Yield of green mass and seeds in promising varieties of rape at summer sowing method in conditions of Novgorod region

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Abstract. The article studies promising varieties of spring rape and makes an agrobiological assessment of them in conditions of summer sowing in Novgorod region on the example of the varieties Oredezh 1, Oredezh 2 and Oredezh 4. We indicate the varieties with the biggest yield of green mass and seeds, as well as having an advantage in a number of other economically valuable traits, relevant and significant for agricultural production. Features of rape in compositions with two varieties of vetch sown for green mass were studied for the first time. The most optimal composition for highest green mass yield and the best sowing season are established. The varieties of rape giving the biggest yield are identified.

1. Introduction
Rapeseed culture is relatively young for cultivation in the Russian Federation. There are many factors inhibiting the rapeseed acreage growth in the structure of all crops, despite the consistently high prices for rape and its high profitability. In the Novgorod region, in 2019, the cultivated area under rapeseed occupies 878 ha. Rapeseed attracts farmers due to its ability to increase soil fertility. It has phytosanitary properties. However, rapeseed crops are prone to a large number of pests, there is no full material and technical base, and there is no established rapeseed oil processing in the households.

Currently, rape is the most important source of raw oilseeds replenishment. Using innovative rapeseed cultivation technologies and performing their techniques in high quality, rapeseed production can be more effective.

To achieve a high level of rapeseed yield, it is necessary to use new varieties and hybrids. Many agricultural enterprises use both domestic and foreign selection achievements, but domestic seeds are a priority [1]. The yield of spring rape on average in Russia so far is modest 1–1.5 t/ha of oilseeds. The yield indicators of 4.5–5.5 t/ha in the farms of Bryansk and Krasnodar regions are more likely an exception to the rule.

Varieties of both spring and winter rapeseed are used for green nutrition, with the condition that the green mass is harvested in the budding phase and the beginning of flowering of plants, since it is during this period that their nutritional ability and feed value reaches its maximum than in later phases of development [2].

The optimal height for mowing rapeseed plants on green fodder is 30–40 cm, in spring at a cutting height of 5–6 cm, in the autumn – of 8–10 cm, it is necessary to maintain the growth point, because after overwintering the plants grow well and you can get a second mowing green mass.

In the phases of budding and flowering, the green mass of rape contains a lot of moisture (84–89%), therefore, 1.5–2 kg of dry feed (hay, straw, pellets, briquettes) should be introduced into the diet of...
animals. It is also advisable to feed rapeseed in a mixture with other herbs, especially cereals (timothy grass, cocksfoot, etc.), which contain sugar and a large amount of dry material.

Rapeseed is a well-silage culture. The optimal harvesting time for silage is the beginning of pods formation. The green mass of rapeseed is better to silage in a mixture with perennial herbs and annual crops, as well as to add straw. In this case, both the quality and nutritional value of the silage will only increase.

When silaging rape in its pure form, straw is added at the rate of 10–20% of the total amount of silage. With rapeseed moisture of 90%, up to 20% of straw is introduced into the silage, at 85% of moisture – up to 15%.

1 kg of spring rape silage contains 0.1–0.18 fodder units and 17–23 kg of digestible protein. 1 fodder unit accounts for 143 g of digestible protein.

Rapeseed silage is recommended to be fed with other types of silage, for example, corn, mixed, because of the increased amount of compounds it has a specific smell and taste.

Spring rape is sown in a mixture with peas. High yields of green mass are obtained on fertile soils and with high doses of fertilizers. From both components, the mixture includes no more than 50-65% of the seeding rate in pure form. With such a mixed sowing of spring rape with peas, the amount of crude protein in the green mass significantly increases when compared with sowing spring rape in its pure form.

According to St. Petersburg Agricultural University, spring rape develops well in mixed crops with legumes in conditions of sufficient rainfall. The yield of green mass mixed with legumes varies from year to year from 1.89 to 4.89 tons per 1 ha. It was also noted that when cultivating spring rape with legumes in the green mass, the protein content increased by 0.6–2% in comparison with pure crops.

To meet the animal's need for feed protein, as well as to fill the shortage of high-grade green food in the summer and autumn periods, rape is usually grown in interplant crops.

Rapeseed is a crop with a short vegetation period, it takes 50–55 days from the beginning of seedlings to flowering, which allows to sow it at different times of the spring-summer period and get high-yield green mass crops until late autumn [3]. Under favorable climatic conditions, namely, a sufficient amount of soil moisture, rapeseed becomes the basis for a green conveyor, since rapeseed can be sown on green feed for several periods. Post-mowing and postharvest rapeseed crops can also give good results provided that there is enough moisture for watering.

Three-year research and production studies of the All-Russian Rapeseed Research Institute confirm the possibility of obtaining high yields of green rapeseed mass not only in main, but also in interplant and postharvest crops. When sowing rapeseed simultaneously with early spring crops, it’s possible to get the highest yield of green mass for two mowings. With two mowing use of rapeseed, its productivity increases by 30–50%. In productivity, it surpasses pure crops of a mixture of vetch and oats.

