The influence of a fallow field on the formation of an agrocenosis and the productivity of spring wheat in the Orenburg Cis-Urals

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Abstract. The article presents the data of long-term field experience on the productivity of wheat and agrocenosis in crop rotations obtained under the influence of different types of fallow in the steppe zone of the Southern Urals. The aim of the study was to determine the influence of the aftereffect of precursors of different pairs in the formation of agrocenosis and productivity of spring wheat under conditions of unstable moisture in the steppe zone of the Southern Urals. Field experiments were carried out from 2011 to 2020 in rainfed conditions on two agricultural feeding grounds: fertilized \((\text{N}_{40}\text{P}_{80}\text{K}_{40})\) and unfertilized. Studies have established the consumption of productive moisture in a meter layer during the growing season of fallow crops and spring wheat. In occupied pairs, the largest amount of productive moisture is used (in the soil-protective one, 98.9 mm, in the green manure, 93.8 mm). A large amount of productive moisture is used by spring wheat (hard and soft) in the aftereffect of black fallows (111.0 and 96.3 mm, respectively). As a result of the replacement of black fallows in the crop rotation with occupied ones, the ratio of segetal vegetation in the agrocenosis changes, which leads to an increase in the number of perennials in the crops of the second and subsequent crops of the crop rotation. The use of different types of steam in crop rotations with the appropriate agricultural technology allows to reduce the contamination of crops by various groups of weeds.

1. Introduction

To increase the productivity of field crops and stable production of high quality grain in the steppe zone of the Southern Urals, it is necessary to improve the structure of arable land, taking into account the zonal climatic and soil characteristics, types of field crop rotations (when selecting predecessors that increase productivity), resource-saving soil cultivation systems [1,2].

An important criterion for assessing the effectiveness of agrocenoses is an increase in productivity achieved by creating high-potential varieties and improving cultivation technology while optimizing the timing and rates of organic and mineral fertilizers, as well as other factors without fallow land (especially in mono-crops, there is a decrease in yield and grain quality due to deterioration of soil fertility, increased weediness and infectious background (primarily in fields without the use of organomineral fertilizers) [3-6]. Cultivation on the same plot, differs little in the biology of plant groups for a long time, leads to an increase in weed infestation of crops and soil by weed species adapted for joint growth with crops [7].

At present, energy- and resource-saving technologies for the cultivation of agricultural crops with biological ecologized methods of plant protection are of paramount importance in the fight against
weeds [8]. The use of soil protection technology in the farming system within a short period of time contributes to the dominance of weedy crops and disrupts the ratio of weeds in the agrocenosis [9]. Intensive mechanical soil cultivation leads to a loss of organic matter as a result of a decrease in the supply of stubble and root residues [10,11].

The leading role in increasing the productivity of agricultural crops and weediness of agrophytocenoses is assigned to scientifically grounded crop rotations with alternating crops and fallow [12]. As the culture moves away from clean fallows, many scientists note an increase in weediness and a sharp increase in segetal vegetation of different biological groups in the third year of crop rotation [13-15].

2. Purpose of the study
To determine the influence of the action and aftereffect of fallow precursors with different types of fallow on the formation of agrocenosis and productivity of spring wheat with unstable moisture in the steppe zone of the Southern Urals.

3. Materials and research methods
Field experiments were carried out in dry conditions from 2011 to 2020, on the site of a long-term station on crop rotation and mono-crops of agricultural crops of the Federal State Budgetary Scientific Institution “Federal Research Centre of Biological Systems and Agricultural Technologies of the Russian Academy of Sciences”. The geographic location of the experimental site with coordinates - 51.775125° lat., 55.306547° east longitude are presented in figure 1.

![Figure 1. Geographic location of the experimental site.](image_url)
2.5 mg of phosphorus and 30-38 mg per 100 g of soil exchangeable potassium. Hydrogen exponent reaction of the soil medium pH = 7.0-8.1 (neutral, slightly alkaline).

The scheme of the experiment includes the following alternation of crops in crop rotations: I. 1. Black rock fallow - 2. Spring durum wheat - 3. Soft wheat - 4. Millet - 5. Soft wheat, barley; II. 1. Soil-protecting fallow (occupied with summer sowing of Sudanese grass) - 2. Spring durum wheat - 3. Spring soft wheat - 4. Millet - 5. Spring soft wheat - 6. Barley; III. 1. Green manure fallow (occupied with mixed sowing of peas - 2. Spring durum wheat - 3. Spring soft wheat - 4. Millet - 5. Spring soft wheat - 6. barley.

