

ROLE OF PHENOLOGICAL PERIODS IN GRAIN YIELD FORMATION OF SPRING WHEAT ACCESSIONS FROM DIFFERENT MATURITY GROUPS UNDER DRY STEPPE CONDITIONS OF NORTHERN KAZAKHSTAN

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Annotation. This study was conducted to evaluate the duration of the main phenological phases in spring soft wheat (*Triticum aestivum* L.) accessions belonging to different maturity groups and to determine their contribution to grain yield formation in the dry steppe zone of northern Kazakhstan. The research was conducted in 2021-2023 at the A.I. Barayev Scientific and Production Center for Grain Farming using a collection of 99 spring soft wheat accessions of various ecological and geographical origins. The accessions were divided into early-ripening, mid-season, and mid-late groups depending on the duration of the growing season. Phenological observations included recording the dates of germination, heading, and wax ripeness. Data were processed using analysis of variance (ANOVA), Tukey's multiple comparison test (HSD), and Pearson's correlation analysis. The results of studies between maturity groups for the duration of the overall growing season and the "seedling-to-heading" period were statistically significant, while the duration of the "heading-to-wax ripeness" period and average grain yield did not differ statistically significantly. The increase in the overall growing season was primarily due to an extension of the "seedling-to-heading" period. A positive correlation between the duration of the "seedling-to-heading" period and grain yield was established for early- and mid-late-ripening varieties. No statistically significant relationships were found in the mid-ripening group. Graphical analysis revealed the following varieties: Tyumenskaya 27, Zauralskaya Volna, Niva Priirtyshya, Start, L.654, and Stepnodar 90, which combine favorable phenological characteristics with high yield. The study results indicate that the germination-to-heading period is the main phenological component determining differences between maturity groups and can be considered an important breeding trait for increasing the adaptability and yield stability of spring soft wheat in northern Kazakhstan.

Keywords: spring soft wheat maturity groups, phenological phases, emergence-heading period, yield.

Introduction. Bread wheat (*Triticum aestivum* L.) provides a significant proportion of calories and protein consumed worldwide and therefore remains a key crop for global food security [1]. Maintaining stable wheat production has become increasingly challenging as climate change has altered temperature regimes, precipitation patterns, and the frequency of droughts and heat waves affecting many wheat-growing regions [2,3]. These environmental changes modify crop development, shorten critical growth stages, and can reduce grain yield, making adaptation to changing climatic conditions a major challenge in modern wheat breeding. For this reason, increasing attention is being paid to phenological adaptation, as the timing of developmental stages determines whether sensitive reproductive processes occur under favorable or stressful environmental conditions [4].

Phenological development in wheat results from complex interactions between genotype and environment and is primarily regulated by the vernalization (VRN), photoperiod (PPD) and

earliness per se (EPS) gene systems, which determine the duration of successive developmental stages and synchronize flowering with favorable environmental conditions [5]. Among the developmental phases, the emergence-heading (EH) period is considered particularly important because it determines the duration of vegetative growth, vegetative development, spike differentiation and the potential number of grains per unit area [6].

In contrast, the heading-maturation period (HWP) primarily involves grain filling and physiological maturation and is more dependent on environmental conditions during the reproductive stage. A longer period before flowering is associated with greater accumulation of spike biomass and an increase in the number of grains, which may contribute to increased grain yield under favorable growing conditions. However, under water-stressed conditions, earlier heading may provide an adaptive advantage, allowing plants to avoid drought at the end of the growing season [7]. These observations suggest that the influence of individual phenological phases on grain yield depends on the interaction between developmental characteristics and the environment.

Spring wheat in northern Kazakhstan is grown in highly variable weather conditions typical of a sharply continental climate. Significant temperature and precipitation fluctuations from year to year often expose crops to drought and heat stress during the reproductive development period, making stable grain production a constant challenge for breeders [8]. Therefore, improving adaptation through appropriate phenological development remains a top priority for regional breeding programs. Although many studies have examined the influence of environmental factor on wheat phenology, significantly less attention has been paid to the role of individual developmental periods in determining grain yield in specific maturity groups. This aspect remains understudied in the arid steppe conditions of northern Kazakhstan.

