Use of biological fertilizers in white mustard crops in the non-Chernozem zone of Russia

D V Vinogradov, K V Naumtseva and E I Lupova
Ryazan State Agrotechnological University Named after P A Kostychev, 1, Kostychev Street, Ryazan, 390044, Russia
E-mail: ksyu.dyachuk.93@mail.ru

Abstract. This article presents statistical parameters for the cultivation of oilseeds in Russia. Ryazan region is not among the regions that are traditional producers of vegetable oil, but recently oilseed production has been actively developing in the region. Gradually developing and processing oilseeds. In 2018, the area under oilseeds in Ryazan region was 121.1 thousand hectares (+ 25.7 thousand hectares by 2017). The prospects for the use of mustard in the region are noted. Currently, the production of mustard grain in Ryazan region has decreased from 18.6 to 13.1 thousand hectares, which indicates an underestimation of the significance of this crop. The study of multicomponent liquid fertilizers in the field confirmed their beneficial effect on the growth and development of white mustard. Foliar dressing according to the vegetation phases contributed to better preservation of plants, due to this, and obtaining the greatest yield of white mustard seed. The maximum number of seeds was obtained on variety Lucius - 13.9 dt/ha, with the effect of Azotovit + Phosphatovit + RauAktiv - 16.5 dt/ha. The effective action of Galleon herbicide on such weed families as Asteraceae, Labiatae, Solanaceae, some species of Polygonacaea and Chenopodiaceae was observed.

1. Introduction
In order to achieve profitability of the agrarian sector, it is necessary to increase the range of cultivated crops, showing an interest in crops that enjoy continuous significant demand from customers. Similar crops are considered to be oilseeds. The products of their activities are used for technical, feed, food and other purposes [1], and also, to meet the needs of animal husbandry in the form of green fodder in the green conveyor system.

Actual oilseeds, are gray and white mustard, oilseed flax, rape. These crops are good predecessors as well as promising as phytosanitary and intermediate crops.

Agriculture is not possible without the crop industry [2]. Due to the presence of a fertile layer of arable land and optimal climatic conditions in our country, it is possible to get high yields of agricultural crops.

Products of the Russian plant growing industry are represented not only by food but also by the production of raw materials for various industries.

Our country is located in several climatic zones, which makes it possible to cultivate the most diverse oilseeds, and there are a lot of enterprises for processing raw materials. Recently, consumer interests have increased, agribusiness enterprises annually make additions to the technology of growing oilseeds and their processing. The most popular oilseeds for today are: sunflower (sunflower oil has a pronounced taste and smell, which improves and emphasizes the taste of the finished dish); soy (the most widely
used product); rapeseed (rapeseed oil is used in the manufacture of mayonnaise, margarine, butter, and is also valued as a honey culture); flax (flax seeds are in demand in medicine and cosmetology); mustard (it has a great many-sided significance; it substantially exceeds many crops of the agrarian sector in its food and fodder advantages) [3]. An important factor is the fact that a short growing season significantly reduces the natural risks of crop shortages, and the cash proceeds from the sale of mustard can come in July and the first half of August [4].

Based on the data of the Federal State Statistics Service, Figure 1 shows the data of the sown areas of oilseeds in Russia for the last eight years [5] in all categories of farms.

![Figure 1. Acreage parameters of Russia.](image)

The total acreage occupied by oilseeds in 2018 was 13.6 million hectares. There was an increase in oilseeds areas in previous years. Today we can say that for the modern world and the development of science it is important to increase the area under oilseeds.

Thus, in 2018, record sunflower crops were 8.1 million hectares, which was 2.6 % more than in 2017 and 8 % more than in 2016. The demand for this culture is high both domestically and abroad. In addition, sunflower has very high marginality, often higher than that of some grains and other oilseeds.

