ISSN: 2707-1146
e-ISSN: 2709-4189

DOI: https://doi.org/10.36719/2707-1146/55/54-63

Turan Ahmadov
Azerbaijan State Agrarian University
https://orcid.org/0009-0007-5054-3811
turan.ahmadov@azsf.az
Gulnara Abbasova
Azerbaijan State Agrarian University
https://orcid.org/0009-0005-8110-7276
gulnara.abbasova@adau.edu.az
Elnara Nazaraliyeva
Azerbaijan State Agrarian University
https://orcid.org/0000-0001-7484-1791
elnara.nazaraliyeva@adau.edu.az

Determination of the Sowing Date of Summer Plantings

Abstract

The importance of soil temperature and its impact on planting history.

Soil temperature is one of the main factors for plant germination, root system development and overall productivity. Each plant requires a certain temperature range to germinate. When optimal temperature conditions are created, seeds germinate faster, plants develop vigorously, and yields increase. Correct measurement and analysis of soil temperature plays an important role in planning the planting process. For this purpose, thermometers and special sensors are used. The depth of measurement should correspond to the level at which the seed is planted. For example, for grain crops, temperature indicators at a depth of 5-10 cm should be taken into account.

Soil temperature directly affects the planting date. Three main temperature levels are determined for planting: minimal temperature – the lowest threshold required for the plant to begin germination, optimal temperature – ideal conditions for maximum yield and rapid germination, high temperature – can reduce yield and slow down plant development. The planting date also affects the harvesting process. (AZERTAC G. 2023). When sowing at the right time, the harvest has optimal humidity during harvesting, the risks of drying out and decay are reduced, and effective management of the technique becomes possible. Thus, careful monitoring of soil temperature and choosing a suitable planting strategy increases the overall productivity of the farm and prevents crop losses.

Keywords: *soil temperature, sowing date, yield, germination process, optimal conditions, agrotechnical measures, corn, sugar beet*

Introduction

The minimum and optimal temperature necessary for the plant to germinate

1. Importance of soil temperature

One of the important factors for the germination of plants and the development of the root system is soil temperature. Each plant has an optimal germination temperature, and this directly affects the yield (Babayev, 2019).

2. Soil temperature measurement

To measure the soil temperature, thermometers or special sensors are used. The temperature measurement depth should correspond to the seed sowing depth of the plant to be planted (for example, 5-10 cm for grains).

3. Influence of soil temperature on planting date

ISSN: 2707-1146
e-ISSN: 2709-4189

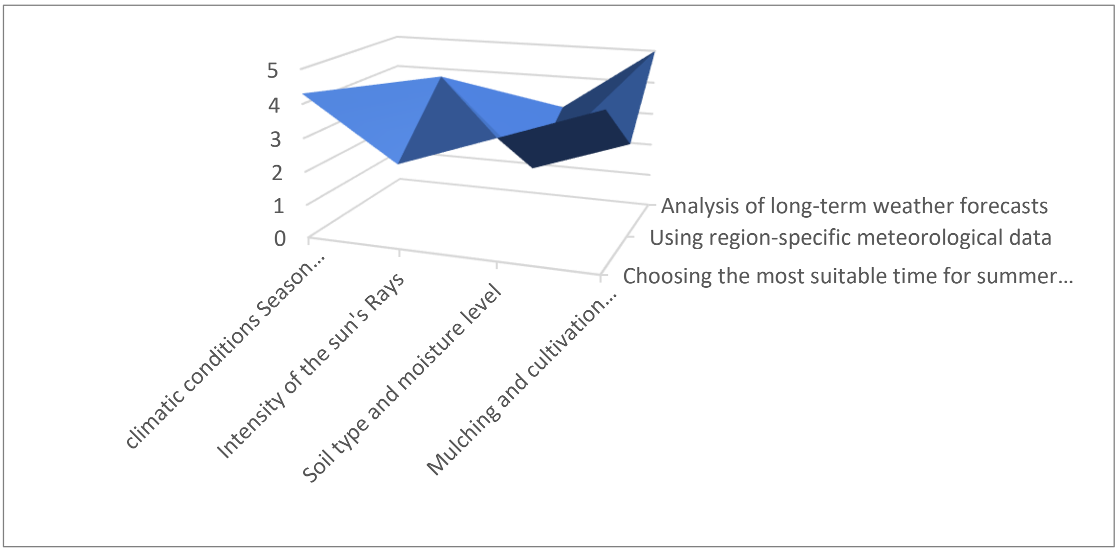
First temperature (minimum required) – minimal temperature so that the plant begins to germinate. Optimum temperature-the temperature necessary for maximum yield and rapid germination (Müller, Klein, 2015).

