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SELECTION OF SPRING SOFT WHEAT (*Triticum aestivum* L.) VARIETIES FOR THE ADAPTABILITY IN THE CONDITIONS OF STEPPE ZONE OF THE AKMOLINSK REGION, KAZAKHSTAN

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Abstract

The spring soft wheat (*Triticum aestivum* L.) planting acreage makes 78 % of the crops of cereals grown in Akmolinsk region, the North Kazakhstan. The wheat productivity can reach 1.4-1.8 t/ha which makes it possible to harvest high yield with high grain quality and high protein level. That is important when cultivating strong wheats, the so called improvers. At the present time, searching for the reserves to increase yield and to improve grain quality in wheats is of interest. Here, the key role is given to a variety because over 20 % of an increase in the crop yield is due to varietal features. This article presents data on phenology, nodal root formation, the main yield elements, and the total yield of spring wheat (*Triticum aestivum* L.) promising varieties Karagandinskaya 22, Karagandinskaya 29, Karagandinskaya 70, Seke, Sary-Arka, and Stepnaya 60. The estimations have been carried out according to the Kazakhstan State Crop Variety Testing protocol. Field trials were carried out in 2011-2013 using fallow land as a predecessor in the test field of Ualikhanov Kokshetau state University (Kokshetau, Kzakhstan). The conditions of the steppe zone were favorable for nodal root development which number per plant reached 5.5 for Karagandinskaya 22, 4.5 for Stepnaya 60, and 5.2 for Seke. The number of nodal roots during plant growth increased from tillering to full grain ripeness. In the arid conditions of the steppe zone the length of growing season is of importance. Among the varieties, the vegetation period was optimal in Karaganda 22 (94 days), with an average 96 day period for all the varieties studied. The main components of wheat yield were shown to be beneficially influenced by the climate conditions. The plant number per 1 m^2 at harvesting was 230-282, the productive tiller number per 1 m2 was 201-333, the seed number per ear was 20-30, and the 1000 seed weight was 36.4-49.6. Grain productivity of the varieties Karagandinskaya 22, Sary-Arka, and Stepnaya 60 was 4.0, 3.6, and 3.4 t/ha, respectively. So their yielding was higher compared to only 1.8 t/ha for the standard variety Svetlanka. During selection for adaptability in the conditions of steppe zone of the region, the main emphasis should be given to the number of kernels per ear (r = 0.86±0.13) and the 1000 grain weight (r = 0.76±0.12). In a model variety for the steppe zone of the region, the main yielding parameters must be as follows: 96 day-length of vegetation, 25 to 30 seeds per ear, productive tillering of 1.1 to 1.2, and the yield of 3.0-4.0 t/ha. The 1000 seed weight should be 33-36 g for the fraction of mid-size seeds, and more than 38-45 g for larger seeds.

Keywords: spring soft wheat, sort, nodal roots, yielding capacity, elements of the structure

Spring soft wheat is the leading cereal in the northern regions of the Republic of Kazakhstan, where its acreage, according to the latest data, is 13.5 million ha. Cultivated varieties stand out for the high quality of their grain, which is not inferior to international standards. However, due to extremely changeable weather conditions, grain yield varies greatly over the years (from 0.4 to 2.7 t/ha), which indicates a reduced biological productivity of the climate [1].

Varieties are the basis of the production of any crop products. They largely determine the zonal technologies of cultivation, size, quality, energy efficiency of the products obtained (2). In modern economic and climatic conditions, the main requirements for varieties are high yields, the possibility of cultivation using energy-saving technologies, environmental resistance to stresses, plasticity, high grain quality, and resistance to damage by pathogens and pests [3, 4]. A prerequisite for the successful creation of such varieties may be a different response of plants to changes in environmental conditions, which is under genetic control [5]. Namely, the drought resistance of a variety depends on the genomes of the parents, especially if one of them belongs to the wild-growing related species [6, 7].

The adaptive capacity helps a variety to uncover its potential yield [8]. In terms of fertility of soils, their optimum moisture content and daylight length, the region of Northern Kazakhstan is suitable for the cultivation of spring soft wheat. These conditions make it possible to grow high-yielding high-protein varieties. The intrazonal identity of varieties affects the yield structure [8]. The ability to adapt offers the varieties an advantage in increasing the number of nodal roots, the coefficient of productive tilling capacity, grain content and yield. Namely, the varieties of the Karaganda selection showed good results with respect to the above indicators in the Akmola Region.

In this study, for the first time, we identified the main features and parameters of the mid-ripening spring soft wheat variety model for the steppe zone of Akmola Region in terms of the duration of the interstage and vegetation periods, the number of nodal roots and the main elements of the yield structure.

