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Performance of Some Important Agronomic Characteristics of *Brassica juncea* L. Genotypes under Fall Sowing at Two Locations of Ankara, Turkey

Fatma KAYAÇETİN
Central Research Institute for Field Crops, Breeding and Genetics Department, Oil Seed Crops Unit, Ankara/Turkey
https://orcid.org/0000-0003-3428-8121
fatmakayacetin@gmail.com

ABSTRACT
The study aimed to compare 29 brown mustard genotypes for their agronomic and oil yield traits under fall sowing conditions of Yenimahalle and Ikizce locations (Ankara) during 2017-2018. The result showed significant differences among the genotypes and the locations. Means of the two locations showed oleic acid, linoleic acid and erusic acid in range of 7.42 to 24.54%, 5.81 to 23.97% and 20.87 to 50.25% in the same order. The highest crude oil yields of 124.3 g plot^{-1} and 123.9 g plot^{-1} were obtained for AK and A3 genotypes, at Yenimahalle and Ikizce locations, respectively. Among the genotypes, AK (427.6 g plot^{-1}) and A3 (373.0 g plot^{-1}) genotypes exhibited outperformance with maximum seed yield and was recommended for further evaluation and use in biofuel production industry.

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Ankara'nın İki Farklı Lokasyonunda Sonbaharda Ekilen *Brassica juncea* L. Genotiplerinin Bazı Agronomik Özellikler Bakımından Performansı

ÖZET
Bu çalışma, 2017-2018 yılında Yenimahalle ve Ikizce lokasyonlarında (Ankara) sonbaharda ekilen 29 kahverengi hardal genotipini, bazı agronomik özellikler ve verim bakımından karşılaştırmayı amaçlamıştır. Sonuç olarak, farklı lokasyonlarda yetiştirilen genotipler arasında önemli farklılıklar tespit edilmiştir. Lokasyonların ortalamalarına göre, oleik asit, linoleik asit ve erusik asit %7.42 ile 24.54, %5.81 ile 23.97 ve %20.87 ile 50.25 arasında değişmiştir. En yüksek ham yağ verimi AK (124.3 g parsel^{-1}) ve A3 (123.9 g parsel^{-1}) genotiplerinde Yenimahalle ve İkizce lokasyonlarında elde edilmiştir. AK (427.6 g parsel^{-1}) ve A3 (373.0 g parsel^{-1}) genotipleri, tane verimi açısından en yüksek performansı göstermiştir. Biyoyakıt endüstrisi ve gelecekteki ıslah çalışmaları için AK ve A3 kahverengi hardal genotiplerinin değerlendirilmesi önerilmektedir.

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Anahtar Kelimeler
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Tohum verimi
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INTRODUCTION

Brown mustard (*Brassica juncea* L.) is an annual plant cultivated worldwide for the industrial oilseed, spice, vegetable and fodder crop species. *B. rapa* [AA (n:10)] and *B. nigra* [BB (n:8)] are two basic diploid species and their natural interspecific cross lead to amphidiploid species, *B. juncea,* [AABB (n:18)] (Nagaharu, 1935; Prakash, 1980; Gomez-Campo et al., 1999; Li et al., 2017). Fertilization of ovules generally stem from self-pollination, with interplant outcrossing rates of 20-30% (Rakow and Woods, 1987). Bees are the major pollen vectors because the pollen is heavy sticky and is not carried to far away locations by wind. Cross-pollination of nearby plants may also stem from physical contact of flowering racemes (Singh, 2013).

Identifying genetic variety can result in effective use the germplasm particularly for crop breeding studies. Previous studies (Turi et al., 2012; Khan et al., 2014; Jan et al., 2017; Manan and Sharma, 2017; Ilyasi et al., 2018) show that yield of rapeseed and mustard can be increased by introducing and adapting high yielding, high quality oil genotypes. It is well known that genetic, ecological and agronomic factors like plant densities, irrigations, sowing times and fertilizers have significant effects on performance of genotypes (Johnson et al., 2003; Shekhawat et al., 2012). *B. juncea* oil contains major saturated fatty acids like palmitic and stearic acids along with mono and polyunsaturated fatty acids like oleic, eicosenoic, erucic, nervonic and linoleic, linolenic acids (Pavlista et al., 2011; Kayacetin et al., 2016; Kayacetin et al., 2018). Morphology and physiological activities of the plants are significantly influenced by environmental and genetic factors in relation to ecological conditions, and cultural activities. At present, the breeders have their focus on breeding of brown mustard cultivars for their use in edible oil and spices industury. Turkey has high deficit of biofuel and there is need to identify and breed desired cultivars for the industry.

In line with above, the study aimed to compare twenty-nine brown mustard genotypes for their important agronomic characters under fall sowing conditions of hot humid continental climate of Yenimahalle and warm temperate climate of Ikizce locations agro climatic conditions during 2017-2018 growing season in Ankara, Turkey.

MATERIALS and METHODS

The field experiment was carried out during fall season of 2017-2018 at the Central Research Institute for Field Crops experimental stations under fall sowing conditions. The study made use of twenty-nine brown mustard genotypes as research material which was selected from among a large number of genotypes belonging to different origin obtained from the USA gene bank and collected locally from diverse ecologies in Turkey. Two standard cultivars were used as control. The detailed information of brown mustard genotypes used in the study is given in Table 1. All genotypes were planted as a fall sowing in the experimental fields located at Yenimahalle location 39°57′ 20.776″N, 32°48′ 49.154″, and 925 m altitude, with hot humid continental climate – Köpen Geiger Dsa type and Ikizce 39°26′ 18.87″N, 32°22.691″, and 1050 m altitude, with warm temperate climate – Köpen Geiger CSb type climatic characteristics under semiarid climatic ecological rainfed conditions.

