Buckwheat productivity depending on agrotechnological techniques of growing in the Krasnoyarsk forest-steppe

V V Keler and O V Martynova
Krasnoyarsk State Agrarian University, 90 Mira Avenue, 660049, Krasnoyarsk City, Russia
E-mail: vica_kel@mail.ru

Abstract. The article describes the application results of various previous crops and pre-sowing using of nitrogen fertilizers for the planned yield for zoned buckwheat varieties in the forest-steppe of the Krasnoyarsk territory. On the basis of the conducted research it is established that statistically significant differences on average productivity of buckwheat were found between studied previous crops, the index of influence was 83.4 %. The maximum average yield increase was observed when buckwheat was sown after potatoes (41.6 c/ha), the minimum (16.4 c/ha) – after previous grain. The greatest reaction to the introduction of ammonium nitrate had Dasha variety, whose average yield for all three previous crops was 38.1 c/ha, and its highest yield was recorded after fertilized potatoes - 50.7 c/ha.

1. Introduction
Buckwheat is the most popular in Russia due to its dietary, taste and nutritional properties. This is due to the high content of digestible proteins, carbohydrates and ash substances, a large share of which falls on P, Ca, Fe, Mn, Cu, Mg, Co. Buckwheat proteins consisting mainly of globulin and gluten are more complete than the proteins of cereals and in terms of nutrition and digestibility are not inferior to leguminous proteins.

2. Methods and results
In 2017 this important cereal crop occupied the country’s area of 1.7 million hectares with an average yield of 1.5 million tons. Moreover, the area is increased by 500 000 ha in comparison with the year 2016. This trend is also noted in the Krasnoyarsk territory: in 2017 the area with buckwheat increased more than twice (table 1).

| Indicators          | 2014 | 2015 | 2016 | 2017 |
|---------------------|------|------|------|------|
| sown area, ha       | 4 213| 3 315| 3 505| 7 240|
| gross production, c | 27 780| 25 094| 20 511| 38 178|
| yield, c/ha         | 6,6  | 7,6  | 5,9  | 5,3  |
Despite the increase in the volume of acreage the yield of this crop remains very low and varies from 5.3 to 7.6 c/ha with an average of 10.1 c/ha in Russia and 22.5 c/ha in the world. At the present stage the State register of breeding achievements approved for use in the Krasnoyarsk territory includes five varieties of buckwheat: Dikul, Design, Zemlyachka, Natasha and Yashlek. Their potential yield is more than 40 c/ha. Therefore, it is obvious that such low yield is due not only to the harsh weather conditions of the agricultural territory in our region, but also to non-compliance with agricultural machinery. Modern agricultural producers can not meet all the biological requirements of buckwheat and reaction of this crop to such agricultural level is extremely low. The growth of buckwheat yield and the achievement of high quality of its grain are possible with the use of intensification means: fertilizer application, the use of growth regulators, chemical protection and methods of accelerating maturation [1].

In connection with the above, the purpose of our research was to study the reaction of zoned and promising buckwheat varieties to fertilizers for the planned yield after various previous crops.

Object and methods of research. Five varieties of buckwheat were used as the object of research, Temp is a mid-early variety and four varieties Dikul, Druzhina, Dasha and Zemlyachka are mid-matured. The experience was carried out in 2017 in the forest-steppe of the Krasnoyarsk territory on the experimental field "Minderlinskoye". Corn, potatoes and grain were selected as previous crops. The soil was luvic Chernozem. Sowing date was 25 thof May. The seeding rate was 3.0 million grains/ha, the method of sowing was ordinary, depth of sowing was 5 cm, the total area of the plot was 12 m², accounting area was 10 m², repeat seeding was fourfold, serial arrangement. To assess the effective fertility in spring before the experiment soil samples were selected, in which the amount of mobile phosphorus, exchangeable potassium and nitrogen was determined. Agrochemical analysis of the soil by its previous crop showed that the content of P2O5 and K2O was high and very high, and nitrate nitrogen was low and very low. As a nitrogen fertilizer before sowing ammonium nitrate was used for the planned yield of 40 c/ha [2]. Phosphorus and potassium were not introduced due to the high content. The results were processed statistically [3] using the software package "Excel»

Weather conditions of the growing season had differences in the amount of moisture and the average daily temperature regimes in comparison with the average annual data (table. 2).

| Indicators                                           | June | July | August | September |
|------------------------------------------------------|------|------|--------|-----------|
| Average daily temperature, °C (2017)                 | 20,4 | 19,5 | 16,9   | 8,4       |
| Temperature, °C - annual average indicator           | 15,2 | 18,4 | 14,9   | 8,2       |
| Amount of precipitation, mm (2017)                   | 21   | 79   | 81     | 79        |
| Precipitation, mm - annual average indicator         | 44   | 69   | 62     | 39        |
| the hydrothermal coefficient(2017)                   | 0,34 | 1,31 | 1,55   | 3,1       |
| the hydrothermal coefficient annual average indicator| 0,96 | 1,21 | 1,26   | 1,6       |

The first month of vegetation was characterized by increased average daily temperature; the difference with the average annual temperatures was more than 5 °C, so the hydrothermal coefficient was only 0.34 units against 0.96 units of average annual [4]. This value of hydrothermal coefficient is characteristic of a severe drought and the zone of deserts and semi-deserts. July in its hydrothermal characteristics was similar to the average annual data. August was characterized by higher temperatures and precipitation, in connection with which the hydrothermal coefficient exceeded the average annual value by 0.3 units and amounted to 1, 55, which is typical for the wet zone of sufficient moisture. In 2017 September was the most abnormal month of vegetation with high rainfall, snow, and as a result,
the hydrothermal coefficient exceeded 3.0, which affected the period of ripening and harvesting negatively.

