KSÜ Tarım ve Doğa Derg 28 (6), 1471-1479, 2025
KSU J. Agric Nat 28 (6), 1471-1479, 2025
https://doi.org/10.18016/ksutarimdoga.vi.1670074

Comparison of Yield and Yield Components of 14 Camelina (*Camelina sativa* L. Crantz) Genotypes

Lütfi NOHUTÇU[1]✉, Murat TUNÇTÜRK[2], Ezelhan ŞELEM[3], Rüveyde TUNÇTÜRK[4]
[1,2,4]Van Yuzuncu Yil University, Faculty of Agricultural, Department of Field Crops, Van, Türkiye, [3]Van Yuzuncu Yil University, Muradiye Vocational School, Department of Landscape and Ornamental Plants Program, Van, Türkiye
[1]https://orcid.org/0000-0003-2250-2645, [2]https://orcid.org/0000-0002-7995-0599, [3]https://orcid.org/0000-0003-4227-5013
[4]https://orcid.org/0000-0002-3759-8232
✉: lutfinohutcu@yyu.edu.tr

ABSTRACT

Camelina (*Camelina sativa* L. Crantz.) is an annual and self-pollinated, well-adapted to cool temperate semi-arid climates with agronomic low-input features. Camelina is resistant to most diseases and pests that are hazardous to oilseed crops. This two-year study aimed to assess the yield and yield parameters of several camelina genotypes to identify the best genotype for cultivation. Several parameters, such as plant height, the height of the first capsule, the number of branches, the number of capsules, the number of seeds in a capsule, 1000 seed weight, seed yield, crude oil ratio, and crude oil yield, were determined. The results showed that three genotypes, namely PI 258367, PI 597833, and PI 311735, performed better than the others in terms of yield parameters. These three genotypes might be recommended for use as oil crops for the oil industry due to their high yield.

Field Crops

Research Article

Article History
Received : 04.04.2025
Accepted : 31.07.2025

Keywords
False flax
Genotype
Oil crops
Oil ratio
Oil yield

14 Farklı Ketencik (*Camelina sativa* L. Crantz) Genotipinin Verim ve Verim Parametrelerinin Karşılaştırılması

ÖZET

Ketencik (*Camelina sativa* L. Crantz.) tek yıllık, kendi kendine tozlaşan, agronomik açıdan düşük girdi özelliklerine sahip, serin-ılıman ve yarı kurak iklimlere iyi uyum sağlamış bir bitkidir. Ketencik, yağlı tohum bitkileri için tehlikeli sayılabilecek çoğu hastalık ve zararlıya karşı dayanıklıdır. Bu iki yıllık çalışma yetiştiricilik için en iyi genotipi belirlemek üzere çeşitli ketencik genotiplerinin verim ve verim parametrelerinin değerlendirmesini amaçlamıştır. Bitki boyu, ilk kapsül yüksekliği, dal sayısı, kapsül sayısı, kapsüldeki tohum sayısı, 1000 tohum ağırlığı, tohum verimi, ham yağ oranı ve ham yağ verimi gibi çeşitli parametreler incelenmiştir. Elde edilen sonuçlar, PI 258367, PI 597833 ve PI 311735 olarak adlandırılan üç genotipin verim parametreleri açısından diğer genotiplerden daha iyi performans gösterdiğini ortaya koymuştur. Bu üç genotipin yüksek verimleri sayesinde yağ endüstrisinde potansiyel yağ bitkisi olarak değerlendirilebileceği kanaatine varılmıştır.

Tarla Bitkileri

Araştırma Makalesi

Makale Tarihçesi
Geliş Tarihi : 04.04.2025
Kabul Tarihi : 31.07.2025

Anahtar Kelimeler
Ketencik
Genotip
Yağ bitkisi
Yağ oranı
Yağ verimi

Atıf Şekli: Nohutçu, L., Tunçtürk, M., Şelem, E., Tunçtürk, R. (2025) 14 Farklı Ketencik (*Camelina sativa* L. Crantz) Genotipinin Verim ve Verim Parametrelerinin Karşılaştırılması. *KSÜ Tarım ve Doğa Derg 28* (6), 1471-1479. https://doi.org/10.18016/ksutarimdoga.vi.1670074

To Cite : Nohutcu, L., Tuncturk, M., Selem, E., Tuncturk, R. (2025) Comparison of Yield and Yield Components of 14 Camelina (*Camelina sativa* L. Crantz) Genotypes. *KSU J. Agric Nat 28* (6), 1471-1479. https://doi.org/10.18016/ksutarimdoga.vi.1670074

INTRODUCTION

Camelina (*Camelina sativa* L. Crantz.) is an annual and self-pollinated oil crop of the family Brassicaceae with agronomic low-input features. Camelina is regaining popularity not only because it is a versatile oilseed crop, but also because it boasts a variety of beneficial characteristics that make it more adaptable to different environmental conditions than most other oilseed crops (Murphy, 2016). Central Asia and the Mediterranean are the natural habitats of camelina (McVay & Lamb, 2008), and it was a crop grown during the Iron Age, and its seeds were used to make oil (Larsson, 2013).

Camelina is a short-duration crop, and its yield potential is similar to that of spring oilseed rape (Crowley & Fröhlich, 1998). However, camelina exhibits a high level of adaptability to cool temperate semi-arid environments (Solis et al., 2013); moreover, it can resist drought and spring freezing better than oilseed rape (Brassica napus L.) (McVay & Lamb, 2008). Camelina is resistant to most diseases and pests that are hazardous for oilseed crops (Zanetti et al., 2017). In terms of growing environments, limitations for camelina are drought during sensitive growth stages and heavy clay soils with excessive precipitation (Ahmad et al., 2021).

