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PRODUCTIVITY AND QUALITY OF SPRING RAPESEED VARIETIES IN THE FOREST STEPPE OF THE MIDDLE VOLGA REGION

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Abstract

With the advent of non-erucic low-glucosinolate varieties, rapeseed has developed into a crop of great potential. In this regard, one of the most important tasks is to identify varieties of spring rape that are capable of forming a stable yield of seeds of good quality in the forest-steppe conditions of the Middle Volga region. The research was carried out at OOO Telegino-Agro of the Penza region on leached heavy loamy chernozem. In terms of meteorological conditions, 2013 was the most favorable. The Ratnik cultivar was distinguished by the maximum field germination (80.1%) and the best preservation (85.2%). The varieties Ratnik, Fregat, Geros had the highest resistance to shattering. On average, over three years, the number of pods per plant and seeds in them by varieties was in the range of 22.8-24.4 and 14.4-15.9 pieces, respectively. The weight of 1000 seeds was practically at the same level (2.55-2.67 g), their weight per plant varied from 0.85 to 0.99 g, and an increase in these indicators was observed in the Ratnik variety. Depending on the variety and hydrothermal conditions, rapeseed is able to form the yield of oilseeds in the range of 0.99-2.19 t/ha. The Ratnik variety in 2013 provided a maximum yield of 2.19 t/ha, and on average over three years 1.68 t/ha, which is 0.34 t/ha higher than the standard. It has been established that the more oil the seeds contain, the lower their protein content. The highest oil content of 41.00% was observed in seeds of the Ratnik variety, with the maximum yield of pure vegetable oil and protein (0.71 and 0.44 t/ha).

Key words*: variety, hydrothermal coefficient, field germination, safety, productivity, oil, protein.*

INTRODUCTION

In Russia, over the past 20 years, against the background of a total reduction in acreage, one can observe the disappearance of some oilseeds and the dominance of others. This situation threatens to lead to a reduction in biodiversity, disruption of the agroecological balance and deterioration of the phytosanitary situation (Smirnov, 2011).

Oilseeds can occupy their ecological niches in addition to traditional sunflower, which will increase the stability of oilseed production (Gavrilova et al., 2007; Volovik et al., 2017).

Rapeseed for Russia is not a new culture, it was still cultivated in the 19th century.

Russian farmers called it "turnip seed" (Gushchina et al., 2015). With the advent of new non-erucic, low-glucosinolate varieties and hybrids, rapeseed has turned into a crop of high potential (Lupova et al., 2020).

Rapeseed oil is used for food and technical purposes. Rapeseed contains 40.1-48.0% oil, 21.0-32.4% protein substances, 6.1-8.9% fiber, 4.3-5.2% minerals. Rapeseed oil containing polyunsaturated fatty acids (linoleic acid (ω-6) - 22.4%, linolenic acid (ω-3) about 8%) meets the requirements of the Institute of Nutrition of the Russian Academy of Medical Sciences to a greater extent than sunflower oil, which is one of the most consumed vegetable oils in the Russian Federation (Gebauer et al., 2006; Haar et al., 2014; Hossain et al., 2012).

Secondary products of oil production (cakes and meal) are used to obtain plant proteins for feed and food purposes, as well as for compound feed (Mustafaev et al., 2012; Gushchina et al., 2018; Sharafi et al., 2015). In fodder production, green mass of rapeseed and silage prepared from it is used (Volovik et al., 2020).

The steady growth of the gross yield of rapeseed oilseeds is the result of the active demand for raw materials from the oil-extracting enterprises. In addition, producers of biodiesel fuel stimulate the production of rapeseed (Gorlov et al., 2006), the value of which lies not only in its reproducibility, but

also in its lower toxicity. During the combustion of rapeseed oil, less hydrocarbons and nitrogen oxides are formed, and the exhaust gases do not contain sulfur and heavy metals (Graf, 2008; Johnson et al. 2007; Matthaus, 2006; Morgan et al., 2000). According to the EU directive, the share of biodiesel fuel should be 20% by the end of 2020.

The use of rapeseed as a green manure crop is promising, which makes it possible to reduce costs by 1.5-2.0 times compared to the introduction of manure (Volovik et al., 2020).

For the successful cultivation of agricultural plants, it is necessary to assess the compliance of the hydrothermal conditions of the cultivation zone with the biological requirements of the crop, and the study of varieties is necessary in order for them to meet the high requirements of modern agricultural producers (Koshelyaev et al., 2012).

