

# Formation of turnip yield when using mineral fertilizers in the conditions of the Republic of Bashkortostan

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**Abstract.** The paper presents data on the study of the formation of turnip yields when using various doses of mineral fertilizers in the Republic of Bashkortostan on leached chernozems. The object of the study is the turnip of the Ostersundomsky variety (approved for use in the Republic of Bashkortostan and the Ural region) and options for applying various doses of mineral fertilizers (NPK), the forecrop is winter wheat. The analysis of yield dynamics, dry matter content, crude protein, crude fiber, crude fat, and ash was carried out with the use of various doses of mineral fertilizers. The results of collecting feed units, digested protein, and feed protein units are shown. The yield and the prospect of growing turnips with the use of various doses of mineral fertilizers in the Republic of Bashkortostan are estimated, and the profitability of cultivation is also calculated.

## 1 Introduction

The urgent tasks of agriculture include the fundamental improvement of feed production and meeting the feed needs of public livestock and livestock owned by citizens.

In strengthening the agriculture forage base, an important place belongs to the cultivation of crops in intermediate crops, which make it possible to obtain two or three harvests per year due to the fullest use of the main factors of plant life by creating a powerful photosynthetic potential in them and prolonging its action throughout the growing season. Turnip catch-crop seedings are an essential source of forage in late autumn.

But increasing the yield of turnips and its feed value is still imperfect, and this raises the question of finding optimal doses of mineral fertilizers to increase the yield and, accordingly, the feed value of this crop [3, 8, 10].

The purpose of the research is to study the productivity and feed qualities of turnip root crops in the conditions of the Republic of Bashkortostan.

In accordance with the purpose set, the following tasks are defined:

- conducting a review of the literature on the research topic;
- laying of field experience in the cultivation of turnips with the use of mineral fertilizers;

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- to study the peculiarities of turnip growth and development when using mineral fertilizers;
- to determine the turnip yield and feed advantages when using mineral fertilizers;
- to give an economic assessment of the conducted experiments and identify the most cost-effective options for cultivating turnip when using mineral fertilizers.

The scientific novelty of the work consists in the fact that it was found that high yield, feed advantages and profitability were observed in the variant where the calculation of NPK for the planned harvest of 600 kg/ha for the conditions of the Republic of Bashkortostan.

## 2 Materials and Methods

The main research methods were field experiment, laboratory analyses, and statistical data processing. Field experiments were conducted in 2021-2022 in the Republic of Bashkortostan, Russia.

The object of the study is the turnip of the Ostersundomsky variety (approved for use in the Republic of Bashkortostan and the Ural region) and options for applying mineral fertilizers (NPK).

The accounting plot area is 28.8 m<sup>2</sup>. The length and width of the accounting plot are respectively 30 m and 0.96 m. The repetition of the options is 4-fold. The soil of the experimental site was represented by leached chernozems of heavy loamy granulometric composition with plain relief. The forecrop was winter wheat.

The average daily air temperature was considered from April to October. In general, the temperature regime was similar except for the months of May and June, during this period in 2021 the average daily air temperature was higher than in 2022.

The year 2022 was more productive in terms of precipitation, nevertheless, at the same time minimal compared to the norms for our Republic of Bashkortostan and the central part of Russia. In 2021, there was a critical minimum in terms of precipitation. Consequently, the weather conditions in 2022 were more favorable for the cultivation of crops than the weather conditions in 2021.

The experiment scheme was as follows:

1. Without fertilizers (control);
2. Calculation of NPK for the planned yield of 400 kg/ha;
3. Calculation of NPK for the planned yield of 500 kg/ha;
4. Calculation of NPK for the planned yield of 600 kg/ha.

Factor – options for applying mineral fertilizers.

In the analytical laboratory of the Bashkir State Agar University, analyses of turnip root crops were carried out, where they determined the following:

- content of dry substances by moisture distillation method;
- content of protein substances in plants according to Barnstein;
- content of crude fiber according to Henneberg and Shtoman;
- content of "raw" ash by accelerated combustion;
- content of crude fat by repeated drying.