Previous studies conducted under the conditions of Northern Kazakhstan have primarily focused on the evaluation of agronomic and yield-related traits and the identification of promising breeding material using multivariate statistical approaches. However, the contribution of individual phenological phases to grain yield within different maturity groups has remained insufficiently investigated [9,10,11]. Therefore, the objective of the present study was to evaluate the duration of the emergence-heading, heading-maturity and total vegetation periods in spring wheat accessions representing different maturity groups and to determine their relationships with grain yield under the environmental conditions of Northern Kazakhstan.

Materials and Methods. Field experiments were conducted over three growing seasons (2021-2023) at the A.I. Barayev Scientific and Production Center for Grain Farming, Nauchnyy village, Akmola region, northern Kazakhstan. The experimental site is located in the dry steppe zone, which is the main spring wheat growing region in the country.

The study examined 99 accessions of spring soft wheat (*Triticum aestivum* L.) of various ecological and geographical origins. The collection was evaluated in accordance with the guidelines of the N.I. Vavilov Institute of Plant Genetic Resources (VIR) [12]. Sowing was carried out at the recommended time for the region using an SSFC-7 seeder. Each accession was grown in 2 m² plots with two replicates, according to the standard experimental design adopted in wheat breeding. Throughout the experiment, all accessions were cultivated using the same agricultural practices recommended for growing spring bread wheat in northern Kazakhstan. Grain was harvested at full maturity using a Wintersteiger combine.

Phenological observations were conducted throughout the growing season by recording the dates of emergence, heading, and wax maturity. Based on these observations, three development periods were calculated: emergence-heading (EH), heading-wax maturity (HW), and the full growing season (VP). For subsequent analysis, accessions were assigned to maturity groups based on the average length of the growing season over the three experimental years. Three maturity groups were identified: early-maturing (75-83 days), medium-maturing (84-86 days), and medium-late (≥ 87 days). For each accession, three-year mean values (2021–2023) were calculated for the duration of the emergence–heading (EH), heading–wax maturity (HW), and total vegetation period (VP), as well as for grain yield. These three-year mean values were subsequently used for comparisons among maturity groups.

Statistical analysis included descriptive statistics, one-way analysis of variance (ANOVA), Tukey's Honestly Significant Difference (HSD) test, and Pearson's correlation analysis. Mean values, standard deviations, and coefficients of variation were calculated for the evaluated traits within each maturity group. Differences among maturity groups were assessed using one-way ANOVA, followed by Tukey's HSD test for pairwise comparisons at $p < 0.05$. Pearson's correlation coefficients between the duration of phenological periods and grain yield were calculated separately for each maturity group. All analyses were performed in R version 4.5.2 using standard statistical functions available in the R environment [13].

Result and discussion. Phenological development is one of the principal characteristics distinguishing maturity groups in spring wheat. To obtain an initial overview of trait variation, the average value, standard deviations, and coefficients of variation were calculated for each maturity group. The descriptive statistics are presented in Table 1.

Table 1 – Descriptive statistics of phenological traits and grain yield

Trait	Statistic	Early-maturing	Medium - maturing	Medium-late
Vegetation period (VP), days	Mean	81.2	84.8	87.3
	SD	1.05	0.97	0.85
	CV, %	1.30	1.15	0.97
Emergence-heading (EH), days	Mean	39.3	42.6	44.4
	SD	2.31	2.28	2.19
	CV, %	5.87	5.36	4.94
Heading – wax maturity (HW), days	Mean	42.0	42.3	42.6
	SD	2.13	2.39	1.52
	CV, %	5.07	5.65	3.56
Grain yield, g/m ²	Mean	181.0	198.0	198.0
	SD	31.6	42.3	38.6
	CV, %	17.4	21.4	19.4

Descriptive statistics showed variation in phenological development among the maturity groups (Table 1). The total duration of the vegetation period (VP) increased from 81.2 days in early maturity accessions to 84.8 and 87.3 days in the medium and medium-late maturing groups, respectively. This pattern is largely explained by variations in the emergence – heading period (EH), which ranged from 39.3 to 44.4 days across the maturity groups. The duration of the heading –wax maturity period (HW) varied only slightly, ranging from 42.0 to 42.6 days.

