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AGROPHYTOCENOTIC RELATIONSHIPS OF CULTIVATED AND WEED PLANTS AT THE LEVEL OF COMPETITION AND ALLELOPATHY

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Abstract

The purpose of the research is to study the relationship between cultivated and weed plants at the level of competition and allelopathy, which will allow us to substantiate a systematic approach to regulating the number of weeds. Species composition of weed vegetation was determined by an instrumental method. The number and biomass of weed plants were counted by the quantitative weight method of Vasilyev et al.(2005). Allelopathic properties of the most common weeds in crops were determined by the method of Grodzinsky (1965). As a result of this research it was found that on average rotational crops remove 103.6 kg/ha of nitrogen, 51.5 kg/ha of phosphorus, and 96.9 kg/ha of potassium. The main species of weeds of field crops remove 124.1, 12.9 and 18.9 kg/ha of nitrogen, phosphorus and potassium, respectively, mainly due to such species as Loliumtemulentum L., Galiumaparine L., Cirsiumarvense L., Ambrosia artemisifolia L. and Chorisporatenella (Pall.) DC. At the same time most of the studied species of weeds have high allelopathic activity. Particular attention should be paid to Loliumtemulentum L., since its grains have the fungus Stromatiniatemulenta, which produces the alkaloid temulin. In high concentrations it has an inhibitory effect on the germination of test-culture seeds. Thus, the growth index at the concentration of the tested solution 1:50 is 0.34, and at 5:50 – 0.16; similar indices were found under the action of Centaureacyanus L. and Taraxacum officinale L. This research suggests that winter wheat agrocenoses contains both allelopathically active species and species to which the plants are tolerant. This is of practical value since it allows a differentiated approach to the system of integrated weed control measures, in particular to the choice of herbicides aimed at destroying allelopathic active weed species. This study was aimed to study the relationships between cultivated and weed plants at the level of competition and allelopathy.

Key words: *field crops, weeds, allelopathic properties, competition*

INTRODUCTION

Weeds are an independent ecological group of plant origin. The source of weed vegetation is natural vegetation. Weeds have separated from natural vegetation by natural selection. As a result, many representatives of weeds have changed their biological features and become closer to cultivated plants. These changes have taken place under the influence of environmental conditions. Weeds need the same life factors as cultivated plants. Therefore, they are competitors of cultivated plants and drastically reduce yields [1, 6, 31].

Weed populations are almost ubiquitously present in the structure of agrocenoses, forming a total weed component with a specific species composition for each field as well as the number of individual weed species, the potential stock of their seeds and vegetative reproduction organs in the soil [23]. Formed in the process of the old land cultivation history, modern populations of weed plants have acquired a complex of well-known properties that allow them to successfully withstand intensive anthropogenic impacts. Consequently, the place of the weed component in the structure of agrophytocenosis is determined by natural, environmentally relevant laws [24].

The history of land cultivation shows that among the numerous natural phenomena that have a negative impact on agriculture, the most tangible in reducing the yield are weeds. As a result of competition with cultivated plants, weeds significantly affect the balance of nutrition elements, physical properties of soil, water-air, as well as heat and light conditions of agrophytocenosis.

The relationship between cultivated and weed plants in agrophytocenosis is formed at two levels. The first is competition in the struggle of plants for light, water and nutrients, and at a higher level, the biochemical mutualism of plants, which is called allelopathy [28, 3, 25, 2, 10].

Emphasized that despite the successful modification of weed management in Iran, more research is needed to further explore and test the best thresholds for each risk level in the weed population control matrix using more weed species [26].

Growing season during different stages of crop development weeds remove from the soil 2.7-14.8 kg/ha nitrogen, 2.2-20.1 kg/ha phosphorus, 6.7-39.0 kg/ha potassium, 1.7-4.5 kg/ha calcium and 0.9-3.1 kg/ha magnesium. The relationship of which nutritional elements were removed depended on the type of weed and its vegetative mass [22].

In field rotation the optimal system of weed control resulted in two times less weed infestation during three rotations and helped to decrease the amount of nutrients taken out by weeds: nitrogen by 4-6 times, phosphorus by 4.5-5.0 times, and potassium by 4.0-5.5 times. At the same time, the consumption of nitrogen increased by 23-25%, phosphorus by 20-23% and potassium by 17-21% [17]. According to Junusov, K.K. (2015) [15] in corn crops, the greatest removal of nutrients from monocotyledonous weeds came from *Echinóchloa crus-gálli L.,* andfrom the dicotyledonous plants *Matricaria perforate L.* and *Chenopodium album L. N*otes that weed plants are reservoirs of the most harmful species of parasitic nematodes. Data on the use of 112 insects, 3 fungi, 1 mite and 1 nematode as hosts established for biological weed control in Hawaii, the continental USA and the Caribbean show that the risk to local flora can be reliably estimated by plant introductions [20].

Found inhibitory effects of spring rape seeds on both seed germination and root development of *Sonchusarvensis L.* (by 46.1 and 75.7%, respectively) and *Convolvulusarvensis L* (by 21.2 and 92.8%, respectively). Seeds of weeds had an insignificant influence on the germinating ability of spring rapeseeds (84 to 93.7% decrease). The effect of glucosinolates and erucic acid in rapeseeds on the germination of weed seeds was not established. The obtained data allow us to speak about the complex allelopathic relationships between spring rapeseed and weed plants during joint germination in the form of negative influence at the biochemical level, which can be observed in natural communities as well [21].

[33] pointed out that different rates of mineralization of plant residues of weeds lead to the fact that the inhibitory allelopathic effect is more pronounced in the initial periods of transformation of plant residues in *Sonchus arvensis L.* and *Convolvulu sarvensis L.* Plant weeds of the Poacea family containing cellulose decompose at a slower rate and inhibit the test winter wheat crop after mineralization for 30 days [7].

Aspects of allelopathy can be used for practical purposes of weed control, and that allelopathic components of the rhizosphere can be studied more directly through plant genomics [4].

Similar data are described by [11, 13, 27].

