RESEARCH ARTICLE

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Yield and yield components of some advanced Camelina (*Camelina sativa* L. CRANTZ) genotypes in Bolu ecological conditions

Yusuf ARSLAN[1] • **Mustafa YASAR**[2] • **Berfin ISLER**[3] • **Sefa UNAL**[4] • **Ilhan SUBASI**[5]

[1] Department of Field Crops, Faculty of Agriculture, Bolu Abant İzzet Baysal University, Bolu, Türkiye
[2] Department of Plant Production and Technologies, Faculty of Applied Sciences, Muş Alparslan University, Muş, Türkiye
[3] Department of Field Crops, Graduate School of Education, Bolu Abant İzzet Baysal University, Bolu, Türkiye
[4] Field Crops Central Research Institute, Ankara, Türkiye
[5] Bolu Abant İzzet Baysal University, Faculty of Agriculture, Department of Seed Technologies, Bolu, Türkiye

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Abstract

The negative effects of global warming are increasing worldwide and this increase is expected to continue. The camelina plant, which can be grown in marginal areas, stands out among other oilseed plants because it is drought-resistant and less costly. In the research, seeds belonging to 8 camelina genotypes, which were prominent in terms of oil rate, seed and oil yield, were used in the trial established in Bolu province, out of a total of 52 genotypes obtained from the seed bank of the United States Department of Agriculture, Agricultural Research Service and Germany. The study was conducted according to the Randomized Complete Block Design in Bolu Abant İzzet Baysal University, Faculty of Agriculture, Research and Application Field in the 2021-2022 production season. In the trait, each plot consisted of six rows with a row length of 3 m, a row spacing of 20 cm, and in row of 5 cm, with three replications. According to the research results; plant height 66.33-71.00 cm, number of branches 3.17-5.07 number plant^{-1}, 1000 seed weight 1.10-1.24 g, seed yield 1095.4-1436.6 kg ha^{-1}, oil content 36.63-40.37%, protein content 23.65-27.22%, oil yield 408.3-559.8 kg ha^{-1} and protein yield 279.0-391.3 kg ha^{-1}. It was found that values between. According to the results obtained from the study, the K52 genotype in terms of seed yield, the K11 genotype in terms of oil rate and the K52 genotype in terms of protein rate came to the fore.

Keywords: Camelina, Yield ve yield components, Oil composition, Bolu

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Correspondence: Mustafa YAŞAR
E-mail: mustafa.yasar@alparslan.edu.tr

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INTRODUCTION

Countries have turned to research new and renewable energy sources because of the high share of fossil fuels in energy production and consequently the limited and continuous decrease of fossil fuel reserves and the negative effects of fossil fuels on the environment and human health. For this reason, the tendency to new and renewable energy sources is increasing day by day due to reasons such as diversifying energy sources and reducing their dependence on foreign energy. When alternative energy sources and developments in this field are examined, the development of biofuels such as biodiesel and bioethanol draws attention. The fact that the raw material of biofuels is agricultural products increases the importance of the subject for the agricultural sector and producers (Yaşar and Eren, 2008).

The developments in the vegetable oil and by-products sector have accelerated the agriculture of oilseed plants in the world and in Türkiye in recent years. Obtaining biofuel from vegetable oils has also positively affected the demand for the production of oilseed plants (Kaya and Eryiğit 2020, Yaşar and Sezgin, 2022). Oilseeds take 4th place among our country's top 10 import items (TUIK, 2022). In Türkiye, biofuel blending has been mandated by EPDK (Republic of

Türkiye Energy Market Regulatory Authority), provided that gasoline and diesel fuel are produced from domestic raw materials. In addition, the obligation to blend biodiesel in diesel oil is 0.5%. This obligation means approximately 105,000 tons of biodiesel blending annually. Türkiye is an importer of vegetable oil and has an annual foreign trade deficit of 1.657 billion dollars (TUIK, 2022). To eliminate this negativity, it is necessary to turn to alternative oil sources and increase vegetable oil production. In this sense, the camelina plant is an important alternative.

Camelina (Camelina sativa L. CRANTZ) is also called by different names such as false flax, German sesame, and Siberian oilseed (Kurt and Seyis, 2008). It spreads naturally in the Mediterranean and Central Asia and has been cultivated for 3000 years (Putnam et al., 1993; Zubr, 1997). It was grown economically in Belgium, France, the Netherlands and the Balkans until the 1930s, in Sweden and Poland until the 1950s, and in the Soviet Union until the 1960s (Zubr, 1997). In the following years, it is seen that this plant has taken the place of camelina due to the spread of varieties without erucic acid as a result of breeding studies on rapeseed (Crowley and Fröhlich, 1998). Although the fat content in camelina varies according to the cultivation and climatic factors, it shows a wide variation between 23-48% (Vollmann et al., 2005 and Katar, 2013). The oil rate varies not only according to the cultivation and climatic characteristics but also according to the variety used. Qualified biodiesel by ASTM D6571 and EN14214 biodiesel standards can be obtained from its oil (Wu and Leung, 2011). It is a plant that can be grown without the use of herbicides and is not damaged by the invasion of common parasitic insects due to the low rate of weeds due to its fertilizer demand and allopathic effect in the area where it is grown. In addition, due to its resistance to diseases, the use of chemicals

is low and this makes the plant an environmentally friendly plant. Camelina is relatively drought-resistant and can be grown in very different areas with different climates and soil structures, except in heavy clay and organic soils (Zubr, 1997).

