Research Article

Effects of Plant Density on Growth Dynamics and Main Stem Height of Sunflower Varieties: A Case Study in Azerbaijan

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Abstract | The purpose of this study was to analyze the effect of plant density on the development dynamics and height of the main stem in sunflower varieties. The plant density applied in the study had different effects depending on the biological and morphological characteristics of the varieties. The same effect was observed in different development stages of the plant. The phenological observations conducted show that the existence of certain differences within the same variety is because of the climate as well as the implementation of various agrotechnical measures. In the varieties, those indicators were different depending on the biological and morphological characteristics of the varieties. As a result of the long-term scientific research conducted by scientists with sunflowers and our research, it became clear that the height of the main stems is not the same as the genotype, biological and morphological characteristics of the varieties. Sometimes, depending on the influence of natural factors, there is a certain difference in the height of the main stems. The implementation of all agrotechnical measures designed for the growth of sunflowers in the optimal time has a positive effect on its development stages in all cases. Despite the prescribed norms of plant density given to sunflower varieties, the unstable climate changes the development dynamics of the varieties.

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Introduction

Ukraine and Russia are the most important sunflower producing countries in the world. Argentina, China, Türkiye and Bulgaria are other important countries. In 2023, 58.6 million tons of sunflower were produced in the world on 30.1 million hectares of land (FAOSTAT, 2025). In Azerbaijan, 28,178 tons of sunflowers were produced on 9,899 hectares of land in 2023. Most sunflower production areas are in the Ganja-Dashkasan, Gazakh-Tovuz and Karabakh economic regions (ASSC, 2025).

The most widely planted varieties of sunflower in Azerbaijan are Gigant-549, VNIIMK-883, Kazio, Alazan, Oreshka varieties (Mammadov and Ismayilov,

2012). Lakomka, Dobrinin, Oreshka, VNIIMK-883 varieties are the most cultivated varieties in the Ganja-Dashkasan region. In sunflower planting, the distance between the rows is 70 cm and distance between the plants can be 25-35 cm depending on soil fertility and rainfall. In short varieties, the distance between plants should be about 25 cm, medium height plant is 30 cm and tall height plants are 35 cm. Arid and less fertile land conditions distance between rows can be 35-40 cm, in irrigated, rainy and fertile soil conditions distance between rows is 25 cm. In one hectare area to be able to get high productivity according to the type and soil conditions any number of plants can be around 4000-5500 (Anonymous, 2017).

It is stated in the "State Program of Socio-Economic Development of the Regions of the Republic of Azerbaijan in 2019-2023: The development of the regions of the Republic of Azerbaijan is an important component of the sustainable socio-economic development strategy successfully implemented in the country. The implementation of the tasks provided for in the adopted and successfully implemented state programs in the field of regional development, as well as in the orders on additional measures for the socio-economic development of the regions, will contribute to the sustainable development of the non-oil sector in the country, the improvement of the quality of communal services and social infrastructure provision in the regions and the further improvement of the entrepreneurial environment, creates conditions for the increase of investment, the opening of new enterprises, jobs and as a result, the increase of employment of the population (Aliyev, 2008, 2019).

By applying the achievements of scientific and advanced practice, the yield of sunflower can be greatly increased. The sunflower plant is of special importance in the social and economic development of Azerbaijan. By applying the achievements of science and advanced experience to the cultivation of sunflowers, its productivity can be further increased. In addition to the increase of the product, it should be given a lot of space to improve its quality, to plant fast-growing varieties, to harvest the product in the optimal time, to apply new technologies and other measures (Aliyev, 1999).

To improve the productivity and quality of the plant, which has such a strategic importance, multi-disciplinary scientific research works are being conducted. Variety has a special role in improving the quality of the product. In recent times, farmers who plant sunflowers have had a lot of difficulty in selecting varieties that give higher yields in the natural and climatic conditions of their farms.

Being the cheapest means of increasing the productivity of a separate plant, variety has now become such a powerful biological management factor that without it, the application of the achievements of science and technology in agriculture, a new efficient system, chemicalization etc. capital investment cannot be optimized. The variety plays a special biological role in the production of modern agricultural plants and the implementation of intensive technology. Applied agro-technical measures have a greater effect on its high and quality yield. This allows any variety to preserve its biological and morphological characteristics for a long time (Seyidaliyev *et al.*, 2014).