The calculation of gross energy is determined based on the results of the chemical composition and the corresponding energy coefficients. The content of metabolic energy in the dry matter of the feed is determined by the Axelson formula in the modification of N.G. Grigoriev and N.P. Volkov. The content of feed units and digested protein was calculated according to generally accepted formulas. Formulas were also used to translate units of measurement and calculate the economic part of the experiments [1, 4, 9].

### 3 Results and Discussion

Harvesting includes several stages: harvesting, yield delivery to the place of post-harvest processing, post-harvest processing, transportation of finished products to warehouses (or for sale), laying for storage [6,7].

**Table 1.** Yield of turnips depending on the calculation of doses of mineral fertilizers for the planned harvest, kg/ha.

| No. | Calculation of NPK for the planned yield | Yield, c/ha |
|-----|--|-------------|
| 1   | Without fertilizers (control)            | 134         |
| 2   | Per 400 kg/ha                            | 152         |
| 3   | Per 500 kg/ha                            | 177         |
| 4   | Per 600 kg/ha                            | 203         |

Due to the fact that weather conditions differed during the years of the experiments, yield indicators varied depending on the year, but had a general increase depending on the norms of fertilizers applied.

On average, over two years of research, the yield of turnips in the control option was 134 c/ha, in the option where the calculation of NPK was 400 c/ha – 152 c/ha, in the option where the calculation of NPK was 500 c/ha – 177 c/ha, and in the option where the calculation of NPK was 600 c/ha – 203 c/ha (Table 1).

The dry matter content was inversely proportional to the yield of this crop.

**Table 2.** The dry matter content in turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield on average for 2021-2022, %.

| No. | Calculation of NPK for the planned yield | Dry matter content, % |
|-----|--|-----------------------|
| 1   | Without fertilizers (control)            | 10.45                 |
| 2   | Per 400 kg/ha                            | 9.96                  |
| 3   | Per 500 kg/ha                            | 8.01                  |
| 4   | Per 600 kg/ha                            | 7.32                  |

In the control option, the dry matter content was higher than in the other options and amounted to 10.45%, in the option where the calculation of NPK was at 600 c/ha, the dry matter content was 7.32%, in the option where the calculation of NPK was at 500 c/ha and 400 c/ha - 8.01% and 9.96%, respectively (Table 2).

Of the root crops, turnips are the most watery food. Turnips are used as a forage crop in many countries of the world, including Russia, and are widely used in feeding farm animals.

Turnip is a lactiferous fodder for cows and goats. It increases milk yield and improves milk quality [2,5].

The crude protein content in turnip roots is shown in Table 3. The crude protein content varies from 6.56% (without fertilizers (control)) to 8.41% (calculation of NPK per 600 kg/ha).

**Table 3.** The content of crude protein in turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield, on average for 2021-2022, %.

| No. | Calculation of NPK for the planned yield | Crude protein content per absolutely dry matter, % |
|-----|--|--|
| 1   | Without fertilizers (control)            | 6.56   |
| 2   | Per 400 kg/ha                            | 7.29   |
| 3   | Per 500 kg/ha                            | 7.88   |
| 4   | Per 600 kg/ha                            | 8.41   |

The content of crude fiber in turnip root crops, depending on the calculation of mineral fertilizers for the planned yield, in the control option amounted to 4.03%, in the 400 c/ha option increased by 0.74%, in the 500 c/ha option it amounted to 5.13% (Table 4).

**Table 4.** The content of crude fiber in turnip root crops, depending on the doses of calculation of mineral fertilizers for the planned yield, on average for 2021-2022, %.

| No. | Calculation of NPK for the planned yield | Crude fiber content per absolutely dry matter, % |
|-----|--|--|
| 1   | Without fertilizers (control)            | 4.03   |
| 2   | Per 400 kg/ha                            | 4.77   |
| 3   | Per 500 kg/ha                            | 5.13   |
| 4   | Per 600 kg/ha                            | 6.74   |

The content of crude ash in turnip root crops during the years of research (2021-2022) showed an increase in average values as the calculated doses of mineral fertilizer increased.