Average yields across groups were 181.0 g/m² for early – maturing samples and 198.0 g/m² for medium and medium late maturity samples.

The coefficients of variation for phenological traits remained below 6%, indicating relatively low variability in developmental timing. In comparison, grain yield showed considerably greater variability, with CV values ranging from 17.4 to 21.4%. The results of the statistical analysis show that differences between maturity groups developed primarily during the emergence-heading period. However, the overall growing season gradually increased from early-maturing to medium-late maturing samples, while the reproductive phase remained remarkably similar across all groups. A similar pattern was observed for spring wheat grown in the continental conditions of the Northern Kazakhstan, where differences in the growing season develop primarily in the early stages of plant development (Lutchenko et al, 2022) [10]. Hyles et al (2020) [4] likewise emphasized that adaptation of wheat maturity is largely achieved through variation in developmental processes before heading. Therefore, the emergence – heading period appears to be principal phenological trait distinguishing the maturity groups evaluated in the present study.

While these descriptive statistics provide a clear overview of the observed variation, they do not indicate whether the differences among maturity groups are statistically significant. To verify this, the data were subjected to one way analysis of variance (ANOVA), and the results are presented in the Table 2.

Table 2 – One way ANOVA comparing phenological traits and grain yield among maturity groups

Trait	df (between group, residual)	F	p-value
Vegetation period (VP), days	2,96	313.2	<0.001
Emergence-heading (EH), days	2,96	43.55	<0.001
Heading – wax maturity (HW), days	2,96	0.60	0.551
Grain yield, g/m ²	2,96	2.50	0.088

One-way ANOVA revealed significant effects of maturity groups on the total vegetation period (VP) and emergence-heading period (EH) (Table 2). The largest variation among maturity groups was observed for the total vegetation period ($F=313.20$, $p<0.001$), followed by emergence-heading period ($F=43.55$, $p<0.001$). By contrast, neither the heading–wax maturity period (HW; $F = 0.60$, $p = 0.551$) nor grain yield ($F = 2.50$, $p = 0.088$) differed significantly among maturity groups. These results demonstrate that differences in maturity were associated mainly with development processes before heading rather than with the duration of grain filling.

The absence of significant differences in the heading–wax maturity period suggests that the extension of the total vegetation period resulted primarily from variation in pre-heading development. This agrees with the concept that adaptation of spring wheat maturity is achieved mainly through changes in pre-heading development, while the reproductive phase remains comparatively stable. Similar conclusions were reported by Villegas et al (2016) [14], who showed that grain filling duration is influenced predominantly by environmental conditions during reproductive growth and therefore exhibits less genetic variation than the period preceding heading. Under the dry-steppe conditions of Northern Kazakhstan, the present results indicate that differentiation among maturity groups is established largely before heading, whereas the duration of the heading–wax maturity period changes only slightly. Although ANOVA confirmed the presence of overall differences among the maturity groups, it does not identify which specific groups differ from one another. Therefore, multiple pairwise comparisons were performed using Tukey's Honestly Significant Difference (HSD) test, and the results are presented in Table 3.

