Plant Archives Vol. 20, Supplement 2, 2020 pp. 1126-1130 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

ADAPTIVITY POTENTIAL OF WINTER OILSEED RAPE VARIETY POPULATIONS BY PRODUCTIVITY ELEMENTS

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Abstract

The article highlights the results of the study on winter oilseed rapes varieties adaptability and stability level by their productivity characteristics - the crops height, the number of first order shoots, the number of seeds per pod. The parameters of adaptive capacity and stability were determined, and valuable source material was selected by the performance components. The Black Giant, Dongon and Nelson varieties were found to be valuable for their high adaptability and stability level by the following characteristics - plant height, number of shoots 1 order, number of seeds per pod - were found.
Keywords: oilseed rape, general adaptive capacity, characteristic, stability, productivity, environmental plasticity factor.

Introduction

Adaptive breeding concerns mainly with creating crop varieties and hybrids with the growth, development, formation and organization of all processes are consistent with changes in the physical environment factors in the cultivation place to the maximum extent possible. In breeding practice, genotypes, which, consistently show a high index level of phenotypic manifestation of the traits for many generations are considered valuable. Extreme environmental factors such as arid conditions during critical periods of growth, excessive moisture supply during the period of crop forming and ripening are critical as well (Zhuchenko 1980; Pylnev *et al.,* 2005; Shokh, 2011). Use of highly adaptive varieties with stable yields during adverse years is one of the conditions for oilseed rape yield increase. Adaptability is the ability to produce stable crops under various weather conditions. Assessment of adaptive capacity in winter oilseed rape varieties allows us to identify forms which manifest a broad response rate in terms of the macro trait components (Kilchevsky, 1997). Indicators of the degree of genotypes response to changing environmental conditions characterize the properties of the variety - its plasticity and stability of the traits level (Litun, 2004). Breeding for oilseed rapeseed productivity involves the creation of varieties with wide environmental adaptability (Pylnev *et al*., 2005). Adaptation to the adverse conditions of individual regions is not sufficiently taken into account in the varieties breeding. Study on oilseed rape genetic potential considering high seed productivity is one of the factors for successful breeding.

Oilseed rape is a rather plastic crop and the ability to form many lateral shoots on thinned sowing along with an increased number of pods on thickened sowings is the biological characteristic of oilseed rape. The main components of oilseed rape productivity include shoots number per plant, pods number per plant, and seeds number per pod.

The number of first order shoots has an average correlation with the number of pods per plant r = 0.540062. The average level of relation between productivity traits indicates the number of pods as the most valuable trait in winter oilseed rape breeding, which is crucial in creating valuable productive forms (Shokh ,2011).

Plant height is one of the important quantitative traits and it directly affects the number of shoots per plant and plant productivity. Lodging resistance depends largely on the plants height. The yield level is to a larger extent influenced by the number of pods per plant and the number of first order shoots (Kyrylchuk, 2012). There is a significant positive correlation between the crop productivity and pods number while pods number per shoot and shoots number per plant, as well as the yield, are highly dependent on the environment (Haidash *et al.,* 1998).

Plant height varies greatly depending on the conditions of different years of cultivation. Plant forms with very short stem usually bloom earlier, and it is advisable to use short stem forms when selecting pairs for hybridization, since its height is dominant. Breeding for precocity involves the creation of short-stemmed forms (Haidash 1998; Pylnev *et al*., 2005). Creating highly adaptable varieties will allow using oilseed rape biological potential more efficiently and produce higher yields.

Analysis of recent research and publications

In Argentina, studies have been conducted on environmental factors that affect oilseed rape adaptability (Takashima *et al.,* 2013).

Pakistan scholars have studied general and specific adaptive capacity and defined genotypes with stable high yields, unstable genotypes and genotypes with specific adaptability (Tahira *et al.,* 2018). Research by the John Innes Center has found that oilseed rape crop stability is not correlated with yield (John Innes Center, 2019). According to the findings of Ali *et al.* (2002), the yield of oilseed rape genotypes and the stability of their crop depend on growing conditions as well. Also, they selected varieties with stable yields, the varieties adapted to cultivation under unfavorable conditions and crop varieties unstable under different conditions.

Analysis of studies conducted by Chilean scientists showed that selecting oilseed rape varieties and hybrids in different conditions provided high yield and the trait stability

(Magaly *et al.,* 2011). Seven-years studies conducted in Serbia have shown that the environment has a significant impact on oilseed rape yield. The yield of a crop is largely influenced by environmental factors, which indicates the adaptability of particular genotypes to particular growing conditions (Jeromela *et al.,* 2011).