Camelina may benefit both producers and customers in a wide range of ways (Ayaşan, 2014; Kuzmanović et al., 2021). Camelina seeds often contain more than 35% oil (Zubr, 1997; Blackshaw et al., 2011; Mohammed et al., 2017), due to these properties; they can be used for biofuel, bio-lubricant production, and other industrial products. Camelina seed oil is unique and has an extraordinary fatty acid pattern, with high amounts of alpha-linolenic acid and low concentrations of erucic acid (Zubr & Matthaus, 2002). Flax oil primarily comprises 90-95% unsaturated fatty acids and 5-10% saturated fatty acids. Polyunsaturated fatty acids constitute approximately 60% of the unsaturated fatty acid content, with linolenic acid accounting for 35-45% and linoleic acid comprising around 15-20% of the total fatty acid profile (Göre & Kurt, 2017). Thus, camelina oil can be used for cholesterol-lowering properties in the human diet thanks to an interesting source of omega-3 (Karvonen et al., 2002).

Given the potential for significant profits and valuable oil components, it is imperative to enhance camelina cultivation. To optimize camelina farmland, both irrigated and unirrigated trials are essential to ascertain yield and quality parameters. This study aims to assess the yield and yield-related characteristics of 14 camelina genotypes with diverse origins under irrigated conditions.

MATERIAL and METHOD

A two-year field trial was conducted during the 2019 and 2020 growing seasons. Field trials were conducted above the sea level of 1680 meters in, experimental area of the Faculty of Agriculture, Van Yuzuncu Yil University (38º33'46" N, 43º17'54" E). The camelina genotypes examined in this study were sourced from the Black Sea Agricultural Research Institute. Table 1 presents the origins of these genotypes.

Table 1. Description of camelina genotypes used in the study.
Çizelge 1. Çalışmada kullanılan ketencik genotiplerinin özellikleri

	Name of Genotype	Country of Origin
1	AMES 31231	Georgia
2	AMES 31224	Georgia
3	PI 258367	Russia
4	PI597833	Denmark
5	PI 650151	Sweden
6	PI 650164	Austria
7	PI 650167	Poland
8	PI 258366	Russia
9	PI 311735	Poland
10	PI 304268	Sweden
11	PI 304269	Sweden
12	PI 650160	Russia
13	PI 311736	Poland
14	PI 650153	Russia

Soil structure in the trial area was sandy-loam, pH was 7.72, salt was 88 dS m^{-1}, organic matter was 1.44%, and lime was 18.8 %. Furthermore, weather data from the Turkish State Meteorological Agency indicated that total precipitation during the 2019 and 2020 growing periods (April to July), as well as the long-term average, were 59.1 mm, 110 mm, and 126 mm, respectively. The mean temperature for these periods was 16.75 ºC, 16.35 ºC, and 15.82 ºC, respectively. Mean humidity levels were recorded at 50.6%, 52.5%, and 50.9%, respectively.

The field trials were carried out in a randomized complete block design (RCBD) with three replicates. Each plot size was 2×1m=2m2 and consisted of 4 rows. Sowing was done manually at a depth of 1–2 cm, in the first week of April in both years, by using 7.5 kg ha^{-1} seed, row space was 25 cm, and plant space within rows was approximately 5 cm.

The soil structure required for effective camelina seeding was achieved. All the plots were equally treated with 80 kg ha^{-1} nitrogen and 60 kg ha^{-1} phosphorus fertilization. Soil humidity in the plots was checked daily, and sprinkler irrigation was implemented as required. Experiments were checked for full maturity period and harvested first year on July 16 and the second year on July 20.

In the study, plant height, height of the first capsule, number of branches, number of capsules, number of seeds in a capsule, 1000 seed weight, seed yield, crude oil ratio, and crude oil yield were analyzed. The seed yields obtained from the plots (2m^2) were recorded and multiplied by 5000 and calculated as seed yield per hectare. The crude oil content was obtained using hexane as solvent on Soxhlet-type extractors, and the results were determined as % based on dry matter (Baydar & Erbaş, 2014). From the middle rows, ten random plants from each plot (30 plants per genotype) were manually harvested to avoid edge effects. All measurements were taken on individual plants at the Department of Field Crops laboratory at Van Yuzuncu Yil University's Faculty of Agriculture.

Data were subjected to analysis of variance (ANOVA) using the COSTAT (version 6.3) statistical program, year by year to compare genotypes, joint years to compare years, and genotype×years interaction. Duncan Multiple Range Test (DMRT) was used to compare the means at a level of 0.05. Principal component analysis (PCA), Cluster analysis, and correlation analysis of camelina genotypes conducted with SPSS ver. 25.

RESULTS and DISCUSSION

In this two-year study conducted within the same trial area, the results indicated statistically significant differences ($p < 0.01$) between the years for all parameters, with the exception of the number of seeds per capsule (Table 2). Furthermore, the differences between genotypes were also statistically significant at the 1% level for all parameters, excluding first capsule height, number of seeds in the capsule, and 1000 seed weight. Additionally, the interactions between year and genotype were found to be statistically significant at the 1% level for the number of branches, number of capsules, 1000 seed weight, seed yield, crude oil ratio, and crude oil yield. Plant height and number of seeds in the capsule were significant at the 5% level, while first capsule height was not statistically significant.