Table 3 – Tukey's HSD multiple comparison test

Vegetation period

Comparison	Mean difference	Lower CI	Upper CI	p-value
Early-maturing	6.08	5.47	6.69	<0.001
Medium - maturing	3.65	3.10	4.19	<0.001
Medium-late	-2.43	-3.08	-1.77	<0.001

Emergence-heading (EH)

Comparison	Mean difference	Lower CI	Upper CI	p-value
Early-maturing	5.10	3.70	6.51	<0.001
Medium - maturing	3.37	2.12	4.63	<0.001
Medium-late	-1.73	-3.24	-0.22	0.021

Heading – wax maturity (HW)

Comparison	Mean difference	Lower CI	Upper CI	p-value
Early-maturing	0.59	-0.70	1.89	0.524
Medium - maturing	0.25	-0.92	1.41	0.869
Medium-late	-0.35	-1.74	1.05	0.826

Grain-yield

Comparison	Mean difference	Lower CI	Upper CI	p-value
Early-maturing	17.03	-5.67	39.72	0.180
Medium - maturing	16.20	-4.14	36.54	0.145
Medium-late	-0.83	-25.24	23.58	0.996

Tukey's HSD test showed that the total vegetation period (VP) differed significantly among all maturity groups (Table 3). The greatest difference was observed between the early- and medium

late – maturing accessions (6.08 days), whereas the medium - and medium late – maturing groups differed by only 2.43 days, although this difference remained statistically significant ($p < 0.001$).

A comparable trend was found for the emergence – heading period (EH). Early-maturing accessions reached heading significantly earlier than both the medium – and medium – late maturing groups. Although the difference between the latter two groups was relatively small (1.73 days), it was also statistically significant ($p = 0.021$).

No significant differences were detected for the heading – wax maturity period (HW) or grain yield ($p > 0.05$). Thus, the separation of the evaluated accessions into maturity groups was determined mainly by variation in the pre-heading development phase, whereas the duration of grain filling remained remarkably similar across all groups.

The results of Tukey’s test refine the ANOVA findings by showing that phenological differentiation followed a gradual rather than abrupt period. The medium-maturing group occupied an intermediate position between the early- and medium-late-maturing groups for both the total vegetation period and the emergence-heading period. Such a distribution suggests continuous variation in developmental timing rather than the presence of sharply defined maturity classes.

The lack of significant differences in the heading – wax maturity period further supports the conclusion that most of the variation developed before heading. Similar relationships have been reported in studies of spring wheat under continental climatic conditions, where the pre-heading period accounted for most of the variation in maturity, whereas the reproductive phase remained comparatively stable (Hyles et al., 2020, Morgounov et al., 2024) [4,15]. These observations indicate that breeding for different maturity groups under the conditions of Northern Kazakhstan relies primarily on modifying vegetative development rather than on extending the grain-filling period. Although Tukey’s test identified the maturity groups that differed significantly in phenological development, it does not explain whether these differences are associated with grain yield. To examine this relationship Pearson’s correlation analysis was performed separately for each maturity group. The results are present in Table 4. The relationship between phenological development and grain yield depended on the development characteristics of the assessed samples, as shown by the obtained correlation coefficients, which differed between groups according to ripening time (Table 4). A weak positive correlation ($r = 0.36$, $p = 0.001$) was found between the yield of early maturing grain varieties and the increase in the duration of the period from germination to heading (EH), while the period from heading to wax maturity (HW) was negatively correlated with productivity ($r = -0.46$, $p = 0.001$). No relationship was found between grain yield and the vegetation period (VP).

Table 4 – Pearson correlation coefficients between phenological traits and grain yield

Trait	Early - Maturing		Medium-maturing		Medium-late	
	r	p	r	p	r	p
VP – Yield	-0.09	0.559	0.13	0.477	0.36	0.103
EH – Yield	0.36	0.001	0.07	0.709	0.59	0.004
HW – Yield	-0.46	0.001	-0.02	0.895	-0.30	0.174

In the medium maturing group of samples, no significant correlations were found with any of the assessed phenological traits ($p > 0.05$), suggesting that differences in development time were not the primary factor influencing productivity in this group. For medium late season samples, grain yield was positively correlated with emergence – heading period ($r = 0.59$, $p = 0.004$), while no significant relationships were found for either the total growing season or the heading-to-wax maturity period. The emergence – heading period was the only phenological trait that consistently demonstrated a relationship with grain yield, although both the strength and direction of this relationship varied across maturity groups.