Recently, mustard oilseeds are popular in our country. The acreage occupied by mustard in 2018 was 160 thousand hectares. The increased interest in the cultivation of oilseeds indicates their demand in the market. They are increasingly used in the food industry, feed production, bioenergy. Oilseeds far exceed grain crops in terms of profitability, and given that their world market is not limited, there are prospects for further increasing their production.

Ryazan region is not among the regions that are traditional producers of vegetable oil, but recently oilseed production has been actively developing in the region. So, in the region there is an opportunity to sell regional raw mustard seeds in a closed cycle.

In general, the introduction of plants is one of the real paths for the development of crop production, the expansion of biodiversity, allowing to reveal all the potential possibilities of species. According to the Ministry of Agriculture and Food of Ryazan Region, the agricultural land in the region is 2,336.9 thousand hectares, including 1,474.9 thousand hectares of arable land. According to the data of the Territorial Body of the Federal State Statistics Service for Ryazan Region, the sown area in all categories of farms in 2018 was 904.8 thousand hectares, which was 3.3 thousand hectares or 0.4 % less than for the 2017 harvest.
Oilseed production in the region has recently increased significantly. Such promising oilseeds as white mustard, soybean, oil flax, rape and others have become common. In 2018, the area under oilseeds was 121.1 thousand hectares (+25.7 thousand hectares in comparison to 2017). Of these, the maximum 50.2 thousand hectares were occupied by rapeseed and 42.2 thousand hectares by sunflower.

In the agro-industrial complex of Ryazan region, a special place is given to oilseeds growing. In 2018, a record yield of oilseeds was harvested - 187.6 thousand tons (+27.7 thousand tons in comparison to 2017). This was the first time in the history of oilseeds cultivation in the region with a yield of 15.5 dt/ha (-1.3 dt/ha). The volume of gross oil production in Ryazan region for the last eight years, is shown in Figure 2.

Achieved results show the expansion of acreage for specific crops and yield increase with minimal effort. The main goal of a specific work is to determine the efficiency of foliar feeding with multicomponent liquid fertilizers under the conditions of the Ryazan region.

2. Target setting
The scale of cultivating a particular culture is increasing. To succeed in the cultivation of oilseeds, it is necessary to study the specifics and characteristics of these plants. And only then it is possible to get maximum results.

Thanks to the improved ratio of fatty acids in new varieties of white and gray mustard, these crops have become new high-quality raw materials for the food industry.

In the structure of oilseed crops in the southern part of the Nonchernozem zone, a significant proportion is occupied by such crops as spring rape and sunflower, but, however, this subsector, in general, has not yet been rebuilt according to the principle of high adaptability and productivity, obtaining biologically valuable products. In this regard, the introduction and expansion of the range of oilseed plants, including such a culture as white mustard and selection of new high-yield crops are the decisive factors for optimizing production systems.

One of the advantages of non-traditional and less common cultures is the increased genetically determined resistance to environmental stress factors. Therefore, such cultures have a great potential and high economic significance [6]. In our opinion, a comprehensive study of oilseeds, first of all cruciferous ones, the study of their adaptive and productive potential at the population, species and ecotypic levels in the Non-Black Earth Region of Russia are relevant. Therefore, the introduction of new types of oilseeds into agricultural production is of great importance and a great prospect.

One of the modern trends in increasing yields can be the introduction of multicomponent liquid fertilizers into the technology, which can improve plant nutrition due to a set of microelements, which is very relevant and of particular scientific and practical interest.
3. Materials and methods

Studies were conducted in the educational and scientific innovation center (ESIC) "Agrotechnopark" of Ryazan region in 2017-2018 on dark gray forest soils.

The aim of the research was to increase the volume of production of oilseed raw materials on the basis of the introduction of new varieties of white mustard into the agricultural production of Ryazan region using multicomponent liquid fertilizers for crops.

The experiments took place on dark gray forest soils, the content of humus in the soil was 3.4-4.5 %, phosphorus 16.2-18.0 mg/100 g of soil and potassium 12.9-14.1 mg/100 g, pH 5.7-5.9.