In both years, it was discovered that there were considerable differences in plant height. Plant heights in the experiment's first and second years ranged from 43.97 to 53.59 cm and 52.76 to 65.86 cm, respectively. The average plant height in 2020 (58.18 cm) was greater than the average plant height in the previous year (49.26 cm). The second year's total precipitation was approximately double that of the first year, a climatic variation that significantly impacted plant parameters, particularly plant height. The first-year highest plant height was measured from genotypes PI 258366 and AMES 31224, the lowest plant height was measured from genotype PI 258367. Similar results were reported in an experiment of winter and summer-sown camelina breeding lines, where the plant height was determined with an average of 78.5 cm for winter-sown and 34.7 cm for summer-sown (Kınay et al., 2019). Another two-year study conducted with camelina reported that first-year plant height was 103.41 cm, while second-year year 67.17 cm (Katar et al., 2012). Environment and genetic properties determine the characteristics of the plant, and for the plant height parameter, high temperature in the first year shortened plant length (Table 2).

Variations in the first capsule height were statistically significant among the genotypes. The first year did not show significant differences in the first capsule height. In the second year, the lowest value was observed in PI 650151, measuring 32.96 cm, similar to two other genotypes, while AMES 31231 exhibited the highest value at 44.86 cm. The average first capsule height was 30.06 cm in the first year and 37.19 cm in the second year. A positive correlation was observed between plant height and first capsule height (Table 5), indicating that as plant height increased, the first capsule height also tended to increase. A camelina study yielded comparable findings, indicating plant height fluctuations ranging from 85.47 cm to 94.29 cm, while the first capsule height ranged from 72.08 cm to 79.08 cm; in addition, the tallest plants exhibited the highest first capsule height (Yıldırım, 2015).

Significant variations in the number of branches among the genotypes were also noted. During the first year, the branch number varied between 18.00 and 26.22, averaging 21.54. The highest value in the first year was observed in genotype PI 258366. In the second year, the number of branches ranged from 13.80 to 23.43, with a mean of 17.86, and the highest value was found in genotype PI 258367. A study involving 24 genotypes demonstrated that the number of branches ranged from 7.0 to 14.7 over a two-year period (Köse et al., 2018).

In both years, differences in the number of capsules per plant were determined to be significant. The first and second-year capsule numbers ranged from 149.40 to 258.73 and 189.86 to 345.00, respectively (Table 3). In the first year, the greatest number of capsules is obtained from genotype PI 650164 and AMES 31231, second year, genotype PI 258367. The mean number of capsules in the second year (255.61) was higher than the mean number of capsules in the first year (190.05). In a previous study, the number of capsules reported by different researchers, Kınay et al. (2019) for summer sown was 37.2 to 93.9 and for winter sown was 58.6 to 104.8, Tuncturk et al. (2019)

87.60 to 157.83, and Çoban & Önder (2014) 49.66 to 119.0. Number of branch with capsule per plant (Table 5), capsule per plant with plant height (Çoban, 2014) has a positive correlation as the parameter of branch number environment has an important effect on the number of capsules, it could explain why first year average number of capsule per plant was higher than second year, and also why our result is slightly higher than the previous study.

Table 2. Results of plant height, first capsule height and number of branches of camelina genotypes
Çizelge 2. Ketencik genotiplerinin bitki boyu, ilk kapsül yüksekliği ve dal sayısı sonuçları

	Plant Height (cm)		First Capsule Height (cm)		Number of Branches (number plant^{-1})	
Genotypes	2019	2020	2019	2020	2019	2020
AMES 31231	51.92±1.20ab	65.50±1.28a	30.08±3.00	44.86±1.27a	21.50±1.08b-e	17.40±1.22cd
AMES 31224	52.38±1.40a	60.20±1.33ab	33.19±1.39	38.36±1.51b-d	18.00±1.51e	21.00±1.40ab
PI 258367	43.97±1.69e	57.15±5.04bc	26.57±1.32	35.36±2.72cd	21.93±2.41b-d	23.43±1.73a
PI597833	49.81±1.39a-d	55.76±2.40bc	32.45±1.14	36.83±3.74b-d	19.30±1.68c-e	16.96±0.33c-e
PI 650151	50.72±2.07a-c	55.96±2.11bc	29.58±3.36	32.96±2.18d	18.93±0.55de	22.53±1.57a
PI 650164	50.08±1.94a-c	52.76±0.58c	28.76±1.52	33.16±0.70d	24.13±1.38ab	19.00±1.15bc
PI 650167	46.88±0.54c-e	53.56±2.13c	29.17±0.76	33.43±1.53d	22.86±1.00a-c	16.90±0.55c-f
PI 258366	53.59±1.76a	55.80±2.72bc	32.79±2.10	37.86±2.63b-d	26.22±0.94a	15.33±0.68d-f
PI 311735	46.32±1.93c-e	55.50±2.72bc	27.99±2.78	34.86±1.95cd	23.90±1.24ab	15.06±0.88d-f
PI 304268	49.80±0.12a-d	61.73±0.93ab	32.34±1.05	40.33±0.80a-c	19.40±1.22c-e	18.06±0.52b-d
PI 304269	50.56±1.52 a-c	61.56±1.99ab	32.37±1.40	39.73±2.04a-c	22.96±0.73a-c	14.13±1.27ef
PI 650160	47.61±1.57b-e	55.96±2.07bc	27.90±1.35	36.53±2.61b-d	18.46±1.64de	17.16±0.35c-e
PI 311736	45.58±2.15de	57.23±0.50bc	25.70±1.60	34.46±2.12cd	22.06±1.63b-d	13.80±1.10f
PI 650153	50.46±0.80a-c	65.86±3.15a	31.96±1.06	41.93±2.40ab	22.00±1.25b-d	19.33±1.24bc
Mean of Year	49.26 B	58.18 A	30.06 B	37.19 A	21.54 A	17.86 B
LSD (5%)	4.475	6.619	5.195	6.136	3.857	3.929
CV	5.413	6.778	10.295	9.829	10.665	15.292
Genotype	0.005**	0.004**	0.074	0.011*	0.010**	0.001**
Year	0.001**		0.001**		0.001**	
Genotype * Year	0.020*		0.328		0.001**	