After processing by methods of mathematical statistics we have obtained the following results (table 3.)

Table 3. The results of statistical analysis of data on the buckwheat yield for various previous crops and backgrounds in the forest steppe of the Krasnoyarsk territory, c/ha.

| Variety | corn | potato | grain |
|---------|------|--------|-------|
|          | without fertilizers | with ammonium nitrate | without fertilizers | with ammonium nitrate | without fertilizers | with ammonium nitrate |
| average | 24,1±3,1 | 24,2±3,7 | 41,6±2,3 | 44,8±1,9 | 16,4±1,4 | 35,1±2,8 |
| min     | 17,5 | 13,1 | 33,7 | 39,8 | 13,3 | 30,9 |
| max     | 32,8 | 33,1 | 47,4 | 50,7 | 20,7 | 46,2 |

In 2017 the variety Temp had the lowest yield in the conditions of the Krasnoyarsk forest-steppe: on average for all three previous crops without fertilizers its productivity amounted to 22.1 c/ha, when ammonium nitrate was used yield increased by 6.0 c/ha - 28.0 c/ha. It should be noted when this variety was planted after potatoes its productivity reached 33.7 c/ha, and after spring wheat fell to 13.6 c/ha.

Analysis of the best yield showed that the variety Druzhina had the highest productivity on the unfertilized previous crop: 32.1 c/ha, it had the highest reaction after potatoes: 43.1 c/ha The variety Dasha had the greatest reaction to the introduction of ammonium nitrate, whose yield averaged 38.1 c/ha for all three previous crops, and its highest yield was on fertilized potatoes - 50.7 c/ha. The average yield of the variety Druzhina was slightly lower after using nitrogen: 35.1 c/ha and 40.8 c/ha, respectively.

![Figure 1](image-url)  
**Figure 1.** Variability in the average buckwheat yield after the previous crops without additional fertilization, c/ha.

Statistically significant (p<0.05) differences in the average yield of buckwheat (at P=2.22 E-05) were found between the studied previous crops, the index of influence was 83.4 %. The maximum average yield increase was observed when buckwheat was sown after potatoes (41.6 c/ha), the minimum (16.4 c/ha) – after grain as previous crop (figure 1, table 5).
Table 4. Results of dispersion analysis of the previous crop influence on the buckwheat productivity in the forest-steppe of the Krasnoyarsk territory.

| Source of variation | SS      | df | MS       | F        | P-value | F critical |
|---------------------|---------|----|----------|----------|---------|------------|
| Among districts     | 1666,267| 2  | 833,1336 | 29,79767 | 2,22E-05| 3,885294  |
| Inside districts    | 335,5163| 12 | 27,95969 | -        | -       | -          |
| Subtotal            | 2001,783| 14 | -        | -        | -       | -          |

Figure 2. Variability of the buckwheat average yield on previous crops after applying fertilizers, c/ha.

Statistically significant (p<0.05) differences in the average yield of buckwheat (at P=0.001) were found between the studied previous crops under the condition of their fertilization with ammonium nitrate, the index of influence was 66.6 %. The maximum average yield increase was observed when buckwheat was sown after fertilized potatoes (44.8 c/ha), the minimum (24.2 c/ha) – after corn as previous crop (figure 1, table 5).

Table 5. Results of dispersion analysis of the fertilized previous crop influence on the buckwheat productivity in the forest-steppe of the Krasnoyarsk territory.

| Source of variation | SS      | df | MS       | F        | p-value | F critical |
|---------------------|---------|----|----------|----------|---------|------------|
| Among districts     | 1025,476| 2  | 512,7381 | 11,97526 | 0,001383| 3,885294  |
| Inside districts    | 513,7975| 12 | 42,81646 | -        | -       | -          |
| Subtotal            | 1539,274| 14 | -        | -        | -       | -          |

On the basis of the conducted research it was established that

1. Statistically significant (p<0.05) differences in the average yield of buckwheat (at P=2.22E-05) were found between the studied previous crops without ammonium nitrate, the index of influence was 83.4 %. The maximum average yield increase was observed when buckwheat was sown after potatoes (41.6 c/ha), the minimum (16.4 c/ha) – after grain as previous crop.

2. Statistically significant (p<0.05) differences in the average yield of buckwheat (at P=0.001) were found between the studied previous crops under the condition of their fertilization with ammonium nitrate, the influence index was 66,6 %. The maximum average yield increase was observed when
buckwheat was sown after fertilized potatoes (44.8 c/ha), the minimum (24.2 c/ha) – after corn as previous crop.

3. Analysis of the best yield showed that the variety Druzhina had the highest productivity on the previous crop without nitrogen: 32.1 c/ha, it had the highest reaction after potatoes: 43.1 c/ha.

4. The variety Dasha had the greatest reaction to the using of ammonium nitrate, whose yield averaged 38.1 c/ha for all three previous crops, and its highest yield was on fertilized potatoes - 50.7 c/ha.

References
[1] Dmitriev V E and Keler V V 2007 Intensification of agricultural practices in the cultivation of spring wheat in Eastern Siberia Siberian Bulletin of agricultural science pp 5-10
[2] Arinushkina E V 1970 Manual of soil chemical analysis (Moscow: Moscow State University Press) p 478
[3] Dospekhov B A 1985 Methodology of field experience with the basics of statistical data processing (Moscow: Agropromizdat) p 351
[4] Keler V V 2007 Ecological and varietal features of technological qualities formation of spring wheat in forest-steppe of the Krasnoyarsk territory (Krasnoyarsk: Krasnoyarsk state agrarian university) p 123