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PHYTOSANITARY STATE OF THE AGROECOSYSTEM OF WINTER WHEAT DEPENDING ON THE PREDECESSORS OF PERENNIAL LEGUMINOUS GRASSES

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The article deals with the issues of increasing the resistance of winter wheat crops to the effects of the most common diseases, weeds and pests for growing after the predecessors of six types of perennial leguminous grasses without using pesticides. The damage caused to the leaf surface of winter wheat by septoria and powdery mildew diseases has been shown. The number of cockchafer larvae has been analysed. Determining the predominant types of weeds in the context of predecessors the level of weed infestation of winter wheat crops has been researched. The level of winter wheat yield depending on its predecessors has been assessed and correlation-regression dependences between it and the spread of pests, diseases and weeds in their crops have been identified. A close correlation between winter wheat yield and the damage caused to the leaf surface by powdery mildew has been proved. It has been shown that the highest level of winter wheat yield is observed after meadow clover. The slightest damage to the leaf surface of winter wheat caused by powdery mildew has been found after the predecessor of meadow clover. After the predecessor of white sweet clover the damage caused to the winter wheat's leaf surface by the septoria disease was minimal. During the sowing season of winter wheat, no cockchafer larvae were found in the arable layer of soil after the predecessors of alfalfa, white sweet clover and fodder galega. The smallest number of weeds during the spring growth of winter wheat was found after the predecessor of white sweet clover.

Meadow clover provides the highest productivity level of the winter wheat yield in case of cultivation after six types of perennial leguminous grasses without additional use of mineral fertilisers – 5,8 t/ha. The minimal damage to the leaf surface of winter wheat plants caused by powdery mildew Erysiphe graminis DC has been found after the meadow clover predecessor – 6%, without using fungicides. The damage to the leaf surface of winter wheat from Septoria tritici Mg disease without fungicides was the smallest after white sweet clover – 5%. During the sowing season of winter wheat no cockchafer larvae Melolontha melolontha L. has been disclosed in the arable layer of the soil after alfalfa, white sweet clover and fodder galega predecessors. The smallest number of weeds in the period of spring growth of winter wheat has been observed after white sweet clover predecessor – 12 pcs/m^2.

Key words: *winter wheat, sowing, phytosanitary state, yield, predecessors, perennial leguminous grasses.*

Table 2. Fig. 1. Lit. 10.

Formulation of the problem. Winter wheat is the main food crop grown in all soils and climatic zones of Ukraine and occupies the largest cultivated area. However, with their subsequent growth and limited set of crops in modern crop rotations, the phytosanitary state of such crops deteriorates significantly.

It has been determined that favourable phytosanitary conditions for winter wheat crops are provided when the share of cereals in the crop rotation structure does not

exceed 15%. With such a structure of cultivated areas, the grain cultivation will not require the use of pesticides. Saturation of crop rotation with cereal crops up to 60-70% sharply worsens the phytosanitary state of winter wheat crops and causes the need for intensive use of pesticides, but this measure does not always provide sufficient protection and at the same time exacerbates the environmental problem. Therefore, an important task is to find the best predecessors for winter wheat that could stabilise the phytosanitary state of its crops with frequent returns to the same place in crop rotation [1].

Analysis of recent researches and publications. Winter wheat crops are affected by many diseases: smut, root rot, powdery mildew, septoria, fusarium, rust and viral diseases. But the most common and harmful winter wheat diseases, which lead to significant crop losses, are smut, root rot, powdery mildew, septoria. The winter wheat yield loss because of these diseases is 12–18%, and in the years of epiphytotics – 25–50% or more [2].

On average winter wheat grain losses caused by the weed infestation of its crops are 0,20–0,35 t/ha. Taking into consideration the fact that these crops are characterised by relatively high competitiveness with weeds, this is a fairly high indicator. The degree of damage caused to weeds in winter wheat crops significantly depends on their species composition, density per unit area, growth and development phases, weather conditions [3].

Winter wheat crops litter the crops close to them in bio-logical cycles of weed development. It has been defined that in case of 10–15 plants of winter weeds per 1 m², grain losses are 0,3–0,4 t/ha. In fields with winter weeds more than 50–70 pcs/m², the yield decreases by 0,5–0,7 t/ha. In winter wheat crops, contaminated with rhaponticum repens in the amount of 15–25 pcs/m², grain losses are 1,18 t/ha [2; 4].

Crop rotation is the main preventive measure that allows us to limit the harmfulness significantly or completely neutralise a large group of potential, mainly specialised pests, diseases and weeds.