It has been determined in many studies that plant density in sunflower can influence yield and product quality (Pekcan and Esendal, 2015; Gül and Ada, 2019; Li *et al.*, 2019; Mladenovic *et al.*, 2020; Karaozan and Ertekin, 2022; Barisik *et al.*, 2024). On the other hand, plant heights may vary depending on the variety. For example, in a study, the plant height was determined as 300 cm in the Giant-(Gigant)-549 variety, 206 cm in the Oreshka variety and 160 cm in the Kazio variety (Kazimov and Ismayilov, 2024).

The food and technical importance of vegetable oils is great. The shell of sunflower seeds is used as a raw material in the industry to obtain hexose and pentose sugars. Alcohol is obtained from hexose sugars and furfural is obtained from pentose sugars, from which artificial fibers, plastics, unbreakable glasses, etc. At the same time, linoleum, tarpaulin, waterproof fabrics, etc. are used in the industry. Oilseeds are also a source of plant protein. 35-40% protein is found in the press cake, which remains when the oil of the seeds is processed. One centner of the remaining press cake after oil processing is equal to 102 feed units or 3.6 kg of protein.

Some studies have been done on the technical and economic aspects of sunflower growing in Azerbaijan (Mammadov and Ismayilov, 2012; Gholinezhad *et al.*, 2015; Ismayilzade *et al.*, 2015; Anonymous,

2017; Huseyn, 2017; Ibrahimov and Valiyeva, 2018; Ismayilova, 2022; Bashirova, 2022; Aslanov and Abbasova, 2022). However, it is necessary to carry out research at the regional level, especially at the technical level, for the development of this branch of production.

The purpose of this study was to analyze the effect of plant density on the development dynamics and height of the main stem in sunflower varieties. In the study, different effects of applied plant density were investigated depending on the biological and morphological characteristics of the varieties. The same effects were also evaluated for different developmental stages of the plant.

Materials and Methods

The study was conducted in 2022-2023. The applications were carried out in the trial area of the Plant Protection and Technical Plants Research Institute in the Samukh region of Azerbaijan. This region is located in the north-west of the country and belongs to the Ganja-Dashkasan (Figure 1).

In this study, the varieties "Alazan", "Oreshka" and "Kazio" are studied comparatively by applying the mentioned complex agrotechnical measures. In study were planned control (without fertilizer), 10 tons of manure, 15 tons of manure, 42,000, 47,000 and 56,000 plant density per hectare, 3, 4, and 5 times irrigation for each of the varieties (Table 1).

The experiment consists of 9 variants. Each variant has 4 repetitions. Each repetition in the experimental area is 50 m long and 2.8 m wide (4 rows, 70 cm between rows). In the study, a replicate area was 140 m^2 and the total experimental area was 5040 m^2. The effects of varieties, plant density and variety x plant density interaction were evaluated using analysis of variance (ANOVA).

Figure 1: *Samukh region in Azerbaijan.*
Source: *Anonymous, 2025.*

Results and Discussion

The plant density applied in the study had different effects depending on the biological and morphological characteristics of the varieties. The same effect was observed in different development stages of the plant. As can be seen from Table 2, plant density has different effects on the general development dynamics of the sunflower plant.

Table 1: *Scheme of the experiment.*

Variants				Repetitions			
Varieties	**Sowing scheme and plant density, (thousand units/ hectare)**	**Organic fertilizer rates**	**Irrigations**	**I**	**II**	**III**	**IV**
Alazan	70×35-1(42 thousand plants)	Control (no fertilizer)	3 times	1	10	19	28
	70×30-1(47 thousand plants)	10 tons of manure	4 times	2	11	20	29
	70×25-1(56 thousand plants)	15 tons of manure	5 times	3	12	21	30
Oreshka	70×35-1(42 thousand plants)	5 tons of manure	3 times	4	13	22	31
	70×30-1(47 thousand plants)	10 tons of manure	4 times	5	14	23	32
	70×25-1(56 thousand plants)	15 tons of manure	5 times	6	15	24	33
Kazio	70×35-1(42 thousand plants)	5 tons of manure	3 times	7	16	25	34
	70×30-1(47 thousand plants)	10 tons of manure	4 times	8	17	26	35
	70×25-1(56 thousand plants)	15 tons of manure	5 times	9	18	27	36