Research

Type of plant	First germination temperature (°C)	Optimum temperature (°C)
Wheat	1-3°C	12-15°C
Corn	8-10°C	18-22°C
Type of plant	First germination temperature (°C)	Optimum temperature (°C)
Sunflower	6-8°C	16-18°C
Potatoes	7-8°C	15-20°C

Factors affecting soil temperature.
Climatic conditions and season temperatures
Intensity of the sun's Rays
Soil type and moisture level
Mulching and cultivation methods
Choosing the most suitable time for summer plantings
Using region-specific meteorological data
Analysis of long-term weather forecasts
Taking into account the relationship between soil temperature and air temperature

Soil temperature is of great importance for efficient planning of beet and corn plantations in Shamkir district. The optimal soil temperature for germination and development of both plants is different, and this plays a key role in correctly determining the sowing date.



Beet: first germination temperature: beet seeds can begin to germinate at a soil temperature of 5-6°C. However, at this temperature, the germination process is slow and the sprouts may be weak.

Optimum germination temperature: for the best germination and vigorous plant development, the soil temperature should be 10-12°C. Under these conditions, germination is fast and uniform. (Gurbanov, Aliev, 2019).

Corn: first germination temperature: corn seeds begin to germinate at a minimum soil temperature of 8-10°C.

ISSN: 2707-1146
e-ISSN: 2709-4189

Optimum germination temperature: the optimum soil temperature for corn is 18-22°C. In this temperature range, germination is fast and uniform, while plants develop healthily (Karimov, Ismailov, 2020).

For example, the history of planting in Shamkir district:

Taking into account the climatic conditions of Shamkir district, it is important to regularly measure the soil temperature in order to determine the sowing date. In general:

Beet plantings: it is advisable to carry out sowing when the soil temperature reaches 10-12°C, that is, usually in late March-early April.

Corn plantings: sowing is recommended when the soil temperature reaches 18-22°C, that is, usually in mid-April - early may.

The temperature of the arable layer of the soil.

Soil temperature changes during the day with a short-term delay from the weather. (Petrov I., &Mammadov L.,2021). For example, in some soil science studies, it is noted that every 10 cm of depth, the soil temperature is observed with a delay of about 2-3 hours. This means that as the depth at which the seed is located increases, the soil temperature is lower during the warmer part of the day. (Shahbaz, 2018).

On the soil surface: average temperature 8°C.

10 cm deep: effective average temperature-about 7°C

15 cm deep: effective average temperature-about 6°C

These calculation rules are based on existing modeling methods and may vary depending on local conditions. The methodology mentioned in the article gives an explanation of the seed germination process at different depths according to the principle of thermal time accumulation (Guliyev, Aliyev, 2020).

Amount of GDD of the plant.

In summer plantings, GDD (Growing Degree Days – harvested effective temperature) is an important indicator for determining the stages of plant development. Periods when the amount of GDD is critical for sugar beet and corn:

Sugar beet.

Germination and initial leaf development (50-150 GDD)

Germination begins when the soil temperature is 5-6°C.

Critical period: if low temperatures and soil moisture are insufficient, germination may be slowed down.

Rosette phase and leaf cover formation (300-600 GDD)

The leaf cover is formed and photosynthesis is enhanced.

Critical period: drought and nitrogen deficiency can weaken the development of leaves. (Ivanova E., & Smirnov A., 2019).

Root growth and sugar harvesting (1000-1500 GDD)

The basis is the stage of sugar collection.

Critical period: drought and high temperatures can reduce the amount of sugar. (Abbasov R.,2018).

Corn.

