

Conference Paper

The Influence of Mineral Nutrition on the Productivity of Spring Rape

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Abstract

This article presents data on the influence of mineral nutrition on the productivity of spring bird rape varieties in the conditions of the non-chernozem zone of Russia. The experiments were carried out on agro-gray loamy soils of the experimental agrotechnological station of the Federal State Budgetary Educational Institution of Higher Education “Ryazan State Agrotechnological University” (FSBEI HE RSATU) in the Ryazan Region in 2016-2018. A level of mineral nutrition for spring bird rape was calculated as $N_{180}P_{100}K_{100}$. Based on this, the options for mineral nutrition in research were established. According to the results of the experiments, the duration of the growing season of spring bird rape varieties was established: 73-91 days. An increase in nitrogen to 150 kg of the active substance turned out to be less effective, as the yield increased slightly or remained at the level of $N_{90}P_{50}K_{50}$. The use of phosphorus-potassium fertilizers did not contribute to the creation of such a nutritional regime that would increase seed productivity. An increase in the nitrogen nutrition of the plants led to increased protein content and decreased oil content in seeds. This trend was observed in all varieties of spring bird rape. The average oil content was 38.5-45.5% and the average protein content was 18.0-24.7%, depending on the variety and the level of mineral nutrition. On average, the highest oil content was shown by varieties Lipchanka (44.1%) and Kulta (42.6%).

Keywords: agro-gray soil, level of mineral nutrition, oil content, productivity, spring bird rape, variety.

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1. Introduction

An important area for expanding the resource base of oil raw materials in the Non-Chernozem zone of the Russian Federation is production of bird rape, primarily spring forms. For the current period, rape has not received widespread distribution, largely due to the fact that its oilseeds contained a high amount of erucic acids and glucosinolates. Being erucic determines the suitability of the produced vegetable oil as a food product.

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It should be noted that the advent of promising domestic and foreign varieties and hybrids of bird rape with high production characteristics, one can hope for the reality of solving the problem of producing oilseeds [1-4], including the region.

New domestic varieties of spring bird rape Novinka, Iskra, Valo, Kulta and Lipchanka, have appeared recently. Breeders recommend more and more new varieties of the crop, and it is very important to be able to choose the best of them on the basis of yield characteristics, oil content, resistance to adverse factors and responsiveness to the application of mineral fertilizers and others [5-7]. Understanding that the potential capabilities of varieties are manifested only in specific soil and climatic conditions, it is important to apply their correct selection, which is possible only with ecological varietal testing on various regional types of soil [8-10], including agro-gray soil or gray forest soil [11-13].

The use of mineral fertilizers, including their effect on the nutritional regime of the soil and crops, is of decisive importance in the technology for the production of spring bird rape seeds [14-16]. The configuration of fertilizers in combination with the area size is of great importance for plant productivity during the growing season, as the volume of moisture, minerals, and solar insolation will depend on this [17-19].

2. Methods and Equipment

Experiments to study the influence of the level of mineral nutrition on the productivity of spring bird rape were conducted on gray forest heavy loamy soil of the experimental agrotechnological station of FSBEI HE RSATU in Ryazan region in 2016-2018.

Agrochemical analysis of the experimental plot showed 3.0-3.2% humus. The reaction of the soil medium was acidic and pH_7 was 5.0. Hydrolytic acidity was low, not exceeding 2.6 MEq/100 g of soil. The total absorbed bases were 15 M-equiv/100 g of soil and the degree of soil saturation with bases was not more than 70%. The content of P_2O_5 was 120-123 mg/kg soil, that of K_2O was 149-153 mg/kg soil and the content of nitrogen was 50 mg/kg soil.

When choosing options for the level of mineral nutrition, the norms for applying mineral fertilizers to get the planned seed yield for spring bird rape of 2.5 t/ha were calculated. Ammonium nitrate (N 34.4%), ammophos (N12%; P 52%), nitrophosphate (N:P:K 16:16:16) and potassium chloride (KCl 56%) were used in the experiment. To obtain the planned yield of spring bird rape, subject to preservation and reproduction of soil fertility, it is necessary to introduce mineral fertilizers in the recommended dose of $N_{180}P_{100}K_{100}$.

