ISSN 2224-4980

International Journal of Ecosystems and Ecology Science (IJEES)

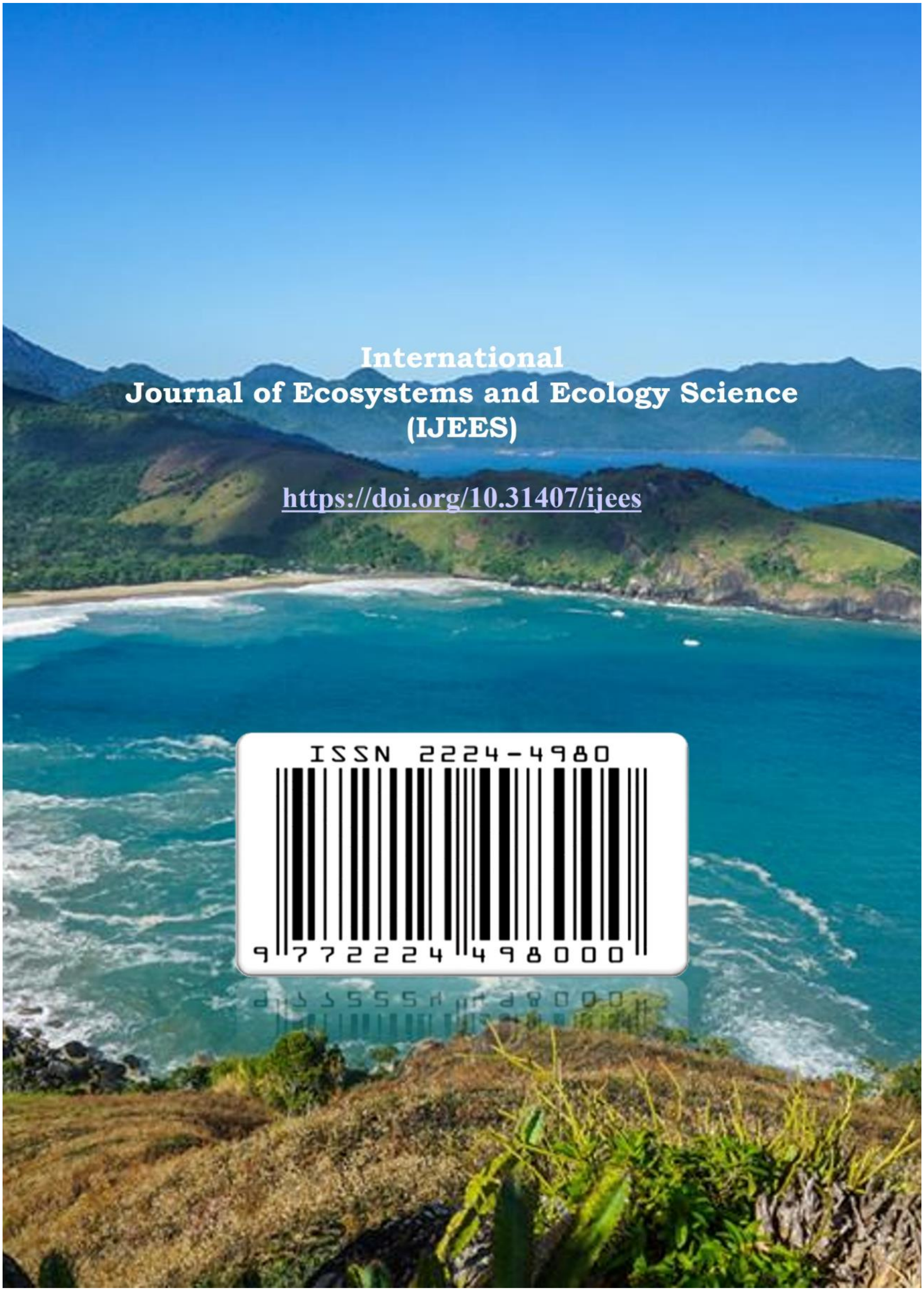
https://doi.org/10.31407/ijees

Essays on Ecosystems and Environmental Research

Volume 11/4, 2021

August - December 2021

http://ijees.net/


International
Journal of Ecosystems and Ecology Science
(IJEES)
https://doi.org/10.31407/ijees
ISSN 2224-4980
9 772224 498000

International Journal of Ecosystems and Ecology Science (IJEES), ISSN: 2224-4980

Volume 11, Issue 4, August - December 2021, (Serial Number 44)

Publication Information:

International journal of ecosystems and ecology science (IJEES), ISSN 2224-4980, publishing original articles, reviews and short communications of high scientific standard on ecosystems and science ecology.
By: Hysen Mankolli, Professor, Ecologist, Plainfield, Illinois, USA; Health and Environment Association, Tirana, Albania;
ISSN International Centre, *Bibliographic Data Section*, PARIS, FRANCE;
Bib - ID 68337; ISO standard 3297;
Key title: International journal of ecosystems and ecology science
Abbreviated key title: *Int. j. ecosyst. ecol. sci.*
ISSN 2224-4980; **http://ijees.net/**
Frequency: four times a year. IJEES Electronic Journal Publication: Plainfield, Illinois, USA;
DOI prefix: 10.31407, **https://doi.org/10.31407/ijees**
ESCI Clarivate, http://ip-science.thomsonreuters.com/cgi-bin/jrnlst/jlresults.cgi?PC=MASTER&Word=ijees
UOI license: http://u-o-i.org/1.01/ijees; http://www.u-o-i.org/index.php/SearchLicense
DPI Digital Library USA and assign unique digital no. DPI: 16.10047.IJEES
U.S. National Library of Medicine,
NLM ID: 101726509 [Serial]; **Other ID:** (OCoLC)879805056;
https://www.ncbi.nlm.nih.gov/nlmcatalog/101726509

This journal has the status of an international journal.