Germination and early development (100-150 GDD)

The soil temperature should be 10°C.

Critical period: cool air and lack of water can negatively affect germination.

Vegetative development (200-800 GDD)

Leaves and stem grow rapidly.

Critical period: nitrogen deficiency and water scarcity can weaken development.

Flowering and fertilization (900-1300gdd)

It is the stage of pollen propagation and fertilization.

Critical period: high temperatures (>35°C) and drought can reduce the viability of pollen.

Filling and ripening from (1400-1800gdd)

Grains collect starch.

ISSN: 2707-1146
e-ISSN: 2709-4189

Critical period: lack of water and frost can reduce productivity.

That is, 1000-1500 GDD in sugar beets and 900-1300 GDD in corn are considered critical stages, since during these periods the balance of water, nutrients and temperature directly affects plant productivity (Maynard, Linder, 2007).

To determine the seed-germination time of Chenopodium album, Amaranthus retro flexus and Amaranthus (albus) species observed in Shamkir district, we present the calculation rules using the thermal time (degree-day) model at a depth of 10 and 15cm.

Weather forecast on the day of the fall of the last frosts in the area over the past 5 years and 2 weeks after the day of planting.

The following steps can be followed to accurately determine the soil temperature:

Measurement depth: soil temperature should be measured at seed sowing depth. For beets, this depth is 2-3 cm, and for corn-5-6 cm.

Measurement time: by taking temperature measurements early in the morning and late in the afternoon, determining the average cost will give a more accurate result.

Regular measurements: it is advisable to monitor the soil temperature for several days before planting and start sowing when the stable optimum temperature is reached.

The last 10 years of frost.

The correct determination of the sowing date in summer plantings directly affects the yield. An important role in this process is played by the date of the last (in 10 years) frosts (frosts), since plants planted after Frost develop healthier and are protected from frost damage. The history of the latter frosts varies depending on climatic conditions and geographical location. For example, in some regions, the last frosts can occur in mid-March, and in others-at the end of April. (Stewart, Glickman, 2019). To determine the date of the last frost, it is possible to use the following sources:

Meteorological data: based on multi-year data provided by official weather forecasting services, the average dates of recent frosts in the region are studied.

The collection and analysis of meteorological data is of great importance, since there is a direct relationship between soil temperature and sowing date. (And Not, 2017). Weather conditions, soil temperature and humidity indicators are some of the factors that are important for the germination and development of plants. By monitoring the temperature regime of the soil through meteorological data, a favorable period for sowing is determined. This minimizes crop losses caused by early or late sowing. At the same time, on the basis of long-term weather forecasts, the irrigation needs of arable land, the risk of frost and periods of drought can also be assessed. Thus, farms can more efficiently plan the planting and harvesting process and achieve high yields using meteorological data.

Local experience: observations from experienced farmers and agronomists can provide valuable information about frost dates in your area. Local practice is traditional knowledge and skills that have been formed over many years in a particular region, applied in agricultural or other fields adapted to local climatic, soil and environmental conditions. These practices are based on the knowledge gained over the years by farmers and agricultural professionals and include optimal methods that match the specific characteristics of the region. Local practice plays an important role in increasing productivity, preserving land and efficient use of resources.

Determining the timing of planting is one of the important factors that directly affect the yield and healthy development of plants. This process requires taking into account a number of environmental and agrotechnical factors (Tunch, 2016). First of all, the soil temperature should be at an optimal level. For each type of plant, the minimum and optimal temperature indicators that ensure germination are different.

When determining the timing of planting after the last frost, it is important to take into account the following points:

Plant species susceptibility to Frost: plant species susceptibility to Frost is determined by their genetic characteristics, stage of development, and environmental factors. Some plants are more tolerant of low temperature conditions, but heat-loving plants such as corn and sugar beets are vulnerable to Frost.Frost can cause frostbite of intracellular water in plants, leading to tissue damage and a halt in development. Frost resistance can be increased by various factors, for example, choosing the right planting date, maintaining soil moisture and taking appropriate agrotechnical measures. It is more appropriate to do the planting of frost-sensitive plants after the last frost.

