Weediness of crops in various crop rotations

S A Zamyatin¹, A Y Efimova¹, S A Maksutkin¹ and N N Apaeva²

¹ Mari Research Institute of Agriculture, Yoshkar-Ola, Russia
² Mari State University, Yoshkar-Ola, Russia

E-mail: zamyatin.ser@mail.ru

Abstract. Weediness of crops of field crops is examined in various crop rotations. Different types of weeds have unequal effects on crop plants. An expression of this effect is the harmfulness of weeds, which leads to a decrease in yield and a deterioration in the quality of the products. It is possible to change the species composition of weeds in the course of time on agricultural crops, which depends on the intensity of the cultivation technology and, first of all, on the alternation of crops and the introduction of straw. Monitoring of weed infestation of crops is necessary to predict the spread of the most harmful weeds in crop rotations. The aim of the research is to trace the dynamics of weediness and species composition of weeds on sod-podzolic soil in field crop rotations. The research was carried out in 1998-2017 on a stationary site, on sod-podzolic medium loamy soil with a high content of mobile forms of phosphorus and exchangeable potassium. The biomorphological spectrum of weed species indicates that 26 species of juvenile weeds occur, and 9 species of perennial species. The appearance of Chenopodium album L. was the most common. There is an increase in the abundance of weeds during the research in the studied agroecosystems. If 61 specimens of weed vegetation per 1 m² were observed in the first rotation, including 50 annual ones, then in the second rotation the abundance of weeds increased to 67 pieces / m². The greatest amount of weed vegetation was observed - 76 pieces/m² in the third rotation of crop rotations. We come to the conclusion that the weediness of field agroecosystems increases, examining the dynamics of contamination of crop field crop rotations, especially over the last six years of research. The number of species of Fumaria officinalis L. and Stellaria media (L.) Vill increases during the study. The number of species of Chenopodium album L. and Echinochloa crus-galli L. has increased significantly over the past six years. We found that the crops in the first crop rotation were the most littered. The rotation, including grasses and row crops, helps to cleanse crops of other crops from weeds. The quantity of weeds in crops of field crops increases with cultivation of crops by organic technology.

1. Introduction

The weed component of agrophytocenosis is one of the most serious problems of modern farming. Weed plants compete with cultural plants for light, heat, water, nutrients, promote the mass spread of diseases and pests. Direct and indirect finding of weeds in the fields leads to a significant decrease in the yield in the long run, simultaneously worsening its quality [1]. Modern populations of weed plants have acquired a complex of properties that allow them to withstand the intense anthropogenic influences that have emerged in the course of the centuries-old history of farming [2].
Weed plants significantly affect the balance of nutrients, physical properties, water-air, thermal and light regimes of agrophytocenosis, in general, on soil fertility, as a result of competition with cultivated plants [3].

It is possible to effectively manage weed-field vegetation when analyzing its species composition. The questions of the floral composition of weeds are of great theoretical importance and a practical understanding of the processes taking place in the field agrophytocenosis. One can speak of the stability of this community, depending on which variety of species is found in the field agrophytocenosis [4].

With prolonged cultivation of a cultivated plant of the same species, there is an increase in the contamination of crops in the same field. On the field will prevail those species of weeds that are better adapted to joint growth with these cultivated plants [5].

The control of weeds in field agrocenoses is mainly carried out by herbicides. It becomes clear that herbicides are an integral part of the system of agriculture at the present stage of the development of agriculture. Different degree of sensitivity of weeds to herbicides leads to the appearance of weed forms resistant to this preparation, which subsequently become the main weeds of crops [6, 7].

Species composition of weed plants varies not only from the use of herbicides, but also from various methods of soil cultivation and other methods of cultivation of crops [8].

According to scientists, the loss of potential productivity of fields with a strong contamination reaches 30% or more, depending on the cultivated crop and their ability to resist weeds [9, 10, 11]. Therefore, agrotechnical methods should be aimed at suppressing weeds, creating conditions for the normal growth and development of cultivated plants and, consequently, increasing productivity.

An important role is played by crop rotations that exclude the dominance of individual weed populations and their adaptation to crop cultivation technologies in controlling the number of weed plants [12].