Table 2: *Effect of plant density on development dynamics of sunflower varieties (2022)*

Varieties	Variants	1st main leaves	2nd main leaves	3rd main leaves	Flowering	Basket formation	Maturing
Alazan	70×35-1(42 thousand plants)	March 25	March 28	April 1	April 24	May 12	June 25
	70×30-1(47 thousand plants)	March 25	March 28	March 31	April 23	May 11	June 27
	70×25-1(56 thousand plants)	March 24	March 27	March 29	April 22	May 9	June 24
Oreshka	70×35-1(42 thousand plants)	March 21	March 24	March 27	April 24	May 10	June 13
	70×30-1(47 thousand plants)	March 21	March 24	March 27	April 23	May 9	June 15
	70×25-1(56 thousand plants)	March 20	March 22	March 25	April 22	May 8	June 14
Kazio	70×35-1(42 thousand plants)	March 19	March 22	March 25	April 18	May 8	June 20
	70×30-1(47 thousand plants)	March 19	March 22	March 24	April 17	May 7	June 24
	70×25-1(56 thousand plants)	March 18	March 21	March 22	April 16	May 6	June 22

Table 3: *Plant density effect of main stem height in sunflower varieties (2022).*

Varieties	Variants	Development stages (cm)		
		Flowering	Basket formation	Maturing
Alazan	70×35-1(42 thousand plants)	62-66	68-75	90-96
	70×30-1(47 thousand plants)	67-78	81-86	97-104
	70×25-1(56 thousand plants)	73-89	86-98	103-111
Oreshka	70×35-1(42 thousand plants)	86-92	145-154	180-194
	70×30-1(47 thousand plants)	91-98	151-164	188-205
	70×25-1(56 thousand plants)	96-105	157-173	197-216
Kazio	70×35-1(42 thousand plants)	78-82	134-145	158-166
	70×30-1(47 thousand plants)	85-92	144-151	165-172
	70×25-1(56 thousand plants)	93-113	153-162	173-181

The phenological observations conducted show that the existence of certain differences within the same variety is because of the climate as well as the implementation of various agro-technical measures. In the varieties, those indicators were different depending on the biological and morphological characteristics of the varieties.

1st main leaves in the Alazan variety on March 25; 2nd main leaves March 28; 3rd main leaves March 31; April 1; March 29; flowering stages April 24; April 23; April 22; basket formation stages May 12; May 11; May 9; the maturing stages is June 25; June 27, June 26 hesitated.

The 1st main leaves in Oreshka variety on 2 options March 21; and March 20, 2nd main leaves on 2 options March 24; and March 22; 3rd main leaves March 27 for 2 options; and March 25; flowering stages April 24; April 23; April 22; basket formation stages May 10; May 9; May 8; the maturing stages is June 13; June 15; June 14 was observed.

1st main leaves on variants in Kazio variety March 19; March 19; and March 18; 2nd main leaves March 22; March 22; March 21; 3rd main leaves March 25; March 24; March 22; flowering stages April 18; April 17; April 16; basket formation stages May 8; May 7; May 6; the maturing stages is June 20; June 24; June 25 was observed.

As can be seen from Table 3, the effect of plant density on the height of the main stem in sunflower varieties was different. The results in different development stages of the sunflower plant were as follows.

In the stages of flowering, basket formation and maturing, the height of the main stems in the variety "Alazan" was 70 x 35-1, the density of 42 thousand plants variant 62-66, 68-75, 90-96 cm; 70x30-1 sowing scheme, 47 thousand plant density variant 67-78; 81-86; 97-104 cm, 70x25-1 sowing scheme, 56 thousand plant density variant 73-89; 86-98; 103-111 cm.

In the flowering stages in the Oreshka variety the sowing scheme of 70x35-1, the density of 42 thousand plants, the height of the main stems was 86-92 cm, in basket formation 145-154 cm and maturity 180-194 cm. Those indicators were 91-98, 151-164, 188-205 cm, in the variant with 70x30-1 sowing scheme, 47 thousand plant density and 96-105, 157-173, 197-216 cm in the variant with 70x25-1 sowing scheme, 56 thousand plant density.