In modern agriculture our understanding and views of the role of weeds in agro-ecosystems are changing. The focus has been on "destruction" and "eradication". However, this is being replaced by the concept of regulating the number of weeds. This concept is based not only on the threat of increasing pollution of agro-ecosystems with herbicides, but also the consideration that weeds are a threat not due to their species diversity or presence in the crop, but by their high numbers. Therefore, instead of costly and virtually unrealistic elimination of weeds, it is more economically feasible to prevent their mass growth and reduce their numbers to a safe level.

Developed a biological method of accelerated suppression of weeds under forest belts based on creating an agrosteptic cover under them - an analogue of floristic rich steppe (meadow) phytocenoses - with extremely saturated axes of ecological niches with perennial virgin grasses, whose competitive power for food elements, moisture and light is significantly higher than that of weeds [9].

According to Mazirov and Arefieva (2014) [18] the content of phenolic substances in the rhizosphere of both annual and perennial weed species (Cirsiumarvense, Sonchusarvensis) increases when tillage is minimized. Boreshnavard (2017) [5] noted that a bean planting scheme can significantly reduce weed populations. Demirak (2018) [8] studied the effect of using olive mill waste and thyme oil for weed control in sequential extraction of Cd, Zn and Cu into the soil as an alternative to herbicides.

Ivashov (2016) [14] recommended the following species of weed plants for biogeochemical monitoring of agroecosystems in terms of their pollution with heavy metals under the conditions of Priamurye: *Amaranthus albus L., Menthaarvensis L., Matricāriachamomīlla L., Sonchusoleraceus L., Polygonumlapathifolium L.,* and *Trifoliumhybridum L.*

This research studied the relationships between cultivated and weed plants at the level of competition and allelopathy, which will make it possible to substantiate a systematic approach in the regulation of weed numbers. In modern agriculture our understanding and views of the role of weeds in agro-ecosystems is changing. The concept of "eradication" and "elimination" is being replaced by the concept of weed control. The basis for this concept is not only the threat of increasing pollution of agro-ecosystems with herbicides, but also the consideration that weeds are a threat not because of their species diversity or presence, but because of their high numbers. Therefore, instead of costly and virtually unrealistic weed eradication, it is more economically viable to prevent weeds from massive spreading and to reduce their numbers to a safe level. In our opinion, the study of allelopathic interactions between cultivated and weed plants can make a significant contribution to the rational regulation of the number of weed plants and the development of rational measures to control them.

MATERIALS AND METHODS

The research was conducted under conditions of the unstable moisture zone of the Central Caucasus in a perennial stationary experiment in eight-field grain-plough rotation with the following crop rotation: pea-oat mixture (fallow) - winter wheat - winter barley - corn for silage - winter wheat - pea - winter wheat - sunflower during 2002-2020. The total area of the plot was 108 m², and the recorded area was 66 m². The experiment was repeated three times. The total area of the experimental plot was 6.4 ha. Mechanical treatment consisted of disk hoeing, no-tillage and cultivation. Pesticides were used for pest control.

In the experiment the following measurements were made: under field conditions plant samples were taken and nutrient removal was determined, under laboratory conditions the allelopathic activity of cultivated and weed plants taken at the flowering phase was determined and the growth index was calculated.

Species composition of weed vegetation was determined by an instrumental method. The number and biomass of weed plants were counted by the quantitative weight method of Vasilyev *et al.*(2005) [12].. Allelopathic properties of the most common weeds in crops were determined by the method of Grodzinsky (1965) [32]. The roots and the above-ground parts (stems + leaves + inflorescences) of weeds were crushed separately and kept for 24 hours at room temperature in a 1:10 water to weight ratio (10 g of weeds per 100 ml of water). Twenty winter wheat seeds were placed in Petri dishes with filter paper, pre-soaked in distilled water for 2 hours. The filter paper was moistened with equal amounts of weed extracts. Seeds which germinated on water-moistened filter paper served as a control. Laboratory germination of seeds was determined in accordance with the State Standard 12038- 84. The vegetation experiment to determine the allelopathic activity of decomposing plant residues of weeds was carried out in 0.5 l vessels filled with calcined sand with the addition of 10 g of crude weight of weed plants.

Winter wheat seeds were sown at two times: immediately after plant residues were incorporated and after 30 days, during which the sand with plant residues was moistened. Plants grown in vessels with sand served as a control.

Biometric indicators of winter wheat were recorded 20 days after sowing. Variants of the experiments were repeated four times.

RESULTS AND DISCUSSIONS

Contents of main nutrients in cultivated and weed plants

The data we obtained indicated that the concentration of nutrients in weeds was at the same level as in cultivated plants, and in some cases it exceeded it.

Nitrogen plays the leading role in growth processes. Increased nitrogen nutrition contributes to enhanced growth of vegetative organs, and the formation of a powerful assimilating apparatus. Lack of nitrogen leads to inhibition of growth, and subsequently to a decrease in yield and quality. In our studies, we found that in the flowering phase, the relative nitrogen content in winter wheat was 2.64%, in winter barley - 2.36%, and in sunflower - 2.6%, There was a somewhat lower nitrogen content in the green mass of pea with oats and corn for silage (Figure 1).

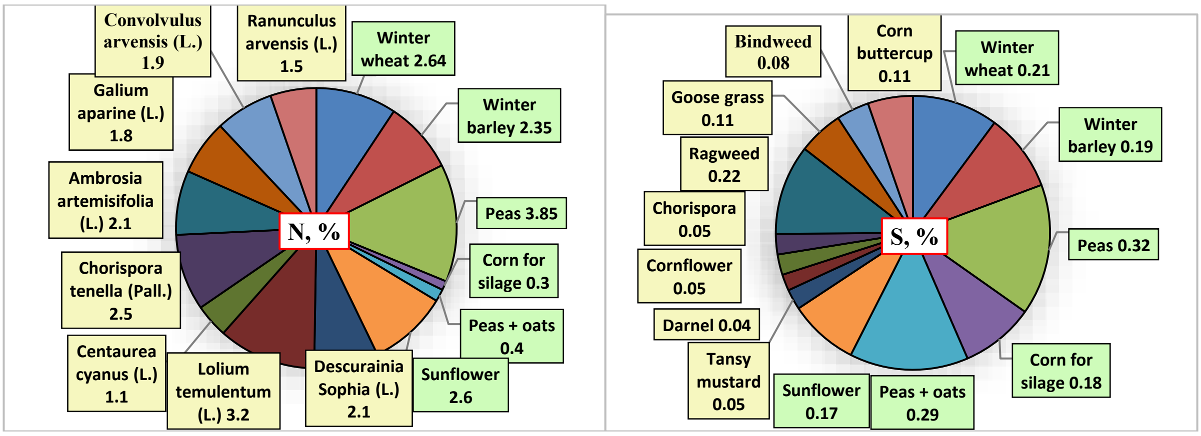

Fig. 1. Relative content of nitrogen (N) and sulfur (S) in green mass of cultivated and weedy plants, %.
Source: Own primary data.

