On the issue of protection of yellow lupine from anthracnose in the field

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Annotation. Over the years of many years of research in the field, it was found that the creation of completely anthracnose-resistant varieties of yellow lupine (Lupinus Luteus L) is not possible. But at each stage of the pathological process, various defense mechanisms operate that determine the resistance or susceptibility of plants to diseases. There is a passive defense associated with morpho-biological features. A positive role in the control of anthracnose of early and mid-season forms with limited second-order shoots, fast-growing ones with anthocyanin coloration, xeromorphic leaf type, dark green color of vegetative organs, intensely colored seeds (2c, 4c, 2d), different corolla colors (numbers 52-87-2113 and 1477-1-17) and a flower (varieties Iputsky and Rodnik). Observations have shown that a waxy coating on a bean or a thick layer of hairs that helps water roll off, a more spreading bush that provides quick ventilation and moisture removal, reduces anthracnose infestation. It was found that the passive defense mechanism is largely due to the totality of morpho-biological characteristics and the nature of their interaction. Different infestation with anthracnose depending on the sowing density was shown: under conditions of sparse sowing (600 thousand seeds / ha), it averaged 4.6% during flowering and 8.0% at bean formation, and in a denser cenosis (1.2 mln. grain / ha), respectively, 18.7 and 62.0%. An active plant defense mechanism has been established and is being studied — hypersensitivity — this is an increased sensitivity of living cells of a plant — a host in places where a pathogen penetrates and its rapid death with the formation of necrosis. It was revealed that necrotic forms of yellow lupine are less affected by anthracnose during all phases of plant growth and development and, especially, during the formation of beans. At the site of penetration of the pathogen, an orange spot develops, around which a roller of dead tissue is formed, i.e., the pathogen's access to living cells stops at the expense of which it feeds. The selected material with bean necrosis, without external sporulation, reduces the infectious load in the infected crops.

1. Introduction
At the end of the 80s of the XX century, crops of yellow lupine began to be affected by anthracnose, and since there are no stable donors, the creation of completely anthracnose-resistant varieties is not possible [1,2,3,4, 5, 6, 7, 8]. Breeding for yellow lupine should be based on the tolerance of the host plant to the pathogen. For this, it is necessary to use hybridization, with the involvement of parental forms that are resistant to anthracnose, followed by selection of a hybrid material that exceeds its best parent.

The main source of primary anthracnose infection is contaminated seed material, on which it persists for two years.
After a seed infection, an insignificant spread of the disease is associated not only with the slow growth rate of lupine, and, as a consequence, a small aboveground mass, but also with the lack of favorable environmental conditions (humidity and air temperature, precipitation).

After the closure of the overgrown yellow lupine plants, that microclimate is created that is favorable for the development of the disease. During this period, the weevil settles, aphids and miner flies reproduce, which, feeding on infected plants, carry the pathogen to clean crops. It should be noted that further development of hyphae and production of spores occurs only in young, growing plant tissue.

The mechanisms of passive plant protection have been established: the shape of the bush and limited shoot formation, early and mid-ripening, xeromorphic leaf type, intensely colored seeds, the presence of anthocyanin, wax bloom or dense hair, a combination of a flower corolla and seed coat.

There is an active plant defense mechanism, which is manifested in the plant's response to the introduction of a pathogen. The nature of the protective reaction of a living organism is determined by the way the parasite feeds and is manifested by the reaction of hypersensitivity of the living cells of the host plant, in the places where the pathogen penetrates, to its rapid death, since the introduced parasite turns out to be isolated from the living cells of the tissue of the host plant by a zone of dead cells with the appearance of necrotic ulcers.

The pathogen, having penetrated into the cell of susceptible plants, provides itself with nutrition, that is, it functions and cohabitates with the host.

After the penetration of the pathogen into resistant varieties, the entire content of the cell begins to darken and it dies along with the parasite, the infectious process is interrupted and the disease does not develop further.

In plants with high resistance, necrosis appears in the form of small dots, which can be difficult to see with the naked eye. This is the highest type of resistance - immunity [10, 11].

