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POST-HARVEST GREEN MANURE YIELD AND AMOUNT OF ORGANIC MATTER APPLIED INTO THE SOIL DURING PLOWING

PRODUKTYWNOŚĆ POPLONÓW PRZEZNACZONYCH NA ZIELONY NAWÓZ ORAZ ILOŚĆ MATERII ORGANICZNEJ WPROWADZANEJ DO GLEBY W CZASIE ORKI

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Streszczenie. W badaniach oceniano produktywność poplonów przeznaczonych na zielony nawóz i stanowiących źródło odżywiania mineralnego upraw następczych. Oceniano ilość suchej masy i ogólną wartość odżywczą poplonów uprawianych w leśno-stepowej strefie Ukrainy. Stwierdzono, że przyrosty zielonej masy przeznaczonej na nawóz zależały od warunków wilgotnościowych w okresie pożniwnym; największe mieściły się w granicach 16–23 $t \cdot ha^{-1}$.

Key words: basic nutrients, dry matter, green manure, organic matter, post-harvest, yield.
Słowa kluczowe: materia organiczna, podstawowe składniki żywieniowe, plon, poplony, sucha masa, zielony nawóz.

INTRODUCTION

One of the foundations of plant growing biologization is wide usage of organic sources of plant nutrition due to the fact that vegetation is a green fertilizer to enrich the soil with organic matter, which has all the elements of plant nutrition. It improves water and air modes by loosening the soil and plant roots structuring. It is also known the phytosanitary effect of organic sources of plant nutrition, aimed at changing the quantity and species of weeds content and soil purification from pathogens and pests (Williams1936; Zinchenko et al. 2006; Patyka et al. 2007).

One of the promising directions to improve the ecological conditions and soil fertility is bringing fresh semi-rotted organic substance which stimulates the activity of microorganisms and can improve soil fertility (Williams 1936; Alekseev, 1957; Alekseev et al.1970; Dovban 1981; Zinchenko et al. 2006; Patyka et al. 2007).

In this regard, the use of manure and green manure increases the amount of humus in the soil, improves its ecological conditions. Manure and green manure use increases the amount of humic acid and fulvic acid, increases the content of labile soil, determines its effective fertility (Williams 1936; Sobolev and Badina 1957; Grinchenko 1976; Patyka et al. 2007).

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MATERIALS AND METHODS

Field trials were conducted at JV "Voytovske" Brovary rayon, Kyiv region during 2006–2008 years on sod and mid-podzol soils on water-glacial sands.

According to trial protocol it was planned to apply 30 t · ha^{-1} of manure (control) and to plow phytomass of fodder beans, yellow lupine, fodder pea, oil radish, white mustard and the mixed: fodder bean + blue lupine+ fodder pea, oil radish+ white mustard. Zoned varieties of green manure crops were used for the trial. Post-harvest green manure grown by conventional technology for the Polissya zone of Ukraine, sowing was performed by domestic drill "Klen".

Treated area was 25 m^2, there were four replications. Weather conditions during the period of research were somewhat different from average annual. In the experimental years the average temperature during the green manures vegetation (August – October) was up to 0,5–1,3% higher than norm, regarding rainfall post-harvest periods of 2005, 2006 and 2008 were satisfactory, while 2007 was poor on moisture.

RESULTS AND DISCUSSION

Green mass yield of green manure crops is a reference indicator which gives the opportunity to make preliminary conclusions on the crop effectiveness as a source of mineral nutrition for the following crops.

For cereals, root crops, tuber crop, silage crops and grasses it is a main indicator, when for green manures also important are gross dry matter content and basic nutrients in it. In addition, unlike field crops, total biomass of the plants matters: the aerial part and roots. Although considered mass of roots only in the layer of 0–40 cm, at least – 0–60 cm (in black soils of Steppe and Forest-Steppe zone of Ukraine), or about 70–80% of the roots. The remaining 20–30% is below plowing layers.

Evaluation and recording of the green mass of fodder legumes and cabbage crops shows that during green manures plowing period their overground mass, depending on moisture conditions in post-harvest period is 16–23 t · ha^{-1} and the annual averages are (2006–2008) – 18,22 – 20,32 t · ha^{-1} (Table 1).