The monthly meteorological data pertaining to vegetation period (September to June) of long years and 2017-2018 agro climatic conditions of Yenimahalle and Ikizce locations are given in Figure 1. There was total rainfall of 366.2 and 371.6 mm, maximum temperature of 20.3 and 33.9 °C, and minimum temperature of -11.5 and -4.6 °C, respectively at Yenimahalle. There was total rainfall of 208.5 and 359.6 mm, maximum temperature of 31.8 and 30.1 °C, and minimum temperature of -15.5 and -13.0 °C, at Ikizce in the same order.

The soils at Ikizce were low in organic matter (1.56% and 1.06%), alkaline with pH of 7.85 and 7.94%, 28.1 and 32.3% lime and all with clay loam characteristics at depth of 0-20 and 21-40 cm depth in the same order (Table 2). Whereas the soil analysis at Yenimahalle and Ikizce location during 2017, was performed by taking soil at a depth of 0-20, 21-40 cm showed low organic matter (1.35% and 1.28% respectively), in alkaline (pH 7.81), limey (5.3% and 5.2%, respectively), and clay-loamy soils of Yenimahalle (Table 3). The data were obtained from Meteorology Stations of the Central Field Crops Research Institute, Ankara Turkey

Table 1. Country of origin and seed color of brown mustard genotypes used in the study
Çizelge 1. Çalışmada kullanılan kahverengi hardal genotiplerinin kökeni ve tohum rengi

Genotype *(Genotip)*		Origin *(Köken)*	Seed color *(Tohum rengi)*	Genotype *(Genotip)*		Origin *(Köken)*	Seed color *(Tohum rengi)*
1	*A2*	Turkey, Izmir	Brown	*17*	*B14*	China	Brown
2	*A3*	Turkey	Brown	*18*	*B15*	Pakistan	Brown
3	*A5*	Turkey, Tekirdag	Brown	*19*	*B16*	Canada	Brown
4	*A6*	Turkey, Kayseri	Brown	*20*	*B17*	Canada	Brown
5	*A7*	Turkey, Tekirdag	Brown	*21*	*B20*	Russian Federation	Yellow
6	*A9*	Turkey, Tekirdag	Brown	*22*	*B21*	Russian Federation	Brown
7	*A10*	Turkey, Kirklareli	Brown	*23*	*B22*	China, Xizang	Brown
8	*A11*	Turkey, Edirne	Brown	*24*	*B23*	Pakistan	Brown
9	*B4*	Turkey	Brown	*25*	*B25*	Germany	Brown
10	*B5*	Turkey, Tekirdag	Brown	*26*	*B27*	United States, Minnesota	Brown
11	*B6*	India	Brown	*27*	*B28*	United States, Minnesota	Brown
12	*B7*	India, Rajasthan	Brown	*28*	*B29*	India	Brown
13	*B8*	Pakistan, Punjab	Brown	*29*	*AK*	Turkey, Konya	Brown
14	*B10*	India	Brown	*30*	*Standart1-A99*	India	Yellow
15	*B12*	Pakistan	Brown	*31*	*Standart2-A20*	India	Yellow
16	*B13*	China	Yellow				

