

## THE INFLUENCE OF THE MIXTURE LUPINE+OAT+RAPE USED LIKE GREEN MANURE UNDER THE MAIN PARAMETERS OF THE SOIL FERTILITY FOR SUSTAINABLE AGRICULTURE SYSTEM IN NORTH WESTERN ROMANIA

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**Abstract.** The paper is based on the research carried out in a long term trial placed in 2000, on a soil with 10% slope at Agricultural Research and Development Station Oradea. The research emphasize the improve of the physical (structure degree, bulk density, total porosity, penetration rezistance, hydraulic conductivity) chemical (pH, mineral nitrogen, mobile phosphorum, mobile potassium) and biological properties (actual dehydrogenase activity, potential dehydrogenase activity, catalase activity, acid phosphatase activity, alkaline phosphatase activity) of the soil in the lupin pure crop and especially in the mixture lupine+oat+rape; as consequence this mixture is recomanded.

**Keywords:** Green manure, lupin, sustainable agriculture

### 1. Introduction

Sustainable agriculture system is based on the following component: crop rotations (central pivot), large structure of crops, organic fertilizers use, chemical fertilizers use in moderate doses correctly soil tillage, integrated management of the plant protection, resources conservation, the use of the farms interne, resources integration between field crop branch and horticulture or zootechnical branch determine to obtain high yields and the environment is protected. [1,2,3,4,5,6,11,13,14,15,20,24,25,26]. Organic fertilization is difficult to realize because the quantities of the manure produced by farms are small and don't provide an optimum fertilization. The green manure use was stimulated by European Union but establishing the harvest period in March, the use of the rape is encouraged and not the use of the leguminous. One of the most known leguminous was used like green manure is the lupin; the problem of the priming effect produced by the use of the lupin in pure crop was solved by Roger (1976)

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using the mixture vetch + oat (rye) + ryegrass. Vetch is very known like excellent fodder and Domuța C. (1987) starting the research using the mixture lupin +oat, lupin + oat + rape, lupin + rye and the mixture of the lupin determined better results than the mixture of vetch. [16,17,18,19]

## 2. Material and methods

The research was carried on eroded soil with slope of 10% at Agricultural Research and Development Station Oradea. In 1999 was placed the experiment with three factors: Factor A: crop rotation, with  $a_1$  = winter wheat – maize;  $a_2$  = oat + clover – clover – maize – winter wheat – maize. Factor B: organic fertilization with  $b_1$  = control, without fertilizers;  $b_2$  = *Lupinus angustifolius*;  $b_3$  = *Lupinus angustifolius* + oat + rape;  $b_4$  = vetch + oat + ryegrass;  $b_5$  = manure, 25 t/hectare;  $b_6$  = manure, 50 t/hectare. Factor C: annual chemical fertilization:  $c_1$  =  $N_0P_0$ ;  $c_2$  =  $N_{120}P_{90}$ . Number of repetition used: 4. The lot surface: 100 m<sup>2</sup>.

In 2013, after winter wheat harvesting, a soil profile was made in the first crop rotation and the cylinders with soil were prelevated for determination in the laboratory, of the bulk density (BD), hydraulic conductivity and penetration resistance (PR); the cylinders were prelevated on a 0 - 10 cm depth and 10 – 20 cm depth and the averages on the 0 – 20 cm are presented in the papers. Other soil samples were prelevated on 0 – 20 cm depth for determination the structure degree, mineral nitrogen, pH, mobile phosphorus, mobile potassium. The soil samples for enzymatic activity determination were prelevated on 0-10 cm, 10-20 cm and 20-30 cm. The following enzymological parameters were: actual and potential dehydrogenase, catalase activity, acid and alkaline phosphatase activity. The usually methods were used for all determinations. [9,10,12,14,27,29,30,31]

Soil reaction was determined by potentiometer method; mobile phosphorus and mobile potassium were determined by Egner – Rhiem – Domingo method. Four repetition were realized for every physical and chemical parameters and the research results were interpreted by variance analysis method. [7,8,21,22,23]

## 3. Results and discussions

### Structure degree

The smallest value of the structure degree was determined in the variant without organic fertilization, 54.70%; the result obtained in the variant *Lupinus angustifolius* like green manure is very close, 54.50%. In the variant with the mixture *Lupinus angustifolius*+ oat +rape, the structure degree increase significant statistically in comparison with control. (Table 1).

### Bulk density and total porosity

All the variants with organic fertilization determined the decrease of the bulk density values in comparison with the control (1.52g/cm<sup>3</sup>), 8% in the variant with *Lupinus angustifolius* (significant statistically), 12% in the variant with *Lupinus angustifolius*+oat+rape (distingue significant statistically). (Table 2).

