The effect of organic fertilizers on the productivity of winter rapeseed in the conditions of the Kaliningrad region

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Abstract. Winter rapeseed is a valuable oilseed and fodder crop. In the conditions of the Kaliningrad region, the cultivation of winter rapeseed is economically profitable, it is one of the leading crops; it occupies from 15 to 30% in the crop rotation**.** Conducted research in the Pravdinsky municipal district, on the fields of Pravdinskoye pig breeding JSC in 2018-2020. Winter rapeseed is demanding of nutrients throughout the growing season. Livestock farming is actively developing in the Kaliningrad region; therefore, the study into the application of organic fertilizers to increase crop productivity is of current relevance. Swine manure, which is primarily a nitrogen-potassium fertilizer, is a valuable quick-acting fertilizer. Liquid organic fertilizers are applied during the main fertilizing procedure minimizing odor and increasing application efficiency. The aim of the study was to investigate the effect of pig manure fraction on the productivity of winter rapeseed. All research results confirmed statistical data. Based on the results, conclusions were drawn.

1 Introduction

Winter rapeseed is a valuable industrial crop.

In the conditions of the Kaliningrad region, winter rapeseed cultivation is economically profitable, so crop production areas are increasing annually. At present, crops cover more than 25% of all crop production areas. On average, the yield of winter rapeseed attains 3.5–5.0 t/ha, in particular, in the Pravdinsky municipal district, it ranges from 2.5 to 4.1 t/ha.

According to long-term observations, rapeseed is a high-risk crop due to the natural and climatic features of the region. The alternation of thaws and frosts and the absence of snow cover in fields can result in significant lesions of the root system and the growth point or even plant death from freezing [1].

An integrated approach to crop cultivation with regard to all conditions and factors is required to ensure annual high yields of winter rapeseed. One of these factors is plant nutrition. A well-designed fertilizer system in compliance with all the norms and terms of

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organic and mineral fertilizer application will provide a significant increase in the yields of winter rapeseed that will not require extra land [2–8].

2 Object and methods of study

The study on the effect of pig manure on the productivity of winter rapeseed plants were conducted in the period of 2018–2022. The soil in the experimental plots chosen for the study was optimal for growing crops with similar agrophysical properties. The soil type was soddy-podzolic medium loamy. The acidity of the studied fields was 6.2 pH, which falls into the optimal acidity range (pH=5.6–6.5) for winter rapeseed, and, therefore, liming was not required. The predecessor was winter wheat.

In the plots, a two-factor experiment was made with two variants for each selected hybrid (Mercedes and Visby), in a 10-fold repetition. The accounting area in each option was 20 m^2. The accounting area of one plot was 2 m^2.

Experiental design.

Option I – Control. Hybrid Mercedes without organic fertilizer application (Mercedes, K).

Option II – Hybrid Mercedes supplemented with a liquid fraction of pig manure (Mercedes, OS_f).

Option III – Control. Visby hybrid without organic fertilizer application (Visby, K).

Option IV – Visby Hybrid supplemented with a liquid fraction of pig manure (Visby, OU_{zh}).

The location of the plots was systematic. All the experiments were performed in accordance with the method of state variety testing of agricultural crops [9].

The climatic conditions during the observation period were unstable. The temperature regime of the air was favorable for the development of winter rapeseed. In 2018–2019, it was early and mild. December was warm and without snow cover, January showed extreme conditions, when the temperature dropped to -19 ˚C, and the awakening of rapeseed was recorded on February 18 (stage 30). In the spring, there were prolonged rains, and the average air temperature did not exceed 3–5 C. The crops exhibited an excess of moisture, and growing stages 32–33 were delayed. The flowering of rapeseed in 2019 began in early April, when the air temperature increased to +15 °C, yet return frosts reduced the number of peduncles, and the first open petals (stage 60) were recorded in early May. The temperature in the summer of 2019 was +20 °C during the day and dropped to +15°C at night. Full ripeness was recorded (stage 90) on July 19.

During the observation period of the autumn–winter period in 2019–2020, short-term precipitations could be observed in November, and the air temperature did not rise above 9 °C. The first frosts up to –2 °C occurred on December 11. No snow cover was observed during the winter. Plants of winter rapeseed actively began to grow (stage 30) on January 30, which is 14 days earlier compared to 2018–2019. In February, winter rapeseed passed through 31 to 49 stages. The spring of 2020 was warm, with air temperatures up to +13 °C. The first peduncles of the main shoot were recorded on March 17, and the first open flowers (stage 60) could be observed on April 17. Pod formation was completed in mid-July.

