Role of allelopathic activity of plants in the regulation of infestation of agrophytocenoses

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Abstract. The study and practical use of the characteristics of allelopathic relations in agroecosystem acquires importance in the process of regulation of the number of weed plants. In 2010-2018 the Department of Agriculture of Voronezh State Agricultural University conducted studies on establishing the dependence of weed infestation of sunflower on using different methods of biologization: stubble sideration (oil radish) and sunflower cultivation in combined sowing with legumes, (alfalfa purple, yellow melilot, Hungarian sainfoin, spring vetch). The allelopathic interconnections of cultivated plants in the process of growth in interspecific agrophytocenosis were studied, as well as their effect on the weed component, and allelopathic activity of oil radish against weed plants was established. The results obtained in the course of the study showed a significant increase of allelopathic activity of sunflower when cultivated in combined sowing with legumes, which was demonstrated in a decrease of germination of such weed plants as cleavers, wild buckwheat, yellow foxtail (by 10-50 abs.%) and reduction of total weed infestation (by 18-26%). At the same time, there was no negative allelopathic effect of cultivated plants on each other. The use of stubble sideration of oil radish in the barley-sunflower crop rotation link also leads to the reduction of weed infestation (by 26-38%): high allelopathic activity of cruciferous crop provides a decrease of laboratory germination of certain weed species by 43-100%. The obtained results can be used in the development of activities directed to the reduction of weed infestation using biological methods.

1. Introduction
Agrophytocenosis is a community of cultivated and weed plants, created and maintained on a regular basis by people in order to produce agricultural products.

One of the characteristics of any plant community is the presence of the relations between its components. Whenever several plant species use the same resources in the process of their growth and development, there appears competition, the effect of which mainly affects plant productivity. At the same time changes occurring in the environment, can be both of qualitative and quantitative nature, having a significant effect on plant morphogenesis, mass ratio of their separate organs and production process in general [1].

2. Problem statement
Biochemical interaction, i.e. allelopathy, is of key importance in the regulation of competitive relations in agrophytocenoses. In the process of plant life cycle cultivated and weed plants release
various physiologically active substances into the environment, characterized significantly by both positive and negative effect on all components of agrocoenosis.

Currently the following chemical agents of allelopathy (colins) are distinguished: phenolic compounds, protein breakdown products, alcohols, aldehydes, organic and oxy acids, microbial metabolites, antibiotics, terpenes and other liposoluble substances, the accumulation in the root environment of which creates allelopathic potential [2].

The regulation of competitive relations in agrocoenoses is usually carried out by standard methods of infestation control. An alternative method for reducing weed vegetation is the use of high allelopathic activity of cultivated plants, which is an important step in the reduction of degree of allelopathic inhibition of field crops by weed plants.

3. Materials and methods

The aim of our study was to establish interaction of germinating seeds of cultivated and weed plants in pure sowing and combined culture sowing.

The studies were conducted in the laboratory conditions of Voronezh State Agricultural University. Germination of seeds was carried out on Petri dishes during the period of 2016-2019. The experiment was repeated in triplicate.

Experiment №1. Study of the effect of the cultivated plant seeds during germination on the laboratory germination of a weed plant.

Oil radish was taken as a cultivated donor plant.

Factor A – the number of seeds of the cultivated plant: 1) 0 – control; 2) 5 seeds; 3) 10 seeds; 4) 15 seeds.

Factor B – weed acceptor plant: 1) lamb's-quarters; 2) yellow foxtail; 3) cleavers; 4) oat grass.

Experiment №2. Study of the effect of the cultivated plant seeds during germination on the laboratory germination.

Cultivated donor plant – sunflower.

Acceptor plant: 1) Hungarian sainfoin; 2) spring vetch; 3) yellow melilot; 4) alfalfa purple.

Experiment №3. Study of the effect of various cultivated plant seeds during germination on the laboratory germination weed plant seeds.

Donor plant: 1) sunflower; 2) Hungarian sainfoin; 3) spring vetch; 4) yellow melilot; 5) alfalfa purple.

Acceptor plant: 1) lamb's-quarters; 2) yellow foxtail; 3) cleavers; 4) pigweed.

Experiment №4. Study of the effect of combined germinating seeds on laboratory germination of a weed plant.

Donor plant: 1) sunflower + Hungarian sainfoin; 2) sunflower + spring vetch; 3) sunflower + yellow melilot; 4) sunflower + alfalfa purple.