MATERIALS AND METHODS

The study of varieties of spring rape was carried out in 2013-2015 in the conditions of the Bessonovsky branch of LLC Telegino-Agro of the Penza region on leached heavy loamy chernozem, the humus content in the arable horizon is 6.9% (GOST 26213-91), mobile phosphorus is 86-89 and exchangeable potassium - 127-140 mg/kg of soil (GOST 26204-91), pH(KCL), 5.3 (GOST 26483), the amount of absorbed bases - 43.0 mg-eq. per 100 g of soil (GOST 27821-88).

The predecessor of the crop was winter wheat, after harvesting of which, stubble plowing and plowing to a depth of 8-10 and 20-22 cm, respectively, were carried out. Presowing soil preparation consisted in early spring harrowing, carrying out two cultivations, from deeper to shallower, and rolling. The method of sowing is an ordinary one with a row spacing of 15 cm. The seeding depth is 2-3 cm. The seeding rate is 2.5 million viable seeds per hectare. All seeds for sowing are treated with an insecticidal disinfectant of systemic action Kruiser, SK (350 g/l thiamethoxam). To combat pests and weeds in the leaf rosette phase, a tank mixture was treated with a contact action insecticide Qi-Alpha, EC (100g / l Alpha-cypermethrin) and herbicide Tatrel-300, BP (300 g/l clopyralid) for control of annual and perennial dicotyledonous weeds... During budding, an insecticide against rape flower beetle and flea beetle was used (List of pesticides and agrochemicals permitted for use in the Russian Federation, 2013). All analyzes and counts were carried out according to the methodology of the State variety testing of agricultural crops (Methodology of state variety testing, 1989).

Four varieties of spring rape (Brassica narus oleifera annua, Metzger), which included in the State Register for the Middle Volga region (7): Radical (st), Ratnik, Frigate and Geros.

RESULTS AND DISCUSSIONS

One of the main factors that are of decisive importance for the productivity and quality of spring rapeseed in the conditions of the Middle Volga region is the amount of precipitation and their distribution over the growing season. The years of research were characterrized by different hydrothermal conditions, which developed quite favorably in the first year of sowing. In total, during the growing season, 251.0 mm of precipitation fall the sum of active temperatures was 2130.1 ° C.

During the sowing period, the soil was well warmed up and moistened, although precipitation fell within the normal range (13.0 mm). Seed germination was influenced by autumn-winter moisture reserves, and seedlings appeared on the sixth day, the hydrothermal coefficient (HC) according to G.T. Selyaninov was 0.9. In the leaf rosette phase, when the harvest of spring rapeseed was laid, precipitation fall only 10.0 mm at a rate of 22.0 mm, the average temperature was 18.0°C, and the HC was 0.5. The stalking phase was also characterized by a moisture deficit (HC - 0.4). Budding proceeded with an abundant amount of precipitation (75.0 mm) and an average temperature of 19.9°C, HC - 2.7. The flowering period was distinguished by a high temperature regime (19.1-21.2°C) and sufficient humidity (21.0 mm), it was at this time that the quality indicators of spring rape seeds were formed.

A significant role in the accumulation of the yield was played by precipitation in late July-early August, since they fall on the period of plant development, corresponding to the ripening phase. Abundant precipitation

(124.0 mm) during the green pod-ripening period prolonged the growing season.

In 2014, during the growing season of rapeseed, precipitation fall 2.3 times less than in the same period in 2013, with a sum of positive temperatures of 2104.1°C. By the time of sowing, the amount of precipitation was 10.0 mm at an average air temperature of 20.3ºC, which is 6.5ºC more than the average annual, HC - 0.7.

The development of a rosette of rapeseed leaves took place with a sufficient amount of moisture (24.5 mm) and heat. During the steming phase, the increased temperature regime (21.5°C) and the deficit of precipitation (2.2 mm) were extremely unfavorable for the growth and development of plants. Lack of precipitation and high temperatures (higher than the average annual by 4.2°C) led to weak branching of plants, HC - 0.1. During the period of flowering and ripening of seeds, there was a deficit of precipitation and hot weather (HC - 0.04-0.30), which had a negative effect on fruit formation and seed formation.

In 2015, during the growing season of rapeseed, 271.6 mm of precipitation fall with a sum of positive temperatures of 2388.0°C, and in May the average daily air temperature was at the level of 13.7°C, and precipitation fell 5.2 times less than the norm, which extended the process of rapeseed germination to 30 days (HC - 0.3).

The periods of rosette leaves - stemming, stemming - budding are characterized as excessively wet (HC - 3.0; 2.8), budding - flowering - acutely arid (HC - 0.2). Dry and hot weather contributed to the rapid and friendly ripening of seeds (HC - 0.2).

