Fallow preceding crops of spring wheat on black soils of Western Transbaikal territory

A Batudaev, M Batueva, B Tsibikov, T Grebenschchikova, V Sobolev, O Altaeva, B Tsydyppov, G Chelpanov, S Mironov and Y Arbotneev

Faculty of Agronomy, Buryat State Academy of Agriculture named after V Philippov; 8, Pushkin Street, Ulan-Ude, 670024, Republic of Buryatia, Russia

E-mail: anton_batudaev@mail.ru

Abstract. The article presents the materials of the study of various preceding crops on the yield of spring wheat in the conditions of black soils in steppe zone of the Republic of Buryatia. The research is a comparative study of next forecrops: summer fallow, green manured fallow and seeded fallow. Crops sown on a seeded fallow are oil radish crops and pea-oat mixture. It was established that the yield of spring wheat on summer fallow for three years in average was – 15.9 c/ha, on the sown fallow (oil radish) - 13.3 c/ha, on the sown fallow (peas – oat) – 14.5 c/ha, green-manured fallow (oil radish) - 15.2 c/ha, and green-manured fallow (peas - oat) - 15.3 c/ha. In steppe zone of the Republic of Buryatia the best forecrop of spring wheat of breeds Buryatskaya 79 on black soil is summer fallow, both in dry and humid years. The best yield of top soil green mass and plant residues provides a pea - oat mixture among the crops in field test that were for seeded fallow crops.

1. Introduction.

Extreme natural and climatic conditions of Buryatia require a special approach to the development of system of farming, in view of low soil fertility, levity of granulometric composition of soils, small quantity of rainfalls, short vegetation seasons, widespread development of both wind and water erosion processes.

One of the main tasks of farming in these conditions is the preservation, maintenance and soil fertility recovery [1-3]. A. P. Batudaev consider that one of the main factors of positive changes in the system of farming of Buryatia at a sufficient level of productivity and environmental protection is improving agronomic principles of regulation of fertility and soil productivity by optimizing the alternation of crops in crop rotations, the use of plants which enrich soil with organic matter, as well as scientific-based and environmentally safe application of fertilizers [4].

The emphasis should be done to the use of green manured fallow and seeded fallow which is aimed at increasing the content of organic matter in the soil and can improve its structural and aggregate composition. Legumes are usually used as green manured crops [5]. In the conditions of Buryatia yellow sweet clover was studied in dry steppe zone on chestnut soils and there were studied such crops as peas, vetch, Sudan grass, oats, spring rape and oil radish in forest-steppes on grey forest soils [6]. But fallow forecrops on black soil remain not studied up to the present.

In this regard, the determination of the effectiveness of various kinds of fallowing which improve keeping, maintenance of soil fertility and the increase soil productivity remain nowadays a very urgent macroeconomic problem and requires its solution in the conditions of black soils of Buryatia.
The research objective is to study the influence of various fallow forecrops on the yield results and qualitative characteristics of grain crops on black soils in steppe territory of Buryatia.

2. Experimental case conditions and research methodology.

The territory on which the experimental study field is placed is included in soil zoning of the Republic of Buryatia in East Siberian territory of steppes of intermountain and mountain forests with low-humus chernozemic soils, chestnut, gray forest soils. On the territory is allocated Tugnuisko - Bichursky district of intermountain depressions with black soils, chestnut and gray forest soils.

The peculiarity of the development of soil cover of this territory is due to the continental climate, the sharp transition of the leveled surface to the mountainous terrain and expressed influence of exposures.

The soil of field study is typically chernozemic soil of mealy-carbonate, low-humus, low-power, light loamy soil. The main agrochemical indicators of the soil of field study are given on the table 1. The agrochemical properties of the powdery black carbonate soils of the field study are close to the data characterizing on the whole the type of this soil.

The main part of the arable lands of the farm is under the mealy-carbonate black soil. As a result of the soil study are shown chernozems with a shortened profile – horizon A+B1 less than 30 cm; low-power chernozems – horizon A+B1 30-40 cm, medium-horizon A+B1 more than 40 cm.