The nitrogen content in weeds was similar. For example, *Loliumtemulentum L.* contained 3.2%, *Chorisporatenella (Pall.) DC)* - 2.5, *Ambrosia artemisifolia L.* and *Descurainia Sophia L.* - 2.1% nitrogen. Weed plants also contained a relatively high amount of sulfur - from 0.17 to 0.05%.

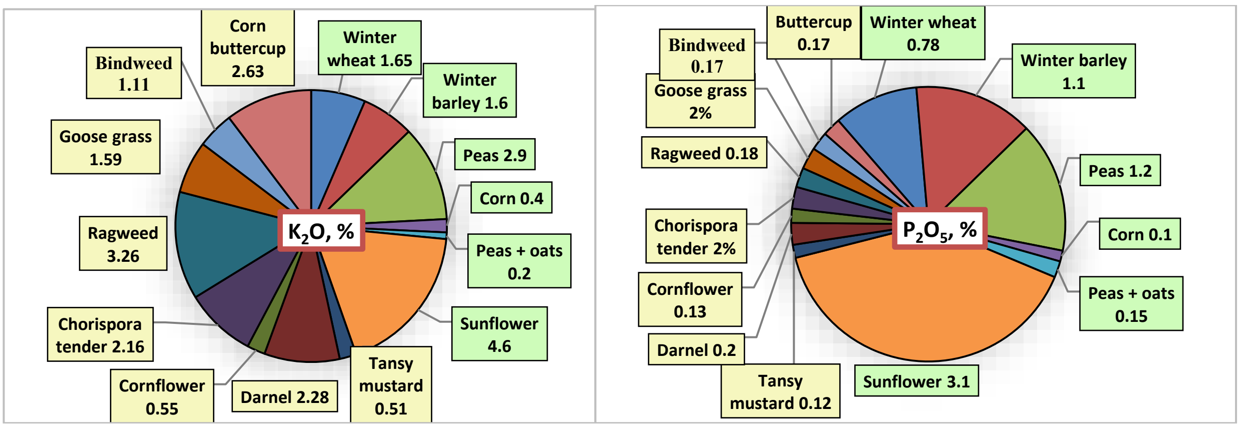

Fig. 2. Relative content of potassium (K_2O) phosphorus and phosphorus (P_2O_5 in the green mass of cultivated and weedy plants, %.
Source: Own primary data.

In plants most of the sulfur is in the composition of proteins (sulfur is part of the amino acids cysteine, cystine and methionine) and other organic compounds - enzymes, vitamins, mustard and garlic oils.

Sulfur is involved in nitrogen and carbohydrate metabolism of plants, respiration and synthesis of fats.

The physiological role of phosphorus and potassium is to participate in the synthesis and movement of organic compounds, energy exchange, especially intensive during the formation of reproductive organs and the formation of spare substances in the marketable part of the crop. If the phosphorus content in weeds is quite low in comparison with cultivated plants, the potassium content is two to three times higher (Figure 2).

Nutrient removal by cultivated and weed plants

The data show that weeds growing in the agrophytocenosis remove significantly more nutrients than the cultivated plants, even with their good development. This is demonstrated in the works of Struve (1926) [26], Bell (1970) [3], Rice (1978) [29], Ballare and Casal (2000) [2], and Einhelling and Rasmussen (2003) [10]. The data analysis presented in Figure 3 shows that on average rotation crops take out 103.6 kg/ha of nitrogen, 51.5 kg/ha of phosphorus, and 96.9 kg/ha of potassium.

a)

