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RELATIONSHIP BETWEEN YIELD AND YIELD PARAMETERS OF CONFECTIONERY SUNFLOWER CULTIVARS

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ABSTRACT

In the world, sunflower is grown mainly for the production of vegetable oil. In some countries, sunflower oil is produced and traded as confectionery as well as oil production. . Cultivation of confectionery sunflower is characterized by the fact that different markets have different demands when it comes to seed size, stem color and other characteristics, making this process more difficult and costly.

This study aimed to determine the productive varieties that have an important place in revitalizing the confectionery sunflower potential in Kırşehir province, as well as to compare the varieties registered in recent years. The experiment was established in the experimental areas of Kırşehir Ahi Evran University with 3 replications, according to the randomized block trial design, in the production season of 2023. In the research, emergence, flowering and maturity time, number of leaves, plant height, stem thickness, table diameter, number of seeds in the table, thousand seed weight, plant yield, seed yield, stem yield, kernel ratio and harvest index values were examined and it was aimed to determine the relationships between all parameters

The strongest positive correlations are obtained between thousand see weight, plant yield, seed yield, harvest index and the other positive strong relation was found kernel ratio and hectolitre. This study also showed that negative significant correlation was found between kernel ratio, number of leaves and seed per plant, table diameter, seed yield, thousand seed weight and harvest index and the other negative strong relation was found table diameter and hectolitre.

Keywords: Confectionery Sunflower, Seed Yield, Yield Traits, Correlation Analysis.

1. INTRODUCTION

Sunflower is generally produced as an oil crop in the world and in Turkey. In addition, its production and use as confectionery is also common. When world production statistics are examined, there is no distinction between confectionery and oil sunflowers. Türkiye keeps oil and confectionery sunflower production statistics separately, unlike the rest of the world, due to significant differences in their usage areas. Although there has been a significant increase in oil sunflower in Turkey in the last twenty years, the cultivation area reached 864.6 thousand hectares in 2023 (Table 1). In addition, the cultivation area of confectionery sunflower has varied between 66 thousand hectares and 105 thousand hectares in the last 20 years, and production was achieved in approximately 87.9 thousand hectares in 2023. (TUIK, 2024).

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Table 1. Changes of sunflower (oil and confectionery) cultivation of Turkiye

Year	Production area (ha)		Rate of confectionery area (%)	Production (ton)		Rate of confectionery production (%)
	Oil	Confectionery		Oil	Confectionery	
2006	509858	75390	12,9%	1010000	108000	9,7%
2007	485455	66742	12,1%	770000	84407	9,9%
2008	509279	68679	11,9%	900387	91613	9,2%
2009	514980	68998	11,8%	960300	96825	9,2%
2010	551389	89954	14,0%	1170000	150000	11,4%
2011	555922	99694	15,2%	1170000	165000	12,4%
2012	504616	100000	16,5%	1200000	170000	12,4%
2013	520138	89524	14,7%	1380000	143000	9,4%
2014	549683	103640	15,9%	1480000	157900	9,6%
2015	568901	116272	17,0%	1500000	180700	10,8%
2016	615349	102968	14,3%	1500000	170716	10,2%
2017	681345	98094	12,6%	1800000	164385	8,4%
2018	648659	85531	11,6%	1800000	149229	7,7%
2019	675236	76457	10,2%	1950000	150000	7,1%
2020	650395	77973	10,7%	1900000	167004	8,1%
2021	810959	89176	9,9%	2215000	200000	8,3%
2022	899254	80436	8,2%	2350000	200000	7,8%
2023	864628	87937	9,2%	1960000	238000	10,8%

When the ratio of oil sunflower and confectionery sunflower planting area is examined, approximately 8.20 to 17.0% of the total sunflower planting area in the last 20 years is made up of confectionery sunflower planting. According to the data, 8.20% of the total sunflower area in 2023 was used as confectionery food, and this rate is the lowest rate in the last 20 years (Table 1).

