UDK 631.811.87.49
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AGROCHEMICAL, AGROECOLOGICAL AND ECONOMICAL ASSESSMENT OF DIFFERENT FERTILIZER SYSTEMS IN POTATO FARMING

The efficiency of different potato fertilization systems was shown on the base of lysimeter's and field's experiment. Green manure was established as the multifaceted method in potato farming ,that is equivalent of 20-40 t/ha farmyard manure, it reduces soil effluent and nutrient's losses; green manure improves product quality due to a significant reduction nitrates in potato tubers and increasing content of starch and protein. Green manure has economic benefits and environmental feasibility.
***Keywords**: potatoes, green manure, lysimeter researches, agrochemical estimation*

Introduction. Current farming system should be energy- and resourcesaving and provide high crop productivity as well as desirable quality. It should provide expanded rebuilding soil fertility and high level of biologization. Whereas farming system is used in the particular field and particular crop rotation, then it should provide rational use of arable land, rainfall, meliorants, fertilizer and solar energy due to characteristics of soil and climate zones.

Summary of own data and researches of Western Europe's scientists shows perspective ways of using green manure in traditional and organic agriculture. (Fig.1).

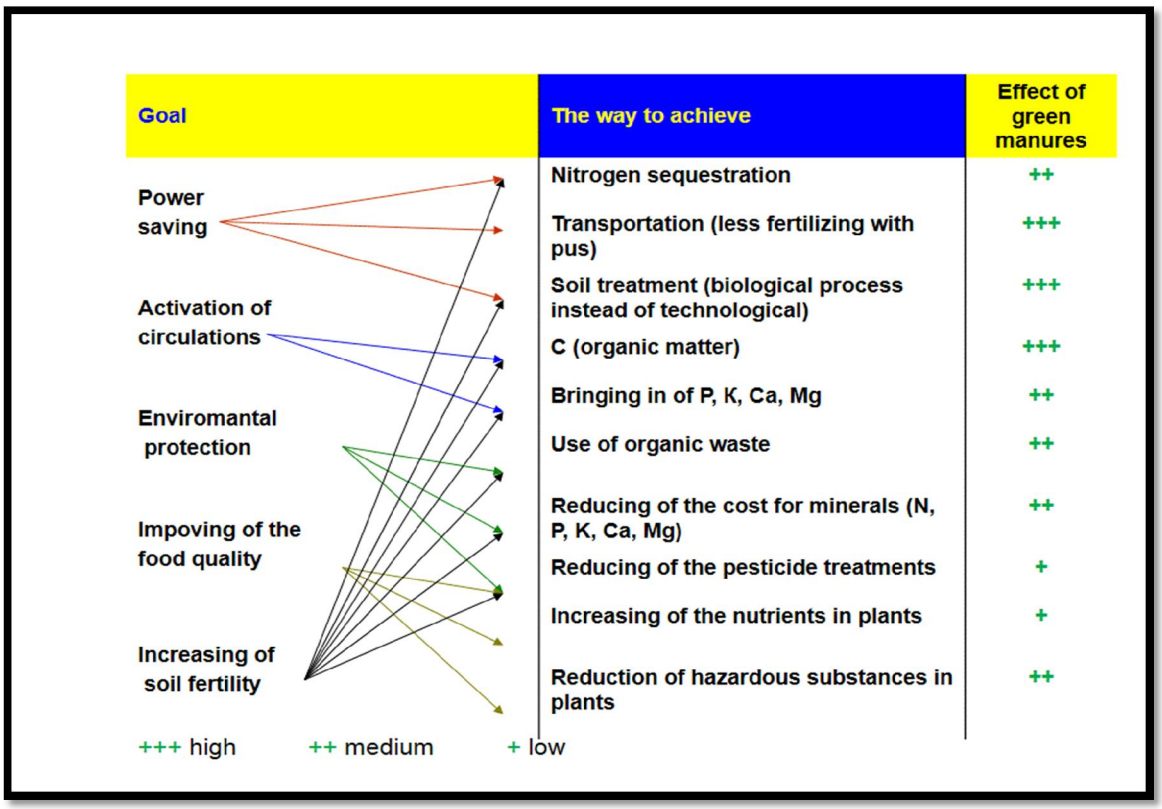

Figure 1. Aims and methods of biological farming, G. Kant, 1982, Berdnikov O.M., 1990

National and international experiences show that using cover crops in current farming can be considered as multifaceted method, which helps to replenish source of organic matter and Nitrogen in the soil; to reduce unproductive costs of moisture and nutrients by reducing infiltration processes in root layer soil and this can increase coefficient of using rainfall, fertilizer and chemical meliorants: to reduce water and wind erosions; to reduce weeds in the crop field, and, in some cases, reduce fungal diseases of crops; to increase bioactivity in the soil; improve agrophysical soil properties and thereby reduce negative impact on soil by heavy machines and hardware, to reduce the tillage cost due to loosening active arable and subsoil layers by biological methods, as well by roots of green manure.

