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PRODUCTIVITY INDICATORS OF NEWLY INTRODUCED STRAWBERRY VARIETIES IN THE SOIL AND CLIMATIC CONDITIONS OF THE GUBA-KHACHMAZ ECONOMIC REGION

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Abstract. The article contains information on the economic and biological characteristics of strawberry varieties introduced to the Guba-Khachmaz economic region. The object of the research work is the strawberry varieties Cupid, Fenella, Flamenco, Christine, introduced from England. We have conducted scientific research on the adaptation of these varieties to the soil-climatic conditions of the Guba-Khachmaz economic region and their productivity. The productivity of strawberry plants depends on many factors such as variety selection, cultivation methods, environmental conditions, etc. The purpose of the research work is to study and generalize modern methods of increasing the yield of strawberry varieties, as well as to analyze their effectiveness. The application of an integrated approach in plant breeding, including the use of balanced fertilizers and biological methods of pest control, affects the yield and quality of berry varieties. According to the results of the research, the Fenella and Cupid varieties stood out from the introduced strawberry varieties in terms of productivity. Thus, on average, 1.1-1.2 kg (61-63 tons/ha) of the crop was obtained from 1 bush and the Fenella variety was recorded as the variety with the largest caliber fruits.

Keywords: *Strawberry, productivity, Azerbaijan, introduction, irrigation, mulching.*

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1. Introduction

The strawberry plant is one of the most loved and consumed berries in the world. With its unique aroma and smell, strawberries are eaten with admiration by both adults and children and are widely grown in our regions (Hansen, 1986).

Obtaining high yields from strawberry plantations is one of the most important tasks facing agronomists and farmers. In this regard, many literatures have reflected the selection of strawberry varieties, cultivation methods, research results and new technologies.

The productivity of strawberry plants (Fragaria × Ananassa) is significantly affected by agrotechnical care measures, soil and climatic conditions of the area and biological characteristics of varieties (Darnell & Stutte, 2001). This article presents the results of

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many years of scientific research aimed at quantitatively and qualitatively evaluating these factors affecting strawberry plant productivity.

Since the root system of the strawberry plant is spread close to the surface of the earth, the plant has difficulty absorbing moisture (water) in deeper layers. For light loamy soils, the moisture content is 65-70% and for heavy clay soils, it is favorable for strawberry cultivation, as it rises to 80% (Hancock, 1999).

Strawberry is a water-demanding plant, with leaves containing 68-72% water and berries containing 80-90% water. The plant's root system is sensitive to the slightest changes in humidity in the environment. For this reason, ensuring that the main part of the strawberry plant's root system is evenly supplied with moisture at a depth of 0-40 cm plays a key role in achieving a high and stable strawberry yield. Low or no humidity in the air and soil during the flowering phase negatively affects the drying of berries, the size and yield of berries when they are filled with plastic mass and the formation of buds during the second growth stage of the growing season (De Klerk *et al*., 1999). Taking all this into account, the strawberry plant should be watered regularly, not allowing the soil moisture to drop to a critical level or even a small decrease. Even when precipitation is observed, the strawberry plant needs to be watered during the flowering, berry formation, fruit filling and bud development stages (Hartmann *et al*., 2011).

The consumption (amount) of irrigation water should be regulated depending on the stage of development of the strawberry plant, weather conditions, soil temperature and humidity. The need for moisture in the soil, depending on the phenological phases of the plant, increases at the beginning of the vegetation period, reaches a maximum during the berry harvest period and decreases at the end of the vegetation period. Irrigation during the growth and reproduction of flower stalks, including during the mass flowering phase, leads to abundant, high-quality flowering and development of berries. Therefore, it is necessary to monitor the soil moisture at the level of 70% during the beginning of the vegetation period and 75% during the flowering phase of the plant (Bollmark *et al*., 1995).

Low soil moisture after harvest has a negative effect by delaying the development of strawberry shoots and the formation of new strawberry seedlings. It also weakens these plants and as a result, minimizes the yield of the following year. High soil moisture after harvest delays the formation of flower buds. In order to prevent such situations, the optimal soil moisture during this period should be maintained at 60% (Beckles, 2012).

The fruits of the strawberry plant belong to the berry group. Since the berries do not have a seed cavity, they are false fruits, with the seeds located directly inside the juicy pulp. The berries are formed as a result of the swelling of the flower bed. The color of the berries of the strawberry plant varies depending on the variety, usually bright red. The taste of the berries is very sweet, sweet or sour-sweet, the juiciness is very juicy, juicy or slightly juicy and the smell is very attractive (Dirr & Heuser, 2006).