Due to the increase in cultivation area, the production amount of oil sunflower has increased significantly, reaching 1.96 million tons in 2023. The highest production in the last 20 years was 2.35 million tons in 2022. Confectionery sunflower production has varied between 84 thousand tons and 238 thousand tons in the last 20 years, and contrary to the decrease in cultivation areas, production has increased and reached 238 thousand tons in 2023 (Table 1).

The ratio of oil sunflower and confectionery sunflower production amounts to approximately 7.10% to 12.40% of the total sunflower production in the last 20 years. According to the data, 10.80% of the total sunflower production in 2023 was realized as confectionery food.

When Turkey's agricultural areas are evaluated in general, the ecology is extremely suitable for confectionery sunflower cultivation, but it is grown in certain provinces. The highest cultivation area and production amount by province was realized in Kayseri, Konya, Aksaray, Denizli, Erzurum, Sivas and Bursa provinces, respectively, in 2023.

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Although it varies significantly from year to year, 1466 hectares of cultivation area and 2068 tons of production of confectionery sunflower were achieved in Kırşehir province in 2023. When compared to other provinces in terms of confectionery sunflower cultivation, Kırşehir province ranked 14th in cultivation area and 20th in production in Turkey.

Since unimproved populations are widely planted as seeds in our production regions, the productivity level has remained low. When the cultivation area of confectionery sunflower is examined by years, the increase in the cultivation area of confectionery sunflower in recent years has been realized in the provinces of Aksaray, Kayseri and Konya, while the cultivation of confectionery sunflower, which was cultivated up to 8 thousand hectares in Kırşehir in 2015, has shown significant contractions in recent years and the cultivation area of confectionery sunflower has decreased to 1.4 thousand hectares.

Confectionery sunflower seed types, which are generally important for consumer preference in consumption, vary depending on the region. While black colored seeds are preferred by consumers in the Balkan countries, light gray striped and white are preferred in our country. The confectionery sunflower seeds preferred by Turkish people are generally larger and longer. The 1000 seed weight is higher (Kaya 2004). Imports of confectionery sunflowers from China have increased in recent years, as the coarse-seeded and high-fat varieties introduced to the market by China have been preferred by Turkish consumers in recent years.

The use of sunflower as a confectionery is very common both in our country and in different countries of the world, and it is the most consumed confectionery by people in many countries. Sunflower has been used by people as a confectionery for a long time and is used in more than a hundred types of food in the world, such as bread, cake, ice cream, chocolate, cookies, etc. Sunflower seeds are used as stuffing (Lofgren. 1997). Not all of the seeds of the confectionery sunflower varieties produced are used as human food. Seeds are generally divided into 3 classes according to their size;

1. The coarse seeds remaining on the 8.7 mm sieve are used salted and roasted (as a confectionery). Their rate is between 15-25%.
2. The seeds remaining in 8.7 mm-7.1 mm sieves constitute 40-60% of the entire product and the shell is removed and used in confectionery, confectionery and bakery products.
3. Those below 7.1 mm constitute 15-20% of the entire product and are used as birdseed. A good confectionery sunflower meets certain criteria. Namely; Relatively large and uniform seed, with a large interior and a flat shell, loose structure and the main shell color is black with bright white stripes on it, not damaged by insects, rodents, fungi or climatic conditions, the outermost layer of the shell is intact, free of sunflower plant particles and other foreign materials. must be purified (Lofgren 1978).

The majority of studies on sunflower in our country are focused on oil sunflower. Although it is limited to confectionery sunflowers, it gains importance in evaluating regional confectionery sunflower varieties in terms of yield and yield criteria. In recent years, in addition to the development of hybrid sunflower varieties, it has become important to register productive varieties from local lines and update these studies at regular intervals.

Correlation and regression analyses regarding yield and yield parameters in sunflower have been widely investigated and important relationships have been detected (Kaya et al., (2006, 2007, 2009); Demir, 2016 and 2021). In addition, there are limited yield studies and correlation studies on confectionery sunflower. Although there are significant differences according to varieties and regions, these studies have made a significant contribution to breeding studies (.