The task of our research is to create a stable hybrid material of yellow lupine in the field, possessing not only passive plant protection mechanisms, but also active ones in the form of necrosis.

2. Methods of the research
Nurseries were laid on the breeding and seed-growing fields of the Novozybkovskaya agricultural enterprise - a branch of the Federal Research Center “VIK im. VR Williams” in 2000-2019. taking into account the requirements of the "Methodology of field experience" [12]. The soil is soddy-podzolic sandy with a humus content of 1.0-1.2% (according to Tyurin), mobile phosphorus 200-250 and exchangeable potassium 40-50 mg / kg (according to Kirsanov), with a weakly acidic reaction of the soil solution.

The distribution of the plots is systematic, the repetition rate is 2-4 times, the predecessor is winter rye. Tillage consisted of autumn discing of stubble with light discs and subsequent fall plowing. In the spring, the field was harrowed to cover moisture, P2O5K2O was introduced in the form of borosilka and potassium chloride for cultivation, before planting, it was rolled with ring rollers or a dominator in 1-2 tracks, depending on the state of the soil.

Accounting for classical lesions with anthracnose was carried out according to seedlings (seed infection), vegetative mass (budding) according to the method of Yakusheva A S and Solovyanova N I [13], according to beans (glaucous bean) with necrosis according to the method temporarily developed by Savvicheva I K.

3. Result of the research and discussion.
The work on the isolation and selection of anthracnose-resistant forms of yellow lupine against field backgrounds began at the base of the All-Union Research Institute of Lupine in the Novozybkovsky branch of the VIUA in 1998, when 2000 plants were selected against the background of significant damage to the breeding material, without visible signs of the disease. In 1999-2000 in the field, about 30 thousand plants from 700 numbers were sown and evaluated [9]. By 2005, the number of numbers studied was reduced to 75. They formed the basis of collectible forms relatively resistant to anthracnose.
Subsequently, the collection was replenished with material obtained from VIR (K-3592, K-3593, K-3721, K-3033, etc.) and VNII lupine (varieties Prestige, Nadezhny, Demidovsky, Brigantina).

The collection material differed in morpho-biological characteristics, directions of economic use, resistance to anthracnose in the field.

The study of collection forms showed that in the development and distribution of anthracnose there are two periods of the most intense damage to plants: 1. damage to vegetative parts - petioles, leaves and stems during the stem-flowering phase; 2 - defeat of beans - phases ovary - ripening bean. In years average in terms of water cut and temperature conditions, anthracnose resistance for most samples both during the flowering period and for beans varies within 7-8 points, which corresponds to stable and highly resistant according to the CMEA scale [14].

In epiphytotic years, the resistance of numbers to the defeat of beans sharply decreases and ranges from 1 to 5 points (highly susceptible - moderately resistant).

Studying them over the course of a number of years allows us to draw some generalizations and conclusions:

1. Early ripening forms are less affected by anthracnose than mid-ripening and late ones.
2. Mid-ripening specimens are better in stability with limited shoots of the second (D-2) order and medium foliage.
3. Preferred are fast-growing forms that provide a quick exit from the rosette phase, limited branching, early maturity. Forms of the usual type of growth branch abundantly, which leads to high foliage, density of the bush, providing a strong defeat by anthracnose (Rodnik, Iputsky, K-3592, K-3593).
4. Forms with intensely colored seeds with black and brown pigments (2c, 4c, 7a) are less affected by anthracnose.
5. Plants with different colors of the flower corolla (yellow, lemon-yellow, orange, white, etc.), are attacked with anthracnose equally often.
6. The color of the flower corolla and seed coat changes the degree of plant damage, which was observed in the group of early ripening samples 52-87-2113 and 1477-1-7 with the same color of seeds, but different color of the corolla. Mid-maturing specimens with limited branching (D-2 and D-3), the same color of the flower corolla, but different color of the seeds, differ in the degree of damage (Druzhny 165, Nadezhny).
7. In a related pair of numbers that have common parents, but differ only in the color of the flower - Rodnik and Iputsky, the degree of damage to the beans, both in ordinary and in epiphytotic years, is not the same.
8. It was noted that the presence of anthocyanin, xeromorphic type of leaf, dark green color of vegetative organs, distinguishes plants with increased resistance to anthracnose.