In the vehicle test with the oil obtained from the seed of the plant and the mineral diesel fuel, it was determined that the power of the plant oil (43.25 kW) was higher than the mineral diesel fuel (38.50 kW), and the fuel consumption (12.57 km/l) was less than the mineral diesel fuel (14.03 km/l). It has been determined that smoke turbidity and CO from the exhaust at engine speeds of more than 2000 rpm are approximately 50% lower than that of mineral diesel oil (Bernardo et al., 1998). Fröhlich and Rice (2005) investigated the evaluation of camelina oil as a feedstock for biodiesel production and found that it gave ester yields similar to rapeseed oil and that the iodine value of the camelina oil ester did not meet European Union standards, but other fuel properties were satisfactory. Camelina is primarily preferred among other vegetable oils due to its oil content and high oil yield per hectare, high-quality renewable fuel properties such as jet fuels (cold flow properties, oxidative stability, kinematic viscosity, cetane number, etc.). In addition, it has similar properties to biodiesel prepared from soybean oil, but because the oil contains high levels of linolenic (32.6%), linoleic (19.6%) and oleic (18.6%) acids, methyl and ethyl esters are compared to canola, palm and soybean oil methyl esters. It has lower oxidation stability and higher iodine values (Moser and Vaughn, 2010). At the same time, the fuel properties of camelina oil methyl and ethyl esters such as cold filter plugging point, acid value, cetane number, kinematic viscosity, fluidity, sulfur and phosphorus contents, surface tension are similar to those of canola, palm and soybean oil methyl esters in low sulfur diesel. It has a mixture of components in its fuel. In addition to these studies, Zaleckas et al. (2012) reported that they had positive results in their studies on the biodiesel properties of camelina oil.

Camelina oil is an important source of Omega-3 with its high content of linolenic fatty acid (C18:3). Linoleic fatty acid is one of the best-known polyunsaturated fatty acids. The importance of polyunsaturated fatty acids in human health and nutrition is very high (Broun et al., 1999; Das, 2016; Horrobin, 2000; Mills et al., 2005; Napier and Sayanova, 2005). Many polyunsaturated fatty acids are essential and obtained from diets. Mammals, including humans, cannot synthesize essential fatty acids such as linoleic acid (18:2n-6) and α-linolenic acid (18:3n-3). From this point of view, camelina oil and oily pulp can have an important place in human and animal nutrition.

Camelina, which is an annual culture plant, has summer, winter and middle forms. It is a self-pollinating plant. Its fruits are in the form of capsules and contain 15 oval-shaped yellow-yellow brown seeds. 1000 seeds weight varies between 0.8-1.8 g. Seed yield is 2.6 t ha-1 in summer varieties, 3.3 t ha-1 in winter varieties, oil rate of summer varieties is 42%, and winter varieties are 45%. The unsaturated fatty acids in its oil are 90% and approximately 50% of the total fatty acids are composed of polyunsaturated linoleic acid (18:2n-6) and α-linolenic acid (18:3n-3). It is reported that the erucic acid (22:1n-9) content in its oil is about 3% and the tocopherol content is about 700 mg kg-1 (Zubr, 1997). It is also reported that it contains many natural antioxidants such as tocopherols, which make the oil stable and usable as edible oil (Kurt and Seyis, 2008).

After removing the oil from the camelina, the remaining pulp contains 10% oil, 45% protein, 13% fibre, 5% mineral substance, and a small amount of vitamins and other substances. The protein of camelina pulp is characterized by the presence of essential amino acids such as arginine, cystine, lysine, methionine and threonine. The composition of amino acids in camelina protein is particularly suitable for feeding poultry (Fogelfors, 1984). It is stated that the pulp of camelina is suitable for feeding ruminant animals and pigs and has high protein and energy content (Schuster and

Friedt, 1998; Koç and Önder, 2012; Matthas and Zubr, 2000).

Camille, a plant that can be grown in marginal areas, is drought tolerant, early maturing and requires less input than other oilseed crops (Urbaniak et al., 2008). In addition, it is supported by the literature that one of the most important alternative oil crops, which will contribute to closing the oil deficit of our country and help meet the raw material needs of the biodiesel industry, is camelina.

One of the most important traits for breeders and researchers is the ability to select genotypes that perform well in a wide variety of environmental conditions (Yaşar, 2023). For this reason, it is aimed to determine the genotypes tdetermine the genotypes that stand out in terms of the traits examined in Bolu ecological conditions.

MATERIALS AND METHODS

In the research, seeds belonging to 8 camelina genotypes, which were prominent in terms of oil rate, seed and oil yield, were used in the trial established in Bolu province, out of a total of 52 genotypes obtained from the seed bank of the United States Department of Agriculture, Agricultural Research Service and Germany (Table 1).

Table 1. Seed materials and origins used in the trial

Trial Code	Original Code	Origin
K-11	PI 304271	Sweden
K-32	PI 650154	Russia
K-36	PI 650158	Poland
K-41	PI 650164	Austria
K-43	PI 650166	Russia
K-45	PI 650168	United States
K-46	PI 652885	Slovenia
K-52	PI 650161	Russia

The field trial was carried out in the research and application field of Bolu Abant İzzet Baysal University, Faculty of Agriculture. Sowing of the trial was done on 1 October (Katar et al., 2012a).

The trial was established in three replications according to the Randomied Complete Block Design, each plot consisted of 6 rows, the plot length was 5 m and the width was 1.2 m. The seeds were sown by hand, with the calculation of 1 kg da^{-1} per decare, equal to 6 rows with 20 cm row spacing (Crowley and Fröhlich, 1998). During the development period of the plants, only weed control was carried out, irrigation and fertilization were not carried out. At the harvest, 0.5 m from the bottom and top of the plot, and one row from the sides were considered as edge effect and the 4 rows in the middle were harvested.