Soil temperature: soil temperature is one of the main factors for plant germination and early development. Each plant has an optimal germination temperature, and this indicator determines how quickly and uniform the seed will germinate. For example, the soil temperature for cereals should be between 5-10°C, and for corn-between 10-12°C. Low temperatures reduce the germination rate of the seed and increase the risk of decay, while high temperatures can disrupt the moisture balance and weaken development (Smith, Nelson, 2014). Therefore, the soil temperature must be constantly monitored, and planting should be carried out in optimal conditions.

Weather forecasts play an important role in the process of planting and plant development. Monitoring short-term weather forecasts is essential to anticipate factors such as expected frosts, temperature changes, rain and wind. In particular, in order to protect frost-sensitive plants, the necessary measures must be taken based on weather forecasts. For example, adjusting the planting time, keeping the soil temperature constant through irrigation methods can prevent frost damage. Therefore, farmers and agronomists should constantly pay attention to weather forecasts and plan their economic activities in accordance with this information (Kuznetsov, Fedorova, 2020)

The role of the 3-week forecast before sowing.

Risk analysis and preparation. The 3-week forecast prior to planting operation helps detect potential cold weather, frost, or unstable weather conditions. During this period, there is an opportunity to delay sowing or take additional measures in accordance with the planned date, assessing the expected weather conditions.

Ensuring Optimal planting conditions. Thanks to the pragnosis data obtained during this time, the time interval during which the optimal soil temperature and moisture level for planting will be formed can be determined with accuracy. This increases the chances of germination of seeds and prevents problems that will arise at an early stage of development.

Practical issues. Careful monitoring of pre-sowing forecast data is necessary both in the preparation of irrigation and fertilization plans, and in the preparation of appropriate technical means (preservation of the quality of seeds, readiness of sowing equipment, etc.) plays an important role in coordination.

The role of the 3-week forecast after sowing.

Monitoring early germination and growth. The first 3 weeks after sowing are the critical period for the germination of seeds and the formation of the first stage of plant development. The weather forecasts obtained in this process indicate what the conditions for the early development of plants (temperature, amount of precipitation, wind speed) will be like. (Kuznetsov, Fedorova, 2020).

Possibility of control and intervention. The post-sowing forecast is if unpredictable weather conditions or risky events (for example, sudden rain, high temperatures, etc.) occur.) if available, it allows you to implement early intervention plans. This is important for taking preventive measures in irrigation, disease and pest control.

Creation of optimal conditions. During this time, on the basis of forecast data, soil moistening, fertilization and other agronomic measures can be planned. These measures create conditions for optimal conditions and healthy growth of plants at the stage of germination and initial development of seeds.

Note: integration of various data collection and integration of various data such as soil temperature, humidity, weather forecasts and local climate statistics are necessary for the correct determination of the sowing date of spring crops. Based on these data, it is ensured that the planting plan is based on scientific foundations.

Assessment of local experience and meteorological data:

By combining data from official meteorological services and the experience of local farmers, the date of the last frost, sudden weather changes and optimal planting dates corresponding to soil conditions can be accurately determined.

ISSN: 2707-1146
e-ISSN: 2709-4189

Risk management:

In order to timely detect and prevent factors such as cold weather, Frost, sudden rain and disease risks, appropriate measures (e.g. delaying the planting date, regulating protective equipment and irrigation/drainage systems) should be carried out.

Flexible and predictive planning:

Due to the variability of weather conditions and other environmental factors, planting plans must be flexible. Continuous updating of the sowing date based on forecasts is the main condition for minimizing risks and increasing yields.

Tracking meteorological data:

Using official meteorological services and local practices, it is important to analyze forecasts for 3 weeks and adapt planting plans to it.

Dynamic planning of planting date:

To react to changes in weather conditions, it is important that the plan is flexible, that the planting date can be updated in real time.

Integrated decision mechanism:

The integrated decision mechanism, developed on the basis of weather forecasts, soil temperature, humidity and other environmental factors, is an effective tool in determining the sowing date.

Critical period of plant development (critical period of pollination, fertilization, disease and pests). Stages of plant development.