**p<0.01 *p<0.05 ns; not statical

Significant differences were observed in the number of seeds in the capsules of the genotypes. The number of seeds in the capsule varied from 11.30 to 16.26 in the first year, and the highest value was obtained from genotype PI 311735. In both years, the lowest value (11.30 and 11.93) was obtained from genotype AMES 31231. The mean number of seeds per capsule in both years is very close (13.76–13.90), and there are no significant variations between the two years. Previous studies reported the number of seeds in the capsule: 14.2-15.3 by Jankowski et al. (2019), 14.0-18.33 by Çoban & Önder (2014), and 6.1-15.9 by Kınay et al. (2019).

The differences in 1000 seed weights of the genotypes were also found to be significant (Table 3). First-year 1000 seed weights were found to range from 0.524 to 0.956 grams, with a mean of 0.81 grams. The most value in the first year was obtained from genotype PI 304268. In the second year, 1000 seed weights varied from 0.80 to 1.11 grams, with a mean of 0.93 grams. The same highest value was obtained from genotypes AMES 31224 and AMES 31231. In camelina, Angelini et al. (2020) found 1000 seed weight between 0.82-1.17 g., Czarnic et al. (2017) found between 0.87-1.13 g., Gugel and Falk (2006) found between 0.90-1.80 g, and Koc (2014) found 0.79-0.89 g.

The seed yields of genotypes showed significant variations (Table 4). Whereas first-year seed yields ranged from 455.5 to 724.8 kg ha^{-1}, second-year genotype seed yields ranged from 485.3 to 1023.7 kg ha^{-1}. First year highest value was obtained from genotype PI 311735. In the second year, the highest value was obtained from genotype PI 258367. The second year mean of the seed yield was (709.4 kg ha^{-1}) higher than the first year (563.2 kg ha^{-1}). Several morphological characteristics, including branches, capsules per plant, and seeds in capsules, have a direct impact on seed yield. Prior research indicates that seed and oil yields are significantly affected by environmental factors, and the performance of genotypes fluctuates in response to these environmental changes, leading to substantial variation in seed yield across different genotypes (Seehuber, 1984; Koncius & Karcauskiene, 2010). In the previous study conducted with different camelina genotypes, the seed yield was reported by Gao et al. (2022) as 449-3170 kg ha^{-1}, Katar et al. (2012) as 440.7-1266.3 kg ha^{-1}, Gugel and Falk (2006) as 962-2751 kg ha^{-1}. The seed yield parameter shows a wide range in the previous study and also in our research. This is not only due to genotypic variation but also to the environment and the response to climatic conditions.

Table 3. Results of number of capsules, number of seed in capsule and thousands seed weight of camelina genotypes
Çizelge 3. Ketencik genotiplerinin kapsül sayısı, kapsülde tohum sayısı ve bin tane ağırlığı sonuçları

	Number of Capsule (piece)		Number of Seed in Capsule (number capsule^{-1})		1000 Seed Weight (g)	
Genotypes	2019	2020	2019	2020	2019	2020
AMES 31231	247.13±4.97ab	285.06±4.06b	11.30±1.03e	11.93±1.22	0.903±0.05ab	1.11±0.05a
AMES 31224	176.20±6.71e-g	273.53±3.99c-e	11.53±0.27de	12.13±0.55	0.756±0.07ab	1.11±0.04a
PI 258367	210.73±9.95cd	345.00±2.91a	13.83±0.84bc	14.33±0.24	0.860±0.07ab	0.80±0.05e
PI 597833	181.33±10.92d-f	231.40±9.10d-f	13.93±0.68bc	15.00±1.78	0.859±0.04ab	0.88±0.04de
PI 650151	197.46±6.10c-e	297.93±7.16b	12.76±0.60c-e	16.43±0.50	0.524±0.13c	0.86±0.04de
PI 650164	258.73±15.56a	277.40±2.32bc	14.80±0.12a-c	13.63±1.75	0.815±0.11ab	0.99±0.08bc
PI 650167	192.93±6.01de	276.66±7.70bc	14.60±0.23a-c	13.76±0.68	0.764±0.09ab	0.86±0.02de
PI 258366	152.33±12.62fg	189.86±3.81g	14.73± 1.00a-c	12.96±0.84	0.726±0.04bc	1.03±0.03ab
PI 311735	226.44±11.79bc	273.66±6.44bc	16.26±1.39a	13.83±0.3	0.871±0.02ab	0.82±0.02de
PI 304268	157.73±13.38fg	240.40±4.72de	15.80±0.38ab	14.93±0.83	0.956±0.09a	0.87±0.03de
PI 304269	153.06±11.27fg	205.73±6.41fg	14.06±0.32bc	13.53±0.32	0.954±0.09a	1.08±0.03ab
PI 650160	179.33±3.19ef	230.26±8.48d-f	13.53±0.38cd	13.63±0.43	0.819±0.05ab	0.91±0.05cd
PI 311736	149.40±13.22g	225.40±18.10ef	12.83±1.01c-e	13.13±0.88	0.831±0.06ab	0.81±0.04de
PI 650153	177.93±8.03e-g	256.33±4.10cd	12.73±0.57c-e	15.46±0.43	0.717±0.01bc	0.88±0.01de
Mean of Year	190.05 B	255.61 A	13.76	13.90	0.81 B	0.93 A
LSD (5%)	29.807	28.373	2.158	2.602	0.201	0.106
CV	9.344	6.613	9.341	11.146	14.810	6.774
Genotype	0.001**	0.001**	0.003**	0.077	0.014*	0.001**
Year	0.001**		0.579		0.001**	
Genotype * Year	0.002**		0.055		0.001**	