The saturation rate of the soil texture of the trial area is 78.1% and it shows clayey characteristics. Soil pH is 7.48 and shows neutral character. The total amount of salt is 0.02%, it is structurally salt-free and there is no salt problem. The lime value is around 6.39% and it is in a medium calcareous state. It contains moderate organic matter at the level of 2.32% as organic matter. It is very low in available phosphorus (0.06 kg da^{-1}) and high in available potassium (47.7 kg da^{-1}). A total of 637 mm precipitation was observed in the trial area throughout the year, the lowest average temperature value was 0.8 °C in January, and the highest average temperature value was 20.6°C in July and August.

In the study, plant height (cm), number of branches (number $plant^{-1}$), maturation time (day), seed yield per plant (g $plant^{-1}$), 1000 seed weight (g), fixed oil ratio (%), oil yield (kg ha^{-1}), fatty acid composition (%), protein content (%) and protein yield (kg ha^{-1}) were investigated.

The oil content was determined by the solvent (hexane) extraction method in the Soxterm 2000 oil analyzer. In order to determine the fatty acid composition, 10 ml of n-hexane was added to 0.1 g oil, 0.5 ml of 2N methanolic KOH was added, mixed and esterified was ensured by shaking for ½ hour. Shimadzu GC-2010 (Japan), flame ionization detector (FID) and Technochroma Capillary column (100 m x 0.25 mm and 0.2 µm film thickness) were used for determination. Isothermal condition of the column furnace, in which helium was applied as the carrier gas with a flow rate of 0.94 ml/min, Split ratio was set as 1:100, operating temperature was set as 250°C for the injection block and the detector. It is programmed to rise to 240 °C with the temperature increase rate and wait for 20 minutes. In the identification of fatty acids, Restek 35077, Food Industry FAME mix (USA) was used as a standard.

The protein content of homogenous sample taken from camelina seeds obtained from each row was made by Dumas method (Velp Scientifica NDA-701) according to AOAC 992.23: Crude Protein in Cereal Grains and Oilseeds method. In the calculation of the protein, the nitrogen factor was taken as 6.25.

Analysis of variance (ANOVA) was performed with JMP Pro11 (SAS Institute Inc., Cary, NC). The mean values of the properties were compared using the Tukey multiple range test (P > 0.05).

RESULTS AND DISCUSSION

The mean values, the groups formed and the results of the analysis of variance of the values of the properties examined in the experiment are given in Table 2.

Table 2. Mean values, formed groups and variance analysis results of the properties examined in the experiment.

Genotypes	PH	DS	SW	SY	OC	OY	PC	PY
ARSLANBEY	70.50 ± 0.71 a	4.85 ± 0.07 abc	1.19 ± 0.10 ab	1233.4 ± 6.27 bc	38.95 ± 0.92 abc	480.7 ± 3.58 bc	25.70 ± 0.62 abc	317.2 ± 2.38 bcd
K11	66.33 ± 4.04 a	4.53 ± 0.93 abc	1.24 ± 0.06 a	1230.1 ± 2.75 c	40.37 ± 0.64 a	496.6 ± 1.44 b	24.75 ± 1.02 bc	304.3 ± 0.98 bcd
K13	68.00 ± 1.00 a	3.73 ± 0.40 abc	1.17 ± 0.01 ab	1427.8 ± 7.11 a	37.03 ± 1.45 bc	528.9 ± 3.71 ab	23.65 ± 1.13 c	337.2 ± 0.47 bc
K36	68.67 ± 1.15 a	4.30 ± 0.26 abc	1.18 ± 0.01 ab	1099.3 ± 6.26 c	37.17 ± 1.00 bc	408.3 ± 1.92 d	26.14 ± 0.52 ab	287.6 ± 2.21 cd
K41	69.67 ± 3.21 a	3.33 ± 0.47 bc	1.10 ± 0.08 ab	1194.1 ± 3.86 c	35.87 ± 1.07 c	428.0 ± 0.30 cd	27.26 ± 0.76 a	325.7 ± 1.85 bcd
K45	67.00 ± 3.61 a	3.17 ± 0.49 c	1.10 ± 0.05 ab	1401.5 ± 5.67 ab	36.63 ± 0.67 bc	513.2 ± 1.22 ab	25.34 ± 0.43 abc	355.0 ± 1.42 ab
K48	70.33 ± 4.04 a	4.80 ± 0.40 ab	1.12 ± 0.03 ab	1095.4 ± 7.08 c	38.87 ± 0.75 abc	425.4 ± 1.93 cd	25.49 ± 0.73 abc	279.0 ± 1.28 d
K52	71.00 ± 1.73 a	5.07 ± 0.68 a	1.07 ± 0.01 b	1436.6 ± 5.93 a	39.00 ± 1.68 ab	559.8 ± 1.60 a	27.22 ± 0.93 a	391.3 ± 2.91 a
HSD 0.05	-81.7	-15.4	-01.4	-164.3	-31.0	-60.5	-23.1	-51.4
Analysis of variance	ns	**	*	**	**	**	**	**

PH: Plant height (cm), NB: Number of branches (number plant^{-1}), SW: 1000 seed weight, SY: Seed yield (kg ha^{-1}), OC: Oil content (%), OY: Oil yield (kg ha^{-1}), PC: Protein content (%), PY: Protein yield (kg ha^{-1}). HSD: Honestly Significant Difference

