KnE Life Sciences
DonAgro
International research conference on Challenges and Advances in Farming, Food Manufacturing, Agricultural Research and Education
Volume 2021

Conference Paper

Biotic Factors in the Phytosanitary Technology of Green Pea Cultivation in the Trans-Urals

Igor Porsev, Andrey Sozinov, Valentina Polovnikova, and Anna Vyunik

Kurgan State Agricultural Academy named after T.S. Maltsev, 641300 Kurgan region, Russia

ORCID:

Andrey Sozinov: http://orcid.org/0000-0002-5286-1561

Abstract

This article presents the results of studying the phytosanitary situation in the cultivation of 10 varieties of green pea in the Trans-Urals. We noted that the economic threshold of harmfulness by the soilborne and leaf-and-stem disease agents was crossed in the majority of the varieties. All varieties of the peas were affected by root rot above the economic threshold of damage (15%). In 2018, the level of root rot development was 55.5% on average in the varieties, or an excess of EPR by 3.7 times; and in 2019, the development of rot was 44.6% or an excess of EPR by 3 times. High rates of Fusarium blight were evident in the Zauralskiy 4, Kulon, Krepysh, and Samarius varieties, and bacterial blight in the Krepysh and Tomas varieties. Rust development varied on average over the two years from 10.5% to 16.5%, and 12% of the standard cultivar Aksayskiy Usatii 55 was affected. 11% of Samarius 13% of Agrointel and 11.5% of Zauralskiy 3 were affected. For all varieties, the development of powdery mildew was below the economic threshold of harmfulness (EPV = 15%). A higher percentage of disease development was noted in the Zauralsky 4 variety (11.0%) and in the Yamalsky 305 variety (13.5%). The productivity of the seeds treated with chemical fungicide increased 1.2-1.9 times as compared to the reference sample. The productivity growth of the seeds treated with biofungicides amounted to 1.09-1.11 times the reference. The authors recommend a pre-sowing treatment of pea seeds with preparations of symbiotrophic nitrogen fixers (such as nitragin, rhizotorfin), combined with their treatment with microelements: ammonium molybdate with 50% content of the active ingredient (250 g / t of seeds) and boric acid (250-300 g / t of seeds).

Keywords: green pea, varieties, diseases, fungicide, yield.

Corresponding Author:
Andrey Sozinov
savrey@ya.ru

Published: 5 April 2021

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the DonAgro Conference Committee.

1. Introduction

In 2017, the areas of the Kurgan region planted with the pea amounted to 18,225 ha with the average yield of 2.72 t/ha [1]. The key biotic factors leading to decreased pea yield include phytopathogens, phytophages, and weedage. They are very harmful as they thin out seedlings, reduce grain productivity and quality [2-4].

The list of pea diseases in the majority of Russian regions is limited to root rots (provoked by Fusarium spp., Pythium spp., Rhizoctonia spp., etc), rust (Uromyces spp.), ascochyta leaf blight (Ascochyta spp.), anthracnose (Colletotrichum pisi Pat.), and mildew (Erysiphe spp.) [3, 5, 6]. The losses of pea yields due to root rots (caused by Fusarium fungi), if severe, may amount to 30-50% and be accompanied with the grain quality deterioration [1, 7].

To rationalize the protective measures, it is crucial to consistently monitor diseases and specify their etiology because regional differences may occur, as well as the change of the dominant phytopathogens caused by technology and natural fluctuations [8, 9].

The goal of this research is to monitor pea root rots and specify the etiology of the disease, as well as develop control actions for the forest-steppe areas of the Kurgan region.

The objectives of the research were as follows:

1. The study of seasonal dynamics of diseases, including root rots in various pea varieties in the forest steppes of Kurgan region;

2. The specification of pea root rot etiology in Kurgan region and development of control actions;

3. The assessment of the impact of pea variety on the development and etiology of root rots.

2. Methods and Equipment

Laboratory and field-based disease recording, including pea root rots, was carried out by drawing samples from the experimental field at the laboratory of the Department of Land Planning, Lan Use, Agrochemistry, and Soil Science of Kurgan SAA.