Pollination and fertilization: this stage vu tests are aimed at the effect of the plant on the skin and proper fertilization. Optimal climatic conditions, temperature and humidity play a huge role in specifying the date of sowing.

Critical period determination: the plant– for example, possible in the fall – the ground, during pollination – weak, and the plant can be stronger against the attack of pests.

Climatic and environmental conditions.

Climatic factors: in the choice of sowing timeit is the role of climatic conditions in the choice of sowing time. Temperature, humidity, wind and intensity of the sun's rays affect the process of pollination and fertilization of the plant.

Environmental impact: microclimate of the Earth impact, soil moisture and other environmental factors contribute to the successful course of the critical period in the development of the plant.

Disease and Pest Management.

Disease risks: the disease (namely, fungal infections) arising at the stage of pollination and fertilization of the plant can affect the yield. The article can talk about the correct installation of preventive devices and treatment methods.

Pest electricity: since the activity of these pests has increased, it is appropriate to mention pest management methods with monitoring systems and integration for their timely detection and management.

Determining the Optimal sowing date.

The danger of Date Selection: Choosing the right sowing date is important for creating optimal conditions in the critical process of plant development. You can give scientific and practical examples from which the effective effects of early or late sowing (in the article, an increase in pests and diseases) are obtained.

Predictive monitoring: the introduction of modern technologies (meteorological data, satellite imagery,) and remedial devices can touch on the determination of sensors and the optimal sowing date.

Weeding type of the site and the minimum temperature at which weeds do not germinate.

1. Black currant (Chenopodium album):

Development temperature: this weed begins to germinate at temperatures above 5°C, and its optimal development is observed between 15-20°C.

2. Asparagus (Stellaria media):

 ISSN: 2707-1146
e-ISSN: 2709-4189

Development temperature: its germination begins at a temperature of 2-5°C and its optimal development is between 1216°C.

3. Chamomile (Matricariachamomilla):

Development temperature: the minimum temperature for its germination is 4-6°C, and its optimal development occurs between 15-20°C.

4. Chicken millet (Echinochloa crus-galli):

Development temperature: its germination begins at temperatures above 10°C and its optimal development is between 20-30°C.

5. Green bristle (Setariaviridis):

Development temperature: the minimum temperature for germination is 12-15°C, and optimal development is observed between 25-30°C.

6. Panjar (Amaranthusretroflexus):

Development temperature: its germination begins at a temperature of 10-12°C, and its optimal development is between 2530°C.

To combat weeds, agrotechnical measures, mechanical methods and the application of appropriate herbicides are important. For the effectiveness of control measures, it is important to correctly determine the type of weeds and choose the appropriate methods.

Mechanical struggle.

Early plowing (in autumn or early spring) – the soil must be deep plowed to prevent weed seeds from sprouting on the surface.

Disking and cultivation – in spring, when the soil reaches 7-10°c, disc and cultivation can be applied to destroy sprouted weeds.

The black herik method-to keep the site empty for a while before spring plantings and destroy the weeds that have appeared.

Agrotechnical struggle.

Watering before sowing and false plowing – giving a small amount of water to the soil surface and creating conditions for the germination of weeds, and then destroying them by cultivating.

Dense planting technology-planting plants in optimal density limits the development of weeds.

Chemical fight (using herbicides)

Herbicides applied before planting

Glyphosate-based herbicides (for example, Roundup) – weeds can be sown after germination (when they are 5-10 cm).

Herbicides that act on the soil (for example, Pendimethalin) – they are injected into the soil before planting to prevent the germination of weeds.

Herbicides applied after planting

If weeds develop after seed germination, selective herbicides should be used (e.g. dicamba or Mesotrione-based herbicides for corn).

The most effective time.

February-March-the method of the first mechanical struggle or black herik.

March-April-herbicide application and mechanical methods before planting

April-May-selective herbicide use as needed after planting

Calculation procedure (with Degree - day model)

To find the number of days elapsed for the seed to germinate for each variety, we use the following formula:

d = G / (T_effective – T_base)* here:

T_effective-average temperature at the depth at which the seed is located (10°C for 7 cm, 15°C for 6 cm),

T_base-accepted base temperature for each type (about 4°C),

G-thermal time (degree-day) required for germination of the variety.