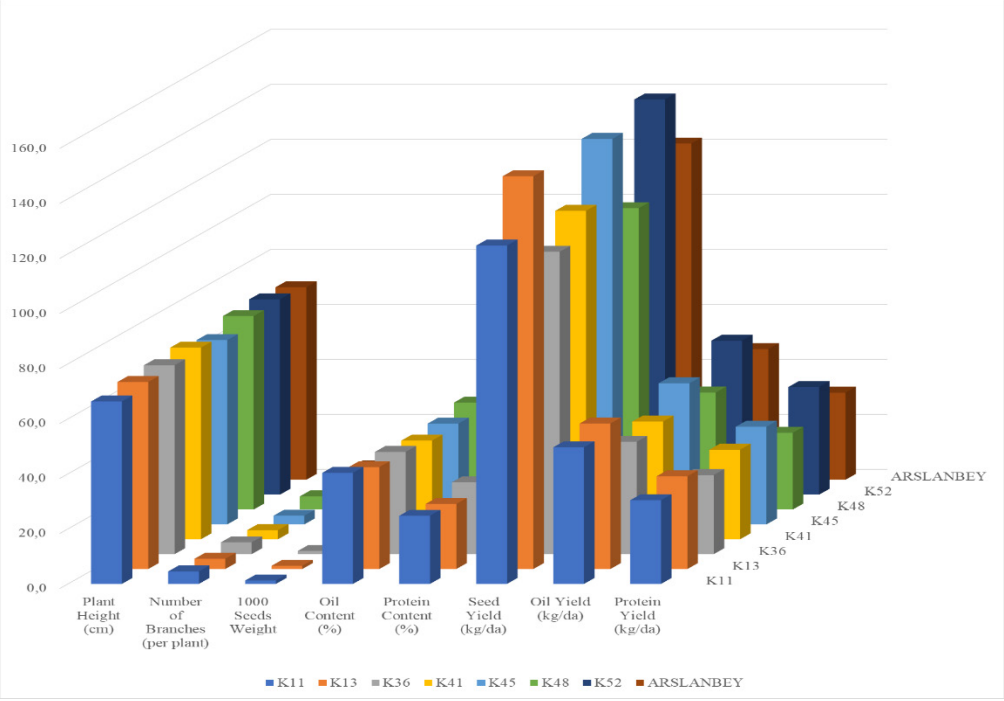

Figure 1. The graph of the mean values of the examined traits

When Table 2, where the analysis of variance values of the trial is given, is examined, it is seen that there is no statistically significant difference between the genotypes in terms of BD, there is a significance at the level of 0.05 in terms of SW, and the difference between the values of NB, SY, OC, OY, PC and PY is significant at the level of 0.001; It is seen that there are no groups in plant height values due to the difference between genotypes, three different groups are formed in NB, two in SW, three in SY, three in OC, three in PC and four in PY.

When the findings were examined, it was observed that in terms of PH, it varied between 66.33 and 71.00 cm and the highest PH value was from the K52 genotype; In terms of NB, it varies between 3.17 and 5.07 and the highest NB value is from the K52 genotype; In terms of SW, it varied between 1.07 and 1.24 g and the highest SW value is from the K11 genotype; In terms of SY, it varies between 1095.4 and 1436.6 kg ha^{-1} and has the highest SY value from K52 and K13 genotypes; The HR values varied between 35.87% and 40.37%, and the highest HR value was from the K11 genotype; OY values varied between 408.3 and 559.8 kg ha^{-1} and the highest OY value was from the K52 genotype; The highest PY value was obtained from the K52 genotype, with the PC values varying between 23.65% and 27.22%, the highest PC value was obtained from the K52 genotype, and the PY values varying between 279.0 and 391.3 kg ha^{-1}. When all the findings are evaluated together, it is seen that the K52 genotype stands out in terms of oil yield and protein yield, which are the main criteria in oilseed plants (Table 2, Figure 1).

Considering the previous studies on camelina, the plant height in camelina was determined by Köse et al. (2018): 72.8-91.5 cm, Francis and Warwick (2009): 30-60 cm, Koncius and Karcauskiene (2010): 50.4-77.9 cm, Çoban and Önder, 2015: 69.0-97.3 cm, Arslan et al. (2014): 116.4-129.7 cm and Arslan et al. (2022): They reported that they detected it in the range of 103.8-59.5 cm. Katar and Katar (2017) reported in their research that the height of the camelina plant was significantly affected by the differences in climatic conditions. Plant height is under pressure from the environment rather than genetics. When these genotypes are tested in a different ecology, they may exhibit different plant heights due to the difference in the response of the genotypes to the environment.

The number of branches in the plant is one of the important factors affecting the yield, especially in oil plants (Vollman and Rajcan, 2009). Considering the results of the research, it is seen that the K52 genotype, which stands out in terms of the number of branches, also stands out in seed yield. The number of branches in the plant, many researchers in their studies, Katar et al. (2012a): 11.45 pieces, Arslan et al. (2014): 3.7-8, and Köse et al. (2018): 8.1-14.7. Although branching is a genetic trait, it increases or decreases depending on the planting frequency. The same genotype may show more branching tendency in sparse planting compared to dense planting. In addition, due to adverse environmental conditions, especially drought and insufficient nitrogen amount, the plant cannot grow as much as its genetic capacity requires and can form fewer branches.

Another important yield factor in camelina plant is 1000 seed weight (Vollman and Rajcan, 2009). This trait is high; It is important in terms of extracting oil from the seed more effectively and providing faster and stronger output in adverse climate and soil conditions (Qatar and Qatar, 2017). It is reported that the 1000 seed weight is a genetic trait as well as being affected by environmental conditions (Köse et al., 2018; Akk and Ilumae, 2005). Regarding the 1000 seed weight in previous studies, Mason (2009): 1.19 g, Katar et al., (2012a): 0.44 g, Katar et al. 2012b: 1.24 g and Katar et al. (2012c): 1.16 g, Arslan et al. (2014): 1.18-1.31 g, Agegnehu (1997): 1.45 g, Köse et al. (2018): 1.04-1.28 g and Arslan et al. (2022): They reported that they detected it in the range of 1.50-0.84 g. The values related to 1000 seed weight obtained from this study show similarities and differences with previous studies. The fact that the 1000 seed weight is a genetic trait as well as being affected by environmental conditions makes the differences understandable.

