УДК 633.1

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AGRONOMY PERFORMANCE AND BIOLOGICAL CHARACTERISTICS OF KHORASAN WHEAT (*TRITICUM TURANICUM* JAKUBZ.) AS A FUNCTION OF THE NITROGEN FERTILIZATION LEVEL.

The aim of this study is to investigate some quantitative and qualitative indicators of Khorasan wheat (*T. turanicum* Jakubz.) A three–year field experiment has been carried out at the experimental field of Department of Crop Science in Agricultural University – Plovdiv. To compare the performance, Sadovo1 common wheat (*T. aestivum* L.) is used as a standard. Both wheat species have been grown on two nitrogen fertilization levels – 80 and 160 kg.ha^{-1} nitrogen. Phenological development of the plants was recorded at the onset of the main phenophase. Inter–phase period has been calculated (number of days). Grain yield (t ha^{-1}) is accounted indirectly by ¼ m^2 plot. The main structural elements of plants have been established. It has been found that phenological development stage of tillering occurs at the same time for both wheat species. Following the start of spring vegetation, common wheat enters a phase earlier than the Khorasan. Common wheat is a high–yielding Khorasan, that puts both proven wheat varieties in different groups.

Khorasan has high tiller appearance but it has a low productive tillering than common wheat. Kamut form lower grain in the spike and lighter grain per spike. Nitrogen fertilization significantly increased harvested grain in common wheat. In Khorasan wheat it has no significant impact on yield.

Key words: Khorasan, Kamut, wheat, yield, nitrogen fertilization

Khorasan wheat or Oriental wheat (*Triticum turanicum* Jakubz. also called *Triticum turgidum* ssp. turanicum) is an ancient tetraploid wheat species [Oliver et al., 2008]. Recent genetic evidence from DNA fingerprinting suggests that the variety is perhaps derived from a natural hybrid between *T. durum* Desf. and *T. polonicum* L., which would explain past difficulties in arriving at a certain classification [Khlestkina et al., 2006].

The exact origin of Khorasan wheat remains unknown. Described by John Percival [1921], this ancient grain likely originates from the Fertile Crescent and derives its common name from the historical province of Khorasan which included a large portion of northeastern Iran into Afghanistan and Central Asia to the river Oxus [Grausgruber et al., 2005]. Some Turkish scientists have suggested that it originated in Anatolia [Gökgöl, 1961]. In 1990 two farmers from Montana registered the protected cultivated turanicum variety QK–77 as the trademark Kamut® [Brester et al., 2009].

Khorasan wheat is used similarly as modern wheat. However, its grains are twice the size of modern wheat kernel. They contain more proteins, lipids, amino acids, vitamins and minerals than modern wheat. Khorasan wheat is well known for its smooth texture and its nutty, buttery flavor [Amal et al., 2012]. The grain has an amber color and a high vitreousness [Quinn, 2009].

The aim of this study is to establish some morphological and biological characteristics of Khorasan wheat (Kamut®), compared with common wheat, depending on the level of nitrogen fertilization. For this purpose, a three–year field experiment has been carried out at the experimental field of Department of Crop Science in Agricultural University – Plovdiv, Bulgaria.

To compare the performance, Sadovo1 common wheat (*T. aestivum* L.) is used as a standard. Both wheat species have been grown on two nitrogen fertilization levels – 80 and 160 kg.ha^{-1} nitrogen. Phenological development of the plants was recorded at the onset of the main phenophase. Inter–phase period has been calculated (number of days).

Grain yield (t ha^{-1}) is accounted indirectly by ¼ m^2 plot. The main structural elements of plants have been established: Plant height, cm; Number of tillers per plant; Number of spikes per plant; Productive tillers, %; Spike length, cm; Numbers of spikelets per spike; Numbers of grains per spike; Mass of grains per spike, g and Mass of glumes per spike, g.

To establish a statistically significant influence of the examined factors and differences between the tested variants was used analysis of variance.

Phenological development of both wheat species in this study during the three years of the investigation indicated as dates for the main phenological stages (Table 1). The different dates of sowing during the three years of the study are due to rainfall conditions and the ability to perform quality tillage and timely sowing. The sowing during of three years has been done later than the optimal period for the region (20 October). This is the reason crops to spring up at different times in each of the years, but both types of wheat germinate at the same time each year. Obviously germination depends on the meteorological conditions, but not on the genotype.

Late germination is the reason of entering the crops the tillering stage in December. Even though this stage of the development of winter cereal crops is influenced mainly by temperature conditions, Kamut enters the tillering stage between 4 and 6 days later than common wheat. The earliest tillering occurs during the first harvest year – between December 10 to 15, and later – during the third year of the study – between 26 to 30 December.

Table 1. Phenological development stages.