Therefore, the study of productivity issues of various varieties of spring rapeseed is impossible without taking into account the prevailing conditions. Analysis of the dynamics of precipitation and thermal regime shows that the modern agro-ecological situation in the forest-steppe conditions of the Middle Volga region is characterized by an aggravation of drought and extreme moisture in certain periods. Under these conditions, the ecological plasticity and drought resistance of the crop are important factors in increasing productivity. In this regard, it is necessary to give more substantiated recommendations for varieties of spring rape, which do not allow a sharp deterioration in the quality of oilseeds.

The germination phase is decisive in the formation of the number of plants per unit area, since not all sown seeds give viable seedlings. The field germination of rapeseed during the years of research was greatly influenced by the conditions in which the sowing was carried out. In 2013, seed germination was 3.9-12.4% higher than in 2014 and 2015 and for the studied varieties was 83.8-85.0%.

The number of plants during the germination period in 2014-2015 is 10.0-31.0 pieces/m^2 less than in the first year and varied according to the experimental options from 179.5 to 185.5 pieces/m^2. A decrease in germination to 71.8-74.2% is associated with dry and hot weather during the sowing-germination period. On average, over three years, the maximum field germination (80.1%) was observed in the Ratnik variety.

The safety of plants for harvesting depends on weather conditions, moisture availability and, to a large extent, on the quality of the care techniques carried out, since during the growing season, partial death of plants occurs as a result of self-thinning.

The highest plant safety was noted in 2013 at 81.0-85.2%, i.e. 171.7-181.1 of plants remained for harvesting per 1 m^2, the Ratnik variety was distinguished by the best preservation.

The number of plants preserved in 2013 exceeded their number in 2014 by 1.4 times, since in the first year of research, more friendly shoots were obtained, which compete well with weeds. The number of plants to be harvested in 2015 was 157.5-166.7 pc/m^2.

Productivity - is an integral indicator of the variety, depending on the degree of development of the elements of the structure of the crop, is associated with a variety of properties reflecting its response to resistance to unfavorable environmental factors, adaptability to soil conditions, resistance to lodging and yield losses, as well as immunity to diseases (Boroevich, 1984; Ashaeva et al., 2016).

Moisture deficiency during the steming period contributed to the weak branching of the plant in 2014. Number of branches of the first order decreased by 29.0-34.8% compared to the previous year, when the number of productive

branches was 4.2-5.0 pcs. Growth processes were more intensive in the Ratnik variety.

In 2013, an increase in relative humidity of air and temperature during the critical period of plant growth and development contributed to an improvement in the elements of its productivity, especially in the varieties Fregat and Geros, which allowed them to form the largest number of pods per plant - 26.7-26.9 pieces versus 21.8 -23.6 pieces in 2014-2015. Lack of precipitation during flowering in these years led to the "physiological wilting" of flowers and their fall. As a result, the number of pods on plants was 8.0-19.0% less than in the first year.

One of the most important features of spring rapeseed varieties is their resistance to pod cracking, which leads to a decrease in yield losses. The varieties Ratnik, Fregat, Geros had the highest resistance to shedding, Radical (st) was distinguished by medium resistance, which to a certain extent influenced the yield (Figure 1).

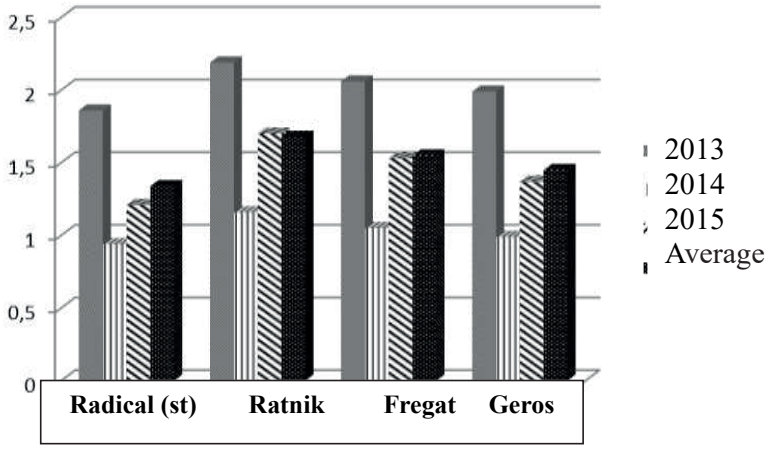

Figure 1. Yield of varieties of spring rape, t/ha

The most significant influence on the formation of productivity of spring rapeseed plants is exerted by the number of seeds in a pod and the weight of 1000 seeds. The maximum number of seeds in the pod was formed in 2013 - 15.9-17.4 pieces, which is 13.0-18.0% higher than in 2014, and 7.0-12.0% than in 2015 year. On average, over three years of research, the number of pods per plant changed insignificantly, as well as seeds in a pod, and varied by cultivars within the range of 22.8-24.4 and 14.4-15.9 pieces, respectively.

