RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
58 (2) 580-590, 2026
http://doi.org/10.54910/sabrao2026.58.2.9
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

# WINTER WHEAT PRODUCTIVITY BASED ON PREDECESSORS AND CULTIVATION TECHNOLOGY UNDER DRY CONDITIONS OF SOUTHERN KAZAKHSTAN

**D.A. SYDYK[1*], R.N. YERKUATOV[1*], SH.S. KOSKARAEVA[1], M.A. SYDYKOV[1], K.J. KULANBAY[2], and A.T. KAZIBAEVA[3]**

[1]South-Western Research Institute of Animal Husbandry and Plant Growing - LLP, Shymkent, Kazakhstan
[2]Kazakh National Agrarian Research University, Almaty, Kazakhstan
[3]Agrarian College, Turkestan Higher Multidisciplinary, Shymkent, Kazakhstan
*Corresponding author's email: sydyk.dosymbek@mail.ru, rahimjan_1996@mail.ru
Email addresses of co-authors: koskaraeva_sh@mail.ru, myrzabeksydykov3@gmail.com, k.kylanbai@mail.ru, shakomet@mail.ru

## SUMMARY

By planting winter wheat over an alfalfa layer in the favorably moistened crop season of 2024, the best productive and yield-related traits were remarkable with the traditional cultivation technology. Data showed better results for the number of plants (298.4 $m^2$), productive tillering (1.2), ear length (9.9 cm), grains per ear (28.3), and 1000-grain weight (44.4 g) compared with minimal soil cultivation and cutting the root collar of alfalfa at depths of 12–14 cm. The productive elements were 284.2 $m^2$, 1.1, 9.5 cm, 28.0, and 44.1 g, respectively. The winter wheat grain-yield formation was 3.4 and 3.22 t/ha, respectively. In the extremely dry year of 2025, the highest number of surviving plants per unit area was 251 $m^2$, with productive tillering (0.83), ear length (8.7 cm), the number of grains (17.9), and 1000-grain weight (28.4 g) obtained through direct sowing of winter wheat after safflower. In the dry year, the maximum productivity (1.5 t/ha) resulted from direct seeding.

**Keywords:** Winter wheat, safflower, alfalfa, traditional technology, minimum tillage, direct seeding, crop rotation, yield, mineral fertilizers, herbicide

**Key findings:** By planting winter wheat on the alfalfa layer using traditional technology, it obtained the highest grain yield (3.4 t/ha) compared with wheat sowing by direct seeding after safflower (3.05 t/ha).

Communicating Editor: Prof. Naqib Ullah Khan

Manuscript received: August 21, 2025; Accepted: October 25, 2025.

**Citation:** Sydyk DA, Yerkuatov RN, Koskaraeva SHS, Sydykov MA, Kulanbay KJ, Kazibaeva AT (2026). Winter wheat productivity based on predecessors and cultivation technology under dry conditions of Southern Kazakhstan. *SABRAO J. Breed. Genet. 58 (2) 580-590. http://doi.org/10.54910/sabrao2026.58.2.9*.

## INTRODUCTION

Soil fertility decrease causes variations in soil properties such as biological, chemical, physical, water, and air (Kurmanbaev and Sundet, 2023). Currently, resource-saving and moisture-saving technologies, such as Mini-Till and No-Till, have become widespread. Zero-tillage technology usage became worldwide in 2009 on an area of about 111 million hectares, and in 2014, the said figure reached 155 million hectares. In previous years, the area has expanded to more than 205 million hectares worldwide. Zero-technology is effective at protecting soil from degradation and erosion and reducing greenhouse gas emissions compared with traditional technology (Krauss *et al*., 2017). In the introduction of soil conservation technology, the first attempt was successful in the cultivation of grain crops in Northern Kazakhstan (Karabaev *et al*., 2005). According to FAO data, Kazakhstan entered the top 10 countries with the introduction of no-till technology in production with 1.5 million hectares during 2009, and in 2014, the said area increased to two million hectares (Karabaev *et al*., 2015). The mulching protective layer on the surface of the field begins to work when the crushed mass accumulates from 3 to 5 tons per hectare (Suleimenov, 2012).

Climate change, as characterized by warming and a constant increase in air temperature from 1.5 °C to 3.7 °C, has increased aridity compared with long-term data in Southeast Kazakhstan. Deviations in climate indicators, such as temperature and precipitation, significantly impacted the growth and development of cultivated crops, which eventually reduced crop yield (Suleimenova and Kalykov 2019a and b). The growth stimulator, microfertilizer, and biofertilizer can significantly improve yield-related traits and grain yield in winter wheat. Using growth stimulator via microfertilizer integration in the growth and development phases increased grain yield by 2.1 times in dry years and 2.0 times in moderately humid years, with a grain yield of 1.46 and 2.21 t/ha, respectively. By using biofertilizers, the grain yield was slightly lower (1.08 and 2.02 t/ha) than the unfertilized variant (Sydyk *et al*., 2022a and b).

