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Short communication

The collection of wild oat species of C.I.S. as a source of diversity in agricultural traits

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Abstract

This work presents the results of studying (1990–1992) such wild oat species as *Avena clauda* Dur., *A. pilosa* M.B., *A. bruhnsiana* Grun., *A. wiestii* Steud., *A. barbata* Pott.; weedy species – *A. sterilis* L., *A. fatua* L. and *A. ludoviciana* Dur. The range of variability by agricultural traits has been shown and plant forms have been identified by such traits as earliness, dwarfness, productive tillering, resistance to lodging, crown and stem rusts, powdery mildew, tolerance to BYDV and other morphological characters. The author has defined parameters of interrelation between the duration of the vegetation period and its separate phases as well as between other agricultural and morphological traits.

Introduction

Genetic resources of wild and weedy oat species are characterized by wide diversity in their morphological and commerical characters. Genes controlling these characters have been used to improve cultivated forms of oats. At present a number of wild *Avena* L. species with different levels of ploidy are used as donors of valuable characters, which is determined by an increasing genetic erosion (Baum, 1977; Coffman, 1964; Ladizinsky, 1988; Trofimovskaya et al., 1976). Many of them possess such priceless agricultural traits as resistance to numerous diseases, earliness, high productive tillering, large size and high quality of grain, etc. (Frey, 1986; Leggett, 1996; Marshall et al., 1992; Pasynkov, 1971).

Materials and methods

Presently the collection preserved at the N.I. Vavilov Institute of Plant Industry (VIR) includes of wild and weedy oat species collected over the whole territory of the former USSR (C.I.S.) (Table 1). All of them were obtained by collecting missions in 1960's and 1970's. Over 85% of these accessions are hexaploid, i.e. they can be easily crossed with cultivated species. According to the classification (Rodionova et al., 1994) these forms represent wild spp. *Avena clauda* Dur., *A. pilosa* M.B., *A. bruhnsiana* Grun., *A. wiestii* Steud. and *A. barbata* Pott. from Azerbaijan and weedy spp. *A. sterilis* L. from Krasnodar Region of Russia and Georgia, *A. fatua* L. and *A. ludovociana* Dur. which occur everywhere (Soldatov & Loskutov, 1991, 1992). Their rich diversity and absence of reliable research data were primary reasons for studying them (Loskutov, 1992b; Soldatov et al., 1991). All forms of the above-mentioned species were analyzed by their diverse morphological and agricultural traits at the field of Pavlovsk Experimental Station of VIR in 1990–1992. The research was based on the COMECON International Descriptors of Avena L. (1984) and Oat Descriptors List (1985).

Table 1. VIR collection of wild species Avena L. from territoy of the former USSR (C.I.S.)

Species	Origin	Number of accesions
A. clauda Dur.	Azerbaijan	7
A. pilosa M.B.	Azerbaijan	13
A. bruhnsiana Grun.	Azerbaijan	3
A. wiestii Steud.	Azerbaijan	11
A. barbata Pott.	Azerbaijan, Turkmenistan, Russian Federation	13
A. ludoviciana Dur.	Azerbaijan, Armenia, Georgia, Russian Federation, Ukraine, Turkmenistan, Tadjikistan, Uzbekistan	149
A. sterilis L.	Georgia, Russian Federation	5
A. fatua L.	Azerbaijan, Armenia, Georgia, Russian Federation, Ukraine, Kazakhstan, Tadjikistan, Uzbekistan	59

Table 2. Resitant and tolerant accessions of wild species from CIS

WIR numbers	Species	Origin	Duration of germination		Plant height cm	Resitance*	
			heading, days	ripening, days		crown rust	BYWV
194	*A. clauda*	Azerbaijan	75	96	83	1	3
201	*A. pilosa*	Azerbaijan	91	115	83	3	5
215	*A. wiestii*	Azerbaijan	64	108	90	3	3
230	*A. barbata*	Azerbaijan	57	84	130	3	5
23	*A. ludoviciana*	Azerbaijan	48	83	107	3	3
317	*A. ludoviciana*	Azerbaijan	61	83	78	3	7
387	*A. ludoviciana*	Armenia	49	86	92	3	3
1781	*A. sterilis*	Russian Federation	88	110	100	3	5
114	*A. fatua*	Azerbaijan	48	80	107	3	5
971	*A. fatua*	Armenia	49	79	82	5	3
286	*A. fatua*	Ukraine	49	80	130	3	7
ST	cv. BORRUS	Germany	47	88	103	7	7

* – 1 – resistant, 9 – susceptible.