All flower color are yellow

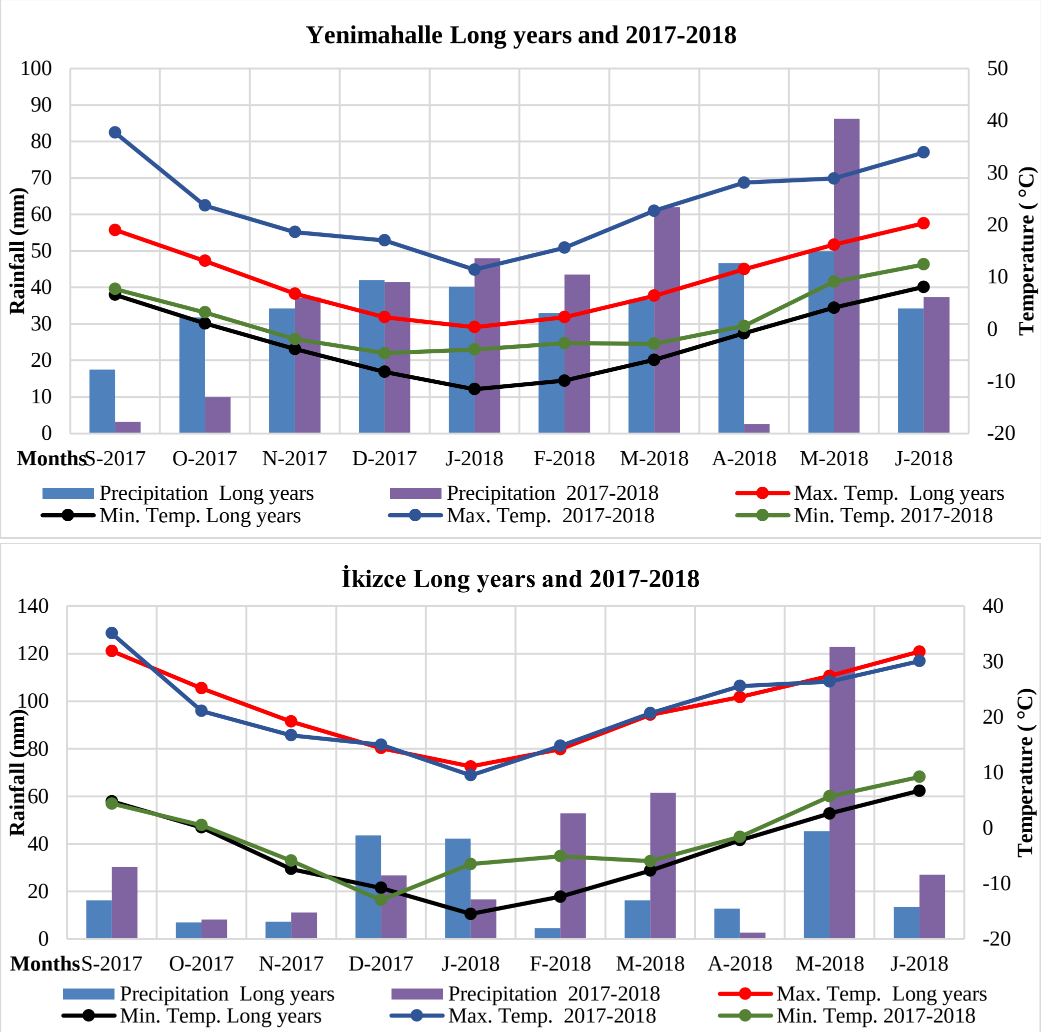

Figure 1. Monthly rainfall, minimum and maximum temperatures values recorded during brown mustard development in experimental areas (S, September; O, October; N, November; D, December; J, January; F, February; M, March; A, April; M, May; J, June)

Şekil 1. Kahverengi hardal gelişim döneminde deneme alanlarında kaydedilen aylık yağış, minimum ve maksimum sıcaklık değerleri (S, Eylül; O, Ekim; N, Kasım; D, Aralık; J, Ocak; F, Şubat; M, Mart; A, Nisan M, Mayıs; J, Haziran)

Table 2. The Soil samples features belonging to locations
Çizelge 2. Lokasyonlara ait toprak örneklerinin özellikleri

Location *(Lokasyon)*	Depth (cm) *Derinlik (cm)*	Texture *Bünye*	Total salt (%) *Toplam Tuz (%)*	*pH*	Lime(%) *Kireç(%)*	Phosphorus (kg ha^{-1}) *Fosfor (kg ha^{-1})*	Potassium (kg ha^{-1}) *Potasyum (kg ha^{-1})*	Organic Substance(%) *Organik Madde (%)*
Yenimahalle	*0-20*	Clay loamy	0.025	7.81	5.3	93	1260	1.35
	21-40	Clay loamy	0.025	7.81	5.2	105	2400	1.28
	Mean		0.025	7.81	5.3	99	1830	1.32
Ikizce	*0-20*	Clay loamy	0.031	7.85	28.1	36	2550	1.56
	21-40	Clay loamy	0.028	7.94	32.3	92	1790	1.06
	Mean		0.030	7.90	30.2	64	2170	1.31

The data were obtained from Soil Fertilizer and Water Resources Institute

The experiment was set up in "Split Plots Randomized Complete Block Design" design with three replications. The effect of locations was studied in the main plots and genotypes in the subplots. The genotypes were planted as two row, 3 m plots with 30 cm row spacing and three replicates. The thousand seed weight and seed yield were determined as described by Kayacetin, (2019). The crude oil content was determined by grinding 10 g of powdered

Table 3. Some characteristics of brown mustard genotypes
Çizelge 3. Kahverengi hardal genotiplerinin bazı özellikleri