The results indicate that prolongation of vegetative development before heading may contribute to higher productivity in some maturity groups, but this response cannot be regarded as universal. Similar conclusions were reported by Gonzalez et al (2011) and Foulkes et al. (2011),

who demonstrated that moderate extension of the pre- anthesis period promote spike growth, floret survival and grain number under favorable environmental conditions [6,7]. At the same time, the absence of significant correlations in the medium maturing group suggests that variation in grain yield was influenced by additional factors beyond phenological duration alone.

Comparable observations were obtained in the KASIB spring wheat collection, where heading date was identified as an important adaptive trait associated with grain productivity (Morgounov et al., 2024) [15]. The present study extends these findings by showing that the contribution of the emergence – heading differs among maturity groups. Consequently, optimization of phenological development should be considered separately for each maturity group when selecting breeding material. To illustrate this relationship, the association between the emergence-heading period and grain yield was examined for individual accessions within each maturity group. Figure 1 presents the distribution of spring bread wheat accessions according to the duration of the emergence-heading period and mean grain yield within the different maturity groups.

Accessions with comparable phenological characteristics frequently differed in productivity, indicating that the length of the emergence-heading period alone was insufficient to explain grain yield variation. At the same time, several accessions consistently combined favorable developmental timing with high productivity and therefore represent promising breeding material. Tyumenskaya 27 and Zauralskaya Volna showed the best performance among early maturing accessions, whereas Niva Priirtyshya and Start were distinguished within the medium maturing group. In the medium – late group, L. 654 and Stepnodar 90 were characterized by both an extended emergence-heading period and grain yield, making them valuable candidates for breeding programs under the environmental conditions of Northern Kazakhstan.

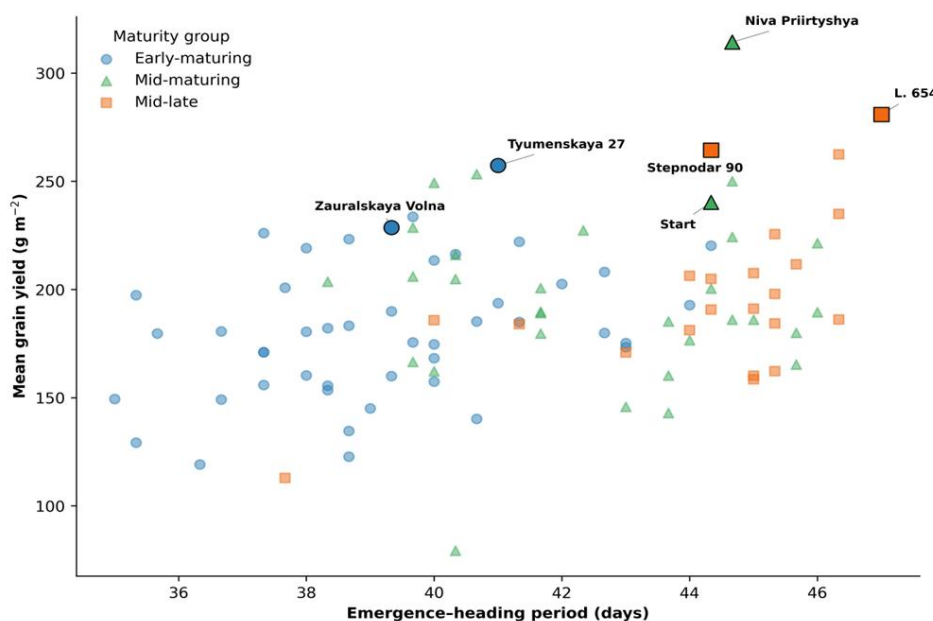


Figure 1 – Distribution of spring wheat genotypes according to the emergence – heading period and mean grain yield across maturity groups

The graphical evaluation provides additional evidence that phenological development should be considered together with grain productivity during the selection of breeding material. Although accessions with similar developmental timing were present within each maturity group, their grain yield differed considerably, emphasizing the importance of simultaneous evaluation of phenological and agronomic traits. These observations are consistent with our previous study of the same spring wheat collection, in which multivariate statistical analyses and selection indices identified several of these accessions as highly productive genotypes (Dolinny et al., 2025) [11]. The present results extend those findings by demonstrating that favorable agronomic performance is accompanied by advantageous phenological characteristics under the dry-steppe conditions of Northern Kazakhstan.