The study was carried out on two agricultural backgrounds (on one third of the plot, mineral fertilizers were applied at a dose of N40P40K40 for unpaired predecessors, the second part of the plot was not fertilized).

The size of fallow plots and under sowing of durum wheat, soft wheat (the second crop after steam) was against a background with fertilizer 14.4 x 30 m (432 m²), against an unfertilized background 14.4 x 60 (864 m²). When splitting the plots in the crop rotations of the fourth field into four plots, their size under millet, spring soft wheat (the fourth crop after fallow), barley was 3.6 x 30 m (108 m²) on a fertilized background, 3.6 x 60 m (216 m²).

4. Research results

Productive soil moisture is a limiting factor in the formation of the yield of field crops and, in general, the productivity of a hectare of arable land. In our experiment, soil moisture was determined at the beginning and end of the growing season of field crops on each plot of a six-field crop rotation. Table 1 shows the yield of spring wheat and fallow crops on two agricultural backgrounds and the amount of productive moisture they used over the years of research (on average for 2010-2020).

**Table 1.** Productivity of spring durum, soft wheat of fallow crops (t per 1 ha) on two nutritional backgrounds and the productive moisture used by them (mm) on average for 2011–2020.

| Type of fallow in a crop rotation | Option | Productive moisture during the sowing period of early cereals | Productive moisture consumed during the growing season | Productive moisture during the sowing period of early cereals | Productive moisture consumed during the growing season |
|----------------------------------|--------|------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------|-----------------------------------------------------|
| Black fallow                     | yield  | 34.4                                                      | 12.7                                                | 0.90                                                       | 36.8                                                | 30.2                                                | 0.83                                                       | 34.6                                                | 28.0                                                |
| Soil protecting                  | -      | 111.2                                                     | 25.3                                                | 0.78                                                       | 136.3                                               | 111.0                                               | 0.85                                                       | 121.4                                               | 96.3                                                |
| Green                            | 13.99  | 42.8                                                      | 35.2                                                | 0.76                                                       | 32.1                                                | 26.7                                                | 0.84                                                       | 34.8                                                | 26.0                                                |
|                                  | 12.78  | 143.5                                                     | 98.9                                                | 0.69                                                       | 109.2                                               | 89.6                                                | 0.83                                                       | 115.5                                               | 87.9                                                |
|                                  | 13.04* | 37.3                                                      | 29.6                                                | 0.70                                                       | 31.4                                                | 22.0                                                | 0.81                                                       | 32.2                                                | 24.7                                                |
|                                  | 9.41   | 117.9                                                     | 93.8                                                | 0.65                                                       | 113.3                                               | 85.3                                                | 0.79                                                       | 110.9                                               | 89.5                                                |

**Note:** yield data above the line - fertilized background, below the line - unfertilized background; productive moisture above the line - a layer of 0-30 cm, below the line - 0-100 cm, * - the yield of the green mass of fallow crops.

On average, over 10 years on plots with soil-protective (busy sowing grass sorghum) fallow in the spring, 143.5 mm of productive moisture accumulated in the meter layer of soil, the arable layer was also wetter than in black and green manure. In black fallows, due to the absence of projective vegetation...
and continuous cultivation in summer, all precipitation and part (25.3 mm) of the moisture reserves of the meter layer are unproductively spent on evaporation.

In occupied fallows (green manure and soil-protective), on average for 10 years, approximately the same (113.3 and 109.2 mm) amount of productive moisture accumulates and remains, which made it possible to obtain the yield of durum wheat on an ordinary agricultural background (without fertilizers) of 0.65 and 0.69 tons per hectare, respectively. The increase in the yield of durum wheat on black fallow with the use of mineral fertilizers was 0.12 tons per hectare, which allows us to conclude that black fallow is the best predecessor for it. On the second crop, after black fallow (soft wheat), there is no effect from the use of fertilizers (an excess of yield against the usual background by 0.02 tons per hectare).

The gross harvest of fodder units from the crop rotation link on a fertilized background due to the leafy mass of grass sorghum was 1.61 tons, without fertilizers, 1.50 tons per hectare (table 2). On average, over the years of research, a link with green manure fallow formed 1.38 tons for fertilized and 1.15 tons of feed units for unfertilized ones.

Depending on the type of fallow in crop rotations, various agro-technological methods are used, leading to an increase or decrease in segetal perennial and annual vegetation.

