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Creating Varieties of The Perennial Cereal Grasses by The Polycross Method in Northern Kazakhstan

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ABSTRACT

In Kazakhstan fodder crops in arable land are mainly perennial grasses, for example wheatgrass, Psathyrostachys juncea, smooth brome and different types of blue grass.

Depending on the conditions of the region's sharply continental climate, development work is carried out to create new varieties of wheatgrass and smooth brome of a hay type with high drought resistance, winter hardiness, a high forage seeds yield and high quality as feed and resistance to disease. In the Barayev Centre the traditional and modern emerging techniques are used in developing grasses such as creating complex hybrid populations, including synthetic populations by the use of the polycross method. In the polycross nursery the nine best examples of clones of broad-eared wheatgrass and eight best clones of smooth brome were selected. The obtained polycross hybrids were evaluated according to the following criteria: combining ability in terms of green mass yield, dry matter and seeds, crude protein content, drought resistance, hardiness, plant height and herbage vigour. After the analysis of combining ability the synthetic populations were formed: 5 components were included in a synthetic wheatgrass (K-1027, K-418, K-1029, K-1024, K-1043), and 4 components in a smooth brome (K-681, K-621, K-712, K-641). Synthetic populations of broad-eared wheat grass variety Shortandinsky shirokokolosy and a smooth brome variety named Ishimsky Yubileiny were transferred to the Kazakhstan state variety testing center in 2005-2007. Recently, these varieties have been released in the regions of northern Kazakhstan.

Keywords: wheatgrass, smooth brome, polycross method, clone, combining ability, synthetic population..

Introduction

In Kazakhstan, most fodder crops in arable land are perennial grasses. With a proper selection of species and varieties for different areas and with the necessary care they provide cheap, varied and nutritious feed. They are dominated by wheatgrass, *Psathyrostachys juncea*, smooth brome and different types of blue grass. The variety of crops and quality seeds contribute significantly to increase productivity and quality of feed products. The climate in the north of Kazakhstan is extremely continental, very arid and dry with cold, moderately snowy winters, very often with little snow. Annual precipitation is 250-350 mm, which characterizes the area as arid.

Analysis of methods of creating perennial grass varieties included in the State register of the Republic of Kazakhstan shows that 60% of the varieties have been created using mass selection, 20% by individual selection, 2% by biotypical selections and 1% by hybridization. Under the conditions of Northern Kazakhstan, when creating better and more productive, adaptable, cold, drought, disease and pest resistant varieties of smooth brome and wheatgrass, the most perspective method may be using of heterosis effect.

The complex polyploidal nature and predominantly cross pollination of smooth brome and wheatgrass presupposes wide use in their selection of the heterotic effects, which can be maintained for a relatively long time in so-called panmictic populations. On the other hand, panmictic populations cannot drastically change their attributes and properties in space and time under steady environmental conditions and biocenotic ratios during the reproduction of the variety.

For anemophilous cross-pollinated species, heterosis can be achieved by creating synthetic populations (synthetics) as developing these species with preliminary emasculation is quite time-consuming and not cost-effective. In addition, individual specimens in created complex hybrid populations can freely interbreed with each other and during the reproduction of such varieties populations a balanced system is formed, which can maintain the heterosis effect for a relatively long time. One of the essential steps in the heterosis synthetic population formation is to determine the combining ability (CA) of their components. The polycross test is assigned an important role in determining the CA. This method is less labour intensive than top crosses and paired crosses, and provides a good amount of high-grade seeds.

If earlier a crop was considered synthetic, having been developed by crossing, mixing, planting in rows of two or more varieties, or cloning of inbred lines with subsequent re-pollination (Henson and Carnahan 1959), in the last decade the creation of synthetic varieties presupposes definition of combining ability (Kedrov-Zihman 1974). The main condition in organising polycross nurseries is that each sample should have an equal opportunity to be pollinated by the pollen of all test samples of the analysed group. There are various plans (schemes) of polycross nursery layouts (Frandsen and Frandsen 1948; Shaepman 1952; Walther 1959; Knowles 1955; Osipova 2006). In the end, their effectiveness is verified by creating cultivars. Success in the selection of synthetic varieties would be significantly promoted by not only an established approach to quality selection of components, but also by the determination of an optimal number for each specific case with consideration being given to the specific nature of each culture. Today the question of the minimum and maximum number of components to create synthetics is controversial. Special experiments conducted with forage grasses to identify the optimal number of components for the formation of synthetics on the basis of CA showed that combining 10 to 20 of the best clones can achieve higher yields of forage than the union of less than 10 and more than 20 clones (Frandsen and Frandsen 1948). Knowles (1955) conducted experiments with five synthetic varieties composed of 4, 5, 6, 7 and 8 clones that had CA higher than average, which was estimated after free pollination. Synthetic varieties consisting of 5 and 6 clones gave first generation fodder yields above 112% compared with the standard. The remaining synthetic varieties didn't have any significant differences with the standard. As for the seed crop was concerned, all five varieties yielded substantial gain compared to the standard grade.