Chernozems with a shortened profile and with a low-power are formed on the slopes, foothills, characterized by a slight capacity of loose sediments and in various degrees of gravel. The medium black soils are formed on aligned surfaces at the foot of the Northern slopes composed of relatively powerful loose sediments.

According to the granulometric composition there are light-loamy and loamy kinds of soils. The humus content in humus horizon is shown to 4%, low humus content - 4-5%.

For the morphological characteristics of chernozems is given a description of the profile pit, laid on the territory of the test field.

| Depth (cm) | Description                                                                 |
|------------|------------------------------------------------------------------------------|
| O 0-22     | Dry brownish-dark, lumpy loam, loose, permeated with roots, distinct transition. |
| A 22-28    | Dry, brownish-dark, loam, lumpy, compacted, riddled with roots, the transition is distinct. |
| E 28-36    | Light, brownish-clear, loam, lumpy, compacted, crusted, distinct transition.  |
| B 36-58    | Fresh, brown, loam, lumpy, compacted, single roots, the transition is distinct. |
| C 58-87    | Fresh, whitish, light loam, without structure, compacted, boils from HCl, the transition is distinct. |
| R 87-100   | A fresh, whitish yellow, light loam, without structure, compacted, boils from HCl. |

The data in table 1 shows that the reaction of the soil solution is neutral, the humus content in the O – A horizons is 4.28-3.82%, the absorbed bases are respectively 25.2-18.5 mg-EQ per 100 g of soil.

| Soil type | Depth (cm) | pHkcl | Black soil, % | Absorbed bases, mg-EQ per 100 g of soil | Ca mg/100 g | Mg mg/100 g | P2O5 mg/100 g | K2O mg/100 g |
|-----------|------------|-------|---------------|----------------------------------------|------------|-------------|--------------|--------------|
| O horizon | 0-22       | 7.0   | 4.28          | 25.2                                   | 18.1       | 7.1         | 32.0         | 57.6         |
| A horizon | 22-28      | 7.1   | 3.82          | 18.5                                   | 13.5       | 5.0         | 30.2         | 57.9         |

The soil-absorbing complex is dominated by calcium. The content of mobile forms of phosphorus and potassium is high. The granulometric texture of mealy-carbonate chernozems (Table 2) is formed by dominance of fine sand fractions that do not have a developed active surface. Particles of this dimension are easily subjected to air transportation, which indicate a high probability of potential erosion processes and erosion practically when using these soils as croplands.
Table 2. Granulometric texture of the soil of the test field plot [7]

| Soil type                      | O horizon | A horizon |
|-------------------------------|-----------|-----------|
| Sampling depth (cm)           | 0-22      | 22-28     |
| 1.0-0.25 mm                   | 5.2       | 5.1       |
| 0.25-0.05                     | 38.5      | 53.2      |
| 0.05-0.01                     | 24.8      | 20.7      |
| 0.01-0.005                    | 10.6      | 6.0       |

Fraction content, % of absolutely dry soil

| ≥ 0.001 mm | 11.3 | 7.8 |
| 0.005-0.001 | 9.6  | 7.2 |
| ≤ 0.01 mm | 29.5 | 21.0 |
| ≤ 0.001 mm | 4.1  | 2.8 |

The name of the granulometric texture of soil light loam light loam

Mealy-carbonate chernozems differ by a fairly high density of composition. Soil density is 1.27-1.37 g/cm³ in the topsoil. The soil of test field has a complex of unfavorable agrophysical and agrochemical properties (high water permeability, low water holding capacity and low potential fertility). Thus, analyzing the above written, it can be concluded that the chernozems of the test field plot have a sufficient supply of nutrients, a small capacity of the humus horizon and sufficiently favorable water-physical properties. To increase their stable productivity and resistance to unfavorable nature and anthropomorphic conditions, it is necessary to use a set of measures to stabilize the humus content and optimize a physical composition of soil.