The objective of the work was to isolate varieties of spring soft wheat (*Triticum aestivum* L.) according to a set of features maximally adapted to the conditions of Northern Kazakhstan, as well as to assess the relationship between the elements of the productivity structure in mid-ripening varieties and the final grain yield.

Techniques. The experiment was carried out using fallow land as a predecessor in the test field of Sh. Ualikhanov Kokshetau State University (Republic of Kazakhstan) in 2011-2013. The experiment area was 3 m^2, with the total area of 5 m^2. Repetition was 4-fold. Variants were placed randomly. Sowing was carried out at the optimum time (May 18-20) manually with a seeding rate of 350 viable kernels per 1 m^2. The soil of the experimental plot is ordinary chernozem with humus content of 3.6 %, pH 6.0-6.5.

The material was promising varieties of spring soft wheat (*Triticum aestivum* L.) of the mid-ripening group created in the Karaganda Research Institute of Crop Science and Plant Breeding: Karagandinskaya 22, Karagan-dinskaya 29, Karagandinskaya 70, Seke, Sary-Arka, and Stepnaya 60. The variety Svetlanka registered in the Akmola Region was used as a standard. We evaluated the duration of interstage and vegetation periods, the dynamics of the nodal roots, the yield and the main elements of its structure: the number of plants, the number of productive stems, the productive tilling capacity, the number of kernels per ear, and the thousand-kernel weight.

The experimental data were analyzed statistically in Microsoft Excel 2010. When determining the means (M), their standard errors (±SEM) were calculated. We calculated the least significant difference ($LSD_{0.05}$), as well as coefficients of variation (*Cv*, %) and correlation (*r*) according to B.A. Dospekhov [9].

Results. The impact of agrometeorological conditions on the yield of spring wheat varieties in the years of the study was not the same. Namely, the hydrothermal coefficient (HTC) in 2011 and 2012 (1.2 and 1.1, respectively) was close to the long-term average annual indicator (0.9) in the zone, while in 2013, which turned out to be overmoistened, the HTC was 2.9.

The soft wheat endures the negative impact of extreme conditions of the spring-early summer drought better during the tillering period, but its productivity is greatly reduced if the impact falls on the booting stage, when ear initiation and differentiation occur (organogenesis stages V—VII). Under the conditions of the steppe zone of Northern Kazakhstan, where droughts are constantly observed, wheat varieties with an extended tillering period are more adapted to local conditions [11, 12]. Yield formation depends on the length of the first half of the vegetation period [13].

During the study years, the average length of the vegetation period for mid-ripening varieties was 98.28 ± 1.88 days (Table 1). Due to the prevailing climatic conditions, the interstage seedling-heading period lasted 41 days. The lack of precipitation in the first half of the summer accelerated the passage of this period. Lengthening of the heading-ripening period (50-57 days) was associated with a decrease in temperature in July and heavy rains in the second decade of August. Among the studied varieties, Karagandinskaya 22 had the shortest (94 days) vegetation period (Table 1). The vegetation period lengthens in case of excessive moisture [13]. The HTC during the observation period was excessive (an average of 3 years — 1.7).

1. Duration (in days) **of interstage periods and vegetation in mid-ripening spring soft wheat varieties (*Triticum aestivum* L.)** (Republic of Kazakhstan, 2011-2013)

Variety	Seedling—tillering	Tillering—booting	Booting—heading	Heading—ripeness	Vegetation period
Svetlanka (standard)	12	14	16	57	99
Karagandinskaya 70	13	14	16	56	99
Seke	13	15	16	55	99
Karagandinskaya 22	14	15	15	50	94
Stepnaya 60	14	14	14	57	99
Karagandinskaya 29	14	14	15	56	99
Sary-Arka	14	14	15	56	99
M ± SEM	13.42±0.48	14.28±0.48	15.28±0.75	55.28±2.42	98.28±1.88
$LSD_{0.05}$	0.08	0.07	0.07	0.14	0.20

The average coefficient of variation over 3 years for the seedling—heading period was 16.1%, for heading—waxy ripeness 21.4%, for the entire vegetation period 9.2%, and depended on the weather conditions and genetic characteristics of the varieties. The results of our studies showed a fairly high positive correlation between the length of the vegetation period and the yield of spring soft wheat (r = 0.83±0.18). Previously, R.K. Kadikov et al. [14] concluded that during a moist year with moderate temperature, the mid-ripening variety shows high grain yield.

The degree of supply of the aboveground organs with water and soil nutrition elements depend on the nature, growth and development, distribution and other morphostructural characteristics of the root system, which affects the stability and productivity of plants [15]. In terms of the number of nodal roots, we identified varietal differences, the manifestation of which is significantly influenced by both environmental conditions and the genetic characteristics of plants. Similar conclusions were drawn by other authors using the example of the Sonora and Currawa genotypes [16, 17]. In the work by A.M. Manschadi et al. [18], the arid variety Seri M 82 compared to the standard Hartog had a compact root system.