Results and discussion

This research has shown that diploid forms were the most diverse group by the number of species and the studied traits. Such species were generally characterized by a prostrate shape of the bush with thin downy stems having elongated upper internodes and narrow leaves, with a long spreading panicle, good leafiness, rather high productive tillering, intensive aftergrowth of stems and poor resistance to lodging. Most of these forms, according to Maltzev (1930), represent spring and winter oats of sod soils: they have decumbent and geniculate ascendant stems and are usually characterized by lateness in ripening.

For the conditions of the North-Western Russia (St. Petersburg) the mean values of the duration of germination/shooting, germination/heading and germination/ripening periods (see Table 2) were respectively 53.5, 70.5 and 94.9 days for *A. pilosa*; 58.9, 77.3 and 101.9 days for *A. clauda*; 49.9, 62.2 and 88.9 for *A. wiestii*; and 49.5, 68.3 and 89.5 for *A. bruhnsiana*. For the earliest forms the duration of the germination/heading period was 64 to 71 days, while the total vegetation period was 91 to 96 days. It seemed possible to regard several samples of spp. *A. pilosa, A. clauda* and *A. wiestii* as late-ripening or semi-winter forms since they demonstrated a considerable delay in heading. Plant height in this group of species showed great variation between different forms. For example,

the average plant height of *A. pilosa* was 86.0 cm; the average height of *A. clauda* was 87.8 cm; for *A. wiestii* it was 84.6 cm, and for *A. bruhnsiana* 93.3 cm. The least plant height (72–79 cm) was observed in several samples of *A. pilosa*, *A. clauda* and *A. wiestii*. The greatest height (120 cm) was reported in *A. wiestii*. In the research process several forms demonstrated resistance to crown rust in *A. clauda* (WIR-194, WIR-267) and *A. wiestii* (WIR-215, WIR-314), and tolerance to barley yellow dwarf virus (BYDV) in *A. pilosa* (WIR-301), *A. clauda* (WIR-194) and *A. wiestii* (WIR-215, WIR-222). In 1990 a number of forms resistant to powdery mildew were identified, and in 1992 the most of accessions of *A. pilosa* and *A. clauda* showed resistance to stem rust. Yield parameters for these species were the lowest in this study.

A. barbata, a representative of the group of tetraploid species, had semierect or prostate configuration of the bush with downy stems of medium thickness and leaves of medium width, very long spreading panicle, rather good productive tillering and medium resistance to lodging (Loskutov, 1990). Nearly all samples represent soddy forms, which was also linked with the duration of the vegetation period. This parameter varied in this species from 84 to 107 days, with the mean value of 96; shooting took place after a period of 38 to 55 days, while heading occurred after 57 to 75 days. Plant height varied from 93 to 150 cm with the mean value of 113,5 cm. There were no accessions with a short straw. Samples resistant to crown and stem rust were not found, though some forms (WIR-230, WIR-278) were tolerant to BYDV. In 1990 most of the samples manifested resistance to powdery mildew. Grain yield parameters were the lowest.

