Crop productivity and variety differences in the content of major nutrient elements in the seeds of garden bean

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Abstract. Bean is a valuable food plant. According to the sown area in the world, bean takes the second place after the soybeans among the cereals (about 24 million hectares). In Russia the area for it is about 53 thousand hectares. The average yield of the varieties of garden bean seeds in the South Transurals on the average for 3 years of study formed at a good level and amounted to the following varieties: Rubin – 2.31, Snezhana (Krasnodar) – 2.54, Oran – 2.12 t/ha. Vegetable bean varieties formed a good crop for the climatic zone, respectively: Moscow White (standard) – 2.75, Sobrat (Krasnodar) – 1.53, Amalthea (Krasnodar) – 1.79 t/ha; Novosibirsk vegetable bean varieties: Darina – 1.53, Solnyshko – 1.47, Viola – 1.40, Yantarnaya – 1.47 t/ha. It is established that there are varietal differences, i.e. the reaction of varieties on the accumulation of nitrogen, phosphorus and potassium in the seeds.

1. Introduction

In global agriculture the area of grain legume exceeds 100 million hectares and occupies 13% of the area of the grain crops. Among the main grain legume (peas, vetch, lentils, chin, chickpeas, horse beans, beans, soybeans, lupine) soybean, bean and peas are most prevalent. According to the sown area in the world bean takes the second place after soybeans among the cereals (about 24 million hectares). In our country the area under it is about 53 thousand hectares [1–4].

In the Russian Federation bean crops are concentrated mainly in the central and Southern regions of the European part of the country. Bean is a valuable high–protein culture having a multilateral use in the national economy. Its main purpose is food: seeds and beans are eaten fresh and canned, and they are a source of essential amino acids for the human body.

In the culture bean is represented by more than 20 varieties, however, no more than 6 varieties are of practical importance in our country, and only two varieties are widely known in the plant cultivation practice, these are garden bean and the type of golden beans (Chickasano pea) only under the conditions of irrigated agriculture [1–5 ].

2. Materials and methods

In 2016–2018 at the experimental site of Kurgan State Agricultural Academy named after T.S. Maltsev resistance to biotic and abiotic environmental factors was studied and compared, as well as the yield of bean varieties of Krasnodar selection of the Research Institute of Rice, Krasnodar such as Snezhana, Amalthea, Sobrat, Siberian selection of the SSI Siberian Research Institute of Crop Production and Selection, Novosibirsk such as Darina, Solnyshko, Viola, Yantarnaya, Nika and the SSI All–Russian Research Institute of grain legumes and cereal crop, Orel: Rubin, Oran, Uslada and new lines [4, 5].
The determination of the actual seeding rate, phenological observations, consideration of the elements of crop structure and yield according to the Methodology of state testing of agricultural crops (1989), the Technique of experimental work [6] Statistical processing of experimental data was carried out using the methods of dispersion and correlation analyzes using the Excel and SNEDECOR application software [6, 7].

3. Results and discussion
In the conditions of South Transurals, leached chernozemic soil was used for a comparative assessment of different garden bean varieties of grain and vegetable lines by seed productivity for the first time. The influence degree of abiotic and biotic factors on the production process of garden bean varieties was determined and the influence of the studied factors on the productivity elements of a given crop and the phytosanitary condition of seeds and crops was shown.

The biotic factor connection with the periods of main element formation of the structure of the bean harvest has been revealed. Comparing the conditions of growth, development and seed yield we can conclude that the varietal reaction of bean manifests itself both on biotic and abiotic environmental factors, which is measured by the level of productivity of bean varieties.

Obtained data indicate that the varieties of garden bean of both grain and vegetable lines are capable of forming a steady crop of seeds in South Transurals (Table 1).

