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Formation of Highly Productive Agrophytocenoses of Peas and Spring Rapeseed in Trans-Urals

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Abstract

In modern conditions, an important reserve for increasing yields and crops is the selection of varieties adapted to the environment. At the same time, there is an increasing need for varieties capable of maximizing the potential for productivity and quality. The purpose of the study is to analyze the ecological plasticity of pea and spring rapeseed varieties to increase the productivity of agrophytocenoses in the Trans-Urals. The studies revealed that in order to increase the productivity of pea and spring rapeseed agrophytocenoses in the conditions of Trans-Urals, high-yield pea varieties Thomas, Aksaisky leafless 55, Zauralsky 3 and Sibur shall be cultivated with a yield of 20.8-24.7 c/ha; spring rapeseed -- Avangard, Atlant, Ozorno, 55 Region with the yield of 19.3-22.8 c/ha. High-intensity pea varieties include Aksaisky leafless 55, Zauralsky 3, Ulyanovets and Flagman 12 with the plasticity index of 1.1-1.2, spring rapeseed -- Novik, Ermak, Altair and Mirakel with the plasticity index of 1.1-1.5 and stability equal to 3.5-10.5. The varieties that are poorly responsive to changing external conditions, but with high stable yields include Vatan, Samarius and Sibur pea varieties, spring rapeseed -- Ratnik, Pramen, Smilla, Avangard, Atlant and Ozorno varieties.

Keywords: peas, spring rapes, ecological plasticity, yield, agrophytocenosis.

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1. Introduction

At present, due to economic and environmental feasibility, a strategy of adaptive intensification of agriculture is being formed in Russia and other countries of the world, which focuses on low-cost, sustainability and environmental stability [1].

The ecological sustainability of agricultural landscapes is determined and depends on the availability of optimal agricultural land structure. However, for each specific agricultural landscapes area, through theoretical research, analysis and synthesis of experimental results, the optimal structure of agricultural land should be refined and improved. Under such conditions, sustainable agricultural production is only possible on

the basis of scientifically sound principles of medium formation and biologization aimed at the introduction of highly efficient and productive crops [2, 3]; introduction of adaptive varieties [4]. The cultivation of highly productive medium-forming agrophytocenoses ensures the most complete and effective use of the bioclimatic potential of each specific field [5].

Previously formed zonal farming systems have been transformed into adaptive and landscape systems [6] in order to design ecologically and economically balanced highly productive and sustainable agricultural landscapes that are maximally adapted to local natural conditions. Modernization of agriculture at the current stage implies the development of the theory of environmentally balanced agricultural landscapes, the system of assessment of resource potential with a high level of information and technological service, stability, normalization of anthropogenic load [7, 8].

Against the background of increasing investments in agroecosystems in various regions, along with increasing instability in crop yields, there is a tendency to decrease the growth rate and productivity of agrocenoses in general [9].

In modern economic conditions with the limited use of mineral fertilizers and other means of chemization, an important reserve for increasing yield and improving grain quality is the selection of varieties adapted to the environment. At the same time, there is an increasing need for varieties capable of maximizing the potential for productivity and quality [10--13].

Taking into account the above, the purpose of the study is to analyze the ecological plasticity of pea and spring rapeseed varieties in order to increase the productivity of agrophytocenoses in Trans-Urals conditions.

2. Materials and Methods

Field experiments, phenological observations, plant accounting and measurements were carried out at Dalmatov State Variety Testing Site and Kurtamysh State Variety Testing Site in accordance with the Methodology of State Crop Testing [14, 15].

Mathematical processing of data was carried out according to the procedure of S.A. Eberhart, W.A. Rassel [16] as expounded by Zykin [17]. This method is based on the calculation of the linear regression coefficient (b_i) characterizing the ecological plasticity of the variety and the mean quadratic deviation from the regression line (S^2_i) determining the stability of the variety under different environmental conditions [18].

Genetic flexibility of varieties was defined as mean yield under contrast (stress and non-stress) conditions ((Ymax+Ymin)/2) [19].

3. Results and Discussion

Meteorological cultivation conditions of peas and spring rapeseed during the years of study were contrasting thus providing for an objective assessment of the studied varieties.