Reducing the oilseed rape genetic diversity limits significantly the potential for its adaptation to biotic and abiotic stresses and limits the development of heterosis populations for hybrids production (Snowdon *et al.,* 2015).

Materials and methods

In recent years, weather conditions in Ukraine, and particularly in the Kiev region, have varied dramatically in a number of indicators. During 2013 – 2015, the vegetation periods at the experimental field of Bila Tserkva NAU differed in weather conditions change varying from arid to excessive moisture ones in summer, hot spring and summer periods and uneven snow cover and temperature changes in winter.

The experimental field of the Bila Tserkva National Agrarian University located in the central forest-steppe of Ukraine (in the center of the northern part of the forest-steppe of Ukraine) is the central experimental base.

The climate of the zone is temperate continental with unstable humidity. Annual average precipitation amount is 540 mm with fluctuations from 450 to 640 mm, but they are unevenly distributed during the growing season. Evaporation accounts for 500-700 mm.

The sum of active temperatures is 2500-2616˚C. The duration of the period with an average daily temperature above 15° C is 110 days, the frost free period lasts an average of 170 days.

The area is characterized by moderately warm and moderately humid climate. The average annual temperature is + 8.5°C with significant fluctuation by months. The coldest month is January (-6°C). The highest average daily temperature is observed in July (+ 19.3°C), steady transition of average daily air temperatures above + 5°C occurs mainly in the second half of October. The duration of this period is 237-255 days.

The terrain of the experimental area is flat with a slight northeast slope. The soil cover of the experimental area is characterized by uniformity and is represented mainly by chornozem typical. Deep penetration of humic substances (100-125 cm and more) is a characteristic feature of this soil type. Soil-forming rock is lass and lassiform loam. The soil is a typical low humus chornozem of light-loam mechanical composition. Humus content (according to Tyurin) - 3.24%; hydrolytic acidity - 2.5 mg-eq per 100 g of absolutely dry soil; absorbed bases sum - 17.9 mg-gq /100 g of soil; alkaline hydrolyzed nitrogen (according to Kornfield) - 109.1 mg/kg; mobile phosphorus (according to Chirikov) - 184.3 mg/kg; exchange potassium (according to Chirikov) – 96.2 mg/kg of soil, salt extract pH – 6.2-6.3.

The quality of the arable soil layer according to the classification scale indicates that it has a weak acid reaction of soil solution (pH 6.2-6.3) with average humus content, low level of plants supply with available nitrogen, high level of mobile phosphorus availability and high content of exchange potassium.

Moisture supply is an important climatic factor. Average annual precipitation amount is 538 mm. Precipitation is distributed unevenly over the seasons: 88 mm in winter, 129 in spring, 201 in summer, 120 mm in autumn. The highest level of precipitation (72 mm) is observed in July. Snow cover in winter is unstable, which is especially noticeable for the last 10 years. Winter begins in the second half of October - early November, when the average daily temperature decreases below -5°C and remains until the second half of March (when the average daily temperature rises above 0°C). In warm winters, thaws occur often and the temperature rises to +10°C during the thaws. Snow cover, on average, gets set in the second decade of December and melts in the second half of March.

In general, the climatic conditions are favorable for winter oilseed rape cultivation. However, in some years deviations from the average annual temperature and rainfall indicators occur, which negatively affects the crops growth and development, its yield and seeds quality.

In general, climatic conditions are favorable for winter oilseed rapeseed cultivation. However, deviations from the average annual temperature and rainfall indicators occur in some years which negatively affect the crops growth and development, its yield and seed quality.

Growing winter oilseed rapeseed is largely dependent on weather conditions. The crop vegetation continues in the autumn and spring-summer periods. Therefore, growing winter oilseed rapeseed requires examining the relationship between the processes of the crop growth and development in certain periods of vegetation and its adaptability to show the traits. Agrometeorological conditions varied significantly during the research years both in the amount of precipitation, especially their distribution in certain months, and in temperature conditions.

The area of experiments placement considering the climate is favorable for winter oilseed rapeseed varieties cultivation, but in some years, under insufficient or exceeding moisture, the yields are significantly reduced. For winter oilseed rapes crop, which is a water-loving crop, such conditions created a natural provocative background to determine the adaptive potential by productivity elements without transferring the plants to different growing zones.