To stabilise the phytosanitary state of winter wheat crops, their predecessors play a significant role. In the fight against septoria, root rot, fusarium, spotting the role of the predecessors of winter wheat is particularly increasing. Placing winter wheat after the best predecessors, the protective properties of agrophytocenoses against such weeds as sow thistle, flixweed, field pennycress, scentless chamomile rise significantly; pests – owlet moths, box tree moths, cereal ground beetles, chiggers, nematodes, Hessian flies, frit flies, thrips, sawflies [5].

In the forest-steppe zone, one of the best predecessors is perennial leguminous grasses. They can accumulate organic matter, nutrients, improve the agrophysical properties of the soil and optimise the phytosanitary state of sowing [6].

Nowadays such unconventional and low-spread varieties of perennial leguminous grasses as fodder galega, bird’s-foot trefoil, sainfoin and white sweet clover, which have certain peculiarities of the potential impact on the phytosanitary state of subsequent crops in crop rotation, compared to traditional leguminous plants – meadow clover and alfalfa.

Considering a wide variety of leguminous perennial plants, which are now broadly used and characterised by an unequal effect on the phytosanitary state of subsequent crops in crop rotation, particularly winter wheat, there is a need to research their impact on the spread of diseases, weeds and pests.

Aim of the article is to research the influence of the predecessors of six types of perennial leguminous grasses on the spread of the most common diseases, pests and weeds in winter wheat crops.

Research materials and methods. Field experiments on the research of peculiarities of the development of harmful organisms in agricultural phytocenoses of winter wheat were laid on the Research Farm "Agronomichne" of Vinnytsia National Agrarian University. Six types of winter wheat' predecessors of six types of perennial leguminous grasses: alfalfa, meadow clover, white sweet clover, sainfoin, bird's-foot trefoil and fodder galega. The experiments were conducted in the period of 2014–2017. The repetitiveness of the experiment is fourfold. The accounting area of the field experiment plot was 50 m^2, the total area of the plot was 70 m^2. Variants in the experiment were placed systematically in 6 blocks.

The soil on the research plot is grey podzolised middle-loam. Agrochemical composition of the soil: humus content – 2,0%, hydrolysed nitrogen (according to Kornfield) – 133 mg/kg of soil, movable compounds of phosphorus and potassium (according to Chirikova methods) – respectively 390 and 64 mg/kg of soil, hydrolytic acidity – 2,53 mg-eq/100 g of soil, reaction of soil solution $pH_{acid.}$ 5,0.

Perennial leguminous grasses had been grown for two years and harvested for a green mass. They were ploughed through at a depth of 20–22 cm in early August after two mowings. Winter wheat seeds were etched with the fungicide Vitavax-200 before sowing. Sowing was carried out with a sower CH-16 in the third decade of September. Wheat variety winter Bohemia was sowed. The seeding rate was 5 mln/ha. The depth of planting seeds was 5 cm.

Crop care included only the introduction of the Granstar herbicide to combat broadleaf weeds in early May. Fungicides and insecticides were not used.

The following records and observations were carried out: grain harvest was accounted using direct harvesting [7]; the weed infestation of agrophytocenoses was determined by the quantitative method [7, 8]; phytopathological records in agrophytocenoses of winter wheat were collected on plots of 50×50 cm in five repetitions on the scale of the methodology of state sorting of crops [7; 8]; entomological records were undertaken by excavating the arable soil layer in five evenly distant places [7, 8]. Correlation-regression analysis was conducted on the basis of mathematical processing of the obtained results on a computer using modern software packages Excel, Sigma, Statistika [9, 10].

In 2014 the amount of precipitation amounted to 550 mm, which was 87% of multi-year average precipitation. The average annual temperature was 8,6º C, which is 1,6º C above the multi-year average indicator. The growing season began in the second decade of March and lasted until the end of the first decade of November. During the growing season, the amount of precipitation made up 442 mm.

The hydrothermal coefficient (HTC) was 1,50.

In 2015 there was 368 mm precipitation, which amounted to only 58% of the multi-year average data. The average annual temperature was 9,3º C, which is 2,3º C above the multi-year average temperature. The growing season began in the third decade of March and lasted until the second decade of November. 235 mm of rainfall were observed during the growing season. HTC reached 0,69, which indicates very unfavourable conditions for the growing season and formation of plant yields.

In 2016 the average annual temperature was 9,0º C, which is 2º C above normal. The amount of annual precipitation amounted to 469 mm, which is 26% less than normal. The growing season began in early April and lasted until the end of September. The hydrothermal coefficient was 0,54, which corresponds to extremely arid conditions of growing season for plants.