Aims and Scope:

The goals of the International journal of ecosystems and ecology science (IJEES), ISSN 2224-4980, are to bring together researchers and scientists with interests in the quality of the ecosystems research results, theories, technologies, systems, tools, applications, the work in progress and experiences on ecosystems used. The main topics of interest are:

- ✓ Ecosystems
- ✓ Agro ecosystems
- ✓ Forest ecosystems
- ✓ Ecology
- ✓ Plant Ecology
- ✓ Animal Ecology
- ✓ Human Ecology
- ✓ Lakes and Rivers ecosystems
- ✓ Applied Biology
- ✓ Applied Ecology
- ✓ Applied Chemistry
- ✓ Biodiversity
- ✓ Energy
- ✓ Geology
- ✓ Bioaccumulation
- ✓ Desalination
- ✓ Water
- ✓ Soil
- ✓ Air pollution
- ✓ Climate Change
- ✓ Ecosystem restoration
- ✓ Environment toxicology
- ✓ Environment protection
- ✓ Environmental radioactivity
- ✓ Environmental legislation
- ✓ Environmental management
- ✓ Environmental education.
- ✓ Green technology
- ✓ Socioeconomic aspects in Ecosystems
- ✓ Agro tourism and National Park
- ✓ Health Care
- ✓ Food security
- ✓ Rights and Environmental Laws
- ✓ Environment Engineering
- ✓ Environment Architecture
- ✓ Eco philosophy Issue

Abstracted / Indexed / Impact Factor in:

International journal of ecosystems and ecology science (IJEES), ISSN 2224-4980,

IJEES: http://ijees.net/
*IJEES have an international status and has been indexed, **abstracted and have impact factors:***

IJEES doi crossref
https://doi.org/10.31407/ijees
IJEES, Volume 11/3, 2021
https://www.ijees.net/journal-81-International--Journal-of-Ecosystems-and-Ecology-Science--(IJEES)--Volume-11-3,-2021.html
Clarivate Analytics
http://ip-science.thomsonreuters.com/cgi-bin/jrnlst/jlresults.cgi?PC=MASTER&Word=ijees
https://mjl.clarivate.com/home?PC=MASTER&Word=ijees
Web of Science Core Collection
https://apps.clarivate.com/mjl-beta/search-results
Emerging Sources Citation Index - JOURNAL LIST
http://mjl.clarivate.com/cgi-bin/jrnlst/jlresults.cgi?PC=EX&Alpha=I
Scilit
https://www.scilit.net/journal-articles/1892436
CiteFactor: IF 2019-2020:1.40;
https://www.citefactor.org/impact-factor/impact-factor-of-journal-International-Journal-of-Ecosystems-and-Ecology-Science-IJEES.php
EBSCO's library products,USA
http://www.ebscohost.com/for-publishers/for-publishers
IARC: Journal Impact Factor (USA), IF=2017**: 1.811; IF=**2016: **1.463; =**2015: **0.861**
http://iarcif.org/index.php/journal_information/show/44/0/2224-4980
Index Copernicus ICV= 2019: **100.00; ICV=** 2018: **100.00; ICV=** 2017: **98.95; ICV=** 2016: **81.17;** 2015: **93.51;**
https://journals.indexcopernicus.com/search/journal/issue?issueId=197247&journalId=31407
Academic Resource Index Research Bible:
http://paper.researchbib.com/view/issn/2224-4980/10/2
Google scholar Cited
https://scholar.google.com/citations?user=W89N8qgAAAAJ&hl=en
MIAR
http://miar.ub.edu/issn/2224-4980
Eduindex Impact Factor
https://www.eduindex.org/2017/08/international-journal-of-ecosystems-and.html
Directory of Research Journals Indexing (DRJI)
http://olddrji.lbp.world/JournalProfile.aspx?jid=2224-4980
WorldCat
https://www.worldcat.org/search?qt=affiliate_wc_org_all&ai=Directory_ashok.drji%252540gmail.com&fq=&q=2224-4980&wcsbtn2w=Go
US. National Library of Medicine, NLM ID: 101726509 [Serial]; **Other ID:** (OCoLC)879805056;
https://www.ncbi.nlm.nih.gov/nlmcatalog/101726509
Global Impact Factor (GIF) IF: 2015: **0.765;** 2014: **0.625;** 2013: **0.541; IF=** 2012: **0.425**;
http://globalimpactfactor.com/journals-list/?snap=I
CAS Chemical Abstracts Service – CAS database
http://cassi.cas.org/search.jsp
Journal Factor: ISSN 2224-4980
http://www.journalfactor.org/advance_search.php
Directory of Research Journals Indexing (DRJI)
http://olddrji.lbp.world/justIncluded.aspx
Environment-and-Nature/Biodiversity/Ecosystem.
http://www.efita.org/Environment-and-Nature/Biodiversity/Ecosystem-Biodiversity/IJEES-details-28892.html
NewJour : Electronic Journal&Newsletters
http://gulib.georgetown.edu/newjour/nj2/index.html
Environmental expert
http://www.environmental-expert.com/magazines/?keyword=ecosystem+science
Currently Indexing at Pro Quest
http://www.proquest.com/en-US/catalogs/databases/detail/periodicals_index.shtml
CABI
http://www.cabi.org/default.aspx?page=1016&site=170&pid=40&xslttab=2&newtitlesonly=1&search=
Academia.edu
http://www.academia.edu/3834422/_2013_Networking_approach_to_the_sustainable_development_of_European_Regions_bordering_major_rivers

Manuscripts and correspondence are invited for publication

Dear Professors, PhD, researchers and scholars of the field of ecosystems and related areas to, such as environmental engineering, agriculture, bio-chemistry, soil, water and air pollution, geology, forestry, urban ecology, resource economics, etc., at the moment, I declare the sending of scientific journal articles to International Journal of Ecosystems and Ecology Science (IJEES) is open. Sending of items can only be done electronically, to the following address: e-mail: editorijees@gmail.com; 2011jiese@gmail.com; mjedisishendeti@yahoo.com; The confirmation of receiving these items will be announced within the period of one to three weeks after sending. Weather the article is accepted or not, will be announced within a period of two to three weeks. Only original articles will be accepted, validated, and not to have or be published in other journals. Publication lasts from two to six months. All Rights Reserved Copyright by © IJEES (the first or correspondent author have responsible for the accuracy of the article).
Submission guidelines and Web Submission System are available at: https://www.ijees.net/page-6-Guide-for-authors.html;
Note: *If the paper is published in another journal or if it includes false or inaccurate claims, it will be rejected or removed automatically as that constitutes a violation. Zero tolerance!*