According to Osipova (2006), the optimal number of constituents to create the synthetic materials may be 9, but it does not exclude other options. Unfortunately, in the Republic of Kazakhstan this successful method is not widely used in selection of grasses, apparently because of the great complexity of its implementation. In the Barayev Centre selection work of the perennial grasses was carried out using traditional and modern methods of selection such as creating complex hybrids, including synthetic populations using the polycross method. This work is aimed at the creation of new varieties of hay grass (wheatgrass, brome) with high drought resistance, winter hardiness, high yield in terms of forage and seeds, high quality feed and disease resistance. The aim of our research is to use the polycross method and to create varieties of wheatgrass and smooth brome adapted to the conditions of Northern Kazakhstan.

Materials and methods

Studies were carried out in the Barayev Research and Production Center for Grain Farming (Akmola region, Kazakhstan). The starting material used in the polycross nurseries was pre-selected wild populations of broad-eared wheatgrass and smooth brome, which have a number of economically important characteristics and properties.

Polycross nurseries were laid out according to method of Kedrov-Zihman (1974). The polycross progeny's test was performed in a control nursery laid out in the standard method. The combining ability (general - GCA and specific - SCA) was determined by the methods that were developed for cross pollinates at the Russian National Institute of Plants (Kobylyansky *et al*.,1977). According to this method GCA was estimated for the yield of hybrids in percentage of average yield of all hybrids in the field experiment; SCA was determined as percentage of average yield of standard. In the initial stages surveys and observations of the selection process were conducted in accordance with the guidelines for the selection of perennial grasses in the Russian National Institute of Feed (Smurigyn, Novoselova and Konstantinova 1985). The experimental material was processed according to Dospehov (1985) guidelines, using the «SNEDECOR» software package.

In the collection nurseries the broad-eared wheatgrass and smooth brome were planted with wide-row method. Amassive selection of individual plants was conducted according to the following criteria: plant vigor, height, leaf color, bush clump shape, bushiness, foliage, ears (panicles), drought resistance, hardiness and resilience to diseases and pests. Seeds from the best plants of selected wild populations were combined and propagated on the isolated areas where negative mass selection was conducted as well.

In our studies, the polycross nurseries of wheatgrass and smooth brome were laid out in a square shape. Clones from isolated propagation nurseries were used as the starting material. The clones of the 9 best samples of broad-eared wheatgrass and 8 best of smooth brome were included in the polycross nursery (Table 1).

Clones or plants of broad-eared wheatgrass were planted in late April-May, in rows in four blocks (replicates) of 60x60 cm, with one plant or clone *per* nest. As smooth brome forms a creeping rhizome from a bushy node, which extends in width as the plant grows and forms underground shoots; its seedlings were planted in blocks of 80x80 cm, which did not allow the bushes to coalesce within the first three years of life.

Seeds from polycross nurseries were gathered separately from each bush (excluding shelter belts), and then the seeds of each species were mixed from all replicates for polycross progeny testing for CA (combining ability) in accordance with the main economically important properties.

Results and discussion

This research was focused on the selection of plant forms with a significant level of CA based on the characteristics most widely used in fodder and, above all, yields of green mass, dry matter and seeds. However, the selection of components for the formation of synthetics which would combine the heterotic effects showing the most economically important traits is not always possible due to its discrete manifestation, including its constituent yield elements (Osipova 2006).

The estimated general combining ability (GCA) of the plants under study facilitated the identification of forms that could be graded as medium (level 3), high (level 4) and very high GCA (level 5) according to the main economically important traits. The formation of synthetics was performed considering not only the GCA, but specific combining ability (SCA) as well. Because the number of components with a discharge of 3 to 5 was too small, which could lead to the loss of valuable genotypes (Table 2), samples were selected which were distinguished by a complex of economically important properties such as: green mass, dry matter and seeds yield, crude protein content, drought resistance, hardiness, plant height, grass, etc., for example, even if the sample was not of a high yield but was the most drought-resistant or tall, it was included in the synthetics (syn) group (Table 3).