Before the pea, the field was fallowed. Planting time: the last third of May in 2018 and 2019. Planting depth: 5 cm, planting rate: 1.0 mil. seeds per ha. Tilling technology: spring harrowing, pre-seeding grubbing. During phase 4 of true leaves, plants were treated with herbicides, and at the bud stage, with insecticides. The distribution of the varieties was randomized, with fourfold replication.

The following observations and analyses were performed: seed purity acc. to GOST 12037-81; viability and germination capacity acc. to GOST 12038-84; 1000 seed weight acc. to GOST 12042-80; seed disease rate acc. to GOST 12044-93. Determining the actual planting rate, phenological observations, morphological analysis of plants, yield formula elements acc. to Methods for official agricultural crop tests. The recording of root rots and the mycological analysis of pea plant organs were carried out using common methods [10].

The statistical treatment of experimental data was performed using dispersion and correlation analysis methods involving the use of Excel and SNEDECOR applications [11].

The vegetation period of 2018 was cool in the first half of the summer and hot in July and August. The amount of precipitation in June was within the long-term annual averages, which facilitated even sprouts. In July and August, the amount of rainfall was below the standard, which was reflected in the productivity of pea varieties (Hydrothermal Index – 1.0). The vegetation period in 2018 was cold in June and hot in July and August. The precipitation in June was at 83% of the standard, in July, it was 67% of the standard, and in August, it was 186% of the standard, which had some impact on the pea harvesting in August. The climate factors mostly have a complex impact that is largely defined by the pea planting time.

3. Results

Pea seed of the 10 varieties under inspection are characterized by good (over 90%) and satisfactory (over 85%) sowing qualities, and they comply with the regulations in Table 1.

However, the majority of 2017 yield specimens had a slightly reduced viability: 70% for the Agrointel variety, 75% for Krepysh, 78% for Samarius, and 79% for Yamalskiy 305, the prevalence of root rots in underground seedlings for the varieties in question was between 18.1 and 60%. The quantities of phytopathogens in these varieties exceeded the threshold values (10%). The spread of bacterial blight is especially notable: it amounted to 7-13% in 2017. The bacterial blight rate for the seeds of the 2018 yield was between 1% (the Kulon variety) and 25% (the Krepysh variety). The latter features a fourfold exceedance of the economic threshold of harmfulness (ETH) for the bacterial blight (ETH=5%). In 2019, the seeds obtained generally had low bacterial blight rates, and the ETH exceedance was only observed in three varieties: Aksayskiy Usatyi 55 – 6%, Tomas – 12%, and Krepysh – 15% in Tables 1, 2.

The root rot incidence rates in all seed batches significantly exceeded the ETH. The worst cases of threshold exceedance were observed in Aksayskiy Usatyi 55, Agrointel, Samarius, and Krepysh varieties, and the best seed quality was obtained from the Kulon and Shevron varieties, where the exceedance of harmfulness threshold was 2-3-fold.

Pea seeds contained several phytopathogens, including the causal agents of both soilborne (4 infections) and leaf-and-stem (3 infections) diseases. The aggregate contamination with dangerous phytopathogens (excluding the low pathogenic group of the Alternaria blight agents) for the majority of the varieties exceeded the maximum permissible level (ETH=10%). The worst ETH exceedance was observed in the seeds of the Agrointel, Samarius, and Krepysh varieties.

The phytosanitary condition of the Aksayskiy Usatyi 55, Zauralskiy 3, Zauralskiy 4, Tomas, and Shevron was relatively good in terms of the pathogen set, with the ETH of 1-1.5.

The correlation analysis showed a valid (significance level of 1%) and close connection (r = –0.945±0.104) of seed viability and the spread of root rots, as well as the link between the viability and the bacterial blight incidence (r = –0.747±0.210). This implies that pea root rot and seed bacterial blight are very harmful.