Genotype		Thousand seed weight (g) *(Bin tane ağırlığı (g))*			Seed yield (g plot^{-1}) *(Tane verimi (g parsel^{-1}))*			Crude oil content (%) *(Ham yağ oranı (%))*			Crude oil yield (g plot^{-1}) *(Ham yağ verimi (g parsel^{-1}))*			Crude protein content (%) *(Ham protein oranı (%))*		
		Y	I	Mean	Y	I	Mean	Y	I	Mean	Y	I	Mean	Y	I	Mean
1	*A2*	2.3 st	2.2 t	2.2 m	294.0 cde	241.3 g-m	267.7 c	29.1 a-e	29.1 abc	29.1 a	85.5 b	70.5 d-j	78.0 c	25.9	22.5	24.2
2	*A3*	2.7 m-p	2.5 pqr	2.6 g-k	445.1 a	300.9 cd	373.0 b	27.9 b-m	28.1 b-l	28.0 b-e	123.9 a	84.5bc	104.2 b	26.5	21.9	24.2
3	*A5*	2.7 m-p	2.6 opq	2.6 f-j	219.3 k-s	247.4 g-l	233.3 def	27.5 g-o	29.1 a-d	28.3 a-e	60.5 i-q	71.6 d-h	66.1 def	24.6	22.9	23.8
4	*A6*	2.8 k-o	2.6 nop	2.7 e-h	227.2 h-r	200.9 n-y	214.1 f-k	28.2 a-k	29.5 a	28.9 ab	64.2 e-m	59.1 k-s	61.7 fgh	25.2	22.9	24.1
5	*A7*	2.8 k-o	2.6 nop	2.7 ef	191.4 q-z	169.1 u-z	180.3 l-o	28.6 a-i	29.0 a-f	28.8 abc	54.7 l-z	48.9 r-z	51.8 i-l	28.3	21.8	25.1
6	*A9*	2.5 pqr	2.4 rs	2.4 l	206.4 m-v	189.9 q-z	198.2 i-n	28.4 a-j	28.5 a-i	28.5 a-d	58.8 k-t	54.1 m-z	56.4 g-j	25.6	21.3	23.5
7	*A10*	2.9 h-l	2.7 m-p	2.8 de	227.2 h-r	224.1 i-r	225.7 f-i	28.4 a-j	29.1 a-d	28.8 abc	64.6 e-m	65.1 e-l	64.9 ef	24.2	21.5	22.9
8	*A11*	3.0 e-h	2.9 h-l	3.0 bc	293.2 c-f	266.3 d-h	279.8 c	27.3 h-o	27.3 i-o	27.3 efg	80.5 bcd	72.7 d-g	76.6 c	25.6	21.1	23.4
9	*B4*	3.1 c-f	2.8 i-m	3.0 bc	281.2 c-g	266.2 d-h	273.8 c	26.4 o	27.4 g-o	26.9 fg	74.4 cde	73.0 def	73.7 cd	24.5	22.6	23.6
10	*B5*	3.0 f-j	2.8 j-n	2.9 cd	229.9 g-m	197.9 o-y	213.9 f-k	27.0 k-o	28.4 a-j	27.7 def	62.1 f-p	56.3 k-z	59.2 f-i	24.8	21.4	23.1
11	*B6*	2.7 l-o	2.7 m-p	2.7 e-h	202.8 cd	196.2 p-z	199.5 h-m	27.1 j-o	28.0 b-m	27.5 d-g	55.0 l-z	54.9 l-z	55.0 h-k	27.6	22.5	25.1
12	*B7*	3.4 ab	3.0 e-i	3.2 a	176.8 g-l	181.6 s-z	179.2 l-o	27.8 c-n	27.5 g-o	27.6 def	49.2 r-z	50.0 q-z	49.6 jkl	23.8	22.2	23.0
13	*B8*	3.4 ab	3.2 cde	3.3 a	173.3 n-y	171.1 u-z	172.2 mno	26.5 no	26.7 mno	26.6 g	46.0 z	45.8 z	45.9 l	24.4	21.5	23.0
14	*B10*	3.0 e-i	2.9 g-k	3.0 bc	177.2 t-z	168.1 vyz	172.7 mno	27.5 g-o	28.0 b-m	27.8 c-f	48.8 s-z	47.1 yz	48.0 kl	24.4	21.4	22.9
15	*B12*	2.8 k-o	2.7 m-p	2.7 efg	170.5 u-z	170.2 u-z	170.4 no	27.8 d-n	28.2 a-k	28.0 b-e	47.4 vyz	48.1 t-z	47.7 kl	26.6	22.3	24.5