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This study aimed to determine the productive varieties that have an important place in revitalizing the confectionery sunflower potential in Kırşehir province, as well as to compare the varieties registered in recent years.

2. MATERIAL AND METHODS

In the research, 10 sunflower varieties (Afgan, Ayberk, TG-400, G1, Ela. Stripy 1, Ahmetbey, Palancı 1, ÇRZ-11-10 and Çiğdem-1) were used as materials.

The experiment was established in the experimental areas of Ahi Evran University Bağbaşı Campus with 3 replications, according to the randomized block trial design, in the production season of 2023.

Climate Data

Climate data for 2023 and long-term average are shown in Table 2. According to the climate data received from the General Directorate of Meteorology, the average maximum temperature in the trial months for many years was 25.28 °C, while the average temperature in the trial months of 2023 was 25.52 °C. In the 2023 trial year, the hottest month was August with 34.03°C. Maximum temperatures were observed in July and August higher than in many years. In terms of minimum temperatures, 2023 was approximately 0.8 °C above many years. In terms of average temperatures, the 2023 growing season is similar to the long-term average. The total rainfall amount was 130.9 mm in the 2023 growing season and was observed to be approximately 18.2 mm lower than the total rainfall in many years (176 mm).

Although the highest rainfall during the plant vegetation period in the year the experiment was conducted was in June with 58.39 mm, it was observed that the rainfall in all months was below the average rainfall for many years. While the average relative humidity for many years during the plant growth period was 54.78%, it decreased by 5.89% to 48.89% in 2023. In general, it can be said that the sunflower growing season in the trial year was hotter and drier than in many years (Table 2).

Table 2. Climate data of research area

	Temperature (°C)						Precipitation (mm)		Relative humidity (%)	
	Maximum		Minimum		Mean					
	2023	**Long-term**	**2023**	**Long-term**	**2023**	**Long-term**	**2023**	**Long-term**	**2023**	**Long-term**
April	16.19	17.2	4.94	4.4	10.03	10.8	55.3	40.8	60.55	63.3
May	21.09	22.1	8.54	8.6	14.45	15.5	16.9	44.2	57.67	61.3
June	25	26.3	12.96	12.4	18.67	19.7	52.1	34.9	58.39	55.5
July	30.12	29.9	15.41	15.7	23.03	23.1	3.5	8.1	40.45	48.9
August	34.03	30.1	18.62	15.7	26.43	23.1	0	7.6	33.7	48.1
September	26.7	26.1	12.25	11.1	19.39	18.6	3.1	13.1	42.58	51.6
Mean	25.52	25.28	12.12	11.32	18.67	18.47			48.89	54.78
Total							130.9	148.7		

The chemical and physical structure of the trial area is slightly alkaline (7.5-8.5), its saturation is clay loam (51-70%). It was determined that the organic matter was at a medium level (1.71-3.0), the available phosphorus was low (<3), the available potassium was high, the salt content was unsalted (<0.98) and the lime content was very calcareous (15-50).

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In the research, emergence, flowering and ripening time, number of leaves, plant height, stem thickness, table diameter, number of seeds in the table, thousand seed weight, plant yield, seed yield, stem yield, inner-shell ratio and harvest index values were examined and it was aimed to determine the relationships between all parameters.

3. RESULT AND DISCUSSION

From phonological observations it was determined that emergence, flowering and maturation times were not related to yield parameters. Only a positive relationship was found between flowering and physiological maturity day. Emergence time of cultivars ranged between 17-23 days, flowering period as 77-91 days and physiological maturity period as 136-153 days, number of leaves per plant 22.00-28.00, plant height 130.25-173.00 cm, stem thickness 19.77-31.82 mm, table diameter 14.70-20.20 cm, number of seed in the table 281,56-475,83, 1000 seed weight 48,25-178,75 g plant yield 51.71-80.11 g, seed yield 1141.8-2411.1 kg/ha, stem yield 913.0-1123.0 kg/ha, kernel ratio 47.12%-53.72%, harvest index 34.11%-44.03%, hectolitre as 240-302g/L in the study (Table 3).