The main research method was field experiment, which was accompanied by phenological observations, records keeping and laboratory analyzes. The records keeping and observations during the growing season were carried out on the basis of “Methods of state variety testing of agricultural crops” [7] and methods of the All-Russian Institute of Feed [8]. The repetition was fourfold. Mathematical processing of research results was performed according to B.A. Dospekhov (1985) and with the help of computer programs [9]. Biochemical analysis of oilseeds was carried out in the laboratories of Ryazan Agrotechnological University, the station of agrochemical services "Ryazan".

The objects of research were varieties of white mustard, Rhapsody and Lucia.

Since 2004 variety Rhapsody has been included in the State Register of Protected Varieties approved for use in production in the Russian Federation. This variety seed breeding is conducted in the State Research Institution All-Russian Scientific Research Institute of Rape in Lipetsk region. Plants are of medium height 96-123 cm, with a strong anthocyanin. The mass of 1,000 seeds is 5.1-5.9 g. The vegetation period varies from 64 to 76 days. The variety is approved for use in all regions of the Russian Federation [10].

Variety Lucia seed breeding has been conducted in the Federal Scientific Institution "Penza Research Institute of Agriculture" since 2016. The vegetation period is 95–96 days. The variety is distinguished by early ripening (it ripens 6-8 days earlier than the Rainbow standard), large seeds (the weight of 1,000 seeds is 7.0–7.1 g, that is 3.9 g higher than the standard) and stable seed yield (on average 1.94 t/ha). The variety is approved for use in all regions [10].

Agrotechnical measures for the cultivation of mustard were in accordance with the existing zonal recommendations. The predecessor was winter wheat. Preparation of the soil before experimental sowing included primary tillage to a depth of 12-14 cm and fall tillage to a depth of the arable layer of 20-22 cm.

In early spring harrowing took place, then 10-12 cm cultivation and immediately before sowing mustard, 2-4 cm cultivation occurred. The seeding rate was 2 million pcs. of viable seeds/ha, actually 12 kg/ha. The depth of seeding was 1.5-2 cm. The method of sowing was a common one, using seeder CCNT-16.

The herbicidal treatment with Galion was carried out 0.3 l/ha. The treatment was carried out with OPSh-15-01 sprayer in an aggregate with MTZ-1221. The working fluid consumption was 200 l/ha.

Multicomponent liquid fertilizers Intermag pro, Azotovit, Phosphatovit and RauAktiv were used in the studies according to the prescribed scheme. The preparations had the following characteristics:

Intermag Pro is a concentrated complex liquid micro fertilizer, designed with the nutritional requirements of oilseeds. It contains a well-balanced set of macro-microelements that fully meet the nutritional requirements of oilseeds. The microelements included in the composition are in a chelate form, which guarantees their complete, high-quality and effective assimilation by the surface of the plants. The registrant is Intermag LLC. The State registration number is 1658-09-204-366-0-0-0-1.

Azotovit is a microbiological liquid fertilizer. Composition - the number of viable Azotobacter chroococum cells is at least 5 billion/cm³. It provides plants with nitrogen nutrition, increases yields, suppresses phytopathogenic microflora, increases the efficiency of application of nitrogen mineral fertilizers, reduces the toxic effect of fungicides on plant seedlings and restores soil fertility. The State registration number is 1085-08-208-106-0-0-0-1.

Phosphatovit is a liquid fertilizer. It contains spores and living cells of bacteria Paenibacillus mucilaginosus with the concentration of not less than 0.12 x 10⁹. It provides plants with phosphate,
potash and nitrogen nutrition, increases the efficiency of application of complex mineral fertilizers. It possesses phosphate-mobilizing properties of soil bacteria, i.e. promote the dissolution of silicate minerals and the release of phosphorus and potassium from complex compounds with their conversion into forms available to the plant. The State registration number is 1086-08-208-106-0-0-0-1.

