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DEVELOPMENT OF SCLEROTINIA IN NARROWLEAF (*Lupinus angustifolius* L.) AND WHITE (*Lupinus albus* L.) LUPIN SINGLE AND MIXED CROPS UNDER DIFFERENT WEATHER CONDITIONS IN BRYANSK REGION

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Abstract

White rot caused by ascomycetous fungus *Sclerotinia sclerotiorum* (Lib.) de Bary. is a widely spread disease of many cultivated and wild plants. In the Non Chernozem zone of Russia the epiphytotic development of white rot in white and narrow-leafed lupin crops began in 2008 and is related to climate change towards warming. The article presents the first report on dependence between weather conditions in the Non Chernozem zone and white rot infection of white and narrow-leafed lupines in single and mixed crops. High significant correlation coefficients have been obtained between air moisture and pods' white rot infection of the narrow-leafed lupin in June (r = 0.95, p = 0.001), and of the white lupin in June and July (r = 0.90, p = 0.006; r = 0.81, p = 0.026, respectively). High significant negative correlation coefficients between narrow-leafed and white lupin yields in single and mixed crops and *Sclerotinia* infection of pods have been revealed (r = –0.92, p = 0.003 and r = –1.00, p = 0.002, respectively; r = –0.97, p = 0.000 and r = –0.88, p = 0.122, respectively). The lupin species differed in susceptibility to the pathogen. This work aimed to evaluate the white rot development and harmfulness in white and narrow-leafed lupin crops depending on weather of the vegetation season and crop type under the conditions of Bryansk region. The narrow-leafed lupin var. Belozernyi 110 and the white lupin var. Dega were cultivated in single crops and in mixed crops with spring wheat var. Iren in 2008-2012, 2014, and 2016 in the North-East of Bryansk region (an experimental field of the All-Russian Lupin Scientific Research Institute). Climatic data were received from the meteorological station on the territory of the institute. Lupin plants were infected with white rot mycelium by the wet chamber method. Plant infection was evaluated during the vegetation period (stem and bud formation, flowering and pods' formation stages). The yield of each plot was weighted after the total threshing (a combine-harvester Sampo-500, Sampo Rosenlew, Finland). Intensive pathogen development on the tested lupin species in single and mixed crops was in rainy and warm June-August, at 66.2-80.3 % air moisture. Under rainy, warm and windy conditions white rot spread among plants in lupin crops both by ascospores and by mycelium particles. The first lesion focuses appeared on stems in low field sites and in dense crops. Depressive disease development occurred at air moisture from 54.1 to 60.3 %. White lupin plants were more susceptible to the disease, probably due to the morphological peculiarities of this species. Under favorable conditions for the disease, the incidence of pod infection averaged 15.3-34.8 % in white lupin single crops and 8.4-34.7 % in narrow-leafed lupin single crops. Herewith seed yield losses made 14.3-39.2 % and 3.0-34.7 %, respectively. Under dry conditions of 2010, the white lupin infection incidence was 0.3 % in mixed crops with no infection of the narrow-leafed lupin observed. The infection of the narrow-leafed and white lupines in their single crops made 0.1 and 1.3 %, respectively. The white rot was more harmful for lupin crops upon a combination of sufficient or excessive moisture and optimal temperature in the second part of vegetation. During this period, the pods were formed on the main and lateral stems, and the plant foliation was maximum too. The latter creates favorable conditions for the pathogen inside the crops. Pod infection in lupines decreased significantly in mixed lupin-and-cereal crops, 1.4-1.6-fold for the white lupin, and 1.3-2.3-fold for the narrow-leafed lupin. Obviously, the lupin-and-cereal mixed crops create the conditions which are less favorable for the pathogen development and spread, therefore decrease infection of lupin plants and pods.

K Keywords: *Sclerotinia sclerotiorum*, crop type, air moisture, harmfulness, *Lupinus angustifolius* L., narrow-leafed lupin, *Lupinus albus* L., white lupin

Lupin is a valuable pulse crop that has high protein content in the grain and herbage and a beneficial effect on soil fertility. Currently, two types of lupin are widely cultivated in the Russian Federation — white (*Lupinus albus* L.) and narrow-leafed (*Lupinus angustifolius* L.). Modern varieties of these cultivars may provide a yield of 3-5 mt/ha of grain and up to 300-500 mt/ha of herbage under production conditions. At the same time, the protein content in the grain is 35-38%, exceeding the same indicator in peas and vetch by more than 10% [1-3]. Lupin protein is a source of crude protein in mixed feeds, which is especially important when there is a lack of high-quality animal feed and expensive imported soybean meal [4, 5].