Strawberry is one of the most important plants in terms of production among berry plants. The strawberry plant has a high adaptability potential and can be cultivated in areas with different climatic types. However, the realization of this adaptability potential depends on the genotype, variety and cultivation conditions of the variety. More than 10 thousand varieties of strawberry plants are known to science worldwide (Garner, 2013).

The benefits of strawberry fruit are endless, as the strawberry plant is a useful fruit for healthy nutrition. Strawberry berries are one of the fruit plants with very rich nutritional value and are beneficial for human health. Strawberry berries, which are rich in vitamin C, strengthen immunity, have a positive effect on skin and eye health. The antioxidants they contain prevent cell damage and reduce the risk of heart disease and

some types of cancer. Strawberry berries, which are rich in dietary fiber, regulate digestion, prevent constipation and protect intestinal health. Strawberry berries regulate blood pressure, reduce bad cholesterol levels and prevent cardiovascular diseases (Pauling, 2008).

Place of research. The research work was carried out at the Zardabi Scientific Experimental Base of the Scientific Research Institute of Fruit and Tea Growing of the Republic of Azerbaijan. The research area is located at an altitude of 200 m above sea level.

The Guba-Khachmaz economic region is located in the northeast of our country and covers the administrative districts of Guba, Gusar, Khachmaz, Shabran and Siyazan. The territory of the economic region, with a total area of 6.96 km^2, consists of mountainous, foothill and plain areas.

In the Guba-Khachmaz economic region, there are mountain rivers such as Gudyalchay, Gusarchay, Velvale and Karachay, which are of irreplaceable importance for the fruit growing sector.

The vast majority of precipitation in the Guba and Gusar districts of the region falls in autumn and spring. The first autumn frosts are observed in the second decade of November.

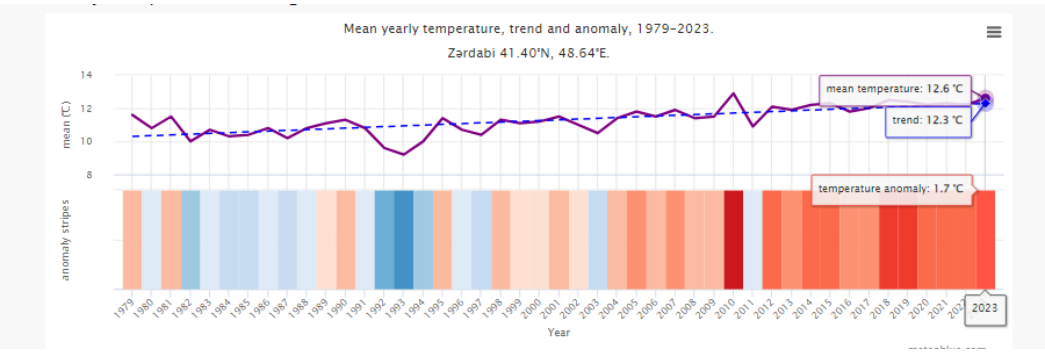

Figure 1. Multi-year average temperature indicators of the area ℃

The multi-year average temperature indicators for the Zardabi settlement of the Guba region are reflected in Figure 1 (1979-2023). The upward line with broken blue lines indicates climate change. As can be seen from the figure, based on the multi-year average indicators, the average annual temperature continues to increase over the years. The warming bands are marked in the lower part of the figure. The colors shown represent the average temperature for a year, with each stripe being blue for cold years and red for warm years. As can be seen from the figure, the average annual temperature in Zardabi settlement of Guba region on the eve of 2021-2023 ranged between 12.2-12.60 ℃.

