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Effect of Different Spring Sowing Dates on Phenology, Growth and Yield Performance of Turkish *Brassica nigra* in Ankara/Turkey

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Abstract

The maximum yield of *Brassica nigra* primarily relates to available photoperiod or day length conditions and secondarily to meteorological components of prevailing weather. This research was performed to determine the developmental responses to four different spring sowing dates (25th March, 10th April, 25th April and 10th May) and temperature to screen them for different morphological and phenological charachteristics for five *B. nigra* genotypes under hot humid continental-Dsa type climate at Yenimahalle, Ankara during 2017 growing season. The seeds of *B. nigra* used in this study were selected from *B. nigra* genotypes obtained from USDA gene bank and collected from diverse ecologies of Turkey. The result showed significant differences among the sowing dates and the genotypes. According to the results the maximum seed yield (28.4 g m^{-2}) and crude oil yield (6.1 g m^{-2}) were obtained from the earliest sowing and the minimum seed yield (1.5 g m^{-2}) and crude oil yield (0.2 g m^{-2}) was obtained from the latest sowing date. The maximum crude oil yield (4.6 g m^{-2}) and seed yield (22.4 g m^{-2}) were noted from *Kayseri* genotype whereas the minimum crude oil yield (1.4 g m^{-2}) and seed yield (6.8 g m^{-2}) were determined from *Sanliurfa* genotype. The maximum seed yield (49.3 g m^{-2}) and crude oil yield (10.3 g m^{-2}) were determined on 25th March × Kayseri genotype whereas the minimum seed yield (0.9 g m^{-2}) and crude oil yield (0.1 g m^{-2}) were obtained for Izmir genotype. Keeping in view the spring sowing dates of *B. nigra* provision of short day length in late March sowings are more desirable. This research highlights the practical importance of spring sowing dates in vegetative and generative phase of development that ultimately affects yield and yield components.

Keywords: *Brassica nigra*, Sowing dates, Morphological and phenological characteristics

Ankara'da Farklı İlkbahar Ekim Tarihlerinde Ekilen *Brassica nigra*'nın Fenoloji, Büyüme ve Verim Potansiyeline Etkisi

Özet

Brassica nigra'da maksimum verim, öncelikle fotoperiyod veya gün uzunluğu koşulları ve ikincil olarak hava koşullarının meteorolojik bileşenleri ile ilgilidir. Bu araştırma, 2017 yılında Yenimahalle'de (Ankara) dört farklı ilkbahar ekim tarihinin (25 Mart, 10 Nisan, 25 Nisan ve 10 Mayıs) beş *B. nigra* genotipi için büyüme, gelişme ve verim özellikleri açısından etkisini belirlemeyi amaçlamıştır. Bu çalışmada kullanılan *B. nigra* tohumları USDA Gen Bankası'ndan elde edilen ve Türkiye'nin çeşitli ekolojilerinden toplanan *B. nigra* genotiplerinden seçilmiştir. Sonuç olarak, farklı ekim zamanları ve genotipler arasında önemli farklılıklar tespit edilmiştir. Sonuçlara göre, maksimum tohum verimi (28.4 g m^{-2}) ve ham yağ verimi (6.1 g m^{-2}) ilk ekim tarihinden elde edilirken; minimum tohum verimi (1.5 g m^{-2}) ve ham yağ verimi (0.2 g m^{-2}) en son ekim tarihinden elde edilmiştir. En yüksek ham yağ verimi (4.6 g m^{-2}) ve tohum verimi (22.4 g m^{-2}) Kayseri genotipinde kaydedilirken, en düşük ham yağ verimi (1.4 g m^{-2}) ve tohum verimi (6.8 g m^{-2}) Şanlıurfa genotipinde belirlenmiştir. En yüksek tohum verimi (49.3 g m^{-2}) ve ham yağ verimi (10.3 g m^{-2}) 25 Mart ekim zamanı × Kayseri genotipinde tespit edilirken, en düşük tohum verimi (0.9 g m^{-2}) ve ham yağ verimi (0.1 g m^{-2}) 10 Mayıs ekim zamanı × İzmir genotipinde belirlenmiştir. Farklı ilkbahar ekim tarihleri göz önünde tutarak *B. nigra*'nın Mart ayı sonlarında yani kısa gün uzunluğunda ekimi daha uygun

görülmüştür. Bu araştırma, ilkbahar ekim tarihlerinin, sonuçta verim ve verim bileşenlerini etkileyen vejetatif ve generatif gelişim dönemlerindeki pratik önemini vurgulamaktadır.
Anahtar Kelimeler: *Brassica nigra*, Ekim tarihi, Morfolojik ve fenolojik özellikler