The dose of preparations is 1 l/ha. The working fluid consumption is 200 l/ha.

The pilot plot scheme is as follows:

1) Control - without treatment.
2) Foliar dressing with Intermag Pro (phase 2-4 true leaves + budding phase + insecticide).
3) Foliar dressing with Azotovit + Phosphatovit (phase 2-4 true leaves).
4) Foliar dressing with Intermag Pro + Azotovit + Phosphatovit (phase 2-4 true leaves).
5) Foliar dressing with Azotovit + Phosphatovit (phase 2-4 true leaves) + RauAktiv (phase of budding - flowering (30 % of the maximum leaf surface, till flowering).

4. Results

The period of white mustard sprouting is 6-10 days. Under favorable conditions sprouts appear earlier.

The field germination is influenced by ecological conditions: soil temperature at the depth of seeds sowing, air temperature, soil moisture, presence of soil pests, soil crust. Varietal parameters had germinating energy and germination ability, which ensured friendly sprouting and significant yield increase. On average, the greatest field germination was obtained by variety Lucia 189.4 pcs/m² with 97 % laboratory germination and 92 % germinating energy, Table 1.

Table 1. Elements of the crop structure of white mustard varieties depending on the action of organic fertilizers

| Variety | Variant | Density of planting before harvesting, pieces/m² | Number of seeds in bolls, pcs. | Weight of 1000 seeds, g |
|---------|---------|-----------------------------------------------|-------------------------------|------------------------|
| Rhapsody | Control (without treatment) | 182.2 | 4.2 | 5.4 |
| | Intermag Pro | 182.6 | 4.8 | 6.5 |
| | Azotovit + Phosphatovit | 183.2 | 4.8 | 5.2 |
| | Intermag Pro + Azotovit + Phosphatovit | 182.8 | 6.0 | 5.3 |
| | Azotovit + Phosphatovit + RauAktiv | 182.8 | 5.0 | 5.7 |
| Lucia | Control (without treatment) | 184.0 | 4.0 | 4.0 |
| | Intermag Pro | 186.2 | 6.0 | 4.4 |
| | Azotovit + Phosphatovit | 182.4 | 6.0 | 4.2 |
| | Intermag Pro + Azotovit + Phosphatovit | 180.0 | 5.0 | 4.2 |
| | Azotovit + Phosphatovit + RauAktiv | 185.8 | 6.6 | 4.6 |

The data in Table 1 show that studying the effects of multicomponent preparations in the field has confirmed their impact on the growth and development of white mustard. The foliar dressing according to the vegetation phases contributed to better preservation of plants, on Lucia variety - 183.7 pcs/m², an increase in the number of seeds in bolls by 2.8 and the weight of 1000 seeds by 2 grams.

Weather conditions in the experiments were favorable for weeds and the average degree of weed was noted. The dominant weeds in studies were wild oat (Avena fatua), types of knotweed (Polygonum spp.), wild spin (Chenopodium album), green amaranth (Amaranthus retroflexus), common orache (Atriplex...
patula) and barnyard grass (Echinochloa crus-galli). Weed infestation by perennial weeds was represented by rhizomatous ones: couch grass (Elytrigia repens), meadow pine (Equisetum arvense) and soboliferous ones: corn thistle (Cirsium arvense), field milk thistle (Sonchus arvensis), field bindweed (Convolvulus arvensis). The total amount of weeds in research remained relatively constant and depended mainly on the time of sowing. The number of weed plants in terms of agrotechnological experimental station in the experiments was about 55.3 - 60.5.0 pcs/m². The effective action of Galleon herbicide on such weed families as Asteraceae, Labiatae, Solanaceae, some species of Polygonaceae and Chenopodiaceae.

The yield of grain crops depends on the potential of the plant, weather, agrotechnical and biological factors. Among the latter, an important place is occupied by numerous infectious diseases that affect plants at all stages of their organogenesis - from seed germination to full ripeness of grain. The obtained data from the analysis of the yield of white mustard varieties are presented in Figure 3.