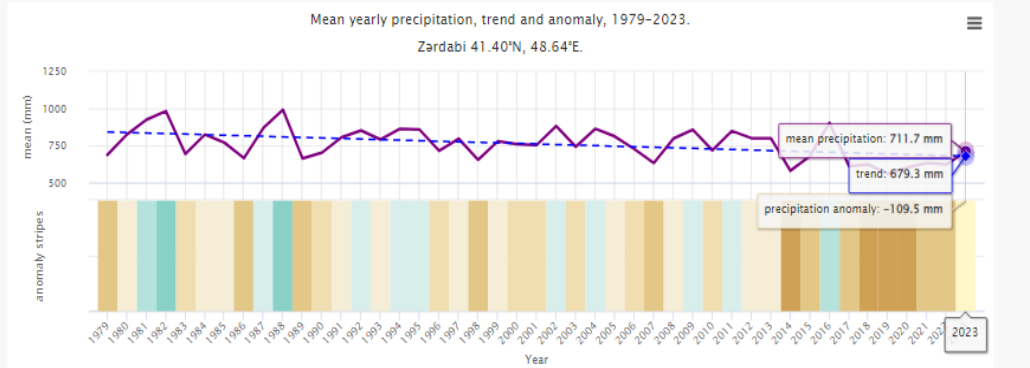

Figure 2. Multi-year average precipitation in the area in mm

The multi-year average precipitation for the Zardabi settlement of the Guba region is shown in Figure 2 (1979-2023). The downward sloping line with broken blue lines shows the change in the amount of precipitation. As can be seen from the figure, based on the multi-year averages, the amount of multi-year average precipitation continues in a decreasing order over the years. The precipitation bands are marked at the bottom of the image. The colors marked represent the average precipitation amount for a year, with each band being green for high precipitation and red for low precipitation. As can be seen from the image, the average precipitation amount recorded in 2023 in Zardabi settlement of Guba region was 711.7 mm.

Table 1. Temperature and precipitation anomaly for the (April-August) active growth period (2023)

№	Months of the year	Temperature, °C	Precipitation, mm	Land surface temperature, °C		Soil moisture, %	
				0-10	10-40	0-10	10-40
1	April	1.1	-18	22-24	20-22	10-12	12-14
2	May	0.6	-9	24-26	22-24	12-14	14-16
3	June	0.4	9	22-24	20-22	14-16	16-18
4	July	0.2	-12	24-26	22-24	12-14	14-16
5	August	2.7	-42	26-28	24-26	14-16	16-18

Table 1 shows the anomaly of soil temperature and humidity indicators of the study area in 2023. As can be seen from the Table 1, the highest temperature anomaly during the strawberry plant vegetation period was 2.7°C in August, the lowest was 0.2°C in July, the precipitation anomaly was -42 mm in August and 9 mm in June. The anomaly of soil surface temperature and soil moisture varied between 20-22 and 26-28°C, 10-12 and 16-18%, respectively. Soil humidity and temperature are the main factors affecting the productivity of strawberry plants. Based on the indicators obtained as a result of observations, plants are watered and fertilized.

Research object. The object of the research work is the strawberry varieties Cupid, Fanella, Kristin and Flamenco introduced from England (Figure 3). Strawberry seedlings were planted on the ridge, with anti-weed mulch, in a planting pattern of 30x15x80 cm.

Figure 3. View of the strawberry field

2. Research methodology

The research work was carried out on the basis "Methodology and program of variety development of fruit, berry and berry fruit plants" of G.A. Lobanov, T.V. Morozova and others (1973), "Methodology and program of variety development of fruit, berry and berry fruit plants" (1999) with the general editorship of Y.N. Sedov and T.P. Ogoltsova. Experiments were conducted on introduced strawberry varieties. Appropriate phenological observations were conducted regularly based on the existing methodology, selecting 10 plants from each variety, the phenological phases of the beginning and end of flowering, fruit ripening and leaf shedding were recorded, the total vegetation period was determined and the distribution and development of the mustaches were studied (Howard, 2008). Regular phenological observations were conducted during the vegetation period to study the degree of disease and pest infestation of introduced strawberry varieties, the quality indicators of fruits in accordance with the existing standards for strawberry plants and the annual development cycle of the varieties. For this purpose, the beginning and end dates of phenological phases such as flowering (beginning - 5%, mass - 70%, end - 95%), fruit ripening and leaf fall (beginning - 5%, end - 95%) were studied and their dates were recorded.

3. Experimental part

Since phenological phases and development dynamics indicate the degree of adaptation of the plant to the area, researchers mainly evaluate it based on these indicators. The duration and timing of flowering is the most important phenological phase that affects the productivity of the strawberry plant. Our observations show that the active development stages of the strawberry plant begin with the opening of flowers and end with the shedding of leaves at the end of vegetation. These stages include the opening of

flower buds, flowering, the formation of leaves and tendrils, the ripening of fruits and the shedding of leaves. The characteristics of the active development stages depend on a number of factors (varietal characteristics, cultivation conditions and applied cultivation technology, environmental factors, etc.). We have studied the flowering phase and duration of strawberry varieties (Table 2).