Despite its valuable properties, lupin is not widely used in agricultural production. The phytosanitary situation in its crops is constantly changing due to many factors. One of them is the change in climatic conditions in the areas of lupin cultivation. According to available forecasts, by the end of the 21st century, the Earth's temperature may increase by 1.8-4.6 °C [6]. In Russia, only from 1990 to 2000, the increase in air temperature was 0.4 °C. According to the Russian Hydrometeorological Center, the most active warming occurs in the northern regions of the country, and the average winter temperature throughout Russia may increase by 2-5 °C. The increase in summer temperatures will be less expressed and will be 1-3 °C. In the next 20-30 years, the heat supply of the central and northern cultivated lands of the Central Federal district may reach or exceed the current indicators of the South of Russia [7]. In the Bryansk Region, from 1976 to 2016, the average annual air temperature increased by 2.1 °C, with fluctuations from 3.4 °C (1987) up to 7.4 °C (2016), with a long-term average of 6.2 °C, and since 1996, it has been increasing steadily [8].

Climate change affects all the functions of living organisms — survival, reproduction rate, spatial distribution, etc. [9-11]. The increase in air temperature in Russia is primarily manifested in warming in the autumn-winter (October-December) and winter-spring (January-May) periods. In recent years, it has led to an increase in the intensity of the development of endogenous diseases, the infectious matter of which persists in the soil, on plant residues, and wintering plants [12-14]. An increase in soil temperature in the spring-summer period stimulates the activity of soil fungi from the genera *Pythium*, *Rhizoctonia*, and *Sclerotinia*, reduces the latent period of their development, and increases the aggressiveness of pathogens [15-17]. As the temperature increases, the number of plant pathogens moving from south to north increases, which leads to an expansion of the areal of thermophilic fungal species [11].

Climate change is now becoming a major problem for all sectors of agriculture. Its effect on the host-pathogen system has been proven. Deviations of climatic parameters from long-term values over the past decades lead to epidemics of plant diseases all over the world. In the context of a changing climate, it is necessary to revise the strategy for combating plant diseases [18-20].

White rot is a widely spread disease of many cultivated and wild plants. The causative agent is the ascomycetous facultative fungus *Sclerotinia sclerotiorum* (Lib.) de Bary (class *Ascomycetes*, order *Helotiales*, family *Sclerotiniaceae*). White rot affects crops in South and North America, Europe, China, Australia, and New Zealand. Especially many cases of its manifestation are registered in countries where crop rotations include soy (USA) [21-23]. Rot caused by *Sclerotinia sclerotiorum* is an economically significant disease of soybean (*Glycine max*) in the north-central United States and other temperate regions of the world. The occurrence and severity of stem rot caused by *S. sclerotiorum* in the field largely depend on environmental factors [24, 25].

Researchers from France, Germany, and Belgium report that *S. sclerotiorum* is the causative agent of stem and fruit rot and causes significant economic damage to crops of narrow-leafed and white lupin. Most of the seedlings that emerge from the affected seeds die during germination. Infection of plants through ascospores occurs on the internodes, in the sinuses of leaves or flowers; it requires drops of liquid or high humidity [26-28].

In the conditions of Belarus and Ukraine, this disease was detected in crops of yellow lupin [29, 30]. In Russia, in the main areas of lupin sowing, primarily in the central regions of the Non-Chernozem zone, economically significant lupin diseases until recently included fusariosis, anthracnose, ceratophorosis, gray rot, phomosis, bacteriosis, and viral overgrowth [31]. White rot on lupin did not occur or was very rare and did not cause significant lesions to lupin crops.

The mass development of white rot on the crops of narrow-leafed and white lupin in the conditions of the Non-Chernozem zone of Russia has begun in 2008. Crop losses of seeds of cultivated lupin species were significant. In the scientific literature, there are few papers devoted to *S. sclerotiorum* on narrow-leafed and white lupin in single-species crop and there are no studies dedicated to mixed crop with cereals. For the further development of lupin sowing in Russia, it is necessary to know about the harmfulness of the disease on narrow-leafed and white lupin in different phases of crop development and how meteorological conditions affect *S. sclerotiorum* during the growing season of the crop.