16	*B13*	2.6 nop	2.5 pqr	2.6 h-k	224.4 i-r	208.4 l-u	216.4 f-j	27.4 g-o	27.7 f-o	27.5 d-g	61.3 h-p	57.7 k-y	59.5 f-i	26.7	22.6	24.7
17	*B14*	2.6 opq	2.5 pqr	2.6 ijk	167.0 vyz	183.6 s-z	175.3 l-o	27.7 e-o	28.3 a-k	28.0 b-e	46.2 z	52.0 o-z	49.1 jkl	23.1	21.2	22.2
18	*B15*	2.6 opq	2.5 pqr	2.6 ijk	211.4 l-t	207.0 m-v	209.2 f-k	27.8 c-n	28.0 b-m	27.9 b-e	58.7 k-t	58.1 k-v	58.4 f-i	23.3	21.0	22.2
19	*B16*	2.6 nop	2.5 pqr	2.6 h-k	189.7 r-z	183.0 s-z	186.4 k-o	28.0 b-m	28.1 b-l	28.0 b-e	53.0 n-z	51.3 p-z	52.2 i-l	23.5	21.3	22.4
20	*B17*	2.7 l-o	2.6 nop	2.7 e-i	174.9 t-z	173.2 t-z	174.1 l-o	27.9 b-m	27.6 f-o	27.8 c-f	48.7 s-z	47.8 u-z	48.2 kl	23.1	21.0	22.1
21	*B20*	3.3 abc	3.1 c-f	3.2 a	199.1 o-y	205.2 m-v	202.1 g-l	29.0 a-f	29.2 ab	29.1 a	57.6 k-y	59.8 j-r	58.7 f-i	24.1	21.5	22.8
22	*B21*	3.1 c-g	3.0 f-j	3.0 b	226.1 i-r	218.0 k-s	222.1 f-i	27.4 g-o	27.8 c-n	27.6 def	62.0 g-p	60.7 i-q	61.3 fgh	24.2	21.3	22.8
23	*B22*	2.7 l-o	2.7 l-o	2.7 ef	181.7 s-z	194.9 p-z	188.3 j-o	27.5 g-o	27.6 f-o	27.6 d-g	50.0 q-z	53.8 m-z	51.9 i-l	25.2	22.1	23.7
24	*B23*	2.5 pqr	2.4 qrs	2.5 kl	259.8 e-j	251.9 g-k	255.9 cde	28.2 a-k	28.7 a-g	28.5 a-d	72.9 def	72.3 d-g	72.6 cde	25.4	22.4	23.9
25	*B25*	2.5 pqr	2.5 pqr	2.5 jkl	310.0 c	240.1 h-n	275.1 c	27.4 g-o	28.0 b-m	27.7 def	85.2 bc	67.1 e-k	76.2 c	24.6	22.0	23.3
26	*B27*	2.9 h-l	2.6 nop	2.8 ef	164.9 yz	157.0 z	161.0 o	27.8 c-n	28.7 a-g	28.3 a-e	45.9 z	45.1 z	45.5 l	24.7	22.3	23.5
27	*B28*	2.9 g-k	2.8 c-f	2.9 cd	237.5 h-o	217.9 k-s	227.7 e-h	26.8 l-o	26.9 k-o	26.9 f-g	63.7 e-n	58.7 k-u	61.2 fgh	24.6	22.2	23.4
28	*B29*	2.6 opq	2.5 pqr	2.6 jkl	253.4 f-k	204.6 m-y	229.0 efg	27.7 f-o	27.6 f-o	27.7 def	70.3 d-j	56.6 k-z	63.5 fg	24.2	22.1	23.2
29	*AK*	3.2 cde	3.1 c-f	3.2 a	450.1 a	405.0 b	427.6 a	27.6 f-o	28.5 a-i	28.1 b-e	124.3 a	115.5 a	119.9 a	23.6	27.9	25.8
**30*	*A99-cultivar*	3.0 e-h	3.1 d-g	3.1 b	232.1 h-p	221.1 j-s	226.6 fgh	28.2 a-k	28.1 a-l	28.2 a-e	65.4 e-l	62.3 f-o	63.8 fg	28.4	27.8	28.1
**31*	*A20-cultivar*	3.1 d-g	3.0 e-h	3.1 b	261.2 d-i	255.0 e-k	258.1 cd	27.8 d-n	27.8 c-n	27.8 c-f	72.5 d-g	70.9 d-i	71.7 def	29.3	29.9	29.6
F value$_L$		2.8 a	2.7 b	0.7*	234.2 a	216.7 b	23.1*	27.7 b	28.1 a	8.2*	64.9 b	61.0 a	718.9*	25.2	22.7	
F value$_G$				0.4*			33.1*			2.3*			1600.7*			
F value$_{GxL}$				0.0*			2.4*			0.3*			115.4*			
CV (%)				4.2			11.0			3.1			10.7			