**p<0.01 *p<0.05 ns; not statical

In both years crude oil ratio showed a significant difference. First year crude oil ratio varied between 21.88-32.60% and genotype PI 311735. The second-year crude oil ratio varied between 26.40-35.89% and genotype AMES 31224 had the highest value. As for many parameters, the second year mean of crude oil ratio (26.33%) was higher than the mean of the first year (31.86%). In the present study, the crude oil content of camelina (26.33-31.86%) was found to be lower than the previously reported range of 40.5-46.6% (Vollman et al., 2007) but consistent with the range of 22.17-39.77% (Katar et al., 2012). Crude oil content of camelina tested in the present study was comparable to previously reported values for camelina, 40.5-46.6% by Vollman et al., (2007), 22.17-39.77% by Katar et al., (2012). All these results show that the oil content of camelina has a wide range because it is affected by many parameters, as well as genotype and environment.

The parameter of crude oil yield showed significant differences. In the first year of the experiment, the crude oil yield ranged from 119.8 to 236.9 kg ha$^{-1,}$ and genotype PI 311735 had the highest value, while in the second year, it ranged from 154.2 to 340.9 kg ha^{-1} and the most value was obtained from genotype PI 258367. Comparing the mean of the crude oil yield shows a great difference (148.7-223.5 kg ha^{-1}), because the parameter of crude oil yield is affected by seed yield and crude oil ratio parameter significantly. Zhang et al., (2022) reported crude oil yield between 489-784 kg ha^{-1} (for fall seeded), Vollman et al., (2007) reported between 641-983 kg ha^{-1}, Gao et al., (2022) reported 373-1081 kg ha^{-1}, Tuncturk et al., (2019) between 191-328 kg ha^{-1}.

The analysis of the correlations between various parameters is presented in Table 5. The findings were, indicated that plant height was significantly correlated with first capsule height at the 1% level. Similarly, the number of branches was significantly associated with the number of capsules at the 1% level. Seed yield exhibited significant positive correlations with the number of branches and the number of capsules at the 5% level, and with the number of seeds per capsule at the 1% level. Furthermore, crude oil yield demonstrated a significant positive correlation with the number of capsules and the number of seeds per capsule at the 5% level and was also correlated with seed yield at the 1% level. Previous research also reported that positive and significant (1%) correlation between plant height and first capsule height, as well as the number of capsules (Çoban, 2014). Another experiment reported that positive and significant (1%) correlation between branch number to seed and oil yield (Tucturk et al., 2019).

Table 4. Results of Seed yield, crude oil ratio and yield of camelina genotypes
Çizelge 4. Ketencik genotiplerinin tohum verimi, ham yağ oranı ve ham yağ verimi sonuçları

	Seed Yield (kg ha^{-1})		Crude Oil Ratio (%)		Crude Oil Yield (kg ha^{-1})	
Genotypes	2019	2020	2019	2020	2019	2020
AMES 31231	561.9±9.77de	577.6±17.76de	29.21±0.45ab	32.55±0.62a-e	164.2±5.08b	188.02±6.54ef
AMES 31224	455.5±19.72f	651.4±39.55d	26.21±1.50b-e	35.89±1.01a	119.8±10.69f	233.1±9.63c-e
PI 258367	604.0±11.76b-d	1023.7±45.11a	25.58±1.07c-e	33.27±0.47a-d	154.7±8.86b-d	340.9±19.65a
PI 597833	569.3±24.69cd	761.3±30.93c	28.77±0.54bc	32.01±2.22a-e	163.6±5.44b	244.8±24.84b-e
PI 650151	552.7±18.80de	935.1±59.19ab	21.88±0.87f	29.35±1.25ef	120.8±4.17ef	273.3±10.62bc
PI 650164	659.7±24.36ab	818.3±65.07c	22.89±1.44ef	26.40±1.13f	150.9±10.20b-e	215.8±18.71d-f
PI 650167	633.4±17.36bc	613.0±31.48d	25.52±1.97c-e	31.37±1.24b-e	162.3±17.06bc	192.8±15.79ef
PI 258366	570.0±9.34cd	590.0±17.52de	23.33±2.03ef	30.76±1.05c-e	132.7±10.05c-f	181.5±8.81ef
PI 311735	724.8±42.37a	607.6±25.50d	32.60±1.32a	31.69±1.41b-e	236.9±20.21a	192.2±8.20ef
PI 304268	552.8±17.72de	829.6±17.28bc	24.28±1.60ef	31.63±1.59b-e	134.6±12.00b-f	261.9±7.69b-d
PI 304269	562.8±26.96de	485.3±44.07e	27.74±0.82b-d	32.08±1.98a-e	156.2±9.70bc	154.2±8.04f
PI 650160	499.4±26.99ef	638.3±19.71d	25.00±0.90d-f	30.00±1.09d-f	124.5±4.74d-f	191.1±2.50ef
PI 311736	469.7±27.62 f	552.4±22.69de	26.16±0.45b-e	34.20±0.73a-c	122.8±6.97ef	189.1±10.36ef
PI 650153	468.4±26.65f	848.3±17.05bc	29.51±0.43 ab	34.87±1.29ab	138.4± b-f	296.2±16.45b
Mean of Year	563.2 B	709.4 A	26.33 B	31.86 A	148.7 B	225.4 A
LSD (5%)	6.925	10.803	3.445	3.903	3.066	4.925
CV	7.326	9.072	7.795	7.299	12.282	10.603
Genotype	0.001**	0.001**	0.001**	0.005**	0.001**	0.001**
Year	0.001**		0.001**		0.001**	
Genotype * Year	0.001**		0.001**		0.001**	