In the flowering stages, the height of the main stems was 78-82 cm in the variant of 70x35-1 seeding scheme, 42 thousand plant density in Kazio variety: 134-145 cm in basket formation and 158-166 cm in maturity. Those indicators were 85-92 in the 70x30-1 sowing scheme, 47 thousand plant density 144-151, 167-172 cm, 70x25-1 sowing scheme, 56 thousand plant density version 93-113, 153-162,172-181 cm.

During the research conducted in 2023, different results were obtained for different varieties of the sunflower plant (Table 4).

The 1st main leaves in the Alazan variety were on March 28; 2nd main leaves March 31; 3rd main leaves on two options April 5; and April 4; flowering stages in two variants April 25; and April 24; basket formation stages May 15; May 13; May 12; the maturing stages is June 29; June 28; June 26.

The 1st main leaves in Oreshka variety were for all variants on March 29; 2nd main leaves for all options March 30; 3rd main leaves on 2 options April 4; and April 5; flowering stages April 23 for option 2; and April 22; basket formation stages May 11; May 10; May 13; the maturing stages on June 14 for 2 variants and June 15.

The 1st main leaves on all variants in Kazio variety were for all variants March 27; and 2nd main leaves on all options March 31; 3rd main leaves April 5; and April 4 on 2 options; flowering stages for all variants April 21; basket formation stages May 9; May 8; May 7; the maturing stages is June 21; 2 options in June 23.

As can be seen from Table 5, the effect of plant density and irrigation on the height of the main stem in sunflower varieties was different.

Table 4: *Effect of plant density on development dynamics of sunflower varieties (2023).*

Varieties	Variants	1st main leaves	2nd main leaves	3rd main leaves	Flowering	Basket formation	Maturing
Alazan	70×35-1(42 thousand plants)	March 28	March 31	April 5	April 25	May 15	June 29
	70×30-1(47 thousand plants)	March 28	March 31	April 5	April 25	May 13	June 28
	70×25-1(56 thousand plants)	March 28	March 31	April 4	April 24	May 12	June 26
Oreshka	70×35-1(42 thousand plants)	March 29	March 30	April 3	April 23	May 11	June 15
	70×30-1(47 thousand plants)	March 29	March 30	April 3	April 23	May 10	June 14
	70×25-1(56 thousand plants)	March 29	March 30	April 5	April 22	May 13	June 14
Kazio	70×35-1(42 thousand plants)	March 27	March 31	April 5	April 21	May 5	June 21
	70×30-1(47 thousand plants)	March 27	March 31	April 3	April 21	May 8	June 23
	70×25-1(56 thousand plants)	March 27	March 31	April 3	April 21	May 7	June 23

Table 5: *Plant density effect of main stem height in sunflower varieties (2023).*

Varieties	Variants	Development stages (cm)		
		Flowering	Basket formation	Maturing
Alazan	70×35-1(42 thousand plants)	43-49	59-67	82-86
	70×30-1(47 thousand plants)	60-63	69-78	92-99
	70×25-1(56 thousand plants)	64-75	80-85	94-102
Oreshka	70×35-1(42 thousand plants)	82-90	135-142	168-174
	70×30-1(47 thousand plants)	89-96	142-151	170-188
	70×25-1(56 thousand plants)	94-107	150-162	182-203
Kazio	70×35-1(42 thousand plants)	72-80	122-135	146-158
	70×30-1(47 thousand plants)	85-92	129-138	154-166
	70×25-1(56 thousand plants)	94-99	135-138	162-175

The results of the research we conducted in 2023 in different development stages of the sunflower plant were as follows.

In the stages of flowering, basket formation and maturing, the height of the main stem in the variety "Alazan" was 70 x 35-1, the density of 42 thousand plants variant was 43-49, 59-67, 82-86 cm; 70x30-1 sowing scheme, 47 thousand plant density variant 60-63, 69-78, 92-99 cm, 70x25-1 sowing scheme, 56 thousand plant density variant was 64-75, 80-85, 94-102 cm.