The best control of cereal weeds occurred by using the herbicide Lastik Top with an adhesive surfactant, Trend, and working fluid consumption, controlling the wild barley, foxtail, wild oats, barnyard grass, and other weeds from 87.2% to 90.5% (Turganbayev *et al*., 2023). Treating seeds with the growth stimulator Vympel and microfertilizer Orakul with simultaneous fungicide dressing proved to be effective. Likewise, superior results emerged from early spring treatment at the tillering phase of winter wheat. Applying the stimulator Vympel and the microfertilizer Orakul multicomplex with simultaneous application of the herbicide Ballerina and the second treatment with the above-mentioned growth stimulators and microfertilizers during the flag leaf emergence in winter wheat was successful. The number of surviving plants was 286.1 $m^2$, with plant height at 88.9 cm, productive tillering at 1.15, grains per ear of 22.2, 1000-grain weight at 34.8 g, and grain yield of 2.21 t/ha (Sydyk *et al*., 2022a and b).

Resource-saving technology in cultivating winter wheat with direct seeding experiments began in 2006 in South Kazakhstan. Over these years, the highest winter wheat yield (4.38 t/ha) manifested with direct seeding under dryland conditions with an SZS-2.1 seeder against the background of mineral fertilizers ($P_{30}N_{50}$ kg/ha) and using systemic herbicide. The direct seeding of winter wheat over the years of research ensured a decrease in direct costs (by 28%–44%), fuel and lubricants (by 36.5%–38.6%), and cost price (by 24.3%–26.3%), along with an increase in net income (by 16.7%–31.5%) (Sydykov and Sydykov, 2015; Sydykov *et al.*, 2017).

With conditions of ordinary sierozem in the rich rainfed land of Southern Kazakhstan and with an improvement of nutritional conditions, the 1000-grain mass increased, with the highest values (37.5–37.2 g) obtained against the background of mineral fertilizers ($P_{45}N_{70}$ kg/ha), significantly exceeding the control variant (30.6–30.3 g). Over the years of experimentation using growth stimulators and microfertilizers, 1000-grain weight was 35.1–34.6 g, which notably exceeded the background without fertilizers (control) (Turebayeva and Sydykov, 2021).

## MATERIALS AND METHODS

### Experimental site and procedure

The related research on the development of resource-saving technology for leading field crops in short-rotation crop rotation began at the stationary experimental site of the South-Western Research Institute of Animal Husbandry and Plant Growing LLP, Shymkent, Kazakhstan. The study focus was the zoned cultivar 'Steklovidnaya-24' of winter wheat. Field experiments had the layout with a single-tier systematic placement of variants according to traditional technology, minimal soil cultivation, and direct sowing of winter wheat according to the experimental scheme in four-fold repetition on a 2.0-ha area. Experiments proceeded in the link of short-rotational crop rotation for rainfed lands of South Kazakhstan: a) winter wheat, b) safflower, c) winter wheat, and d) output field of perennial grasses (alfalfa).

### Observations and statistical analysis

During the vegetation period of crop plants, the following observations and their analyses focused on the determination of nutrient contents, phenological investigation on the winter wheat development, plant density, and the crop structure. All the recorded data’s analysis used the methodology of Dospekhov (1985).

## RESULTS AND DISCUSSION

The soil cover of the experimental site had the representation of southern ordinary sierozems, and according to their mechanical composition, these soils belong to medium-loamy and forest-like, comprising mainly coarse dust and clay fractions. The initial content of fertility elements of ordinary sierozem soils revealed the following characteristics. By cultivating winter wheat after safflower in the arable horizon (0–7.5 cm), the humus content was 2.13%, the mobile form of nitrate nitrogen was 5.5 mg/kg, phosphorus was 14.7 mg/kg, potassium was 347 mg/kg, and the pH was 8.61. However, with the depth of 15.0–22.5 cm, the above indicators were significantly lower (2.04%, 9.7 mg/kg, 7.7 mg/kg, 268 mg/kg, and pH at 8.76, respectively). The provision with mobile forms of nutrients was as follows: nitrogen was low, phosphorus was weak, and potassium was good. Similar soil fertility patterns in sierozem soils of Central Asia also gave reports of a decline in humus and available phosphorus with increasing depth (Karimov *et al*., 2021). Additionally, Liu and Chen (2020) confirmed alkaline pH values in sierozem soils often reduce phosphorus availability.

The results further revealed that in the 0–20 cm horizon, the bulk density of ordinary sierozems with traditional technology was 1.33 g/cm$^3$. However, with a depth of 20–40 cm, its value displayed a slight increase (1.35 g/cm$^3$). Particularly, low soil compaction rates were notable with no-till technology (1.30 and 1.32 g/cm$^3$ in 0–20 and 20–40 cm layers, respectively). This may be because leaving plant residues on the soil surface during direct sowing in the soil significantly reduces physical evaporation of moisture, thereby reducing soil compaction. With traditional cultivation technology, soil cultivation methods corresponded to the previously recommended technologies (deep plowing to a depth of 27 cm, thinning in two tracks to break up clods, and harrowing), and with minimal soil cultivation, pre-sowing cultivation of the experimental plot progressed by the BDT 7.0 unit to a depth of 8–12 cm, followed by winter wheat sowing. In the abovementioned variants, winter wheat sowing experiments transpired using a conventional grain seeder SZ 3.6, with a depth of 4–6 cm and a rate of 3.5 million viable grains. In the experimental third variant, direct sowing of winter wheat took place using a Turkish Sakalak seeder model ANZEK 28 without any soil cultivation at the rate of 3.5 million viable grains with the depth of 4–5 cm. Previous studies have also shown that no-till systems reduced the bulk density compared with conventional plowing due to crop residue retention, which improves soil structure and moisture retention (Huang *et al*., 2018).