**p<0.01 *p<0.05 ns; not statical

Table 5. Correlation matrix of parameters in camelina genotypes.
Çizelge 5. Ketencik genotiplerinin korelasyon analizi sonuçları

	Plant Height	First Capsule Height	Number of Branches	Number of Capsule	Number of Seed in Capsule	1000 Seed Weight	Seed Yield	Crude Oil Ratio	Crude Oil Yield
Plant Height	1.000								
First Capsule Height	**,854****	1.000							
Number of Branches	-0.130	-0.220	1.000						
Number of Capsule	-0.270	-0.273	**,538***	1.000					
Number of Seed in Capsule	-0.332	-0.176	0.226	0.182	1.000				
1000 Seed Weight	0.493	0.513	-0.249	-0.233	-0.352	1.000			
Seed Yield	-0.314	-0.275	**,626***	**,631***	**,758****	-0.361	1.000		
Crude Oil Ratio	0.297	0.425	-0.275	0.064	-0.235	0.024	-0.319	1.000	
Crude Oil Yield	-0.204	-0.064	0.429	**,618***	**,635***	-0.444	**,811****	0.240	1.000

Correlation is significant at the 0.05 level * and 0.01 level ** (2-tailed).

Results of cluster analysis, including similarities/dissimilarities, were given in Figure 1. Genotypes formed four main groups, and the genotype PI 258367 independently formed its own group. PI 258366, PI 304269, PI 650160, and PI 311736 in the first group, AMES 31231, AMES 31224, PI 650164, and PI 650167 second group, while PI597833, PI 650151, PI 311735, PI 304268, and PI 650153 in the third group.

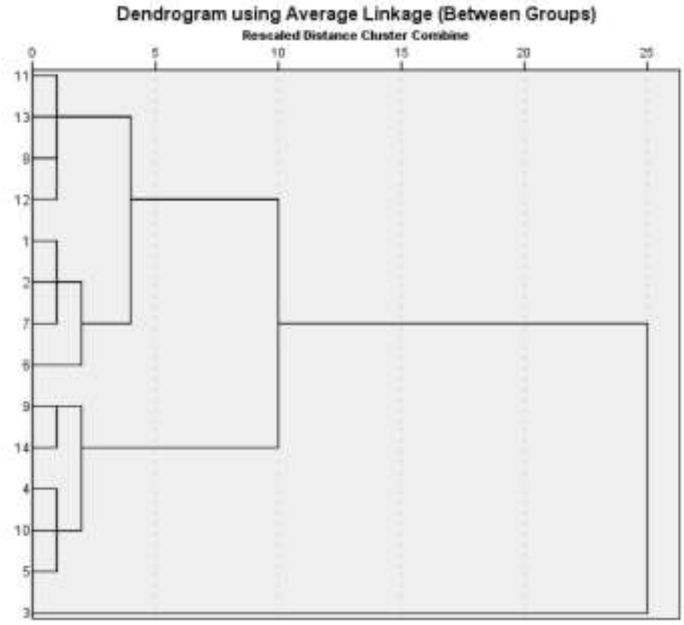

Figure 1. Cluster analysis results of camelina genotypes.
Şekil 1. Ketencik genotiplerinin kümeleme analiz sonuçları

Principal component analysis results to the classification of studied camelina genotypes based on morphological parameters are given in Figure 2. As a result of the principal component analysis performed with the averages of the two-year data obtained as a result of the study, a total of 62.64% of the total variance between the variables was explained, 41.09% in the first dimension and 21.55% in the second dimension. Four genotypes (PI 258367, PI 597833, PI 311735, and PI 650153) were superior to other genotypes in terms of yield characteristics. When Figure 2 is analyzed, it is seen that the parameters of seed yield, oil yield, and number of seeds in capsule have a narrower angle of 90º and they are far from the central axis, which reveals that they have a high positive relationship with each other.

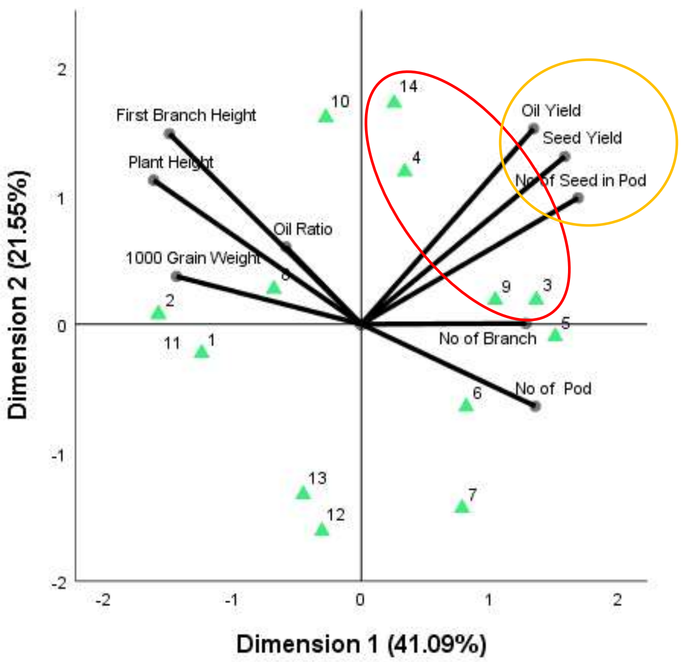

Figure 2. Principal component analysis to the classification of studied camelina genotypes
Şekil 2. Ketencik genotiplerinin temel bileşen analizi sonuçları