Relatively large over ground mass was in beans (20.48 t · ha^{-1}), oil radish (20.32 t · ha^{-1}) and cabbage – radish and mustard (20.31 t · ha^{-1}). The lowest rate in peas was 18.27 t · ha^{-1}. This reduction in yield is statistically significant.

However, as for the post-harvest crops obtained green manure yield is quite high.

The lowest rates were in 2007, due to minimal amounts of moisture in the arable soil layers and 1-meter soil layer for sowing period. First of all it caused reduction of initial growth of post-harvest crops, and secondly – the yield was obtained mainly by precipitation in September-October, in low temperatures, which also influenced soil nutrient regime. The yield of green manure crops in this year was significantly lower than in 2006 and 2008.

Table 1. Post-harvest green manures yield
Tabela 1. Produkcja zielonego nawozu w uprawie poplonowej [t · ha^{-1}]

Crop, crop mixture Gatunek, Mieszanka	Year – Rok			Average Średnia
	2006	2007	2008	
Beans Fasola	21.93	18.62	20.89	20.48
Lupine Łubin	20.94	18.06	19.27	19.42
Pea Groch	19.60	17.08	18.19	18.27
Oil radish Rzepak	22.50	19.00	19.47	20.32
White mustard Gorczyca biała	20.07	16.93	18.29	18.43
Beans + lupine + peas Fasola + łubin + groch	22.26	17.97	20.86	20.36
Radish + mustard Rzepak + gorczyca	22.91	18.42	19.60	20.31
$LSD_{0.05}$ – $NIR_{0,05}$	0.58	0.43	0.53	

Thus, unfavourable, in terms of moisture availability, year 2007 slightly reduced average yield of green manure crops in the trial. According to the literature, such conditions of post--harvest crops vegetation predominate in areas of southern steppes, where similar yield in 2007 was obtained.

High yield of cabbage crops – oil radish and mixtures of radish with white mustard has to be highlighted. They are cold resistant compared to legumes – beans, lupine and peas. But as mentioned above radish and mustard somewhat inferior to the legumes, especially lupine in regard of nitrogen content in the green mass. Among legumes in all the years of the research there was relatively lower yield of peas up to 1.0–2.5 t · ha^{-1}. There is a need of further research on selection of more productive varieties of peas for the post-harvest green manures.

Data on yields of different post-harvest crops and mixtures for green fertilization provides only a general idea of agrotechnical efficiency of post-harvest sideration as studied crops have different content of dry matter and major nutrients, as well as such an important element for soil fertility as calcium.

A more comprehensive and objective conclusions about the value of post-harvest sideration can be obtained by comparing the weight and quality of organic matter in green manure crops with manure.

It is necessary to compare the amount of dry matter of green manures and manure. Comparing the two years (favourable and less favorable for humidification) during the vegetation period of green manure in the experiments carried out it showed that the difference in the amount of organics in manure and green manure can be significant. So, in best year 2006, in terms of moisture conditions, amount of dry matter in green manure mass before plowing, depending on the crop, ranged at 3,67–4,24 t · ha^{-1}. The difference between the extremes – lower and higher rates, was 15,5% (Table 2).

Table 2. Organics amount in soil while plowing of post-harvest green manures depending on moisture conditions
Tabela 2. Materia organiczna wprowadzana do gleby podczas zaorywania zielonego nawozu w różnych warunkach wilgotnościowych

Crop, crop mixture Gatunek, mieszanka	2006			2007			Average – Średnia		
	green mass zielona masa [t · ha^{-1}]	dry matter sucha masa [%]	dry matter sucha masa [t · ha^{-1}]	green mass zielona masa [t · ha^{-1}]	dry matter sucha masa [%]	dry matter sucha masa [t · ha^{-1}]	green mass zielona masa [t · ha^{-1}]	dry matter sucha masa [%]	dry matter sucha masa [t · ha^{-1}]
Beans Fasola	21.93	18.4	4.04	18.62	19.6	3.65	20.28	19.0	3.85
Lupine Łubin	20.94	18.6	3.89	18.06	19.7	3.56	19.5	19.2	3.74
Pea Groch	19.60	19.7	3.87	17.08	21.0	3.59	18.94	20.4	3.74
Oil radish Rzepak	22.50	17.8	4.01	19.20	18.7	3.55	20.75	18.3	3.80
White mustard Gorczyca biała	20.07	18.3	3.67	16.93	19.4	3.28	18.50	18.9	3.50
Beans + lupine + + peas Fasola + łubin + + groch	22.26	19.0	4.23	17.97	20.3	3.65	20.12	19.7	3.97
Radish + + mustard Rzepak + + gprczyca	22.91	18.5	4.24	18.42	18.8	3.46	20.67	18.7	3.87
Manure (control) Obornik (kontrola)	–	–	–	–	–	–	30.0	22.0	6.6