Editorial Office:

IJEES Electronic Journal Publication: Plainfield, Illinois, USA; E-mail: editorijees@gmail.com;
Health and Environment Association, Tirana, Albania; E-mail: mjedisishendeti@yahoo.com;

International
Journal of Ecosystems and Ecology Science
(IJEES)
DOI: https://doi.org/10.31407/ijees

Volume 11/4, 2021
DOI: https://doi.org/10.31407/ijees11.4

Table of contents:

International Journal of Ecosystems and Ecology Science (IJEES) **Vol. 11 (4):** 895-902 (2021)
https://doi.org/10.31407/ijees https://doi.org/10.31407/ijees11.4

AGROECOLOGICAL ASSESSMENT OF GREEN MANURES GROWN FROM WINTER GRAIN HARVEST LOST IN THE CONDITIONS OF THE RIGHT-BANK FOREST-STEPPE OF UKRAINE

Razanov Serhiy[1*], Ovcharuk Vitaliy[2], Krasnyak Olena[3], Bakhmat Mykola[4], Bakhmat Oleg[5]

[1,2,3]Vinnytsia National Agrarian University, 3, Soniachna Str., 21008, Vinnytsia, Ukraine;*
[4,5]State Agrarian and Engineering University, 13, Shevchenko Str., 32316, Kamianets-Podilskyi, Ukraine;

[*]Corresponding Author Razanov Serhiy, e-mail: razanovsergej65@gmail.com;

Received July 2021; Accepted August 2021; Published September 2021;

DOI: https://doi.org/10.31407/ijees11.429

ABSTRACT

To increase soil fertility and reduce their pollution by various harmful substances, including heavy metals, to replace chemical fertilizers, which are a source of these toxicants the main task for nowdays. The content of nitrogen, macro- and microelements in the vegetative mass grown from lost (from 5% to 8%) grain during the harvest of winter wheat, winter barley, winter rape and winter peas was studied. It was found that the yield of vegetative mass grown from grain lost during harvesting is 4500 kg ha^{-1} – winter wheat, 3700 kg ha^{-1} – winter barley, 11500 kg ha^{-1} – winter rape and 6200 kg ha^{-1} – winter peas. The concentration of phosphorus, potassium, calcium, magnesium and sodium in the vegetative mass of these greens was respectively in the range of 0.65 g kg^{-1} – 1.25 g kg^{-1}; 3.1 g kg^{-1} – 4.8 g kg^{-1}; 1.01 g kg^{-1} – 3.1 g kg^{-1}; 0.21 g kg^{-1} – 0.75 g kg^{-1}; and 0.18 g kg^{-1} – 0.52 g kg^{-1}. While the concentration of lead, cadmium, copper, zinc, manganese and cobalt in the vegetative mass of green manures grown from grain harvested during the harvest of winter wheat, winter barley, winter rape and winter peas was 0.02 mg kg^{-1} – 0.024 mg kg^{-1}, 0.0015 mg kg^{-1} – 0.0024 mg kg^{-1}, 44 mg kg^{-1} – 48 mg kg^{-1}, 0.45 mg kg^{-1} – 0.8 mg kg^{-1}, 3.2 mg kg^{-1} – 7.8 mg kg^{-1}, 4.3 mg kg^{-1} – 7.3 mg kg^{-1} and 0.017 mg kg^{-1} – 0.22 mg kg^{-1}. The nitrogen content in the vegetative mass of green manures obtained from 1 ha ranged from 21600 to 52100 g. The use of these green manures in crop production has a higher environmental efficiency of fertilizers due to low concentrations of lead, cadmium, zinc and copper compared to mineral fertilizers. The coefficient of accumulation in the vegetative mass of green manures was from 0.016 to 0.019 for lead, from 0.0053 to 0.0085 for cadmium, from 0.2 to 0.27 for zinc and from 0.59 to 0.78 for manganese.

Key words: Green manure, Winter wheat, Winter barley, Winter rape, Winter peas, Yield, Nitrogen, Macronutrients, Microelements, Grain.

INTRODUCTION

The growing intensity of the natural resources use, in particular, agricultural soils in some areas of Ukraine leads to their degradation, which threatens their natural recovery. The consequence of degradation of agricultural soils is a decrease in their fertility and the accumulation of various toxicants, including heavy metals, which has a negative impact on the quality of crop products (Falcone et al., 2019).

Climate change also had a significant impact on the condition of soils and the efficiency of their use in agricultural production over the last few decades (El-Sadek et al., 2020). In particular, due to a significant increase of air temperature, uneven rainfall and long dry periods, the total soil moisture decreased, which negatively affects the efficiency of their use.

The agrosphere of Ukraine is characterized in some regions by the rapid development of agriculture due to the intensification of the industry. Characteristic of this region is the cultivation of cereals such as wheat, corn, barley and others cultures (Mazur et al., 2018; Razanov et al., 2020; Tkachuk et al., 2020; Honcharuk, 2021).

Intensive farming on these soils leads to increased yields of nutrients, which sometimes negatively affects their fertility. Under such conditions, there is a need for constant replenishment of soil nutrients, which occurs mainly through the use of mineral fertilizers (Mazur et al., 2020). In the conditions of intensive agriculture of Ukraine there is a tendency to increasing use of mineral fertilizers in crop production. One of the negative consequences of fertilizing soils with mineral fertilizers is their contamination with various toxicants, in particular, heavy metals (Hazrat et al., 2019). It is known that with each kg of ammonium nitrate 0.5 mg of lead and 0.05 mg of cadmium enters the soil, with double superphosphate 4.4 mg of lead and 0.05 mg of cadmium and with potassium chloride 3.0 mg of lead and 3.0 mg of cadmium, with organic fertilizers (manure) up to 25 mg zinc, 4.5 mg of copper, 4.4 mg of lead and 0.25 mg of cadmium. Only in the cultivation of winter rape with ammonium nitrate, double superphosphate and potassium chloride in the soil per 1 hectare gets from 495 mg to 2199 mg of lead, from 412 mg to 701 mg of cadmium, and in the cultivation of sunflower – up to 1881 mg of lead and 411 mg of cadmium.