The growth and development of agricultural crops along with soil conditions are determined by the annual weather conditions, in particular by precipitations and weather temperature, especially during the growing seasons. During the years of research (2016-2018) meteorological conditions have developed differently (Table 3) on the territory of test establishment. During these years, very uneven precipitations were observed over ten-days period of growing season, although the total amount of precipitations was much lower in 2017. This year, precipitations fell 233 mm, in 2016 - 352 mm, and in 2018-306.5 mm with an average long-term norm of 284.1 mm. May-June drought was observed in all the years under consideration. So, in 2016, starting from the second decade of May to the end of June, only 22.5 mm precipitations fell, with an average long-term norm of 64.3 mm. A similar picture took place in 2017. In contrast of these two years, a different situation was noted in 2018 - 84.4 mm, which is significantly higher than other years. The temperature regime of growing season in all three years under consideration is significantly higher than the average long-term value. With an average long-term norm of temperature regime of 12.8°C, the temperature was in the range of 14.5-14.8°C in 2016-2018, and the average ten days air temperatures of 2016-2017 significantly exceeded the average annual value until the second decade of August.

The scheme of field test.
1. summer fallow (control)
2. seeded fallow (oil radish)
3. green-manure fallow (oil radish)
4. sown fallow (peas + oats)
5. green-manure fallow (peas + oats)

The plot area of field test is 25-50 m², accounting: for green manure – 10 m², for spring wheat – 25 m². Placing options is consistent in one tier. The replication is threefold.
Crop management practices of cultivation of crops sown on a summer fallow are made according to the zonal system of farming of Buryatia. Green manure was plowed from July 20 to July 25 with the PLN-4-35 plow without plow skimmers after preliminary grinding of the BDT-2.2 top ground mass.

Fertilizer background: without fertilizers. Breeds: spring wheat – Buryatskaya 79, oat - Mergen, pea - Aksayskiy, oil radish - Tambovchanka. Seeding time: wheat - 10-15 of May, fallow-grown crops – 25 of May. Seeding rate: spring wheat -5 million seeds per 1 ha. Seeding depth: spring wheat - 6-8 cm, peas + oats - 6-8 cm, oil radish - 2-2.5 cm.

3. Results and Discussion

At present, the problem of improving soil fertility and productivity is becoming highly relevant due to decrease of soil fertility, the lack of sufficient amounts of organic fertilizers application (manure) and high prices of mineral fertilizers. A.P. Batudaev in his research on chestnut soils of Buryatia [4] notes that a special place among the forecrops is occupied by fallows – summer and seeded fallows. It should be noted that fallowing has not lost its great importance in farming of Buryatia still nowadays. However, with all its positive properties, summer fallow has some unsatisfactory features. They are – the lack of harvest during the year of fallowing and activation of the process of destruction of soils’ organic matter, the complexity of protecting soil from wind and water erosions. For these reasons, as an alternative to summer fallow can be used seeded and green-manure fallows.

The adoption of green manure and sown fallow into the crop rotation systems can serve as a very low cost method of maintaining the fertility of soils. Legumes are most often used as green manure.
crops. It is known that the effectiveness of crops as green manure is determined by the yield of biological mass applying in the soil when it is plowed and by the content of nutrients in them. A.A. Vasiliev in his research [8] in forest-steppe zone of the southern Urals noted that during green manure crop fallow the annual crops are able to make from 14.95 t/ha to 30.30 t/ha of green mass, which provides the application of dry organic matter from 3.15 t/ha to 6.21 t/ha into the soil.

In our researches, the most common crops for cultivation in farms of Buryatia are studied - oil-radish and pea-oat mixture crops. According to our data, it is obtained that under the conditions of chernozemic soils of steppe zone of Buryatia, the yields of top-ground green mass of crops sown on a summer fallow and the yield of plant residues differ significantly during the years of the research. The yield of the top-ground mass of pea-oat mixture crop over three years in average is 11.7 t/ha, and in the oil-radish - 9.7 t/ha, which exceeds to 17.1% (table 4).