Higher performance was in following crops: beans – 4.04 t · ha^{-1}, mixtures of beans with lupine and peas – 4.23 t · ha^{-1}, radish with mustard – 4.24 t · ha^{-1}.

Somewhat lower rates were in lupine, pea, oil radish – 3.89; 3.87, and 4.01, the lowest in white mustard – 3.67 t · ha^{-1}.

In 2007 dry matter yield was in the range of 3.28-3.65 t · ha^{-1}. The difference between the extreme variant was small – 0.37 t, but at lower yields. The difference between the variants is 11.3%.

In unfavourable conditions of year 2007, except for beans and legumes mixtures (as in 2006), best results were also observed in pea. Its performance was on the level with other crops – beans, lupines, mixtures of legumes and oil radish. Markedly lower rate observed in white mustard.

Average organic content in green manure within two years, with different moisture conditions during vegetation, have a similar distinction.

Number of dry matter in manure is 6.6 t · ha^{-1}. Compared with the extreme performance 3.50 (white mustard) and 3.97 t · ha^{-1} (legume mixtures), the difference reaches respectively 47 and 40%.

It should be mentioned that the green manure was compared with semi-rotted manure which was stored in field clamps. During this time there was a complete destruction of straw, a significant component of manure. Manure in Polissya conditions has relatively low dry matter content – about 22% since the clamps gets significant rainfall during the period of storage. The best option would be to store manure in specially equipped field manure storages.

As shown by comparison of organics amount, which enters the soil during plowing of green manure with manure (30 t · ha^{-1}), during research period (2006–2008), it comes in average 53,0–60,6% of organic matter by post-harvest sideration (compared with manure). More organics are provided by mixtures of legumes – beans + lupines + peas, beans, 60,6; 58,0 and mixtures of radish with mustard – 58,2%. The lowest ratio compared to the control variant observed on mustard white – 53,3%. Almost similar rates are at variants of lupine, pea – 56,7; 56,4 respectively (Table 3).

Table 3. Amount of organics (dry matter), which enters soil while plowing the post-harvest green manure (2006–2008)
Tabela 3. Ilość suchej masy organicznej wprowadzanej do gleby w czasie zaorywania zielonego nawozu (2006–2008)

Crop, crop mixture Gatunek, mieszanka	Yield of green manure mass Plon zielonego nawozu [t · ha^{-1}]	Dry matter Sucha masa [%]	Plowed amount of organics Ilość zaoranej masy organicznej [t · ha^{-1}]	Total Ogółem [%]
Manure 30 (control) Obornik 30 (kontrola) [t · ha^{-1}]	–	22.0	6.6	100
Beans Fasola	20.4	19.6	3.85	58.0
Lupine Łubin	19.5	19.2	3.74	56.7
Pea Groch	18.22	20.4	3.72	56.4
Oil radish Rzepak	20.62	18.3	3.80	57.1
White mustard Gorczyca biała	18.97	18.9	3.50	53.0
Beans + lupine + peas Fasola + łubin + groch	20.28	19.7	4.00	60.6
Radish + mustard Rzepak + gorczyca	20.51	18.7	3.84	58.2

Indicators of chemical content of green manure organic matter significantly and considerably differ. Generally more nitrogen is contained in beans, phosphorus - in cabbage, potassium and calcium, similar to nitrogen, accumulate more legumes (Table 4).

Calculations of the nutrition elements amount that comes with green manure weight (without root residues), are following: nitrogen 85,5–117,4 kg · ha^{-1} compared to controls (148,5 kg) 56,7–77,4%, phosphorus – 14,13–24,2 (53,6–103,1%), potassium – 45,59–57,6 (43,4–54,5%), calcium – 36,2–45,6 (50,3–62,8%) compared to the control parameters: nitrogen – 148,5, phosphorus – 22,4, potassium – 105,6, calcium – 72,6 kg · ha^{-1}.