Y, Yenimahalle; I, Ikizce

Table 4. Fatty acid composition of brown mustard genotypes
Çizelge 4. Kahverengi hardal genotiplerinin yağ asitleri kompozisyonu

Genotypes		*Palmitic acid (C16:0)*		*Stearic acid (C18:0)*		*ΣSFA*		*Oleic acid (C18:1n9c)*		*Eicosenoic acid (C20:1)*		*Erusic asid (C22:1n9t)*		*Nervonic acid (C24:1)*		*ΣMUFA*		*Linoleic acid (C18:2n6c)*		*Linolenic acid (C18:3n6)*		*ΣPUFA*	
		Y	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*	*Y*	*I*
1	*A2*	3.2	2.8	2.0	1.9	5.2	4.7	21.9	22.6	11.8	11.3	22.4	21.0	1.1	1.2	56.0	54.9	21.5	21.8	12.4	13.1	33.9	35.0
2	*A3*	3.0	3.0	1.9	1.6	4.9	4.6	21.7	21.5	11.6	11.6	23.9	24.1	1.1	1.3	57.1	57.2	20.5	20.0	12.5	13.1	33.0	33.1
3	*A5*	3.3	3.3	1.9	2.0	5.2	5.2	21.9	21.6	12.3	12.7	22.9	22.1	1.1	1.2	57.2	56.4	20.7	21.9	12.2	12.5	32.8	34.4
4	*A6*	3.3	3.1	1.9	1.8	5.2	4.9	20.9	20.1	11.5	11.0	23.6	23.4	1.2	1.3	56.0	54.6	21.1	21.0	12.6	14.7	33.7	35.6
5	*A7*	3.4	3.2	2.0	2.1	5.4	5.3	21.7	21.5	11.4	11.0	22.4	22.9	1.2	1.3	55.4	55.4	21.8	21.2	12.2	13.3	34.0	34.4
6	*A9*	3.1	3.2	1.8	1.9	4.9	5.1	19.5	22.0	11.6	12.1	23.6	22.3	1.3	1.1	54.8	56.4	21.3	21.0	14.3	13.9	35.6	34.9
7	*A10*	3.3	3.4	2.0	2.0	5.3	5.4	21.3	21.2	11.8	11.7	21.8	22.0	1.2	1.2	54.9	54.8	21.4	21.3	13.5	13.5	34.9	34.8
8	*A11*	3.5	3.9	2.0	1.7	5.5	5.6	21.3	19.8	11.7	11.0	20.9	22.1	1.2	1.3	53.9	52.8	22.3	23.6	13.2	13.1	35.6	36.7
9	*B4*	3.2	3.1	1.6	1.6	4.9	4.7	22.8	22.5	11.8	11.6	22.2	23.0	1.0	1.3	56.8	57.1	21.0	20.5	12.7	12.9	33.6	33.4
10	*B5*	3.1	3.6	1.7	2.0	4.8	5.6	19.9	20.2	11.5	11.7	23.5	21.8	1.3	1.2	54.9	53.7	21.0	21.7	14.7	13.9	35.6	35.6
11	*B6*	2.9	3.1	1.5	1.3	4.4	4.4	15.5	16.5	9.9	10.6	31.2	30.1	1.5	1.1	56.6	57.1	18.7	19.6	13.4	13.1	32.1	32.6
12	*B7*	3.0	3.0	1.3	1.5	4.3	4.6	15.4	14.8	9.1	9.0	36.2	35.8	1.4	1.6	60.6	59.5	19.8	18.9	10.1	11.3	29.8	30.2
13	*B8*	3.1	3.0	1.5	1.7	4.5	4.7	13.9	13.9	6.7	7.3	41.0	41.5	1.8	1.6	61.7	62.7	17.7	17.9	9.3	10.0	27.0	27.8
14	*B10*	2.9	2.9	1.3	1.4	4.2	4.3	13.4	13.6	8.3	8.4	39.3	39.0	1.7	1.6	61.0	60.9	18.8	17.9	9.1	10.0	27.9	27.9
15	*B12*	3.4	3.1	2.0	2.1	5.4	5.4	17.2	17.2	11.7	11.8	28.0	28.1	1.2	1.2	56.8	57.1	21.3	20.9	13.5	13.1	34.8	33.9
16	*B13*	3.8	3.5	1.9	2.0	5.7	5.4	14.5	13.9	9.1	9.0	29.8	30.0	1.6	1.6	53.4	52.8	22.6	22.1	13.4	13.7	36.0	35.7
17	*B14*	3.8	3.3	1.4	2.1	5.2	5.4	15.4	14.6	9.3	9.0	31.1	30.5	1.4	1.7	55.8	54.1	21.0	22.0	13.4	13.0	34.5	35.0
18	*B15*	2.7	2.9	1.7	1.7	4.5	4.6	14.4	13.6	14.4	12.9	35.0	37.0	1.7	1.5	63.8	63.4	13.8	15.0	11.1	10.1	24.9	25.1
19	*B16*	3.2	3.3	1.8	1.7	5.0	5.0	17.1	18.2	11.2	11.0	30.1	31.0	1.2	1.3	58.4	60.1	19.1	18.9	12.0	11.8	31.1	30.6
20	*B17*	3.3	3.2	1.8	1.8	5.1	5.0	14.0	14.5	9.0	8.6	33.6	32.9	1.6	1.6	56.6	56.1	20.0	19.9	11.9	12.4	31.9	32.2
21	*B20*	2.7	2.8	1.5	1.6	4.2	4.4	19.1	20.1	9.3	9.9	32.1	31.9	1.4	1.3	60.5	61.8	19.4	20.1	10.1	10.0	29.5	30.1
22	*B21*	2.9	3.0	1.5	2.1	4.4	5.1	16.7	16.2	8.6	8.4	32.1	32.4	1.6	1.5	57.4	57.1	21.6	20.8	11.2	11.9	32.8	32.7
23	*B22*	3.2	2.9	2.2	2.1	5.4	5.0	14.9	15.2	7.6	8.1	35.6	36.1	1.7	1.5	58.0	59.4	20.6	19.0	9.0	9.8	29.6	28.8
24	*B23*	2.7	2.9	1.2	1.4	4.0	4.3	14.8	14.3	8.8	7.5	36.8	37.8	1.8	1.6	60.4	59.5	18.7	19.3	10.1	10.0	28.8	29.3
25	*B25*	3.5	3.1	1.7	1.6	5.2	4.7	16.0	14.6	8.8	7.6	30.2	33.5	1.5	1.6	55.0	55.7	21.0	21.5	12.0	12.0	33.1	33.5
26	*B27*	3.0	3.2	1.9	1.9	5.0	5.1	21.8	21.4	12.1	13.4	24.3	23.1	1.2	1.2	58.2	57.9	19.5	20.5	12.4	11.6	31.9	32.2
27	*B28*	3.1	3.0	1.6	1.3	4.7	4.3	17.5	18.1	11.1	11.1	28.5	30.0	1.1	1.3	57.1	59.2	20.5	19.5	12.8	12.0	33.3	31.6
28	*B29*	3.0	2.9	1.8	1.8	4.8	4.7	20.4	20.1	10.8	11.1	24.1	23.9	1.4	1.4	55.3	55.0	20.8	20.3	14.0	13.6	34.8	33.8
29	*AK*	3.0	2.7	1.6	1.6	4.6	4.3	21.8	21.7	11.5	11.6	20.7	21.4	1.3	1.4	54.0	54.6	22.8	21.2	11.7	12.9	34.5	34.1
**30*	*A99-cultivar*	3.3	3.3	1.9	1.8	5.2	5.0	21.0	21.3	11.0	11.1	24.3	24.2	1.4	1.3	56.2	56.6	19.9	20.0	14.2	14.0	34.2	34.0
**31*	*A20-cultivar*	4.0	3.6	2.2	2.1	6.3	5.7	16.2	15.6	9.5	9.1	23.0	23.8	1.7	1.8	48.7	48.5	24.9	25.9	15.2	14.9	40.1	40.8
Maximum		4.0	3.9	2.2	2.1	6.3	5.7	22.8	22.6	14.4	13.4	41.0	41.5	1.8	1.8	63.8	63.4	24.9	25.9	15.2	14.9	40.1	40.8
Minimum		2.7	2.7	1.2	1.3	4.0	4.3	13.4	13.6	6.7	7.3	20.7	21.0	1.0	1.1	48.7	48.5	13.8	15.0	9.0	9.8	24.9	25.1
Mean		3.2	3.2	1.7	1.8	5.0	4.9	18.2	18.1	10.5	10.4	28.4	28.5	1.4	1.4	56.8	56.8	20.4	20.5	12.3	12.4	32.7	32.9