Oilseed rape cultivation technology was generally accepted in the area. All the observations in the experiment were carried out according to the methodological guidelines for conducting research with oilseed rape. The studies were performed using the method of laboratory and multifactor field stationary experiment. Field studies were set and carried out according to the conventional methods - State variety testing methodology, Variety examination methodology (BOC) (2000, 2004).

The collection specimens of domestic and foreign breeding varieties were used as a the source material for the 2013-2015 research. The specimens were provided by the National Center for Plant Genetic Resources of Ukraine with varieties registered and recommended for cultivation in Ukraine. The collection nursery numbered 25 varieties of winter oilseed rapeseed. The Standard variety of Black Giant is a national standard, registered and recommended for cultivation in Ukraine.

The obtained biometric data were processed using the method of variation statistics and variance analysis. The method by A.V. Kilchevsky and L.V. Khotylyova [1997] was used to estimate the parameters of the media, the genotypes adaptive capacity and stability.

The parameters of adaptability of the investigated varieties were determined by the general (GAC = vi) and specific (SAC = σSACi,) adaptive capacity, relative stability of the genotype (Sgi) and the index of the genotype breeding value (GBVi) (Kilchevsky and Khotylyova, 1997).

The genotype response to the improvement of growing conditions was determined by the magnitude of the genotype regression coefficient on the medium - *bi*. Environmental plasticity coefficients *bi* were calculated according to the methods of Eberhart, Russel (1966).

The indicator of the genotype relative stability *Sgi* allows to compare the results of experiments with various sets of genotypes and crops.

Results and Discussion

Assessment of the parameters of adaptive capacity is made to study the response of genotypes to changing environmental conditions. General adaptive capacity (GACi) is defined as the ability of crops to produce a constantly high yield under variable conditions of cultivation and characterizes the average value of the trait under different environmental conditions.

Specific adaptive capacity (SACi) is the ability to respond to and withstand certain adverse environmental factors, including low temperatures, drought, diseases, and is defined as deviation from GAC in a particular environment (Kilchevsky, Khotylyova, 1985). To determine the genotype stability, the SAC - σSACi variance is used.

GACi and SACi assessment enables to select quantitative characteristics series for the adaptive capacity.

In our studies, there was significant variability in plant height for the years, but some varieties of oilseed rape showed a fairly stable level of the indicator. Oilseed rape varieties were characterized by relatively low GACi. The highest general adaptive capacity in oilseed rape was found in the varieties of Nelson (10.9) and Black Giant (11.2) (Table 1). All the selected varieties with a high level of GACi are characterized by a higher plant height. That is, varieties with a maximum value of GACi can provide the maximum average index in different environmental conditions.

Table 1 : Statistical characteristics of the "plant height" trait in winter oilseed rape varieties (average for 3 years)

Variety	Average	GACi	σSACi	Sgi	bi	GBVi
Black Giant - st	118.2	11.2	9.14	7.7	1.73	54.2
Helio	102	-5.1	11.9	11.7	0.10	38.27
Vectra	95.1	-12.0	12.46	13.1	0.51	35.05
Landar	97.0	-10.1	9.79	10.1	0.63	50.46
Dongon	112.7	5.7	4.3	3.8	1.45	82.2
Nelson	117.9	10.9	10.7	9.1	1.49	45.2
Senator lux	114.5	7.5	9.99	8.7	1.13	49.3
Nadiya	99.0	-8.1	4.9	4.9	0.45	78.7

Specific adaptive capacity is an element of trait stability, and the evaluation of varieties by SACi reveals various levels of stability in oilseed rape plants.

The research results have shown that oilseed rape varieties were characterized by an average specific adaptive capacity. The highest SACi and, accordingly, the plant height stability in the experiment by years were observed in the varieties of Helio (11.9) and Vectra (12.46). Vectra variety had the lowest plant height among the studied varieties (95.1) for 3 years which is confirmed by the indicator of the genotype relative stability.

According to the studies, relative stability of the genotype (Sgi) for all the studied traits ranged from 3.8 to 32.6. The highest indicator of the plant height was observed in the Vectra variety (13.1), number of first order shoots – in the Nadiya variety (32.6) and the Dongon variety (27.6). The variety-standard of Black Giant was distinguished for its seeds number in the pod as it was characterized by the highest relative stability (Table. 2).

The high rate of the genotype response to the medium (bi) by the plant height feature was observed in the Black Giant variety, which is the national standard of Ukraine for the yield among winter oilseed rape varieties. This variety is characterized by the ability to produce more seeds per pod in unfavorable years (Table 3). Due to the adaptive reaction, a larger seeds yield per plant is formed. As to the genotype stability complex indicator of GBVi, the varieties of Nadiya (78.7) and Dongon (82.2) are selected.