**Table 1.**The influence of the green manure and manure on structure degree of the eroded soil from Oradea, 2013

Variant	Structure degree		Difference %	Statistically significant
	Val %	%		
1. Control	54.70	100	-	Control
2. <i>Lupinus angustifolius</i>	54.50	99	-1	-
3. <i>Lupinus angustifolius</i> + oat + rape	58.80	108	8	*

LSD 5% 3.96%; LSD 1% 6.02%; LSD 0.1% 13.56%

**Table 2.**The influence of the green manure and manure on bulk density (BD) of the eroded soil from Oradea, 2003

Variant	BD		Difference	Statistically significant
	g/cm <sup>3</sup>	%		
1. Control	1.52	100	-	Control
2. <i>Lupinus angustifolius</i>	1.0	92	-8	0
3. <i>Lupinus angustifolius</i> + oat + rape	1.35	88	-12	00

LSD 5% 0.10; LSD 1% 0.15; LSD 0.1% 0.21

### Total porosity

Calculating the total porosity the smallest value was obtained in the control, 43%. The difference registered in the variant with *Lupinus angustifolius* (9%) is insignificant statistically. It was registered a difference of 14% in the variant with *Lupinus angustifolius* + oat + rape (significant statistically). (Table 3).

**Table 3.**The influence of the green manure and manure on total porosity (TP) of the eroded soil from Oradea, 2013

Variant	TP		Difference (%)	Statistically Significant
	%	%		
1. Control	43	100	-	Control
2. <i>Lupinus angustifolius</i>	47	109	9	-
3. <i>Lupinus angustifolius</i> + oat + rape	49	114	14	*

LSD 5% 4.5; LSD 1% 7.5; LSD 0.1% 11.0

### Penetration rezistance

The biggest value of the penetration rezistance 25.0 kgf/cm<sup>2</sup>, was registered in the control; in the variants with organic fertilization, the values of penetration rezistance decreased; the differences were distingue significant statistically. (Table 4).

### Hydraulic conductivity

The hydraulic conductivity had the smallest value in the control. In the variant with green manure pure crop, the hydraulic conductivity increased with 17% (unsignificant statistically); in variant with mixture *Lupinus angustifolius*+rape, the increase was significant statistically. (Table 5)

**Table 4.**The influence of the green manure and manure on penetration rezistance (PR) of the eroded soil from Oradea,2013

Variant	PR		Difference (%)	Statistically significant
	Kg/cm <sup>2</sup>	%		
1. Control	25.0	100	-	Control
2. <i>Lupinus angustifolius</i>	19.8	79	-21	00
3. <i>Lupinus angustifolius</i> + oat + rape	18.9	76	-24	00

LSD 5% 3.5; LSD 1% 6.3; LSD 0.1% 11.30

**Table 5.**The influence of the green manure and manure on hydraulic conductivity (HC) of the eroded soil from Oradea,2 013

Variant	HC		Difference (%)	Statistically significant
	mm/h	%		
1. Control	13.30	100	-	Control
2. <i>Lupinus angustifolius</i>	15.58	117	17	-
3. <i>Lupinus angustifolius</i> + oat + rape	16.47	124	24	-

LSD 5% 2.70; LSD 1% 4.72; LSD 0.1% 7.29

### Soil reaction

The value of the pH determined in the control was of 6.3. The values determined in the studies variants are very close and to control but the difference are unsignificant statistically (Table 6).

**Table 6.**The influence of the green manure and manure on the pH of the eroded soil from Oradea, 2013

Variant	pH		Difference	Statistically significant
	Value	%		
1. Control	6.30	100	-	Control
2. <i>Lupinus angustifolius</i>	6.29	99	-1	-
3. <i>Lupinus angustifolius</i> + oat + rape	6.32	101	+1	-

LSD 5% 0.13; LSD 1% 0.24; LSD 0.1% 0.40

### Mineral nitrogen

The value of the N – NO<sub>3</sub> determined in the control was of 0,70 ppm. The difference registered in the variant with *Lupinus angustifolius* (64%) was distinguishable statistically. In the variant with *Lupinus angustifolius* + oat + rape the difference are very significant statistically. (Table 7).

The N – NH<sub>4</sub> content is bigger than N – NO<sub>3</sub> content in the variants. In the control was registered the smallest value, 2.6 ppm.

In the all variants with organic fertilization the N-NH<sub>3</sub> the content was very significant bigger.