Conclusion. The present study evaluated the duration of the principal phenological phases and their relationships with grain yield in 99 spring bread wheat genotypes representing three maturity groups under the environmental conditions of Northern Kazakhstan. The obtained results demonstrated that phenological differentiation among maturity groups was determined primarily by variation in the duration of the emergence-heading period, whereas the heading-wax maturity period remained comparatively stable.

Despite significant differences in phenological development, mean grain yield did not differ among maturity groups, indicating that different maturity strategies may provide comparable productivity under the dry-steppe conditions of Northern Kazakhstan. Correlation analysis further showed that the influence of the emergence-heading period on grain yield was maturity-group dependent. Significant positive relationships were detected in the early- and medium-late maturity groups, whereas no significant association was observed among medium-maturing genotypes.

The graphical analysis identified Tyumenskaya 27, Zauralskaya Volna, Niva Priirtyshya, Start, L.654, and Stepnodar 90 as promising breeding material combining favorable phenological characteristics with high grain productivity. These accessions represent valuable parental material for breeding programs aimed at improving adaptation and yield stability under the environmental conditions of Northern Kazakhstan. Overall, the results indicate that optimization of the emergence-heading period, rather than extension of the total vegetation period, should be considered an important breeding target for the development of highly adapted and productive spring bread wheat cultivars.

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СОЛТҮСТІК ҚАЗАҚСТАННЫҢ ҚҰРҒАҚ ДАЛАЛЫ АЙМАҚ ЖАҒДАЙЫНДА ПІСУ ТОБЫ ӘРТҮРЛІ ЖАЗДЫҚ ЖҰМСАҚ БИДАЙ ҮЛГІЛЕРІНІҢ ӨНІМ ҚАЛЫПТАСТЫРУДАҒЫ ФАЗААРАЛЫҚ КЕЗЕҢДЕРІНІҢ РӨЛІ

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Андатпа. Осы зерттеудің мақсаты әртүрлі пісу топтарына жататын жаздық жұмсақ бидай (*Triticum aestivum* L.) үлгілерінің негізгі фенологиялық кезеңдерінің ұзақтығын зерттеу және олардың Солтүстік Қазақстанның құрғақ дала аймағы жағдайында астық өнімділігінің қалыптасуына қосатын үлесін анықтау болды. Зерттеулер 2021-2023 жылдары А.И Бараев атындағы Астық шаруашылығы ғылыми-өндірістік орталығында әртүрлі экологиялық-географиялық тектегі жаздық жұмсақ бидайдың 99 үлгісінен тұратын коллекцияны пайдалана отырып жүргізілді. Үлгілер вегетациялық кезеңінің ұзақтығына қарай ерте пісетін, орташа пісетін және орташа кеш пісетін топтарға бөлінді. Фенологиялық бақылаулар көктеу, масақтану және балауызданып пісу фазаларының басталу

