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Evaluation of Camelina (*Camelina sativa*) Genotypes Grown in Winter at Different Sowing Dates in Northern Turkey Ecological Conditions in Terms of Yield and Oil Ratio

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ABSTRACT

This research was conducted to determine the effect of sowing dates on the yield and oil ratio of Camelina genotypes. The research was conducted in Northern Turkey during the 2017-2019 growing season with the use of 4 sowing dates (23 October, 3 November, 13 November, and 23 November) and two camelina genotypes (PI-650142 and PI-304269). Yield varied between 0.90-1.76 kg ha^{-1} and oil ratio between 28.4-30.8%. It was concluded based on present oil ratio findings that the second sowing date (3 November) was more suitable for camelina cultivation in the winter season in Northern Turkey ecological conditions, while it was concluded based on present yield findings that the fourth sowing date (23 November) was more appropriate. PI-650142 genotype seemed to be more adaptable to ecological conditions of Northern Turkey in terms of investigated oil ratio, and PI-304269 genotype can be preferred in terms of yield. Advancing or delaying sowing dates could have adverse effects on yield and yield components of the camelina genotypes.

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1. Introduction

Camelina (*Camelina sativa* L. Crantz) is the only economically important species of seven species (*C. alpcoyensis*, *C. sativa*, *C. laxa*, *C. rumelica*, *C. microcarpa*, *C. hispida ve C. anomala*) in the *Brassicaceae* (*Cucumberaceae*) family and the camelina genus (Davis, 1965; Göre, 2015). Camelina, which is also called by different names such as "Siberian oilseed", "German sesame", is also called "False Flax" in Turkey (Göre and Kurt, 2017). While forms of camelina as summer and winter forms are annual, the wild forms are perennial. The morphological differences between the forms appear primarily in the shape and color of the leaves, the shape of the capsules and seeds, and more specific characters. It has been reported that physiological differences are related to the growth and development of plants and some characteristics such as winter and drought resistance (Zubr, 1997).

Camelina can be grown successfully in different climatic and soil conditions, excluding heavy clay and organic soils (Kahrizi *et al*., 2015). Camelina is a drought and cold-tolerant plant, as well as can grow in high-altitude areas (Rostami Ahmadvandi and Faghihi, 2021). The seeds of camelina planted in the ground under suitable conditions will sprout within a few days. The vegetation period of camelina cultivars grown as a summer residence is approximately 120 days. On the other hand, camelina varieties grown in winter reach harvest maturity at the beginning of June, allowing the second product to be grown.

Parallel to the increasing population all over the world, the need for industrial products and energy, especially foodstuffs, is increasing day by day. It has been determined that some diseases are observed at a higher rate than in underdeveloped countries, as a result

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of the lack of balance between Omega-6 (n-6) and Omega-3 (n-3) fatty acids, especially in the foods of people in developed countries (Berti *et al.*, 2016). The idea that omega-3 fatty acids should be obtained from plant sources rather than animal sources has led to an increased interest in plants such as camelina, which is rich in omega-3 fatty acids (Toncea *et al.*, 2013).

Thanks to its superior properties, camelina can be an oil plant that contributes to closing the oil shortage in Turkey, and it can also be considered as a resource that will reduce foreign dependency on industrial products. As in all oil crops, oil rate and yield are a feature with complex inheritance, which is formed by the interaction of many morphological and physiological parameters, separately and together, during the growth and development period of the plant from planting to harvest. Knowing how and how much these parameters affect yield and quality is very important in terms of the farmer. In addition, the effects of these studies to be carried out in the conditions of that region are extremely important in order for the plants to be grown in a region to be grown efficiently and with high quality.

Based on this idea, this study was conducted to determine the yield and oil ratio of two different camelina genotypes planted in the Black Sea (Northern Turkey) ecological conditions in winter. Based on the data obtained in the research, it is aimed to suggest the most suitable planting time, taking into account the yield and oil ratio.

2. Materials and methods

2.1 Materials

Two different camelina genotypes obtained from the USDA (United States Department of Agriculture) were used. Information on genotypes is given in Table 1.