The content of N – NO<sub>3</sub> + NH from the control is of 3.16 ppm. The values of the N – NO<sub>3</sub> + NH<sub>4</sub> from the variants with organic fertilization are bigger than the value determined in the control; the biggest difference, 94%, was registered in the variant with *Lupinus angustifolius* + oat + rape (Table 7).

**Table 7.** The influence of the green manure and manure on the N – NO<sub>3</sub>+ N – NH<sub>4</sub> of the eroded soil from Oradea, 2013

Variant	N – NO <sub>3</sub>			N – NH <sub>4</sub>			N – NO <sub>3</sub> + NH <sub>4</sub>		
	ppm	%	Statistically significant	ppm	%	Statistically significant	ppm	%	Statistically significant
1. Control	0.70	100	Control	2.46	100	Control	3.16	100	Control
2. <i>Lupinus angustifolius</i>	1.15	164	**	3.82	153	***	4.97	157	***
3. <i>Lupinus angustifolius</i> + oat + rape	1.20	172	***	4.94	201	***	6.14	194	***

LSD 5% 0.17

LSD 1% 0.28

LSD 0.1% 0.51

LSD 5% 0.60

LSD 1% 0.64

LSD 0.1% 1.12

LSD 5% 0.23

LSD 1% 0.46

LSD 0.1% 0.81

### Mobile phosphorus

The mobile phosphorus is median in the control (34.6 ppm) and good in the others variants.

The differences registered in comparison, with the control are insignificant statistically. (Table 8).

**Table 8.** The influence of the green manure and manure on mobile phosphorus (PAL) content of eroded soil from Oradea, 2013

Variant	PAL		Difference	Statistically significant
	ppm	%		
1. Control	34.6	100	-	Control
2. Lupinus angustifolius	37.8	109	9	-
3. Lupinus angustifolius + oat + rape	39.0	113	13	-

LSD 5% 7.8; LSD 1% 12.6; LSD 0,1% 21.3

### Mobile potassium

The smallest content of the mobile potassium was registered in the control, 196.2 ppm.

The differences registered in the variants with green manure and in the variant with manure 27 t/hectare are insignificant statistically. (Table 9).

**Table 9.** The influence of the green manure and manure on mobile potassium (KAL content of the preluco soil from Oradea, 2013

Variant	KAL		Difference	Statistically significant
	ppm	%		
1. Control	192.2	100	-	Control
2. Lupinus angustifolius	199.3	102	2	-
3. Lupinus angustifolius + oat + rape	204.7	104	4	-

LSD 5% 13.2; LSD 1% 18.4; LSD 0.1% 27.8

### Actual dehydrogenase activity

The values of the actual dehydrogenase activity are bigger on the depth of 0 – 10 cm in comparison with the one on 10 – 20 cm and 20 – 30 cm. The smallest value of the actual dehydrogenase activity were determined in the variant without fertilizer: 5.50 mg TPF/24 hours on 0 – 10 cm, 4.51mg TPF/24 hours on 10 – 20 cm and 2.72 mg TPF/24 hours on 20 -30 cm.

The use of the manure and green manure determined a bigger value of the actual dehydrogenase activity, in average on the depth of 0 - 30 cm, in comparison with the variant without fertilizers, the use of Lupinus angustifolius used as a green manure determined an increase with 66%, insignificant from a statistical

point of view. In the variant with a mixture of *Lupinus angustifolius* + oat + rape the actual dehydrogenase activity increased with 116%, significantly statistically. (Table 10).

**Table 10.** Green manure influence on actual dehydrogenase activity (ADA) on the eroded soil from Oradea 2013

Variant	ADA		Diffrence %	Sstatistically significant
	mgTPF/24 h	%		
Depth 0 – 10 cm				
1.Control	5.50	100	-	control
2. Lupin	9.18	167	67	x
3.Lupin +oat + rape	11.62	212	112	x
LSD 5% 3.27		LSD 1% 6.74		LSD 0.1% 10.90
Depth 10 – 20 cm				
1.Control	4.51	100	-	control
2. Lupin	7.06	157	57	-
3.Lupin +oat + rape	10.20	227	127	x
LSD 5% 3.60		LSD 1% 6.90		LSD 0.1 11.20
Depth 20 – 30 cm				
1.Control	2.72	100	-	control
2. Lupin	4.90	181	81	-
3.Lupin +oat + rape	5.76	212	112	x
LSD 5% 2.28		LSD 1% 4.70		LSD 0.1% 6.76
Average Deapth 0 – 30 cm				
1.Control	4.25	100	-	control
2. Lupin	7.05	166	66	-
3.Lupin +oat + rape	9.20	216	116	x
LSD 5% 3.05		LSD 1% 6.14		LSD 0.1% 9.62