The main purpose in the production of oil crops is to increase seed and oil yield. Two important factors affecting oil yield in camelina plant are seed yield and oil content (Katar et al. 2012a). It has been reported that the seed yield, oil rate and, accordingly, the oil yield are largely under the influence of environmental conditions, and the performances of genotypes differ according to changing environmental conditions (Seehuber, 1984; Koncius and Karcauskiene, 2010). Regarding the seed yield in the studies, Katar et al. (2012): 48.2-700.0 kg ha^{-1}, Arslan et al. (2014): 875.3-1811.3 kg ha^{-1}, Köse et al. (2018): 478-1024 kg ha^{-1} and Arslan et al. (2022), They reported that they detected it in the range of 188-3152 kg ha^{-1}. Seed yield in oilseed plants is a trait that is highly affected by environmental conditions as well as genetic capacity. Therefore, the same genotype can exhibit very different yield potential in different ecologies or conditions. This study reveals the performance of genotypes in Bolu ecological conditions in terms of seed yield.

In the breeding program of oilseed plants, oil content is one of the main breeding criteria. The oil content trait determined by the genetic structure can be listed with the effect of environmental conditions. The plant can reveal its existing genetic capacity only if there are optimum conditions. Therefore, the oil content in the seed may fall below the genetic capacity depending on the environment and growing conditions. Arslan et al., (2014) reported that phosphorus and nitrogen applications affect the oil content in camelina positively, and nitrogen and phosphorus applications increase it up to a certain dose. Regarding seed yield in previous studies, Katar et al. (2012a): 21.4-35.4%, Katar et al. (2012d): 23.4-32.7%, Köse et al. (2018): 30.0-34.3 %, Subasi et al. (2021): 34.35-37.88% and Subaşı et al.

(2022): They reported that they found it in the range of 26.69-39.17%.

After the oil is removed from the seeds of the oilseed plants, the remaining meal is a very valuable animal feed because of the protein they contain. The main criterion that determines the feed value of the pulp is the high or low digestible protein content. For this reason, it is desirable that the protein content in the seed is high as well as the oil content. Protein content, like oil content, is one of the features controlled by genetic structure, and it reveals the plant's capacity in optimum environmental conditions, otherwise, it cannot display its genetic potential. Therefore, the environment and cultivation techniques can affect the protein content. The same genotypes can give different protein content values in different ecologies or environmental conditions. Regarding protein content in previous studies, Subaşı et al. (2021): Reported that they detected it in the range of 25.76%-27.64%.

There were statistically significant differences between genotypes in terms of oil components. While there was no difference between the genotypes in terms of C22:2, C24:0 and C24:1 fatty acids, C20:0 fatty acids were at the level of 0.05, C16:0, C18:0, C18:1, C18:2, C18:3, C20:2. The difference between C22:0 and C22:1 fatty acids was 0.01 (Table 3).

Table 3. Mean values of the oil components of the genotypes, the resulting groups and variance analysis results.

Level	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C20:2	C22:0	C22:1	C22:2	C24:0	C24:1
ARSLANBEY	5.26 ± 0.05 ab	2.70 ± 0.00 ab	15.86 ± 0.07 ab	17.09 ± 0.02 c	50.14 ± 0.10 bc	1.30 ± 0.17 ab	1.83 ± 0.00 bc	0.31 ± 0.00 a	4.28 ± 0.00 a	0.16 ± 0.01 a	0.17 ± 0.00 a	0.90 ± 0.00 ab
K11	5.41 ± 0.07 a	2.65 ± 0.01 ab	16.13 ± 0.09 a	17.50 ± 0.09 bc	49.43 ± 0.36 c	1.35 ± 0.11 ab	1.83 ± 0.01 bc	0.27 ± 0.00 bc	4.16 ± 0.02 ab	0.15 ± 0.00 a	0.17 ± 0.00 a	0.84 ± 0.00 ab
K13	5.49 ± 0.09 a	2.58 ± 0.11 bc	13.88 ± 0.15 c	17.45 ± 0.34 bc	51.65 ± 0.72 a	1.49 ± 0.01 a	1.98 ± 0.01 a	0.31 ± 0.01 a	3.94 ± 0.48 abc	0.18 ± 0.02 a	0.16 ± 0.01 a	0.86 ± 0.25 ab
K36	5.35 ± 0.08 ab	2.74 ± 0.01 a	15.97 ± 0.27 ab	17.54 ± 0.25 bc	49.60 ± 0.16 bc	1.45 ± 0.02 ab	1.83 ± 0.03 bc	0.31 ± 0.01 a	4.04 ± 0.17 abc	0.16 ± 0.00 a	0.16 ± 0.01 a	0.82 ± 0.08 ab
K41	5.32 ± 0.05 ab	2.71 ± 0.09 ab	15.96 ± 0.34 ab	17.41 ± 0.17 bc	50.68 ± 0.55 ab	1.33 ± 0.01 ab	1.75 ± 0.06 c	0.28 ± 0.01 bc	3.53 ± 0.26 bc	0.15 ± 0.01 a	0.32 ± 0.29 a	0.78 ± 0.05 ab
K45	5.49 ± 0.02 a	2.48 ± 0.01 c	14.44 ± 0.23 c	17.13 ± 0.12 c	51.62 ± 0.35 a	1.36 ± 0.01 ab	1.96 ± 0.02 a	0.29 ± 0.02 abc	3.98 ± 0.13 abc	0.18 ± 0.01 a	0.14 ± 0.01 a	0.86 ± 0.02 ab
K48	5.14 ± 0.10 b	2.67 ± 0.04 ab	15.52 ± 0.19 b	17.81 ± 0.18 ab	49.90 ± 0.28 bc	1.43 ± 0.04 ab	1.86 ± 0.02 b	0.30 ± 0.01 ab	4.02 ± 0.12 abc	0.17 ± 0.01 a	0.17 ± 0.00 a	0.95 ± 0.02 a
K52	5.44 ± 0.15 a	2.64 ± 0.01 ab	16.06 ± 0.19 ab	18.30 ± 0.31 a	49.71 ± 0.20 bc	1.28 ± 0.00 b	1.84 ± 0.04 b	0.27 ± 0.01 c	3.51 ± 0.22 c	0.15 ± 0.02 a	0.32 ± 0.26 a	0.65 ± 0.05 b
HSD0.05	0.24	0.15	0.59	0.60	0.21	1.11	0.08	0.03	0.64	0.03	0.39	0.27
Variance Analysis	**	**	**	**	**	*	**	**	**	ns	ns	ns