Weather conditions for the growing season of 2020–2021 enhanced rapid emergence of winter rapeseed, but in the initial period of growth and development (August 2020), the precipitations attained more than 20 mm, which caused some inhibition of plants. However, later, in the autumn, the air warmed up to 19 °C, which allowed the plants of winter rapeseed to gain sufficient vegetative mass for successful overwintering. In the spring, when the air temperature reached 10 °C, the shoots started to grow actively. Flowering (stage 60) began

on May 17 and lasted (stage 69) to June 01. The formation of the first pods (stage 71) was recorded from 03 June. The average air temperature during the period of seed ripening was 20 °C. The plants reached full ripeness (stage 89) on July 18, 2021.

During the observation period of 2021–2022, the weather conditions in the growing season also provided good shoots to winter rapeseed plants. The optimal temperature values, similar to those in the previous observation period, allowed winter rapeseed plants to accumulate sufficient vegetative mass for successful overwintering. It should be noted that in the winter of 2021–2022, the temperature sharply dropped from positive temperatures to –8 °C, and the snow cover attained 10–15 cm. In the spring of 2022, the air temperature quickly warmed up to 15 °C, which allowed winter rapeseed plants to reach the beginning of flowering (stage 60) on May 10–13, which is 3–4 days earlier as compared to 2020–2021. The summer of 2022 was dry, precipitations did not amount to 2 mm (0 mm); therefore, pods were formed (stages 71–79) under conditions of insufficient moisture. This could have a negative effect on seed formation and decrease the productivity of winter rapeseed. During the growing season of 2021–2022, winter rapeseed hybrids completed their maturation (stage 99) and were ready for harvesting.

During the growing seasons, phenological observations were performed for the growth and development of winter rapeseed. To determine the effect of the liquid fraction of pig manure on the productivity of winter rapeseed, the number of productive stems, the number of pods, and the number of seeds per pod were counted. At the final stage of the study, the average productivity was evaluated with respect to the experiment options. The data obtained during four years of observations were analyzed.

3 Study Results

In the experimental plots, the main application of the liquid fraction of pig manure was performed at a dose of 25 t/ha. The organic fertilizer was applied intrasoil using a trailed injector. Due to uniform mixing of the soil with plant residues, liquid fertilizer penetrated the soil to a depth of 15–20 cm. Liquid organic fertilizer ensures the presence of nutrients in the soil throughout the entire growing season of winter rapeseed.

Table 1 shows the number of productive shoots per plant in growing seasons for the period from 2018 to 2022.

Table 1. The number of productive shoots per plant grown with application of the liquid fraction of pig manure, pcs. (2018–2022).

Option	The number of productive shoots per plant, pcs.			
	Year of study			
	2018–2019	2019–2020	2020–2021	2021–2022
Mercedes, Control	8±1.8	3±1.2	5±1.0	3±1.2
Mercedes + OU	7±1.6	6±1.5	7±1.1	4±1.0
Wisby, Control	6±1.7	5±1.9	5±1.0	3±1.5
Wisby + OU	7±1.4	6±1.7	6±1.1	4±1.3

The data presented in Table 1 show that the average number of productive shoots per plant for the entire observation period is 5 pcs. During the observation period of 2018–2019, the largest number of productive shoots (8) could be observed in the Mercedes hybrid in the option without the application of organic fertilizers, while in other observation periods, the value of this indicator ranged from 3 to 5 productive shoots per plant. In the options with the Visby hybrid with the application of the liquid fraction of pig manure, the number of productive shoots was higher by 1 shoot compared to the control.

In the study, the number of pods per plant was counted; the obtained data are presented in Table 2.

Table 2. The number of pods on the main shoot of winter rapeseed grown with application of the liquid fraction of pig manure, pcs. (2018–2022).

Option	Number of pods on the main shoot, pcs.			
	Year of study			
	2018–2019	2019–2020	2020–2021	2021–2022
Mercedes, Control	17±2.5	15±3.4	15 ±1.4	13±2.0
Mercedes + OU	21±2.8	24±3.7	19 ±1.6	18±2.2
Wisby, Control	18±3.0	17±2.7	16 ±2.0	12±1.6
Wisby + OU	24±3.5	21±3.0	18 ±1.6	17±3.3

Analysis of the data presented in the table revealed an increased number of pods per plant in the options with the liquid fraction of pig manure compared to the control; the increase is from 2 to 9 pcs.