Y, Yenimahalle; I, Ikizce

mustard seed samples and extracting by hexane that were used with Gerhardt 2000 soxhlet apparatus (Singh et al., 2014). The crude protein contents were performed according to AACC Method 46-30 (Crude Protein/Combustion Method) on a Velp Scientifica model NDA-701 Dumas Nitrogen Analyzer protein determination device as N%×6.25 (Anonymous, 2000). The fatty acid compositions of eight major fatty acids palmitic (C16:0), stearic (C18:0), oleic (C18:1n9c), eicosenoic (C20:1), erusic (C22:1n9t), nervonic (C24:1), linoleic (C18:2n6c), linolenic (C18:3n6), were determined as content of total fatty acids by gas chromatography (GC) (Christie, 1973). The following methods were applied to the seeds obtained from each of the plot and replication to determine the thousand-seed weight, seed yield, crude oil content, crude protein content, crude oil yield and fatty acid compositions. All genotypes were grown under natural conditions without using any fertilizer or pesticide to measure their potential under natural conditions. When the seeds of these genotypes were mature enough to harvest on achieving 8.5% moisture content (CFIA, 1999) at both locations, they were harvested. At Yenimahalle location sowing date, emergence date, harvest date and days to maturity were 31 October 2017, 12 November 2017, 22 November 2018 and 225-229 d. At Ikizce location sowing date 12 October 2017, emergence date 22 November 2018, harvest date 15 June 2018, days to maturity 244-246 d.

Statistical analysis: All data excluding crude protein content and fatty acid compositions were subjected to analysis of variance (ANOVA) using the MSTAT-C computer statistical software. The significant differences between the group means were separated using LSD test at 0.05 probability level (Steel and Torrie, 1984). Measurements for crude protein content and fatty acid compositions were done for each plot in two parallels followed by computing means of the respective parameters.

RESULTS and DISCUSSION

The thousand seed weight (g), seed yield (g plot^{-1}), crude oil content (%), crude protein content (%), crude oil yield (g plot^{-1}) are shown in Table 3 and fatty acid compositions are presented in Table 4. The results showed significantly ($p<0.05$) different effects location and genotypes on the agronomic parameters. Similarly, genotypes × locations also showed a significantly important interaction ($p<0.05$) on the agronomic characteristics ($p<0.05$) (Table 3).

Thousand seed weight may contribute information to seed yield, that vary among genotypes. The thousand seed weight (2.8 g) at the Yenimahalle location was higher compared to the thousand seed weight (2.7 g) at the Ikizce location (Table 3). The maximum thousand seed weight was determined at Ikizce with 3.2 g for B8 genotypes; at Yenimahalle location with 3.4 g for B7 and B8 genotypes. These genotypes showed a higher value when compared to standard cultivars (control). There was no statistically significant difference between B7 and B8 genotypes. The minimum thousand seed weight was obtained (2.3 and 2.2 g) at Yenimahalle and Ikizce locations for A2 genotype (Table 3). Acording to mean of locations, the maximum thousand seed weight was determined for B7 (3.2 g), B8 (3.3 g), B20 (3.2 g) and AK (3.2 g) genotypes with no statistical differences among them lying in the same group. The differences in thousand seed weight for different genotypes could be due to variable adaptation and genetic potential of the genotypes used in the study (Yousaf et al., 2013). The results showed that hot humid continental climate of Yenimahalle was more effective in improving and gain of thousand seed weight compared to warm temprate climate of Ikizce.

There were highly significant differences among brown mustard genotypes for seed yield. The seed yield (234.2 g plot^{-1}) of Yenimahalle location was higher compared to the seed yield of Ikizce location (216.7 g plot^{-1}) (Table 3). The maximum seed yield was determined at Yenimahalle (450.1 g plot^{-1}) and at Ikizce locations (405.0 g plot^{-1}) for AK genotype compared to the standards. The minimum seed yield was obtained at Yenimahalle (164.9 g plot^{-1}) and Ikizce (157.0 g plot^{-1}) locations for B27 genotype (Table 3). The means of locations showed the maximum seed yield was determined for AK genotype (427.6 g plot^{-1}). The differences in the seed yield of genotypes were due to the better performance of genotypes may be due to genetic potential of these brown mustard genotypes. Different lines or genotypes were used by Yousaf et al. (2013); they also obtained similar conclusions using different mustard varieties under dessert conditions of Bahawalpur Pakistan, where June is the warmest month (35.6 °C) and January is the coldest month (13.4 °C). The results further showed that the *B. juncea* has very stable and adaptable genotypes resistant to varying environmental and ecological conditions and could behave similarly and the genetic potential of varieties are very important in Brassica. Stability among the tested genotypes was mainly associated with their greater tolerance to abiotic stress created by low rainfall, temperature and late sowing. Only promising mustard genotypes with greater tolerance to abiotic stress show above mean seed yield. This may help in selection of more stable mustard genotypes for development of new breeding cultivars (Anjum et al., 2005; Aslam et al., 2009). Johnson et al. (2002) and Mondal et al. (2018) emphasize that besides genetic factors seed yield of mustard is also affected by ecological and agronomic factors like plant density, irrigation, sowing time and rate of fertilizer etc.

The crude oil content was determined at Ikizce (28.1%) and at Yenimahalle (27.7%) locations. The maximum crude oil content was determined at Ikizce with 29.2%

yield; whereas, its yield at Yenimahalle location was 29.1% for A2 genotype that was higher compared to the standards. The minimum crude oil content obtained at Yenimahalle (26.4%) for B4 and Ikizce (27.3%) locations for A11 genotype (Table 3). Acording to mean locations, the maximum crude oil content (29.1%) was determined for A2 genotype. The results emphasize that these differences between locations might be due to environmental factors like soil structure, air temperature and precipitation (Shafii et al., 1992; Walton et al., 1999; Kayacetin et al., 2019). The results suggest potential of these genotypes for use in future breeding programs and supported the findings of Getinet et al., (1997); Ashraf et al., (1999).