CONCLUSION

The two-year study's results indicated that genotypes PI 258367, PI 597833, and PI 311735 outperformed the other genotypes with respect to yield parameters, specifically seed yield, crude oil ratio, and crude oil yield. These promising genotypes warrant further investigation under various fertilization regimes, planting seasons (winter and summer), and non-irrigated conditions in arid regions to optimize oil production and identify high-yielding cultivars. Additionally, it is essential to assess the oil content of these genotypes to evaluate their potential for edible oil applications. Based on these results, the identified genotypes could be proposed as viable options for oil crop cultivation in the industry.

Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

Conflict of Interest

The authors declare that there is no conflict of interest between them.

REFERENCES

Ahmad, Z., Anjum, S., Skalicky, M., Waraich, E.A., Muhammad Sabir Tariq, R., Ayub, M.A., Hossain, A., Hassan, M.M., Brestic, M., Sohidul Islam, M. (2021). Selenium Alleviates the Adverse Effect of Drought in Oilseed Crops Camelina (*Camelina sativa* L.) and Canola (*Brassica napus* L.), *Molecules, 26*, 1699. https://doi.org/10.3390/molecules26061699

Akk, E., Ilumäe, E. (2005). Possibilities of growing Camelina sativa in ecological cultivation. *Estonian Res Institute Agric, 1,* 28-33.

Angelini, L.G., Abou Chehade, L., Foschi, L., Tavarini, S. (2020). Performance and potentiality of camelina (*Camelina sativa* L. Crantz) genotypes in response to sowing date under Mediterranean environment. *Agronomy, 10(12)*, 1929. https://doi.org/10.3390/agronomy10121929

Ayaşan, T. (2014). Ketencik bitkisinin (*Camelia sativa* L.) kanatlı beslenmesinde kullanılması. *KSÜ Doğa Bilimleri Dergisi*, *17*(2), 10-13. https://doi.org/10.18016/ksujns.02874

Baydar, H., Erbaş, S. (2014). Oil Crops Science and Technology. SDU Publications, Pub number: 97, Isparta/ Türkiye.

Blackshaw, R., Johnson, E., Gan, Y., May, W., McAndrew, D., Barthet, V., ... & Wispinski, D. (2011). Alternative oilseed crops for biodiesel feedstock on the Canadian prairies. *Canadian Journal of Plant Science, 91(5)*, 889-896. https://doi.org/10.4141/cjps2011-002

Çoban, F. (2014). Ekim sıklıklarının ketencik (*Camelina sativa* (L.) Crantz) bitkisinde önemli agronomik özellikler üzerine etkileri (Tez no 80910). [Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü Tarla Bitkileri Ana Bilim Dalı]. Yükseköğretim Kurulu Ulusal Tez Merkezi.

Çoban, F., Önder, M. (2014). Effects of sowing densities on the important agronomic characteristics of camelina [*Camelina sativa* (L.) Crantz] plant. *Selcuk Journal of Agriculture and Food Sciences*, *1*(2), 50-55.

Crowley, J.G., Fröhlich, A., (1998). *Factors affecting the composition and use of Camelina*. TEAGASC Arable Crops Research Centre, Oak Park, Co Carlow.

Czarnic, M., Jarecki, W., Jamro, D.B. (2017). The effects of varied plant density and nitrogen fertilization on quantity and quality yield of *Camelina sativa* L. *Emirates Journal of Food and Agriculture., 29 (12)*, 988-993. https://doi.org/10.9755/ejfa.2017.v29.i12.1569

Gao, Y., Jiang, C., Zhang, Y., Liu, L., Wang, Y., Kim, D. S., ... & Zhang, C. J. (2022). Agronomic performance of camelina genotypes selected for seed yield and quality characteristics in eastern China. *Industrial Crops and Products, 184*, 115077. https://doi.org/10.1016/j.indcrop.2022.115077

Göre, M., Kurt, O. (2017). Determination of Crude Oil Contenta and Fatty Acid Composition of Different False Flax [*Camelina sativa* (L.) Crantz.] Genotypes. *KSU J. Nat. Sci., 20 (Special Issue),* 201-205. https://doi.org/10.18016/ksudobil.349198

Gugel, R. K., Falk, K.C. (2006). Agronomic and seed quality evaluation of *Camelina sativa* in western Canada. *Canadian journal of plant science, 86(4)*, 1047-1058. https://doi.org/10.4141/P04-081

Jankowski, K. J., Sokolski, M., & Kordan, B. (2019). Camelina: Yield and quality response to nitrogen and sulfur fertilization in Poland. *Industrial Crops and Products, 141*, 111776. https://doi.org/10.1016/j.indcrop.2019.111776

Karvonen, H.M., Aro, A., Tapola, N.S., Salminen, I., Uusitupa, M.I.J., Sarkkinen, E.S., (2002). Effect of α-linolenic acid-rich *Camelina sativa* oil on serum fatty acid composition and serum lipids in hypercholesterolemic subjects. *Metabolism, 51*, 1253–1260.

Katar, D., Arslan, Y., Subaşı, İ. (2012). 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. (2012). 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.