Number of the leaves per plant was significantly and positively correlated with emergence time, flowering time, maturity time, number of leaves per plant, plant height, stem thickness, table diameter, number of seeds in the table, thousand seed weight, plant yield, seed yield and stem yield (Table 4-5).

Table 3. Descriptive analysis of parameters

Parameters	Minimum	Maximum	Mean	Std. Deviation
Emergence time (day)	17,00	23,00	19,83	1,34
Flowering time(day)	77,00	91,00	84,17	3,73
Maturity time (day)	136,00	153,00	143,20	4,41
Number of leaves per plant	22,00	28,00	25,09	1,70
Plant height (cm)	130,25	173,00	152,95	10,43
Stem thickness(mm)	19,77	31,82	24,74	2,48
Table diameter(cm)	14,70	20,20	17,77	1,65
Number of seeds in the table	281,56	475,83	382,67	59,23
Thousand seed weight (g)	48,25	178,75	120,86	21,78
Plant yield (g/plant)	51,71	80,11	65,97	7,46
Seed yield(kg/ha)	1142,8	2411,10	1763,56	338,06
Stem yield (kg/ha)	913,0	1123,00	1016,7	5,78
Kernel ratio	47,12	53,72	49,42	1,37
Harvest index	34,11	44,03	39,28	2,63
Hectolitre	240,00	302,00	269,73	17,22

This means that an increase in the value of one of these parameters also leads to an increase in the parameter with which it is significantly related. Similar strong and positive significantly

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corelation was observed between plant height and stem thickness, table diameter, number of seeds in the table, thousand seed weight, plant yield and seed yield. It means that increase in plant height cause to more number of leaves per plant, plant height, stem thickness, table diameter, number of seeds in the table, thousand seed weight, plant yield, seed yield. Stem thickness was significant and positive corelated with table diameter, number of seeds in the table and harvest index.

Table 4. Linear Correlations (Pearson coefficients) between growth and yield parameters of confectionery sunflower cultivars (1)

	FT	MT	NL	PH	ST	TD	NS
ET	0,123	-0,087	-0,015	0,243	-0,157	-0,097	-0,004
FT	1	0,440*	0,038	0,195	0,275	0,169	0,119
MT		1	-0,319	-0,062	-0,037	-0,329	-0,158
NL			1	0,236	0,253	0,421*	0,449*
PH				1	0,182	0,483**	0,484**
ST					1	0,382*	0,414*
TD						1	0,818**
NS							1

ET: Emergence time (day), FT: Flowering time(day), MT: Maturity time (day), NL: Number of leaves per plant, PH: Plant height (cm), ST: Stem thickness(mm), TD: Table diameter(cm), NS: Number of seeds in the table, *Significant at p≤0.05; **Significant at p≤0.01

Table diameter is the most positively correlated with number of seeds in the table, thousand seed weight, plant yield, seed yield, harvest index and negative significant correlation between table diameter and kernel ratio and hectolitre (Table 5).

Table 5. Linear Correlations (Pearson coefficients) between growth and yield parameters of confectionery sunflower cultivars (2)

	TSW	PY	GY	SY	HR	HI	HL
ET	0,018	0,023	-0,027	0,128	0,325	-0,156	0,276
FT	-0,055	0,145	-0,037	-0,161	-0,186	0,017	-0,337
MT	-0,265	-0,254	-0,285	0,237	-0,281	-0,130	0,253
NL	0,448*	0,401*	0,421*	-0,550**	0,387*	0,257	-0,342
PH	0,441*	0,523**	0,360	0-,427*	0,265	0,305	-0,252
ST	0,322	0,325	0,144	-0,205	-0,118	0,371*	-0,194
TD	0,781**	0,866**	0,682**	-0,535**	0,021	0,789**	-0,641**
NS	0,804**	0,849**	0,441*	-0,399*	-0,011	0,819**	-0,317