The use of multicomponent liquid fertilizers has led to an increase in the yield of white mustard seeds in all varieties, as compared with the control.

The maximum number of seeds was obtained by variety Lucia on the variant with the use of preparations Azotovit, Phosphatovit, RauAktiv - 16.5 dt/ha. The used preparations also contributed to an increase in yield parameters of Rhapsody variety - 14.9 dt/ha. There was an increase in yield on other variants, compared with the control.

5. Conclusion
The achieved level of crop yields is far from exhausting the potential of the varieties tested in the region as a whole. Scientists and production workers face the task of developing or improving the basic elements of adaptive-zonal cultivation technology. The introduction of oilseeds to the region could contribute to the improvement of the economic situation of the agricultural enterprises of the south of the Non-Black Earth region, including such a cropper as white mustard.
The use of organic preparations Azotovit, Phosphatovit, RauAktiv had a stimulating effect on the growth and development of plants. When using multi-component preparations, they confirmed their effect on the growth and development of white mustard. Foliar dressing according to vegetation phases contributed to better plant preservation, maximum parameters on variants with Lucia variety (safety 87.6-93.5 %), as well as increasing the number of seeds in bolls and the weight of 1000 seeds compared with the control.

The maximum number of seeds was obtained on variety Lucia - 13.9 dt/ha, with the effect of Azotovit + Phosphatovit + RauAktiv - 16.5 dt/ha.

The effective action of Galleon herbicide on such weed families as Asteraceae, Labiatae, Solanaceae, some species of Polygonaceae and Chenopodiaceae was observed.

The goal is achieved. The program of foliar feeding of mustard plants was chosen, which, in turn, makes it possible to maintain the balance of micronutrients much more efficiently. And also, to improve the quality of yields of the resulting products.

References
[1] Vasileva V 2015 Aboveground to root biomass ratios in pea and vetch after treatment with organic fertilizer. *Global J. of Environmental Sci. and Managem.* 1(2) 71–74
[2] Ilieva A and Vasileva V 2013 Effect of liquid organic humate fertilizer Humustim on chemical composition of spring forage pea. *Banat’s J. of Biotechnology* IV(7) 74–79
[3] Vinogradov D V, Lupova E I, Byshov N V, Kruchkov M M, Fadkin G N 2019 Production of Oil Flax Seed in Non-Black Earth Zone of Russia. *Int. J. of Advanced Biotechnology and Res.* 10(2) 406–416
[4] Vinogradov D V, Lupova E I, Khromtsev D, Vasileva V The influence of bio-stimulants on productivity of coriander in the non-chernozem zone of Russia *Bulgarian J. of Agricult. Sci.* 24(6) 1078–1084
[5] Official site Federal State Statistics Service [Electronic resource]. Access mode: http://www.gks.ru
[6] Vinogradov D V, Byshov N V, Evtishina E V., Lupova E I, Tunikov G M and Morozova N I 2018 Peculiarities of growing gold-of-pleasure for oilseeds and its use in feed production in the non-chernozem zone of Russia. *Amazonia Investig.* Colombia, 7(16) 37–45
[7] Fedin M A 1985 *Methodology of state variety testing of agricultural crops.* (Moscow) p. 263.
[8] Kosolapov V M and Trofimov I A 2011 Scientific support of Russian meadow farming. *Feed production.* 8 47–48
[9] Dospekhov B A 2011 *Methods of field experiment (with the basics of statistical processing of research results): a textbook for students of higher agricultural educational institutions in agronomic specialties.* 6th ed. stereotype. Reprint from the fifth edition of 1985. Moscow, Alliance: p 352
[10] The State Register of Breeding Achievements Approved for Use. Vol. 1. Plant Varieties (official publication). (Moscow, Rosginformagrotekh) p. 504