From the soil heavy metals along the trophic chain migrate into the vegetation, adversely affecting its quality and safety. It has been established that plants are able to accumulate large amounts of heavy metals through the root system, and the concentration of heavy metals in plants can exceed their amount in the soil several times. Contamination of soils with a toxicant such as cadmium is one of the main problems today due to the high level of its transition to vegetation, even in cases of minimal concentration in the soil (Lambert et al., 2007; Chorna et al., 2018; Makarenko et al., 2020). Intensive accumulation of zinc by plants is also known, comparatively less – of copper and lead.

It was found that the intensity of heavy metals migration into plants depends on their botanical origin, mechanical composition of the soil, the amount of organic matter, acidity, phosphorus content, etc., as well as climatic and soil conditions, soil properties, varietal and biological characteristics of plants, the level of soil contamination by toxicants (Bondar et al., 2019; AL-Robai et al., 2020; Dursun et al., 2020).

The danger of soil contamination with heavy metals is the entry of these toxicants into plant material and food produced from them. Analyzing food safety in recent years in Ukraine revealed that they exceeded the hygienic standards for the content of heavy metals. It has been found that about 10% of food samples may contain heavy metal salts, half of which exceed the MPC. The use of foods that contain heavy metals leads to various disorders at all levels of the human body, accompanied by a number of diseases of the population. It is proved that 80% of cadmium enters the human body with food and 20% – with air through the lungs. The intensity of cadmium accumulation in food is different and can range from 9 μg kg^{-1} to 500 μg kg^{-1} in crop products and from 6 μg kg^{-1} to 250 μg kg^{-1} in livestock products. Cadmium has teratogenic, mutagenic and carcinogenic effects, blocks the work of some enzymes. Cadmium compounds are known to damage internal organs, in particular the lungs, kidneys, liver, pancreas, and cardiovascular system. This element damages and destroys red blood cells and can cause anemia, hereditary disorders (Rafati Rahimzadeh et al., 2017).

At present, it is found that almost all foods contain lead, which annually with atmospheric air is deposited on the earth's surface about 400 thousand tons. It is known that foods, in particular fruits, contain (mg kg^{-1}) from 0.01 to 0.6; vegetables – from 0.02 to 1.6; cereals – from 0.03 to 3.0; bakery products – from 0.03 to 0.82; meat and fish – from 0.02 to 0.78; milk – from 0.01 to 0.1. Lead adversely affects metabolism and damages the hematopoietic, nervous, urinary, cardiovascular and endocrine systems (Brown et al., 2016). Therefore, one of the priority areas to reduce the load on these aspects is to prevent the migration of heavy metals in the soil-plant system.

An alternative to increasing soil fertility, reducing their degradation and improving the quality and safety of crop production is organic farming, which has recently been introduced in Ukraine (Vdovenko et al., 2018; Yezerkovskyi et al., 2018). Its essence is to unite agro-industrial producers who support the organic production of high quality agricultural products by replacing synthesized chemical fertilizers with safe environmental products (Reganold et al., 2016; Watson et al., 2017; Möller, 2018; Ostapenko et al., 2020). The introduction of sustainable crop rotations, the use of crop residues, vegetative mass, manure, compost, perennial legumes, green manure as a source of organic matter, mechanical and biological means of weed control, pests and plant diseases (Razanov et al., 2018; Röös et al., 2018; Tkachuk, 2020).

Particular attention in organic farming is paid to preserving soil fertility. One of the reserves to increase soil fertility is the use of vegetative mass of plants, which are included in the common name – green manure (Liebman et al., 2012). By general definition, green manures are plants that are grown before sowing the main crop in order to increase the fertility of the topsoil and improve its structure. The most common greens used for green manure are: white mustard, rye, barley, buckwheat, oats, lupine, phacelia, vetch, canola, radish and others (Madsen et al., 2016; Terzić et al., 2019).

It is known that phacelia is undemanding to the type of soil, it can grow even on stony and sandy soils, is undemanding to moisture, tolerates prolonged drought and shading, as well as frost to minus 9^0 C. White mustard refers to cold-resistant greens, characteristic of this culture is a rapid period of formation of vegetative mass. The minimum period from sowing of this culture to mowing under green manures lasts 5 weeks. Vetch belongs to precocious crops, has a relatively short growing season. Sowing for growing under green manure is carried out throughout the growing season, most often used for melons. Oats as a green manure is cold-resistant. It is a good precursor to crops that are picky about potassium, particularly for tomatoes and peppers (Jabbar et al., 2021; Al-dulaimi et al., 2021). Barley as a green manure is characterized by drought resistance (Danici´c et al., 2019), so it is used in areas with insufficient moisture, it also has high frost resistance.

MATERIALS AND METHODS

The research was carried out in the conditions of FE "Zorya Vasylivka" of Tyvriv district, Vinnytsia region on light gray forest soils. The soils of the studied territory of Tivriv district of Vinnytsia region belong to the Central agro-soil district, which occupies a significant area within the region. This is the highest area of the right-bank Forest-Steppe and the most ruined. The peculiarity of this area is gray podzolic and typical light gray soils (76%). The approximate area of dark gray soils is 18%, podzolic chernozems – 3%. The soils of the district are less fertile in comparison with the soils of other districts of the region, humus reserves are quite low – from 1.4% to 2.7%. Relatively mild winters, moderately humid and warm summers, fertile soils create the most favorable conditions for high and stable yields of various crops, including winter and spring wheat, rye, oats, barley, potatoes, sugar beets, vegetables and fodder crops, fruit trees.

