Some results of ecological breeding of yellow lupine

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Abstract. The studied and generalized data indicate the ambiguity of the reaction of varieties of yellow Lupinus (Lupinus Luteus L), created in various research institutes in the country and abroad, to the ecological and geographical conditions of the regional zone. The strain VNII of lupine Reliable formed grain yield of 1.16 t/ha, at the level of varieties of breeding Novozybkov agricultural experimental station (NAS) Friendly 165 – 1.17 and Novozybkosky 100 – 1.22 t/ha, and varieties Brigantine and Bulat on grain yield was, respectively, 0.09 to 0.24 t/ha and 0.14-0.29 t/ha. Kastrychnik and Vladko (Belarusian selection) decreased productivity relative to Druzhny 165 by 0.25-0.45 t/ha and Novozybkosky 100 by 0.30-0.50 t/ha. Varieties of foreign selection Mister and Lord undergo a period of adaptation to the soil and climatic conditions of the regional zone, so the grain yield is lower than Amicable 165 by 0.29-0.49 t/ha and Novozybkosky 100 by 0.34-0.54 t/ha. In the hybrid material of the 2008-2014 NSOS of the crossing years, samples 1-08-7-75, 5-10-84, 2-13-33 and 7-13-65 were distinguished by grain yield of 1.32-1.34 t/ha, while the remaining numbers were at the level of the best varieties by productivity. Anthracnose infestation in 2018 and 2019 of green mass and beans was low due to arid vegetation conditions. In 2020, climatic conditions contributed to the development of Anthracnose in the phase of the blue-brilliant bean, dividing the studied varieties into highly resistant ones: Friendly 165, Novozybkosky 100, Reliable, Mister and Lord and stable: Brigantine, Bulat, Kastrychnik and Vladko. Hybrid samples were affected by 15.7-19.7%, with the exception of the number 5-10-84-34.1% and are highly resistant and stable. Under conditions of radioactive contamination of the soil, the concentration of caesium-137 in the grain of Druzhny 165, Novozybkosky 100 and Reliable varieties was at the level of 300-393 Bq/kg, which is 1.5-2.0 times higher than the standard for feed grain of 200 Bq/kg. Kastrychnik exceeded the norm by 1.7-2.4 times, and Mister and Lord accumulated a radioisotope within the norm in 2018 and above it by 1.8-2.3 times in 2019. Samples of hybrid material (data for 2018) contained 137Cs in grain at the standard level: with fluctuations from 112 to 265 Bq/kg. Thus, to solve the problem of providing livestock with high-protein feed, preserving the soil fertility of sandy soils, it is very important to develop ecological breeding that makes maximum use of the agro and bioclimatic resources of the zone.

1. Introduction

Biologization of agriculture in the non-Chernozem zone of the Russian Federation is closely related to the cultivation of legumes, where yellow Lupin occupies a special place. Since the Foundation of the Novozybkovskaya agricultural experimental station NSOS (1916) and up to the present time, the
research team has been breeding for the creation and testing of yellow lupine varieties of various morphotypes of universal use. In the pre-war years, varieties 4645 (Gorky) were created, then Maloalkoloidnye 1 and 2, in the post-war forage fast-Growing 4, cultivated for grain, green mass, silage and siderate (author K. I. Savvichev). In the 80-90 years of the last century, breeders of the experimental station were zoned (co-authored) varieties Bryansky-6, Druzhny 165, Iputsky, Rodnik, novozybkovsky 100 [1, 2].

Such attention to this crop is due to its versatile use: protein-rich feed for livestock (in green mass up to 20%, in grain up to 43%), a source of organic matter for poor soil fertility (up to 50-70 t/ha of aboveground green mass). The deep-penetrating root system of yellow lupine extracts phosphorus, potassium and other trace elements from the sub-arable soil horizons and transfers them to the arable one, which makes it an excellent precursor for all agricultural crops [3, 4].

