; rape; rape + oat; manure 25 t/hectare and manure 50 t/hectare. Annual fertilization included the graduations: N_0P_0, $N_{120}P_{90}$. Number of repetition used: 4; the plot surface: 100 m^2; the experiments surface: 7200 m^2.

The green manures, were sowed like 2nd crop in the 15th July, 3rd August and 20th August. The sead rates used were: *Lupinus angustifolius* in pure crop, 200 kg/hectare; *Lupinus angustifolius* in mixture, 10 kg/hectare;

vetch, 40 kg/hectare; oat , 80 kg/hectare; ryegrass, 10 kg/hectare; rape 20 kg/hectare in pure crop and 10 kg/hectare in mixture crop.

Green manures harvesting were harvestest at the flowering of the *Lupinus angustifolius*; the green manures were maintained on the soil surface 15 days and after that a plough land was made.

Water use efficiency was calculated reporting the yield with water consumption. The water consumption was determined by soil water balance based on direct determination of the moisture. Water balance depth used was 0-150cm.

RESULT AND DISCUSSION

The rainfall after sowing data.

At the sowing data of the green manure, on 0-25 depth, soil water reserve was over the easily available water content (in 15th July) was a little bellow this parameter (in 3rd August), or a deficit of the soil moisture was registered. In the first stage, after 2 days, the rainfall of 8.4 mm were registered; in the next stages, the first rainfall after sowing were registered after 7 days (30.7 mm) and 8 days (3.0 mm, insignificant). The rainfall registered during the vegetation periods of the green manure were much bigger than multi annual average for these periods; the differences were of 78.2% for first stage, 86.9% for second stage and 65.8% for last sowing stage. (Table 1).

Table 1

The analisys of the conditions registered at the green manure sowing, Oradea 2010

Sowing data	Soil water reserve analisys					Number of days to 1st rainfall	1st rainfall (mm)	Total rainfall during the vegetation period (mm)	
	WR	Wea		WP				2010	Multianual average
	(m^3/ha)	(m^3/ha)	%	(m^3/ha)	%				
15.07	774	+111	+17	+439	131	2	8.4	271.0	152.1
03.08	576	-87	-13	+241	71	7	30.7	218.3	116.8
20.08	461	-202	-30	+126	37	8	3.0	161.8	97.6

WR-Soil water reserve (on 0-25 cm depth);
Wea- Easily available water content;
WP- Wilting point;

Yields green manure

The very favorable regime of the rainfall determined to obtain the big yields of green manure in the first and second stage of the sowing (exception, in rape crop, due *Chaetocnema tibialis* attack) and good yields

in the third stage (exception, the mixture with vetch; usually, in very few years, in the middle of the August, the good yields in 2nd crops are possible).

The variance analysis emphasized that in the other type of the green manure were obtained the yield smaller than in *Lupinus angustifolius*, pure crop; the exception is the mixture *Lupinus angustifolius*- oat- rape. In the average on the 6 green manure types, the sowing datum of 20 August determined a yield decrease, very significant; the differences were of - 44% in comparison with sowing datum of 15.07 and of – 41% in comparison with sowing datum of 3th July. (Table 2).

Table 2

The influence of the sowing datum on green manure yield, t/ha, Oradea 2010

Sowing datum	Green manure variant						The average of the sowing period
	Lupinus angustifolius	Vetch + oat+ ryegrass	*Lupinus angustifolius* +oat + rape	*Lupinus angustifolius* + rape	Rape+ Oat	Rape	
15.07	41.0	28.6	41.1	28.7	27.0	30.4	32.8
03.07	41.3	35.7	38.0	33.6	21.6	15.7	31.0
20.08	29.6	8.9	17.4	18.6	16.3	20.3	18.5^{000}
The average on the variant	37.3^{Mt}	24.4^{000}	32.3^{0}	27.00^{000}	21.6^{000}	22.1^{000}	-

	Sowing datum	Green manure variant	Green manure variant x sowing datum	Sowing datum x Green manure variant
LSD 5%	4.20	2.30	2.92	7.28
LSD 1%	5.62	3.49	4.83	9.74
LSD 0.1%	7.36	5.60	6.95	12.74

Maize yields the first year of the organic fertilizer effect

In the variant with pure crop of *Lupinus angustifolius*, in comparison with the control, the yields gains were of 499 kg/hectare for first sowing stage of the green manure, 396 kg/hectare for second sowing stage and 380 kg/hectare for third sowing stage. In the *Lupinus angustifolius* mixture and in the mixture with vetch, the yield gains were bigger than yield gain obtained in *Lupinus angustifolius* pure crop; the yield gains obtained in *Lupinus angustifolius* mixture were bigger than yield gain obtained using the mixture with vetch. The rape and their mixture determined an yield gains smaller than the yield gain registered in the variant with *Lupinus angustifolius*. Both doze of the manure determined to obtain an yield gain bigger than yield gains obtained in the variants with green manure.