In the autumn of 2023, the prevailing weather and climate conditions were favorable for the development of winter crops. In October, 59.3 mm of precipitation surfaced, wherein 31.5 mm was in the second 10-day period and 23.0 mm in the third 10-day period. Taking advantage of the favorable weather conditions, winter wheat sowing commenced on October 13, with full uniform shoots of winter wheat obtained on October 23. With direct sowing, the highest field germination (95.7%) was evident. Similarly, fairly better indicators of field germination were noticeable with the traditional technology (86.1%) and with minimal soil cultivation (88.3%). However, to some extent, these were less comparable to direct seeding. Several studies highlighted the critical importance of adequate autumn precipitation for winter wheat emergence, revealing sufficient soil moisture during sowing significantly enhances germination and establishment rates (Turebayeva *et al*., 2022).

Quite better precipitation materialized in April (67.8 mm), in which 41.9 mm of it fell in the first 10-day period of April, which also favored the intensive emergence of weeds and their rapid development. In the prevailing weather conditions of the reporting year, winter wheat crops sustained treatment with the herbicide Efir Premium S.E. at the rate of 0.5 L/ha. Treatments were against annual and some perennial dicotyledonous weeds in a mixture with Lastik Top, M.K.E., at the rate of 0.5 L/ha against annual cereal weeds. The herbicides showed the highest biological efficiency against dicotyledonous (85.3%–90.7%) and slightly lower against cereal (74.8%–83.6%) weeds. Reports confirmed similar levels of herbicide efficiency against broadleaf and cereal weeds in winter wheat fields were effective in combinations of selective herbicides, providing efficient control under favorable precipitation conditions (Balykin *et al*., 2021).

In the first 10-day period of April, the heavy precipitation and gradual warming of 12 °C, along with a fairly high reserve of productive moisture in the one-meter layer (0–100 cm) of 187 mm (Table 1), expected the appearance of winter wheat diseases. Considering the danger of damage and the disease spread, in the third 10-day period of April, the use of fungicide Kolosal Pro k.m.e. on winter wheat crops had the rate of 0.4 L/ha. As a result, the outbreak of yellow and stem rust, septoria leaf spot, powdery mildew, and helminthosporium spot succeeded in their prevention. Subsequently, winter wheat developed more intensively, and at the beginning of the second 10-day period of May, the heading phase began. In winter wheat, the grain filling took place at an optimal air temperature of 18.1 °C with 28.7 mm of precipitation. In total, 77.2 mm of precipitation was evident in May in a continuous and heavy rainfall, which was 1.4 times higher than the long-term average with an optimal temperature background (Figure 1). Oliver *et al*. (2018) observed the timely fungicide application effectively controlled rusts and leaf spots under moist spring conditions. Moreover, their findings confirmed that favorable temperature and rainfall in May contribute to stable grain filling.

In winter wheat, after placing them on a layer of 3-year-old alfalfa, the formation of productivity indicators was higher than its cultivation after safflower. The best productivity indicators appeared with traditional technology (298.4 $m^2$, 1.2, 9.9 cm, 28.3, and 44.4 g); rather high indicators of productive elements were evident with minimal soil cultivation with cutting the root collar of alfalfa to a depth of 12–14 cm (284.2 $m^2$, 1.1, 9.5 cm, 28.0, and 44.1 g, respectively). However, comparatively worse indicators occurred with direct seeding (277.7 $m^2$, 0.87, 8.9 cm, 23.1, 40.0, and 38.0 g, respectively). In the link of fruit-changing crop rotation and by placing winter wheat after safflower and without any soil treatment, the best productive indicators resulted from direct seeding in winter wheat. With direct seeding, the number of surviving plants before harvesting was 289.0 $m^2$, with the average productive bushiness at