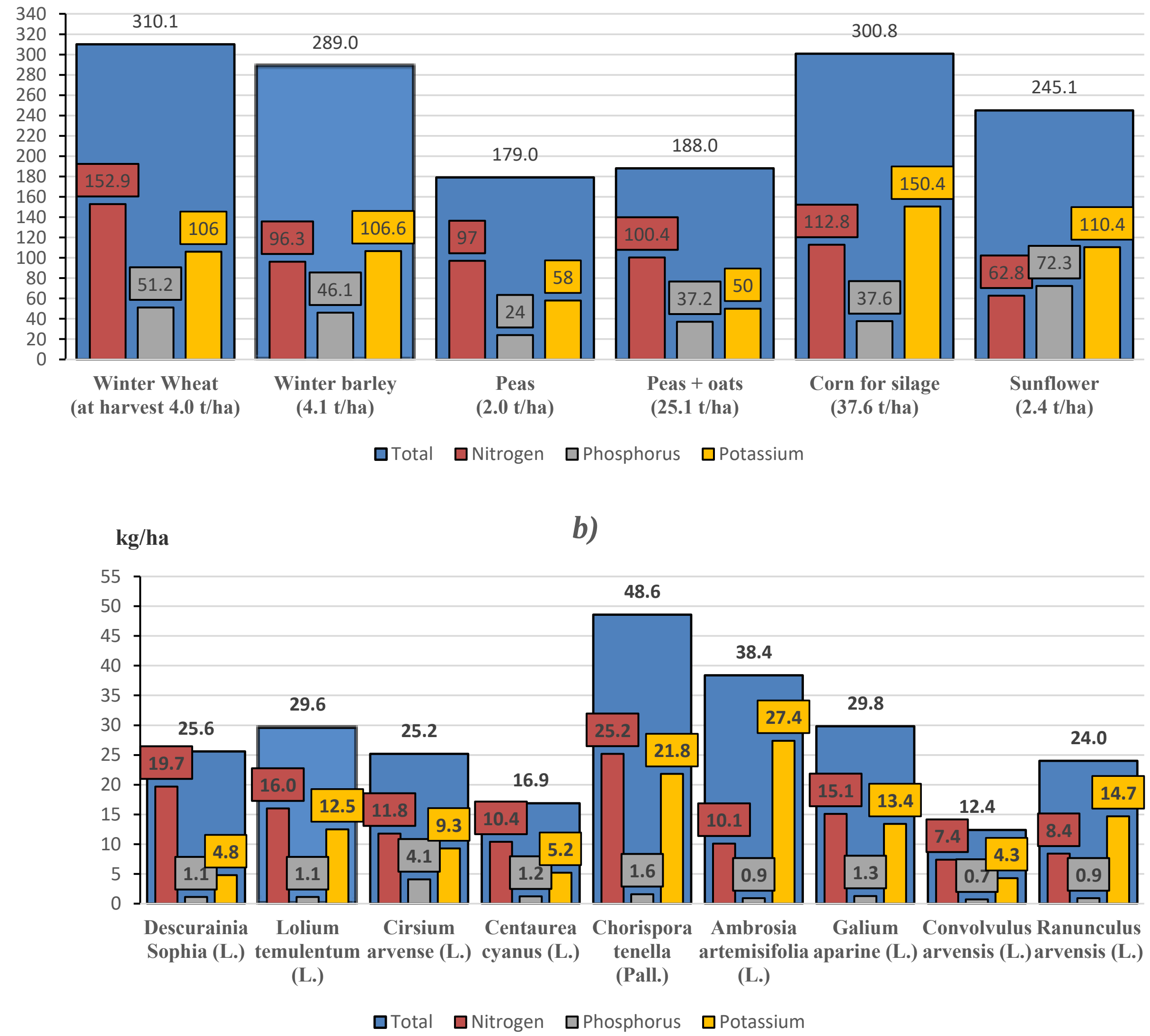

Fig. 3. Nutrient removal, kg/ha: a) by cultivated plants, b) by weeds.
Source: Own primary data.

The main species of weeds of field crops remove nitrogen, phosphorus and potassium, respectively, 124.1, 12.9 and 18.9 kg/ha, mainly due to such species as Lolium temulentum L., Galium aparine L., Cirsium arvense L., Ambrosia artemisifolia L. and Chorisporatenella (Pall.) DC.

Consequently, weeds are competitors to cultivated plants in the struggle for life factors, in particular for the elements of nutrition. Consuming from the soil a significant amount of basic nutrients - macro-, microelements, organogenes, they deprive the cultivated plant of the opportunity to fully use nutrients to form a quality crop.

Allelopathic mechanisms of mutual influence of cultural and weed components of agrophytocenosis

Trofimova*e al*. Nesmeyanov Shayev (2019)[29] demonstrated that the highest allelopathic activity among the weed species under study was in *Galiumaparine L., Avenafatua L., Agrimóniaeupatória L., and Cyclachaenaxanthiifolia (Nutt.) Fresen*. Cruciferous weeds have a high inhibitory effect on the germination processes of winter wheat due to their high biochemical activity, e.g.: *Lolium temulentum L., Galium aparine L., Cirsium arvense L., Ambrosia artemisifolia L., Descurainia Sophia L., Chorisporatenella (Pall.) L., Convolvulusarvensis L., Ranunculus arvensis L., Centaureacyanus L., Descurainia Sophia L.,* and*Cirsiumarvense L*. High allelopathic activity of the donor plant under study, oil radish, has been found. Khramchankova and Mileika A. (2020) [16] revealed the dependence of lichen allelopathic action on weeds on the amount of applied lichenomass. According to Om H. *et al*. (2002)[19] green fertilizers of sunflower and wheat reduced the population of Phalaris minor by 100% under laboratory conditions and by 42% and 15%, respectively, under field conditions, indicating the inhibitory role of allelochemicals. Tursumbekova (2014) [30] noted that regardless of the species of cereal crops, the greatest inhibitory effect on seed germination was seen in *Chenopodium album L.* aqueous extracts, and on the growth of germinal roots and coleoptiles - *Thlaspiarvense L.* We found that the extract of *Stellaria media (L.) Vill.* from the above-ground parts had the least allelopathic effect on seed germination of all cereal crops.

The data presented show that the removal of nutrients with the crop by cultivated plants was close to the removal of these elements by weeds. However, it is not always appropriate to estimate the full picture of the degree of harmfulness and yield reduction of crops due to competition with weeds. In addition to competition between cultivated and weed plants for nutrients, moisture, light, and space, there are also allelopathic interactions.

The share of influence of different factors in the self-organization of agrophytocenosis is understood differently. Together with the recognition of competition for resource consumption, a significant factor in the organization of agrophytocenoses is chemical interference, i.e., allelopathy.

However, some questions about the degree of allelopathic influence of monocotyledonous and dicotyledonous weeds on the cultivated plant remain unclear.

Our laboratory studies showed that there was a high degree of allelopathic effect of weeds which was manifested in the inhibition of germination processes of the test crop, as well as in slowing the rate of germination, growth and development of winter wheat. The degree of action of weed extracts on the germination of the test crop (radish seeds) depended on the type of weeds and the concentration of the extract. Allelopathic activity of aqueous extracts of weed plants at a concentration of 1:50 was most significant with respect to seed germination of the test crop.

Extracts of these plants had a pronounced inhibitory effect which began with minimal concentrations. At a 1:50 weight ratio of the weed and water, 16 to 21% of radish seeds germinated. With increasing solution concentration, the inhibition ranged from 90 to 80% compared to the control (Figure 4).

Most of these species belong to the Asteraceae family, the peculiarity of which is that the cell sap of these plants contains substances of a glycosidic nature - taraxacin and taraxacerin, rubber-like substances. Dandelion roots contain triterpenes -

taraxerol, taraxasterol. Triterpenes are derived components of essential oils, plant hormones and enzymes of a terpene nature.

It has been found that essential oils and their components affect not only seed germination but also the growth of seedlings and their organs, cause deeper changes in photosynthesis, respiration and other processes.