мерзімдерін тіркеу арқылы жүргізілді. Алынған деректерді өңдеу үшін дисперсиялық талдау (ANOVA), Тьюкидің (HSD) көптік салыстыру критерий және Пирсонның корреляциялық талдауы қолданылды. Зерттеу нәтижесінде пісу топтары арасында жалпы вегетациялық кезеңнің және «көктеу – масақтану» кезеңінің ұзақтығы бойынша статистикалық тұрғыдан маңызды айырмашылықтар анықталды, ал «масақтану – балауызданып пісу» кезеңінің ұзақтығы мен орташа астық өнімділігі бойынша елеулі айырмашылық байқалмады. Жалпы вегетациялық кезеңнің ұзаруы негізінен «көктеу – масақтану» кезеңінің ұзаруымен байланысты болды. «Көктеу – масақтану» кезеңінің ұзақтығы мен астық өнімділігі арасында оң корреляциялық байланыс ерте пісетін және орташа кеш пісетін үлгілерде анықталды, ал орташа пісетін топта статистикалық тұрғыдан маңызды байланыстар табылған жоқ. Графикалық талдау нәтижесінде Тюменская 27, Зауральская Волна, Нива Прииртышья, Старт, Л. 654 және Степнодар 90 үлгілері қолайлы фенологиялық ерекшеліктері мен жоғары өнімділікті үйлестіретін перспективалы селекциялық материал ретінде ерекшеленді. Зерттеу нәтижелері «көктеу – масақтану» кезеңі пісу топтары арасындағы айырмашылықтарды айқындайтын негізгі фенологиялық компонент екенін және Солтүстік Қазақстан жағдайында жаздық жұмсақ бидайдың бейімделгіштігі мен өнімділік тұрақтылығын арттыруда маңызды селекциялық белгі ретінде қарастырылуы мүмкін екенін көрсетті.

Тірек сөздер: жаздық жұмсақ бидай, пісу топтары, фенологиялық кезеңдер, «көктеу – масақтану» кезеңі, астық өнімділігі.

РОЛЬ МЕЖФАЗНЫХ ПЕРИОДОВ В ФОРМИРОВАНИИ УРОЖАЙНОСТИ ОБРАЗЦОВ ЯРОВОЙ МЯГКОЙ ПШЕНИЦЫ РАЗЛИЧНЫХ ГРУПП СПЕЛОСТИ В УСЛОВИЯХ СУХОСТЕПНОЙ ЗОНЫ СЕВЕРНОГО КАЗАХСТАНА

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Аннотация. Данное исследование проводилось с целью изучения продолжительности основных фенологических фаз у образцов яровой мягкой пшеницы (*Triticum aestivum* L.), относящихся к различным группам спелости, и определение их вклада в формирование урожайности зерна в условиях сухостепной зоны Северного Казахстана. Исследования проводили в 2021-2023 гг. в Научно-производственном центре зернового хозяйства им. А.И. Бараева с использованием коллекции из 99 образцов яровой мягкой пшеницы различного эколого-географического происхождения. Образцы были распределены на раннеспелую, среднеспелую и среднепозднюю группы в зависимости от продолжительности вегетационного периода. Фенологические наблюдения включали фиксацию дат всходов, колошения и восковой спелости. Обработку данных проводили с использованием методов дисперсионного анализа (ANOVA), критерия множественных сравнений Тьюки (HSD) и корреляционного анализа Пирсона. Статистически значимыми оказались результаты исследований между группами спелости по продолжительности общего вегетационного периода и периода «всходы-колошение», тогда как продолжительность периода «колошение-восковая спелость» и средняя урожайность зерна статистически значимо не различались. Увеличение общей продолжительности вегетационного периода было обусловлено главным образом удлинением периода «всходы-колошение». Положительная корреляция между продолжительностью периода «всходы-колошение» и урожайностью зерна установлена у раннеспелых и среднепоздних образцов. Статистически значимых взаимосвязей в среднеспелой группе не выявлено. Графический анализ позволил выделить образцы Тюменская 27, Зауральская Волна, Нива Прииртышья, Старт, Л.654 и Степнодар 90, которые сочетают благоприятные фенологические характеристики с высокой урожайностью. Результаты исследования свидетельствуют о том, что период «всходы – колошение» является основным фенологическим компонентом, определяющим различия между группами спелости, и может рассматриваться как важный селекционный признак для повышения адаптивности и стабильности урожайности яровой мягкой пшеницы в условиях Северного Казахстана.

Ключевые слова: яровая мягкая пшеница, группы спелости, фенологические фазы, период всходы – колошение, урожайность.