In this paper, the dependence between the weather conditions of the Non-Chernozem zone and the white rot of narrow-leafed and white lupin in single-species and mixed crops was revealed for the first time. It was found that at high humidity, the spread and development of the fungus *Sclerotinia sclerotiorum* on lupin occurred not only by ascospores but also by mycelium particles, and differences in the susceptibility of lupin species to the pathogen were revealed.

Our goal was to assess the development and harmfulness of white rot on white and narrow-leafed lupin crops, depending on the weather conditions of the growing season and the type of crop in the Bryansk Region.

Methods. The research has been carried out in 2008-2012, 2014, and 2016 in the North-East part of the Bryansk Province (an experimental field of the All-Russian Lupin Scientific Research Institute). Narrow-leafed lupin variety Belozernyi 110 and white lupin variety Dega were cultivated in single-species and mixed crops with spring wheat variety Iren. The plot area was 34 m^2, the repetition was 4-fold. The crop was sawn with an SN-16PM seeder (MZOK VIM, Russia) in the standard way. Data on climate indicators were provided by a weather station located in the territory of the Institute.

Parts of lupin plants (stems and pods) were infected with white rot mycelium by the wet chamber method [32] in 2009 and 2011. From the end of flowering to the beginning of pod formation, a fragment of mycelium was placed on a healthy part of the plant. The infection of lupin plants with white rot was evaluated during the growing season (the phases of stemming, budding, flowering, and pod formation). The sample consisted of 5 plants from the plot in 12-fold repetition. The seed yield from each of the 12 plots was determined by continuous threshing of the crops with a Sampo-500 combine harvester (Sampo Rosenlew, Finland).

Statistical processing of the results was carried out by the method of variance analysis at a 95% confidence interval with the determination of the least significant difference between the variants according to Fischer *F*-test [33]. The mean values (*M*) and standard deviations of the mean values (±SD) were calculated. The correlation analysis method (STATISTICA 7.0, StatSoft, Inc., USA) was used to identify the relationship between air humidity, white rot lesion, and lupin yield. The tables show the least significant difference (LSD) for yield values, correlation rates (*r*), and significance level (p).

Results. Mass destruction of lupin pods by white rot, which led to serious losses of the seed yield and a decrease in their crop qualities, was first identified in the region in 2008 during a survey of the crops. To find out the cause of the occurrence and intensive development of the disease in lupin crops, meteorological indicators for June-August were analyzed. In general, the weather conditions during this growing season were warm and humid. The average daily air temperature exceeded the long-term average values by +0.9 °C, the amount of precipitation by 11 mm. The warmest and wettest conditions were in July. The amount of precipitation was 88.9 mm, which was 6.9 mm higher than the long-term average. The average daily temperature (19.3 °C) exceeded the long-term average by 1.1 °C. The average monthly humidity was also the highest, 78%. In June and August, the average monthly humidity was also high and amounted to 76.3 and 73.8%, respectively (Table 1).

Fig. 1. White rot (*Sclerotinia sclerotiorum*) on the stem of the white lupin (*Lupinus albus* L.) variety Dega in a single-species crop: a — formation of white cottony mycelium, b — formation of black matte sclerotia (the experimental field of the All-Russian Lupin Research Institute, Bryansk Province, 2012).

The first signs of white rot infection of lupin plants were found in a single-species crop at the end of June. They were observed on the surface near the root and higher up the stem (a white cottony coating of fungal mycelium and black sclerotia of various shapes). Then, the stems of neighboring plants were infected. The affected tissue was discolored, softened, acquired a brownish-green color, and then a wet rotting spot was formed, subsequently covering the entire stem and spreading up and down from the infection place. A cottony dense mycelium has developed on the surface and inside the affected stem (Fig. 1, a). Later, odd-shaped sclerotia of 0.5-2.0 cm formed on it, which were matte-black on the outside, and white on the inside (see Fig. 1, b). The stems and leafstalks became fragile and eventually broke, and the whole plant died and dried up.

Long rainy and warm period in July-August contributed to the intensive development and spread of white rot, which led to significant losses in the seed crop. At this time, pods were formed on the main and lateral branches, and the plants were as leafy as possible, which created favorable conditions for the active development of the pathogen inside the crop. First, the pods that were on the main stem were affected, since they were located lower than the side pods, and were less ventilated from moisture.