Hexaploid weedy oat species are the most important from the viewpoint of breeding practice, for they can be directly crossed with cultivated oats. The samples of *A. sterilis* and *A. ludoviciana* were characterized by a semierect or prostrate bush sometimes having partially downy thick stems and broad leaves, a large-sized spreading panicle and high productive tillering. As for the duration of the vegetation period, the accessions of the most representative species *A. ludoviciana* had the germination/shooting period of 44.4 days, germination/heading period of 65.2 days, and the whole vegetation period of 94.6 days. At the same time these forms demonstrated variation of this character in the geographic aspect. For example, germination/shooting, germination/heading and total vegetation period had the minimum duration with the accessions from Armenia (41.5, 52.5 and 93.1 days respectively) and the maximum duration with those from Ukraine (49.7, 106.3 and 127.9 respectively). The most early-ripening (79–82 days) samples with the shortened first half of the vegetation period were those from Azerbaijan and Armenia. Samples from Georgia, Russia (Krasnodar Region) and Ukraine (Crimea) may be attributed to the semi-winter type. A small number of forms of *A. sterilis* from Russia had a rather long vegetation period. Plant height in *A. ludoviciana* varied from 60 to 160 cm in different years of the research period, and the mean height was 103.1 cm. The least mean height (70–78 cm) was observed in the forms from Azerbaijan and Armenia, while the highest mean values in plant height (125–133 cm) were demonstrated by the samples from Georgia. The forms of *A. sterilis* showed plant height levels similar to those of *A. sativa* (100–110 cm). Among the samples of this group there were forms resistant to lodging with thick and shortened low internodes (Loskutov, 1992a). The majority of forms tolerant to crown rust were representatives of *A. ludoviciana* from Azerbaijan (WIR-23, WIR-317) and Armenia (WIR-387), but the most resistant were *A. sterilis* forms from Georgia (WIR-328). It was the epiphytic incidence of 1992 that helped, as a result, to identify tolerant forms from Azerbaijan, Georgia and Armenia. BYDV-tolerant accessions of *A. ludoviciana* came from Azerbaijan (WIR-110, WIR-124, WIR-250, WIR-963), Georgia (WIR-360, WIR-975), Armenia (WIR-387, WIR-972, WIR-973) and Russia (WIR-324). High yielding were the spring forms from Azerbaijan, Georgia, Armenia, Tadjikistan and Ukraine, which produced stable grain yields per plot.

Hexaploid *A. fatua* was characterized by an exclusively erect bush shape with thick hairless stems and broad leaves, spreading panicle and many morphological characters similar to those of *A. sativa*. The distinctive feature of this species is its earliness. The mean duration of the germination/shooting period was 40.1 days, with 50.3 days from germination to heading and the whole vegetation period of 84.2 days. The earliest forms were collected in Georgia; their germination/shooting, germination/heading the vegetation periods were respectively 40.4, 48.6 and 81.1 days. The most late-ripening forms were found in Azerbaijan (41.3, 54.8 and 90.0 days respectively). In addition, earliness on the level of standard oat cultivars was typical to a number of forms from Armenia, Kazakhstan, Tadjikistan, Russia and Ukraine. The mean plant height for this species was 101.4 cm. This parameter was highly variable in different years of research:

110.5 cm in 1990; 80.0 cm in 1991; and 113.9 cm in 1992. Thus, many of the short forms identified in 1991 were of medium height in the next year and their plant height had a different rank. At the same time, noticeable were the accessions with the stable plant height level of 70–90 cm: their origin were Azerbaijan, Georgia, Armenia, Russia and Ukraine. Forms resistant to lodging were identified among the accessions with plant height of approximately 100 cm (Loskutov, 1992a). The analysis of disease resistance performed in the field resulted in identification of a number of accessions tolerant to crown rust (from Azerbaijan WIR-114 and Ukraine WIR-286), but no forms were found to be tolerant to stem rust. BYDV-tolerant were forms from Azerbaijan (WIR-116, WIR-226), Armenia (WIR-48, WIR-971), Ukraine (WIR-39,WIR-43) and Georgia (WIR-45). At the same time, disease resistance was not typical for the accessions of this species collected in the C.I.S. countries. During the years of study the most high-yielding were forms from Azerbaijan, Georgia, Armenia and Russia. It should be marked that productivity of this group of accessions was the highest and most stable of all studied species.

The forms of specific diversity which have a shortened vegetation period (especially its first half) and quick grain-ripening process are capable of producing high-quality planting materials in a hybrid population with cultivated oat. At the same time, the duration of the vegetation period and its separate phases showed the highest variability which depended on the group of species and the year of study. In order to define the dependence between meteorological parameters and separate phases of the vegetation period in different species, a correlation analysis was carried out.

As a result, for diploid forms it was found that a rise of the mean air temperature in May/July is followed by an increase of the periods from germination to shooting and, especially, to heading; an increase of the precipitation amount, especially in the second half of the vegetation period, increases the duration of the heading/ripening period; decrease of the mean value of the hydro-thermal coefficient (HTC) in May provides for an increase of the duration of the first half of the vegetation period, while an increase of HTC in the second half of June and in July accounts for an increase in the duration of the second half of vegetation.