**Table 2.** Productivity of field crops and crop rotation links with different types of fallow on two backgrounds (on average for 2011-2020).

| Fallow type                        | Feed background | Productivity, t from 1 ha of feed units |
|------------------------------------|-----------------|----------------------------------------|
|                                    | seeded fallow   | durum wheat | soft wheat | by the link of crop rotation | fallow field precursor (barley) |
|                                    | green-manured   |             |            |                           |                                    |
| Weedfree strip-sown                 | I               | 1.14        | 1.06       | 0.73                       | 1.39                               |
|                                    | II              | 0.99        | 1.09       | 0.69                       | 1.23                               |
|                                    | A               | 0.61        | 0.66       | 0.41                       | 1.24                               |
|                                    | B               | 0.65        | 0.71       | 0.40                       | 1.00                               |
|                                    | A+B             | 0.09        | 0.11       | 0.11                       | 0.27                               |
| HCP<sub>05</sub> by factors        | I               | 2.80        | 0.96       | 1.07                       | 1.61                               |
|                                    | II              | 2.56        | 0.88       | 1.06                       | 1.50                               |
|                                    | A               | 0.77        | 0.75       | 0.70                       | 0.65                               |
|                                    | A+B             | 0.33        | 0.16       | 0.11                       | 0.12                               |
| Soil-protective (engaged in sowing Sudanese grass) | I               | 2.22        | 0.89       | 1.04                       | 1.38                               |
|                                    | II              | 1.62        | 0.82       | 1.01                       | 1.15                               |
|                                    | A               | 0.79        | 0.58       | 0.63                       | 0.59                               |
|                                    | A+B             | 0.70        | 0.73       | 0.73                       | 0.62                               |
|                                    | A               | 0.32        | 0.19       | 0.13                       | 0.13                               |
| Sideral (peas + oats)              | I               | 1.30        | 1.06       | 0.73                       | 1.15                               |
|                                    | II              | 0.89        | 0.65       | 0.41                       | 0.73                               |
|                                    | A               | 0.41        | 0.29       | 0.12                       | 0.41                               |
|                                    | A+B             | 0.32        | 0.19       | 0.13                       | 0.32                               |

**Note:** I - fertilized background, II - unfertilized. HCP05 is calculated taking into account the conversion of productivity to grain units.

The use of crop rotations with different types of fallow and the corresponding agricultural technology allows to reduce weed infestation by various groups of weeds. Particular attention is paid to soil cultivation in multi-pair crop rotations. So, when plowing with a fallow turnover, most of the annual weed vegetation is conserved, the seeds of which, falling to the bottom of the furrow, enter a state of dormancy and do not germinate from the soil surface. During the subsequent moldboard tillage, part of the seeds of previous years is again turned up on the surface, some of which lose their viability, which has a positive effect on the reduction of segetal (weed) vegetation in crops. This agrotechnical method
of moldboard plowing is used in crop rotations with green-manured fallows, in which, when using several (3–4) cultivations, the overwhelming amount of weeds, both annual and perennial, is destroyed (as a result of cutting the roots of perennials, plastic substances are actively used, which leads to exhaustion and death).

The viability of weed seeds with deep planting in the soil is lost within 4-5 years, and some species after 1-2 years. The alternation in the crop rotation of deep and shallow moldboard plowing makes it possible to deprive weed seeds of their viability.

With deep moldboard-free loosening in soil-protective crop rotations (occupied with summer sowing of Sudanese grass), there is no conservation of seeds of annual weeds that remain on the soil surface, germinate with abundant loss precipitation and perish during processing.

5. Conclusions

1. The use of an agronomic technique in the form of various fallows in crop rotations helps to reduce the infestation of crops by different groups of weeds.
2. Black pairs have a positive effect on the accumulation, maintenance of productive moisture and biological suppression of segetal annual vegetation.
3. The replacement of black fallows in the crop rotation by occupied ones causes a change in the ratio of weeds in the agrocenosis and leads to the growth of perennial weeds in the second and subsequent crops after a couple. So, on average, over 10 years of research, the number of perennial weeds for harvesting in soft wheat crops (the second crop after steam) in the aftereffect of soil-protective fallow on a fertilized background was 4.2 pcs., unfertilized 3.7 pcs. per 1 m², unfertilized 3.7 pcs. per 1 m². In the crop rotation with green manure, the number of perennials for harvesting the second crop after fallow on average over the years of the study was 3.2 pcs. on a regular background and 3.2 pcs. per 1 m² fertilized.

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