The crude oil yield was determined at Yenimahalle (64.9 g plot^{-1}) and Ikizce (61.0 g plot^{-1}) locations. The crude oil yield of mustard at Yenimahalle location was higher compared to Ikizce location. The maximum crude oil yield was determined at Yenimahalle location with 124.3 g plot^{-1} in AK genotypes and at Ikizce location with 115.5 g plot^{-1}. The minimum crude oil yield was obtained (45.9 and 45.1 g plot^{-1}) at Yenimahalle and Ikizce locations for B27 genotypes higher than standards (Table 3). The means of locations showed maximum crude oil yield for AK genotypes (119.9 g plot^{-1}). Mean seed yield and crude oil yield at Ikizce location were higher compared to the seed yield and the crude oil yield at Yenimahalle. Contrarily, the crude protein content was lower at Yenimahalle compared to Ikizce. Whereas, Kayacetin (2019) emphasise that oil yields should be preferred compared to seed yields of genotypes; as seed and oil yields may not be correlated with low oil yielding genotypes.

The maximum crude protein content (25.2 and 22.7%, respectively) was determined at Ikizce and Yenimahalle locations. The maximum crude protein content was determined as 29.9%, and 29.3% at Ikizce and Yenimahalle location in the same order for A20 cultivar. The minimum crude protein content of 23.1% and 21.0% was obtained at Yenimahalle for B14 and at Ikizce locations for B15 and B17 genotypes respectively (Table 4). The means of two locations showed maximum crude protein content determined for A20 cultivar (29.6%) that was higher compared to all genotypes. These differences might have resulted due to the effects of ecological conditions of the location's and their soil structure and other factors like air temperature and precipitation. Si et al., (2003); Si and Walton, (2004) observed that high spring temperatures and drought stress were associated with lower oil and higher protein content in canola while, Pritchard et al., (2000) noted high oil contents with cooler spring. These results of this study are in agreement with the findings of Gunasekera et al., (2006) in brown mustard and canola under the Mediterranean conditions.

The results indicated detection of eight fatty acid components like saturated palmitic and stearic acids along monounsaturated fatty acids like oleic, eicosenoic, erucic, nervonic, and polyunsaturated fatty acids like linoleic, linolenic acids. The saturated fatty acids (5.0%) of Ikizce location were higher compared to that of Yenimahalle location (4.9%). The maximum saturated fatty acids percentage as determined at Yenimahalle (6.3%) and at Ikizce (5.7%) locations for cultivar A20 was higher in comparison to brown mustard genotypes. The minimum saturated fatty acids at Yenimahalle (4.0%) and Ikizce (4.3%) locations was determined for B23 and B10 genotypes. The monounsaturated fatty acids mean (oleic, eicosenoic, erucic and nervonic acids) of Yenimahalle and Ikizce locations were 56.8%. There were no difference between locations. The maximum monounsaturated fatty acids was determined at Yenimahalle (63.8%) and at Ikizce (63.4%) locations for B15 genotype. The minimum monounsaturated fatty acids were obtained at Yenimahalle (48.7%) and Ikizce (48.5%) locations for cultivar A20. The polyunsaturated fatty acids mean (linoleic and linolenic acids) of Ikizce (32.9%) location was higher compared to the seed yield of Yenimahalle (32.7%) location (Table 4). The maximum polyunsaturated fatty acids was determined at Yenimahalle (40.1%) and at Ikizce (40.8%) locations for cultivar A20. The minimum polyunsaturated fatty acids was noted (24.9 and 25.1%) at Yenimahalle and Ikizce locations for B14 genotype (Table 4). The fatty acid composition acording to the mean locations, saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids varied between 4.0-6.3%, 48.5-63.8% and 24.9-40.8%, respectively. The differences between fatty acids compositions among genotypes were obvious. Oleic acid (13.4 to 22.8%), linoleic acid (13.8 to 25.9%) and erusic acid (20.7 to 41.5%) were the most prominent components. These differences can be owing to the genetic background of the experimental material (Zubr and Matthäus, 2002; Rai et al., 2018). Although there were no significant differences between locations, there were significant differences among the performance of genotypes (McCartney et al., 2004; Karaca and Aytac, 2007). It can be understood that mustard fatty acid compositions were affected more due to genetic characters of genotypes than locations. Despite the slight change in order of abundance of some fatty acids, their profiles and contents were similar to those reported in the literature (Eryilmaz, 2009; Pavlista et al., 2011; Kayacetin et al., 2018). Seed oil quality and utility usually depend on fatty acid composition. Thus, fatty acid composition may be used as to identify useful biological resources, as well their current use for oil authentication (Li et al., 2011; Qiao et al., 2017; Kayacetin et al., 2018). Ogut and Oguz, 2006; Ogut, 2007; Kayacetin et al., (2016) also reported that the accessions with high monounsaturated fatty acid

(MUFA) content could be used as optimal and effective germplasm resources for biodiesel production.

CONCLUSION

Brown mustard (*B. juncea* L.) genotypes evaluated in this study exhibited an important level of diversity for seed yield, crude oil content, crude oil yield, crude protein content and fatty acid compositions. Genotype AK and A3 were among the genotypes that showed statistically significant and higher seed yield and crude oil yield in comparison to all other genotypes or cultivars used in the study. So, these two genotypes could take for further evaluation in yield trials and in different breeding programs to breed high yielding fall season cultivars for biofuel production. Knowledge of the characteristics of the genotypes along with their yield and quality features like oil makes will facilitate their use in biofuel production.

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Statement of Conflict of Interest

Author has declared no conflict of interest.

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