In 2017 weather conditions were characterised by an average annual temperature of 9,1º C, which is 2,1º C above normal. The amount of annual precipitation amounted to 503 mm, which makes up 80% of the multi-year norm. HTC was 0.86, which corresponds to unfavourable growing season conditions.

Main research results. The agroecological role of the predecessors of winter wheat is explained by their impact on limiting the spread of harmful objects (pests, diseases and weeds) in its agroecosystems. In the process of ploughing perennial leguminous grasses for sowing winter wheat, soil excavations were carried out to determine the number of cockchafer larvae *(Melolontha melolontha L.)*, as a potential pest of winter wheat that could remain in the soil after growing perennial leguminous grasses. Most of pest was found after bird's-foot trefoil – 0,40 pcs/m^2, after meadow clover – 0,13, sainfoin – 0,10 pcs/m^2. After the remaining predecessors no cockchafer larvae were found (Table 1).

Table 1

Development of Pests in Agroecosystems of Winter Wheat Depending on the Predecessors, 2014–2017, M±m

Predecessor	Number of cockchafer larvae *Melolontha melolontha L.*, pcs/m^2	Damage to the leaf surface caused by powdery mildew *Erysiphe graminis DC*, %	Damage to the leaf surface caused by Septoria *Septoria tritici Mg*, %	Weed infestation in spring, pcs/m^2
Alfalfa	-	8±2,83	21±1,41	44±5,66
Meadow clover	0,13±0,04	6±1,41	25±2,83	28±2,83
Sainfoin	0,10±0,03	10±2,83	26±1,41	44±2,83
White sweet clover	-	9±1,41	5±1,41	12±2,83
Bird's-foot trefoil	0,40±0,04	11±2,83	30±2,83	52±2,83
Fodder galega	-	12±1,41	10±2,83	20±5,66

Source: generated by the authors

The damage to the leaves of winter wheat caused by powdery mildew *(Erysiphe graminis DC)* is estimated in 6–12% of the surface. It has been noticed that the leaves are the most damaged after fodder galega and bird's-foot trefoil, and the least damaged after meadow clover.

Septoria *(Septoria tritici Mg)* damaged 5–30% of winter wheat's leaves. The slightest damage was observed after white sweet clover, and most of all after bird's-foot trefoil.

The weed infestation of winter wheat agroecosystems was researched in the spring period at time of intensive spring growth. Determination of weeding at that time provides establishing the efficiency of the predecessors of perennial leguminous grasses to reduce a number of weed species.

In spring the weed infestation of the agroecosystem system of winter wheat was 12–52 pcs/m^2. The smallest number of weeds was found noticed after white sweet clover, and the largest – after bird's-foot trefoil.

The species composition of weeds mainly depended on the predecessors of winter wheat: chickweed *(Stellaria media L.)*, dandelion *(Taraxacum officinale L.)*, pale persicaria *(Polygonum lapathifolium L.)* prevailed after sainfoin; European stickseed *(Lappula squarrosa Retz. Dumort)*, chickweed *(Stellaria media L.)*, pale persicaria *(Polygonum lapathifolium L.)* – after bird's-foot trefoil; pale persicaria *(Polygonum lapathifolium L.)*, wild radish *(Raphanus raphanistrum)*, common yarrow *(Achillea millefolium L.)* and fodder galega grown from rhizomes – after fodder galega; dandelion *(Taraxacum officinale L.)* and pale persicaria *(Polygonum lapathifolium L.)* – after white sweet clover; pale persicaria *(Polygonum lapathifolium L.)*, yellow rocketcress *(Barbaréa vulgáris R. Br.)*, chickweed *(Stellaria media L.)* – after meadow clover; shepherd's purse *(Capsella bursa-pastoris L.)*, dandelion *(Taraxacum officinale L.)*, pale persicaria *(Polygonum lapathifolium L.)* – after alfalfa.

Summarising the research results on the spread of pests in the winter wheat agroecosystems after various types of predecessors, it is necessary to mention:

- meadow clover as a predecessor contributes to the slightest damage caused by powdery mildew *Erysiphe graminis DC*;
- the use of fodder galega as a predecessor causes the greatest damage to plants with powdery mildew *Erysiphe graminis DC*;
- bird's-foot trefoil leads to the greatest number of cockchafer larvae *Melolontha melolontha L.* in the soil, damage to plants caused by powdery mildew *Erysiphe graminis DC* and maximal weed infestation;
- the use of white sweet clover as a predecessor contributes to the damage to plants caused by *Septoria tritici Mg* and minimal weed infestation.