**Table 1.** The productive moisture reserves under dryland conditions in winter wheat crops during 2024–2025.

| Sampling time frames | Moisture reserves, mm | | | | | |
|---|---|---|---|---|---|---|
| | 0-20 | | 0-50 | | 0-100 | |
| | 2024 | 2025 | 2024 | 2025 | 2024 | 2025 |
| 08.03 | 43 | 29 | 99 | 92 | 189 | 186 |
| 18.03 | 41 | 23 | 99 | 80 | 186 | 102 |
| 28.03 | 37 | 15 | 93 | 40 | 196 | 83 |
| 08.04 | 35 | 12 | 90 | 33 | 187 | 69 |
| 18.04 | 31 | 8 | 87 | 28 | 158 | 62 |
| 28.04 | 25 | 6 | 78 | 21 | 141 | 53 |
| 08.05 | 29 | 1.5 | 60 | 13 | 128 | 48 |
| 18.05 | 28 | 1.5 | 57 | 11 | 110 | 45 |
| 28.05 | 24 | 1 | 48 | 9 | 98 | 43 |
| 08.06 | 7 | 2 | 23 | 10 | 58 | 44 |
| 18.06 | 6 | 1 | 20 | 6 | 40 | 33 |
| 28.06 | 4 | - | 17 | - | 30 | - |

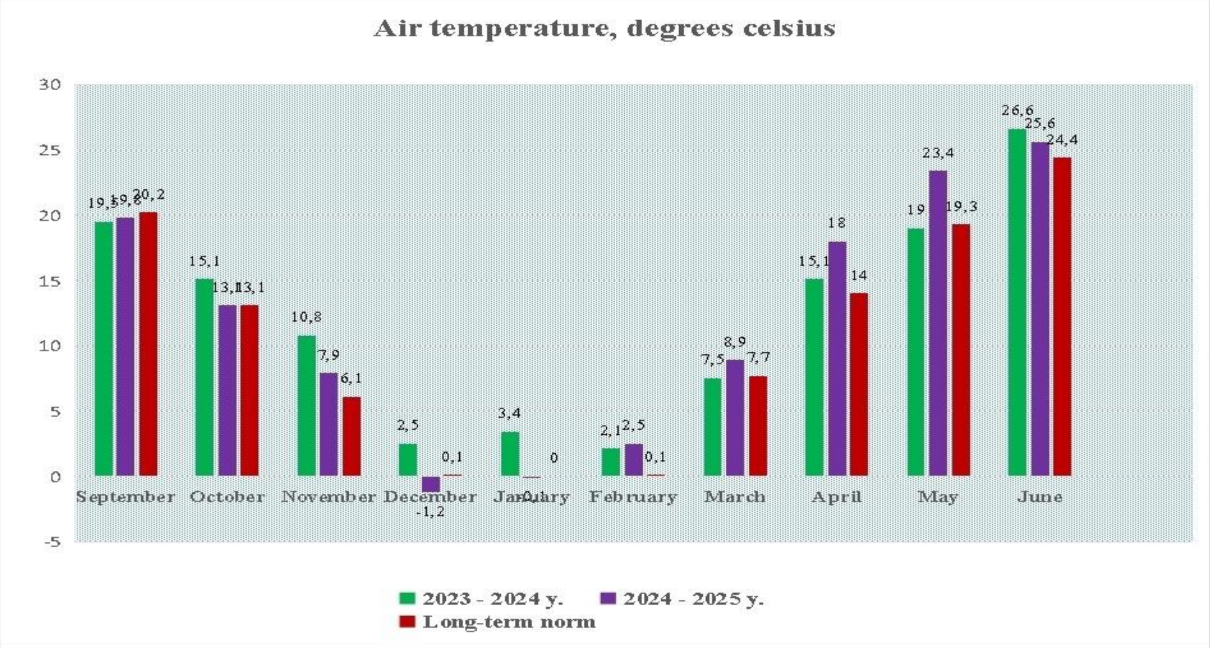

**Figure 1.** Air temperature indicators for winter wheat crops in the observation area according to the Shymkent-Agro weather station, 2023–2025.

1.15, ear length at 9.3 cm, grains per ear at 26.8, and 1000-grain weight at 42.8 g (Table 2). Smith *et al*. (2019) also reported legumes, such as alfalfa, significantly improve the subsequent wheat productivity due to enhanced soil fertility and residual nitrogen benefits. Additionally, Chen and Li's (2021) findings revealed minimal tillage practices can maintain competitive yield levels compared with conventional tillage and improve soil structure.

In 2024, the highest grain yield of winter wheat (3.4 t/ha) resulted from the traditional technology of cultivation on a 3-year-old alfalfa layer. With minimal soil cultivation by cutting the root collar of 3-year-

**Table 2.** Formation of productive elements of winter wheat yield based on predecessors and soil cultivation technology during 2024–2025.