1. White rot infection and yield of green-ripened seeds of narrow-leafed lupin (*Lupinus angustifolius* L.) variety Belozernyi 110 and white lupin (*Lupinus albus* L.) variety Dega in a single-species and mixed crops depending on the air humidity (*M*±SD, the experimental field of the All-Russian Lupin Research Institute, Bryansk Province)

Average monthly humidity, %			Narrow-leafed lupin				White lupin			
			infection rate, %		seed yield, ha		infection rate, %		seed yield, ha	
June	July	August	2	2	1	2	1	2	1	2
					2008					
76.3	78.0	73.8	12.3	5.4	12.8±4.80	8,7±0,28	21,8	13,7	18,9±0,22	12,7±0,22
					2009					
72.1	76.6	73.7	10.7	8.4	13.7±0.28	7,1±0,22	15,3	9,7	21,7±0,35	14,3±0,22
					2010					
58.6	59.8	63.4	0.1	0	17.3±0.29	12,4±0,27	1,3	0,3	25,3±0,26	15,8±0,22
					2011					
72.7	79.4	73.1	8.4	6.7	16.8±0.23	8,2±0,20	21,7	15,4	19,2±0,20	13,9±0,24
					2012					
78.4	74.3	80.3	20.3	–	11.3±0.22	–	34,8	–	15,1±0,24	–
					2014					
60.3	52.4	54.1	0	–	16.7±0.29	–	0,7	–	24,7±0,26	–
					2016					
66.2	79.1	78.3	2.2	–	17.1±0.22	–	22,9	–	20,8±0,25	–
				LSD_{05}	2.69	0.38		LSD_{05}	0.38	0.34

N o t e. 1 — single-species crop, 2 — mixed crop with spring wheat variety Iren. Dashes indicate no mixed crops in the years of observation.

Fig. 2. White rot (*Sclerotinia sclerotiorum*) on pods of the white lupin (*Lupinus albus* L.) variety Dega (a) **and narrow-leafed lupin (*Lupinus angustifolius* L.) variety Belozernyi 110** (b). The formation of a white cottony mycelium and black sclerotia is shown (the experimental field of the All-Russian Lupin Research Institute, Bryansk Province, 2012).

The development of the disease on the pods began with their lower part, which was attached to the stem. By spreading, the pathogen could infect all the pods on the main stem. The affected pod tissue softened, first turning pale green, then brown. Over time, the pods were completely covered with the white cottony fungal mycelium, on which black sclerotia of various shapes and sizes appeared (Fig. 2).

From the affected pod leaves, the disease spread to the seeds, which were covered with a white coating of mycelium; subsequently, the mycelium turned into dark sclerotia. The affected pods became loose and fell to the ground along with the rotted seeds. If dead plants were present in the crop during this period, they were completely affected by white rot and died. According to Han et al. [25], a severe infection of *Canavalia gladiata* DC crops with white rot in South Korea in 2018 led to necrotic formations of stems and pods in contact with the soil.

It should be noted that in the conditions of the growing season of 2008, narrow-leafed lupin showed greater resistance to the disease in comparison with white lupin. In the green ripeness stage, the highest percentage of pod infection in single-species and mixed crops was observed on white lupin, 21.8% and 13.7%, respectively. The lesion of narrow-leafed lupin pods was significantly less, 12.3% in a single-species crop and 5.4% in a mixed crop (see Table 1). A similar pattern of lesion of narrow-leafed lupin and white lupin was observed in other years favorable for the disease development.

When examining lupin crops, the researchers found small fragments of whitish mycelium on unaffected parts of plants that were close to the affected plant with a cottony fungal mycelium. To establish the possibility of spreading white rot by mycelium particles with the help of wind and rain, in 2009 and 2011, the artificial infection of white and narrow-leafed lupin with the pathogen mycelium was carried out in the field. In warm weather (18-22 °C) and sufficient moisture, the mycelium was introduced into the tissue of a growing pod or leaf of the plant with a dark spot formation, then a white mycelium and black sclerotia. The symptoms of the disease during artificial infection did not differ from the natural infection during this period on other crops. Consequently, the spread of white rot in lupin crops occurs not only with the help of ascospores but also with the transfer of mycelium particles from plant to plant by wind and rain. This increases the infection load in the crop, and under conditions favorable for the fungus (high humidity) leads to epiphytotic development of the disease and significant losses of seed yield. During the examination, the first foci of the disease on the stems of lupin plants were detected in low areas of the field and thickened crops, therefore, the disease in the crops has a focal nature.