One of the many functions performed by the rotation is phytosanitary. It is important to establish the alternation of crops in the compilation of crop rotations, which differ in their biological characteristics and cultivation technologies. All this will hinder the rapid growth and development of weed plants. Correctly compiled crop rotation reduces the total contamination of three-five times the crops of solid sowing, and the double cropping contributes to the suppression of the most dangerous perennial root-crop weeds [13]. It can be seen that the infestation of permanent crops is three to four times higher than in crop rotation, according to research by many scientists. The contamination exceeds 8-10 times in certain years.

The purpose of our research is to determine the species composition of weeds on sod-podzolic soil, to establish the contamination of field crops in various types of crop rotation.

2. Experimental research

The research was carried out in 1998 -2017 at the stationary section of the experimental field of the Mari Scientific Research Institute of Agriculture. The soil of the experimental section is sod-podzolic, medium loamy with the following agrochemical indicators of the arable layer at the time of the experiment: the humus content is 1.7-1.8%, the reaction of the soil solution is 5.6-5.9, Hg is 1.6-1 , 9 mg. equivalent to 100 g of soil, the sum of absorbed bases is 7.4-7.9 mg. equivalent to 100 g of soil.

The content of phosphorus 240-270, exchange potassium 130-160 mg per 1 kg of soil. The repetition of the variants in the experiment is threefold. The investigations were carried out in the rotations of four species, deployed in time.

Types of crop rotations are:

- The first crop rotation (oats + clover, clover, winter crops, vetch + oats for grain, spring wheat, barley) - 83% of cereals - control.
- The second crop rotation (vetch + oats for green mass, winter crops, barley, potatoes, vetch + oats for grain, spring wheat) - 67% of cereals.
The third crop rotation (vetch + oats for grain, spring wheat, potatoes (manure 80 t / ha), barley + clover, clover, winter crops) - 67% of cereals.

The fourth crop rotation (barley + clover, clover 1 year of life, clover 2 years of life, winter crops, potatoes, oats) - 50% of cereals.

Ordinary and organic technology was used in the cultivation of crops.

- The usual technology includes: removal of straw after harvesting of crops, low cut of clover (cutting height 8-10 cm).
- Organic technology includes: a shredding of chopped straw cereals and a high clover cut (20 cm).

All soil cultivation was carried out according to conventional technologies in accordance with the requirements of culture.

Weediness of cereals and leguminous crops was determined at the end of vegetation (in the phase of milk ripeness), potatoes in the phase of the closing of the foliage, clover and annual grasses in the beginning of flowering phase. The calculation of the contamination was carried out quantitatively using a 0.25 m² frame in a fourfold repetition.

3. Results and considerations

We determined the species composition of weeds that occur in crops of crops. The biomorphological spectrum of weed species indicates that 26 species of juvenile weeds occur, and 9 species of perennial species. Young weeds that were found in crops: Stellaria media (L.) Vill., Fallopia convolvuluis L., Polygonum scabrum Moench, Polygonum aviculare L., Fumaria officinalis L., Galeopsis tetrarh L., Galeopsis speciosa Mill., Galium aparine L., Spergula arvensis L., Veronica polita L., Chenopodium album L., Echinochloa crus-galli L., Gnaphalium uliginosum L., Amaranthus retroflexus L., Erodium cicutarium L., Cirsium arvense (L.) Scop., Sonchus arvensis L., Linaria vulgaris Mill.

From perennial weeds, the share of spring early is 31%, spring late 19%, wintering 42%. Ephemerals are represented by only one species of Stellaria media (L.) Vill. And biennial weeds are Viola arvensis Murray. From perennial weeds, root-off weeds prevailed. It accounted for 44% of all perennial weeds. This group refers to hard-to-root weeds.

Some weeds were found on the site, but did not hit the registration area. Such weeds include Spergula arvensis L., Gnaphalium uliginosum L. and Myosotis micrantha Pall. They can be considered random species. We took a rotation rotation for the convenience of identifying the dynamics of the number of weed infestations.