In the flowering stages, the Oreshka variety has a 70x35-1 sowing scheme, a density of 42,000 plants variant the height of the main stem was 82-90, 135-142 cm in basket formation and 168-174 cm in maturity. Those indicators were 89-96,142-151, 170-188 cm the variant with 70x30-1 sowing scheme, 47 thousand plant density variant, 70 x 25-1 sowing scheme, 56 thousand plant density variant was 94-107, 150-162, 182-203 cm.

In the flowering stages, in the Kazio variety, the sowing scheme is 70x35-1, the density of 42 thousand plants variant the height of the main stem was 72-80 cm, 122-135 cm in basket formation and 146-158 cm in maturity. Those indicators were 85-92 129-138, 154-166 cm in the 70x30-1 sowing scheme, 47,000 plant density; 70x25-1 sowing scheme, 56 thousand plant density version were 94-99, 135-138, 162-175 cm.

Typically, the average oilseed sunflower yield of an experienced farmer in fertile soil range from 2.3 to 2.8 t/ha. These numbers are decreased when the crop grows in dry conditions without irrigation and few rainfalls, reaching 0.7-2.0 t/ha. Studies conducted in different countries have shown that sunflower yields can vary. Sunflower yields were determined as 2,782 kg/ha in Türkiye (Gül and Coban, 2020), 2,575 kg/ha in Kazakhstan (Gordeyeva *et al*., 2024), and 2,798 kg/ha in Ethiopia (Awoke and Anteneh, 2022).

As a result of our research in 2022, the effect of sowing scheme and plant density on the productivity of sunflower varieties was different. In the control (70x35-1/ 42 thousand plants) version of the "Alazan" variety, the yield per hectare was 25.8 centners (1 centner=100 kg). 70x35-1 sowing scheme, with a density of 47 thousand plants per hectare, yielded 32.3 centners. This means 5.8 centners or 22.4% more than the control variant. 70x25-1 sowing scheme, 56,000 plant density options per hectare yielded 31.0 centners/ha, which means 5.2 centners or 20.1% more yield than the control variant (Table 6).

In "Oreshka" variety, 70x35-1 sowing scheme, 42 thousand plant density per hectare yielded 33.6 centners, which means 7.8 centners or 30.2 % more yield. İn the 70x30-1 sowing scheme, with a density of 47 thousand plants per hectare, the yield per hectare was 35.9 centners, which means 10.1 centners and 39.1% excess yield. In the 70x25-1 sowing scheme, with a density of 56 thousand plants per hectare, the yield per hectare was 34.6 centners, which means 8.8 centners and 33.9% excess yield.

Table 6: *Effect of sowing scheme and plant density on productivity of sunflower varieties (2022).*

Varieties	Variants	Productivity per repetition (centner/ha) (*)				Average yield (centner/ha) (*) (**)	Product increase	
		I	II	III	IV		(centner/ha) (*)	%
Alazan	70×35-1(42 thousand plants)	25.4	26.2	24.9	26.7	25.8	-	-
	70×30-1(47 thousand plants)	29.9	32.7	31.8	32.3	31.6	5.8	22.4
	70×25-1(56 thousand plants)	29.5	31.6	32.5	30.4	31.0	5.2	20.1
Oreshka	70×35-1(42 thousand plants)	33.1	34.6	33.2	33.8	33.6	7.8	30.2
	70×30-1(47 thousand plants)	35.2	34.9	36.7	36.9	35.9	10.1	39.1
	70×25-1(56 thousand plants)	34.8	33.4	34.6	35.6	34.6	8.8	33.9
Kazio	70×35-1(42 thousand plants)	29.4	30.5	31.5	32.0	30.8	5.0	19.3
	70×30-1(47 thousand plants)	32.4	33.1	31.8	32.3	32.4	6.6	25.5
	70×25-1(56 thousand plants)	30.9	32.6	30.7	31.8	31.5	5.7	22.0

(*) 1 centner = 100 kg (**) Significant at the 0.05 level

Table 7: *Effect of sowing scheme and plant density on productivity of sunflower varieties (2023).*