Species	Sowing	Germination	Tillering	Stem elongation	Spike emergence	Maturity
2010						
Wheat	28.10.2009	12.11.2009	10.12.2009	09.04.2010	28.04.2010	28.06.2010
Kamut			15.12.2009	15.04.2010	05.05.2010	01.07.2010
2011						
Wheat	04.11.2010	15.11.2010	14.12.2010	11.04.2011	02.05.2011	30.06.2011
Kamut			20.12.2010	18.04.2011	07.05.2011	02.07.2011
2012						
Wheat	01.11.2011	15.11.2011	26.12.2011	16.04.2012	05.05.2012	27.06.2012
Kamut			30.12.2011	22.04.2012	12.05.2012	30.06.2012

The beginning of the durable spring vegetation and the entering of the plants the phase of stem elongation occurs at different times in each of the species. In common wheat difference between the year with the early and later occurrence of the stage of stem elongation is 7 days (between 9 and 16 April), while Kamut – seven days (April 15 – 22). Similar to stage of stem elongation, the spike emergence in the common wheat occurs earlier (between April 28 and May 5) compared to Kamut, wherein the spike emergence was recorded between 5 to 12 May. The maturity occurs at different times for both types of wheat. The phase of full maturity in common wheat was registered 2 – 3 days earlier compared to Kamut.

In both species during the three years of study differences in the dates of entering the main stages of development of the crop are not registered, depending on the level of nitrogen fertilization, which gives grounds to consider that nitrogen fertilization does not affect phenological development of the wheat.

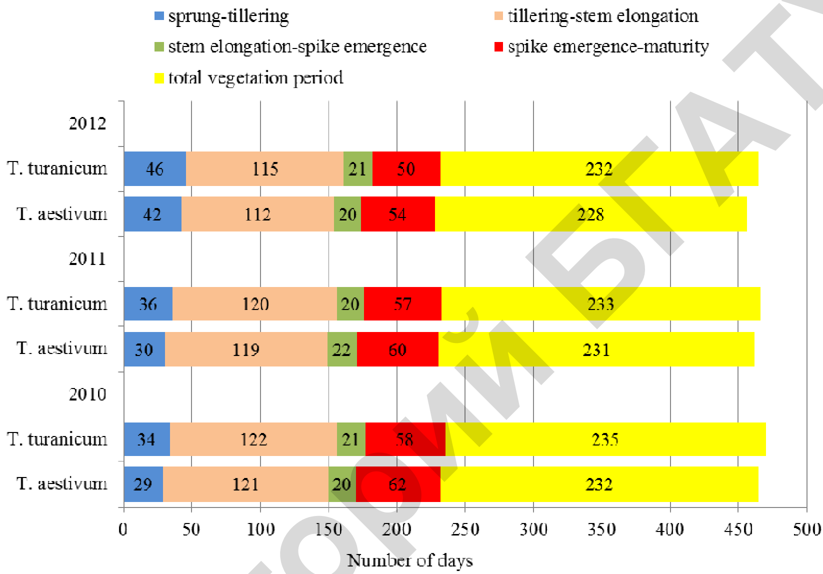

Figure 1. Inter–phase periods (number of days).

Different dates of entering the main stages of development are the reason of different lengths of inter–phase periods in both types of wheat (Fig. 1). Inter–phase period germination – tillering in Kamut lasts between 34–46 days and in common wheat is shorter – between 29–42 days depending on the year. During the three years of study the period between tillering and stem elongation is longer by 1–3 days at Khorasan to common wheat. The period between phase of stem elongation and spike emergence is shorter in einkorn – 20–21 days during the three harvest years, while in common wheat – between 20–22 days. Even though maturity occurs first in common wheat, interphase period spike emergence – maturity is shorter in Kamut – 50 days in year 2012 and 57 days in the second year of study. Differences in the duration of inter–phase periods in wheat species are the reason of the different lengths of vegetation from germination to maturity. The vegetation period of common wheat is between 228–232 days, while for the Khorasan wheat is longer an average of 3 days – between 232–235 days.

Table 2. Grain yield, t ha^{-1}

Species	N rate, kg ha^{-1}	Years			Average
		2010	2011	2012	
T. aestivum L.	80	4.532**	4.128**	3.265**	3.975**
	160	6.657***	6.053***	4.867***	5.859***
T. turanicum Jakubz.	80	2.524*	2.781*	2.084*	2.558*
	160	2.872*	3.061*	2.210*	2.684*
LSD 5%		*0.354*	*0.284*	*0.254*	*0.291*

*Values with the different symbols are statistically proven.

Grain yield of the tested species of wheat varies during three years of study, as in the three harvest years, common wheat variety Sadovo1 significantly exceed the yields obtained from Kamut (Table 2). Due to the very large differences in yields between the two species, the differences in the three years are statistically proven. In common wheat highest yields were obtained in the first harvesting year – an average of 5.595 t ha^{-1} for both fertilization rates, while einkorn yields are highest in the second year of study – 2.921 t ha^{-1}. The lowest yields in both species were obtained during the third harvest year.

Nitrogen fertilization increases the yield in both species, but during the three years of study and average for the period at Khorasan wheat the difference between the two levels of fertilization are smaller than the least significant difference (*LSD*). In common wheat during the three studied years and average for the three years higher fertilizer rate of 160 kg ha^{-1} nitrogen proved increases grain yield by an average of 1.884 t ha^{-1}.

Table 3. Structural elements of the crop.