Chenopodium album

T_base: 4°C

G (required thermal time): approximately 80 degree-day

10 cm depth:

T_effective = 7°C → daily effective thermal growth = 7-4 = 3°C d = 80/3 ≈ 26-27 days

15 cm depth: T_effective = 6°C → daily effective growth = 6 – 4 = 2°C d = 80 / 2 = 40 days

Amaranthusretroflexus

T_base: 4°C

G: approximately 100 degree-day

10 cm depth:

T_effective = 7°C → daily increase = 7 – 4 = 3°C d = 100 / 3 ≈ 33 days

15 cm depth:

T_effective = 6°C → daily increase = 6 – 4 = 2°C

d = 100 / 2 = 50 days

Amaranthusalbus (albums)

T_base: 4°C

G: approximately 90 degree-day

10 cm depth:

T_effective = 7°C → daily growth = 7 – 4 = 3°C d = 90 / 3 = 30 days

15 cm depth:

T_effective = 6°C → daily growth = 6 – 4 = 2°C d = 90/2 = 45 days

According to the corresponding calculations, if the average air temperature is 8°C:

Chenopodium album:

at a depth of CM, seed germination occurs in about 26-27 days, and at a depth of 15 cm-in 40 days.

Amaranthus retroflexus:

at a depth of CM, germination can be observed in about 33 days, and at a depth of 15 cm-in 50 days.

Amaranthus albus:

At a depth of 10 cm, germination can occur in about 30 days, and at a depth of 15 cm-in 45 days.

These calculation rules are based on existing modeling methods and may vary depending on local conditions. The methodology mentioned in the article gives an explanation of the seed germination process at different depths according to the principle of thermal time accumulation.

The temperature of the day changes like a sine wave. issues, daily temperature recorded data with detailed model:

T (t) = Torta + a ·Sin(2p / 24 (t - tmax))

Here:

T (t) - temperature at any time of the day

T or t A – average temperature during the day

A-temperature amplitude (half of the maximum and minimum temperature difference)

Tmax-the hour at which the maximum temperature of the Day occurs (usually at noon, for example, 14:00) (Martina Hancova, Andrej Gajdos and Jozef Hanc, 2021).

Calculation of average temperature:

If the temperature changes at night (00:00 - 06:00), and during the day it changes differently, then this can be calculated by dividing it into two parts:

$$\text{Torta} = \frac{1}{24}\int_{0}^{24} T(t)dt$$

If the night temperature creates an additional difference (for example, 3 hours different, then 2 hours different), it is necessary to create a separate model of these differences. For this, separate models such as:

Daytime temperature-changes based on Sinus function.

Night temperature-or, if it is different in hours, it is possible to take another sinus or temperature constant in that hour interval.

Farm facilities.

You can discuss how modern farming technologies, automation systems, sensors, Geographic Information Systems (GIS) and soil analysis methods increase farm productivity. How the introduction of these technologies affects the economy's innovation and decision-making process can also be highlighted (Petrov, Mammadov, 2021).

Soil quality, irrigation systems and proper management of Water Resources affect its productivity. Facts and methodologies about soil analysis and water resource optimization the construction of the topic can be carried out.

Preparatory Stage.

Analysis of soil and Water Resources.

Establishment of climatic and weather conditions.

Assessment of the capabilities of the farm (equipment, labor, financial resources, etc.).

Strategic planning and planning.

Application Stage.

Building modern technology: farm compatible implementation of Drondrons, sensors and automated systems.

Training and training of personnel: research of employees on new technologies and methods.

Transition to ecological agriculture: application of modern cultivation methods to prevent soil erosion.

Monitoring and evaluation.

Measurement of the results of systems of their implementation.

Identification of problematic directions and carrying out work for improvement.

Collection and analysis of statistical data.

Pivot Irrigation System.

30-50% less water consumption by traditional methods

An even and continuous supply of water to plants is healthier

Effective in different reliefs and different plants

Pivot irrigation conserves resources, increases productivity and improves farm quality.

Harvesting period.

Proper sowing allows you to determine the optimal harvesting time.

Sowing sooner or later can affect the quality and effect of the crop.