Drought during flowering and seed filling in 2014-2015 led to a decrease in the mass of 1000 seeds by 0.11-0.24 g in relation to the first year of research. The mass of seeds per plant was the highest (1.08-1.21 g) in 2013, which is 1.2-1.6 times higher than in 2014-2015.

On average, over three years, the weight of 1000 seeds was practically at the same level (2.55-2.67 g), the weight of seeds per plant varied from 0.85 to 0.99 g, and an increase in these indicators was observed in the Ratnik variety.

According to the years of research, the yield of seeds of spring rape is significantly varied. In 2013, favorable for hydrothermal conditions, it was almost 2.0 times higher than in 2014 and by 0.49-0.65 t/ha more than in 2015 and amounted to 1.86-2.19 t/ha, depending on the variety, and the maximum yield was provided by the Ratnik variety, which exceeded the standard by 0.34 t/ha, and Fregat - by 0.13 t/ha.

Radical (st) Ratnik Fregat Geros

The value of spring rapeseed is determined mainly by the content of fats and proteins, which are of great nutritional and feed value (Schierholt et al., 2001). The chemical composition of oilseeds varies significantly depending on weather conditions and agricultural practices (Gushchina et al., 2015). The even distribution of atmospheric precipitation and moderate average daily air temperatures during the growing season of

2013 contributed to the full passage of all phases and stages of development of spring rapeseed. Later, this had a positive effect on the oil accumulation processes. The variability of seeds of spring rapeseed in 2013 was 46.74-46.93%, depending on the variety, protein content 21.97-22.23%. Increased temperature and insufficient the amount of moisture in 2014 during the growing season of plants contributed to a greater accumulation of protein (33.45-33.78%) and a decrease in fat in seeds to 35.00-35.58%. In 2015, the content of oil and protein in seeds was 39.15-40.51% and 27.06-27.93%, respectively.

On average, over three years, the seeds of the Ratnik variety had the highest oil content of 41.00%, and the grain of the Geros variety accumulated more protein - 27.85%.

Thus, the process of oil accumulation in grain of spring rapeseeds depends on both weather conditions and the variety. Increased rainfall over the flowering period - seed formation increases fat and decreases protein.

Oil content is not a determining factor in productivity. An important indicator is the yield of oil per hectare. The maximum amount of oil (1.03 t/ha) was obtained with the yield of the Ratnik variety in 2013 with a yieldseed rate 2.19 t/ ha, protein harvest was 0.48 t/ha. With the harvest 1.86 t/ha variety Radical provided 0.89 t / ha of oil, 0.41 t/ha of protein.

The lowest oil yield (0.33-0.41 t/ha) was obtained in dry 2014 due to low yield (0.94-1.16 t/ha) and oil content of seeds (35.00-35.58%). However, the maximum (0.41 t/ha) was reached by the Ratnik variety. The highest protein harvest of 0.39 t/ha was provided by the same variety. The protein yield by varieties varied within 0.32-0.39 t/ha. In 2015, the amount of oil was 1.5-1.9 times less than in 2013 and 1.2-1.7 times more than in the previous year.

On average, over three years of research, 0.60-0.71 tons of rapeseed oil and 0.35-0.44 tons of protein were obtained from one hectare.

CONCLUSIONS

Thus, the field germination capacity of spring rapeseed varieties largely depended on weather conditions. In 2013, it was more favorable in terms of moisture supply, it was higher by 11.8-12.4%, the Ratnik variety was distinguished by the best preservation - 80.1%. The process of forming the elements of the structure of the yield of spring rape was greatly influenced by the weather conditions of the growing season. An increase in air temperature with sufficient moisture supply during the critical period of plant growth and development in 2013 contributed to the improvement of the elements of its productivity. The maximum seed yield of 1.68 t/ha was provided by the Ratnik variety. The yield increase in relation to the standard was 0.28 t/ha. The seeds of the Ratnik variety had the highest oil content of 41.00%, and the seeds of the Geros variety accumulated more protein - 27.85%. Depending on the variety, 0.60-0 was obtained per hectare.

REFERENCES

Ashaeva O.V., Koblova I.S., Baluev Yu.S. (2016) Influence of sowing dates on the yield of spring rape seeds. *Bulletin of the Nizhny Novgorod State Agricultural Academy, 4*(12), 13–17.