Only annual fertilization with $N_{120}P_{90}$ determined to obtain an yield gain of 28% (1360 kg/ha).

Annual fertilization with $N_{120}P_{90}$ associated with green manure and manure fertilization determined to obtained the biggest maize yield; the differences sense were similar with the sense described before (Table 3,4,5).

Table 3

The influence of the fertilization with green manure second crop on maize yield (kg/ha) 1st and 2nd year of effect, in the conditions from Oradea, Romania

Green manure type)	Annual fertilization				Average on green manure fertilization	
	N_0P_0		$N_{120}P_{90}$		V_1	V_2
	V_1	V_2	V_1	V_2		
1. Control	4272	2938	5555	4280	4914	3609
2. *Lupinus* sp	4668	3312	5935	4690	5302	4001
3. Vetch +oat +ryegrass	5285	3790	6593	5020	5939	4405
4. *Lupinus* sp + oat	5235	3710	6628	5080	5932	4395
5. *Lupinus* sp + oat + rape	5510	3990	6868	5110	6189	4550
6. Rape	4368	3110	5685	4420	5027	3765
7. Rape + oat	4758	3480	5818	4640	5288	4060
Average on annual fertilization	4871	3475	6155	4749	-	-

V_1-1st year of the effect; V_2-2nd year of the effect

Factor A: green manure type; Factor B: annual fertilization

	A		B		B X A		A X B	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
LSD5%	179	225	181	259	237	342	254	398

Table 4

The influence of the fertilization with green manure second crop (15.07.2010) on maize yield (q/ha) 1st and 2nd year of effect, in the conditions from Oradea, Romania

Green manure type	Annual fertilization				Average on green manure fertilization	
	N_0P_0		$N_{120}P_{90}$		V_1	V_2
	V_1	V_2	V_1	V_2		
1. Control	4695	3073	6055	4210	5375	3642
2. *Lupinus* sp	5185	3345	6585	4620	5885	3982
3. Vetch +oat +ryegrass	5520	3680	6970	4980	6245	4330
4. *Lupinus* sp + oat	5610	3776	6905	4910	6290	4343
5. *Lupinus* sp + oat + rape	5760	3832	7195	5140	6478	4486
6. Rape	4892	3258	6378	4580	5635	3920
7. Rape + oat	5138	3420	6660	4796	5899	4108
Average on annual fertilization	5432	3483	6678	4748	-	-

V_1-1st year of the effect

V_2-2nd year of the effect

Factor A: green manure type

Factor B: annual fertilization

	A		B		B X A		A X B	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
LSD 5%	140	210	76	150	155	248	197	324

Table 5

The influence of the fertilization with manure on maize yield (kg/ha) 1st and 2nd year of effect, in the conditions from Oradea, Romania

Green manure type	Annual fertilization				(Average on green manure fertilization)	
	N_0P_0		$N_{120}P_{90}$		V1	V2
	V1	V2	V1	V2		
1. Control	4740	3125	5390	4338	5065	3732
2. Manure, 25 t/hectare	6380	4012	7350	5142	6865	4577
3. Manure, 50 t/hectare	7080	4730	7930	6020	7505	5375
Average on annual fertilization	6067	3956	6890	5167	-	-

V_1-1st year of the effect
V_2-2nd year of the effect
Factor A: manure type
Factor B: annual fertilization

	A		B		B X A		A X B	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
LSD 5%	214	330	261	376	320	416	342	490

Maize yield in the second year of the organic fertilizer effect

In the second year of the organic fertilization effects, the level of the maize yields were lower because the rainfall registered during the maize vegetation period were of 194.9 mm in comparison with 296 mm in the first year of the effect; the rainfall distribution in the first year of the effect was better, too.

In the variant with *Lupinus angustifolius* without annual fertilization, the differences in comparison with the control were of 273 kg/hectare for first sowing period of the green manure, 374 kg/hectare for second sowing period and of 133 kg/hectare for third sowing period of the green manure.

In the variants with mixture of *Lupinus angustifolius* and in the variants with vetch mixture, the difference obtained in comparison with control was bigger than *Lupinus angustifolius* pure crop; the biggest yield was obtained in the variant with the mixture *Lupinus angustifolius* + oat + rape.

The rape in pure crop determined to obtain an yield gain smaller than *Lupinus angustifolius* and in the mixture with oat, the rape determined an yield gain close of the yield gain obtained in *Lupinus angustifolius* in pure crop.

Annual chemical fertilization of the organic variant determined to obtain the maize yield gain bigger than maize yield gain obtained in the variant with organic fertilization only. The yield gains were between 49% (in the variant with rape + $N_{120}P_{90}$) and 67% (in the variant with *Lupinus*

angustifolius + oat + rape) in the variants with green manure and 67.3% and of 95.9% in the variants with manure 25 t/hectare and 50 t/hectare.