The study of the morpho-biological features of yellow lupine showed that disease resistance is due not so much to individual signs that can be clearly recorded (early maturity, type of growth, color of the corolla and seed coat, etc.), but to a greater extent by the combination of these signs and the nature of their interaction.

The seeding density has a significant influence on the distribution and development of anthracnose. Under conditions of sparse sowing (600 thousand germinating seeds / ha), the damage to plants by anthracnose is much less than under conditions of a denser cenosis.

Sample numbers of yellow lupine in sparse crops showed resistance to anthracnose in terms of vegetative mass (1.4-8.5%) and beans (2.8-15.8%), and according to the CMEA scale they are classified as highly resistant.

At a seeding rate of 1.2 million germinating seeds per hectare, the anthracnose infestation of these samples in terms of aboveground weight in 6 out of 11 increased and amounted to 19.3-66.7%, i.e., on the scale of resistance, it varied from resistant (4 numbers) to susceptible (1 number). The pathogen affected the samples of the bean nursery much higher: 3 numbers were highly susceptible, hitting 82-90.0%, the rest - moderately resistant by 43.2-78.3%.
In the case of the usual classical lesion of beans, from the point of introduction of the parasite along the outer part of the bean valve, the infection spreads (darkening of the tissue), gradually penetrating into the bean and affecting the seeds located there. Under favorable conditions, sporulation develops on the outer side of the pod valve, which infects adjacent plants (Fig. 1).

Analysis shows that the state of the seed inside the affected pod depends on its location relative to the point of introduction of the parasite. With the classic defeat of the bean anthracnose (no more than 1/3 of the surface is affected), the seed located directly at the point of introduction usually dies, and the seed nearby has signs of the disease. When the infestation is 3-5 points on the CMEA scale (3/4 of the bean surface), most of the seeds (70-100%) die.

With necrosis on the beans, necrotic ulcers with a diameter of 1 - 5 mm of a clearly expressed rounded shape are formed, surrounded by a roller of dead tissue (Fig. 2).

There is no development of the disease outside the roller, the edges of the ulcer are clean, in depth it can be perforated, breaking the parchment layer, or only reaching it. In this case, a dark or light spot is observed on the inside of the valve - the center of the ulcer.

The seed located directly in the zone of introduction of the parasite, with the perforated nature of the ulcer, often dies or has signs of damage, if the parchment layer is not broken, the seed is outwardly healthy (Fig. 3).

Figure 1. Classic infestation of beans and seeds with anthracnose

Figure 2. Necrotic ulcers on lupine beans

Figure 3. Anthracnose damage to seeds.
a) perforated ulcer - the seed dies
b) not a perforated ulcer - the seed is healthy

The seeds located next to the affected grain do not show signs of disease, are normally fulfilled, which indicates that there is no spread of the disease inside the bean. Sowing seeds from beans with necrotic ulcers in a breeding nursery on the principle of moving away from the place of introduction of the parasite gives a normally developed, healthy offspring.

4. Results

The mechanisms of passive plant protection have been established: the shape of the bush and limited shoot formation, early and mid-ripening, xeromorphic leaf type, intensely colored seeds, the presence of anthocyanin, wax bloom or dense hair, a combination of a flower corolla and seed coat. To a greater extent, resistance to anthracnose is due to a combination of morpho-biological characteristics and the nature of their interaction.

Yellow lupine bean necrosis indicates a sign of active immunity affecting anthracnose resistance. The formed roller of dead tissue around the site of infection cuts off the access of food to living cells and leads to the death of the parasite, preventing the spread of infection inside the pod. This significantly reduces the damage and death of seeds, as well as additional infection of the infected crop.

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