Boroevich, S.S. (1984). Principles and methods of plant breeding, 344.

Volovik, V.T., Shpakova, A.S. (2020). Rapeseed production in Central Russia: state and prospects. *Feed production, 10*. 3–8.

Gavrilova, V.A., Brach, N.B., Podolnaya, L.P., Dubovskaya, A.G., Kutuzova, S.N. (2008) Results of the study of a different direction of using the gene pool of oilseeds and spinning crops in breeding. *SPb. T. 164*, 119–141.

Gorlov, S.A., Bochkareva, E.B. (2006), State, prospects and scientific support of rapeseed production in the Russian Federation. Rape: oil, protein, biodiesel: materials of the International Scientific and Practical Conference. Minsk: ITC of the Ministry of Finance, 21–26.

Count, V.D. (2008), Fuel from "field refueling". Features, chances and problems of its use in practice. *New Agriculture, 4*. 122–124.

Gushchina, V.A., Lykova, A.S. (2015). Influence of cultivar and hydrothermal conditions of the growing season on the productivity of spring rapeseed. *Niva of the Volga region, 2*(35), 13–18.

Koshelyaev, V.V., Koshelyaeva, I.P., Kudin, S.M. (2012), Varietal potential of spring soft wheat and barley in the Penza region. *Niva of the Volga region, 1*(22), 17–21.

Lupova, E.I., Vinogradov, D.V., Sazonkin, K.D., Verteletsky, P.I. (2020). Agroecological testing of rapeseed varieties and hybrids in the Ryazan region. Scientific, educational and applied aspects of production and processing of agricultural products:

collection of materials of the International Scientific and Practical Conference. Cheboksary, 200–205.

Mustafaev, S.K., Mkhitaryants, L.A., Korneva, E.P., Martovshchuk, E.V. (2012). Industry technology (acceptance, processing and storage of oilseeds): textbook for universities, 2012, 248.

Smirnov, A.A. (2011). Increasing biodiversity - the path of sustainable development of crop production in Russia. *Penza: Rostra LLC*, 25.

List of pesticides and agrochemicals. approved for use on the territory of the Russian Federation, 2014: reference edition. 2013, 692.

Volovik, V.T, Prologova, T.V. (2017). Breeding Winter Rapeseed for the Temperate Forest Zone. *Russian Agricultural Sciences, 43*(3), 213–218.

Gebauer, S.K., Psota, T.L., Harris, W.S., Kris-Etherton, P.M. (2006). N-3 fatty acid dietary recommendations and food sources to achieve essentiality and cardiovascular benefits. *Am. J. Clin. Nutrf., 83*. 1526–1535.

Gushchina, V.A., Lykova, A.S., Sharunov, O.A. (2018). The Substantiation of the Seeding Rate of Spring Rape in The Conditions of Unstable Moistening of Forest-Steppe of The Middle Volga Region. *Research Journal of Pharmaceutical, Biological and Chemical Sciences, 9*(1), 149–154.

Haar, D., Mùller, K., Bader-Mittermaier Eisner, P. (2014). Rapeseed proteins - production methods and possible application ranges published by EDP Sciences. *Oilseeds& fats Crops and Lipids, 21*(1), 2–8.

Hossain, S., Kadkol, G.P., Raman, R., Salisbury, P.A., Raman, H. (2012). Breeding Brassica napus for shatter resistance. World's largest Science, Technology & Medicine Open Access book publisher. URL: http://www.intechopen.com/bodks/plant-breeding.

Johnson, Gh, Keast, D.R., Kris-Etherton, P.M. (2007). Dietary modeling shows that the substitution of canola oil for fats commonly used in the United States would increase compliance with dietary recommendations for fatty acids. *Am. Diet. Assoc, 107*. 1726–1734.

Matthaus, B. (2006). Utilization of high-oleic rapeseed oil for deep-fat frying of French fries compared to other commonly used edible oils. *Eur. J. Lipid Sci. Technol., 108*. 200–211.

Morgan, C.L., Ladbrooke, Z.L., Bruce, D.M., Child, R., Arthur, A.E. (2000). Breeding oilseed rape for pod shattering resislanc. *Journal of Agricultural Science, 135*. 347–359.

Schierholt, A., Rücker, B., Becker, H. (2001). Inheritance of high oleic acid mutations in winter oilseed rape (*Brassica napus* L.). *Crop. Sci. Vol. 41*. 444–449.

Sharafi, Y., Majidi, M.M., Goli, S.H., Rashidi, F. (2015). Oil content and fatty acids composition in Brassica species. *J. Food Prop., 18*. 2145–2154.