Due to its short vegetation period, rape grows well after harvesting the main crops (annual grasses and winter rye for green fodder). At the second mowing, the yield reaches 15.9 and 12.8 t / ha, respectively.

Since spring rapeseed can be damaged by pests, in particular, by cruciferous flea, without use of plant protection chemicals in spring sowing, specialists from the Department of Alternative Crops developed recommendations according to which spring rapeseed can be sown for seeds until June 20, for green fodder – up to August 4 [5].

1 kg of rape contains 1.4–2 fodder units, 180–200 g of digested protein, 400–450 g of fat. The protein is rich in essential amino acids (lysine, methionine, cysteine, tryptophan, etc.). Fat contains essential fatty acids: oleic, linoleic, which are necessary for the growth of animals and have a beneficial effect on their health and productivity.

Rape seeds are widely used in the production of edible and technical oils. The oil is used in the chemical, food industry and for the production of biofuels. The obtained by-products (oilecake and extraction flour) are used to feed animals, since they contain a significant amount of protein and essential amino acids, which makes them valuable feed additives. However, rapeseed extraction flour is always limited in use because it contains glucosinolates such as sinapine and tannin, which have an unpleasant
smell and taste. The use of them for farm animals is extremely dangerous because they cause changes in their internal organs, especially affect the liver and thyroid gland.

In the modern world, thanks to developed breeding work, rapeseed varieties with a low glucosinolate content, the so-called 00-varieties, have been successfully created [6]. Rapeseed with a lower glucosinolate content is considered high quality; 20 µmol per 1 g of air-dried substance or 34 µmol per 1 g of fat-free rapeseed. Rapeseed flour contains less crude protein and more crude fiber than soy.

In the North-West zone, the leading breeding institution is the Leningrad Research Institute of Agriculture “Belogorka”, where such varieties of spring rape as Oredezh 1, Oredezh 2, Oredezh 4, Oredezh 5 were created.

To establish the optimal variety for obtaining green fodder and seeds in the Novgorod region, the authors set the aim to study and agrobiologically evaluate promising varieties of spring rape using the summer sowing method, as well as to isolate early ripening varieties having advantages in a number of other characteristics.

Therefore, the following research objectives are set:
1) to substantiate the agrobiological evaluation parameters for promising varieties of spring rape using the summer method of sowing.
2) to study the green mass and seed yield formation features in promising varieties of spring rape using the summer method of sowing.

2. Materials and methods
The research on the agrobiological evaluation of promising varieties of rapeseed was conducted on an experimental plot in the Novgorod district of the Novgorod region in 2015–2016.

The objects of research were three varieties of spring rape: Oredezh 1, Oredezh 2 and Oredezh 4. The variety Forum used in farms was used as a standard [7]. The experimental plots area was 40 m² (the registered area – 24 m²), sowing was carried out in 4-times repetition, the plots were located randomly. In 2015–2016, the studied varieties were sown on June, 20. During the research, phenological observations on the growth and development of spring rape plants were carried out, and the green mass and seeds yield was registered. The morphological structure of plants was registered on August 22. In addition, the authors laid the experience of studying varieties of spring rape as a part of simple agrocenoses with sowing vetch of different varieties on green fodder.

3. Results
In the Non-chernozem zone, the main problem of spring rape production is to obtain seeds, which prevents the expansion of the area for this important fodder crop. Seed productivity of existing varieties largely depends on meteorological conditions in the growing season and can be reduced by 2 times at adverse weather conditions.

The introduction of new varieties needs a preliminary study of morphological, biological and other valuable characteristics. During two years, we studied the structure of spring rape plants of promising varieties. Their morphological structure at summer method of sowing is shown in table 1.

| Variety      | Height, cm | plant mass, g | Ratio, %   | yield, t/ha |
|--------------|------------|---------------|------------|-------------|
|              | min.  max. | av.           | leaves     | stems       | generative organs |         |
| Oredezh 1    | 70  102   | 79.3          | 19.27      | 17.8        | 69.7            | 12.5     | 31.3   |
| Oredezh 2    | 66  118   | 104.2         | 23.27      | 29.0        | 56.3            | 14.7     | 34.8   |
| Oredezh 4    | 77  95    | 85.9          | 20.85      | 26.3        | 26.0            | 17.7     | 32.7   |
| Forum-st.    | 65  110   | 90.5          | 15.03      | 23.1        | 67.3            | 9.6      | 26.4   |
| LSD 0.5      | 5.6        | 1.7           |            |             |                 |          | 2.9    |
Two months after sowing, the spring rape plants bloomed and started to form pods. Their height was from 65 to 118 cm, thus it varied over a fairly wide range. The plants of Oredezh 4 were the most aligned, their height was about 77–95 cm, the highest plants were in Oredezh 2, in average 104.2 cm.