The technology of growing spring bird rape in the experiment was generally accepted for the Non-chernozem zone. The predecessor was winter cereals. Sowing was carried out to a depth of 2-2.5 cm, with a seeding rate of 2.5 million pcs of germinating seeds per 1 hectare, in the first decade of May, by continuous ordinary method with the help of seeder SSNT-16 in the MTZ-1221 aggregate. For the best contact of seeds with the soil and friendly seedlings, mandatory seed rolling was carried out by star-wheeled rollers 3KKSh-6 after sowing. Pesticide treatments against pests, diseases and weeds have been used throughout the growing season.

Spring rape varieties Kulta and Lipchanka were the object of the study.

Variety Kulta is included in the State register of selection achievements approved for use in the Russian Federation in the Central (3) and Volga-Vyatka (4) regions. It is characterized as a productive variety (up to 2.8 t/ha) with a high content of oil content and meal. The growing season in the Central region is on average 95-103 days. The content of undesirable erucic acid is not more than 0.6% and is often observed in the form of traces. It is declared as resistant to lodging and shedding, suitable for mechanized cleaning and technological variety. It suits well for growing oilseeds and herbage for feed.

Variety Lipchanka is characterized as high-yielding, up to 2.3 t/ha of seeds. The growing season is 65-72 days, resistance to lodging and shedding of oilseeds is above average. Susceptibility to blight is low and moderate to fusariosis. It is declared as a 000-type variety. The variety has high quality oil and meal. It is technological. The oil is not erucic. It suits well for growing oilseeds and herbage for feed.

Harvesting was mechanized by "Taryon-2010" and manual in the phase of full ripeness. Plant mowing was started in the yellow ripeness phase, when seeds in lower pods of the central branch acquired a brown or yellow color characteristic of the variety.

Recordings and observations during the growing season of spring bird rape were on the basis of "Methods of state cultivation testing of agricultural crops" (1985) [8]. Mathematical processing of the results was performed according to B.A. Dospekhov (1985) and using computer programs [2, 20]. Biochemical analysis of oilseeds and soil analysis of experimental plots were carried out in laboratories of FSBEI HE RSATU, FSBI "Station of the agrochemical service "Ryazan", LLC "EMZ-Kubanmaslo" of Tula region.

3. Results

Holding on the calculation method, the following data were used: the average values of nutrient removal per unit of the main crop yield, taking into account the secondary

one, the nutrient content in agro-gray soil according to agrochemical indicators, as well as the averaged nutrient utilization rates by plants from the soil and fertilizers. Based on the difference between the removal of nitrogen, phosphorus and potassium by the crop and the amount of these elements obtained by plants from the soil, the missing amount of these elements was calculated, which corresponded to the norm of mineral fertilizers in kg of active substance per 1 ha.

The brand of mineral fertilizers was determined based on biological characteristics of spring bird rape, as well as mineral fertilizers present in the market of Ryazan region.

Over the past decades, the region has been focusing on the use of complex fertilizers containing two or more plant nutrients. In addition, the main element limiting the quantity and quality of the crop on gray forest soils is nitrogen and only potassium fertilizers can serve as a source of potassium for oil plants. In this regard, ammonium nitrate (N - 34.4%), ammophos (N - 12%; P - 52%), nitrophoska (N: P: K-16: 16: 16) and potassium chloride (KCl - 56%) were chosen.

The estimated level of mineral nutrition for bird rape is $N_{180}P_{100}K_{100}$. The level of mineral nutrition half as low and the effect of single nitrogen on the crop were also studied in the production technology of spring bird rape.

To obtain the planned yield of spring bird rape, subject to the preservation and reproduction of soil fertility, it is necessary to introduce mineral fertilizers in the recommended norms and established dates: most mineral fertilizers will be applied in spring before sowing the studied crops. Additional fertilizing is considered irrational.

Based on long-term observations, weather conditions of 2016 were characterized by an average temperature regime and slightly increased humidity. The hydrothermal coefficient was 1.49. 2017 was marked by fluctuations from the norm of temperature and water regimes and the hydrothermal coefficient was 1.57. Insufficient moisture in the first half of the growing season of spring bird rape, with a predominance of higher than average temperatures, was characterized by weather conditions in 2018, when the hydrothermal coefficient was 0.64.