Acceptor plant: 1) lamb's-quarters; 2) yellow foxtail; 3) cleavers; 4) pigweed.

In any phytocenosis there is a donor plant that releases active compounds and an acceptor plant that they have effect on. Physiologically active substances released by donor plants can be in two forms: volatile compounds and compounds dissolved in water [3-6]. In this work we are going to pay attention to water-soluble compounds released by plants.

4. Results and discussion

As the result of studies №1 high allelopathic activity of oil radish was established (Table 1).

The most significant inhibitory effect of germinating seeds of oil radish on laboratory germination of weed plants was manifested in relation to lamb's-quarters: the reduction of germination index as related to control was 79-100%. The reduction of germinative capacity of oat grass as a result of the allelopathic effect of oil radish varied within 68-79%, cleavers – 55-72%, yellow foxtail – 43-55%. At the same time, increase in the number of donor plant seeds up to 15 pieces was accompanied by sharp reduction in germinative ability of weed plant seeds. Considerable reduction was registered in variants with oat grass and lamb's-quarters.
Table 1. Effect of oil radish seeds on the laboratory germination of weed plants

| Number of seeds of donor plant (oil radish) | Laboratory germination of weed acceptor plant, % | RCU, mg/l |
|-------------------------------------------|-----------------------------------------------|-----------|
|                                           | Oat grass | Cleavers | lamb's-quarters | Yellow foxtail | Oat grass | Cleavers | lamb's-quarters | Yellow foxtail |
| 0 – control                                | 90        | 80       | 90             | 80             | -         | -        | -               | -              |
| 5                                          | 22        | 25       | 11             | 37             | 275       | 230      | 470            | 130            |
| 10                                         | 11        | 25       | 0              | 37             | 470       | 230      | 1364           | 130            |
| 15                                         | 11        | 8        | 0              | 25             | 470       | 600      | 1364           | 230            |
| HCP₀₅                                      | 7.57      | 18.27    | 5.35           | 20.02          |           |          |                 |                |

The definition of the concentration of coumarin according to the scale offered by Grodzinsky A.M. (a well-known growth inhibitor, accepted as a standard) showed that complete inhibition of the process of seed germination of lamb's-quarters was noted at a maximum concentration of coumarin: RCU – 1364 mg/l. The value of the RCU indicator for other variants varied from 130 to 600 mg/l, which also indicated the inhibitory effect of germinating seeds of oil radish on germinative capacity of the weed plants studied.

Thus, the use of oil radish as, for instance, fallow-grown crop or stubble (postcut) crop can lead to the reduction of infestation by these species of weed plants.

This conclusion was confirmed by the results of scientific research based on stationary experiment [7]. The use of oil radish as a stubble crop in barley-sunflower crop rotation link ensured the formation of a significantly lower level of infestation in the phase of its full germination (Table 2).

Table 2. Infestation of crops in the phase of full germination of a stubble crop (2011-2016)

| Variant                                | Infestation, pcs. /m² |
|----------------------------------------|-----------------------|
| Background (without stubble sideration) - control | 34                    |
| Stubble siderate oil radish            | 21                    |
| Stubble siderate wild mustard          | 25                    |
| HCP₀₅                                  | 8.86                  |

Combined sowing of sunflower and legume grasses, which have been studied by the department of agriculture since 2010, is characterized by lower level of infestation in comparison with pure sowing of oilseeds (Table 3).

Table 3. Weed infestation of sunflower seeds in the phase of full germination (2011-2019)

| Variant                        | Infestation, pcs. /m² |
|--------------------------------|-----------------------|
| Pure sowing – control          | 38                    |
| Binary sowing with yellow melilot | 31                  |
| Binary sowing with alfalfa purple | 29                  |
| Binary sowing with spring vetch | 28                   |
| Binary sowing with Hungarian sainfoin | 28                 |
| HCP₀₅                          | 5.64                  |

The determination of allelopathic effect of cultivated plants on weed component in such agrocoenoses demonstrated (Table 4) that combined vegetation of sunflower and legume grasses really helps to reduce germinative capacity of such weed plants as cleavers (by 10-40 abs. %) and yellow...
foxtail (by 26-50 abs. %). Combined sowing of sunflower with spring vetch and sainfoin also provides significant reduction of germinative capacity of wild buckwheat: by 8 and 11 abs. % respectively.