### Table 1. Yield of Garden Bean Seeds, Experimental Site, Kurgan State Agricultural Academy

| No. | Variety | The yield of bean seeds, t/ha (humidity 15%) | average |
|-----|---------|---------------------------------------------|---------|
|     |         | 2016 | 2017 | 2018 |         |
| 1   | Rubin standard | 2.38 | 2.13 | 2.41 | 2.31 |
| 2   | Snezhana | 2.84 | 2.24 | 2.53 | 2.54 |
| 3   | Oran | 2.21 | 2.10 | 2.05 | 2.12 |
| 4   | Usłada | –    | 1.14 | 1.16 | 1.15* |
| 5   | 09–197 | –    | 2.48 | 1.72 | 2.10* |
| 6   | 12–322 | –    | 1.87 | 0.97 | 1.42* |

**Garden bean of vegetable line**

| No. | Variety | The yield of bean seeds, t/ha (humidity 15%) | average |
|-----|---------|---------------------------------------------|---------|
| 7   | Moscow White, standard | 3.36 | 2.76 | 2.12 | 2.75 |
| 8   | Sobrat | 2.23 | 1.27 | 1.09 | 1.53 |
| 9   | Amalthea | 2.58 | 1.64 | 1.15 | 1.79 |
| 10  | Darina | 1.68 | 1.71 | 1.21 | 1.53 |
| 11  | Solnyshko | 1.75 | 1.57 | 1.08 | 1.47 |
| 12  | Viola | 1.56 | 1.53 | 1.10 | 1.40 |
| 13  | Yantarnaya | 1.56 | 1.79 | 1.05 | 1.47 |
| 14  | Yantarnaya | 1.75 | 1.02 | 1.38* |

| HCP₀.₀₅ | 0.04 | 0.05 | 0.08 |

* two years of testing

The average yield of seeds of grain line bean varieties of 3 year–old study was formed at a good level and amounted to the following varieties: Rubin – 2.31, Snezhana (Krasnodar) – 2.54, Oran – 2.12 t/ha. The decrease in the yield level in 2018 is due to the lack of precipitation in July and August, during the formation of the garden bean crop varieties and the development of the diseases [8].

Vegetable bean varieties formed a good crop for the climatic zone, respectively: Moscow White (standard) – 2.75, Sobrat (Krasnodar) – 1.53, Amalthea (Krasnodar) – 1.79 t/ha; Novosibirsk vegetable bean varieties: Darina – 1.53, Solnyshko – 1.47, Viola – 1.40, Yantarnaya – 1.47 t/ha. Decreasing in the
yield of bean seed varieties in 2017 and 2018 compared with 2016 can be explained by the weather conditions and the development of root rot.

The recoupment of expenses of obtaining seeds from new varieties varied from 3.31 p. for Nick variety to 4.10 p. for Amalthea variety. The maximum yield, as well as the recoupment of expenses, was in the standard variety Moscow White, it was 2.75 t/ha with a payback of 6.08 rubles.

A higher energy coefficient was obtained in varieties of garden bean of ordinary grain direction, which may indirectly confirm their higher resistance to biotic and abiotic factors. These are the varieties: Ruby with energy coefficient 5.5; Snezhana – 6.0; Oran – 5.1 and 09–197 – 5.1. Varieties Uslada and 12–322, which sharply reduced yields, yielded a low energy coefficient.

On the basis of numerous analyzes conducted in the biochemical laboratory, the chemical composition of garden bean seeds (as a percentage of dry matter) is as follows: protein 20.8–26.5, nitrogen–free extractive substances 50.8–58.0, fat 0.8–1.5, fiber 5.2–7.9, ash 2.1–2.3%. However, in some parts of the seed the content of substances is not the same: the protein in the cotyledons contains (in percent) 24–27, in the peel of the seed there is only 3, nitrogen–free extractive substances in cotyledons is 52–60, in the peel is 34–46, fat in the cotyledons is 1–1.6, in the peel of seeds is from 0.1 to 0.9, fiber, respectively, 1–1.7, in the peel there is 49–56, ash is about the same percentage.