In terms of green mass yield, dry matter and seeds of broad-eared wheatgrass hybrids with a high level of GCA, one hybrid of the 9 studied, stood out (level 5) and three hybrids were marked as medium (level 3); to a green mass yield and dry matter with a very high level of SCA there were 5 polycross hybrids and the excess was 12.4-86.6% and 13.5-91.9%, respectively. In terms of seed yield with very high GCA and SCA there was only one polycross hybrid, the remaining samples were low or very low in character (rank 1-3). These 5 polycross hybrids excelled in other economically important traits as well: plant height, drought tolerance, winter hardiness, crude protein content. The difference in plant heights was from 3 to 5 cm between standard and hybrid plants, the difference in the crude protein content was 1.3-2.1% respectively.

From 8 studied smooth brome polycross hybrids there were only 2 hybrids which reached medium GCA level (level 3) for the green mass yield, the others had a low level of GCA and SCA as well. Only one polycross hybrid had a high GCA level (4) for dry matter yield and a very high SCA level (5), the second hybrid had the medium GCA and SCA levels (3); others had a low level ranking of 1-2. For seed yield in polycross hybrids smooth brome had two very high GCA and SCA rankings, their excess in GCA and SCA was on 28.6-66.6%. The rest showed low CA levels with regard to basic economically important traits (crude protein content, plant height, drought tolerance and winter hardiness) four polycross hybrids showed a good result.

An increase in hybrid on the standard in plant height was from 4 to 7 cm, the content of crude protein - 0.6-0.9%. These hybrids were more drought-resistant and winter-hardy.

So after the analysis of CA the synthetic populations were formed: for wheatgrass 5 components were included in syn (K-1027, K-418, K-1029, K-1024, K-1043); for smooth brome - 4 components (K-681, K-621, K-712, K-641).

The results of such differentiated selection of synthetics components have proved effective in creating synthetic varieties: the yield of synthetic populations of perennial grasses formed using polycross method, it was above standards in competitive strain testing (Table 4).

Synthetic populations of broad-eared wheatgrass called Shortandinsky shirokokolosy and smooth brome Ishimsky yubileiny were transferred to the Kazakhstan State Variety Testing Center in 2005-2007.

Currently, the variety of wheatgrass Shortandinsky shirokokolosy was released for the North-Kazakhstan region in 2011.

According to the results of the State variety trials in the North-Kazakhstan region the seed yield of the new variety of wheatgrass was higher by 27% than yield of previously recognized standard variety - Batyr. Green mass yield of wheatgrass Shortandinsky shirokokolosy exceeded the standard by 19%; dry weight by 20%.

The variety of smooth brome Ishimsky yubileiny was released for the North Kazakhstan and Kostanay region in 2011.

According to the results of the State variety trials in the North-Kazakhstan region the green mass yield of smooth brome Ishimsky yubileiny on average for two years (2010-2011) was 12.2 t/ha, dry matter -3.49 t/ha, seeds yield - 0, 47 t/ ha, exceeding the standard by 13%, 19.1%, 17.5% , relatively. The variety differed from the standard by height.

Thus, the use of the polycross method with the estimation of the CA allows creating varieties of smooth brome-grass and wheat grass for the environment of Northern Kazakhstan.

The number of constituents in the formation of synthetic materials is determined by the individual characteristics of the base material for the studied species and it can vary from 4 to 5, but does not exclude other options.

Table 1. Selected samples of smooth brome and wheatgrass in a nursery of the polycross

Species	Number of selected samples	Name and origin of the parental population
Broad-eared wheatgrass	9	K-1027 Karaganda region (Kazakhstan), K-418 Kostanay region (Kazakhstan), K-104, IK-1061 Akmola region (Kazakhstan), K-1083 Novosibirsk region (Russia), K-1024 Orenburg region (Russia), K-1000 Altay region (Russia), K-1029 Povolzhie (Russia); K-1021 Armeniya
Smooth brome	8	K-641Altay region (Russia), K-673 Chelyabinsk region (Russia), K-621 Kemerov region (Russia), K-681, K-683, K-679 Ekaterenburg region (Russia), K-712 Krasnoyarsk region (Russia), K-647 Bashkortostan (Russia)

Table 2. The combining ability in polycross progenies selected from wild specimens of smooth brome and wheat grass included in the synthetics (syn)