At the same time it is worth mentioning that allelopathic activity of sunflower, which is characterized by a lower level in relation to bedstraw, joint weed and pigweed at pure sowing, significantly increases when cultivated in combination with legume grasses.

The study of interaction of cultivated plants while growing in combined crops demonstrated a very low level of the concentration of relative coumarin units (RCU) – from 8.5 to 19.5 mg/g, which indicates an insignificant effect of physiologically active substances released by the cultivated plants studied (Tables 5-6).

### Table 4. Effect of cultivated plant seeds on the laboratory germination of weed plants

| Donor-plant      | Laboratory germination of acceptor – weed plant, % | RCU, mg/l |
|------------------|----------------------------------------------------|-----------|
|                  | Cleavers                                           | Wild buckwheat | Pigweed | Yellow foxtail | Cleavers | Wild buckwheat | Pigweed | Yellow foxtail |
| Control          | 90                                                 | 16          | 62      | 80             | 12.8     | 350         | 43      | 19.5           |
| Sunflower        | 90                                                 | 15          | 60      | 25             | 12.8     | 360         | 47      | 228            |
| Alfalfa purple   | 70                                                 | 10          | 25      | 74             | 30       | 500         | 228     | 25             |
| Yellow melilot   | 82                                                 | 8           | 28      | 76             | 17.9     | 580         | 200     | 23             |
| Spring vetch     | 50                                                 | 20          | 85      | 30             | 74       | 290         | 15.8    | 181            |
| Hungarian sainfoin | 55                                          | 5           | 90      | 30             | 58       | 800         | 12.8    | 181            |
| Sunflower + alfalfa | 80                                          | 10          | 55      | 54             | 19.5     | 500         | 63      | 62             |
| Sunflower + melilot | 80                                        | 10          | 45      | 50             | 19.5     | 500         | 91      | 74             |
| Sunflower + vetch | 55                                                 | 8           | 65      | 30             | 58       | 580         | 37      | 181            |
| Sunflower + sanfoin | 50                                        | 5           | 55      | 32             | 74       | 800         | 63      | 165            |
| HCP₀₅            | 1.90                                               | 6.12        | 16.86   | 25.40          |          |             |         |                |

Despite a decrease of laboratory germination rate of acceptor-plants, there was no any inhibitory interference. All deviations were insignificant. This suggests that growth of sunflower in combined crops with legume grasses is characterized by favorable relations between the components of interspecific agrophytocenosis.

### Table 5. Effect on sunflower seeds on the laboratory germination of legume grasses

| The number of donor plant seeds (sunflower) | Laboratory germination of acceptor plant, % | RCU, mg/l |
|-------------------------------------------|--------------------------------------------|-----------|
|                                           | Alfalfa purple                             | Yellow melilot | Spring vetch | Hungarian sainfoin | Alfalfa purple | Yellow melilot | Spring vetch | Hungarian sainfoin |
| 0 - control                               | 80                                         | 82          | 95          | 60                   | 60             | 19.5         | 19.5        | 11            | 84             |
| 5                                         | 80                                         | 80          | 93          | 47                   | 19.5           | 19.5         | 11          |                |                |
| HCP₀₅                                      | 16.92                                      |             |             |                      |                |              |              |                |                |
Table 6. Effect of the seeds of legume grasses on the laboratory germination of sunflower

| Donor-plant         | Laboratory germination of acceptor plant, % | RCU, mg/l |
|---------------------|--------------------------------------------|-----------|
| Sunflower 0 – control | 100                                        | -         |
| Alfalfa purple      | 87                                         | 14        |
| Yellow melilot      | 93                                         | 11        |
| Spring vetch        | 100                                        | 8.5       |
| Hungarian sainfoin  | 93                                         | 11        |
| HCP<sub>05</sub>    | 13.81                                      |           |

5. Conclusion

In the system of measures in relation to regulation of weed infestation the use of allelopathic antagonists against certain weed plants should be of considerable importance [8]. In barley-sunflower crop rotation link the reduction of infestation of crops with cleavers, wild buckwheat and yellow foxtail can be provided by inclusion of allelopathic active components in agrophytocenoses: stubble siderate of oil radish and legume grasses as binary components. Under these conditions the development of the system of farming in the direction towards boosting soil fertility should be based on the activation of physiological and biochemical processes that increase allelopathic potential of a cultivated plant, which has positive effect on inhibition of weed components of agrophytocenosis.

References

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