The yield of leguminous crops contains more nitrogenous substances than the yield of cereals. Proteins of leguminous crops are higher in quality than proteins of wheat and corn. Their biological value is due to the presence of essential amino acids among which a special place belongs to lysine. The protein digestibility coefficient is 86; it is higher than that of peas and lentils. The minimum protein content (15%) is in the seeds of tepary bean (Tepari), the maximum (33%) is in the garden bean in conditions of cultivation on fertile soils.

From the table 2 it can be seen that there are varietal differences, i.e. the variety reaction on the accumulation of nitrogen, phosphorus and potassium in the seeds [8].

Table 2. Content of major nutrient elements in the seeds of garden bean varieties in the control (according to the Federal State Budgetary Enterprise SAS "Shadrinskaya", 2016–2018)

| No. | variety of grain line | major nutrient elements, % | variety of vegetable line |
|-----|-----------------------|----------------------------|--------------------------|
|     |                       | nitrogen | phosphorus | potassium |      |                | nitrogen | phosphorus | potassium |
| 1   | Rubin (standard)      | 3.91     | 0.48       | 1.61      | 7    | Moscow White, standard | 3.58     | 0.52       | 1.70      |
| 2   | Snezhana              | 3.06     | 0.48       | 1.55      | 8    | Sobrat                | 3.20     | 0.32       | 1.53      |
| 3   | Oran                  | 3.31     | 0.33       | 1.50      | 9    | Amalthea              | 3.56     | 0.35       | 1.59      |
| 4   | Uslada                | 3.60     | 0.39       | 1.78      | 10   | Darina                | 3.32     | 0.34       | 1.48      |
| 5   | 09–197                | 3.59     | 0.32       | 1.55      | 11   | Solnyshko             | 3.17     | 0.48       | 1.37      |
| 6   | 12–322                | 3.67     | 0.33       | 1.56      | 12   | Viola                 | 3.58     | 0.45       | 1.67      |
| 13  | Yantarnaya            | 3.13     | 0.45       | 1.55      | 14   | Nika                  | 3.32     | 0.38       | 1.58      |

The garden bean is the most demanding on the conditions of nutrition of all grain legumes crops. It grows well and gives high yields on fertile soils that have a neutral or close to it reaction of the soil solution. The place of bean on the cultivated soils after the fertilized precursors with a content of the
available forms of phosphorus and potassium more than 15 mg per 100 g of soil, humus not less than 4.5% provides a grain yield of 20 t/ha and more without fertilizer.

Nitrogen fertilizers for bean are usually applied in the amount of 25–45 kg/ha, phosphoric and potash fertilizers – 45–60 kg/ha of the active substances. From phosphate fertilizers, bean can be applied not only to superphosphate, but also to phosphate rock since the roots of bean are characterized by the ability to absorb phosphorus from the hard solute compounds.

The removal of the nutrients from the soil with garden bean at a yield of 18 centers per hectare of seeds and 16 centers per hectare of straw (stalks and leaves) according to the averaged data is (in kg/ha): N – 165; P2O5 – 70; K2O – 137; and CaO – 140. According to the scientists’ opinion when the bean is harvested from the nitrogen soil 83.7 kg/ha, only 71.2 of it is synthesized by the bean from the atmosphere and only 12.5 kg/ha is removed from the mineral compounds of the soil. Thus, if nitrogen fertilizers are not applied under the beans, it is not soil enrichment with nitrogen, but its slight depletion.

The application of mineral fertilizers according to the steam precursor contributes to an increase yield of both seeds and beans of garden bean in the conditions of South Transurals. On the average over the years of research, the highest yield in the control was noted for Snezhana grain bean variety – 2.59 t/ha, which is 0.28 t/ha more than Rubin standard. The greatest yield increase was obtained from the use of “azophoska” and it amounted to 0.46 t/ha on Rubin variety, 0.47 t/ha on Snezhana variety and 0.46 t/ha on Oran variety. On the average, according to the results of three-year research, the use of double superphosphate increased the yield on the varieties of grain bean by 1.05 times in Snezhana variety up to 1.11 times in Oran variety. The use of the complex fertilizer "Azofoska" contributed to an increase in the yield of varieties of grain bean on the average 1.2 times.