In recent years, the acreage under this crop has sharply decreased due to the occurrence of diseases such as fusariosis, virus and Anthracnose [5, 6]. To increase the stability of regional agroecosystems, it is necessary to create breeding varieties of yellow lupine that are extremely adapted to specific zones, making maximum use of their agro and bioclimatic resources. This conclusion is confirmed by a competitive test, which reveals ambiguity in the response of varieties to ecological and geographical conditions. So varieties of the Belarusian selection Vladko, Kastrychnik in our conditions are affected to a strong degree by viral growth (45.35%, respectively); Bryansk Institute of lupine Brigantine, Prestige, Bulat (37, 30, 25%), Fusarium, and in epiphytotic years Anthracnose; varieties of foreign selection - Mister and Lord – viruses, Fusarium. There is a differentiation of varieties by the duration of individual phenophases and, ultimately, the growing season, plant habit, disease incidence and productivity. In conditions of radioactive contamination of sandy soils, obtaining high-protein feed for livestock within the limits of the standard content of caesium-137 in green mass and grain is very relevant, which is confirmed by many studies [7, 8, 9, 10, 11, 12].

The aim of the research was to study yellow lupine created in Belarus, the lupine research Institute, foreign selection and hybrid material of the NSOS selection for productivity, resistance to Anthracnose, and low accumulation of radioactive caesium in the grain.

2. Methods and materials

The object of research was selected fields of the laboratory of breeding and seed production of the Novozybkovsky agricultural experimental station-a branch of the Federal research center "VIC named after V. R. Williams". The soil is sod-podzolic sandy in mechanical composition with a content of silty particles of 5-10%, which explains their lack of structure and high water permeability. The content of humus is 1.0-1.2%, in which fulvic acids (2/3) exceed humic acids (1/3), mobile phosphorus is high 220-250 and exchange potassium is low 50-70 mg/kg of soil, the reaction of the soil solution is slightly acidic, which indicates a low level of fertility. Plots were laid in a competitive variety test with an accounting area of 10 m2 in three-fold repetition on a natural Fusarium background, the predecessor - winter rye. Tillage recommended for our zone: winter plowing at 18-20 cm, pre-sowing cultivation in 1-2 tracks and rolling. Sowing with the szn-16 seeder at the beginning of the third decade of April, with a seeding rate of 1 million germinating seeds per hectare. During the growing season, phenological observations were made on the main growth and development phases of yellow lupine. The incidence of Anthracnose was taken into account on permanent sites (1m2) in a three-fold repetition: - by cotyledons (seed infection), stalking and in the phase of a blue-shiny bean (before the beginning of maturation). The determination of the caesium content in grain was carried out by the Obninsk Institute of agricultural radiology. A record harvest of grain – hand, solid at pelenechny followed thresh to the stationary thresher and weighed.

Meteorological conditions over the years of research differed in precipitation and temperature during the growing season. So 2016 turned out to be the most prosperous year, in which only twice during the season the values of the hydrothermal coefficient (GTC) fell to 0.1-0.5: in the first decade of may (seedlings) and June (budding). In 2017, the April-June months were dry with a SCC of 0.0 to 0.3 and only in July there were heavy heavy rains. May and two decades of June in 2018 turned out to be dry
with a GTC of 0.0-0.7, but in the third decade of June and all of July there were heavy rains, which led to a decrease in temperature and photosynthesis. Extremely unfavorable weather conditions have developed in 2019. April is dry, and heavy precipitation in the first decade of May caused irreparable damage to the upper layer of the soil, washing it away along with the seed material and seedlings. In flowering (the first decade of June), it was dry and the main brush of plants bloomed in the morning and ended with 2-3 whorls blooming in the evening. Precipitation in July could not correct the situation: the main brush formed beans in 2-3 whorls, and on the side shoots of the ovary was not.

3. Results and discussion

According to research data, the varieties of NSOS selection Druzhny 165, novozybkovsky 100, as well as the variety of the research Institute lupina Reliable in grain yield were at the same level, Brigantine and Bulat reduced it by 8-26 and 13-31%. Varieties of Belarusian selection were inferior to ours: Kastrychnik 21-25%, Vladko-38-41%. Relatively low yields of yellow lupine grain over the years and on average in foreign varieties Mister 0.88 and Lord 0.68 t / ha indicate that they are not fully adapted to our soil and agro-climatic conditions.