Table 1. Data on PI number and origin of camelina genotypes.

Number	Material Name	PI Number	Origin
1	No:402	PI 304269	Sweden
2	Ames 26665	PI 650142	Denmark

2.2 Soil property of field

This research was carried out in Samsun Province, Alaçam District, Geyikkoşan locality. The height of the experiment area is 4 meters from the sea, the soil structure is clayey, calcareous, salt-free, the pH level is slightly alkaline, organic matter is medium, phosphorus level is medium and potash level is high (Table 2).

2.3 Climate property of field

When the climate data of the experimental area as the average of the growing seasons and long years are evaluated, it is seen that the average temperature and humidity of the vegetation periods are higher than the average of many years; It is seen that the average of the monthly total precipitation amount belonging to the vegetation periods is lower than the averages of many years (Table 3).

Table 2. Data on different characteristics of soil structure of the field area.

	% Texture	pH	% Limy ($CaCO_3$)	% Total Tuz	Phosphorus (P_2O_5) kg da^{-1}	Potassium (K_2O) kg da^{-1}	% Organic matter
Result	79.0	7.71	1.7283	0.0271	6.6435	75.9213	2.8312
Degree	Clayey	Slightly alkaline	Limy	Saltless	Medium	High	Medium

Table 3. Data on humidity, temperature and precipitation for the breeding season and long years (Samsun regional directorate of meteorology observation reports, 2019)

Climate data / mounth	10	11	12	1	2	3	4	5	6
2017 Temperature (^{0}C)	14.7	11.1	10.0	7.2	8.6	10.1	12.2	15.0	20.8
2018 Temperature (^{0}C)	16.8	11.8	8.0	7.5	6.8	7.6	10.7	17.6	21.9
Long Years Temp. (^{0}C)	15.8	12.0	8.5	6.4	7.2	8.5	11.4	16.2	21.1
2017 Humidity (%)	81.4	85.9	79.3	91.5	94.0	96.5	92.5	92.2	87.0
2018 Humidity (%)	97.0	98.4	97.0	85.7	96.8	92.1	98.7	97.9	90.7
Long Years Humidity (%)	87.3	85.4	83.5	82.3	85.1	87.2	90.0	90.7	87.2
2017 Rainfall (mm)	30.0	64.2	145.0	102.4	45.0	115.4	7.6	61.8	36.4
2018 Rainfall (mm)	45.4	59.0	35.8	34.8	28.4	34.2	35.0	24.8	8.0
Long Years Rainfall (mm)	74.70	70.96	116.68	89.74	41.36	57.58	50.31	53.66	56.28

2.4 Methods

The experiments were conducted in the randomized complete block design with 3 replications arranged in split-plot (the cultivars were placed in the main plots and the sowing dates were placed in subplots). Sowing dates were arranged as October 23th, November 3rd, November 13th and November 23rd during the 2017 and 2019 winter seasons, respectively. In each plot, genotypes were planted in 5 rows with a length of 3 meters, 20 cm between rows and 5 cm above rows. The length between the blocks has been adjusted to be 1 meter for ease in weed control. Necessary standard maintenance procedures were performed throughout the experiment. Harvest was done step by step when the plants reached physiological maturity according to sowing dates (in June). After taking 10 plant samples from the parcels that reached physiological maturity, the remaining parcels were harvested.

Oil Ratio (%)*:* oil analysis was performed using Ankom XT15 automatic Soxhlet device in accordance with AOAC (1991).

Yield (kg ha^{-1}): Parcel yields were determined by weighing the seeds obtained after harvesting and blending the plants in the middle after the edge effect was removed from each plot. Yields were calculated by converting the obtained parcel yields to kg ha^{-1}.

2.5 Data analysis

Analysis of variance of all data obtained was done using SPSS 17.0 statistical package software.

Before analysis of variance, a homogeneity test was performed on all data using the same software. According to the results of the analysis of variance, Duncan's multiple test was examined at α=0.01 significance level among those with significant differences (Gomez and Gomez, 1984).