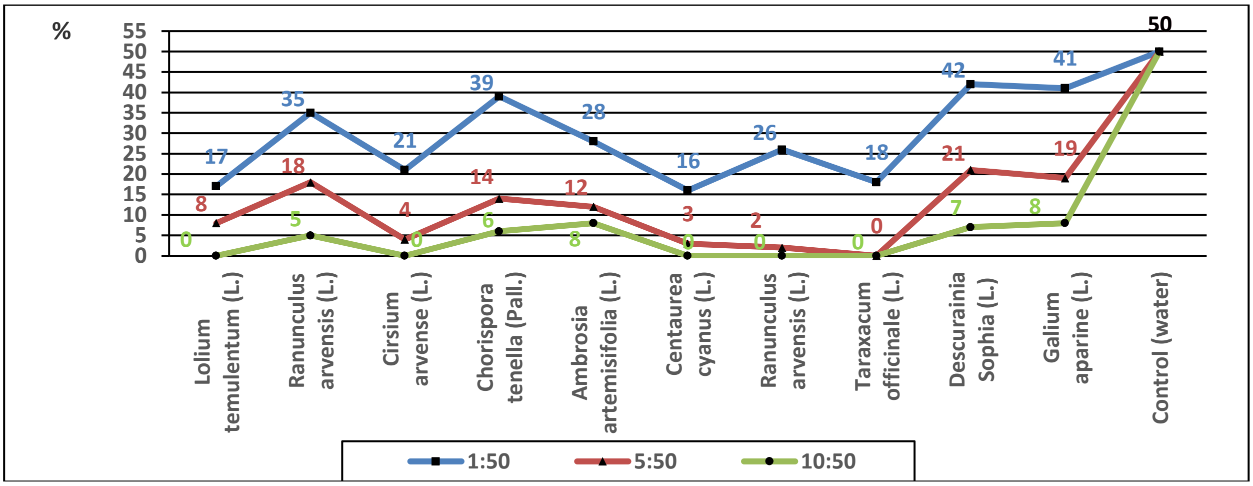

Fig. 4. Allelopathic properties of weed plants(germinated seeds of the test crop, %)
Source: Own primary data.

At a 10:50 weight ratio of weed to water, the suppression is 100%. Particular attention should be paid to the intoxicating weed *Lolium temulentum L.*, in the grains of which there is a fungus *Stromatinia temulenta*, which produces the alkaloid temulinum. At high concentrations, it has an inhibitory effect on the germination of test-culture seeds. Thus, the growth index at the concentration of the tested solution 1:50 is 0.34, and at the concentration 5:50 – 0.16. Similar indices were obtained under the action of blue cornflower and dandelion. The latter had a more powerful inhibiting effect as seen by the fact that already at the ratio of the weed and water 5:50 no germination processes of the test-culture were observed.

Such species as *Descurainia Sophia L. and Chorisporatenella (Pall.) DC*. slow down the germination of the test crop to a lesser extent. The growth indices of the test cultures exposed to *Descurainia Sophia L*. extracts of the concentrations studied were 0.84, 0.42 and 0.14, respectively (Figure 5).

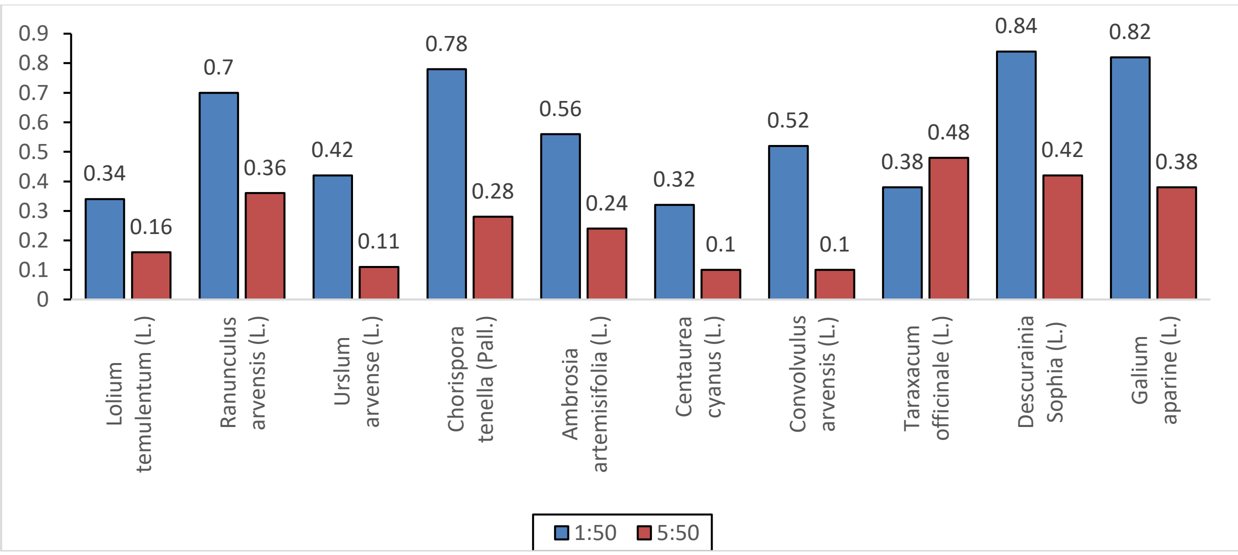

Fig. 5. Growth indices of the test crop under the influence of aqueous extracts of weed plants
Source: Own primary data.