| Predecessor | Experience options | Number of plants before harvesting m$^2$ | Plant height (cm) | Productive bushiness | Ear length (cm) | Grains ear$^{-1}$ | Grain weight ear$^{-1}$ (g) | 1000-grain weight (g) |
|---|---|---|---|---|---|---|---|---|
| 2024 year | | | | | | | | |
| Alfalfa layer | Traditional technology | 278.4 | 96.8 | 1,2 | 9.9 | 28.3 | 1,2 | 44.4 |
| | Minimal processing | 284.2 | 95.5 | 1,1 | 9.5 | 28.0 | 1.15 | 44.1 |
| | Direct seeding | 277.7 | 98.4 | 0.87 | 8.9 | 23.1 | 0.9 | 30.0 |
| Safflower | Traditional technology | 251.2 | 92.7 | 1.0 | 9.0 | 24.0 | 0.9 | 42.3 |
| | Minimal processing | 266.1 | 91.2 | 1.0 | 8.9 | 23.9 | 1.0 | 41.9 |
| | Direct seeding | 289.0 | 90.7 | 1.15 | 9.3 | 26.8 | 1.08 | 42.8 |
| 2025 year | | | | | | | | |
| Safflower | Traditional technology | 244.0 | 69.9 | 0.80 | 8.6 | 17.8 | 0.67 | 28.2 |
| | Minimal processing | 218,0 | 69.0 | 0.72 | 8.3 | 17.3 | 0.70 | 27.3 |
| | Direct seeding | 251.0 | 73.9 | 0.83 | 8.7 | 17.9 | 0.86 | 28.4 |
| Winter wheat | Traditional technology | 186.0 | 68.8 | 0.70 | 8.2 | 16.9 | 0.67 | 26.7 |
| | Minimal processing | 192.1 | 66.3 | 0.69 | 8.2 | 17.0 | 0.68 | 26.6 |
| | Direct seeding | 226.0 | 72.5 | 0.72 | 8.6 | 17.2 | 0.71 | 27.1 |

**Table 3.** Winter wheat grain yield based on predecessors and soil cultivation methods during 2024–2025.

| Predecessor | Experience options | Average grain yield (t/ha) |
|---|---|---|
| 2024 (wet year) | | |
| Alfalfa layer | traditional technology | 34.0 |
| | minimal processing | 32.2 |
| | direct seeding | 22.1 |
| LED$_{05}$ - 6.29 | | |
| Safflower | traditional technology | 28.1 |
| | minimal processing | 28.9 |
| | direct seeding | 30.5 |
| LED$_{0.05}$ | | 2.86 |
| 2025 (an extremely dry year) | | |
| Safflower | traditional technology | 14.3 |
| | minimal processing | 13.7 |
| | direct seeding | 15.0 |
| LED$_{0.05}$ | | 0.88 |
| Winter wheat | traditional technology | 13.1 |
| | minimal processing | 12.2 |
| | direct seeding | 13.8 |
| LED$_{0.05}$ | | 0.76 |

old alfalfa to a depth of 12–14 cm, the grain yield was 3.22 t/ha. Under dryland farming conditions, cutting the root collar of alfalfa in usually wet years happens at the end of May and the beginning of June. In this case, the cut root collar of alfalfa dries out completely over the summer and loses the ability to regrow. Direct sowing of winter wheat on the alfalfa layer resulted in the lowest grain yields (2.21 t/ha), which was 1.19 t/ha lower than the traditional cultivation technology (Table 3). By sowing winter wheat after safflower, the highest grain yield (3.05 t/ha) prevailed with direct seeding, and with traditional technology and minimal soil cultivation, the grain yield was slightly lower (2.81 and 2.89 t/ha, respectively) and was 0.24 and 0.16 t/ha lower than direct seeding. The results revealed that in winter wheat sowing after safflower, the best productive indicators and grain yield were successful with direct sowing (3.05 t/ha), and by cultivating winter wheat on a layer of alfalfa, the highest grain yield (3.4 t/ha) emerged with traditional technology. Mukhitdinov *et al*.'s (2020) findings showed alfalfa as a preceding crop enhances wheat yield due to improved soil fertility and moisture retention. Similarly, Johnson and Arslan (2019) highlighted direct seeding after oilseed crops can provide competitive yields under dryland farming.

For the year 2024, in the first and second 10-day periods of October, the precipitation was 39.9 mm. In all the studied variants, the agrotechnology corresponded to the experimental scheme, and, due to the better moisture content in the arable horizon, the processing quality was good. In autumn (October), the precipitation was 84.3 mm, which was 2.2 times more than the long-term norm (38 mm). For October, the thermal regime of the air was 13.1 °C, which was at par with the norm. However, due to the sufficient precipitation and heat, the winter wheat shoots were intense, and, by the end of October, the uniform full shoots manifested. At the beginning of April 2025, there were 14.7 mm of rain, which contributed to intensive growth in the initial period of stem formation. But in April, the atmospheric precipitation was 14.8 mm, with a monthly norm of 74.0 mm, which was five times lower than the optimal value. From April 1st, the high air temperature was prevalent, and the average monthly indicator was +18.0 °C, which was +4.0 °C higher than the long-term norm. The reserves of productive moisture in the meter-thick soil layer also decreased to 53 mm (Figure 2). Pu *et al*. (2020) reported that spring drought under elevated temperatures leads to a marked reduction in soil moisture reserves and negatively affects winter wheat development.