3. Results and discussion

As a result of the research, it was determined that the year, genotype, GxY, sowing date, YxSD, GxSD and GxYxSD interactions had a significant ($p<0.01$) effect on the yield parameter (Table 4). The highest yield is of the PI-650142 genotype (1.42 kg ha^{-1}) when evaluated based on genotype (Fig. 1). According to the results of the GxSD interaction multiple comparison tests, the highest yield was obtained from the PI-304269 genotype and 4th sowing date (1.68 kg ha^{-1}). The highest yield was obtained from the 2018 PI-650142 genotype (2.10 kg ha^{-1}) when the GxY interaction is evaluated according to the results of the multiple comparison test. The highest yield in terms of sowing date was obtained from the 4th sowing date (1.63 kg ha^{-1}). According to the YxSD interaction multiple comparison test results, the highest yield was obtained from the 4th sowing date in 2018 (2.68 kg ha^{-1}). The highest yield of GxYxSD interaction was obtained from the 4th sowing date of the PI-304269 genotype in 2018 (2.76 kg ha^{-1}).

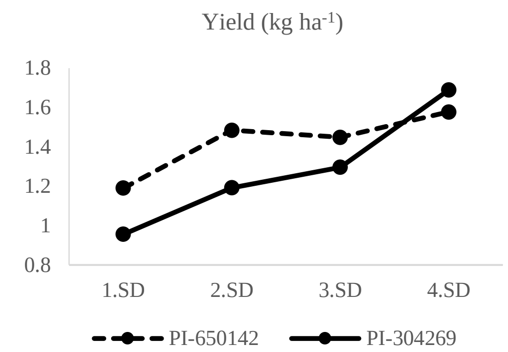

Figure 1. Variation in yields of camelina genotypes according to sowing dates.

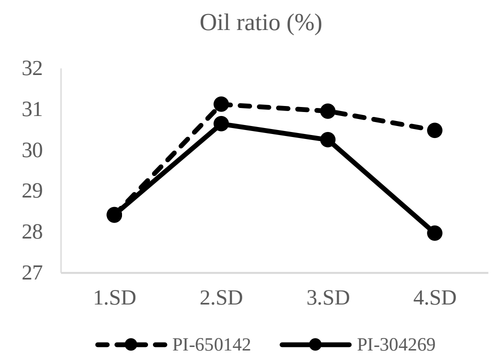

Figure 2. Variation in oil ratio of camelina genotypes according sowing dates.

As a result of the research, it was determined that the year, genotype, GxY, sowing date, YxSD, GxSD and GxYxSD interactions had a significant ($p<0.01$) effect on the oil ratio parameter (Table 4). The highest oil ratio in terms of genotype was obtained from PI-650142 with 30.24%. When evaluated in terms of GxY interaction, the highest oil ratio was obtained from the PI-650142 genotype (30.66%) in 2019. In terms of sowing date, the highest oil ratio was obtained from the 2nd sowing date (30.88%) (Fig. 2). The highest oil ratio in the YxSD interaction was obtained from the 2nd sowing date of 2019 (32.45%). The highest oil ratio in the GxSD interaction was obtained from the 2nd sowing date (31.12%) of the PI-650142 genotype. When evaluated in terms of GxYxSD interaction, the highest oil ratio was obtained from the 2nd sowing date (33.21%) of the PI-304269 genotype in 2019.

Table 4. The variance table of the parameters examined in the research

Variation sources	SD	yield	Oil ratio
General	47		
Genotype (G)	1	3705,06 **	96,81 **
Year (Y)	1	691062,32 **	193,73 **
Block	4	0,43	1,77
GxY	1	22,47 **	19,56 **
Error1	4		
Sowing Date (SD)	3	19961,92 **	95,42 **
YxSD	3	63884,94 **	73,33 **
Error2	12		
GxSD	3	2230,19 **	15,24 **
GxSDxY	3	790,35 **	8,73 **
Error3	12		
CV (%)		0.48	1.63