The material of the study was the vegetative mass of winter wheat, winter barley, winter rape and winter peas, obtained as a result of germination of seeds lost during threshing. To form organic fertilizer, the vegetative mass of winter wheat, winter barley, winter rape and winter peas was mowed no later than two weeks before sowing the main spring crops. Selection of vegetative mass was performed by the method of spot tests.

The content of total nitrogen in plants was determined by the Kjeldahl method, crude ash by the dry ashing method, and the concentration of heavy metals by the atomic absorption method. Accum (accumulation factor) was determined by the formula:

$$\text{Kaccum.} = \frac{\text{Metal content in the vegetative mass}}{\text{Metal content in the soil}}$$

RESULTS AND DISCUSSION

In the vegetative mass of plants, the maximum permissible concentrations of metals (MPC) are: lead – 5.0 mg kg^{-1}, cadmium – 1.0 mg kg^{-1}, zinc – 10 mg kg^{-1}, copper – 5.0 mg kg^{-1}. Analysis of the results of the study shown in table. 1 showed that the cultivation of green manure for spring crops from grain lost as a result of threshing yields from 3700 kg ha^{-1} to 11,500 kg ha^{-1} of green manure, in particular, from winter wheat – 4500 kg ha^{-1}, winter barley – 3700 kg ha^{-1} , winter rape – 11500 kg ha^{-1} and winter peas – 6200 kg ha^{-1}.

The highest amount of vegetative mass from 1 ha of area was obtained when growing it from grain lost during the harvest of winter rape. Thus, the vegetative mass of winter rape was 2.5 times higher compared to winter wheat, 3.1 times higher than to winter barley and 1.8 times higher than to winter peas.

Table 1. The content of macronutrients in the vegetative mass, g kg^{-1} (n = 4, M ± m)

Green manure	The content of macronutrients in the vegetative mass per 1 kg					Yield of vegetative mass kg ha^{-1}
	Phosphorus	Potassium	Calcium	Magnesium	Sodium	
Vegetative mass of winter wheat	0.71±0.02	4.1±0.07	1.01±0.06	0.21±0.03	0.52±0.01	4500
Vegetative mass of winter barley	0.65±0.04	3.1±0.03	1.14±0.02	0.34±0.09	0.18±0.04	3700
Vegetative mass of winter rape	1.11±0.03	4.4±0.08	2.8±0.05	0.62±0.04	0.23±0.07	11500
Vegetative mass of winter peas	1.25±0.04	4.8±0.08	3.1±0.07	0.75±0.08	0.27±0.08	6200

It was found that the vegetative mass of winter wheat obtained from a hectare of area during its mowing before preparing the soil for sowing spring crops (two weeks before sowing) contained 3195 g of phosphorus, 18450 g – potassium, 1.01 g – calcium, 0.21 g of magnesium and 0.52 g – sodium. The content of phosphorus, potassium, calcium, magnesium and sodium in 1 kg of vegetative mass of winter barley was 0.65 g, 3.1 g, 1.14 g, 0.34 g and 0.18 g, winter rape – 0.11 g, 4.4 g, 2.8 g, 0.62 g and 0.23 g and winter peas – 1.25 g, 4.8 g, 3.1 g, 0.75 g and 0.27 g. The gross content of phosphorus, potassium, calcium, magnesium and sodium in the vegetative mass of green manures obtained from one hectare, in particular, winter wheat was 3195 g, 18450 g, 4545 g, 945 g and 2340 g; winter barley – 2405 g, 11470 g, 4218 g, 1258 g, 666 g; winter rape – 12765 g, 50600 g, 32200 g, 7130 g, 2645 g; winter peas – 7750 g, 29760 g, 19220 g, 4650 g, 1674 g, respectively. At the same time, it should be noted that the highest amount of phosphorus, potassium, calcium and magnesium was observed in the vegetative mass harvested from 1 ha of winter peas, and sodium – winter wheat.

Thus, in the vegetative mass of winter peas grown from grain lost during harvesting there was a higher concentration of phosphorus, potassium, calcium and magnesium compared to the vegetative mass of winter rape, respectively 1.12 times, 1.09 times, 1.1 times and 1.2 times, winter barley – 1.92 times. times, 1.54 times, 2.7 times and 2.2 times, winter wheat – 1.76 times, 3.06 times and 3.06 times and 3.5 times. The concentration of sodium in the vegetative mass of green manure grown from winter wheat was higher compared to the vegetative mass grown from grain lost during harvesting winter barley 2.3 times, winter rape – 2.2 times and winter peas – 1.9 times.

Table 2. The content of trace elements in the vegetative mass, mg kg^{-1} (n = 4, M ± m)

Green manure	The content of macronutrients in the vegetative mass per 1 kg					
	Iron	Copper	Zinc	Manganese	Cobalt	Yield of vegetative mass kg ha^{-1}
Vegetative mass of winter wheat	46±0.43	0.8±0.031	7.8±0.14	7.2±0.12	0.22±0.01	4500
Vegetative mass of winter barley	48±0.11	0.45±0.041	3.2±0.17	4.3±0.27	0.06±0.007	3700
Vegetative mass of winter rape	45±0.17	0.68±0.021	4.4±0.51	5.1±0.31	0.017±0.002	11500
Vegetative mass of winter peas	44±0.33	0.7±0.034	4.3±0.43	5.5±0.28	0.018±0.004	6200

Analysis of trace elements in the vegetative mass grown from grain lost during harvest showed that the iron content ranged from 44 mg kg^{-1} to 48 mg kg^{-1}, copper – from 0.45 mg kg^{-1} to 0.8 mg kg^{-1}, zinc – from 3.2 mg kg^{-1} up to 7.8 mg kg^{-1}, manganese – from 4.3 mg kg^{-1} to 7.2 mg kg^{-1}, cobalt – from 0.017 mg kg^{-1} to 0.22 mg kg^{-1}. In the vegetative mass of winter wheat obtained from one hectare, the gross content of iron, copper, zinc, manganese and cobalt was 207000 mg, 3600 mg, 35100 mg, 32400 mg, 990 mg, respectively; winter barley – 177600 mg, 1665 mg, 11840 mg, 15910 mg and 222 mg, winter rape – 517500 mg, 7820 mg, 50600 mg, 58650 mg, 195 mg; winter peas – 272800 mg, 4340 mg, 26660 mg, 34100 mg, 111 mg.