Varieties	Variants	Yield per repetition (centner/ha) (*)				Average yield (centner/ha) (*) (**)	Yield increase	
		I	II	III	IV		(centner/ha) (*)	%
Alazan	70×35-1(42 thousand plants)	22.1	24.5	22.7	23.5	23.2	-	-
	70×30-1(47 thousand plants)	25.5	29.3	26.7	27.1	27.1	3.9	16.9
	70×25-1(56 thousand plants)	26.6	28.4	27.9	25.2	27.0	3.8	16.4
Oreshka	70×35-1(42 thousand plants)	24.5	29.6	28.3	30.7	28.2	5.0	21.5
	70×30-1(47 thousand plants)	29.4	32.0	32.8	32.9	31.7	8.5	36.6
	70×25-1(56 thousand plants)	26.6	31.7	32.3	31.8	30.6	7.4	31.8
Kazio	70×35-1(42 thousand plants)	25.1	27.4	29.2	26.7	26.9	3.7	15.9
	70×30-1(47 thousand plants)	27.2	29.6	30.3	28.8	28.9	5.7	24.8
	70×25-1(56 thousand plants)	26.7	28.8	29.6	28.5	28.4	5.2	22.4

(*) 1 centner = 100 kg (**) Significant at the 0.05 level.

In "Kazio" variety 70x35-1 sowing scheme, 42 thousand plants per hectare, 30.8 centners of yield was obtained, which means 5.0 centners or 19.3% more yield. In the 70x30-1 sowing scheme, with a density of 47 thousand plants per hectare, the yield per hectare was 32.4 centners, which means 6.6 centners and 25.5% excess yield. In the 70x25-1 sowing scheme, with a density of 56 thousand plants per hectare, the yield per hectare was 31.5 centners, which means 5.7 centners and 22.0% excess yield.

Productivity in all 3 varieties was slightly different from the effect of applied agrotechnical measures. It varied greatly depending on plant density and sowing scheme. The highest yield was 35.9 centners in the 70x25-1 sowing scheme of the Oreshka variety, with a density of 47,000 plants per hectare, which means 10.1 centners and 39.1% excess yield.

As a result of study in 2023, the effect of sowing scheme and plant density was different on the productivity of sunflower varieties. In the control (70x35-1 (42 thousand plants)) variant of the Alazan variety, the productivity per hectare was 23.2 centners. 70x30-1 sowing scheme, with a density of 47 thousand plants per hectare, yielded 27.1 centners. This means 3.9 centners or 16.9% more productivity than the control variant. 70x25-1 sowing scheme, with a density of 56,000 plants per hectare, yielded 27.0 centners/ha, which means 3.8 centners or 16.4% more than the control variant (Table 7).

In the Oreshka variety, 28.2 centners of yield was obtained in the 70x35-1 sowing scheme, with a density of 42,000 plants per hectare, which means 5.0 centners or 21.5% more yield. In the 70x30-1 sowing scheme, with a density of 47 thousand plants per hectare, the yield per hectare was 31.7 centners, which means 8.5 centners and 36.6% excess yield. In the 70x25-1 sowing scheme, with a density of 56 thousand plants per hectare, the yield per hectare was 30.6 centners, which means 7.4 centners and 31.8% excess yield.

70x35-1 sowing scheme of Kazio variety, 26.9 centners yield was obtained in variant with 42 thousand plants density per hectare, which means 3.7 centners or 15.9% more yield. 70x30-1 sowing scheme, 47,000 plant density per hectare and 4 times irrigation, yield per hectare was 28.9 centners, which means 5.7 centners and 24.8% excess yield. In the 70x25-1 sowing scheme, with a density of 56 thousand plants per hectare, the yield per hectare was 28.4 centners, which means 5.2 centners and 22.4% excess yield.

Productivity in all 3 varieties was slightly different from the effect of applied agrotechnical measures. It varied greatly depending on plant density and sowing pattern. The highest yield was 31.7 centners in the variety Oreshka, 70x30-1 sowing scheme, 47 thousand plants per hectare, which means 8.5 centners and 36.6% excess yield.

Some previous studies have also shown that fertilization increases the yield and quality of sunflower (Baraich *et al.* 2016; Gawande *et al.* 2022). In some studies, it has been determined that increasing plant density significantly increases seed yield (Barros *et al.*, 2004; Szabo and Pepo, 2007). In a study conducted in Türkiye, the yield and oil yield of sunflower varieties were positively affected by increasing plant density. It was determined that the yield varied between 3,132

and 4,810 kg/ha (Barisik *et al*., 2024).