**Table 4. Yield of top-ground mass and plant residues (t/ha)**

| Crops sown on a summer fallow | the yield of the top-ground mass | plant residues |
|-------------------------------|--------------------------------|---------------|
|                               | 2015  | 2016 | 2017 | x   | 2015 | 2016 | 2017 | x   |
| pea + oat                     | 12.7  | 11.5 | 10.8 | 11.7 | 1.9  | 1.7  | 1.4  | 1.7 |
| oil radish                    | 10.3  | 9.5  | 9.2  | 9.7  | 1.6  | 1.2  | 1.1  | 1.3 |

The yield of plant residues in pea+oat mixture is also slightly higher than that of oil radish, 1.7 t/ha and 1.3 t/ha, respectively.

In the selection of green manure crops for the conditions of the steppe zone of Buryatia [6] on gray forest soil, it was established that preference should be given to cabbage crops (spring rape and oil radish), which accumulate respectively 14.3 and 11.5 t/ha. In the tested cereal crops, the yield of the top-ground mass varies from 8.6 t/ha (Sudanese grass) to 11.3 t/ha (oats for green mass). Close yield levels were obtained for legumes – 9.6 t/ha in vetch and 9.9 t/ha in peas.

Our studies provide for the use of this mass in one case for incorporation into the soil during sieration and use as feed, in the second case. When green manuring wraps himself all biological mass of crops, the cultivation of their on a seeded fallow of plant residues.

Different conditions for the growth and development of spring wheat, formed by the predecessors determined the magnitude of the yield. We have determined the yield of grain of spring wheat for three years (table 5). In conditions of dry years (2016 and 2017) for all the considered variants of the experience, the yield of spring wheat is significantly inferior to the yield of 2018, which turned out to be more moist.

**Table 5. Productivity of spring wheat depending on predecessors, (t/ha)**

| Fallow preceding                  | 2016 | 2017 | 2018 | x   |
|----------------------------------|------|------|------|-----|
| summer fallow (control)          | 1.4  | 1.4  | 2.0  | 1.6 |
| seeded fallow (oil radish)       | 1.1  | 1.1  | 1.8  | 1.3 |
| green-manure fallow (oil radish) | 1.2  | 1.3  | 2.1  | 1.5 |
| sown fallow (peas + oats)        | 1.1  | 1.3  | 1.9  | 1.4 |
| green-manure fallow (peas + oats)| 1.3  | 1.3  | 2.0  | 1.5 |

| NSR0.95 (t/ha)                   | 0.21 | 0.19 | 0.37 |

During three years in average, the highest yield of spring wheat is obtained by summer fallow, a bit less as to green manure fallow (oil radish and pea-oat mixture). The lowest yields were observed for the sown fallow. It should be noted that in more humid years, green manure fallow provides the yield of spring wheat on the level of spring fallow. Therefore, the best forecrops is summer fallow in the conditions of chernozemic soils of forest-steppe zone. Green manure fallow somehow loose in the productivity to summer fallow, but keep ahead the seeded fallow.
4. Conclusion
On the black soils in the steppe zone of the Republic of Buryatia the best forecrop of spring wheat breeds of Buryatskaya 79 is summer fallow both in drought and humid years. So in exceptionally dry years (2016-2017) for the summer fallow obtained 1.6 t/ha of spring wheat grain. On average, over the years of research, the yield of spring wheat for sown fallow was in the range of 1.3-1.4 t/ha, and for green manure fallow it was at the level of 1.5 t/ha.

Considered in field test of seeded fallow, a pea-oat mixture provides the best yield of top-ground green mass and plant residues. The yield of the above-ground mass of the pea-oat mixture averages over three years 11.7 t/ha and in the oil radish 9.7 t/ha, and the yield of plant residues in the pea-oat mixture is also higher than that of the oil radish (1.7 t/ha and 1.3 t/ha, respectively).

In the steppe zone of the Republic of Buryatia on the black soil, such seeded fallow as pea-oat mixture and oil radish mixture can be considered promising for their use in the green manure fallow.

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