The most significant increase (9 pcs.) was observed in the Mercedes hybrid during the growing season of 2019–2020, and in the Visby hybrid, the increase (6 pcs.) was recorded during the growing season of 2018–2019. During the observation period of 2021–2022, the Wisby hybrid in the control formed an average of 12 pods on the main stem, which is the minimum number recorded for the four years of observation. It should be noted that in the growing season of 2021–2022, winter rapeseed plants formed the least number of pods on the main stem, which could further affect the productivity.

To determine the effect of organic fertilizers on the productivity of winter rapeseed, the number of seeds in a pod was counted (Table 3).

Table 3. Effect of the application of the liquid fraction of pig manure on the number of seeds, pcs. / pod (2018–2022).

Option	Number of seeds, pcs/pod			
	Year of study			
	2018–2019	2019–2020	2020–2021	2021–2022
Mercedes, Control	20±2.5	17±2.6	21±1.0	21±1.9
Mercedes + OU	21±3.8	25±3.8	25±1.2	26±2.5
Wisby, Control	20±1.7	20±2.8	20±1.2	20±1.7
Wisby + OU	25±3.6	21±4.0	27±2.2	26±2.7

The data presented in Table 3 show that during the four observation periods, the number of seeds in a pod in the options with the pig manure (liquid fraction) was higher compared to the control in both hybrids. For the Mercedes hybrid, the difference was 1–6 seeds, whereas for the Wisby hybrid, this value attained 1–7 seeds.

Table 4 presents analysis of the productivity of winter rapeseed in the period from 2018 to 2022.

Table 4. Productivity of winter rapeseed hybrids grown with application of the liquid fraction of pig manure, t/ha

Option	2018–2019	2019–2020	2020–2021	2021–2022
Mercedes, K	2.36	2.85	2.60	2.35
Mercedes, oh $_w$	3.77	3.90	3.93	4.20
Wisby, K	2.73	2.24	2.68	2.13
Wisby, oh $_w$	3.91	4.01	4.15	3.92

Analysis of the data presented in Table 4 shows that the average productivity of hybrids in the control is significantly lower as compared to the options with the application of organic fertilizers. The maximum productivity for the Mercedes hybrid was recorded in 2021–2022, and that for the Visby hybrid was observed in 2020–2021.

4 Conclusion

The use of the liquid fraction of pig manure has a beneficial effect on the productivity of winter rapeseed.

The results of the count performed for a four-year observation period revealed a positive trend in an increase in the number of productive shoots per plant, as well as the number of pods on the main stem. In the options with organic fertilizer, the number of seeds per pod is observed to increase, which, accordingly, will positively affect the productivity.

The productivity of winter rapeseed grown with the application of the liquid fraction of pig manure increases by more than 1 t/ha and ranges from 3.7 to 4.2 t/ha, while in the options with the control, the productivity of hybrids does not exceed 2.85 t/ha.

References

1. V.I. Panasin, L. M. Grigorovich, T.A. Shogenov, etc. Fertilizer, technology and productivity: guide to the chemicalization of agriculture, 315 (2018).
2. J. Beres, D. Becka, J. Tomasek, J. Vasak. Plant Soil Environ., 65, 435–441 (2019)
3. K.J. Jankowski, M. Sokólski, A. Szatkowski. Agronomy 9, 849 (2019).
4. M. Gugała, A. Sikorska, K. Zarzecka. Agronomy, 10, 519. (2020).
5. M.A. Rozhgar d. Tikrit Journal for Agricultural Sciences, 18(4), 29–38 (2018).
6. W. Jarecki, J. Buczek, D. Bobrecka-Jamro. Plant Soil Environ, 65, 125–130. (2019).
7. M. Vicianová, L. Ducsay, P. Ryant, M. Provazník, A. Zapletalová, M. Slepčan. Acta Univ. Agric. Silvic. Mendelianae Brun. 68, 129-136 (2020).
8. Matsera O. The scientific heritage, 58, 4–15 (2021).
9. M.A. Fedin Methodology of state variety testing of agricultural crops. Issue 3. Oilseeds, essential oil, medicinal and industrial crops, mulberry, silkworm, 185 (1983).