In Azerbaijan, the state applies different subsidies to sunflower farmers. The effect of subsidies on fertilizer and pesticide costs was determined as 28.5%, and on fuel and motor oils as 11.3% (Fikratzade, 2020).

Conclusions and Recommendations

As a result of the long-term scientific research conducted by scientists with sunflowers and our research, it became clear that the height of the main stems is not the same from the genotype, biological and morphological characteristics of the varieties. Sometimes, depending on the influence of natural factors, there is a certain difference in the height of the main stems. The implementation of all agro-technical measures designed for the cultivation of sunflowers in the optimal time has a positive effect on its development stages in all cases. Despite the provision of plant density to sunflower varieties, the unstable climate changes the development dynamics of the varieties. As a result of this study with sunflower, it was found that the productivity of all 3 varieties was different from the effect of applied agrotechnical measures. As a result of the experiments carried out in both years, the highest productivity was obtained in the Oreshka variety in the 70x25-1 sowing scheme, with a density of 47 thousand plants per hectare.

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Novelty Statement

To improve the productivity and quality of the plant, which has such a strategic importance, multi-disciplinary scientific research works are being conducted. The variety has a special role in improving the quality of the product. In recent times, farmers who plant sunflowers have a lot of difficulty in selecting varieties that give higher yields in the natural and climatic conditions of their farms.

Author's Contribution

All authors contributed equally to the article. The results obtained in the study were interpreted together and all authors read and checked the article.

Conflicts of interest

The authors have declared no conflict of interest.

References

Aliyev, H.A., 1999. Decree on some issues related to acceleration of agrarian reforms, Baku.

Aliyev, I.H., 2008. Food security program in the Republic of Azerbaijan. "Xalq" newspaper, Baku.

Aliyev, I.H., 2019. State Program of Socio-Economic Development of the Regions of the Republic of Azerbaijan in 2019-2023, Baku.

Anonymous, 2017. Sunflower Growing and Harvesting-Recommendations, Ministry of Agriculture of the Republic of Azerbaijan, Ganja, pp. 25.

Anonymous, 2025. Samukh District, https://en.wikipedia.org/wiki/Samukh_District, Access Date: 20.02.2025.

Aslanov, H.A. and N.T. Abbasova. 2022. Influence of mineral fertilizers on sunflower yield in the Western Zone of Azerbaijan. Agrarian Sci., 2022(1): 93-96. https://doi.org/10.32634/0869-8155-2022-355-1-93-96

Awoke, T. and Anteneh, T., 2022. Evaluation of sunflower (*Helianthus annuus* L.) varieties for growth, yield and yield components under ırrigation at Lowland Area of South Omo Zone, Southern Ethiopia, J. Agric. Aquacult., 4(2): 1-6.

Azerbaijan State Statistical Committee (ASSC), 2025. Agricultural Statistics, https://www.stat.gov.az/?lang=en, Access Date: 23.02.2025.

Baraich, A.A.K., A.W. Gandahi, S. Tunio and Q. Chachar. 2016. Influence of micronutrients and their method of application on yield and yield components of sunflower. Pak. J. Bot., 48: 1925-1932.

Barisik-Kayin, G., H. Kayin and A.T. Goksoy. 2024. Effects of plant density on micronutrient uptake in sunflower (*Helianthus annuus* L.) varieties. Turk. J. Field Crops, 29(1): 9-17. https://doi.org/10.17557/tjfc.1349344

Barros, J.F.C., M.D. Carvalho and Basch, G., 2004. Response of sunflower (*Helianthus annuus* L.) to sowing date and plant density under mediterranean conditions. Eur. J. Agron., 21: 347- 356. https://doi.org/10.1016/j.