In addition, it should be noted that the highest amount of iron in the vegetative mass of greens per 1 kg was found in winter barley, copper, zinc, manganese and cobalt – in winter wheat. In particular, the concentration of iron in the vegetative mass of winter barley grown from grain lost during harvesting was 1.04 times, 1.06 times and 1.09 times higher compared to the vegetative mass of winter wheat, winter rape and winter peas.

Table 3. The content in the vegetative mass of nitrogen, g kg^{-1} (n = 4, M ± m)

Green manure	Nitrogen content g kg^{-1}	Yield of vegetative mass kg ha^{-1}	Gross nitrogen content in grams (g) in vegetative mass obtained from one ha
Vegetative mass of winter wheat	4.8±0.12	4500	21600±43.7
Vegetative mass of winter barley	4.5±0.41	3700	16650±21.5
Vegetative mass of winter rape	5.4±0.33	11500	62100±17.6
Vegetative mass of winter peas	6.1±0.31	6200	37820±22.7

The obtained research results showed that the vegetative mass grown from winter peas, grown from grain lost during threshing, had the highest amount of nitrogen, which was 6.1 g kg^{-1}. Compared with the vegetative mass of winter wheat, winter barley and winter rape, the nitrogen content in the vegetative mass grown from winter peas was 1.27 times, 1.35 times and 1.13 times higher, respectively. The gross nitrogen content in the vegetative mass of green wheat green manure, winter barley, winter rape and winter peas grown from lost grain during the harvest per 1 ha was 21600 g, 16650 g, 62100 g and 37820 g, respectively.
The highest nitrogen content obtained from one hectare of area was in the vegetative mass grown from grain of winter rape lost during harvesting. Thus, the nitrogen content in the vegetative mass of winter rape harvested from one hectare was 2.8 times higher than the vegetative mass of winter wheat, 3.7 times higher than winter barley and 1.6 times higher than winter peas.

Table 4. The coefficient of of heavy metals accumulation in the vegetative mass of different greens

Green manure	Lead			Cadmium			Zinc			Copper		
	Concentration in soil, mg kg^{-1}	Concentration in veg. mass, mg kg^{-1}	K/N	Concentration in soil, mg kg^{-1}	Concentration in veg.mass, mg kg^{-1}	K/N	Concentration in soil, mg kg^{-1}	Concentration in veg.mass, mg kg^{-1}	K/H	Concentration in soil, mg kg^{-1}	Concentration in veg.mass, mg kg^{-1}	K/N
Vegetative mass of winter wheat	1.25	0.021	0.017	0.28	0.0015	0.0053	9.0	2.1	0.23	0.52	0.31	0.59
Vegetative mass of winter barley	1.25	0.02	0.016	0.28	0.0017	0.006	9.0	1.8	0.20	0.52	0.37	0.71
Vegetative mass of winter rape	1.25	0.024	0.019	0.28	0.0021	0.0075	9.0	2.3	0.25	0.52	0.41	0.78
Vegetative mass of winter peas	1.25	0.024	0.019	0.28	0.0024	0.0085	9.0	2.5	0.27	0.52	0.40	0.76

The coefficient of accumulation of heavy metals in the vegetative mass of green manures (Table 4) ranged from 0.016 to 0.019 for lead, from 0.0053 to 0.0085 for cadmium, from 0.20 to 0.27 for zinc and from 0.59 to 0.76 for copper. The lowest coefficient of accumulation of lead and zinc was observed in the vegetative mass of green manure from winter barley, cadmium and copper – from winter wheat. Thus, the coefficient of accumulation of lead in the vegetative mass of green barley green manure was 1.06 times, 1.18 times and 1.18 times lower compared to the vegetative mass of winter wheat, rapeseed and peas, respectively. The coefficient of cadmium accumulation in the vegetative mass of winter wheat green manure was 1.13 times, 1.4 times and 1.6 times lower compared to the vegetative mass of barley, rape and winter peas, respectively. The zinc accumulation coefficient in the vegetative mass of winter barley was 1.15 times, 1.25 times and 1.35 times lower in comparison with the vegetative mass of winter wheat, winter rape and winter peas. In the vegetative mass of winter wheat, the coefficient of copper accumulation was 1.2 times and 1.28 times lower than the vegetative mass of barley, rape and winter peas, respectively.

Table 5. Comparative assessment of the content of heavy metals in the vegetative mass of green manures and mineral fertilizers, mg kg^{-1}

Green manure	**Heavy metals**			
	Lead	Cadmium	Zinc	Copper
Vegetative mass of winter wheat	0.021±0.007	0.0015±0.0004	2.1±0.1	0.31±0.04
Vegetative mass of winter barley	0.02±0.004	0.0017±0.002	1.8±0.14	0.37±0.032
Vegetative mass of winter rape	0.024±0.002	0.0021±0.002	2.3±0.12	0.41±0.041
Vegetative mass of winter peas	0.024±0.0025	0.0024±0.003	2.5±0.12	0.40±0.022
Mineral fertilizer mixture (NPK)	3.1±0.16	1.3±0.12	15.3±0.7	6.8±0.21

N - ammonium nitrate
P - double superphosphate
K - potassium chloride

The results of the research shown (Table 5) that green manures grown from winter grain lost during harvesting contain lower concentrations of lead, cadmium, zinc and copper compared to mineral fertilizers, which indicates its higher environmental safety compared to mineral fertilizers. In particular, the vegetative mass grown from the grain of winter wheat, winter barley, winter rape and winter peas lost during harvesting contains a lower concentration of lead 147.6 times, 155, 129, and 129 times; cadmium – 866 times, 764, 619 and 541 times; zinc – 7.2 times, 8.5, 6.6 and 6.1 times; copper – 2.2 times, 18.3, 16.5 and 17 times, respectively, compared with mineral fertilizers (NPK).