It should also be noted that the highest indicator was in the variant where 600 kg/ha was added at the rate of the planned harvest - 7.12% for absolutely dry matter. In the control option it was 4.60%. In the option for 400 c/ha – 5.59%, and 1.05 more in the option where the calculation was made for the planned yield of 500 c/ha (Table 5).

**Table 5.** The content of crude ash in turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield, on average for 2021-2022, %.

| No. | Calculation of NPK for the planned yield | Content per absolutely dry matter, % |
|-----|--|--------------------------------------|
| 1   | Without fertilizers (control)            | 4.60                                 |
| 2   | Per 400 kg/ha                            | 5.59                                 |
| 3   | Per 500 kg/ha                            | 6.64                                 |
| 4   | Per 600 kg/ha                            | 7.12                                 |

The crude fat content in turnip roots is shown in Table 6. Based on the presented data, we noted that the crude fat content also increases as the calculated doses of fertilizers used increase. Thus, in the control option, the crude fat content was 0.83%, already in the option where 400 kg/ha were added for the planned yield, the crude fat content was 0.91%, at 500 kg/ha – 1.13%, and in the option with 600 kg/ha increased to 1.23%.

**Table 6.** The content of crude fat in turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield, on average for 2021-2022, %.

| No. | Calculation of NPK for the planned yield | Crude fat content per absolutely dry substance, % |
|-----|--|---|
| 1   | Without fertilizers (control)            | 0.83  |
| 2   | Per 400 kg/ha                            | 0.91  |
| 3   | Per 500 kg/ha                            | 1.13  |
| 4   | Per 600 kg/ha                            | 1.23  |

The content of nitrogen-free extractives (NFE), on the contrary, decreased as the calculated doses of fertilizers used increased. In the fourth option it was 76.50%, in the third - 79.22%, in the second option - 81.44%. In the control version, this indicator was 83.98% (Table 7).

**Table 7.** The content of nitrogen-free extractives (NFE) in turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield on average for 2021-2022, %.

| No. | Calculation of NPK for the planned yield | Crude fat content per absolutely dry substance, % |
|-----|--|---|
| 1   | Without fertilizers (control)            | 83.98   |
| 2   | Per 400 kg/ha                            | 81.44   |

|   |               |       |
|---|---------------|-------|
| 3 | Per 500 kg/ha | 79.22 |
| 4 | Per 600 kg/ha | 76.50 |

The forage value of plants is determined by the content of nutrients, the degree of their digestibility, as well as the digestibility of animals. A conventional feed unit with a certain productive effect has been adopted as a unit of measurement of the total nutritional value of feed.

**Table 8.** Gross harvest of fodder units of turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield on average for 2021-2022, kg/ha.

| No. | Calculation of NPK for the planned yield | Collection of feed units, kg/ha |
|-----|--|---------------------------------|
| 1   | Without fertilizers (control)            | 13.49                           |
| 2   | Per 400 kg/ha                            | 20.55                           |
| 3   | Per 500 kg/ha                            | 24.36                           |
| 4   | Per 600 kg/ha                            | 46.83                           |

Data on the gross harvest of feed units showed the following results: the control option was 13.49 c/ha; in the option where the calculated dose was 400 c/ha for the planned yield - 20.55 c/ha, in the option where the calculated dose was 500 c/ha for the planned yield - 3.81 c/ha, in the option where the calculated dose was 600 c/ha for the planned yield - 46.83 c/ha (Table 8).