Table 1: Sowing qualities and phytosanitary condition of pea seed by year of yield, %

Year	Variety									
	Aksayskiy Usatyi 55	Agrointel	Zauralskiy 3	Zauralskiy 4	Samarius	Kulon	Krepysh	Tomas	Shevron	Yamalskiy 305
Viability										
2017	85	70	85	88	78	88	75	83	83	79
2018	87	90	95	89	88	90	85	85	88	89
2019	93	99	93	95	91	95	86	94	90	97
LSD05 for ‘year’ = 4.2; for ‘variety’ = 2.1										
Root rot spread										
2017	22.5	60.0	16.1	23.0	55.4	10.0	35.0	15.6	12.0	18.1
2018	18.5	30.0	11.1	21.0	38.4	8.0	25.0	12.0	10.0	15.1
2019	21.5	20.2	25.8	24.2	39.6	13.7	34.9	17.0	19.1	16.5
LSD05 for ‘year’ = 5.4; for ‘variety’ = 3.8										

Data from Table 3 show that all of the pea varieties were smitten with root rots at the levels exceeding the ETH (ETH=15%). In 2018, the average root rot progression value across the varieties was 55.5%, i.e. 3.7 times over the ETH; and in 2019, the root rot progression amounted to 44.6% or 3 times over the ETH. The progression of the disease in these years could have been impacted by different weather during the vegetation periods. We did not identify varieties that resisted the root rots. The average disease progression rate by the harvesting time for two years varied from 32.4% (Tomas) to 58.6% (Zauralskiy 4). The high progression of the disease could have impacted the productivity of the varieties.

The rate of Fusarium fungi infection in the pea roots amounted to 20-80%. The observed Fusarium fungi included: Fusarium oxysporum Schltdl., F. solani Koord., F. poae (Peck) Wollenw., F. sporotrichioides, etc.

Table 2: Seed contamination with phytopathogens per year of yield, % (2017-2019)

Year	Variety									
	Aksayskiy Usatyi 55	Agrointel	Zauralskiy 3	Zauralskiy 4	Samarius	Kulon	Krepysh	Tomas	Shevron	Yamalskiy 305
Fusarium spp. (Fusarium blight)										
2017	8.0	9.0	4.0	10.0	12.0	10.0	13.0	11.0	6.0	7.0
2018	11.0	5.0	2.0	3.0	19.5	8.0	11.0	6.0	2.0	5.0
2019	7.0	4.0	7.0	15.0	10.0	11.0	10.0	9.0	8.0	4.0
LSD05 for 'year' = 2.7; for 'variety' = 1.2										
Alternaria spp. (Alternaria blight)										
2017	31.0	25.0	24.0	22.0	20.0	18.0	28.0	21.0	24.0	31.0
2018	29.0	16.0	28.0	17.0	13.0	14.0	15.0	16.0	21.0	17.0
2019	45.0	27.0	49.0	29.0	27.0	27.0	25.0	26.0	34.0	25.0
LSD05 for 'year' = 5.3; for 'variety' = 3.1										
Bacteriosis										
2017	10.0	12.0	4.0	2.0	11.0	3.0	13.0	9.0	5.0	7.0
2018	18.0	21.0	8.0	3.0	21.0	1.0	25.0	17.0	9.0	14.0
2019	6.0	2.0	2.0	4.0	5.0	2.0	15.0	12.0	1.0	4.0
LSD05 for 'year' = 3.8; for 'variety' = 2.1										