In the first 10-day period of May, a sharp rise in air temperature (+23.5 °C) was noticeable, which was +5.8 °C higher than the long-term average, contributing to the friendly heading in winter wheat in May. Thus, by placing winter wheat after safflower using traditional technology and minimal soil cultivation, the heading phase cropped up on May 03, 2025, and with direct sowing on April 30, 2025. High thermal air conditions were also evident in the second 10-day period of May at 24.6 °C, and the daytime temperature reached 38 °C–40 °C, which was uncharacteristic for this month. Under the current hot climate conditions, milk ripeness of winter wheat with direct sowing was notable on May 16–18, 2025, and with traditional technology on May 19–20, 2025. By analyzing the maturation of winter wheat grains, wax ripeness occurred in early June and full ripeness in the middle of the specified month. This was probably due to the lack of effective precipitation in May (7.6 mm) with high air temperature (23.4 °C), which was +4.1 °C higher than the perennial norm (Figure 1). Asseng *et al*.'s (2015) findings demonstrated that heat stress during heading and grain filling significantly shortens phenological stages and reduces the ripening duration.

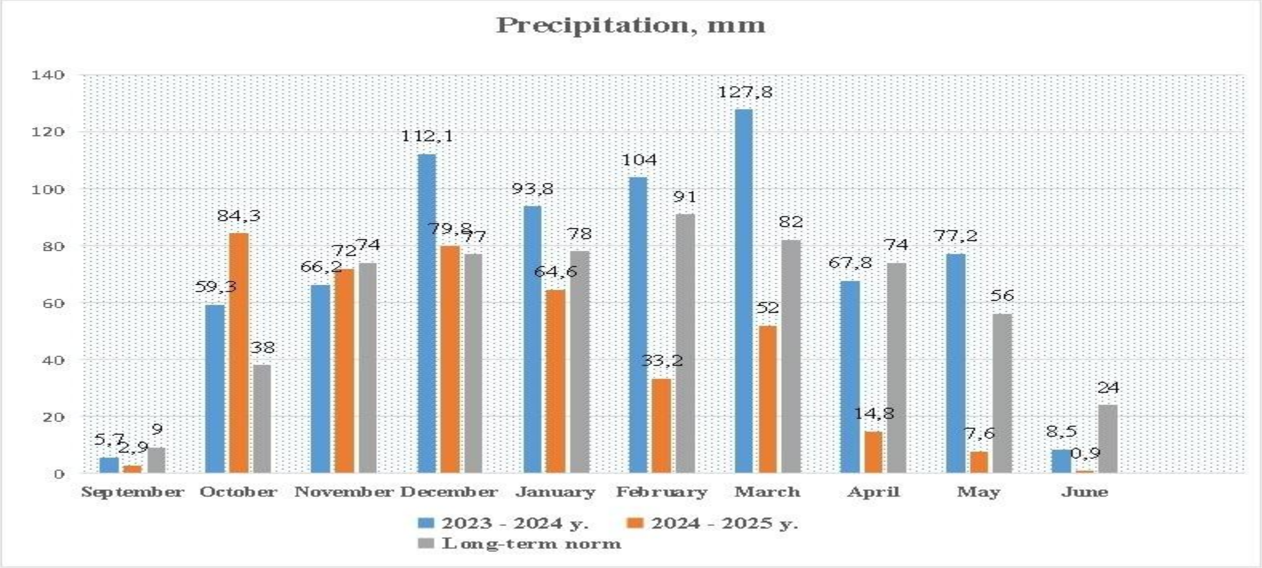

**Figure 2.** Atmospheric precipitation during the growing season of winter wheat in the observation area according to the Shymkent-Agro meteorological station, 2023–2025.

Under the current conditions of dry, hot climate in 2025, the best formation of productive elements appeared by placing winter wheat after safflower with direct seeding. Thus, it achieved the most number of surviving plants per unit area (251 $m^2$), with productive tillering (0.83), ear length (8.7 cm), grains per ear (17.9), and 1000-grain weight (28.4 g) in direct seeding of winter wheat after safflower. By growing winter wheat as a second crop after winter wheat, the productive indicators were significantly worse than the variant after safflower placement. Thus, with the traditional cultivation technology, the number of surviving plants was 186.0 $m^2$, with productive tillering (0.70), ear length (8.2 cm), grains per ear (16.9), and 1000-grain weight (26.7 g). A similar pattern of productive elements resulted in the variant by minimizing soil cultivation with slightly worse parameters. Tokbergenov *et al*. (2020) mentioned that placing wheat after oilseed crops, such as safflower, enhances productive tillering and grain weight due to improved nutrient availability and reduced soil fatigue.

By placing winter wheat with direct seeding, satisfactory formation of the productive indicators prevailed. Thus, with direct seeding, the plant height was 72.5 cm, the surviving plants were 226 $m^2$, with productive tillering (0.72), ear length (8.6 cm), grains per ear (17.2), and 1000-grain weight (27.1 g). With direct seeding of winter wheat, plant residues of the previous crop (safflower and winter wheat) entailed preservation on the soil surface, which reduces direct solar insolation with a decrease in physical evaporation of moisture from the soil. These also protected the soil surface from excessive heating, which favorably affects the formation of productive elements in winter wheat. In the extremely dry year of 2025, when winter wheat planting occurred after safflower, its highest productivity (1.5 t/ha) surfaced with direct seeding. However, in the variant with traditional technology and minimal soil cultivation, the grain yield indicators were slightly lower (1.43 and 1.37 t/ha, respectively) and were 0.07 and 0.13 t/ha lower than direct seeding (Table 2). Similar positive effects of residue retention on soil moisture conservation and wheat productivity under no-till were contents in past studies (Gozubuyuk *et al*., 2021).