The mass of the rape plants was 15–25 g, the variety Oredezh 2 stood out in this parameter – having 23.27 g in average, and this plant was also well leafed (29% of the mass accounted for leaves). The green mass yield of the spring rape in this period was 25.0–35.0 t of green mass per 1 ha and depended on the plants height (r=0.35), mass of one plant (r=0.99), and leafiness (r=0.49). By the yield of green mass during summer sowing, the spring rape variety Oredezh 2 stood out, the yield of which amounted to 34.8 t/ha. The productivity of the aboveground mass of spring rape in this period was 20–50 t/ha or 4–10 tons of dry matter per 1 ha, with generative organs of plants accounting for about 30% of the mass, and the proportion of leaves was negligible.

Since spring rape is a highly productive plant with a short growing season, i.e. in a short period of time it is capable of gaining large biomass, the multivariate use of this culture in the green conveyor system is possible. In 2015, Among the two-component mixtures of the spring sowing period, there were crops with spring rape, which had two crops of 36.0–36.4 tons of green mass per 1 ha, for comparison, the vetch-oat mixture provided only 24.0 tons of green mass per 1 ha (table 2).

|                  | First mowing | Second mowing | Total for growing period |
|------------------|--------------|---------------|--------------------------|
|                  | Green mass   | Dry material  | Green mass   | Dry material  | Green mass   | Dry material  |
| Vetch (var. Vera) + spring rape (Oredezh 2) | 22.6         | 6.6           | 13.8         | 3.5           | 36.4         | 10.1          |
| Vetch (var. Uzunovskaya-91) + spring rape (Oredezh 1) | 24.8         | 3.9           | 11.2         | 2.9           | 36.0         | 6.7           |

In 2016, at spring sowing, the rape in the two-component mixtures was damaged by cruciferous flea and did not provide a high yield.

In one-component sowings, higher yield of green mass (comparing with other varieties) was given by the variety Oredezh 2 during two years in average (41.8 t/ha).

Summer season of spring rape sowing provides more favorable conditions for high productivity. The seeds yield during two years in average was 2.9–3.9 t/ha, and the green mass yield was 26.4–34.8 t/ha.

The introduction of spring rape into two-component mixtures with vetch (var. Vera and Uzunovskaya-91) allowed to get a green mass yield of 36.0–36.4 t per ha during two mowings.

The spring rape seeds of summer sowing in 2015 ripened in the second decade of September. To the moment of harvesting, the plants were 100–155 cm high. In this parameter, Oredezh 2 stood out, having an average height of 126 cm.

The productivity of the aboveground mass of spring rape in this period was also 20–50 t/ha or 4–10 tons of dry matter per 1 ha, with generative organs of plants accounting for about 30% of the mass, and the proportion of leaves was negligible. In seeds productivity in summer sowing, the variety Oredezh 4 stood out, though the difference was reliable only in comparison with Forum-standard (table 3).

| Variety    | 1st repetition | 2nd repetition | 3rd repetition | 4th repetition | Average |
|------------|----------------|----------------|----------------|----------------|---------|
| Oredezh 1  | 3.1            | 4.2            | 3.0            | 3.5            | 3.5     |
| Oredezh 2  | 3.6            | 4.0            | 3.2            | 2.9            | 3.4     |
| Oredezh 4  | 3.9            | 3.6            | 3.8            | 4.2            | 3.9     |
| Forum-st.  | 3.1            | 2.9            | 3.6            | 2.2            | 2.9     |
| LSD₀.₀₅   |                |                |                |                | 0.8     |
The rapeseed yield in the summer sowing period was higher than during spring sowing, since the seedlings of rapeseed were not damaged by the cruciferous flea, and the adult plants were not damaged by the rapeseed beetle and snout beetle.

4. Conclusion
The height of plants of rapeseed varieties during summer sowing ranged from 65 to 118 cm, that is, varied over a fairly wide range. The plants of Oredezh 4 were more aligned, the height of which was 77–95 cm, the highest plants were Oredezh 2 varieties, on average 104.2 cm.

Spring rape plants had a mass of 15–25 g. According to this indicator, Oredezh 2 variety stood out, its plants had an average weight of 23.27 g. The plants of this variety were well leafy (leaves accounted for 29% of the plant weight). The green mass yield was 25.0–35.0 t/ha and depended on the plant height (r=0.35), one plant mass (r=0.99) and leafiness (r=0.49). In the green mass yield during summer sowing, the outstanding variety was also Oredezh 2, as its yield was 34.8 t/ha.

Summer sowing of spring rape provides more favorable conditions for the rapeseeds crop formation. The average yield of seeds over two years was 2.9–3.9 t/ha, and the yield of green mass was 26.4–34.8 t/ha. Introduction of spring rape in the composition of two-component mixtures (with common vetch, var. Vera and var. Uzunovskaya-91) allows to get 36.0–36.4 t/ha of green mass for two mowings. The rapeseed yield is determined by the number of pods on the plant (29.0–41 pcs.), the number of seeds in the pod (29.2–34.1), the number of side branches on the plant (2–7 pcs.). The highest seed yield in the years of research was obtained from the spring rape variety Oredezh 4 and amounted to 3.05 t/ha.

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