eja.2003.10.005
Bashirova, G., 2022. Directions for the development of the sunflower sector along the value chain. Agric. Econ., 40(2): 68-80.
FAOSTAT, 2025. Crop production statistics, http://faostat.fao.org, Access Date: 21.02.2025.
Fikratzade, F.F., 2020. Assessment of the effectiveness of agricultural subsidies in Azerbaijan. Agric. Econ., 31(1): 6-16.
Gawande, R.S., P.N. Karanjikar, P.S. Waghmare, A.P. Kokate and D.S. Sawant. 2022. Effect of soil and foliar application of zinc sulphate and ferrous sulphate on growth and yield of sunflower (*Helianthus annus* L.). Pharma Innov., 11(1): 1349-1352.
Gholinezhad, E., R. Darvishzadeh and I. Bernousi. 2015. Evaluation of sunflower grain yield components under different levels of soil water stress in Azerbaijan. Genetika, 47(2): 581-598. https://doi.org/10.2298/GENSR1502581G
Gordeyeva, Y., V. Shelia, N. Shestakova, B. Amantayev, G. Kipshakbayeva, V. Shvidchenko, S. Aitkhozhin, A. Kurishbayev and G. Hoogenboom. 2024. Sunflower (*Heliánthus ánnuus*) yield and yield components for various agricultural practices (sowing date, seeding rate, fertilization) for steppe and dry steppe growing conditions. Agronomy, 14: 36. https://doi.org/10.3390/agronomy14010036
Gül, A. and R. Ada. 2019. Determination of effects of different intra-row spacing on yield and quality in sunflower (*Helianthus annuus* L.). J. Bahri Dagdas Crop Res., 8(2): 289-298.
Gül, V. and Coban, F., 2020. Determination of yield and quality parameters of oil sunflower genotypes grown in Türkiye. Turk. J. Field Crops, 25(1): 9-17. https://doi.org/10.17557/tjfc.609749
Huseyn, R.Z., 2017. The problems of ıncreasing of competitiveness of plant-growing products in the republic of Azerbaijan, Ministry of Agriculture of the Republic of Azerbaijan, Agricultural Economy Scientific Research Institute, Baku, 30 p.
Ibrahimov, A.Q. and M.A. Valiyeva. 2018. Sunflower, plant protection and technical crops scientific research ınstitute, Ganja, pp. 105.
Ismayilova, H., 2022. Preliminary processing of sunflower seeds in azerbaijan based on tshe ımplementation of new technologies. Agrarian Sci. J., 2022(2): 99-102. https://doi.org/10.28983/asj.y2022i2pp99-102
Ismayilzade, N.N., V.S. Samedov, B. Kard and C.L. Jones. 2015. Sunflower seed damage and economic ınjury level of the european sunflower moth (Lepidoptera: Pyralidae) in the Republic of Azerbaijan. J. Entomol. Sci., 50(2): 138-146. https://doi.org/10.18474/JES14-41.1
Karaozan, M.M. and I. Ertekin. 2022. Evaluation of feed quality in some varieties of snack sunflower cultivated with different sowing densities. J. Agric. Nat. Mus Alparslan Univ., (2): 41-49.
Kazimov, N.N. and A.E. Ismayilov. 2024. Study of farm value indicators of new and prospective introduced sunflower varieties. Scientific works of ADAU, Ganja, p. 20-25.
Li, J., Z. Qu, J. Chen, B. Yang and Y. Huang. 2019. Effect of planting density on the growth and yield of sunflower under mulched drip irrigation. Water, 11(4): 752. https://doi.org/10.3390/w11040752
Mammadov, Q.Y. and M.M. Ismayilov. 2012. Crop production, East-West Publishing House, Baku, pp. 356.
Mladenovic, E.,S. Cvejic, S. Jocic, N. Cuk, J. Cukanovic, M. Jockovic and A.M. Jeromela. 2020. Effect of plant density on stem and flower quality of single-stem ornamental sunflower genotypes. Hortic. Sci. (Prague), 47(1): 45-52. https://doi.org/10.17221/10/2019-HORTSCI
Pekcan, V. and E. Esendal. 2015. The Effects of irrigation, nitrogen levels and plant population on yield and quality characteristics in confectionary sunflower (*Helianthus annuus* L.). Anadolu J. AARI, 25(2): 24-36.
Seyidaliyev, N.Y., F.H. Gurbanov and M.Z. Mammadova. 2014. Seed science. Baku, pp. 315.
Szabo, A. and P. Pepo. 2017. Effect of plant density on yield and oil content of different sunflower genotypes. Cereal Res. Commun., 35: 1121-1124. https://doi.org/10.1556/CRC.35.2007.2.239