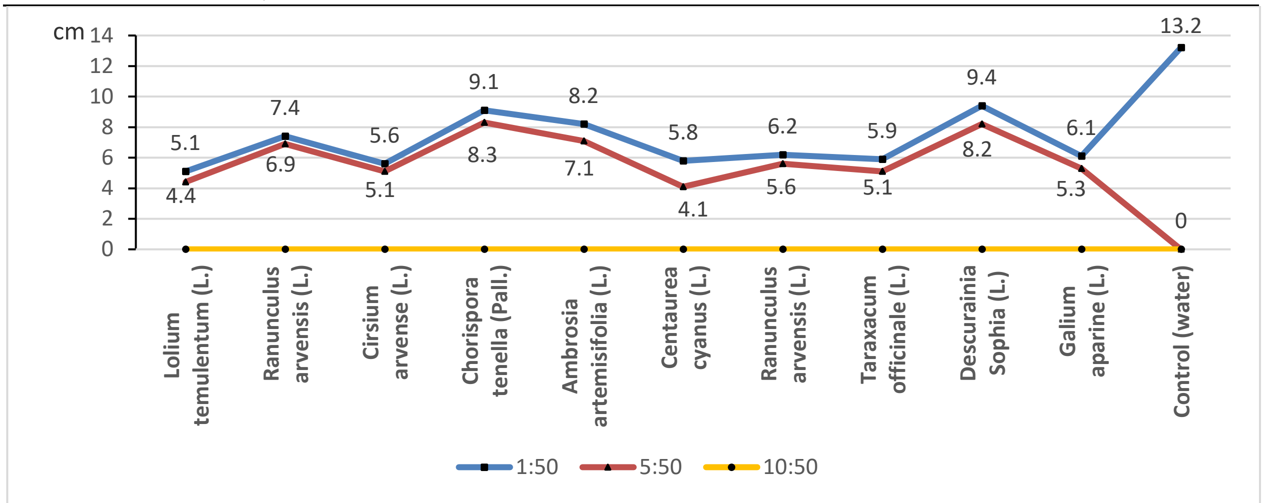

Fig. 6. Allelopathic effects of weed plant extracts on the growth of winter wheat (length of aboveground parts, cm)
Source: Own primary data.

As a result of the *Chorisporatenella* extract impact, the growth indices were 0.78, 0.28 and 0.12, i.e., at solution concentration 1:50 their effect was close to control. In order to determine the degree of influence of extracts from weed plants on growth processes of winter wheat we germinated the seeds of the crop in aqueous extracts of weed species under study. We found a negative lifetime effect of monocotyledonous and dicotyledonous weeds on wheat seedlings. When the ratio of aqueous extracts was 10:50, the processes of germination of winter wheat grains were absent, that is, the concentration of physiologically active substances that inhibit the processes of germination of winter wheat increased when the weediness of crops was high. Under the action of aqueous extracts of weeds, the growth of the aboveground and root parts of winter wheat was reduced in comparison with the control, which was water. Species of the Asteraceae family are especially active. So, if the length of the aboveground parts of winter wheat plants is 13.2 cm in the control at a 1:50 ratio, then extracts of such weeds as field thistle, blue cornflower, field loosestrife, dandelion, or hollyhock reduce this index by half (Figure 6).

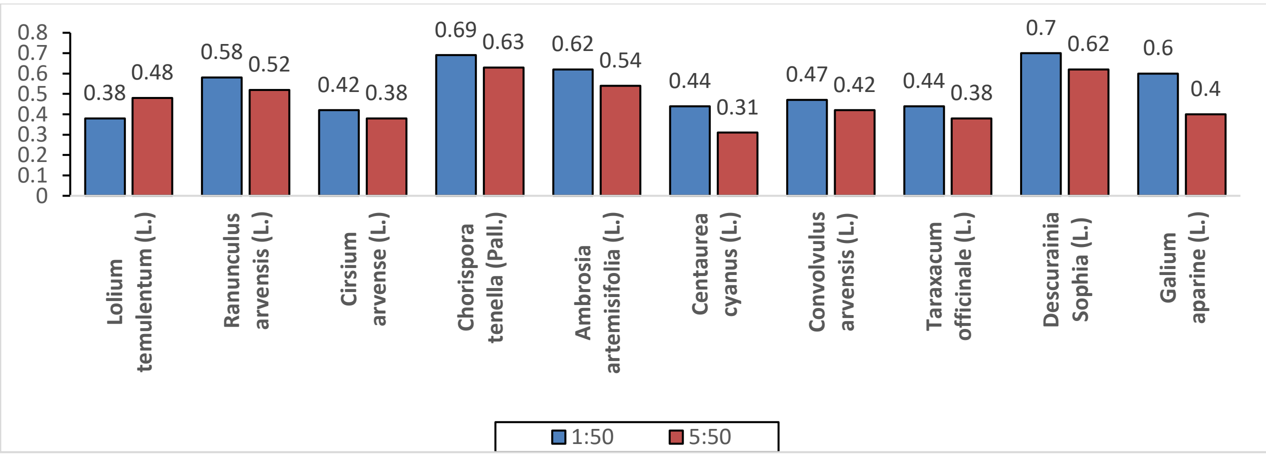

Fig. 7. Growth indices of the aboveground part of winter wheat under the influence of aqueous extracts of weed plants
Source Own primary data.

At the same time, perennial weeds, e.g., dandelion and field thistle, which have a strong root system and had formed flowers at the time of the study, to a greater extent slow the growth of winter wheat.

When the ratio of the weed suspension and water was 5:50 there was a decrease in the length of the aboveground parts from 10 to 30%, but the patterns described above were repeated.

Thus, the growth index of the aboveground part of winter wheat when exposed to a solution of field thistle at a ratio of 1:50 was 0.42, and at 5:50 - 0.38, when exposed to the extract of dandelion medicinal growth indexes were, respectively, 0.44 and 0.38, while the extract of *Chorisporatenella*to a lesser extent inhibited growth of the aboveground parts of winter wheat, growth indices at the above concentrations were 0.69 and 0.63.

Spruce weed intoxicant also contributed to the inhibition of growth of the aboveground parts of the crop, with a ratio of weed and water 1:50 growth index of 0.38 (Figure 7).

The root system of plants suffers to a greater extent from allelopathic active substances of weeds, since the root system first of all absorbs the water solution and all substances in it, including those harmful to the plant, in connection with which its suppression is more intense (Figure 8).

