THE FEATURE OF THE VEGETATION PERIOD OF VARIETIES OF OAT (*AVENA SATIVA* L.) UNDER CONDITIONS OF CENTRAL YAKUTIA

УДК: 633.13:631.559:631.527.5
DOI:10.24411/2588-0209-2019-10089

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The article presents the results of research in 2011-2017 on the features of the vegetation period and its relationship with the grain yield in varieties of oats cultivated in the permafrost soils of the Central Yakutia. The aim of the research was to reveal the peculiarities of the length of the vegetative period of the varieties of the oat cultivated in the conditions of the Central Yakutia and its relationship with grain yield. *Avena sativa* L. – one of the leading grain crops used for fodder purposes in the permafrost zone of the Central Yakutia. Field studies in the nursery of competitive variety trials were carried out in 2011-2017 on the permafrost taiga-yellow soils of the Kangalasskyd district of the Central Yakutia. It was found that the main role in the overall phenotypic variation of the vegetation period in the Central Yakutia belongs to the conditions of vegetation – 63.9% and genotype (variety) - 28.5% (at 1% level of significance). In dry years, the reaction of the length of the vegetation period in oat varieties to weather conditions was more non-specific than in years with high moisture. In these years of research, the relationship between the length of the vegetation period and yield of grain was positive and significant at 1% level. In the conditions of Yakutia, there is a need to create adaptation programs in the crop industry to climate change, expand research related to stress resistance, modeling the joint action of stressors in the laboratory. New innovative approaches are needed that take into account information about the microbial community of a

particular habitat (metagenomic technologies), the use of modern molecular biological methods based on the use of transcriptomic, metabolomic and proteomic analyses of plants.

Key words: *Avena sativa* L., varieties, vegetation period , competitive variety trial, grain yield.

Introduction

The oat (*Avena sativa L.*) is one of the leading grain crops cultivated under the Central Yakutia conditions; both in its pure form as well as mixed with other legumes for hay, silage, haylage, and vitamin flour production [1]. The climate of Central Yakutia is characterized by its sharp continentality with distinctly low temperatures during the winter and, in contrast, high in summer. The characteristic features of this territory climate are prolonged exposure to the sunlight in the summer months, and in winter the minimum temperature can reach – 56*C. Grain crops are exposed to the complex effects of prolonged daylight hours, high average daily air temperatures in May and June, scarce water supply in the soil as well as in the air, drastic fluctuations in temperatures between the nighttime and daytime, and spring, summer and autumn ground frosts occurring by permafrost background [2-3].

By taking into the account climatic characteristics of Central Yakutia, it is evident that one of the crucial goals in oat cultivation is the development of its varieties that are capable of forming a high yield with increased grain quality under conditions of an short-termed Yakutian summer [4]. According to Nikolay Vavilov, the growing season is one of the main inquiruies in plant breeding area, due to its close association with their numerous attributes [5]. From this viewpoint, it is necessary to identify the relationships between the length of the growing season and grain yield – a crucial criterion for the cultivation of crops.

The purpose of this study is to distinguish the peculiarities of the length of the growing season in oats varieties grown in Central Yakutia and its relationship with grain yield.

Materials and methods

The materials for this study were previously cultivated oats varieties adapted to the local conditions of Yakutia and included in the State Register of Selection Achievements in the East Siberian Region: Pokrovskiy, Vilenskiy. Pokrovskiy 9 and Khibiny 2.

Research was conducted in 2011-2017 in the Pokrovsk division of the Yakutsk Research Institute of Agriculture located in the middle taiga zone of Khangalassk district of the Republic of Sakha (Yakutia).

The soil of the experimental plot was taiga’s pale, mid-loam permafrost type. The humus content in the arable layer was 2.67% and at deeper levels its content decreased up to 0.44%. The content of mobile phosphorus was 104.3 m/kg of soil, exchange potassium 274 m/kg of soil, and total nitrogen varied from 0.12% to 0.24%.

The accounting area of nurseries of competitive variety testing was 25 m^2, there were four replications with a randomized placement. Observations and calculations were carried out based on generally accepted methods [6]. The experimental material was processed by variances analysis according to Armor using assistance from the application package "SNEDECOR" [7, 8].

Results and discussion

The length of the growing season for oat varieties cultivated in Yakutia varied from 58 to 78 days throughout the research years (2011-2017). The range of variation of R (x_{max} - x_{min}) in 2011-2017 fluctuated from 10 to 12 days, and in the dry years of 2012 and 2015 - from 1 to 6 days, depending on the oat variety (Table 1).

Consequently, the reaction of the growing season lengths in oats to weather conditions was more equivocal in dry years than in years with high water availability. Previously, Loskutov *et al* also pointed out to a change in the reaction of the duration of the growing season influenced by weather conditions among wild-growing genus *Avena* representatives [9]. Earlier, we noted that under the Central Yakutia conditions, water availability and variety genotype have a significant effect on the yield. Moreover, in more dry years, the reaction of varieties in terms of grain yield mainly was not significant [10].