In previous studies on the plant; Katar et al. (2012d) C16:0 in the range 6.21-6.82%, C18:0 in the range of 2.43-2.90%, C18:1 in the range of 15.1-17.1%, C18:2 in the range of 18.6-2.4%, C18 they found :3 in the range of 30.5-33.4%, C20:0 in the range of 1.6-2.0%, C20:2 in the range of 1.7-1.9%, and C22:1 in the range of 2.9-3.6%; Qatar et al. (2012a) C16:0 in the range of 5.9-7.1%, C18:0 in the range of 2.5-3.0%, C18:1 in the range of 16.0-17.6%, C18:2 in the range of 18.5-23.4% , C18:3 in the range of 24.9-32.3%, C20:0 in the range of 0.3-1.9%, C20:2 in the range of 1.3-1.9%, C22:0 in the range of 0.3-1.9, and C22:1 in the range of 2.9 They found in the range of -3.5%; Arslan et al. (2014) C16:0 in the range 5.1-6.1%, C18:0 in the range of 2.6-2.9%, C18:1 in the range of 15.9-19.8%, C18:2 in the range of 17.1-21.5%, C18 they found:3 in the range of 26.3-34.1%, C20:0 in the range of 1.4-1.8%, and C22:1 in the range of 2.56-3.72%; Kıralan et al. (2018) C18:1 in the range of 5.1-5.2%, C18:2 in the range of 17.1-17.7%, C20:0 in the range of 1.5-1.6%, C18:3 in the range of 33.9-34.6%, and C22, They found:1 in the range of 2.80-2.82 and Subaşı et al. (2022) reported that they found C18:3 in the range of 8-36% and C22:1 in the range of 2.1-5.0%. When the values obtained from studies conducted with different genotypes in different years and ecological conditions are examined, the fatty acid ratio values obtained from this study show similarities with the exception of the linolenic fatty acid ratio. Looking at the data obtained from existing studies, it can be said that linolenic fatty acid ratios differ more than other fatty acid ratios and this fatty acid is more affected by environmental conditions.

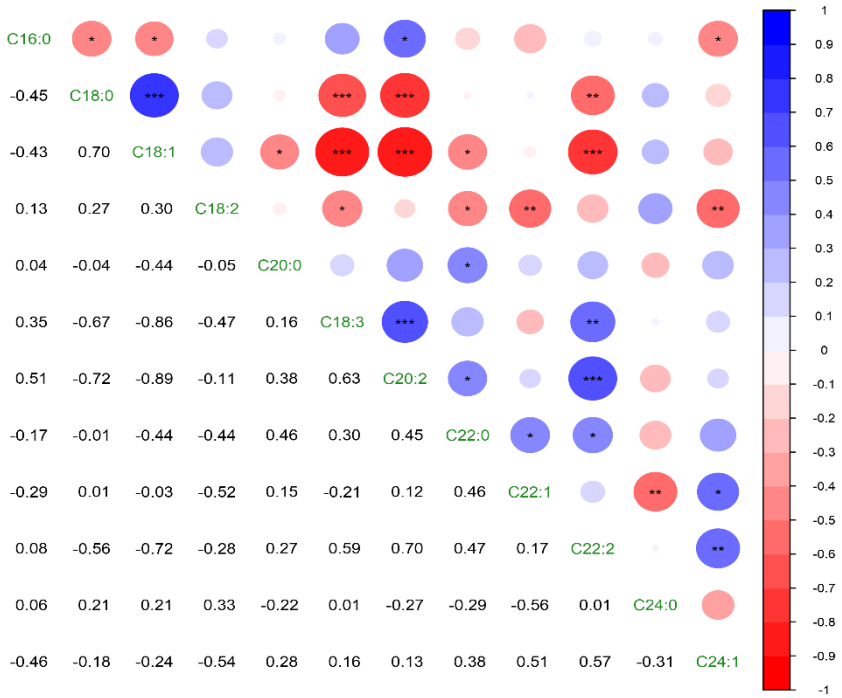

Figure 2. Fatty acids correlation chart

When the findings obtained from this study are examined, it is seen that between C16:0 and C18:1 and C24:1, between C18:1 and C20:0, C18:3, C20:2 and C22:1, between C18:2 and C18:3 and C20. :0 and C22:1 to C24:0 are negative; It is seen that there is a positive correlation between C16:0 and C20:2, between C20:0 and C22:0, between C18: and C20:2, between C20:2 and C22:0 and C22:2, and between C22:0 and C22:1 (Fig. 2).

Although there are not many studies showing the correlation between the fatty acid components of the camelina plant, Subaşı et al. (2022), in their study with 39 camelina genotypes, there was a negative correlation between C18:1 and C18:2 and C18:3, and between C18:2 and C18:3 and C16:0; It is reported that there is a positive correlation between C18:1 and C16:0 and between C18:2 and C18:3.