Variety	Dry matter %		Vitamin C, мг/%		Sugar/acidity indice	
	GCA	SCA	GCA	SCA	GCA	SCA
			Broad-eared wheatgrass			
K-381	112.4 / 2	163.0 / 5	117.6 / 3	161.3 / 5	117.2 / 2	124.5 / 3
K-382	116.1 / 3	168.3 / 5	115.3 / 3	158.1 / 5	98.6 / 1	104.8 / 1
K-409	116.7 / 3	169.2 / 5	113.5 / 3	155.6 / 5	80.0 / 1	85.1 / 1
K-418	119.5 / 3	173.3 / 5	118.8 / 3	162.9 / 5	97.7 / 1	103.8 / 1
K-427	128.7 / 5	186.6 / 5	140.0 / 5	191.9 / 5	140.7 / 5	149.5 / 5
LSD05	5.3	5.4	6.3	6.2	12.1	12.5
			Smooth brome			
K-681	109.4 / 2	111.0 / 2	97.7 / 1	99.0 / 1	142.9 / 5	166.6 / 5
K-621	113.1 / 3	115.0 / 3	128.5 / 4	129.9 / 5	128.6 / 5	150.0 / 5
K-712	105.1 / 3	107.0 / 2	109.0 / 2	110.0 / 2	85.7 / 1	100.0 / 1
K-641	99.0 / 1	101.0 / 1	112.9 / 3	114.1 / 3	85.7 / 1	100.0 / 1
LSD_{05}	3.3	3.3	2.7	2.8	2.3	2.2

Note. Numerator - GCA (% to the average of all hybrids in the experiment) and SCA (% of the average yield in the standard experiment); the denominator - the level of GCA and SCA.

Table 3. The ratio of components in the formation of synthetic populations of wheatgrass and smooth brome.

Species	Total components syn_1	The number of components included in the syn_1						
		Extracted by the CA			Other economically valuable features			
		productivity						
		Green weight	Dry matter	Seeds	High crude protein content	Drought-resistance	Hardiness	Height
Wheatgrass (syn_1)	5	5/100	5/100	2/40	5/100	5/100	5/100	5/100
Smooth brome (syn_1)	4	4/100	3/75	4/100	4/100	4/100	4/100	3/75

Note. The numerator is the number of the separated components syn1, denominator indicates the percentage of ratio.

Table 4. Yield of synthetic populations of broad-eared wheatgrass and smooth brome formed using the polycross method of different schemes, competitive strain testing (average for 6 years).

Crop	Productivity, t/ha					
	Green mass		Dry matter		-	
	x	% tost	x	% tost	x	% tost
Broad-eared wheatgrass						
syn_1	9,1*	115,2	4,91*	116,1	0,27*	122,7
St, Karabalukskiy 202	7,9	100,0	4,23	100,0	0,22	100,0
Smooth brome						
syn_1	17,4*	123,4	6,71*	124,7	0,40*	133,3
St, Limanniy	14,1	100,0	5,38	100,0	0,30	100,0

Note. *- significant at the 5% level of significance

References

Dospehov BA (1985). Field experiments methodology. Moscow, Russian publishing house «Kolos», p. 351.

Frandsen HN and Frandsen KI (1948). Polycross-methoden massekrydsnings-methode ved foraedling of fremmedbefrugtende planter. Nordisk Jordfruksforskning, pp: 239-261.

Hanson AA and Carnahan HL (1959). Breeding perennial forage grasses. Moscow, Russia. 2nd Ed, p. 182.

Kedrov Zihman OO (1974). The polycross test in plant developing. Minsk, Belarus, p.128.

Knowles RP (1955). Testing for the combining ability in bromegrass. Agron. J. 47, pp: 15-93.

Kobylyansky VD, Katerova AG and Lapikov NS (1977). Guidelines for Heterosis developing rye using CMS. VIR, Russia, p. 28.

Osipova GM (2006). Smooth brome. (Features of biology and developing in Siberia). Novosibirsk, Russia, p. 228.

Shaepman H (1952). Application of the polycross tests to grass developing. Euphytica, pp: 105-111.

Pflanzenzucht 42, pp: 11-24.

Smurigyn MA, Novoselova AS and Konstantinova AM (1985). Guidelines for the selection of perennial grasses. Russian National Institute of Feed. Moscow, Russia, p. 188.

Walther F (1959). Modellversuche zur Erzeugung synthetischer Heterosis beim Roggen. Z.