Table 2. Flowering phase and duration of strawberry varieties (2022-2023)

Varieties	Flowering					
	Beginning		The end		Duration of treatment, days	
	2022	2023	2022	2023	2022	2023
Cupid	11.V	04.V	14.VI	04 VI	34	31
Flamenco	08.V	01.V	11.VI	01VI	34	31
Fenella	07.V	01.V	09.VI	06VI	33	35
Christine	04.V	29.IV	06.VI	05VI	33	37

We have studied the flowering phase and duration of strawberry varieties (Table 2). Table 2 shows that the beginning of flowering in strawberry varieties was May 04-11 in 2022, April 29-May 04 in 2023 and the end was June 06-14 in 2022 and June 01-06 in 2023. During the flowering phase, the average daily air temperature in 2022 was +27°C and in 2023 this indicator was +29°C. The duration of the flowering phase lasted 31-37 days in 2022-2023. The Christine variety bloomed relatively early compared to other varieties, while the Cupid variety bloomed relatively late. The Christine variety bloomed 5 days earlier than the Cupid variety and 2 days earlier than the Flamenco and Fenella varieties. Depending on the varieties, the duration of the flowering phase was observed in 2022 as 34 days in the Cupid and Flamenco varieties and 33 days in the Fenella and Christine varieties. In 2023, this period was the longest, 37 days in the Kristin variety, 35 days in the Fenella variety and 31 days in the Flamenco and Cupid varieties. We studied the fruit ripening phase and duration of strawberry varieties (Table 3).

Table 3. The beginning and end of the ripening of berries of strawberry varieties (2022-2023)

Variety	Fruit ripening					
	Beginning		The end		Duration of operation, days	
	2022	2023	2022	2023	2022	2023
Cupid	31.V	26 V	23.VI	18.VI	23	28
Flamenco	24.V	18.V	26.VI	20.VI	33	33
Fenella	26.V	21.V	20.VI	15.VI	25	25
Christine	22.V	16.V	24.VI	18.VI	32	33

As can be seen from Table 3, the ripening of fruits by varieties in 2022 covered the dates of May 22-31, in 2023 - May 16-26 and the end of fruit ripening covered the dates of June 20-26 in 2022 and June 15-20 in 2023. The average daily air temperature during the fruit ripening period was +30°C in 2022 and +32°C in 2023. The ripening of berries of strawberry varieties was 23-35 days in 2022-2023. When comparing the ripening times of the introduced strawberry varieties, the earliest ripening variety was recorded as the Christine variety (16.V-18.VI) and the latest ripening variety was recorded as the Cupid variety (31.V-18VI). Flamenco and Fenella varieties were recorded as relatively medium-ripening compared to other varieties. In 2023, the most productive period was observed in the Christine and Flamenco strawberry varieties with a fruit ripening period of 33 days, in the Fenella variety with a fruiting period of 25 days and in the Cupid variety with a

fruiting period of 28 days. The fact that strawberry bushes bear fruit for such a long time is due to their being in the full productive period.

In our research, we studied the productivity indicators of strawberry varieties (Table 4). As can be seen from the Table 4, the number of buds on 1 bush varied between 7-10, with the highest number observed in the Cupid variety and the lowest in the Flamenco variety. The number of fruits on 1 bush varied between 56-70, with the highest number observed in the Cupid variety and the lowest in the Flamenco variety. The sizes and weights of the fruits of the research varieties were investigated by us. The length of the fruit for strawberry varieties was 3.67-4.25 cm, the width was 3.29-3.82 cm and the weight of 1 berry varied between 17.36-21.26 g. Thus, based on the scientific research and measurement work conducted, the Fenella variety with 4.25x3.82 cm and 21.26 g was distinguished among the strawberry varieties according to the caliber sizes of the fruits and the weight of 1 cherry fruit. We studied the productivity indicators of strawberry varieties and obtained 0.99-1.27 kg of product per bush and 49.5-63.5 tons of product per hectare, respectively. It is clear from the Table 4 that all introduced strawberry varieties are high-yielding varieties. However, a comparison of the productivity indicators of introduced strawberry varieties shows that Fenella is the variety with the highest productivity among the varieties with 63.5 t/ha. The Cupid variety had a relatively low yield of 61.5 t/ha, 2 tons less than the Fenella variety. The Flamenco variety had the lowest yield of all introduced strawberry varieties, at 49.5 t/ha.