Table 3: Pea root rot progression and etiology before harvesting, Kurgan SAA

Variety	Disease progression, %			Root contamination with fungi, %		
	2018	2019	average	*Fusarium spp.*	*Pythium spp.*	Other
Aksayskiy Usatyi 55 (st)	46.4	32.5	39.4	80	10	10
Agrointel	45.6	42.5	44.1	20	60	20
Zauralskiy 3	65.0	38.8	51.9	70	30	0
Zauralskiy 4	67.3	50.0	58.6	70	20	10
Samarius	51.8	43.8	47.8	40	50	10
Kulon	53.6	53.8	53.7	40	40	20
Krepysh	53.1	28.8	41.0	70	30	0
Tomas	47.9	16.9	32.4	40	40	20
Shevron	58.3	51.3	54.8	50	40	10
Yamalskiy 305	55.6	50.0	52.8	50	50	0
Average	55.5	44.6	50.1	52.5	35.0	12.5
LSD_{05}	9.6	5.5		10.6	8.9	5.6

Apart from the Fusarium fungi, pea roots were contaminated by the Pythium fungi that are quite harmful to the pea. The proportion of the Pythium fungi in the pathogenic set of pea root rots is between 10 and 60%.

The category of "Other" comprises the Alternaria fungi (Nordman, Tomas, and Shevron varieties) Colletotrichum fungi (Aksayskiy Usatyi 55, Agrointel, and Samarius varieties), Trichoderma fungi (Kulon, Tomas), Mucor (Agrointel), Penicillium (Kulon and Tomas). Besides, we found streptomycetes (the Tomas variety) and nematodes (Kulon and Samarius varieties) in the pea plant residues. We also observed hibernating cleistothecium of the pea mildew in the plant residues [12].

Pea rust, i.e. light-brown dust pouches on the leaves and stems of the pea plants was observed in the middle of the summer. By the end of the summer, dark-brown or almost black pouches appear. This disease is caused by the rust fungus Uromyces pisi D. B. Its spring stages (spermagones and aecidii) develop on the intermediary host, the milkwort (Euphorbia), and uredospores and teleutospores form on the pea plants. In severe rust cases, pea leaves turn yellow and dry prematurely, which leads to plant death and a dramatic reduction of the yield [13].

Table 5 presents the data on the development of rust and mildew across the pea varieties. The table shows that the rust rates vary across the pea varieties, which, in the end, impacts the yield of the crop. The average progression of the disease for two years varied from 10.5% (Kulon) to 16.5% (Zauralskiy 4). The standard Aksayskiy Usatyi 55 variety had a disease rate of 12%. The recognized varieties of Samarius, Agrointel, and Zauralskiy 3 had 11%, 13%, and 11.5% respectively.

For all of the varieties, the mildew progression is below the harmfulness threshold (ETH=15%). The higher disease rates were observed in Zauralskiy 4 (11.0%) and Yamalskiy 305 (13.5%).

Table 4: The progression of leaf-and-stem diseases in pea varieties, Kurgan SAA, %

Variety	Rust			Mildew		
	2018	2019	average	2018	2019	average
Aksayskiy Usatyi 55 (st)	14.0	10.0	12.0	5.0	4.0	4.5
Agrointel	11.0	15.0	13.0	6.0	7.0	6.5
Zauralskiy 3	13.0	10.0	11.5	7.0	8.0	7.5
Zauralskiy 4	16.0	17.0	16.5	10.0	12.0	11.0
Samarius	11.0	11.0	11.0	8.0	10.0	9.0
Kulon	9.0	12.0	10.5	5.0	5.0	5.0
Krepysh	15.0	16.0	15.5	9.0	10.0	9.5
Tomas	10.0	16.0	13.0	5.0	9.0	7.0
Shevron	15.0	11.0	13.0	6.0	5.0	5.5
Yamalskiy 305	15.0	10.0	12.5	13.0	14.0	13.5
LSD_{05}	1.0	1.1		1.3	1.5	

The productivity of the pea varieties can be used to determine their resilience against biotic and abiotic factors [14]. The highest yield in the two years of study was obtained from the standard variety of Aksayskiy Usatyi 55: 2.98 t/ha. The varieties recommended for planting in the Ural region that includes the Kurgan region showed good productivity level: Agrointel – 2.17 t/ha, Zauralskiy 3 – 2.45 t/ha, Samarius – 2.83 t/ha (Table 6).