In the conditions of a frequent spring-summer drought, the time of nodal root initiation and growth and their late dying-off at the end of the vegetation become important. Our studies of mid-ripening varieties showed that the initiation of the tillering node for most of them began during the fourth leaf period. The works of foreign authors contain information that the nodal roots can be distinguished during the third leaf period, since they are expanded in diameter and are formed from the tillering node from a different angle [18]. In spring soft wheat varieties during the tillering stage one plant had from 1.9 (Karagandinskaya 29) to 3.3 nodal roots (Karagandinskaya 22), while the standard Svetlanka had 2.6 nodal roots. The average number of nodal roots was (2.78 ± 0.45) per plant (Table 2). According to M. Watt [19], spring wheat was observed to have one nodal root, rarely two. Therefore, agricultural practices aimed at the accumulation and preservation of moisture in the upper layers of the soil will contribute to the better development of nodal roots [8].

The growth and development of the root system, like other morphophysiological characteristics, always vary [8]. In wheat, in terms of the share of influence on grain yield, such a characteristic as the nodal root formation accounts for 50% [20]. During the booting stage, we observed the highest growth in the nodal roots (3.9) in plants of the Karagandinskaya 22 variety, while Karagandinskaya 29 had the smallest value of this indicator (2.5). The average value of this characteristic in all varieties was (3.27 ± 0.42) roots per plant. During the heading period, the largest number of nodal roots was observed in the Karagandinskaya 22 and Seke varieties, i.e. 4.6 and 4.1 roots per plant, respectively; the average value was 3.75 ± 0.45 roots per plant. During the milky ripeness stage, the Seke and Karagandinskaya 22 varieties were characterized by the best indicators, i.e. 4.9 and 5.2 roots per plant, with the average value of (4.58 ± 0.44) roots per plant.

According to V.K. Movchan (quoted in 20), the varieties capable of forming a large number of seminal roots (5 or more) have a relatively high drought resistance, produce stable yields and can be used to create new productive genotypes.

2. Number of nodal roots (roots per plant) **in mid-ripening spring soft wheat varieties (*Triticum aestivum* L.) depending on the development stage** (Republic of Kazakhstan, 2011-2013)

Variety	Tillering	Booting	Heading	Flowering	Milky ripeness	Waxy ripeness	Complete ripeness
Svetlanka (standard)	2.6	3.3	3.6	4.1	4.7	5.0	5.1
Karagandinskaya 70	2.7	3.4	3.6	4.5	4.7	4.9	5.0
Seke	3.1	3.2	4.1	4.6	4.9	5.1	5.2
Karagandinskaya 22	3.3	3.9	4.6	4.8	5.2	5.3	5.5
Stepnaya 60	3.0	3.5	3.6	3.9	4.3	4.4	4.5
Karagandinskaya 29	1.9	2.5	3.2	3.6	3.8	3.9	3.9
Sary-Arka	2.9	3.1	3.6	4.1	4.5	4.7	4.9
M ± SEM	2.78±0.45	3.27±0.42	3.75±0.45	4.22±0.42	4.58±0.44	4.75±0.47	4.87±0.52
$LSD_{0.05}$	0.05	0.03	0.03	0.05	0.05	0.09	0.04

The variability in the number of nodal roots of the varieties prior to the booting stage was small (*Cv* 2.2-5.1%). This indicator increased towards the heading stage (8.1%), and then slightly decreased during the kernel milky ripeness period (7.2%). In terms of the number of nodal roots, the correlation relationship with the yield of the spring soft wheat varieties studied was moderately positive (r = 0.62 ± 0.20). It should be noted that most of the varieties were characterized by the early and simultaneous emergence of nodal roots, the formation of which continued until the end of the vegetation period, which was associated with rainfall and adequate moisture in the soil during the years of observation. A number of ecological and morphophysiological parameters of the root system can be used as additional criteria for predicting the productivity of a genotype under specific conditions [8].

The development of the root system enhances the integration of elements of the productivity structure in promising varieties [21]. Of the seven varieties we studied, Karagandinskaya 22 and Seke stood out for their productive tilling capacity (1.2) surpassing the standard (1.0). According to Ye.A. Korenyuk, the productive tilling capacity account for 94.1 to 96.8% [22] in the spring wheat yield structure. According to Yu.S. Krasnova, the yield of spring soft wheat grain depends on the high value of productive tilling capacity (r = 0.4 ± 0.06). This feature should be included in breeding programs to achieve a stable grain yield [14].