Studies have shown that field crop rotation has affected the dynamics of the number of weed infestations. If only 20 species of weeds were observed in the first rotation (six years) of the crop (14 annuals and 6 perennial ones), then in the second rotation the species composition of the weeds increased to 27 species. In the agrocenoses, the appearance of such annual weeds as Polygonum aviculare L., Erodium cicutarium L., Veronica polita L., Capsella bursa-pastoris (L.) Medic, Crepis tectorum L. and Viola arvensis Murray. From perennial weeds appeared weed Stachys palustris L.

| Table 1. Dynamics of weediness of field crop rotations. |
|------------------------------------------------------|
| Annuals                                              |
| 1998-2005 years | 2006-2011 years | 2012-2017 years |
| Species                        | 2017 | 2018 | 2019 |
|-------------------------------|------|------|------|
| *Erodium cicutarium* L.       | 0    | 0.04 | 0.13 |
| *Centaurea cyanus* L.         | 2.43 | 1.70 | 0.45 |
| *Veronica polita* L.          | 0    | 0.08 | 0.14 |
| *Fallopia convolvulis* L.     | 0.68 | 0.53 | 0.65 |
| *Polygonum aviculare* L.      | 0    | 0.60 | 0.88 |
| *Polygonum scabrum* Moench    | 1.16 | 1.73 | 0.72 |
| *Fumaria officinalis* L.      | 2.01 | 2.28 | 2.17 |
| *Stellaria media* (L.) Vill.  | 1.03 | 2.90 | 0.96 |
| *Psammophiliella muralis* (L.) Ikonn. | 0 | 0 | 0.91 |
| *Chenopodium album* L.        | 19.19| 24.17| 27.81|
| *Erigeron canadensis* L.      | 0    | 0    | 2.99 |
| *Apera spica-venti* (L.) Beauv. | 3.08 | 1.74 | 0.49 |
| *Capsella bursa-pastoris*     | 0    | 0.08 | 0.11 |
| *Capsella bursa-pastoris* (L.) Medic | 0.91 | 0.42 | 0.11 |
| *Galeopsis speciosa* Mill.    | 2.97 | 1.53 | 0.63 |
| *Galeopsis tetrahita* L.      | 2.21 | 1.65 | 0.56 |
| *Galium aparine* L.           | 0    | 0    | 0.68 |
| *Androsace filiformis* Retz    | 12.64| 17.04| 20.29|
| *Echinochloa crus-galli* L.   | 0.77 | 0.34 | 1.36 |
| *Matricaria perforate* Merat  | 0    | 0.36 | 0.11 |
| *Crepis tectorum* L.          | 0    | 0.04 | 1.28 |
| *Amaranthus retroflexus* L.   | 0.79 | 0.26 | 0.09 |
| *Thlaspi arvense* L.          | 0.95 | 1.19 | 0.05 |
| *Sum*                         | 50.80| 58.69| 63.56|

**Perennial**

| Species                        | 2017 | 2018 | 2019 |
|-------------------------------|------|------|------|
| *Cirsium arvense* (L.) Scop.  | 2.05 | 1.51 | 0.63 |
| *Convolvulus arvensis* L.     | 1.05 | 1.03 | 0.69 |
| *Linaria vulgaris* Mill       | 0.04 | 0.06 | 0.08 |
| *Taraxacum officinale* Wigg.  | 0.83 | 0.35 | 0.14 |
| *Sonchus arvensis* L.         | 3.80 | 3.49 | 4.19 |
| *Plantago major* L.           | 0    | 0    | 1.26 |
| *Artemisia vulgaris* L.       | 0    | 0    | 0.17 |
| *Equisetum arvense* L.        | 2.20 | 2.10 | 3.57 |
| *Stachys palustris* L.        | 0    | 0.24 | 1.64 |
| *Sum*                         | 9.98 | 8.79 | 12.35|
Species composition of field agroecosystems increased by 5 more species in the third rotation of crop rotations. The increase in the number of annual species was due to Erigeron canadensis L., Psammophiliella muralis (L.) Ikonn and Androsace filiformis Retz. From perennial weeds, the following species appeared: Plantago major L. and Artemisia vulgaris L.