CONCLUSION

- ✓ Growing in the Forest-Steppe of the right-bank Ukraine of green manure from grain lost during harvesting makes it possible to obtain green fertilizer from winter wheat 4500 kg ha^{-1}, winter barley 3700 kg ha^{-1}, winter rape 1100 kg ha^{-1} and winter peas 6200 kg ha^{-1}, in which the nitrogen content is 21,600 kg ha^{-1}, 16,650 kg ha^{-1}, 62,100 kg ha^{-1} and 37,820 kg ha^{-1}.
- ✓ The concentration of phosphorus, potassium, calcium, magnesium and sodium in the vegetative mass of green manures was, respectively, winter wheat – 0.71 g kg^{-1}, 4.1 g kg^{-1}, 1.01 g kg^{-1}, 0.21 g kg^{-1} and 0.52 g kg^{-1}; winter barley – 0.65 g kg^{-1}, 1.14 g kg^{-1}, 0.34 g kg^{-1} and 0.18 g kg^{-1}; winter rape – 1.11 g kg^{-1}, 4.4 g kg^{-1}, 2.8 g kg^{-1}, 0.62 g kg^{-1} and 0.23 g kg^{-1}; winter peas – 1.25 g kg^{-1}, 4.8 g kg^{-1}, 3.1 g kg^{-1}, 0.75 g kg^{-1} and 0.27 g kg^{-1}, respectively.
- ✓ The concentration of iron, copper, zinc, manganese, cobalt, lead and cadmium in the vegetative mass of green manure was, respectively, winter wheat – 46 mg kg^{-1}, 0.8 mg kg^{-1}, 7.8 mg kg^{-1}, 7.2 mg kg^{-1}, 0.22 mg kg^{-1}, 0.021 mg kg^{-1} and 0.0015 mg kg^{-1}; winter barley – 48 mg kg^{-1}, 0.45 mg kg^{-1}, 3.2 mg kg^{-1}, 4.3 mg kg^{-1}, 0.06 mg kg^{-1}, 0.02 mg kg^{-1} and 0.0017 mg kg^{-1}; winter rape – 1.5 mg kg^{-1}, 0.68 mg kg^{-1}, 4.4 mg kg^{-1}, 5.1 mg kg^{-1}, 0.017 mg kg^{-1}, 0.024 mg kg^{-1} and 0.021 mg kg^{-1} and winter peas – 4.4 mg kg^{-1}, 0.7 mg kg^{-1}, 4.3 mg kg^{-1}, 5.5 mg kg^{-1}, 0.018 mg kg^{-1} and 0.024 mg kg^{-1}, respectively.

- ✓ In the vegetative mass of green manures grown from grain lost during the harvest of winter wheat, winter barley, winter rape and winter peas per 1 kg, the concentration of lead was lower from 129 to 147.6 times, cadmium – from 541 to 866 times, zinc from 6.1 to 7.2 times and copper from 2.2 to 18.3 times compared to the same mass of a mixture of mineral fertilizers (ammonium nitrate, simple superphosphate, potassium chloride).
- ✓ The coefficient of accumulation in the vegetative mass of greens from winter wheat, barley, rape and peas was in the range from 0.016 to 0.019 for lead; from 0.0053 to 0.0015 – for cadmium; from 0.20 to 0.27 – for zinc and from 0.59 to 0.76 – for copper. The lowest coefficient of accumulation of lead and zinc was observed in the vegetative mass of green manures grown from winter barley, and cadmium and copper – from winter wheat.

REFERENCES

1. Al-dulaimi, Zaman, S.A., Al-Asady, Maher, H.S., Ali, Husham, S. 2021. Effect of sowing date and planting distance on growth and yield of Oat. *Eco. Env. & Cons.* 27 (1): 410-415;
2. AL-Robai, Hazim, Aziz, Al-Jbouri, Russel, Jabbar. 2020. Single modified fractionation technique of lead in sediments of Shatt Al-Hilla-Iraq. *Eco. Env. & Cons.* 26 (3): 995-999;
3. Bagheri, F., Kazemeini, S.A., Bahrani, M.J., Heidari, B. 2018. Effect of nitrogen, wheat residues, and compost rates on the growth and yield of sunflower. *Ukrainian Journal of Ecology*. 8 (1): 736-744;
4. Bondar V., Makarenko N., Symochko L. Lead mobility in the soil of different agroecosystems. International Journal of Ecosystems and Ecology Sciences. 2019. 9(4). P. 709–716. https://doi.org./10.31407/ijees9416;
5. Brown, S.L., Chaney, R.L., Hettiarachchi, G.M. 2016. Lead in Urban Soils: A Real or Perceived Concern for Urban Agriculture? *Journal of Environmental Quality*. 45 (1): 26-36;
6. Chorna, V.I., Voroshylova, N.V., Syrovatko, V.A. 2018. Cadmium distribution in soils of Dnipropetrovsk oblast and its accumulation in crop production. *Ukrainian Journal of Ecology*. 8 (1): 910-917;
7. Danici´c, M., Zeki´c, V., Mirosavljevi´c, M., Lali´c, B. 2019. The Response of Spring Barley (Hordeum vulgare L.) to Climate Change in Northern Serbia. *Atmosphere.* 10 (14): 1-15;
8. Dursun S., Symochko L., Mankolli H. Bioremediation of heavy metals from soil: an overview of principles and criteria of using. Агроекологічний журнал. 2020. № 3. С. 6–12. https://doi.org/10.33730/2077-4893.3.2020.211521;
9. El-Sadek, A.N., Abd EL-Ghany, F.I., Shaalan, A.M. 2020. Simulating the effect of tillage practices on the yield production of wheat and barley under dryland condition. *Agronomy Research.* 4: 2374-2390;
10. Falcone, G., Stillitano, T., Montemurro, F., De Luca, A.I., Gulisano, G., Strano, A. 2019. Environmental and economic assessment of sustainability in Mediterranean wheat production. *Agronomy Research.* 17(1): 60-76.
11. Hazrat, Ali, Ezzat, Khan, Ikram, Ilahi. 2019. Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation. *Journal of Chemistry*. Volume: 1-14;
12. Honcharuk, I. 2021. Energy needs of the agricultural sector and the potential for addressing them. Humanities and Social Sciences: Latvia. Vol. 29 (1): 95-113;
13. Jabbar, Mundher, Kh., Hasan, Hayder, A. 2021. Response of Avena sativa L. intercropping with Egyptian clover to different planting density and distances in green fodder yield. *Eco. Env. & Cons.* 27 (1): 365-368;
14. Lambert, R, Grant, C, Sauvé, S. 2007. Cadmium and zinc in soil solution extracts following the application of phosphate fertilizers. *Sci Total Environ.* Jun 1. 378 (3): 293-305;
15. Liebman, M., Graef, R.L., Nettleton, D., Cambardella, C.A. 2012. Use of legume green manures as nitrogen sources for corn production. *Renewable Agriculture and Food Systems*. 27(3): 180-191;
16. Sorensen, J.N., Thorup-Kristensen, K. 2011. Plant-based fertilizers for organic vegetable production. *Journal of Plant Nutrition and Soil Science*. 174 (2): 321- 332;
17. Madsen, H., Talgre, L., Eremeev, V., Alaru, M., Kauer, K., & Luik, A. 2016. Do green manures as winter cover crops impact the weediness and crop yield in an organic crop rotation? *Biological agriculture & horticulture* 32(3): 182-191;