The most favorable conditions for pea cultivation were in 2016 and 2017. In these years the index of environmental condition was the maximum (16.2 and 13.1). Adverse environmental conditions were in 2009, 2010, 2012 and 2014, with environmental index taking negative values.

Pea yields over the years of study ranged from 7.1 to 38.6 c/ha with an average yield of 18.2 c/ha. On average, over the years of study, the maximum yield was typical for Thomas variety and made 24.7 c/ha, 3.8 c/ha higher than the standard variety (Table 1).

The yield of Zauralsky 3 and Samarius varieties was at the level of standard variety Aksaisky leafless 55. The yield of the remaining varieties was below standard by 2.7-5.7 c/ha.

TABLE 1: Results of ecological test of peas at Kurtamysh State Agricultural University on average over 2008-2017.

Variety	x	Y_{min}	Y_{max}	$\frac{Y_{max}+Y_{min}}{2}$	b_i	S^2d_i
Aksaisky leafless 55 (st.)	20.9	9.9	38.6	24.3	1.2	10.0
Aksaisky leafless 4	16.7	8.2	23.6	15.9	0.9	5.5
Agrointel	18.5	7.1	33.4	20.3	0.9	7.9
Zauralsky 3	20.8	8.2	35.3	21.8	1.1	9.7
In the memory of Khangildin	15.9	11.2	23.8	17.5	1.0	5.6
Ulyanovets	16.5	11.6	26.3	19.0	1.2	6.6
Flagman 12	17.2	12.7	26.3	19.5	1.1	6.1
Vatan	15.2	7.7	22.1	14.9	0.9	5.7
Samarius	21.1	11.6	30.0	20.8	0.8	6.8
Sibur	18.2	12.5	24.6	18.6	0.9	5.1
Kumir	15.4	8.6	21.9	15.3	1.0	7.2
Ruslan	15.6	8.9	22.5	15.7	1.0	7.0
Thomas	24.7	9.1	34.7	21.9	1.1	12.2

The average yield of varieties in contrast (favorable and adverse conditions) $(Y_{max}+Y_{min})\div 2$ characterizes their genetic flexibility. The genetically flexible pea varieties were Aksaisky leafless 55, Agrointel, Zauralsky 3, Samarius and Thomas and the genetic flexibility coefficient took the maximum values and made 20.3-24.3.

Ecologically plastic (narrow-adaptive) type includes varieties with a plasticity index higher than one. Under optimal conditions, they give high yields. Such varieties include Aksaisky leafless 55, Ulyanovets, Zauralsky 3, Flagman 12 and Thomas.

Varieties with high environmental plasticity at b_i equal to one include the following: in the memory of Khangildin, Kumir and Ruslan.

The neutral type (wide-adaptive) includes varieties with a plasticity index below one, they have stable yield. Under unfavorable conditions, their productivity is less reduced. Such varieties include the following: Aksaisky leafless 4, Agrointel, Vatan, Samarius and Sibur with a plasticity index of 0.8-0.9.

Varieties with b_i>1 are the most valuable and the stability tends to zero. Such varieties are highly intensive, responsive to improved conditions and have stable yields. They include such varieties as Aksaisky leafless 55, Zauralsky 3, Ulyanovets and Flagman 12. Varieties with b_i>1 and stability close to zero are poorly responsive to changes in external conditions, but have high stable yields. Such varieties include Vatan, Samarius and Sibur.

The most favorable conditions for growing spring rapeseed at Dalmatov State Agricultural University were in 2009-2011, 2014 and 2016, 2017. In these years the index of environmental conditions was positive (2.5-9.2). Unfavorable environmental conditions were in 2008, 2012 and 2015. During these years the environmental index was negative.

TABLE 2: Results of ecological test of spring rapeseed at Dalmatov State Agricultural University on average over 2008-2017.