Biological characteristics of the plant. The ripening time of each plant is different.

Climatic and weather conditions – temperature, precipitation and sunlight-affect the rate of crop ripening.

Sowing date-the later the sowing, the more delayed the harvesting.

Soil and irrigation conditions-the rate of ripening of irrigated and non-irrigated crops is different. Maximum yield and high-quality assembly of the product:

The optimal level of humidity of cereals and other crops.

Reducing the risks of drying out and decay.

More effective management of the collection technique and employee.

Conclusion

The date of the last frosts is great importance in determining the date of sowing in summer plantings. Waiting 1 week after the last frost ensures the protection of plants from frost damage and allows them to germinate under optimal conditions. This approach contributes to increasing yields and healthy development of plants.

The importance of the weather forecast and the history of sowing. Determining the date of planting is closely related not only to soil temperature and climatic conditions, but also to weather forecasts. Forecasts for 3 weeks before and after sowing ensure the successful implementation of the seed germination and early growth phase, minimizing the risks of the sowing process.

ISSN: 2707-1146
e-ISSN: 2709-4189

The harvesting period is closely related to the sowing date. A properly planned sowing and harvesting process increases productivity, reduces losses and increases farm productivity.

References

1. Abbasov, R. (2018). Technology of sugar beet cultivation in Azerbaijan. *Journal of Agricultural Research*, 22 (3), 45-52.
2. And not only. (2017). Sowing dates and yields: the experience of Azerbaijan. *Agriculture and economics*, 30(3), 110-120.
3. AZERTAC. (2023). The effect of soil temperature on plant development based on experiments. *Azerbaijan Agricultural Journal*, 34 (2), 101-110.
4. Babaev, R. (2019). The influence of climate and soil conditions on the timing of planting. *Agricultural and climate research*, 12 (1), 50-58.
5. Guliev, V., Aliev, M. (2020). The effect of planting time and temperature on plant germination. *Azerbaijan Journal of Soil Science*, 19 (1), 35-40.
6. Gurbanov, F., Aliev, N. (2019). Effective use of fertilizers in the cultivation of sugar beet. *International Agronomic Journal*, 18 (2), 67-75.
7. Khantsova, M., Gaidos, A., Khank, J. (2021, June 7). Practical and efficient calculation of gamma difference distributions using open tools8. And Not (2017). Sowing time and productivity: Azerbaijan experience. *Agriculture and Economics*, 30(3), 110-120.
8. Ivanova, E., Smirnov, A. (2019). Biological features of sugar beet: the effect of the sum of active temperatures on growth and development. *Bulletin of plant breeding*, 12 (3), 55-63.
9. Karimov S., Ismailov A. (2020). Modern methods of corn cultivation: agrotechnical recommendations. *Grain Crops Magazine*, 15 (1), 32-40.
10. Kuznetsov M., Fedorova O. (2020). The sum of active temperatures as a factor of corn productivity: experimental data. *Journal of Agronomic Research*, 16 (2), 78-85.
11. Maynard A., Linder H. (2007). The effect of soil temperature on seed germination and early crop growth. *Journal of Soil Science*, 68 (6), 319-327.
12. Muller, J., Klein, M. (2015). The timing of sowing crops and their impact on yields. *Agronomic Journal*, 107 (3), 865-873.
13. Petrov I., Mammadov L. (2021). Comparative analysis of traditional and innovative methods of corn cultivation. *Agroeconomicheskiy vestnik*, 10 (4), 112-119.
14. Shahbaz, M. (2018). The effect of soil moisture on the timing of sowing. *Soil science and irrigation,* 25 (4), 144-150.
15. Smith, K. and Nelson, R. (2014). Influence of temperature on germination and early development of plants. *Journal of Agronomy and Crop Production*, 200 (2), 98-104.
16. Stewart, W., Glickman, J. (2019). Optimal planting dates and their impact on crop productivity. *Farming methods*, 11 (2), 48-54.
17. Tunc, M. (2016). The relationship between plant development and soil temperature. *Plant Physiology and Agronomy*, 22 (5), 10-17.

Received: 21.01.2024
Accepted: 06.04.2025