Kınay, A., Yılmaz, G., Ayısıgı, S., Dokulen, S. (2019). Yield and quality parameters of winter and summer-sown different camelina (*Camelina sativa* L.) genotypes. *Turkish Journal of field crops, 24(2)*, 164-169. https://doi.org/10.17557/tjfc.631133

Koç, N. (2014). Farklı zamanlarda ekilen ketencik [*Camelina sativa* (L.) Crantz]'in verim ve bazı agronomik özelliklerinin belirlenmesi (Tez no 356979). [Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü Tarla Bitkileri Ana Bilim Dalı]. Yükseköğretim Kurulu Ulusal Tez Merkezi.

Koncıus, D. & Karcauskıene, D. (2010). The effect of nitrogen fertilizers, sowing time and seed rate on the productivity of Camelina sativa. *Agriculture, 97(4)*, 37-47.

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.

Kuzmanović, B., Petrović, S., Nagl, N., Mladenov, V., Grahovac, N., Zanetti, F., ... & Jeromela, A. M. (2021). Yield-related traits of 20 spring camelina genotypes grown in a multi-environment study in Serbia. *Agronomy, 11(5)*, 858. https://doi.org/10.3390/agronomy11050858

Larsson, M. (2013). Cultivation and processing of *Linum usitatissimum* and *Camelina sativa* in southern Scandinavia during the Roman Iron Age. *Veget Hist Archaeobot 22*, 509–520. https://doi.org/10.1007/s00334-013-0413-3

Lošák, T., Vollmann, J., Hlušek, J., Peterka, J., Filipčík, R., & Prášková, L. (2010). Influence of combined nitrogen and sulphur fertilization on false flax (*Camelina sativa* [L.] Crtz.) yield and quality. *Acta Alimentaria, 39(4)*, 431-444. https://doi.org/10.1556/aalim.39.2010.4.5

McVay, K.A., Lamb, P.F. (2008). Camelina Production in Montana. Bull. MT200701AG. Montana State Univ(online) Available from *http://msuextension.org/publications/ AgandNaturalResources/MT200701AG.pdf.* (Accessed 04 January 23).

Mohammed, Y.A., C. Chen, R. Keshavarz-Afshar. (2017). Nutrient requirements of camelina for biodiesel feedstock in central Montana. *Agronomy. J. 109,* 309–316. https://doi.org/10.2134/agronj2016.03.0163

Murphy, J.E. (2016). Camelina (*Camelina sativa*). *In Industrial Oil Crops*, 1st ed.; McKeon, T., Hayes, D., Hildebrand, D., Weselake, R., Eds.; AOCS Press: Urbana, IL, USA, pp. 207–230.

Seehuber, R. (1984). Genotypic variation for yield-and quality-traits in poppy and false flax. *Fette-Seifen-Anstrichmittel*, *86(5),* 177-180.

Solis, A., Vidal, I., Paulino, L., Johnson, B. L., Berti, M. T. (2013). Camelina seed yield response to nitrogen, sulfur, and phosphorus fertilizer in South Central Chile. *Industrial Crops and Products, 44*, 132-138. https://doi.org/10.1016/j.indcrop.2012.11.005

Tunçtürk, R., Kulaz, H., & Tuncturk, M. (2019). Effects of different sowing times and phosphorus application on yield and quality of camelina (*Camelina sativa* L. Crantz). *Yuzuncu Yıl University Journal of Agricultural Sciences, 29(2),* 274-281. https://doi.org/10.29133/yyutbd.525311

Vollmann, J., T. Moritz, C. Kargl, S. Baumgartner, and H. Wagentristl. (2007). Agronomicevaluation of camelina genotypes selected for seed quality characteristics. *Ind. Crops Prod. 26*, 270–277. https://doi.org/10.1016/j.indcrop.2007.03.017

Wysocki, D. and N. Sirovatka, (2007). Camelina a potential oilseed crop for semiaridic Oregon.// *Agronomy Abstracts*.- http://extention. Oregonstate.edu/catalog/htm//sr/sr 108-e/sr 1083-09. Pdf

Yıldırım, H. *Azot ve fosfor dozlarının ketencik [Camelina sativa (L.) Crantz] bitkisinde bazı verim ve kalite bileşenlerine etkileri* (Tez no 418853). [Yüksek Lisans Tezi, Selçuk Üniversitesi Fen Bilimleri Enstitüsü Tarla Bitkileri Ana Bilim Dalı]. Yükseköğretim Kurulu Ulusal Tez Merkezi.

Zanetti, F., Eynck, C., Christou, M., Krzyzaniak, M., Righini, D., Alexopoulou, E., Stolarski, M.J., Van Loo, E.N., Puttick, D., Monti, A. (2017). Agronomic performance and seed quality attributes of Camelina (*Camelina sativa* L. Crantz) in multi-environment trials across Europe and Canada. *Ind. Crop. Prod., 107*, 602–608. https://doi.org/10.1016/j.indcrop.2017.06.022

Zhang, C. J., Wu, N., Diao, J., Kim, D. S., Wang, Y., Gao, Y., ... & Yan, X. (2022). Agronomic evaluation of a Chinese camelina [*Camelina sativa* (L.) Crantz] cultivar in multiple semi-arid locations of northern China. *Italian Journal of Agronomy, 17(2)*, 2034. https://doi.org/10.4081/ija.2022.2034

Zubr, J. (1997). Oil-seed crop: *Camelina sativa. Ind. Crops Prod. 6*:113–119. https://doi.org/10.1016/S0926-6690(96)00203-8

Zubr, J., Matthaus, B. (2002). Effects of growth conditions on fatty ¨ acids and tocopherols in *Camelina sativa* oil. *Ind. Crops Prod. 15*, 155–162. https://doi.org/10.1016/S0926-6690(01)00106-6