Hybrid samples of different years of crossing were at the level of the best varieties in terms of grain productivity: 17-10-72, 3-12-182, 4-12-302, 3-14-223 and 5-14-11, or exceeded them: 1-08-7-75 by 0.17 and 0.12 t/ha, 5-10-84, 2-13-33 – by 0.16 and 0.11 t/ha, 7-13-65 –by 0.15 and 0.10 t/ha. Brigantine and Bulat varieties are less adapted to the cultivation zone and are lower in productivity than hybrid samples: Brigantine by 0.04 - 0.26 t / ha, Bulat by 0.19-0.41 t / ha. The varieties of yellow lupine of the Belarusian selection Kastrychnik and Vladko in grain yield were inferior to the hybrid material of NSOS, respectively, 0.20-0.42 t/ha and 0.40-0.62 t / ha. The Vladko variety has a good passive immunity, against diseases – anthocyanin color, covering all parts of the aboveground mass, including beans. However, the climatic conditions of our zone negatively affect the field germination of seed material, the variety is strongly affected by viral germination, which makes it impossible to get healthy seeds even for hybridization. The average yield of Mister 0.88 and Lord 0.68 t/ha, which is lower than hybrid samples by 21-44% and 39-49%, respectively (table 1).

Table 1. Yield of yellow lupine grain, t / ha.

| Varieties and hybrids         | Research year |
|------------------------------|---------------|
|                              | 2016 | 2017 | 2018 | 2019 | Cp  |
| NSOS varieties               |       |      |      |      |     |
| Druzhny 165                  | 1.96 | 1.22 | 0.80 | 0.70 | 1.17|
| Novozybkovsky 100            | 1.78 | 1.26 | 1.15 | 0.70 | 1.22|
| Lupin Research Institute     |       |      |      |      |     |
| Brigantine                   | 2.01 | 0.80 | 0.90 | 0.60 | 1.08|
| Reliable                     | 1.84 | 1.10 | 1.00 | 0.70 | 1.16|
| Bulat                        | 1.18 | 1.00 | 1.02 | 0.50 | 0.93|
| Belarus                      |       |      |      |      |     |
| Kastrychnik                  | 0.90 | 1.20 | -    | 0.65 | 0.92|
| Vladko                       | 1.23 | 1.16 | 0.20 | 0.30 | 0.72|
| Foreign selection            |       |      |      |      |     |
| Mister                       | 1.00 | 1.20 | 0.50 | 0.70 | 0.88|
| Lord                         | 1.00 | 1.80 | 0.60 | 0.30 | 0.68|
| Hybrid NSOS material         |       |      |      |      |     |
| 1-08-7-75                    | 1.80 | 1.46 | 1.21 | 0.90 | 1.34|
| 5-10-84                      | 1.70 | 1.50 | 1.30 | 0.80 | 1.33|
| 17-10-72                     | 1.56 | 1.25 | 1.10 | 0.75 | 1.17|
| 3-12-182                     | 1.74 | 1.31 | 1.23 | 0.80 | 1.27|
| 4-12-302                     | 1.50 | 1.15 | 1.17 | 0.70 | 1.13|
| 8-12-240                     | 1.54 | 1.09 | 1.30 | 0.80 | 1.18|
| 2-13-33                      | 1.35 | 1.40 | 1.68 | 0.90 | 1.33|
| 7-13-65                      | 1.71 | 1.47 | 1.31 | 0.80 | 1.32|
As a general rule, it should be noted that all varieties and hybrid material in 2019 sharply reduced their grain productivity due to unfavorable growing conditions. However, for the tested varieties, the grain yield ranged from 0.30 to 0.70 t / ha, while for hybrids it varied from 0.70 to 0.90 t / ha. The climatic conditions of the yellow lupine vegetation determined the yield by more than 60%, and the varieties and hybrids adapted to local conditions were more productive, which confirms the correctness of the task.

In obtaining a highly productive hybrid material, the main role is given to the selection of parent forms. So in numbers 1-08-7-75 and 5-10-84, the sample 1-00-2-9 (Novozybkovsky 100) and the paternal form 1-00 and 17-00, respectively, were taken as the maternal form. In numbers 2-13-33, the maternal form is provided by the VIR k3593 sample, while the paternal form is 1-00-2-9. Number 7-13-65 was created when crossing D-3400 (Friendly 165) with the F1 8-12 hybrid, which received the right to hybridization due to the presence of highly productive samples CH1408 and 2-08-48 in its pedigree. In the combinations of 2012 crosses, the varieties Reliable, Druzhny 165, Novozybkovsky 100, and CH 1408, well adapted to soil and climatic conditions, were taken as parent forms. Hybrid numbers of 2014 were created using the Novozybkovsky 100 variety and old samples of 1987 crosses. Therefore, the importance of ecological selection based on the selection of pairs of crossing combinations adapted to the agro and biological characteristics of the zone is confirmed.