The winter wheat yield after the predecessors of perennial leguminous grasses made up 4,03–5,80 t/ha. Cultivation of winter wheat after meadow clover provides the highest yield. Cultivation of winter wheat ensures10% lower grain yield after white sweet clover and 14% – after sainfoin. After bird's-foot trefoil the winter wheat yield was the lowest – 31% less than after meadow clover (Table 2).

Table 2

Grain Yield of Winter Wheat Depending on Predecessors, 2014–2017, M ± m

Predecessor	Grain yield, t/ha	Deviation before control, ± t/ha
Alfalfa	4,38±0,01	-
Meadow clover	5,80±0,01	+1,42
Sainfoin	4,99±0,03	+0,61
White sweet clover	5,21±0,03	+0,83
Bird's-foot trefoil	4,03±0,04	–0,35
Fodder galega	4,55±0,03	+0,17

Source: generated by the authors

The highest grain productivity of winter wheat agrocenoses after the predecessor of meadow clover, compared to other predecessors – perennial leguminous grasses, results from the minimal damage to the leaf surface by powdery mildew after this predecessor. After the bird's-foot trefoil predecessor the lowest grain yield of winter wheat results from the largest number of cockchafer larvae *Melolontha melolontha L.* found in the soil, the greatest damage to winter wheat plants caused by powdery mildew *Erysiphe graminis DC* and the maximal weed infestation.

There is a strong feedback (r = –0,687) between the grain yield of winter wheat and the damage to its leaf surface caused by powdery mildew *Erysiphe graminis DC*. The dependence of the winter wheat yield (y) on the share of the surface damaged by powdery mildew on the leaf surface of winter wheat plants (x), as well as the regression equation between the factors studied is shown in Fig. 1.

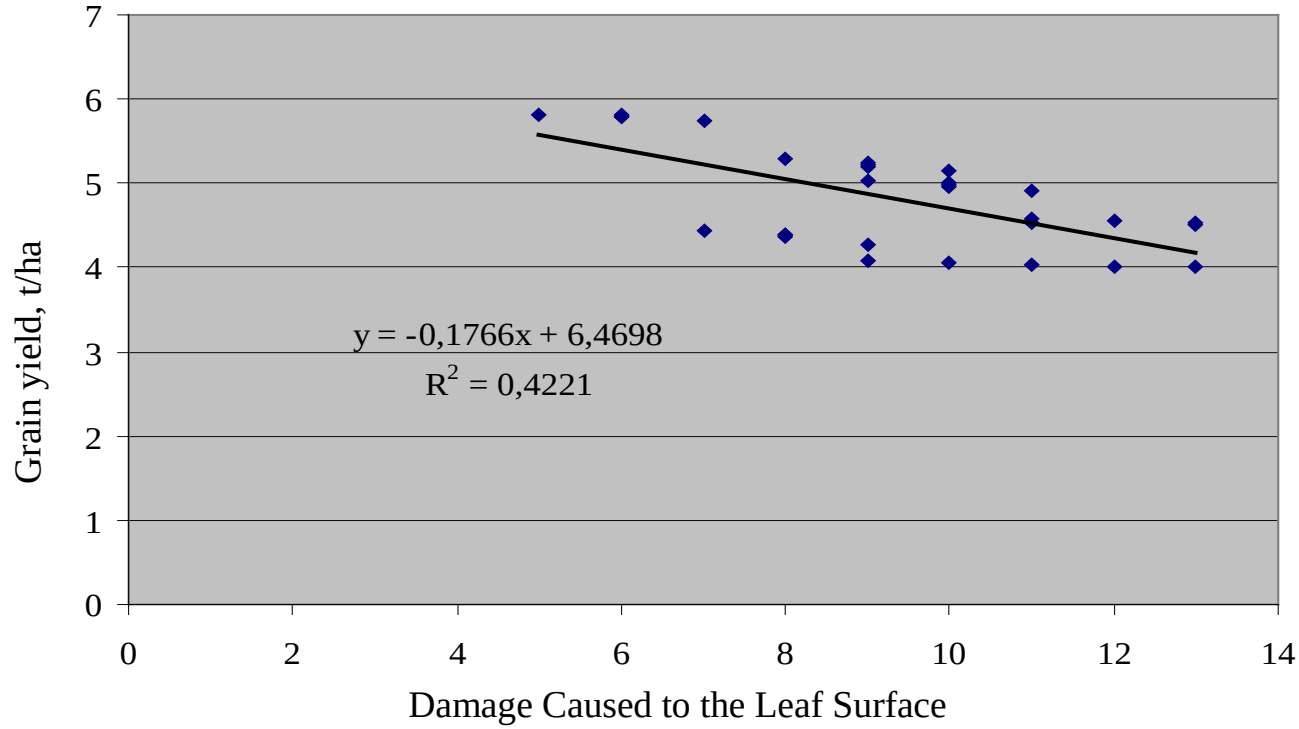

Fig. 1 **Correlation-regression dependence on the damage to the leaf surface caused by powdery mildew (x) and grain yield of winter wheat (y)**