**Table 9.** Collection of digestible turnip protein depending on the calculation of doses of mineral fertilizers for the planned yield on average for 2021-2022, kg/ha.

| No. | Calculation of NPK for the planned yield | Collection of digestible protein, c/ha |
|-----|--|--|
| 1   | Without fertilizers (control)            | 2.67                                   |
| 2   | Per 400 kg/ha                            | 3.46                                   |
| 3   | Per 500 kg/ha                            | 4.57                                   |
| 4   | Per 600 kg/ha                            | 5.25                                   |

Data on the collection of digestible protein are presented in Table 9. The collection of digestible protein varied from 2.67 c/ha (control option) to 5.25 c/ha (option - 600 c/ha). In the options where the planned yield was calculated for 400 and 500 kg/ha – 3.46 and 4.57 kg/ha.

**Table 10.** The content of feed protein units (FPU) in turnip root crops, depending on the calculation of doses of mineral fertilizers for the planned yield on average for 2021-2022, c/ha.

| No. | Calculation of NPK for the planned yield | FPU, c/ha |
|-----|--|-----------|
| 1   | Without fertilizers (control)            | 18.76     |
| 2   | Per 400 kg/ha                            | 25.86     |
| 3   | Per 500 kg/ha                            | 32.75     |
| 4   | Per 600 kg/ha                            | 47.02     |

Fodder protein units (FPU) are the final indicator of the fodder value of turnips and other fodder root crops.

In our experiments, the FPU showed results from 18.76 c/ha (control option) to 47.02 (at an estimated dose of 600 c/ha for the planned yield) – in this case, the difference is significant, which indicates a positive result of our experiments (Table 10).

Data on the economic efficiency of turnip cultivation in the Republic of Bashkortostan on average for 2021-2022 are presented in Table 11.

**Table 11.** Economic efficiency of turnip cultivation, on average for 2021-2022.

| Indicators                      | Experiment options            |               |               |               |
|---------------------------------|-------------------------------|---------------|---------------|---------------|
|                                 | Without fertilizers (control) | Per 400 kg/ha | Per 500 kg/ha | Per 600 kg/ha |
| Yield per 1 ha, t               | 13.4                          | 15.2          | 17.7          | 20.3          |
| yield increase from 1 ha, t     | 0.0                           | 1.8           | 4.3           | 6.9           |
| Cost of products per 1 ha, rub. | 33500.0                       | 53200.0       | 70800.0       | 101500.0      |
| Cost of 1 c of products, rub.   | 28761                         | 33479         | 31339         | 29594         |
| Cost recovery, %                | 86.9                          | 104.5         | 127.6         | 169.0         |
| Profitability, %                | -13.1                         | 4.5           | 27.6          | 69.0          |

In the control option, the profitability was negative and amounted to -13.1%, in the option with 400 kg/ha for the planned yield, the profitability was 4.5%, in the option with 500 kg/ha for the planned harvest, the profitability increased to 27.6%, in the option with 600 kg/ha for the planned harvest, the profitability was maximum and amounted to 69.0% (Table 11).

## 4 Conclusion

Based on the data from field experiments and laboratory studies, we concluded that, on average, over two years of research, the yield of turnips in the control option was 134 c/ha, in the option where the calculation of NPK was 400 c/ha – 152 c/ha, in the option where the calculation of NPK was 500 c/ha – 177 c/ha, and in the option where the NPK calculation was for 600 c/ha – 203 c/ha.

The dry matter content in the control option is higher than in the others and amounted to 10.45%, in the option where the calculation of NPK was at 600c/ha, the dry matter content was 7.32%, in the option where the calculation of NPK was at 500c/ha and 400 c/ha was 8.01% and 9.96%.

According to the chemical composition, turnips showed the following results: the content of crude protein, crude fiber, crude ash, and crude fat increased with increasing doses of applied mineral fertilizers, and the content of NFE decreased.

The experiment option is without fertilizers, that is, the control option has low indicators for collecting feed units, collecting digestible protein, and collecting feed protein units. High rates in the option where fertilizers were applied for the planned yield at the rate of 600 kg/ha.

From an economic point of view, it is most cost-effective to cultivate turnips for a planned yield at the rate of 600 kg/ha. The profitability was 69%.

In turnip crops in the conditions of the Republic of Bashkortostan, we recommend using the option where the calculation of NPK for the planned yield 600 kg/ha.

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