### Potential dehydrogenase activity (PDA)

The values of the potential dehydrogenase activity were bigger than the value of the actual dehydrogenase activity and decreased together with the increase of the determination depth. The smallest set of values of the potential dehydrogenase activity were determined in the variant without fertilizers: 10.56 TPF/24 h on 0 - 10 cm, 9.31 mg TPF/24 h on 10 - 20 cm and 7.88 mg TPF/24 h on 20 - 30 cm. In average on the 0 – 30 cm depth the value of potential dehydrogenase activity was of 9.25 mg TPF/24 h; the green manures determined a significant increase compared with the control. The increases were of 67% in the variant with *Lupinus angustifolius* and 98% in the variant with *Lupinus angustifolius* +oat+rape. (Table 11).

**Table 11.** Green manure influence on potential dehydrogenase activity (PDA) on the eroded soil from Oradea 2012

Variant	PDA		Difference %	Statistically significant
	mgTPF/24 h	%		
Depth 0 – 10 cm				
1.Control	10.56	100	-	control
2. Lupin	22.68	215	115	xx
3.Lupin +oat + rape	24.18	229	129	xx
LSD 5% 4.20		LSD 1% 9.72		LSD 0.1% 14.20
Depth 10 – 20 cm				
1.Control	9.3	100	-	control
2. Lupin	15.30	165	65	x
3.Lupin +oat + rape	16.66	179	79	x
LSD 5% 3.60		LSD 1% 7.85		LSD 0.1% 12.40
Depth 20 – 30 cm				
1.Control	7.88	100	-	Control
2. Lupin	8.33	107	7	-
3.Lupin +oat + rape	14.30	182	82	x
LSD 5% 3.52		LSD 1% 7.60		LSD 0.1% 12.02
Average Deapth 0 – 30 cm				
1.Control	9.25	100	-	control
2. Lupin	15.44	167	67	x
3.Lupin +oat + rape	18.38	198	98	x
LSD 5% 3.78		LSD 1% 8.39		LSD 0.1% 12.88

### Catalase activity (CA)

Catalase activity decreases according with the increase of the depth determination. The green manure determined bigger values of the catalase activity in comparison with the control; the differences were statistically assured.

In the variant with *Lupinus angustifolius* the catalase activity increased with 145%. In the variant *Lupinus angustifolius*+oat+rape the difference in comparison with the control was of 107%. (Table 12).



**Table 12.** Green manures influence on catalase activity (CA) on the eroded soil from Oradea 2013

Variant	CA		Difference %	Statistically significant
	mg H <sub>2</sub> O <sub>2</sub> /1 h	%		
Depth 0 – 10 cm				
1.Control	0.80	100	-	control
2. Lupin	1.96	245	145	xx
3.Lupin +oat +rape	2.40	300	200	xxx
LSD 5% 0.25		LSD 1% 0.41		LSD 0.1% 0.96
Depth 10 – 20 cm				
1.Control	0.73	100	-	control
2. Lupin	1.70	233	133	xx
3.Lupin +oat +rape	2.20	302	202	xxx
LSD 5% 0.31		LSD 1% 0.72		LSD 0.1% 1.15
Depth 20 – 30 cm				
1.Control	0.61	100	-	control
2. Lupin	1.60	263	163	xx
3.Lupin +oat +rape	2.01	330	230	xxx
LSD 5% 0.33		LSD 1% 0.76		LSD 0.1% 1.27
Average Deapth 0 – 30 cm				
1.Control	0.72	100	-	control
2. Lupin	1.76	245	145	xx
3.Lupin +oat +rape	2.21	307	207	xxx
LSD 5% 0.30		LSD 1% 0.63		LSD 0.1% 1.13

### Acid phosphatase activity (AcPA)

The values of the acid phosphatase activity decreases according with the increase of the determination depth but the differences are smaller than the differences registred in the previous enzymological parameters.

The smallest values of the acid phosphatase activity were registred in the control: 2.60 mg phenyl/ g soil/ 2h on 0 -10 cm; 2.30 mg phenyl/ g soil/ 2h on 10 - 20 cm and 2.2 mg mg phenyl/ g soil/ 2h on 20 - 30 cm.

In average on the 0 - 30 cm in comparison with the control 2.38 mg phenyl/ g soil/ 2h, a signifiant result from a statistical point of view is *Lupinus angustifolius* (15%). The variant with *Lupinus angustifolius* + oat + rape registred 20%. (Table 13).