Due to more intensive accumulation of the vegetative mass by spring bird rape, an accelerated consumption of nitrate nitrogen was noted on fertilized options compared with the control. The nitrogen content becomes almost the same and does not change until the end of the growing season.

The content of phosphorus and potassium in the 0-20 cm layer also changed under the influence of fertilizers. Throughout the growing season of bird rape on fertilized options, the content of available phosphorus was higher than that of the control. The dynamics of mobile phosphorus was less pronounced than nitrate nitrogen. On average,

a year cultivation of spring bird rape against the background of natural fertility (control) led to a decrease in the phosphorus content in the soil by 1.5-1.75 mg/100 g of soil and a decrease in potassium content was less significant and amounted to 0.75-0.95 mg/100 g of soil.

The duration of the growing season of varieties of spring bird rape was 73-91 days. The introduction of nitrogen fertilizers lengthened the growing season of the crop, compared with the control, on average, by 4-8 days. A longer growing season was noted in wet years of the research. With an increase in the level of nitrogen mineral nutrition, the flowering and ripening periods lengthened by 4–6 days compared with the control.

The studies showed that the use of mineral fertilizers for spring bird rape had a positive effect on the formation of elements of the crop structure, photosynthetic indicators and crop productivity in Table 1.

TABLE 1: The structure of varieties of spring bird rape according to the level of mineral nutrition in 2016-2018

The level of mineral nutrition, kg of active substance / ha	Variety	The density of plants before harvesting, pcs/m ²	Number of pods per 1 plant, pcs.	The mass of 1,000 seeds, g	Seeds in 1 pod, pcs.
Control	Kulta	221.8	24.8	2.2	17.1
	Lipchanka	225.2	26.1	2.1	17.8
N ₉₀	Kulta	232.3	28.8	2.3	18.1
	Lipchanka	235.1	32.1	2.4	19.5
N ₁₈₀	Kulta	233.7	39.1	2.5	19.8
	Lipchanka	237.3	40.4	2.7	20.4
N ₉₀ P ₅₀ K ₅₀	Kulta	227.9	30.1	2.3	19.1
	Lipchanka	227.9	31.1	2.3	20.3
N ₁₈₀ P ₁₀₀ K ₁₀₀	Kulta	228.5	42.4	2.3	19.7
	Lipchanka	229.2	40.8	2.5	21.1

The indicator of the number of pods per 1 plant, which is the basis for the formation of seed increase plays a great role in the structure of the crop. High indicators of the number of pods per 1 plant were noted on options of Lipchanka with the action of N₁₈₀ and N₁₈₀P₁₀₀K₁₀₀ (40.4; 40.8 pcs. / 11 plant, respectively). The maximum number of pods per plant was on option N₁₈₀P₁₀₀K₁₀₀ of variety Kulta (42.4 pcs.).

The mass index of 1,000 seeds is a relatively stable indicator. It slightly varies depending on the level of mineral nutrition, and often depends on genetic properties of a particular variety or hybrid.

The experiments showed that the increase in yield mainly depended on the dose of nitrogen introduced. High yields were obtained by the action of rich nitrogen mineral nutrition in Table 2.

TABLE 2: Yield of spring bird rape varieties depending on the level of mineral nutrition, t/ha

Level of mineral nutrition	Variety	Yield, t/ha			
		2016	2017	2018	average
Control (without fertilizer)	Kulta	1.58	1.67	1.80	1.68
	Lipchanka	1.64	1.78	1.84	1.75
N ₉₀	Kulta	1.75	1.87	2.15	1.92
	Lipchanka	1.78	2.26	2.12	2.05
N ₁₈₀	Kulta	1.91	2.20	2.46	2.19
	Lipchanka	2.06	2.31	2.41	2.26
N ₉₀ P ₅₀ K ₅₀	Kulta	1.66	1.93	2.13	1.91
	Lipchanka	1.70	2.00	2.17	1.96
N ₁₈₀ P ₁₀₀ K ₁₀₀	Kulta	1.85	2.12	2.41	2.13
	Lipchanka	1.87	2.05	2.23	2.05
HCP ₀₅ t/ha, interactions AB by factor A (nutritional level) by factor B (variety)		0.23 0.17 0.11	0.24 0.17 0.11	0.41 0.29 0.18	