Our long-term observations have shown that the development and spread of white rot in lupin crops are promoted by moderate, sometimes heavy rains and high humidity in the second half of the lupin growing season. It is confirmed by studies conducted in different regions of the world on other cultures. For example, Simic et al. [34] found that the grain yield and the manifestation of disease symptoms varied significantly depending on the amount of precipitation and temperature during the growing season of the sunflower. The authors note that the minimum grain yield (1.14 mt/ha) and the highest frequency of disease symptoms (24-67% of diseased plants) were observed in the wet year 2005, and the highest yield (3.87 mt/ha) and the lowest white rot lesion (3.2-5.8% of diseased plants) in 2007. According to the results of studies conducted in Vietnam [35], white rot is often found in the cool, humid winter and spring seasons on dwarf and climbing pods, peanuts, and sometimes on Chilli pepper plants. A severe lesion was observed in peanut crops in the spring of 2008 after a period of wet weather, in the phase of the beginning of flowering. The results of laboratory experiments with millet confirm that the duration of humidity and incubation temperature affects the germination of *Sclerotinia sclerotiorum* ascospores and the effectiveness of ascosporic infection. Ascospore germination is optimal when incubated at constant humidity at 21 °C. Lower germination was observed at 10 and 30 °C. Interrupting wet incubation delayed the manifestation of disease symptoms and inhibited plant infection [15].

In this study, favorable weather conditions for the development of white rot on lupin crops were in 2009, 2011, 2012, and 2016, when in June-August the relative humidity was 13.8-17.0% higher compared to 2010 and 2014, characterized by less precipitation and low relative humidity. The greatest infection of white rot was observed on crops of white lupin, but the disease caused the maximum lesion to both types of lupins in 2012. Wet and excessively wet conditions of the growing season developed in all the ten-day periods of June and August, while the average daily humidity was high and amounted to 78.4% and 80.3%, respectively. In July, the indicator slightly decreased, reaching 74.3%. The rate of fungus development was higher in single-species crops of narrow-leafed and white lupines. The lesion of pods in the green ripeness stage by white rot was the maximum and amounted to 20.3% and 34.8%, respectively. The seed yield this year was the lowest, 10.7 and 15.1 dt/ha. In comparison with the indicator obtained in 2010, the significant decrease in the yield of narrow-leafed and white lupines was 6.0 dt/ha (34.7%; LSD_{05} 2.69) and 10.2 dt/ha (40.3%; LSD_{05} 0.38), respectively.

The pods located on the main stem were more affected by lesions, especially in the white lupin. It may be due to differences in morphology. Plants of the narrow-leafed lupin in the green ripeness stage are less leafy than white, therefore, the crops are better ventilated, moisture evaporates from their surface faster, which reduces the intensity of the pathogen development. On white lupin plants, a larger number of leaves are formed by the green ripeness stage, which helps to create a denser crop, in which moisture persists longer, the illumination of the pods decreases, especially on the main stem, and favorable conditions for fungus development are created.

According to the results obtained by the authors, the development of white rot was determined by the humidity of the air, especially in July and August (see Table 1). Thus, in 2014, during these months, the humidity was 52.4% and 54.1%, and the disease development on the narrow-leafed lupin was not observed, and on the white lupin, it was insignificant (0.7%). With a small amount of precipitation and low relative humidity, the affected parts of the plants dried up, and the sclerotia formed on them fell off. Plants with affected stems died. In the dry years 2010 and 2014, the disease development on lupin occurred only near the root and in the middle part of the stem. The lowest lesion of white lupin in mixed crops (0.3%) was observed in the dry conditions of the growing season 2010. The lesion of narrow-leafed lupin in the same crop was absent. In a single-species crop, the lesion of narrow-leafed and white lupin plants was 0.1% and 1.3%, respectively.

2. Correlations between the studied variables in single-species and mixed crops of narrow-leafed lupin (*Lupinus angustifolius* L.) variety Belozernyi 110 and white lupin (*Lupinus albus* L.) variety Dega ((the experimental field of the All-Russian Lupin Research Institute, Bryansk Province, 2008-2012, 2014, 2016)