In the case of a tetraploid species, decrease of precipitation in May/July, decrease of the mean HTC value and increase of the mean air temperature in June/July provide for prolongation of the shooting and heading phase and respectively for decreasing the duration of the second half of the vegetation period; the duration on the whole vegetation period depends to a greater extent from the temperature conditions during the whole period of vegetation.

In the group of hexaploid species, with an increase of the air temperature and decrease of the precipitation amount *A. ludoviciana* forms show an increase of the duration of the first half of the vegetation period. The whole vegetation period is directly correlated with the precipitation amount of June and adversely correlated with the mean temperature in August. The period limited by shooting, which largely determined the duration of the total vegetation period, is closely connected with the HTC in June.

In *A. sterilis*, which is in many studied parameters similar to the previous species, the duration of the germination/shooting and germination/heading phases were adversely related to the precipitation amount in July, while the duration of the whole vegetation period showed direct dependence from the precipitation amount and mean HTC value in July.

A. fatua was characterized by a large amount of genuine spring forms. With an increase of the mean air temperature in June/July this species reduced the duration of germination/shooting and germination/heading periods; an increase of the mean temperature in August affected the duration of the second half of plant development; the whole vegetation period was directly correlated with the precipitation amount in May and adversely with the sum of air temperatures in June and the mean HTC value in May.

The effect of the duration of separate plant development phases on the duration of the whole vegetation period was represented by reliable correlations identified throughout the whole specific diversity. Essential direct correlations were found between the duration of the germination/shooting phase and the duration of the whole vegetation period: it was 0.93 for diploid forms, 0.87 for tetraploid and 0.73 for hexaploid ones. Direct correlations linked the duration of the germination/heading phase and the whole vegetation period: 0.92 for diploids, 0.90 for tetraploids and 0.94 for hexaploids. Distinctly correlated were such parameters as the bush shape type, on the one hand, and the duration of the first half of the vegetation period, on the other.

It was found out that the prostrate bush type and a longer first half of the vegetation period correlated between one another: this parameter was 0.67 for diploid forms, 0.71 for tetraploid and 0.46 for hexaploid ones. Another important trait, resistance

to lodging directly correlated in the field with straw thickness and adversely with plant height in diploid and tetraploid species, while for hexaploid species this correlation was the opposite, but its manifestation was weak (Loskutov, 1992a, b). Variation of plant height in different years of study was, in its turn, directly linked in all groups of species with the aggregate amount of precipitation in June and July, and also dependent on the HTC value for the same period. Correlation with the air temperature was in most cases adverse and insignificant by value.

Conclusion

Thus, this field analysis has resulted in the conclusion that for diploid and tetraploid species disease resistance is the most important character from the practical point of view. Forms, in which this trait is combined with a shorter vegetation period, short straw, good leafiness and quick growth habit, may be used as genetic sources for improvement of oat cultivars. Hexaploid forms demonstrated wide diversity of morphological and agricultural characters, such as dwarfness, productive tillering, earliness, resistance to diseases and lodging, and other traits which can easily be transferred upon cultivated oat.

Results of the correlation analysis helped to find out that in all species the duration of the vegetation period and its separate phases depended to a greater extent on the air temperature. Plant height was directly more dependant on the aggregate precipitation amount and adversely on the air temperature in the years of study, which seems to be linked with the development of the root system.

It was reliably proven that the duration of the vegetation period is influenced by the duration of the germination/shooting phase and, in particular, germination/heading phase. At the same time, the duration of the first half of the vegetation period is interlinked with the bush shape, which helps to evaluate plant materials from the tillering phase to the heading phase for the duration of the vegetation period and the type of development (winter or spring).

This research showed that resistance to lodging depends upon the straw thickness and plant height. It may provide for a possibility to search for resistant forms using indirectly associated characters. Such regulations are more important for wild oat species, than for weedy forms, because the latter are more diverse in the development rapidity and morphological traits.

Studying the numerous and representative collection of *Avena* spp. with different levels of ploidy disclosed rich ecological and geographical variability in all the analyzed characters, which makes it possible to conduct a targeted search of the most valuable forms for breeding practice in definite areas of their richest diversity in the C.I.S. countries.

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