So at the level of mineral nutrition N₁₈₀P₅₀K₅₀, the maximum yield was observed for variety Kulta (2.13 t/ha). When N₉₀P₅₀K₅₀ and N₁₈₀ it was 1.96 and 2.26 t/ha (Lipchanka), respectively. An increase in doses of nitrogen to 150 kg of the active substance turned out to be less effective, as the yield increased slightly, or remained at the level of N₉₀P₅₀K₅₀. The action of a single phosphorus-potassium fertilizer did not contribute to the creation of such a diet that would increase seed productivity.

Here are the qualitative indicators of the most common varieties of spring bird rape that are cultivated in the Non-chernozem zone of Russia. These varieties were grown at the experimental agrotechnological station in Table 3.

4. Discussion

Values of the contributions of particles of different kinds α_i , providing the smallest value of Φ_1 are shown in Figure 4 in the logarithmic (a) and linear (b) scale. Since according to the data of [7], the particle size distribution is more accurately reconstructed by minimizing the sum of the squared deviations of the diagonal elements of the matrix (Φ_2), then the same figure shows the contribution values for this case. On the vertical axis in Figure 4 shows the relative fraction of particles of a representative set with

TABLE 3: Yield and quality of seeds of various varieties of spring bird rape, level of mineral nutrition $N_{180}P_{100}K_{100}$, average for 2016-2018

Variety	Yield, t/ha	Protein, %	Oil percentage, %	Acid, %					
				oleic	linolic	linolenic	palmitic	stearic	others
Valo	1.73	21.6	38.5	55.3	26.2	10.9	1.8	1.8	4.0
Kulta	2.13	18.3	42.6	60.3	20.3	9.6	2.7	1.5	5.6
Lipchanka	2.05	18.0	44.1	54.1	25.6	9.8	3.0	2.5	5.0
Yantarnaya	1.95	23.6	39.3	60.7	23.0	7.6	2.3	3.5	2.9
Zolotistaya	1.61	21.5	41.6	51.9	19.8	13.0	6.6	4.0	4.7
HCP ₀₅	1.76	2.55	3.70						

dimensions lying in the interval $r_i - r_i + \Delta r_i$. For aggregates, this is their relative share, and for spheroids, the sum of the contributions (α_p) of particles with different values of ϵ for each size range. For aggregates, the values of R_v are taken as their size. The size distribution obtained by minimizing the function Φ_2 more accurately reflects the actual, since it has a maximum in the region of the smallest particle sizes. For the retrieved distribution, the fraction of coarse fraction is $10^{-4} - 10^{-5}$. It should be noted that in the distributions obtained there is an extremum in the range of 200–400 nm corresponding to the maximum in the distribution of coarse fraction particles (Figure 2(b)), and an extremum in the range of 30–60 nm corresponding to the maximum in the distribution of aggregates.

5. Conclusion

Thus, on the basis of the obtained material, it can be argued that the most effective level of mineral nutrition for varieties of spring bird rape is $N_{90}P_{50}K_{50}$. The influence of varieties of spring bird rape on the change in the content of nutrients in the soil is not as significant as the effect of fertilizers, primarily nitrogen. At the level of mineral nutrition $N_{180}P_{50}K_{50}$, the maximum yield was observed for variety Kulta (2.13 t/ha). When $N_{90}P_{50}K_{50}$ and N_{180} it was 1.96 and 2.26 t/ha (Lipchanka), respectively. With an increase in nitrogen nutrition of plants, the protein content increased and led to a decrease in oil content in seeds, on average, by 1.5-2.5% according to research options. This trend was observed in all varieties of spring bird rape. The average oil content was 38.5-45.5% and protein content was 18.0-24.7%, depending on the variety and the level of mineral nutrition. On average, the high oil content was shown by variety Lipchanka (44.1%) and Kulta (42.6%). An increase in the mineral nutrition level of plants increased the quality of spring bird rape oil.

Conflict of Interest

The authors have no conflict of interest to declare.

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