Variables	*r* and p values		
	June	July	August
Single-species crop			
White lupin			
Air humidity (%) × lesion of pods (%)	–0.94* (p = 0.002)	–0,71 (p = 0,071)	–0,83* (p = 0,021)
Yield (dt/ha) × lesion of pods (%)	0.90* (p = 0.006)	0,81* (p = 0,026)	0,92* (p = 0,003)
Air humidity (%) × lesion of pods (%)	–0.97* (p = 0.000)	–0,97* (p = 0,000)	–0,97* (p = 0,000)
Narrow-leafed lupin			
Air humidity (%) × lesion of pods (%)	–0.80* (p = 0.029)	0,38 (p = 0,399)	–0,56 (p = 0,190)
Yield (dt/ha) × lesion of pods (%)	0.95* (p = 0.001)	0,58 (p = 0,174)	0,71 (p = 0,072)
Air humidity (%) × lesion of pods (%)	–0.92* (p = 0.003)	–0,92* (p = 0,003)	–0,92* (p = 0,003)
Mixed crops with spring wheat			
White lupin			
Air humidity (%) × lesion of pods (%)	–0.89 (p = 0.105)	–0,86 (p = 0,144)	–0,94 (p = 0,060)
Yield (dt/ha) × lesion of pods (%)	0.95 (p = 0.050)	0,97* (p = 0,029)	0,91 (p = 0,089)
Air humidity (%) × lesion of pods (%)	0.88 (p = 0.122)	–0,88 (p = 0,122)	–0,88 (p = 0,122)
Narrow-leafed lupin			
Air humidity (%) × lesion of pods (%)	–0.93 (p = 0.074)	–0,93 (p = 0,075)	–0,88 (p = 0,116)
Yield (dt/ha) × lesion of pods (%)	0.90 (p = 0.096)	0,91 (p = 0,090)	0,85 (p = 0,147)
Air humidity (%) × lesion of pods (%)	–1.00* (p = 0.002)	–1,00* (p = 0,002)	–1,00* (p = 0,002)

* *r* values are statistically significant at p < 0,05.

Our observations have shown that the type of crop has a significant impact on the development and spread of the disease on lupin. In the conditions of the Bryansk Province, the greatest losses of the seed yield from white rot were observed in the single-species crop of white lupin. With prolonged precipitation and high humidity in the second half of the growing season, pod lesions varied from 15.3% to 34.8%, which reduced the seed yield by 14.3-39.2% (LSD_{05} = 0.38 at 95% significance level). The correlations revealed a significantly high dependence of the lesion of white lupin plants in a single-species crop on humidity in June and July, the r = 0.90 (p = 0.006) and r = 0.81 (p = 0.026), respectively (Table 2).

The lesion of lupin pods under similar conditions ranged from 8.4% to 20.3%, and the yield loss from 3.0% to 34.7% (LSD_{05} = 2.69). In June, in the single crop of narrow-leafed lupin, a high reliable relationship between humidity and white rot lesion to plants (r = 0.95, p = 0.001) and an inverse reliable relationship between yield and pod lesion (r = –0.92, p = 0.003) were revealed.

Multi-year observations have shown that in a mixed crop with cereals, both lupins were less affected by white rot than in a single-species crop. Thus, in 2011, which was favorable for the disease development, in the mixed crop, the lesion of pods in narrow-leafed and white lupins was 6.7% and 15.4%, respectively, while in a single-species crop, 8.4% and 21.7% pods were affected. In the mixed crop in the years with high humidity (2008, 2009, 2011), the yield of narrow-leafed and white lupin seeds decreased 1.4-1.7 and 1.2 times, respectively (LSD_{05} = 0.38, LSD_{05} = 0.34) compared to the year with low humidity (2010). It can be assumed that in mixed crops with cereals, microclimatic conditions are created that are less favorable for the disease development, which reduces the lesion to plants and lupin pods.

Thus, the development and spread of white rot on crops of white and narrow-leafed lupin in the Non-Chernozem zone of Russia is largely determined by meteorological conditions. Intensive development of the pathogen in single-species crops and crops mixed with spring wheat occurs in case of rainy and warm weather in June-August and the air humidity of 66.2-80.3%. In years with less precipitation and low relative humidity, white rot lesion to lupin crops fell sharply or was absent. The species dependence of the susceptibility of lupin to the disease was revealed. The greatest white rot lesion was noted on white lupin. The lesion of white lupin pods in a single-species crop reached 15.3-34.8%, of narrow-leafed lupin pods 8.4-34.7%. In a single-species crop, high reliable negative correlation (r = –0.97, p = 0.000) was obtained between the yield of white lupin and its white rot lesion. In a mixed crop with cereals, the pod lesion decreased 1.4-1.6 times in white lupin and 1.3-2.3 times in narrow-leafed lupin. The specificity of mixed crops, where the second component is a cereal crop, allows suggestion on their deterrent role in the development of the studied fungal disease. To reduce the harmfulness of white rot on lupin, it is advisable to cultivate it in mixed crops with cereals.

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