Table 4. Yield of strawberry varieties

Variety	Number of buds/ bush	Number of fruits/bush	Weight of 1 cherry, g	Fruit size		Productivity	
				length, cm	width, cm	kg/ bush	ton/ha
Cupid	9-10	70±3	17.65±3.45	3.73±0.76	3.62 ±0.64	1.23	61.5
Flamenco	7-8	56 ±2	17.78±3.28	3.67±0.25	3.29± 0.42	0.99	49.5
Fenella	7-9	60 ±2	21.26±6.31	4.25±0.52	3.82± 0.45	1.27	63.5
Christine	8-10	67±3	17.36±3.65	4.07±0.43	3.56 ±0.30	1.15	57.5

5. Conclusion

The following results were obtained by comprehensively studying the economic and biological characteristics of 4 strawberry varieties introduced to the Guba-Khachmaz economic region in 2022-2023:

1. The flowering phase of strawberry varieties varied from year to year, covering the period from April 29 to June 14 and the average daily air temperature during the flowering phase was +27...+29 °C. The duration of the flowering phase was 31-37 days in 2022-2023.

2. The ripening of berries in strawberry varieties varied by year and covered the period from June 16 to 26, with an average daily air temperature of +30...+32 °C observed during this stage. The ripening of berries in strawberry varieties lasted 23-35 days in 2022-2023.

3. Among the introduced strawberry varieties, the earliest ripening variety was recorded as Christine (16.V-18.VI) and the latest ripening variety was Cupid (31.V-18VI). Flamenco and Fenella varieties were recorded as relatively medium ripening compared to other varieties.

4. The number of fruits per bush was observed to be 56-70, with the highest number observed in the Cupid variety and the lowest number observed in the Flamenco variety. According to the results of scientific research, the Fenella variety with 4.25x3.82 cm and 21.26 g stood out among strawberry varieties according to the caliber size of the fruits and the weight of 1 berry.

5. According to the productivity indicators of strawberry varieties, the yield per bush was 0.99-1.27 kg and accordingly, the yield per hectare was 49.5-63.5 tons. All introduced strawberry varieties are high-yielding varieties. However, the highest productivity among the introduced strawberry varieties was observed in the Fenella variety with 63.5 t/ha.

Recommendations

1. It is advisable to plant Fenella and Cupid varieties selected from 4 strawberry varieties introduced in the Guba-Khachmaz economic region in the creation of new high-yielding varieties in selection-oriented research and on farms, taking into account their adaptation to the climatic conditions of the geographical area, valuable economic and biological characteristics and high quality indicators;

2. It is recommended to plant strawberry seedlings on ridges, with weed control mulch applied, in a planting pattern of 30x15x80 cm;

3. It is advisable to conduct a soil analysis to study the balance of nutrients in the soil's acidity, to improve the soil's structure and productivity, to cultivate the soil using organic fertilizers such as compost or manure and to plant plants at an optimal distance to ensure good air circulation and lighting;

4. It is recommended to use organic mulch (straw, wood chips) or plastic mulch to maintain soil moisture, suppress weeds and protect berries from contamination and drip irrigation to provide even moisture to the area and reduce the risk of disease;

5. For the development of strawberry plants and for abundant and stable yields, it is advisable to use balanced micro and macro fertilizers, taking into account the results of soil analysis and the stages of plant development. It is advisable to use nitrogen fertilizers during the vegetation period and phosphorus and potassium fertilizers during flowering and yield;

6. In order to reduce the consumption of nutrients that strawberry plants take from the soil and increase productivity, it is recommended to regularly prune the bushes, improve air circulation within the plant and reduce the risk of disease infection and spread of diseases by cutting off old and diseased leaves and thinning the bushes;

7. In order to improve the quality of the berry crop, it is recommended to use biological control methods (predatory insects, biopreparations) against strawberry pests and carry out regular inspections and to use chemical control measures against diseases and pests only when necessary, in accordance with label and safety regulations;

8. It is advisable to use greenhouses or temporary shelters to protect plants and fruits from adverse weather conditions (frost, heavy rain, etc.) and white covers to protect them from birds and insects;

9. Growing strawberries in the same place for several years leads to disease infestation and depletion of the soil's nutrient balance. To prevent this, it is recommended to apply crop rotation using predecessor plants.

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