In general, plant height adaptability analysis did not identify varieties with the highest adaptability and stability simultaneously.

The number of first order shoots is an important adaptive trait that ensures the formation of increased yields under optimal conditions and determines the plasticity of the plant organism in stress conditions.

A wide range of variation of shoots number per plant was observed due to the fact that oilseed rape plants are able to form more shoots under favorable cultivation conditions and a stable number of shoots under stressful conditions growing.

Analysis of first order shoots number adaptability was made and forms with high manifestation of phenotypic traits were identified - the varieties of Dongon (8.3 shoots) and Nelson (8.4 shoots) (Table 3). High rates of adaptive capacity and environmental plasticity (bi) also differentiate the varieties of Dongon and Nelson (GACi = 1.8, 1.9; bi = 2.23, 2.41), indicating a high manifestation of adaptive response and the formation of larger number of shoots under favorable environmental conditions.

Table 2 : Adaptive capacity parameters based on first order shoots number

Variety	Average	GACi	σSACi	Sgi	bi	GBVi
Black Giant - st	6.4	-0.93	1.48	23.1	0.32	3.8
Helio	7.5	0.18	1.34	17.8	1.75	4.12
Vectra	6.6	-0.73	1.14	17.2	1.25	4.6
Landar	6.7	-0.63	1.56	23.3	-0.13	3.6
Dongon	8.3	1.08	2.27	27.0	2.23	1.9
Nelson	8.4	1.09	0.97	11.5	2.41	5.0
Senator lux	8.0	0.68	1.28	16.0	1.31	4.3
Nadiya	5.6	-1.73	1.83	32.6	0.12	2.9

The Dongon variety was also characterized by high rates of specific adaptive ability (σSACi) and the genotype relative stability (Sgi), that is, it showed the highest stability in the experiment on first order shoots number and is valuable for use in the selection of highly adaptive varieties and hybrids.

The breeding value of the genotype was determined in order to select simultaneously the forms for the general adaptive ability and stability. A high level of GBV = 5.0 in the experiment on the Nelson variety also indicates the value of the variety in the stable manifestation of a high level of first order shoots number trait.

Analysis of seeds number per pod indicates the wide range of the trait variation by the the varieties - from 22.3 pcs in the Vectra variety to 27.2 pcs in the Nelson variety (Table 3).

Table 3 : Statistical characteristic of seeds number per pod (average for 3 years)

Variety	Average	GACi	σSACi	Sgi	bi	GBVi
Black Giant - st	27.0	1.8	8.02	29.7	-1.75	6.88
Helio	25.1	-0.1	2.52	10.1	1.56	15.1
Vectra	22.3	-2.9	2.59	11.6	1.31	14.8
Landar	22.7	-2.5	1.75	7.6	2.31	18.2
Dongon	26.8	1.6	4.09	15.2	2.25	8.84
Nelson	27.2	2.0	1.12	4.1	0.25	20.72
Senator lux	26.2	1.0	3.58	13.7	1.13	10.88
Nadiya	23.9	-1.3	1.94	8.1	0.94	17.44

The variety standard of Black Giant was selected on the basis of seeds number per pod. According to the indicators of general and specific adaptive ability and relative stability of the genotype the variety manifested the highest level among the experiment varieties (GACi = 1.8, σSAC = 8.02, Sgi = 29.7) .

At the variety standard level, the Nelson variety was characterized by a higher number of seeds per pod among the studied varieties - 27.2 pc and had high rates of general adaptive capacity (GACi = 2.0) and stability (GBV= 20.72), indicating a high adaptive capacity potential of the variety. But its low level of specific adaptive capacity, relative stability and ecological plasticity characterize the variety as unstable by manifestation of the seeds per pod trait.

Conclusions

Varieties with high general and specific adaptive capacity by plant productivity components were identified as the most valuable source material for selection.

The study of performance variability and the components interaction distinguished the varieties of Black Giant, Dongon and Nelson by the parameters of adaptive ability and stability.

The variety of Black Giant with its high levels of adaptability and stability was distinguished by the traits of plant height and the seeds number per pod. The varieties of Dongon and Nelson with larger number of first order shoots proved to have high adaptive capacity in the experiment.

Highly adaptive variety of Nelson was identified as its genotype provided a high and stable level of first order shoots number manifestation and high general adaptability of the seeds number per pod trait in plants.

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