Among the new varieties, high yields were obtained from the Kulon (2.75 t/ha), Yamalskiy 305 (1.94 t/ha), and Shevron (1.84 t/ha) varieties. The vegetation period of 2019 was characterized by droughts in July. The soil drought and dry hot winds on July 12-16 influenced the yield structure elements.

Table 5: Pea variety productivity, the experimental field of Kurgan SAA

Variety	Yield, t/ha		
	2018	2019	average
Aksayskiy Usatyi 55 (st)	3.46	2.50	2.98
Agrointel	2.38	1.95	2.17
Zauralskiy 3	2.58	2.32	2.45
Zauralskiy 4	2.28	1.88	2.08
Samarius	3.45	2.21	2.83
Kulon	3.63	1.86	2.75
Krepysh	1.77	1.56	1.66
Tomas	1.82	1.55	1.69
Shevron	1.89	1.80	1.85
Yamalskiy 305	1.95	1.92	1.94
Average	2.52	1.96	2.24
LSD_{05}	0.3	0.5	

Due to the adverse phytosanitary condition, pea seeds have to be heated up and treated with disinfectant before planting to improve their field viability and protect from phytopathogens. If the pea shall be planted early, it is possible to use systemic agents; if planted late, contact disinfectants and biofungicides can be applied.

We studied the problem of protecting pea seeds and underground seedlings using chemical disinfectants like Depozit ME (1 l/t), Protekt (2 l/t) and biofungicides like Fitosporin M, P (0.6 kg/t) and Biokompozit Korrekt (2 l/t) to restrict the progression of pea root rots. The experimental design is presented in Table 7.

The average biological efficiency of Depozit ME (1 l/t) chemical solution containing fludioxonil (40 g/l), imazalil (40 g/l), and metalaxyl (25 g/l) for the study years amounted to 80% (Zauralskiy 3), 72.1% (Agrointel), and 77.2% (Samarius). The average biological efficiency of Protekt (2 l/t) containing fludioxonil (25 g/l) for the study years amounted to 73.6% (Zauralskiy 3), 70.5% (Agrointel), and 73.4% (Samarius).

The use of bacteria-based biofungicides, such as Fitosparin M, Biokompozit Korrekt to combat pea root rots proved to be efficient.

The biological efficiency of using Fitosparin M equaled 46.4% for Zauralskiy 3, 44.0% for Agrointel, and 52.1% for Samarius. The same parameter for Biokompozit Korrekt was 51.2% for Zauralskiy 3, 53.7% for Agrointel, and 54.3% for Samarius. The efficiency of biological solutions in restraining pea root rot progression was lower than that of chemical fungicides. However, biological solutions are more environmentally-friendly and can be used to treat seed batches with low root rot agent infection rates.

Table 6: The progression of root rot and the biological efficiency of modern fungicides in treating pea seeds (experimental field of Kurgan SAA), 2018-2019

Variety	Zauralskiy 3		Agrointel		Samarius		average	
	progress-ion	*BE	progress-ion	*BE	progress-ion	*BE	progress-ion	*BE
Control sample	51.9	-	44.1	-	47.8	-	47.9	-
Depozit ME – 1 l/t	10.4	80.0	12.3	72.1	10.9	77.2	11.2	76.6
Protekt – 2 l/t	13.7	73.6	13.0	70.5	12.7	73.4	13.1	72.6
Fitosporin M, P – 0.6 kg/t	27.8	46.4	24.7	44.0	22.9	52.1	25.1	47.6
Biokompozit Korrekt – 2 l/t	25.3	51.2	20.4	53.7	19.9	58.4	21.9	54.3
LSD_{05} for 'disinfectant' = 5.6; for 'variety' = 6.2								

*Biological efficiency

Protective measures using chemical and biological solutions to treat highly-productive varieties of the green pea facilitate the increase of crop yield in Table 8.