18. Makarenko, N., Bondar, V., Makarenko, V., Symochko, L. (2020). Factors affecting mobility of zinc in soils of Ukraine. International Journal of Ecosystems and Ecology Science (IJEES), Volume 10 (4), 2020:587-594. https://doi.org/10.31407/ijees10.402;
19. Mazur, V.A., Branitskyi, Y.Y., Pantsyreva, H.V. 2020. Bioenergy and economic efficiency technological methods growing of switchgrass. *Ukrainian Journal of Ecology*. 10 (2): 8-15;
20. Mazur, V., Didur, I., Pantsyreva, G., Telekalo, N. 2018. Energy-economic efficiency of growth of grain-crop cultures in conditions of rightbank forest-steppe zone of Ukraine. *Ukrainian Journal of Ecology*. 8(4): 26-33;
21. Möller, K. 2018. Soil fertility status and nutrient input–output flows of specialised organic cropping systems: a review. *Nutrient Cycling of Agroecosystems*.112: 147-164;
22. Ostapenko, R., Herasymenko, Y., Nitsenko, V., Koliadenko, S., Balezentis, T., Streimikiene, D. 2020. Analysis of Production and Sales of Organic Products in Ukrainian Agricultural Enterprises. *Sustainability*. 12 (8): 3416;
23. Rafati, Rahimzadeh, M., Kazemi, S., Moghadamnia, A.A. 2017. Cadmium toxicity and treatment: An update. *Caspian Journal of Internal Medicine*. 8 (3): 135-145;
24. Razanov, S.F., Tkachuk, O.P., Bakhmat, O.M., Razanova, A.M. Reducing danger of heavy metals accumulation in winter wheat grain which is grown after leguminous perennial precursor. *Ukrainian Journal of Ecology*. 2020. 10 (1): 254-260;
25. Razanov, S.F., Tkachuk, O.P., Mazur, V.A., Didur, I.M. 2018. Effect of bean perennial plants growing on soil heavy metal concentrations. *Ukrainian Journal of Ecology*. 8 (2): 294-300;
26. Reganold, J.P, Wachter, J.M. 2016. Organic agriculture in the twenty-first century. *Nature Plants*. 2: 1-8;
27. Röös, E., Mie, A., Wivstad, M., Salomon, E., Johansson, B., Gunnarsson, S., Wallenbeck, A., Hoffmann, R., Nilsson, U., Sundberg, C., Watson, C. 2018. Risks and opportunities of increasing yields in organic farming. *Agronomy for Sustainable Development*. 38: 1-21;
28. Skudra, I., Ruza, A. 2019. Effect of nitrogen fertilization management on mineral nitrogen content in soil and winter wheat productivity. *Agronomy Research*. 17(3): 822-832;
29. Terzić, D., Popović, V.M., Malić, N., Ikanović, J., Rajičić, V., Popović, S., Lončar, M. and Lončarević, V. 2019. Effects of long-term fertilization on yield of siderates and organic matter content of soil in the process of recultivation. *The J. Anim. Plant Sci.* 29(3): 790-795;
30. Tkachuk, O., Telekalo, N. 2020. Agroecological potential of legumes in conditions of intensive agriculture of Ukraine. Integration of traditional and innovation processes of development of modern science: collective monograph. Latvia: Riga: 91-108;
31. Tkachuk, O. 2020. Height dynamics of perennial leguminous herbs in the context of soil contamination with heavy metals. *Sciences of Europe*. 49: 7-12;
32. Vdovenko, S.A., Polutin, O.O., Kostiuk, O.O., Kutovenko, V.B., Vdovychenko, I.P. 2018. Productivity of organic tomatillo grown in the open ground under conditions of the right-bank forest-steppe of Ukraine. *Ukrainian Journal of Ecology*. 8 (3): 254-258;
33. Watson, C.A., Reckling, M., Preissel, S., Bachinger, J., Bergkvist, G., Kuhlman, T., Lindström, K., Nemecek, T., Topp, C.F., Vanhatalo, A., Zander, P., Murphy-Bokern, D., Stoddard, F.L. 2017. Grain legume production and use in European agricultural systems. *Advances in Agronomy*. 144: 236-303;
34. Yezerkovskyi, A.V., Bogatyr, L.V., Karaulna, V.M., Kozak, L.A., Grabovskyi, M.B., Grabovskaya, T.O. 2018. Efficiency of basic cultivation and fertilization for winter rye organic growing on peat-gley soils in the Left bank of Forest Steppe. *Ukrainian Journal of Ecology*. 8(2): 128-133;