Source: own development

There is a weak feedback (r = –0,177) between the grain yield of winter wheat and the damage to its leaf surface caused by *Septoria tritici Mg*, a sufficient feedback (r = –0.355) between the grain yield and the number of cockchafer larvae *Melolontha melolontha L.* while ploughing thick-growing grass of perennial legumes, a sufficient feedback (r = –0,550) between the grain yield and the weed infestation of its agrophytocenosis.

Conclusions. Meadow clover provides the highest productivity level of the winter wheat yield in case of cultivation after six types of perennial leguminous grasses without additional use of mineral fertilisers – 5,8 t/ha. The minimal damage to the leaf surface of winter wheat plants caused by powdery mildew *Erysiphe graminis DC* has been found after the meadow clover predecessor – 6%, without using fungicides. The damage to the leaf surface of winter wheat from *Septoria tritici Mg* disease without fungicides was the smallest after white sweet clover – 5%. During the sowing season of winter wheat no cockchafer larvae *Melolontha melolontha L.* has been disclosed in the arable layer of the soil after alfalfa, white sweet clover and fodder galega predecessors. The smallest number of weeds in the period of spring growth of winter wheat has been observed after white sweet clover predecessor – 12 pcs/m^2.

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АНОТАЦІЯ
ФІТОСАНІТАРНИЙ СТАН АГРОЕКОСИСТЕМИ ПШЕНИЦІ ОЗИМОЇ ЗАЛЕЖНО ВІД ПОПЕРЕДНИКІВ БОБОВИХ БАГАТОРІЧНИХ ТРАВ

Стаття присвячена вирішенню проблеми підвищення стійкості посівів пшениці озимої до впливу найпоширеніших хвороб, бур'янів і шкідників за вирощування після попередників шести видів бобових багаторічних трав без використання пестицидів. Показано частку ураження листкової поверхні пшениці озимої хворобами септоріоз і борошниста роса. Проаналізовано чисельність личинок травневого хруща. Досліджено рівень забур'яненості посівів пшениці озимої у розрізі попередників із визначенням переважаючих видів бур'янів після кожного з них. Досліджено рівень урожайності пшениці озимої залежно від попередників та виявлено кореляційно-регресійні залежності між нею та поширенням шкідників, хвороб і бур'янів у їх посівах. Доведено тісний кореляційний зв'язок між урожайністю пшениці озимої та часткою пошкодження листової поверхні борошнистою росою. Показано, що найвищий рівень урожайності пшениці озимої спостерігається після конюшини лучної. Найменше ураження листової поверхні рослин пшениці озимої борошнистою росою було виявлено після попередника конюшини лучної. Ураження листової поверхні пшениці озимої хворобою септоріоз було найменшим після попередника буркуну білого. На період сівби пшениці озимої не було виявлено личинок хруща травневого в орному шарі ґрунту після попередників люцерни посівної, буркуну білого і козлятнику східного. Найменшу кількість бур'янів на час весняного росту пшениці озимої було виявлено після попередника буркуну білого.

Конюшина лучна забезпечує найвищий рівень продуктивності врожаю озимої пшениці при вирощуванні після шести видів багаторічних бобових трав без додаткового застосування мінеральних добрив – 5,8 т/га. Мінімальне пошкодження листкової поверхні рослин озимої пшениці, спричинене борошнистою росою Erysiphe graminis DC, виявлено після попередника конюшини лучної – 6 % без використання фунгіцидів. Пошкодження листкової поверхні озимої пшениці від хвороби Septoria tritici Mg без фунгіцидів було найменшим після конюшини лучної – 5%. Під час сівби озимої пшениці в орному шарі ґрунту після попередників люцерни посівної, конюшини лучної та галеги східної не виявлено личинок дротяника Melolontha melolontha L.. Найменша кількість бур'янів у період весняного росту озимої пшениці спостерігається після попередника конюшини лучної – 12 шт./м^2.

Ключові слова: *пшениця озима, посів, фітосанітарний стан, урожайність, попередники, бобові багаторічні трави.*

Табл. 2. Рис. 1. Літ. 10.

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