Climate change, observed in recent decades, is associated with an increase in annual precipitation and snow moisture reserves in Central Yakutia. It also causes a number of negative consequences when harvesting crops. At almost all years of research, except of dry ones, strong overgrowths in crops (unfertile stems) were observed near the end of grain formation. These overgrowths considerably complicate harvesting process and reduce the grain quality in general. Considering above mentioned, there is necessity for additional technological applications. In particular, the desiccation of oat crops involves plants dehydration before harvesting for its maturing acceleration and then apply chemicals treatment to facilitate harvesting. The next procedure is keeping the plants with roots on until the strong nightly ground frosts period. As a result, stems quickly lose moisture and to a large extent succumb during the harvesting and subsequent cleaning of the grain.

Two-way analysis of variances of the data from competitive varieties analysis showed that the general phenotypic variation of the length of the growing season is mainly dependent on the growing season - 63.9%. Nevertheless, the influence from the genotype (variety) was also significant with 28.5% at 1% significance level threshold. Random variation was insignificant - 7.6% (Table 2).

An analysis of the relationships between the length of the growing season, yield and grain yield showed that in 2015, a particularly dry year with the precipitation during the growing season 164.5 mm, there was positive correlation with reliability under the 1% significance level threshold (Fig. 1, Table 3) The similar trend was observed in the year of 2012 with a low precipitation during the growing season of 230.3 mm. The difference in daily average air temperatures during the growing season of oat plants during the research years was insignificant (Fig. 1).

Table 1

The length of vegetation period of oat varieties in competitive variery trial under Central Yakutia conditions as of 2011-2017

Variaty	Length of vegetation period, days	Lim		R	
		2011-2017y.	2012, 2015 y.	2011-2017 y.	2012,2015 y.
Pokrovskiy 9	70	66-76	67-68	10	1
Pokrovskiy	72	66-78	68-72	12	4
Vilenskiy	69	66-76	64-68	10	4
Khibiny 2	65	58-69	58-64	11	6

Not: Lim- limits, R- range of variation ($x_{max} - x_{min}$)

The consequences of climate change in Russia, including in Yakutia, have the most significant impact on local agriculture which principally depends on weather conditions. Thus, establishment of agricultural adaptation programs to climate change is necessary. For crop production, programs should incorporate scientific research for improving the stress tolerance of plants, for example, by changing the species composition of cultivated plants, introducing novel varieties, technologies, remedies, and other measures [11].

Table 2

Contribution of genotypic and environmental variability to the general phenotypic variation against the growing period length in oat varieties cultivated in Central Yakutia according to two-way variance analysis as of 2011-2017.

Source of variability	Sum of square deviations	Degree of freedon	Average square of dispersions	$F_{fact.}$	Variation proportion, %
General	2536,0	111	22,847		100
Genotype (factor A)	723,428	3	214,143	127,7*	28,5
ГТК (factor B)	1620,0	6	270,0	143,0*	63,9
Random factors	192,571	102	1,888		7,6

*P value <0,001

Fig. Average daily temperature and precipitation during the vegetative period

Table 3

Correlation coefficient between the length of vegetative period, productivity and yiled in oat seeds that are cultivated under Central Yakutia conditions as of 2011-2017

Trait	Year of study						
	2011	2012	2013	2014	2015	2016	2017
Seed productivity	0,03	0,25	0,09	-0,08	0,64*	0,29	0,28
Yield	-0,12	0,59*	0,55	-0,02	0,63*	0,33	-0,.21

Примечание. * - P<0,001

Previous studies reported that the response of the plant to two or more stressors is distinctive and cannot be simply extrapolated as the response to a single stress factor. When exposed to damaging factors, plant response elements are distinguished into the specific and non-specific resistance. However, there is still no generally accepted view on whether the adaptive responses complex occurring in plants exposed to harmful factors is non-specific [12-13]. The important task at the current stage is the identification of the most stress-tolerant species, varieties of agricultural crops, for specific soil and climatic conditions, taken into the account the existence of climate change. At this point, the crops tolerance can be understood as the ability of populations, varieties, plants to tolerate the adverse effects of one or another environmental factor without a severe decline in its productivity [14-15].

Conclusions

The most of the impact to the growing season length phenotypic variation in Central Yakutia comes from the growing conditions - 63.9% and genotype (variety) - 28.5% (significance level under 1% threshold).

In dry years, the oats growing season length reaction against weather conditions was more undefined than in years with high water accessibility. During these years of research, correlations between the length of the growing season, yield and grain yield were positive supported with 1% significance.

It is necessary to establish adaptive programs to climate in Yakutia, to develop scientific research for the improvement of the crops stress resistance, to model the combined effect of stress factors under laboratory conditions. New innovative approaches are also needed. For example, considering the microbial community of a certain habitat (metagenomic technologies), the application of modern molecular biological methods based on the transcriptomic, metabolic and proteomic datasets.

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