Under semi-provided dryland conditions, by sowing winter wheat after safflower, the creation of promising productive indicators and grain yield (1.5 t/ha) were valid with direct sowing. However, by cultivating winter wheat as a second crop after winter wheat, a satisfactory grain yield (1.38 t/ha) was distinct with direct sowing (Table 3). Summarizing the above, the effect of global warming was obvious on crops every year. Therefore, the development of soil-resource-saving cultivation technology considering the regional characteristics and their improvement with the biological properties of studied crops in the link of crop rotation is a priority area of agricultural research.

According to the economic evaluation for 2024–2025, the application of resource-saving technologies in winter wheat cultivation significantly improved production efficiency. The highest net income and profitability resulted under direct seeding—approximately USD 180/ha and 15.9**%**, respectively. This was due to reduced fuel consumption, lower labor costs, and improved soil moisture retention. Minimum tillage also showed stable economic indicators (USD 130/ha net income; 9.8% profitability), while traditional plowing proved less cost-effective because of higher energy and material expenditures. These results confirm the adaptive use of direct seeding and minimum tillage is an economically viable and sustainable approach for agricultural enterprises in Southern Kazakhstan.

Production trials of resource-saving winter wheat cultivation technologies conducted at the "Ush Bastau" Production Cooperative in 2024–2025 confirmed their extreme efficiency and practical applicability. The average grain yield under direct seeding after safflower reached 2.89 t/ha in 2024 and 1.43 t/ha in 2025, exceeding the yields obtained under traditional tillage by 0.32–0.17 t/ha. The use of direct seeding reduced energy consumption and improved soil moisture conservation, which is especially crucial under the arid conditions of Southern Kazakhstan. The introduction of this technology into production practices contributes to strengthening the sustainability of grain farming and enhancing the adaptation of agriculture to climate change.

## CONCLUSIONS

In the favorable year of 2024, by sowing winter wheat after safflower, the formation of the best productive indicators and grain yield (3.05 t/ha) was successful with direct sowing. However, by cultivating winter wheat on the alfalfa layer, the best productive elements with the production of the highest grain yield (3.4 t/ha) emerged with the traditional technology. In the extremely dry year of 2025, by planting winter wheat after safflower, the obtained maximum productivity (1.5 t/ha) occurred in direct seeding. In the variant with traditional technology and minimal soil cultivation, the grain yield indicators were slightly lower than direct seeding, amounting to 1.43 and 1.37 t/ha, respectively, which were 0.07 and 0.13 t/ha lower than direct seeding.

## ACKNOWLEDGMENTS

This work proceeded within the framework of the program-targeted financing of the Ministry of Agriculture of the Republic of Kazakhstan under the scientific and technical program "Develop and implement sustainable farming systems for profitable production of agricultural products in a changing climate for various soil and climatic zones of Kazakhstan" (STP program code BR22885719) for 2024–2026.

## REFERENCES

Asseng S, Ewert F, Martre P, Rötter RP, Lobell DB, Cammarano D, Kimball BA (2015). Rising temperatures reduce global wheat production. *Nat. Climate Change* 5(2): 143–147.

Balykin M, Klyushin P, Shchukin V, Zakharov A (2021). Effectiveness of herbicides in winter wheat crops under varying weather conditions. *Agron. Res.* 19(2): 123–132. https://doi.org/10.15159/AR.21.048.

Chen Y, Li X (2021). Comparative performance of conventional, reduced, and no-till systems on wheat yield and soil quality. *Soil Tillage Res*. 206: 104838.

Dospekhov BA (1985). Methods of Field Experiment (in Russian). Moscow: Agropromizdat.

Gozubuyuk Z, Karaca M, Unlu M (2021). Effects of residue management and conservation tillage on soil water use and wheat yield under semi-arid conditions. *Soil Tillage Res*. 212: 105065.

Huang Y, Ren W, Wang L, Hui D, Grove JH, Yang X, Tao B, Goff B (2018). Greenhouse emissions gas and crop yield in no-tillage systems: A meta-analysis. *Agric. Ecosyst. Environ*. 268: 144–153. https://doi.org/10.1016/j.agee.2018.09.002.

Johnson P, Arslan A (2019). Impact of conservation tillage and oilseed crop rotation on wheat yield stability under rainfed conditions. *Field Crops Res.* 236: 45–53.

Karabaev M, Vasko I, Matyushkov M, Bektemirov A, Kenzhebekov A, Bakhman T, Friedrich T, Makus L, Morgunov A, Darinov A, Sagimbaev M, Suraev V, Cherezdanov V, Rodionov A, Wall P (2005). No-till and direct seeding technologies for grain crops in Northern Kazakhstan. Almaty Astana, pp. 64.