There is an increase in weed species during the research in the studied agroecosystems. 60.78 specimens of weed vegetation per 1 m$^2$ were observed in the first rotation, including 50.8-annual ones, the species composition of weeds increased by 11% in the second rotation. The number of annual weeds increased by 15.5%. The number of weeds was more by 25% in the third rotation of crop rotations. Not only the amount of annual weeds increased, but also the number of perennials increased.

Accounting for the weediness of field crops showed that the least number of weed plants was in the fourth crop rotation. There were 31.5 weed plants per m$^2$ with an air-dry mass of 33.0 g/m$^2$ on average over 6 years of research, in this crop rotation. The largest crop was crop rotation, where 83% of the fields are occupied by crops and the third crop rotation, where 80 t/ha of manure is applied to potatoes, with a contamination of 42.7 and 42.4 specimen/m$^2$, respectively.

### Table 2. Weediness of crops, depending on the type of crop rotation and, cultivation technologies (average for 2012-2017 years).

| Options                        | Number of weeds, pieces / m$^2$ | Air-dry weight, g/m$^2$ |
|--------------------------------|---------------------------------|-------------------------|
|                                | total including perennial | total including perennial |
| By types of crop rotation      |                                |                         |
| First crop rotation            | 42.7  4.7                      | 60.3  8.5               |
| Second crop rotation           | 40.2  4.3                      | 56.7  7.6               |
| Third crop rotation            | 42.4  5.0                      | 47.1  8.5               |
| The fourth crop rotation       | 31.5  3.8                      | 33.0  5.9               |
| By technology of cultivation   |                                |                         |
| Conventional technology        | 38.1  4.3                      | 47.5  7.4               |
| Organic technology             | 40.3  4.6                      | 51.0  7.9               |

The plowing of chopped straw contributed to an increase in debris up to 5.8% when cultivating crops using organic technology. We assume that together with the straw, more seeds of weed vegetation have entered the soil.

Crops of different cultures differ in their weediness. The vetch in the mixture with the oats turned out to be the most littered. Crops of winter rye were the least clogged from grain crops. This culture fights well with weeds due to its bushiness. In contrast to spring wheat, the amount of weeds was 1.4 times less.

### Table 3. Weediness of crops of different crops in crop rotations.

| Field crops       | Number of weeds, pieces / m$^2$ | Air-dry weight, g / m$^2$ |
|-------------------|---------------------------------|---------------------------|
|                   | Total including perennial | Total including perennial |
| Spring Wheat      | 40.6  5.2                      | 59.5  9.5                 |
| Barley            | 37.1  4.3                      | 49.5  8.8                 |
| Oats              | 38.3  3.7                      | 53.4  6.7                 |
| Vetch + oat for grain | 58.4  5.6               | 97.8  12.5                |
| Vetch + oat on green mass | 48.6  4.7               | 70.1  9.2                 |
| Winter rye        | 28.4  3.6                      | 20.6  3.8                 |
| Clover            | 45.0  6.1                      | 26.9  5.8                 |
| Potatoes          | 24.3  2.5                      | 34.2  5.7                 |
Frequent mechanical processing of potatoes reduced the weediness of this crop, here for 6 years of research was 24.3 specimens / m\(^2\), with an air-dry weight of 34.2 g / m\(^2\). There were a lot of weed plants on the clover fields, but they were in a drowned state. Their air-dry mass was not high.

4. Conclusion
Monitoring of the weediness of field crop rotations has shown that the species composition of weeds and their number increases with the years. There were new 7 species of plants in the second rotation, 5 more new species in the third. The dynamics of the infestation of field crop rotations increases every year.

High saturation of crop rotation by crops increases the weediness of crops. Introduction to the rotation of perennial grasses reduces their weediness. Rotten crops reduce weediness, but the presence of protective zones during the processing of potatoes allows the weeds to successfully complete the vegetation in this area and contaminate the upper layer of the soil with seeds, which does not help to reduce the contamination of subsequent crops.

Cultivation of field crops by organic technology increases the weediness of crops. Crops of spring grain crops were the most weediness.

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