The yield of the green pea treated with Depozit ME (1 l/t) chemical fungicide increased by 1.23 times for Zauralskiy 3, 1.91 for Agrointel, and 1.22 for Samarius. If treated with Protect (2 l/t), the yield increased by 1.91 times of the reference for Zauralskiy 3, 1.22 times for Agrointel, and 1.2 times for Samarius.

When using biofungicides, the average yield across the varieties increased 1.09 times for Fitosparin M, and 1.11 times for Biokompozit Korrekt.

4. Discussion

The level of distribution of phytopathogens on the studied pea varieties indicates the need to use appropriate plant protection products – chemical and biofungicides. In addition to measures aimed directly at the destruction or suppression of pathogens, it is recommended to use techniques that promote the development of beneficial microflora and eliminate the deficiency of peas in trace elements.

Pea seed inoculation with symbiotrophic nitrogen fixer (like nitragin or rhizotrophine) is desirable for all pea varieties [15], and it should be complemented with microelement treatment, such as the acid ammonium molybdate with the content of active ingredient of 50% (250 g per a ton of seeds) and boric acid (250-300 g per a ton of seeds). Microelements should be dissolved in 10 liters of water before use.

Table 7: The productivity of pea varieties treated with fungicides prior to seed planting (experimental field of Kurgan SAA) 2018-2019

Variety	Pea seed productivity, t/ha			
	Zauralskiy 3	Agrointel	Samarius	average
Reference	2.45	2.17	2.33	2.32
Depozit ME – 1 l/t	3.01	2.71	2.84	2.85
Protekt – 2 l/t	2.92	2.65	2.80	2.79
Fitosporin M, P – 0.6 kg/t	2.64	2.42	2.57	2.54
Biokompozit Korrekt – 2 l/t	2.67	2.49	2.56	2.57
LSD_{05} for 'disinfectant' = 1.3; for 'variety' = 1.2				

If seed inoculation is planned, their disinfection is performed in advance, 2-3 weeks before the planting. If inoculation is not planned, seeds can be disinfected directly before planting.

To increase the field viability of seeds, they should be warmed up before planting. It can be done in the sun or a drying cabinet at 35-40°С and it will take 2 days. The pea seed treatment sequence: warm-up → disinfection → inoculation.

5. Conclusion

1. Pea seed of the 10 varieties are characterized by good and satisfactory (over 85 %) sowing qualities, and they comply with the regulations. The spread of root rot in underground seedlings exceeded the ETH for all of the varieties.

2. Pea seeds contained several phytopathogens, including the causal agents of both soilborne (4 infections) and leaf-and-stem (3 infections) diseases. The aggregate contamination with dangerous phytopathogens for the majority of the varieties exceeded the maximum permissible level (ETH=10%). The worst ETH exceedance was observed in the seeds of the Agrointel, Samarius, and Krepysh varieties.

3. The causing agents for the Fusarium blight were found in all of the pea varieties but they reached or exceeded the ETH (10%) only in 4 of them: Zauralskiy 3, Kulon, Krepysh, and Samarius. The highest rate of Fusarium blight, 1.5 ETH, was observed in the seeds of Zauralskiy 4 variety.

5. The causing agents for the bacterial blight were found in all of the varieties, and the ETH (5%) in the Krepysh and Tomas varieties was exceeded up to 3 times.

6. The mycological analysis showed that root rots were mostly caused by the Fusarium and Alternaria fungi irrespective of the pea variety. The rate of Fusarium fungi infection in the pea roots amounted to 20.8-95%. The observed Fusarium fungi included: Fusarium oxysporum Schltdl., F. solani Koord., F. poae (Peck) Wollenw., F. sporotrichioides, etc.