CONCLUSION

In the study, no great variation was observed among the camelina genotypes in terms of the major fatty acids palmitic acid (16:0), oleic acid (18:1), linoleic acid (18:2) and linolenic acid (18:3). Considering that K13 and K52 genotypes may be suitable genotypes in terms of seed yield among the camelina genotypes, but K52 genotype is superior to other genotypes in terms of oil yield and protein yield, it has been determined that it is the most suitable genotype for Bolu ecological conditions and similar climatic and soil conditions.

COMPLIANCE WITH ETHICAL STANDARDS

Peer-review

Externally peer-reviewed.

Conflict of interest

The authors declare that they have no competing, actual, potential or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the text, figures, and tables are original and that they have not been published before.

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REFERENCES

Agegnehu, M., Honermeier, B. (1997). Effects of seeding rate and nitrogen fertilization on seed yield, seed quality and yield components of false flax (Camelina sativa Crtz). Die Bodenkultur. 48 (1).
Akk, E. E. Ilumäe. (2005). Possibilities of Growing Camelina sativa in Ecological Cultivation. www.eria.ee/public/files/camelina-envirfood.pdf.
Arslan, Y., Subaşı, İ., Katar, D., Kodaş R., Keyvanoğlu, H. (2014). Farklı Azot ve Fosfor Dozlarının Ketencik Bitkisi (*Camelina sativa* L. CRANTZ)'nin Bazı Bitkisel Özellikleri Üzerine Olan Etkisinin Belirlenmesi. Anadolu Tarım Bilim Dergisi. 29(3):231-239.
Arslan, Y., Subaşı, İ., Hatipoğlu, H., Abrak, S., İşler, B. (2022). Study on Correlation of Agromorphologic Properties in Some Camelina (*Camelina sativa* L. CRANTZ) Genotypes. Yuzuncu Yıl University Journal of Agricultural Sciences, 32(4), 835-842.
Bernardo, A., Howard-Hildige, R., O'Connell, A., Nichol, R., Ryan, J., Rice, B., Leahy, Crowley, J. G., Fröhlich, A. (1998). Factors Affecting the Composition and Use of Camelina. Crops Research Centre, Oak Park, Carlow. ISBN 1 901138666.
Broun, P., Gettner, S., Somerville, C. (1999). Genetic engineering of plant lipids. Annu. Rev. Nutr. 19:197–216.
Çoban F., M. Önder. (2015). Ekim Sıklıklarının Ketencik (*Camelina sativa* (L.) Crantz) Bitkisinde Önemli Agronomik Özellikler Üzerine Etkileri. Selçuk Tarım Bilimleri Dergisi. 1(2): 50-55.
Das, U. N. (2006). Essential fatty acids: biochemistry, physiology and pathol- ogy. Biotechnol. J. 1:420–439.
Fogelfors, H. (1984). Useful weeds, Part 5. Lantmannen (Sweden) 105:28.
Francis, A., Warwick, S.I. (2009). The Biology of Canadian Weeds. 142. *Camelina alyssum* (Mill.) Thell. Can.J. Plant Sci. 89:791–810.
Frohlic, A., Rice, B. (2005). Evaluation of Camelina sativa oil as feedstock for biodiesel production. Industrial Crops and Products 21(1): 25-31
Horrobin, D. F. (2000). Essential fatty acid metabolism and its modification in atopic eczema. Am. J. Clin. Nutr. 71(Suppl. 1):367S–372S.
Kaya A.R, Eryiğit T. (2020). Bazı Yağlık Ayçiçeği (*Helianthus annuus* L.) Çeşitlerinin Önemli Kalite Özelliklerinin Tespiti Üzerine Bir Araştırma. Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 10(3): 2143-2152, 2020. ISSN: 2146-0574, eISSN: 2536-4618.
Katar, D., Arslan, Y., Subaşı, İ. (2012a). Ankara Ekolojik Koşullarında Farklı Ekim Zamanlarının Ketencik (*Camelina sativa* (L.) Crantz) Bitkisinin Yağ Oranı ve Bileşimi Üzerine Olan Etkisinin Belirlenmesi. Tekirdağ Üniversitesi Ziraat Fakültesi Dergisi 9(3): 84-90.
Katar, D., Arslan, Y., Subaşı, İ. (2012b). Ankara Ekolojik Koşullarında Farklı Ekim Zamanlarının Ketencik (*Camelina sativa* (L.) Crantz) Bitkisinin Verim ve Verim Unsurları Üzerine Olan Etkisinin Belirlenmesi. Atatürk Üniversitesi Ziraat Fakültesi Dergisi 43(1): 23-27.
Katar, D., Arslan Y., Subaşı, İ. (2012c). Kışlık Farklı Ekim Zamanlarının Ketencik (Camelina sativa (L.) Crantz) Bitkisinin Verim ve Verim Öğelerine Etkisi. GOÜ Ziraat Fakültesi Dergisi, 29(1), 105-112.
Katar, D., Arslan, Y., Subaşı, İ. (2012d). Genotypic variations on yield, yield components and oil quality in some Camelina (*Camelina sativa* (L.) Crantz) genotypes. Turkish Journal of Field Crops, 17(2), 105-110.
Katar D. (2013). Determination of fatty acid composition on different false flax (Camelina sativa (L.) Crantz) genotypes under Ankara ecological conditions. Turkish Journal of Field Crops, 18(1), 66-72, Ankara.
Katar, D., Katar, N. (2017). Farklı Sıra Aralıklarında Uygulanan Ekim Normlarının Ketenciğin (*Camelina sativa* (L.) Crantz) Verim ve Verim Unsurlarına Etkisi. GOÜ Ziraat Fakültesi Dergisi, 34(1), 76-85.
Kıralan, M., Kıralan, S. S., Subaşı, I., Aslan, Y., Ramadan, M. F. (2018). Fatty acids profile and stability of Camelina (Camelina sativa) seed oil as affected by extraction method and thermal oxidation.
Koç, N., Önder, M. (2012). Biyodizel Hammaddesi Olarak Ketencik. Biyoyakıt Dünyası Sayı 16, 8-12.
Koncıus, D., Karcauskıene, D. (2010). The Effect of nitrogen fertilizers, sowing time and seed rate on the productivity of Camelina sativa. Agriculture, 97(4): 37-46.
Köse, A, Bilir, Ö., Katar, D., Arslan, Y. (2018). Bazı ketencik (*Camelina sativa* (L.) Crantz) genotiplerinin agronomik özelliklerinin belirlenmesi üzerine bir araştırma. Uludağ Üniversitesi Ziraat Fakültesi Dergisi, 32(1), 101-111.
Kurt, O., Seyis, F. (2008). Alternatif Yağ Bitkisi: Ketencik (*Camelina sativa* (L.) Crantz). OMU. Zir. Fak. Dergisi, 23(2): 116-120.
Koncius, D., Karcauskıene, D. (2010). The Effect of Nitrogen Fertilizers: Sowing Time and Seed Rate on the Productivity of Camelina sativa. Agriculture. 97:37-46
Mason, H. (2009). Yieldand Yield Component Responses to Camelina Seeding Rate and Genotype.http:/ag.montana.edu/nwarc/research/CroppingSystems/Camelina/09CSeeding Rate Genotype.pdf
Mattha¨ Us, B., Zubr, J. (2000). Variability of specific components in Camelina sativa oilseed cakes. Ind. Crops Prod. 12: 918.
Mills, S. C., A. C. Windsor, S. C. Knight. (2005). The potential interac- tions between polyunsaturated fatty acids and colonic inflammatory pro- cesses. Clin. Exp. Immunol. 142:216–228.
Napier, J. A., L. V. Michaelson, Stobart, A. K. (1999). Plant desaturases: harvesting the fat of the land. Curr. Opin. Plant Biol. 2:121–122.
Napier, J. A., Sayanova, O. (2005). The production of very-long-chain PUFA biosynthesis in transgenic plants: towards a sustainable source of fish oils. Proc. Nutr. Soc. 64:387–393.
Putnam, D.H., Budin, J.T., Field, L.A., Brene, W.M. (1993). Camelina: a promising low-input oilseed. p. 314-322. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.
Seehuber, R. (1984). Genotypic variation for Yield – and Quality – Traits in Poppy and False Flax. Fette, Seifen, Anstrichmittel. 86:177-180.
Schuster, A., Frıedt, W. (1998). Glucosinolateconte nt and composition as parameters of quality of Camelina seed. Ind. Crops Prod. 7: 297302.
Subaşı, İ., Arslan, Y., Güler, S., Hatipoğlu, H., Abrak, S., Köse, A. (2021). Oil and Protein Stability in Some Camelina (*Camelina sativa* L. Crantz) Genotypes. Turkish Journal of Agriculture-Food Science and Technology, 9(8), 1368-1374.
Subaşı, İ., Arslan, Y., Eryiğit, T., Çiftçi, V., Çamlıca, M. (2022). Determination of Some Seed Characteristics of False Flax (*Camelina sativa*