Species	N rate, kg ha^{-1}	Plant heigh, cm	Number of tillers per plant	Number of spikes per plant	Productive tillers, %
T. aestivum L.	80	70.5*	2.8*	2.5*	89.3***
	160	88.6**	3.2*	2.6*	81.2**
T. turanicum Jakubz.	80	104.9***	3.6*	2.4*	66.6*
	160	110.1***	3.8*	2.5*	65.8*
LSD 5%		*14.8*	*1.4*	*0.4*	*3.1*

*Values with the different symbols are statistically proven.

The structural elements of the crop for the two species of wheat enable them to be compared, both in height and density (Table 3). Plant height in both species is drastically different. In Khorasan wheat the average height of the crop is 107.5 cm – proved higher by 27.9 cm the formation of sowing Sadovo1 – 79.6 cm. Similar to the results for yield, nitrogen fertilization has no proven change in the height of the plants in Kamut, while wheat variety Sadovo1the higher fertilizer rate leads to proven raising of the height of the crop to 18.1 cm. Overall species *Triticum turanicum* Jakubz. formed higher stem than common wheat.

Crop density, determined by the number of tillers per plant allows Khorasan wheat to be defined as more strongly tillering species compared to common wheat. For both species nitrogen fertilization has no proven change in the number of tillers per plant. Number of spikes per plant is a factor determining how many of formed tillers are productive. Even though Kamut differs as dramatically strong tiller species, spikes formed on one plant are almost as many as on the common wheat. This puts both species close to each other by this indicator, since the difference does not exceed the necessary least significant difference (*LSD*), which indicates that it is not statistically significant. This is the main reason for the big difference, for productive tillering, which is in favor of common wheat. Khorasan wheat has a low productive tillering for only about 65% of the generated tillers become productive, while Sadovo1 variety, despite the relatively small number of tillers per plant, over 80% of them form spikes. Nitrogen fertilization has no proven effect on productive tillers on Kamut, while on common wheat it increases productive tillers by 8.1%.

In addition to the structure of the crop, the structural elements of the spike are essential for the productive potential of wheat (Table 4). The length of the spike is higher in common wheat in comparison with Kamut by about 1.5 cm, so the difference of the spike in common wheat in comparison with Khorasan wheat may be considered to be statistically proven. Nitrogen fertilization did not significantly affect this feature in Kamut, while common wheat higher nitrogen rates lead to the formation of a longer spike. Although common wheat formed a longer spike, the number of spikelets per spike are on average 2 more in Khorasan wheat. In both wheat species nitrogen fertilization had no proven effect. In common wheat the number of grains per spike varies proven under the influence of nitrogen fertilization from 37.4 in fertilization with N_{80} to 39.6 in higher fertilization rates N_{160}. As Kamut forms less grains in spikelet, the number of grains per spike is similar to the number of spikelets. The mass of grain per spike in common wheat has been proven heavier about 0.5 g than in Khorasan wheat. In Kamut nitrogen fertilization had no proven effect on this feature, while on common wheat difference in the weight of the grain between the two fertilization rates has been proven statistically.

Table 4. Structural elements of the spike.

Species	N rate, kg ha^{-1}	Spike length, cm	Numbers of spikelets per spike	Numbers of grains per spike	Mass of grains per spike, g	Mass of glumes per spike, g
T. aestivum L.	80	9.4**	20.7*	37.4**	1.45**	0.04*
	160	10.5**	21.3*	39.6***	1.87***	0.05*
T. turanicum Jakubz.	80	8.2*	22.1**	33.1*	0.88*	0.20**
	160	8.7*	23.4**	34.2*	1.09*	0.22**
LSD 5%		*1.1*	*1.6*	*2.3*	*0,21*	*0.06*

*Values with the different symbols are statistically proven.

Typical of Khorasan wheat, with longer glumes and awn, causing to form heavier glumes (0.21 g). In common wheat weight of glumes is low, compared with Kamut. Nitrogen fertilization did not significantly affect this feature in both species of wheat.

Conclusions

In Khorasan wheat, vegetation period is longer by an average of 3 days, compared to the common wheat. The reason for this is the late entry in the main stages of development in Kamut and different lengths of inter–phase periods in both wheat species. Nitrogen fertilization does not affect phenological development of both types of wheat.

In common wheat grain yields are significantly higher than Khorasan wheat. The main reasons for this are that Kamut has higher tiller appearance but it has a lower productive tillering than common wheat. Khorasan wheat forms lower grain in the spike and lighter grain per spike.

Nitrogen fertilization significantly increased harvested grain in common wheat. In Kamut it has no significant impact on yield.

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УДК 631.158:331.102.2

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КАДРОВОЕ ОБЕСПЕЧЕНИЕ ИННОВАЦИОННОГО РАЗВИТИЯ СЕЛЬСКИХ ТЕРРИТОРИЙ

Распоряжением Правительства Российской Федерации от 2 февраля 2015 года N 151–р утверждена Стратегия устойчивого развития сельских территорий Российской Федерации на период до 2030 года.

В стратегии указано, что сельские территории Российской Федерации являются важнейшим ресурсом страны, значение которого стремительно растет в условиях углубляющейся глобализации при одновременном усилении значения природных и территориальных