It is relevant to study the use of mineral fertilizers to increase the yield of seeds and beans of vegetable varieties of bean in the studied area.

On the average, over the years of research, the use of double superphosphate in seed cultivation increased yields by the varieties of vegetable bean by the average of 1.1 times, which can be explained by the decrease of root rot development and the increase of plant resistance to the biotic factors.

The use of the complex fertilizer “Azofoska” promoted an increase yield receiving seeds 1.22 times for Moscow White, Amalthea, Viola varieties to 1, 28 times for Yantarnaya variety.

Diseases which pathogens are fungi of the genus Fusarium Link those cause a significant damage to the crop, and its quality in all areas of cultivation of the grain legumes crops. The introduction of the varieties that are less affected by the dry root rot into the production, and the timely implementation of all agrotechnical measures is the most important condition for reducing the incidence of bean root rot. Dry root rot or fusarium is soon found after the emergence of bean seedlings. External signs of the ill seedlings are the appearance of the constriction on the mesocotyl above the multicellular caudex. The base of the footstalk becomes thinner than the top (above the waist).

Then fungus spreads from the multicellular caudex up the footstalk and infects the vascular system, which disrupts the water supply. As a result, plants die or dramatically reduce productivity. In dry weather, plants die from this disease much faster than in wet weather.

Myological analysis of plants after the harvest showed that the root rot was caused by Fusarium species, regardless of the variety. The contamination of the underground organs of the bean varieties with the fungi of the Fusarium genus ranged from 40 to 87% in the central zone and from 20 to 75% in the north–west of the region. In addition to the fungi of the Fusarium genus, the roots were infested with the fungi of the Alternaria genus, which are quite harmful on legumes, but the prevalence of these fungi is lower than that of the Fusarium genus. The degree of the root rot development in the central zone was, on the average of bean varieties was 15% higher than in the northwestern zone.

Decrease in germination and root rot are caused by a complex of pathogenic pathogens – the causative agents of Fusarium, Alternaria blight, pod spot, mold deteriorate and bacterial blight, which exceeded the threshold of harmfulness altogether (10%) by 3–7 times. These seed lots must be treated with the preparations with a pronounced fungicidal and bactericidal spectrum of activity such as TMTD, TMTD +, Vitavax 200FF, Vitaros, etc. The biological effectiveness of TMTD was 6 kg/t, Rubin variety was 80.1%; on Snezhana variety was 83.2%.
4. Conclusions
According to the results of three–year tests the varieties of the garden bean Snezhana (grain line), Amalthea and Darina (vegetable line) are promising for cultivation in South Transurals.

In conditions of South Transurals the phytosanitary technology for the cultivation of garden bean for seeds should be considered as the most effective, including the following elements:

- highly productive varieties of grain direction Rubin, Snezhana and line 09–197, varieties of vegetable direction for obtaining seeds and beans of Moscow white, Amalthea, Darina;
- pretreat seeds before sowing by the preparations with a pronounced fungicidal and bactericidal spectrum of activity such as TMTD, TMTD +, Vitavax 200FF, Vitaros, etc. The treatment by biofungicides is effective in the fight against the root rot of garden bean: Fitosparin M – 0.6 kg / ton, Biocomposite Correct 2 liters per ton and Trihotsin – 30 g/ton;
- sowing should be done at the end of the third decade of May, the beginning of the first decade of June, with a seeding rate of 0.25 million viable seeds per hectare and a row spacing of 45 cm;
- apply mineral fertilizers before sowing of garden bean in doses of P40 – double superphosphate, or N32P32K32 azofoska.

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