The issue of increasing the acreage of yellow lupine for food is directly related to the problem of the spread of Anthracnose disease. During epiphytotic years, the disease significantly reduces the yield of green mass and almost completely destroys seed productivity (80-100%) (5). Chemical plant protection products of yellow lupine do not always solve the problem of reducing the incidence. However, selection for disease resistance is very difficult, since the pathogen is characterized by high adaptability and variability (6). Increasing the resistance of yellow lupine plants to diseases should be solved on the basis of an integrated approach to the host-parasite-environment system. An important role in this system is assigned to the climatic conditions of the growing season. Seed infection without appropriate weather conditions: the air temperature is 25°C with high soil humidity at 1.5-1.7 GTC, significantly reduced. Due to the violation of environmental conditions, a type of pathogen appears that affects the green mass of lupine and subsequently beans. In such crops, plants that are less affected by Anthracnose are selected, i.e. tolerant, providing an optimal balance between the host and pathogen. In 2018-2019, the incidence of Anthracnose in green mass and beans and in all varieties and hybrid numbers was low. In 2020, due to violation of the conditions of the third component in the host-pathogen-environment system during bean formation, there is a significant increase in the incidence. Varieties of the experimental station selection remained in the group of highly resistant beans (19-23%), Reliable was affected by the pathogen by 19.4%, while Brigantine and Bulat (27.4 and 26.7%) moved to the group of resistant. Varieties of Belarusian selection were stable with a degree of damage of 26.7 -27.7%, and highly resistant-20.4-22.6%.

Of the hybrid samples, Anthracnose number 5-10-84 was the most affected – 34.1%. However, it is considered stable. The degree of Anthracnose damage to the beans of the rest of the hybrid material was at the level of 15-20%, which is lower by 5-12% compared to the varieties of the Lupin research Institute (with the exception of the Reliable variety), Belarusian and foreign. Data on the resistance of varieties to Anthracnose once again confirm the position on the need to develop zonal breeding put forward and justified by N. I. Vavilov and continued by academician A. A. Zhuchenko [1].

The results of studies on the accumulation of caesium -137 in grain indicate in favor of ecological selection under conditions of radioactive contamination of soils. Analysis of data on the accumulation of radioisotope in conjugated samples (grain-green mass-soil) leads to the conclusion that the relationship between its accumulation and the density of soil contamination is diverse both by year and by variety. In the example of varieties selected by NSOS, we see that with different densities of soil
contamination over the years (1061-1852 Bq/kg), the concentration of 137Cs in the grain is of the order of 340-393 Bq/kg. The Reliable variety increased the content of caesium - 137 in grain (300 Bq/kg) by 1.3 times with an increase in soil contamination. The Belarusian variety Kastrychnik also reacted to the increase in the density of soil contamination, increasing it in grain by 1.5. 137Cs significantly increased by 1.8-2.3 times in Mister and Lord varieties at a concentration of 204 and 173 Bq/kg in 2018, respectively. Samples of hybrid origin (data only for 2018) to a lesser extent accumulated caesium-137: fluctuations ranged from 112 to 345 Bq/kg, so samples 5-14-11, 3-14-223, 7-13-65, 8-12-240 and 17-10-72 it was at the level of the standard content. The increase in the concentration of 137Cs in 2019 is explained not only by the increase in soil contamination (with annual site changes), but also by the low grain yield, where minimal biological dilution was observed.

4. Conclusion
Taking into account the peculiarities of agro-bioclimatic conditions of the regional zone, we consider it necessary to strengthen the development of ecological breeding for yellow lupine, as this is confirmed by increased productivity and resistance to Anthracnose, less accumulation of radioceesium in the grain. In the hybrid material obtained from crosses involving varieties that are adaptive to local conditions as parent forms, a number of numbers 1-08-7-75, 5-10-84, 2-13-33, 7-13-65 with high grain yield, low Anthracnose infestation and Cs accumulation is identified, which indicates the importance of this direction in terms of expanding the acreage of forage yellow lupine.

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