The average winter sowing season temperature is 12.4 °C, the total rainfall is 501.0 mm and the relative humidity is 91.0% in the research. Temperature and relative humidity parameters are higher than the long-term average of the research region. However, the total rainfall is lower than the long-term average (Table 3). In addition, the total rainfall (459.6 mm) in the second-year vegetation period was approximately 15% lower than the rainfall in the first year (542.4 mm), which also created a difference between the vegetation years. It is thought that these differences between vegetation periods and between climate parameters for many years may affect all growth parameters as well as yield. This difference explains the emergence of statistically significant results in all interactions depending on the year and the year. Day length and sunshine duration in the winter sowing season are important factors affecting the growth and development of plants. The 10-day difference between each planting time also affects the total lighting and total temperature times. The increase in the sunshine duration in the winter sowing season as the vegetation progresses, and the 4th sowing date reaching the highest yield in camelina genotypes proves this. As in all cultivated plants, the vegetation period and sowing date some of the most critical cultural practices in the camelina. Delayed sowing dates in the winter vegetation period caused an increase in yield (Fig. 1). The yield of camelina grown in winter has been reported as 2.70 kg ha^{-1} (Crowley, 1999), 0.5-1.95 kg ha^{-1} (Karahoca and Kırcı, 2005); 0.47 kg ha^{-1} (Katar *et al*., 2012); 0.85-1.81 kg ha^{-1} (Arslan *et al*., 2014); 1.36-2.54 kg ha^{-1} (Ayışığı, 2015) and 1.90 kg ha^{-1} (Kurasiak-Popowska *et al*., 2018) according to previous research results. The reported results are in line with the results obtained in this research (0.37-2.76 kg ha^{-1}).

The basis of yield in camelina, which is considered as an oil plant, is the oil ratio. Besides oil ratio is affected by environmental factors and cultural practices (Raizei *et al*., 2018). As a matter of fact, in research conducted in different locations, it was reported that the average oil ratio varies between 29.7-33.2% in winter sowing seasons, although it varies according to the regions, and the oil ratio is significantly affected by the location difference (Guy *et al*., 2014).

The oil ratio is a character affected by seasonal differences and sowing dates. It has been reported that late sowing has a negative effect on the oil ratio in camelina, and the oil ratio varies between 28.4% and 32.5% depending on the sowing date (Neupane, 2019). On the other hand, it has been reported that the oil rate in the winter planting season varies between 23.6%-32.3% (Arslan *et al*., 2014) and 33.5% (Katar and Katar, 2017). It has also been determined that sowing should not be late in the winter sowing season in terms of oil ratio and the oil ratio varies between 32.19-36.18% (Akbaş and Önder, 2018). As a result of this research, the oil ratio was determined as 28.4-30.8% in the winter sowing season, depending on the sowing date (Fig. 2). It was also obtained as a result of this research that the sowing date should not be delayed in terms of oil ratio in the winter sowing season, and this confirms the results of the previous research.

4. Conclusion

Good agronomical practices and appropriate sowing dates play a great role in high yields from camelina. Present findings agree with the results of previous studies highlighting the significant effects of sowing dates on yield and oil ratio. In terms of investigated oil ratio, the PI-650142 genotype seemed to be more adaptable to the ecological conditions of Northern

Turkey. The highest oil ratio was mostly obtained from the 2nd sowing date (3rd November). On the other hand, the PI-304269 genotype can be preferred in terms of yield in Northern Turkey. The highest yield was obtained from the 4th sowing date (23th November). PI-650142 genotype seemed to be more adaptable to ecological conditions of Northern Turkey in terms of investigated oil ratio, and PI-304269 genotype can be preferred in terms of yield. Advancing or delaying sowing dates could have adverse effects on yield and yield components of the camelina genotypes. Advancing or delaying sowing dates could have adverse effects on yield and yield components of the camelina genotypes.

Conflict of interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

MG was in study design, work, statistical analysis and manuscript writing. OK was supervisor.

Informed consent

The authors declare not to use any patients in this research.

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