In general, green manure allows using agroclimatic resources in the best way. So in this case, using green manure in the current farming is considerated as an important input in the energy saving technologies. [1, 2, 3, 4].

In Ukraine, growing green manure as intercropping can be in the area with sufficient moisture, under all kinds of soils, but the main condition for the success of this method is the available warm season after the harvest of winter and early spring grain crops. it takes usually 60 - 80 days and includes the sum of effective temperatures in the rate of 800 - 1000 ° C, this is 30-40% of all agro-climatic resources in the warm season [5].

Long-term investigations showed: most of field crops that are used in the intercropping, require 120-200 mm of precipitation to receive yield at the rate of 20,0-25,0 t / ha of green mass and 3.0-4.0 t / ha of dry matter. The rainfall of July-September's period is 147-215 mm in the Chernihiv region, where our researches were conducted. It confirms the potency of green manure in the intercropping and with sufficient moisture providing.

As about solar energy, then its using will be always important for agriculture KA Timiriazev wrote that a beam of light that was not used by green leaf plants, would be lost wealth forever[6].

On the other hand, it is important to have a science-based representation of processes and balance of nutrients in the soil-plant-fertilizer to develop farming practices, aimed at improving the plant use coefficients of moisture, nutrients, soil and fertilizer and to prevent environmental pollution and to regulate the quality of obtained products. Nowadays, lysimeter is the most important measuring device which can help to measure the amount of actual evapotranspiration and follow the process of infiltration.

The purpose of our research is to give comprehensive assessment (agrochemical, agroecological, natural and economic) of different fertilizer systems in potato field; to substantiate the main methods of greening and energy efficiency of agriculture in the area Polessye.

Materials and methods. Investigation of different fertilizer systems in potato's fields were conducted in stationary experiments during 2009-2013. Crop rotation in researching fields included winter rye - potato - spring wheat - lupine. Scheme of the experiment is based on examination fertilizer's types with comparing various combinations.

The total area of research field is102 m^2 , accounting area-is 60 m^2, 4 times of repetition is in the experiment. The sort of potato is Malych.

Granulometric compositions of the sod-podzolic soils are sandy and sandy-loam light. The average acidity of soil in the stationary and lizimetr experiments is 4,9 pH_{KC}, humus content is 1.1%, mobile forms of phosphorus is 179.0 mg/kg of soil, potassium exchange is 70-90 mg/kg soil, hydrolytic acidity is 2.8 mEq.per100 g of soil.

Lysimeter was built in 1971-1972 years by individual project of Chernihiv Department of the Institute Hidrotsyvilprombudu according to methodological guidelines of BA Golubev, E.F.Arinushkova [7, 8].

Lysimeter has 48 sections, placed in two parallel rows of 24 each one. It has receivers to collect the filtrate and concrete structure. Lysimeter's cell is filled with soil sequentially, ranging from bedrock, considering the capacity of genetic horizons. Total area of lysimeter's plot is 3,8 m^2, with 4

fourfold repetition. One plot has 155 cm of soil, its weight - 10.5 tons. Cultivation is adopted for this zone.

Results and discussion. Long-term, lysimeter research, that is conducted on the podzolic loam soil of Polessye, shows: average precipitations per research years were 543,7 mm of moisture , with minor deviations by years - 95,2 mm or 82% and 199,4 mm or 137 % compared to the average long-term level. 42% of all years had insufficient rainfall, 33% is waterlogged and 25% was close to the average multi-index.

So, for years there has been a steady regime of moisturizing that is typical for Polessye. Regarding the seasonal moisture, then the maximum rainfall is observed in the summer months - June and July, during which 71,4 and 97,6 mm falls. During the late autumn and winter 143 mm of precipitation came from the atmosphere that is 26 % of annual rate, spring time had 110 mm, or 20 %, summer time had 41%and autumn time had 67 mm or 13%.

Thus, growing of potato and corn that are main cultivated crops in Polessye includes 3-4 months when the soil is protected by vegetation; less than half annual rainfall can be used in this time. With growing winter crops, soil are protected by vegetation or plant remains during nine months per year. Impact of different crops were observed in lysimeter within 0-155 cm of soil (tabl. 1). The most intensive process of soil leaching is on the fallow land. Average, long-term cost of moisture is 98 mm of precipitation, or 18 % of total annual precipitation in the fallow field, 75 mm of precipitation, or 14% is on the potato field and 44 mm, or 8 % is in the wheat field.