Variety	x	Y_{min}	Y_{max}	$\frac{Y_{max}+Y_{min}}{2}$	b_i	S^2d_i
Ratnik (st.)	16.5	5.6	24.0	14.8	0.8	6.2
Novik	16.9	13.7	20.6	17.2	1.1	3.5
Ermak	17.1	14.0	23.0	18.5	1.4	5.1
Granit	14.2	5.6	22.7	14.2	1.0	12.1
Kupol	11.6	3.5	19.6	11.6	0.9	11.4
Makro	14.7	2.1	23.4	12.8	1.2	11.2
Kalibr	18.2	8.5	28.9	18.7	1.1	10.2
Highlight	12.7	4.1	21.3	12.7	1.0	12.2
Almaz	8.8	4.4	13.2	8.8	0.9	6.2
Altair	9.7	3.0	16.3	9.7	1.3	9.4
Gedemin	7.8	3.0	12.5	7.8	0.9	6.7
Mirakel	12.5	5.0	19.9	12.5	1.5	10.5
Pramen	6.8	2.6	11.0	6.8	0.8	5.9
Smilla	8.8	5.4	12.2	8.8	0.7	4.8
Avangard	19.6	18.2	20.9	19.6	0.5	1.9
Atlant	19.3	17.0	21.5	19.3	0.8	3.2
Ozorno	22.8	21.1	24.4	22.8	0.6	2.3
Solar KP	15.9	7.5	28.4	18.0	1.1	11.1
Amulet	16.1	14.4	17.8	16.1	1.0	2.4
55 Region	21.7	19.9	23.5	21.7	0.9	2.5

The yield of spring rapeseed varieties at Dalmatov State Agricultural University varied from 6.8 to 28.9 c/ha, and the average yield made 14.6 c/ha. On average, during the years of study Avangard, Atlanta, Ozorno, 55 Region varieties showed the maximum yield amounting to 19.3-22.8 c/ha, which is 3-6 c/ha higher than the standard variety Ratnik. The yield of Novik, Ermak, Solar KP and Amulet varieties was at the standard level and did not exceed 17.1 c/ha. For the remaining varieties the yield was below the standard (Table 2).

The genetic flexibility coefficient was maximum for such varieties as Ermak, Avangard, Atlant, Ozorno, Solar KP and 55 Region and made 18.5-22.8, thus these varieties were genetically flexible.

Varieties with high ecological plasticity include 8 varieties of spring rapeseed -- Granit, Kupol, Kalibr, Highlight, Almaz, Gedemin, Amulet and 55 Region with a plasticity index of 0.9-1.0.

The neutral type (wide-adaptive) includes six varieties: Ratnik, Pramen, Smilla, Avangard, Atlant and Ozorno. They are more stable in yield and have less reduction in productivity under unfavorable hydrothermal conditions. The plasticity index of these varieties was 0.4-0.8.

Ecologically plastic (narrow-adaptive) type includes varieties with a plasticity index higher than one. Under optimal conditions, they give high yields. These are such varieties as Novik, Ermak, Makro, Kalibr, Altair, Mirakel and Solar KP with a plasticity index of 1.1-1.5.

High intensity varieties include Novik, Ermak, Altair and Mirakel with a plasticity index of 1.1-1.5 and stability of 3.5-10.5. Varieties that are poorly responsive to changing external conditions include Ratnik, Pramen, Smilla, Avangard, Atlant, and Ozorno.

4. Conclusion

In order to increase the productivity of agrophytocenoses of peas and spring rapeseed in the conditions of Trans-Urals, high-yield pea varieties Thomas, Aksaisky leafless 55, Zauralsky 3 and Sibur shall be cultivated with a yield of 20.8-24.7 c/ha; spring rapeseed -- Avangard, Atlant, Ozorno, 55 Region with the yield of 19.3-22.8 c/ha.

High intensity varieties include such pea varieties as Aksaisky leafless 55, Zauralsky 3, Ulyanovets and Flagman 12. The varieties that are poorly responsive to changing external conditions, but with high stable yields include Vatan, Samarius, and Sibur.

High intensity varieties of spring rapeseed include Novik, Ermak, Altair and Mirakel with a plasticity index of 1.1-1.5 and stability of 3.5-10.5. Varieties with high stable yields include Ratnik, Pramen, Smilla, Avangard, Atlant and Ozorno.

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