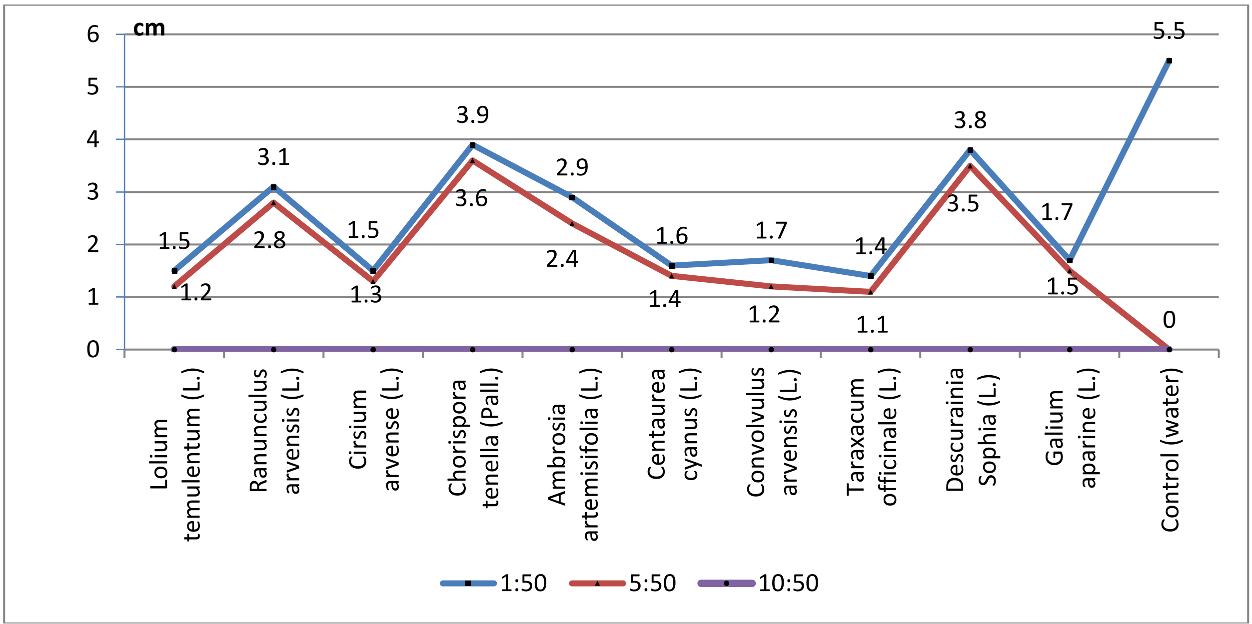

Fig. 8. Allelopathic effects of weed extracts on the growth of winter wheat (root length, cm)
Source Own primary data.

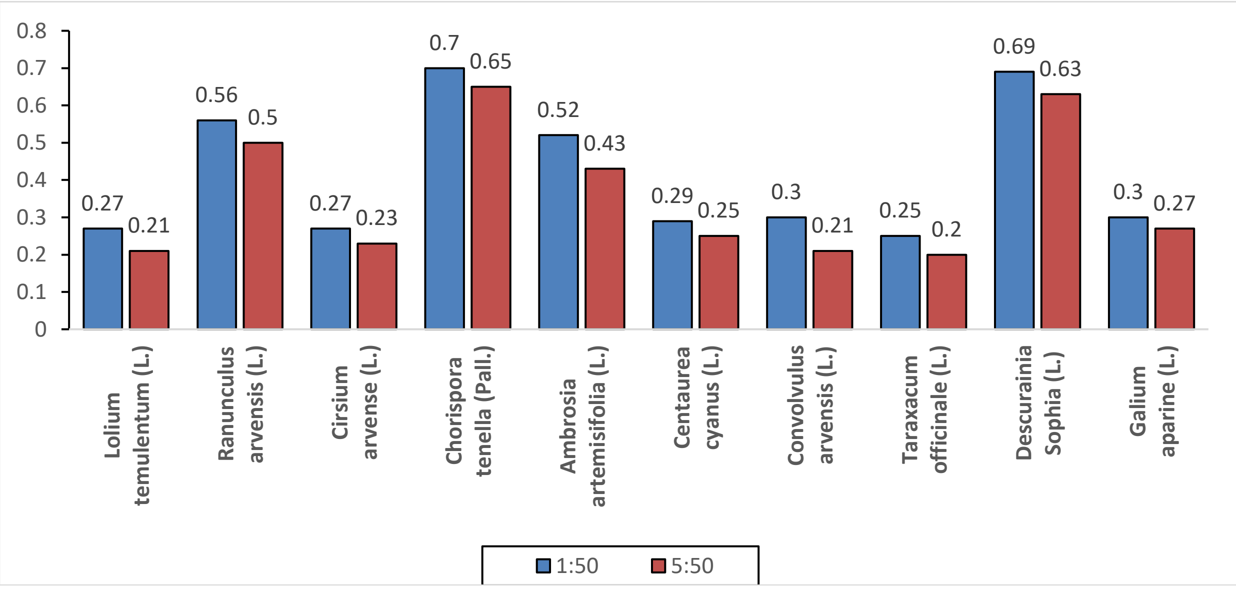

Fig. 9. Root growth indices of winter wheat under the influence of aqueous extracts of weed plants
Source: Own primary data.

Thus, growth indices (Figure 9) under the influence of allelopathically active species ranged from 0.27 to 0.30 at a solution concentration of 1:50 to 0.1-0.2 at 5:50.
Growth indices of less active species were higher: 0.52-0.70 at low concentration and 0.43-0.63 at higher concentration.

CONCLUSIONS

From the above we can conclude that in the agrocenosis of winter wheat, both allelopathic active species and species to which the plants are tolerant grow. This provision is of practical importance, as it allows a differentiated approach to the system of integrated weed control measures, in particular the selection of herbicides, aimed at destroying allelopathic active species of weeds.
Weeds have high allelopathic activity, which manifests itself in the suppression of growth processes of winter wheat. Inhibition of aqueous extracts from weeds ranges from 80 to 90% compared with the control. Most allelopathically active species belong to the Asteraceae family, the feature of which is that the cell sap of these plants contains substances of a glycosidic nature - taraxacin and taraxacerin, rubber-like substances. In the agrocenosis of winter wheat there are weed species to which cultivated plants are tolerant, which is of practical importance because it allows a differentiated approach to the system of protective measures.