L. Crantz) Genotypes Grown Under Semi-Temperate Conditions. The Philippine Agricultural Scientist, 105(4), 341-348.
Urbaniak, S.D., Caldwell, C.D., Zheljazkov, V.D., Lada, R., Luan, L. (2008). The Effect of cultivar and applied nitrogen on the performance of Camelina sativa L. in the Maritime provinces of Canada. Can J Plant Sci., 88: 111-119.
Vollmann, J., Grausgruber, H., Stıft, G., Dryzhyruk, V., Lelley, T. (2005). Genetic diversity in camelina germplasm as revealed by seed quality characteristics and RAPD polymorphism. Plant Breeding, 124, 446-453
Wu, X., Leung, D. Y. (2011). Optimization of biodiesel production from camelina oil using orthogonal experiment. Applied Energy, 88(11), 3615-3624.
Yaşar, M. (2023). Sensitivity of different flax (*Linum usitatissimum* L.) genotypes to salinity determined by GE biplot. Saudi Journal of Biological Sciences, 30(4), 103592. DOI: https://doi.org/10.1016/j.sjbs.2023.103592
Yaşar, B., Eren, Ö. (2008). Türkiye'de Tarım Sektöründe Kullanılan Petrodizelin Çevresel Etkileri ve Biyodizel Alternatifiyle Karşılaştırılması.
Yasar M., Sezgin M. (2022). Investigation of Genotype x Environment Interactions by AMMI Analysis of Oilseed Sunflower Genotypes Grown in Different Environmental Conditions. Journal of the Institute of Science and Technology, 12(4): 2532 - 2542. DOI: https://doi.org/10.21597/jist.1159707
Zaleckas, E., Makarevičienė, V., Sendžikienė, E. (2012). Possibilities of using Camelina sativa oil for producing biodiesel fuel transport, 27(1), 60-66.
Zubr, J. (1997). Oil-seed crop: Camelina sativa. İndustrial Crops and Products (6): 113-119.
Vollmann, J., Rajcan, I. (2009). Oil crop breeding and Genetics, In Handbook of Plant Breeding, Vol. 4. Oil Crops, Vollmann and Rajcan J. (eds), Springer Verlag, Dordrecht, Heidelberg London, New York. pp 1-30.