Karabaev M, Wall P, Sayre K, Zhapayev R, Akhmetova A, Zelenskiy Yu, Fileccia T, Friedrich T, Guadagni M, Morgounov A, Braun HJ (2015). Adoption, advancement, and impact of conservation agriculture in Kazakhstan. Proceed. 9th Int. Wheat Conf., Sydney. pp. 57.

Karimov A, Yuldashev T, Mavlyanov D (2021). Soil fertility dynamics of irrigated sierozem soils under crop rotation. *Eur. Soil Sci.* 54(3): 399–408. https://doi.org/10.1134/S1064229321030050.

Krauss M, Ruser R, Muller T, Hansen S, Mader P, Gattinger A (2017). Impact of reduced tillage on greenhouse gas emissions and soil carbon stocks in an organic grass-clover ley - winter wheat cropping sequence. *Agric. Ecosyst. Environ*. 239: 324–333. https://doi.org/10.1016/j.agee.2017.01.029.

Kurmanbaev AA, Sundet TR (2023). The concept of soil health and modern indicators of soil health. *Soil Sci. Agrochem.* 2: 91–106. https://doi.org/10.51886/1999-740X_2023_2_91.

Liu Y, Chen H (2020). Nutrient availability and pH interactions in arid zone soils. *Soil Tillage Res.* 196: 104478. https://doi.org/10.1016/j.still.2019.104478.

Mukhitdinov RM, Karimova ZA, Suleimenov M (2020). Effect of legume precursors on the productivity of winter wheat in arid regions of Central Asia. *Eurasian J. Soil Sci.* 9(2): 102–110.

Oliver RP, Hewitt HG, Brent KJ (2018). Fungicides in crop protection. 2nd Edition. CAB International, Wallingford, UK. https://doi.org/10.1079/9781780641669.0000.

Pu B, Zhang X, Li J (2020). Response of soil water in a winter wheat field to precipitation and temperature in semi-arid regions. *Agronomy* 10(11): 1710.

Smith J, Brown P, Evans R (2019). Legume-based rotations and their impact on wheat productivity and soil fertility in dryland systems. *Field Crops Res.* 231: 30–38.

Suleimenov MK (2012). On terms in agriculture and plant growing. *Agrarian Sector* 3(12): 36–40.

Suleimenova NSh, Kalykov DB (2019a). Climate change and the agro-industrial complex of the Almaty region. *Res. Results* 3(83): 252–256. https://doi.org/10.37884/3-83-2019.

Suleimenova NS, Kalykov DB (2019b). The Impact of climate change on the functioning of the AIC in Southeast Kazakhstan. *Res. Results* 2(82): 226–279. https://doi.org/10.37884/2-82-2019.

Sydyk DA, Kazybaeva AT, Erkuatov RN (2022a). Winter wheat productivity depending on fertilizer application in the zone of provided rainfed land in Southern Kazakhstan. *Bull. Korkyt Ata Kyzylorda Uni.* 3(62): 16–32. https://doi.org/10.52081/bkaku.2022.v62.i3.077.

Sydyk DA, Kazybaeva AT, Turganbaev NO (2022b). The influence of growth stimulants, biofertilizers and microfertilizers on the formation of productive elements of winter wheat in dryland conditions in the south of Kazakhstan. *Bull. Korkyt Ata Kyzylorda Uni.* 4(63): 58–79. https://doi.org/10.52081/bkaku.2022.v63.i4.131.

Sydykov MA, Sydykov DA (2015). Direct sowing of winter wheat on rainfed lands of southern Kazakhstan - Global climate change and biodiversity. Almaty. pp. 177-182.

Sydykov MA, Tastanbekova GR, Sydykov DA, Duisenova MU (2017). Formation of productive elements of winter wheat with direct seeding depending on the nutrition background on rainfed sierozems of southern Kazakhstan. Collection of scientific papers Agrarian Science - Agricultural Production of the Southwestern region of Kazakhstan. *Shymkent* 2: 211–217.

Tokbergenov T, Amanzholov A, Nurbekov A (2020). Influence of oilseed predecessors on winter wheat productivity in arid farming systems of Kazakhstan. *Eurasian J. Agric. Res*. 18(4): 55–63.

Turebayeva S, Zhapparova A, Yerkin A, Aisakulova K, Yesseyeva G, Bissembayev A, Saljnikov E (2022). Productivity of rainfed winter wheat with direct sowing and economic efficiency of diversified fertilization in arid region of South Kazakhstan. *Agronomy* 12: 111. https://doi.org/10.3390/agronomy12010111.

Turebayeva SD, Sydykov MA (2021). The impact of prevailing weather conditions on the growth and development of winter wheat during direct sowing in the South Kazakhstan region. *Sci. Edu.* 2(63): 32–41.

Turganbayev NO, Sydik DA, Kenenbayev SB, Sydykov MA, Kazybayeva AT (2023). Optimization of winter wheat nutrition with zero tillage technology in the rainfed zones of Southern Kazakhstan. *SABRAO J. Breed. Genet*. 55(5): 1–11. http://doi.org/10.54910/sabrao2023.55.5.