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REFERENCES

[1]Balah, M.A., Pudake, R.N., 2019, Use nanotools for weed control and exploration of weed plants in nanotechnology. In the book: Nanoscience for Sustainable Agriculture, 207-231.
[2]Ballare, C.L., Casal, J.J., 2000, Light signals perceived by crop and weed plants. Field Crops Research Vol. 67 2: 149-160.
[3]Bell, D., 1970, Allelopatic effects of Brassica nigra on annual grassland. Ph. thesis Univ. of Calif: 340–351.
[4]Birkett, M.A., Chamberlain, K., Hooper, A.M., Pickett, J.A., 2001, Does allelopathy offer real promise for practical weed management and for explaining rhizosphere interactions involving higher plants. Plant and Soil Vol. 232. 1-2: 31-39.
[5]Boreshnavard, M., 2017, The effect of cultivation patterns and weed management on kidney bean's yield and yield component. Theoretical & Applied Science 1 (45): 139-144.
[6]Caussanel, J.P., Barralis, G., Vacher, C., 1986, La determination des seuils de nuisibilite des mauvaises herbes: methodes d'etudes. Perspect 108: 58–65.
[7]Chekalina, N.V., Belova, T.A., 2015, Experimental study of allelopathic mutualisms of cultivated and weed plants. Modern trends in science and technology development 6-3: 105-107.
[8]Demirak, A., Dilek, N., Keskin, F., Yildiz, D., Kaçan, K., 2018, Influence of olive mill wastes and thyme oil on some metal sequential extractions in greeenhouse soils. Sakharov readings 2018: environmental problems of the XXI century. Proceedings of the 18th International Scientific Conference: in 3 parts. edited by S.A. Maskevich, S.S. Poznyak: 113-114.
[9]Dudchenko, L.V., 2010, New biological method of weed control and their groups in field-protective forest plantations. Agrarny vestnik Urala 4 (70): 78-81.
[10]Einhelling, F., Rasmussen, I., 2003, Allelopatic effects of Rumexcrispus on Amaranthusretroflexus, grain sorghum and field corn. Amer. Midland Natur 1: 79–86.
[11]Falaleeva, L.V., Ulitina, M.V., 2017, Allelopathy as a method in biologicalization of agriculture. In the collection: Agrotechnical method of plant protection from pests. Materials of VIII international scientific-practical conference, dedicated to the 95th anniversary of Kuban State Agrarian University: 452-456.
[12]Grodzinsky, A.M. Allelopathy in the life of plants and their communities / A.M. Grodzinsky. - Kyiv: Naukova Dumka, 1965. - S. 189-198.
[13]Han, C., Shao, H., Zhou, S., Mei, Y., Cheng, Z., Hunag, L., Lv, G., 2021, Chemical composition and phytotoxicity of essential oil from invasive plant, Ambrosia artemisiifolia L. Ecotoxicology and environmental safety 211: 111879.
[14]Ivashov, P.V., 2016, Micronutrients in weed plants of Priamurye. Ecological Bulletin of the North Caucasus. Vol. 12(3), 65-70.

[15]Junusov, K.K., 2015, Weed plants as reservoirs of the most harmful species of crop parasitic nematodes. Bulletin of K.I. Skryabin Kyrgyz National Agrarian University 2 (34), 107-110.

[16]Khramchankova, V.M., Mileika, A., 2020, Allopathic effects of the lichen biomass on the weed plants seedlings from poaceae family. Theoretical & Applied Science 4 (84), 68-72.

[17]Konova, A.M., Derzhavin, L.M., Samoilov, L.N., 2011, Competition of cultivated and weed plants in crop rotation for nutrients. Fertility 4 (61), 36-38.

[18]Mazirov, M.A., Arefieva, V.A., 2014, Allelopatic potential of weeds under the minimalization of soil treatment. Eurasian Journal of Soil Science 3: 25-27.

[19]Om, H., Dhiman, S.D., Kumar, S., Kumar, H., 2002, Allelopathic response of phalaris minor to crop and weed plants in rice-wheat system. Crop Protection Vol. 21(9), 699-705.

[20]Pemberton, R.W., 2000, Predictable risk to native plants in weed biological control. Oecologia Vol. 125(4), 489-494.

[21]Perederieva, V.M., Vlasova, O.I., Shutko, A.P., 2011, Allelopathic properties of weed plants and their plant residues during mineralization. Polythematic network electronic scientific journal of Kuban State Agrarian University 73: 482-492.

[22]Pestereva, A.S., Soroka, S.V., 2013, The removal of major nutrients by spring triticale and weeds in organogenesis.Soil Science and Agrochemistry 1(50), 217-225.

[23]Petson, E.V., Drotikova, A.M., Ordenko, N.S., 2011, Detection and diagnosis of quarantine weed seeds. Plant Protection and Quarantine 4: 45-46.

[24]Puponin, A.I., Zakharenko, A.V.,2014, Control of weed component of agrophytocenosis in land cultivation systems, Moscow Agricultural Academy Publishing house, 154 p.

[25]Rice, E., 1978, Allelopathy. Moscow: Mir. 392 p.

[26]Sohrabi, S., Downey, P.O., Gherekhloo, J., Hassanpour-bourkheili, S., 2020, Testing the Australian post-border weed risk management (wrm) system for invasive plants in Iran. Journal for Nature Conservation 53: 125780.

[27]Strik, B. C., Davis, A. J., 2021, Individual and Combined Use of Sawdust and Weed Mat Mulch in a New Planting of Northern High bush Blueberry. III. Yield, Fruit Quality, and Costs. Hortscience Vol. 56(3), 363-367.

[28]Struve, V.P., 1926, On biological interaction on weed plants of some crops. Proceedings of applied botany, genetics and selection. Vol. XVI. 3: 171-179.

[29]Trofimova, T.A., Nesmeyanova, M.A., Shaeva, N.P., 2010. Study of allelopathic properties of cultivated and weed plants. Biologization of agriculture: prospects and real possibilities. Materials of international scientific-practical conference dedicated to 105th anniversary of doctor of agricultural sciences, Prof. corresponding member of Vaskhnil M.I. Sidorov and 70th anniversary of doctor of agricultural sciences, Prof. N.I. Zezyukov, 106-111.

[30]Tursumbekova, G. Sh., 2014, Allelopathic effects of weed plant extracts on seeds and seedlings of cereal crops. Agri-food policy of Russia 4 (28), 38-40.

[31]Urakchintseva, G.V., 2018, Influence of species diversity of weed plants on the formation of agrocenosis biomass. Ways to implement the Federal Scientific and Technical Program for Agricultural Development in 2017-2025. Proceedings of the international scientific-practicalиconference dedicated to the 75th anniversary of Kurgan region. Edited by S.F. Sukhanova, 979-982.

[32]Vasiliev, I.P. Workshop on agriculture KolosS 2005 424 p.

[33]Zhidkova, E.N., Goryagina, E.B., 2016, Allelopathic mutualism of spring rapeseed (*Brassica Napus* l.) and weed plants during seed germination. Bulletin of Voronezh State Agrarian University 2 (49), 43-49