**Table 13.** Green manures influence on acid phosphatase activity (AcPA) on the eroded soil from Oradea 2013

Variant	AcPA		Difference %	Statistically significant
	mg phenol/g soil/2 h	%		
Depth 0 – 10 cm				
1.Control	2.60	100	--	control
2. Lupin	2.80	108	8	x
3.Lupin +oat + rape	2.92	105	5	xx
LSD 5% 0.19		LSD 1% 0.34		LSD 0.1% 0.60
Depth 10 – 20 cm				
1.Control	2.30	100	-	control
2. Lupin	2.74	120	20	xx
3.Lupin +oat + rape	2.85	124	24	xx
LSD 5% 0.17		LSD 1% 0.29		LSD 0.1% 0.57
Depth 20 – 30 cm				
1.Control	2.22	100	-	control
2. Lupin	2.68	121	21	xx
3.Lupin +oat + rape	2.73	123	23	xx
LSD 5% 0.20		LSD 1% 0.34		LSD 0.1% 0.62
Average Deapth 0 – 30 cm				
1.Control	2.38	100	-	control
2. Lupin	2.74	115	15	xx
3.Lupin +oat + rape	2.84	120	20	xx
LSD 5% 0.19		LSD 1% 0.33		LSD 0.1% 0.60

### Alkaline phosphatase activity (AlkPa)

The values of alkaline phosphatase activity were smaller than the values of the acid phosphatase activity and decreased with the depth of the collected sample.

The smallest values of the alkaline phosphatase activity were registered in the variant used as control. In average the value of the alkaline phosphatase activity on the depth of 0 - 30 cm was 1.29 mg phenyl /g soil/ 2 h. In the variants with green manure the values were bigger than the control.

The difference for *Lupinus angustifolius* in pure crop was 19%, significant statistically. (Table 14).

**Table 14.** Green manures influence on alkaline phosphatase activity (CA) on the eroded soil from Oradea 2013

Variant	AlkPa		Difference %	Statistically significant
	mg phenol/g soil/2 h	%		
Depth 0 – 10 cm				
1.Control	1.36	100	-	control
2. Lupin	1.68	124	24	x
3.Lupin +oat + rape	1.96	144	44	xxx
LSD 5% 0.18		LSD 1% 0.37		LSD 0.1% 0.61
Depth 10 – 20 cm				
1.Control	1.32	100	-	control
2. Lupin	1.52	116	16	-
3.Lupin +oat + rape	1.69	128	28	xx
LSD 5% 0.17		LSD 1% 0.29		LSD 0.1% 0.54
Depth 20 – 30 cm				
1.Control	1.20	100	-	control
2. Lupin	1.39	116	16	x
3.Lupin +oat + rape	1.52	127	27	x
6. Manure 50 t/ha	1.67	140	40	xx
LSD 5% 0.15		LSD 1% 0.27		LSD 0.1% 0.58
Average Deapth 0 – 30 cm				
1.Control	1.29	100	-	control
2. Lupin	1.53	119	19	X
3.Lupin +oat + rape	1.73	134	34	xx
LSD 5% 0.17		LSD 1% 0.31		LSD 0.1% 0.58

### Conclusions

The research carried out in a long term trial from the Agricultural Research and Development Station Oradea permitted the following conclusions:

(1) physical parameters of the soil were improved in the variants with green manure in comparison with the control: bulk density and penetration resistance decreased, total porosity and hydraulic conductivity increased; a more favourable values were obtained in the variant with *Lupinus angustifolius*+oat+rape in comparison with *Lupinus angustifolius*, pure crop. Regarding the soil structure degree, in the variant with *Lupinus angustifolius* pure crop, a little smaller value was registered in comparison with the control but in the variant with *Lupinus angustifolius*+oat+rape the value of the structure degree is bigger than the value registered in the control;

(2) regarding the soil chemical properties the different situation were registered: the pH value didn't determinate the differences statistically assured in the variants with organic fertilization in comparison with the control; the N-NO<sub>3</sub> + NH<sub>4</sub> content are bigger in the variant with green manure in comparison with the manure. In comparison with the value determinate in the control, 3.16 ppm, in the all variants studied were registered the differences very significant statistically; mobile phosphorus and potassium content increased in the variants with green manures in comparison with the control;

(3) enzymological activity (actual and potential dehydrogenase, catalase activity, acid and alkaline phosphatase activity) were the smallest values in the control, the enzymological activity increased in the variant with *Lupinus angustifolius* pure crop but the biggest values were registered in the variant with *Lupinus angustifolius*+oat+rape;

The result research sustain the use of the lupin like green manure mixture crop (*Lupinus angustifolius*+oat+rape) because the lupin is known for this destination and don't sustain the use of the *Lupinus angustifolius*, pure crop.

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