The influence of the fertilization on water use efficiency

The green manure use determined the improve of the water use efficiency in comparison with control both first year of the effect and second year of the effect. The differences were between 5% (in rape) and 23% (in *Lupinus angustifolius* + oat + rape) in the first year of the effect and between 7% and 25% (in rape and *Lupinus angustifolius* + oat + rape) in the second year. Organic fertilization with manure determined bigger values of the water use efficiency in comparison with green manure. The differences in comparison with control were of 36% in the first year and 30% in the second year of the effect for 25 t/hectare and of 51% in the first year and 54% in the second year of the effect for 50 t/hectare (Table 6).

Organic fertilization with manure and green manure associated with annual fertilization with $N_{120}P_{90}$ gave the biggest values of the water use efficiency. In comparison with control fertilized with $N_{120}P_{90}$ only, in the first year, the differences were between 5% (in rape) and 31% (manure 50 t/hectare) and in the second year the differences were between 9% and 43% (in the rape and manure 50 t/hectare).

Table 6

The influence of the fertilization with manure on water use efficiency on maize crop in the conditions from Oradea, Romania

Green manure type	Annual fertilization							
	N_0P_0				$N_{120}P_{90}$			
	V_1		V_2		V_1		V_2	
	Kg/m^3	%	Kg/m^3	%	Kg/m^3	%	Kg/m^3	%
1. Control	1.11	100	0.89	100	1.44	100	1.22	100
2. *Lupinus* sp	1.23	111	0.97	109	1.56	108	1.34	109
3. Vetch +oat +ryegrass	1.31	118	1.07	120	1.65	115	1.44	118
4. *Lupinus* sp + oat	1.33	120	1.09	122	1.64	114	1.42	116
5. *Lupinus* sp + oat + rape	1.37	123	1.11	125	1.71	119	1.49	122
6. Rape	1.16	105	0.95	107	1.51	105	1.33	109
7. Rape + oat	1.22	109	0.99	111	1.58	110	1.39	114
8. Manure, 25 t/hectare	1.51	136	1.16	130	1.74	121	1.49	122
9. Manure, 50 t/hectare	1.68	151	1.37	154	1.88	131	1.75	143

V_1-1st year of the effect
V_2-2nd year of the effect

CONCLUSION

The research were carried out during 2010-2012 at Agricultural Research and Development Station Oradea and the following conclusions were determined:

- the green manure were seeded like second crop and the first rainfall was registered 2 days after seeding in 15th July, 8 days after seeding in 3rd July and 8th days after seeding in 20th August. The rainfall registered during the green manure vegetation period were bigger than multiannual average: 271.0 mm vs. 152.1 mm; 218.3 mm vs 116.8 mm; 161.8 mm vs 97.6 mm;
- the biggest quantities of the green manure were registered seeding in 15th July; in the all tree seeding stage the biggest yields were obtained in the variants with *Lupinus angustifolius* pure crop and the smallest yields were obtained in the variant with rape. In the variants with rape and rape+oat was registered the attack of *Chaetocnema tibialis*;
- the maize yields determined in the first and second year of the green manure fertilization show the bigger yields in the variants with *Lupinus angustifolius*+oat+rape and *Lupinus angustifolius*+oat in comparison with the yields obtained in the variant with Lupinus angustifolius pure crop both in the variants with N_0P_0 and in the variants with $N_{120}P_{90}$. The smallest yields were determined in the variant with rape;
- in the variant with manure 25 t/ha the yields were bigger than the yields from variants with green manure pure crop or mixture both in the variant with N_0P_0 and in the variants with $N_{120}P_{90}$. The biggest yields were obtained in the variants with manure 50 t/ha;
- both in the variant with N_0P_0 and in the variant with $N_{120}P_{90}$ the smallest quantity of maize yield obtained for 1m^3 water used was obtained in the variant without organic fertilization both in the first year and in the second year.

These variants are followed by the variants with rape and rape+oat, *Lupinus angustifolius* pure crop, vetch+oat+ rygrass, *Lupinus angustifolius*+oat and *Lupinus angustifolius*+oat+rape. In the variant with manure 25 t/hectare the values of the water use efficiency were bigger than the values registered in the variants with green manure. The biggest values of the water use efficiency were registered in the variant with manure 50 t/hectare.

The result research sustain the use of lupin like green manure mixture crop (*Lupinus angustifolius*+oat+rape or *Lupinus angustifolius*) because the lupin is known for this destination and don't sustain the mixture vetch+oat+rygrass because the vetch is known like fodder. The seeding data will be before 15th July because after that, the quantity and regime of the rainfall don't provide the assurance of the green manure yields.

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