ET: Emergence time (day), FT: Flowering time(day), MT: Maturity time (day), NL: Number of leaves per plant, PH: Plant height (cm), ST: Stem thickness(mm), TD: Table diameter(cm), CS: Number of seeds in the table, TSW: Thousand seed weight (g), PY: Plant yield (g/plant), GY: Seed yield(kg/ha), SY: Stem yield (kg/ha), HR: Kernel ratio, HI: Harvest index, HL: Hectolitre, *Significant at p≤0.05; **Significant at p≤0.01

Number of seed in the table has significant, strong and positively correlated with thousand-seed weight, plant yield and harvest index and it has negative and significant relation with stem yield. Increase in table diameter seed yield and seed number in the table cause to take high ration in plant weight (Table 5).

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Table 6. Linear Correlations (Pearson coefficients) between growth and yield parameters of confectionery sunflower cultivars (3)

	ET	FT	MT	NL	PH	ST	TD
TSW	0,018	-0,055	-0,265	0,448*	0,441*	0,322	0,781**
PY	0,023	0,145	-0,254	0,401*	0,523**	0,325	0,866**
GY	-0,027	-0,037	-0,285	0,421*	0,360	0,144	0,682**
SY	0,128	-0,161	0,237	-0,550**	-0,427*	-0,205	-0,535**
HR	0,325	-0,186	-0,281	0,387*	0,265	-0,118	0,021
HI	-0,156	0,017	-0,130	0,257	0,305	0,371*	0,789**
HL	0,276	-0,337	0,253	-0,342	-0,252	-0,194	-0,641**

ET: Emergence time (day), FT: Flowering time(day), MT: Maturity time (day), NL: Number of leaves per plant, PH: Plant height (cm), ST: Stem thickness(mm), TD: Table diameter(cm), CS: Number of seeds in the table, TSW: Thousand seed weight (g), PY: Plant yield (g/plant), GY: Seed yield(kg/ha), SY: Stem yield (kg/ha), HR: Kernel ratio, HI: Harvest index, HL: Hectolitre, *Significant at $p \leq 0.05$; **Significant at $p \leq 0.01$

The strong and important correlation was found between thousand seed weight with plant yield and harvest index. The increase in thousand seed weight causes an increase in seed yield and harvest index (Table 7). The positive effect of thousand seed weight on plant yield is greater than its effect on seed yield. Since the harvest index is the ratio of plant yield to plant weight, a higher relationship has been formed since it increases plant productivity.

Table 7. Linear Correlations (Pearson coefficients) between growth and yield parameters of confectionery sunflower cultivars (4)

	NS	TSW	PY	GY	SY	HR	HI
TSW	0,804**	1					
PY	0,849**	0,858**	1				
GY	0,441*	0,701**	0,694**	1			
SY	-0,399*	-0,354	-0,399*	-0,362*	1		
HR	-0,011	0,304	0,110	0,358	0,065	1	
HI	0,819**	0,868**	0,822**	0,556**	-0,391*	-0,206	1
HL	-0,317	-0,302	-0,381*	-0,381*	0,809**	0,171	-0,389*

Plant yield was positively correlated with seed yield and harvest index, and negatively correlated with stem yield and hectoliter. The highest correlation of plant yield was found with harvest index. The increase in plant yield causes the decrease in stem yield and hectoliter value.

Seed yield was positive and significant corelated with harvest index and negative significant corelate with stem yield and hektoliter. Stem yield strong positive and significant corelate with hektoliter. Stem yield has negative significant relation with harvest index.

4. CONCLUSION

This study aimed to evaluate the correlations between different yield and yield parameters of different confectionery sunflower cultivars. This study showed that some positive correlations are significant while others are not. The strongest positive correlations are obtained between thousand see weight, plant yield, seed yield, harvest index and the other positive strong relation was found kernel ratio and hectolitre. This study also showed that negative significant correlation

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was found between kernel ratio, number of leaves and seed per plant, table diameter, seed yield, thousand seed weight and harvest index and the other negative strong relation was found table diameter and hectolitre.

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