Table 1

Effect of the vegetation type on the filtering intensity

Vegetation type	Loss of moisture		
	of precipitation		% of fallow
	%	мм	
Fallow field	18	98	100
Cultivated crops	14	25	76
Winter crops	8	41	45
Ley farming	6	30	31

Considering the reported data you can see that ley farming reduced moisture loss in the soil more than in tree times, winter wheat growing reduced in the two times and potato growing – on the 25 %. In some years winter wheat can reduce moisture loss above 4-5 times, especially in the wet years with intensive snowmelt and summer rainstorms.

Conducted analysis indicates that vegetation and its type determined amount of filtered water in all seasons: spring, summer, autumn, and autumn-winter. The greatest decreasing of infiltration processes was affected by winter crops in the spring, when there is in peak of seasonal vertical migration. Long-term investigation shows that potato can reduce moisture loss on the 14 mm in comparing with fallow field.

Due to the necessity of environmental protection, regulating of nutrients circulation including nitrogen, as the most movable and vital element became very important.

Our investigations showed that leaching of nitrate in the nitrogen form was 184kg/ha or equivalent to element - 42kh/ha in average. Nitrogen losses were less on 32% in the potato field then in the fallow field.

During the wet years, it was fixed 353,9-466,1 kg/ha of nitrate's losses (converting to the nitrogen is 81-105 kg / ha) in the fallow. The highest nitrogen loss is within 27 kg / ha converting to the element in potato field and 0.8 kg / ha in the fallow. Loss of soluble humic substances in fallow are within 9.7 -42.8 kg / ha, 37,0-40,8 is in the potato field.

Thus, the intensity of water infiltration and therefore the loss of nutrients are caused by the type of vegetation.

The methods of reducing nitrogen losses are very valuable on the sod-podzolic soil, as the nitrogen mainly causes crop yield and soil fertility. In average loss of nitrogen in the form of nitrates are higher twice in potato field in comparing to the control.

Five-year lisymetr researches in the potato fields shows following patterns: loss of calcium oxide was the highest compared to all investigated elements, green manure reduced loss in 4,2 times; in the control field puss loss was 37,0 kg/ha and combination of puss and NPK increased the loss in 1,4 times, so replacing pus the green manure reduces loss of nutrients on 18-20 %. versus control field. Green manure reduced the loss of calcium in the 3,2-5,7, magnesium is in 2.1 - 5.2 times. The type of green manure is chosen due to purpose: the source of organic matter, nitrogen and other nutrients, biological soil loosening, prevention of soil compaction erosion and so on.

To assess green manure as fertilizers is necessary to have information about green mass accumulation and dry matter per unit area, as well as information about macro- and mesoelements that remained after green manure for the next crop and in absolute terms and compared with manure. These data about different kind of green manure were obtained on sod-podzolic soils.

Table 2

Agrochemical evaluation of various type of intercrops in comparison with pus

Type of green manure	Equivalent of puss per ha					
	dry matter	N	P_2O	K_2O	CaO	MgO
Lupin angustifolia	43	61	31	38	56	106
Lupinus polyphyllus	32	50	26	27	82	156
Lupinus luteus	8	10	5	9	9	29
Annual ryegrass	22	29	16	29	17	25
Perennial ryegrass	30	44	26	41	22	31
Ryegrass,aftergrass	44	66	40	62	24	69
Ryegrass + ornithopus +aftergrass	46	73	41	51	25	65
Ryegrass + oil radish+ aftermass	29	40	23	35	17	46

It is believed that ha green manure equivalent to the action yields the following culture of pus in the number 25-30t/ha. It is known, that field of green manure is equally to 25-30 t/rha of pus. Our calculations and economic analysis showed that evaluation of chemical composition and root phytomass of green fertilizers enables to equate green manure and pus per each element (table. 2).

On our view, the basic indicators of comparative evaluation green manure and pus are dry matter and nitrogen per unit area, as well green manureimprove arable soil layer by calcium and magnesium due to "pump" it from the deeper soil layers.

Results of field stationary experiment showed that using of lupine angustifolia in potato field is equivalent to mineral fertilization system or 40 t/ha of pus. The achieved yield capacities of unilateral fertilizer application exceed control on the 66 -77%. Combination of organic and mineral fertilizers provided 17,6-18,9 t/ha of potato yield. At the same time variant of green manure + NRK showed lower on 7 % result then variant of pus + NRK, but the quality of potato yield was higher with green manure and the nitrate content in tubers was least with it (table. 3).