In addition, the Karagandinskaya 22, Sary-Arka, Stepnaya 60 varieties were distinguished by a higher thousand-kernel weight, which directly depended on the temperature conditions and the amount of precipitation. A similar effect was noted in field tests during the study of grain quality indicators in spring wheat varieties with *Lr*-translocations depending on temperature and humidity conditions (23). In our experience, the coefficient of variation of the thousand-kernel weight was 13.2%, and the conjugate dependence was expressed by direct correlation with yield (r = 0.76 ± 0.12). The thousand-kernel weight varied from 36.4 g in the Karagandinskaya 70 variety to 49.6 g in the Karagandinskaya 22 variety and averaged (42.00 ± 5.06) g.

A similar pattern, reflecting the high coefficient of heritability of the number of seminal roots, which closely correlates with a change in the thousand-kernel weight and ear grain content, was noted earlier when studying the manifestations of drought resistance in spring soft wheat in the Central Kazakhstan [15].

3. Элементы структуры урожая у среднеспелых сортов яровой мягкой пшеницы (*Triticum aestivum* L.) в зависимости от фазы развития (Республика Казахстан, 2011-2013 годы)

Variety	Number, pcs./m^2		Productive tilling capacity	Number of kernels per ear, pcs.	Thousand-kernel weight, g	Biological yield, t/ha
	of plants	of productive stems				
Svetlanka (standard)	277	290	1.0	20	39.6	1.8
Karagandinskaya 70	297	201	0.6	27	36.4	2.9
Seke	230	288	1.2	27	40.2	2.5
Karagandinskaya 22	270	333	1.2	25	49.6	4.0
Stepnaya 60	282	269	0.9	28	43.0	3.4
Karagandinskaya 29	260	280	1.0	28	37.4	2.7
Sary-Arka	233	236	1.0	33	47.8	3.7
M ± SEM	264.14±25.00	271.00±42.23	0.98±0.20	26.85±3.89	42.00±5.06	3.00±0.75
$LSD_{0.05}$	13.00	25.70	0.10	6.97	5.75	0.45

The number of kernels in an ear depends on weather conditions during flowering. The increase in the amount of grain is compensated by a significant decrease in its weight (up to 5%) [24, 25], but we obtained different results during our study. Namely, in case of Sary-Arka, as the number of kernels per ear increased (33 pcs.), the thousand kernel weight increased (47.8 g) and, accordingly, the biological yield increased (3.7 t/ha) (Table 3). The coefficient of variation of the number of kernels per ear was 23.3%, the correlation dependence showed a close relationship between the ear grain content and yield (r = 0.86 ± 0.13). However, in case of the Karagandinskaya 22 variety with the ear grain content of 25, the thousand-kernel weight was 49.6 g, and yield 4.0 t/ha. Therefore, when selecting varieties, the focus should be on the absolute grain weight (thousand-kernel weight) (40-43 g) in combination with such a quantitative feature of an ear as high grain content (up to 27 pcs.) [26, 27]. In terms of ear grain content, the most adapted selection varieties were Sary-Arka (33 pcs.), Karagandinskaya 29 and Stepnaya 60 (28 pcs.).

Varieties should be placed on high agricultural backgrounds, which will allow them to form high yields thanks to their responsiveness to changing environmental conditions [28]. With an increase in yield of up to 1.5 t/ha in the Republic of Kazakhstan, it is possible to harvest up to 20-22 million tons of grain annually. The use of the Karagandinskaya varieties of spring soft wheat in the Akmola Region in rapidly changing weather conditions in a sharply continental climate contributes to an increase in the gross grain harvest [29]. Among promising varieties, Karagandinskaya 22 stood out for its high yields, i.e. 4.0 t/ha [30]. In terms of yield, the Sary-Arka (3.7 t/ha) and Stepnaya 60 (3.4 t/ha) varieties should also be noted, with the average value of their biological yield of (3.00 ± 0.75) t/ha. In modern conditions of agricultural production, an increase in grain yield should be combined with adaptability, ecological plasticity and stability of varieties in various environmental conditions [28].

Thus, in mid-ripening varieties of spring soft wheat, we established a close positive relationship between the length of the vegetation period and the grain yield, the number of nodal roots and the productivity of plants in years with favorable weather conditions. A correlation was also found between the grain yield and the quantitative characteristics — the number of kernels per ear and the thousand-kernel weight. The main elements of the crop structure in the studied varieties were the number of plants per 1 m^2 (230-282 pcs./m^2), the number of productive stems (201-333 pcs./m^2), the number of kernels per ear (20-30 pcs.), the thousand-kernel weight (36.4-49.6 g). In the studied collection, the Karagandinskaya 22, Sary-Arka and Stepnaya 60 varieties were considered optimal in terms of grain yield for the steppe zone of the Akmola Region.

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