7. The yield of the green pea treated with Depozit ME (1 l/t) chemical fungicide increased by 1.23 times for Zauralskiy 3, 1.91 for Agrointel, and 1.22 for Samarius. If treated with Protect (2 l/t), the yield increased by 1.91 times of the reference for Zauralskiy 3, 1.22 times for Agrointel, and 1.2 times for Samarius. When using biofungicides, the average yield across the varieties increased 1.09 times for Fitosparin M, and 1.11 times for Biokompozit Korrekt.

Acknowledgement

The authors would like to thank their colleague for their contribution and support to the research. They are also thankful to all the reviewers who gave their valuable inputs to the manuscript and helped in completing the paper.

Conflict of Interest

The authors have no conflict of interest to declare.

References

[1] Toropova, Y. Y., *et al*. (2019). Pea Root Rot Etiology in Forest Steppes of Western Siberia and Transurals. *Vestnik of Kurgan SAA*, vol. 3, issue 31, pp. 34-37.

[2] Gorobey, I. M. and Konyaeva, N. M. (2014). *Diseases of Leguminous Crops and their Phytosanitary Control in Western Siberia*. Novosibirsk: State Scientific Institution SibNSKhB Russian Agricultural Academy.

[3] Postovalov, A. A. (2018). The Impact of Mineral Fertilizers on the Phytosanitary Condition of the Pea Rhizosphere. *Vesting of Kurgan SAA*, vol. 1, issue 25, pp. 45-47.

[4] Cousin, R. (1997). Peas (*Pisum sativum* L.). *Field Crops Research*, vol. 53, issue 1–3, pp. 111-130.

[5] Gorobey, I. M., Ashmarina, L. F. and Konyayeva, N. M. (2011). Fusarium Blights of Grain Legumes in Forest Steppes of Western Siberia. *Plant Protection and Quarantine*, vol. 2, pp. 14-16.

[6] Kozyavina, K. N. (2015). The Impact of Root Rot Causing Agents on the Growth and Development of Underground Pea Seedlings. *Russian Agricultural Science Review*, vol. 6, issue 6-1, pp. 191-192.

[7] McDonald, G. K. and Peck, D. (2009). Effects of Crop Rotation, Residue Retention and Sowing Time on the Incidence and Survival of Ascochyta Blight and its Effect on Grain Yield of Field Peas (*Pisum sativum* L.). *Field Crops Research,* vol. 111, issue 1-2, pp. 11-21.

[8] Kirik, N. N. and Pikovskiy, M. I. (2006). Fungoid Diseases of the Pea. *Plant Protection and Quarantine*, vol. 6, pp. 46-49.

[9] Kotova, V. V. (2011). *Vetch and Pea Root Rots and Protective Measures*. St. Petersburg: VIZR.

[10] Chulkina, V. A., *et al*. (2007). Phytosanitary Optimization of Agroecosystems in Western Siberia. *Plant Protection and Quarantine,* vol. 1, pp. 14-19.

[11] Dospekhov, B. A. (1985). *Methods for Field Experiments*. Moscow: Agropromizdat.

[12] Ganopoulos, I., *et al*. (2018). Microsatellite Genotyping and Molecular Screening of Pea (*Pisum Sativum* L.) Germplasm with High-Resolution Melting Analysis for Resistance to Powdery Mildew. *Plant Gene,* vol. 15, pp. 1-5.

[13] Barilli, E., *et al*. (2009). Identification of Resistance to *Uromyces pisi* (Pers.) wint. in *Pisum* spp. Germplasm. *Field Crops Research*., vol. 114, issue 2, pp. 198-203.

[14] Le May, C., *et al*. (2009). Ascochyta Blight Development on a New Winter Pea Genotype Highly Reactive to Photoperiod Under Field Conditions. *Field Crops Research,* vol. 111, issue 1-2, pp. 32-38.

[15] Lecoeur, J. and Sinclair, T. R. (2001). Nitrogen Accumulation, Partitioning, and Nitrogen Harvest Index Increase During Seed Fill of Field Pea. *Field Crops Research*, vol. 71, issue 2, pp. 87-99.