Table 3

The effect of green manure on potato's productivity and quality

№	Variant	Yield cwt/ha	Content indicators					Marketability, %
			dry mater, %	starch, %	protein, %	vitamin C, mg %	nitrate, mg/kg	
1	No fertilizer (Control)	82,4	20,7	14,7	1,6	8,9	61	69
2	$N_{120}P_{90}K_{120}$	146,2	21,5	14,3	2,3	11,2	115	77
3	Green manure	146,2	21,4	14,9	2,3	10,0	75	76
4	Farmyard manure, 40t/ha	134,0	22,1	15,3	2,5	12,3	149	72
5	Farmyard manure + NPK	189,4	22,3	14,6	2,5	12,6	160	75
6	Green manure+ NPK	175,9	22,1	14,6	2,3	11,5	82	79
	lSD_{01}	1,54						

Economical estimation shows that replacing farmyard manure to green manure is economically feasible and it's conditional net income is 15 thd. hrn/ha with 300 % rentability (table. 4). Unilateral application of mineral fertilizers is economically feasible, and it's combination with green manure gives highest economic efficiency. Unilateral application of farmyard manure has low net income of 2,6 thd. hrn and 30 % of rentability.

Table 4

The economic efficiency of potato fertilization inputs and its combinations

Variant	Yield, t/ha	Growth, t/ha	Cost growth hrn/ha	Total costs, hrn/ha	Total costs, hrn/ha	Net income, hrn/ha	Recoupment rate, %
No fertilizer	8,24	-	-	-	-	-	-
$N_{120}P_{90}K_{120}$	14,62	6,38	15312	2925	5222	10090	293
Green manure	14,62	6,38	15312	782	3079	12233	497
Pus, 40 t/ha	13,40	5,16	12384	7916	9773	2611	127
Pus+ NPK	18,94	10,70	25680	10841	14693	10987	175
Green manure+NPK	17,59	9,35	22440	3707	7073	15367	317

The combination of manure with the fat (traditional fertilization system of potatoes) is economically feasible, and increases profitability and opportunistic net income in 1.4 and 4.2 times relative to alternative systems of organic fertilization (manure 40 t / ha).

Conclusions. Using green manure is multifaceted method in potato farming and is equivalent with 20-40 t/ha of pus, reducing of soil effluent and cost for the organic matter; green manure improves product quality due to a significant reduction nitrates in potato tuber and increasing content of starch and protein. Green manure has economic benefits and environmental feasibility when using in the Polissya.

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Анотація

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Агрохімічна, агроекологічна та економічна оцінки різних систем удобрення при вирощуванні картоплі

На основі проведених досліджень в стаціонарній лізиметричній установці та стаціонарному польовому досліді показана ефективність різних систем удобрення за вирощування картоплі: мінеральної, органо-мінеральної (традиційної), сидеральної, органічної та сидерально-мінеральної. Встановлено, що зелені добрива (сидерація) при вирощуванні картоплі є заходом багатопланової дії, який забезпечує компенсацію 20-40 т/га гною, знижує внутрішньогрунтовий стік вологи і втрати біогенних елементів за межі кореневмісного шару ґрунту, сприяє суттєвому підвищенню врожайності картоплі та покращує її якісні показники. Експериментально підтверджено економічну та екологічну доцільність застосування сидерації у технології вирощування картоплі в умовах Полісся України.

Ключові слова: *картопля, сидеральні культури, лізиметричні дослідження, агрохімічна оцінка*

Аннотация

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Агрохимическая, агроэкологическая и экономическая оценки разных систем удобрения при выращивании картофеля

На основе проведенных исследований в стационарной лизиметрической установке и стационарном полевом опыте, показана эффективность разных систем удобрения при выращивании картофеля: минеральной, органо-минеральной (традиционной), сидеральной, органической и сидерально-минеральной. Установлено, что зеленые удобрения (сидерация) при выращивании картофеля является приемом многостороннего действия, который обеспечивает компенсацию 20-40 т/га навоза, снижает внутрипочвенный сток влаги и потерю биогенных элементов за пределы корнесодержащего слоя почвы, способствует существенному увеличению урожайности картофеля и улучшает его качественные показатели. Экспериментально подтверждена экономическая и экологическая целесообразность применения сидерации в технологии выращивания картофеля в зоне Полесья Украины.

Ключевые слова*: картофель, сидеральные культуры, лизиметрические исследования, агрохимическая оценка*