Thus, only content of phosphorus in green mass of oil radish and mustard and radish with mustard are almost at the same level as in manure. In other crops it is less at 8–10 kg · ha^{-1} or 36–44% compared to the control.

Table 4. Amount of organic matter and elements of mineral nutrition, which enters soil, while plowing post-harvest green manure (2006–2008)
Tabela 4. Ilość materii organicznej i składników żywienia mineralnego wprowadzana do gleby w czasie zaorywania zielonego nawozu (2006–2008)

Crop, crop mixture Gatunek, mieszanka	Green mass Zielona masa [t · ha^{-1}]	Dry matter in green mass Sucha masa w zielonej masie [%]	Dry matter Sucha masa [t · ha^{-1}]	Dry matter – Sucha masa							
				N-NO_3		phosphorus fosfor		potassium potas		calcium wapń	
				%	kg · ha^{-1}	%	kg · ha^{-1}	%	kg · ha^{-1}	%	kg · ha^{-1}
Beans Fasola	20.71	19.0	3.94	2.82	107.7	0.37	14.13	1.40	53.48	1.12	42.78
Lupine Łubin	19.50	19.2	3.74	3.14	117.4	0.36	13.5	1.53	57.22	1.15	43.01
Pea Groch	18.22	20.4	3.72	2.65	98.6	0.36	13.4	1.36	50.59	1.16	43.15
Oil radish Rzepak	20.62	18.3	3.77	2.56	96.5	0.64	24.1	1.25	47.13	0.96	36.19
White mustard Gorczyca biała	18.97	18.9	3.59	2.41	85.5	0.62	22.3	1.27	45.59	1.04	37.34
Beans + lupine + + peas Fasola + łubin + + groch	20.28	19.7	4.00	2.87	114.8	0.37	14.8	1.44	57.60	1.14	45.60
Radish + + mustard Rzepak + + gorczyca	20.51	18.7	3.84	2.44	93.7	0.63	24.2	1.27	48.80	1.00	38.4
Manure (control) Obornik (kontrola)	30.0	22.0	6.6	2.25	148.5	0.34	22.4	1.60	105.6	1.1	72.6

Remark: Content of dry matter, nitrogen, phosphorus, potassium and calcium in manure, is obtained on cattle farms.
Uwaga: Zawartość suchej masy, azotu, fosforu, potasu i wapnia w oborniku otrzymano z farm hodowli bydła.

Conducted studies have made for the first time possible to set amount of different organic green manure post-harvest crops compared with manure in t/ha and in percentage for the region of southern Polissya (Kiev Polissya).

However in post-harvest green manures certain amount of organic matter and nutrition elements is accumulated in root residues. In this regard a relevant study was made.

CONCLUSIONS

The yield of green mass of green manure crops is relatively large in beans (20,48 t · ha^{-1}), oil radish (20,32 t · ha^{-1}) and cabbage crops – radish and mustard (20,31 t · ha^{-1}). The lowest rates are in peas – 18,27 t · ha^{-1}.

Amount of dry matter during manure application is 6,6 t · ha^{-1}. Compared with the extreme indicators 3,50 (white mustard) and 3,97 t · ha^{-1} (legume mixtures), the difference reaches respectively 47 and 40%.

By post-harvest sideration, comparing with manure, comes 53,0–60,6% of organic matter. More organics is provided by mixture of legumes: beans + lupine + peas, beans – 60,6, 58,0% and mixtures of radish with mustard – 58,2%.

Thus, only green manure mass of oil radish and mustard and radish with mustard contains almost the same amount of phosphorus as manure. In other crops it is at 8–10 kg · ha^{-1} or 36–44% less compared to the control.

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Zinchenko O.I. 2006. Efficacy of organobiological system of crop growing in field crop rotation of south part of Forest-steppe zone of Ukraine. Rational soil usage of arable and eroded lands. Dniprop. DAU, 204–206.

Abstract. It was studied the yield of post-harvest green manure on crop efficacy as a source of mineral nutrition of the following crops and gross dry matter content and basic nutrients in it in the Forrest-Steppe zone of Ukraine. It was found that the greatest increase in green mass of green manure, depending on moisture conditions of post-harvest period was 16–23 t · ha^{-1}.