1.Introduction

Brassica nigra L. (black mustard) species belong to Cruciferae family has an annual growth habit, pile rooted, herbaceous, yellow flowering ensued by seed-set (Uhl, 2000; Kayacetin, 2019). This species grow in Turkey as weed (Guner et al 2012; Anonymous, 2019; Anonymous, 2020). Leaves, flower, young shoots and seeds of *B. nigra* are used as spices, culinary and medicinal purposes (Akan and Bakir, 2015; Darwesh, 2017; Oguz, 2017). Palle-Reisch et al. (2013) reported that *B. nigra* can be used variably as spice and has the sharpest taste. *B. nigra* powder is used as additive in meat, sausage and salami industries (Akgul, 1993). *B. nigra* oil is also used in some formulations in pharmacy (Kokcu et al., 2015). *B. nigra* is important because of its potential utilities for spice and medicinal industries. It is important to introduce and breed more new oilseed crops by using the huge diversity of oilseed crops.

Growth and yield is fixed within the life cycle of a plant but the time taken to a particular growth stage is influenced by environmental factors mainly temperature, increasing/decreasing day length (photoperiod) and meteorological parameters like soil and air temperature, heat, humidity and precipitation etc. Phenology, growth and yield performance of Brassica spp. are significantly related to day length related ontogenetic changes and climatic variations (Major, 1987; Kar and Chakravarty 2000; Laureti and Peiri, 2001; Gupta et al., 2017; Kumar et al., 2018). Sowing dates can have a important impact on different *B. nigra* genotypes. There is no available information on the response of *B. nigra* to spring sowing dates for the genotypes grown in Turkey. The main aim of the study was to evaluate favorable spring and mild summer sowing time or day lengths (photoperiod) with changing day length from short to long days + temperature on phenology, growth and yield performances of five Turkish *B. nigra* genotypes under hot humid continental - Dsa type climate.

2. Materials and Methods

The experiments were performed during the growing season of 2017 at the experimental fields located at Yenimahalle 39°12′ - 43°6′ N, 35°58′ - 37°44′ E, and 925 m altitude, with hot humid continental - Dsa type climate of Ankara as classified by Köppen-Geiger ecological conditions of Turkey (Kottek et al., 2006; Climate-Data, 2018). The seeds of *B. nigra* genotypes selected from *B. nigra* genotypes obtained from USDA gene bank collected from diverse ecologies of Turkey. These were multiplied and selected for use in the experiment in Central Research Institute for Field Crops during 2012-2017. *B. nigra* genotypes were grown under natural conditions without using any fertilizer or pesticide. The experiment was set up in "Split Plots Randomized Complete Block Design" design with three replications. The effect of sowing dates was studied in the main plots and genotypes in the subplots. Each genotype was sown manually in one row, three meter long plots with 30 cm long row spacing with sowing depth of ~1.0-1.5 cm and seed rate of 3000 g ha^{-1} (Kayacetin, 2019). Each genotype was performed four different spring sowing dates (25th March–11 h 27 min to 13 h 26 min or short day length, 10th April-13 h 01 min to 14 h 37 min short to short–long day length, 25th April–13 h 01 min to 14 h 37 min short–long day length to intermediate day length and 10th May–14 h 02 min to 15 h 35 min long day length) and temperature.

Monthly meteorological data pertaining to vegetation period (March to July) of long term and 2017 climatic conditions of Yenimahalle are shown in Table 1. There was total precipitation of 181.8 and 264.9 mm, average temperature of 15.6 and 16.2 °C, and an average humidity of 55.2 and 52.4%, respectively.

Soil analysis during 2017, from the soil taken at a depth of 0-20, 21-40 cm showed low organic matter (1.32%), in alkaline (pH 7.81), limey (5.3%), and clay-loamy soils of the experimental plots (Table 2).

In this study, days to emergence (d), days to 50% flowering (d) and days to 90% physiological maturity (d), plant height (cm), number of branches (branch $plant^{-1}$), number of capsules (capsule $plant^{-1}$), thousand seed weight (g), seed yield (g m^{-2}), crude oil content (%) and crude oil yield (g m^{-2}) were determined as described by Kayacetin (2019). Morphological and yield parameters of genotypes were done on five plants. The oil content was determined by grinding 10 g of powdered mustard seed samples and extracting

by hexane were use with Gerhardt 2000 soxhlet apparatus.

All data were subjected to analysis of variance (ANOVA). The significant differences between the group means were separated using LSD's test.

Table 1. Monthly meteorological data of black mustard during growing season
Çizelge 1. Siyah hardalın gelişim döneminde aylık iklim verileri

Climatic factors		Months					Total/Mean/Maximum/Minimum
		March	April	May	June	July	
Total precipitation (mm)	Long years	36.7	46.7	49.9	34.2	14.3	181.8
	2017	46.1	19.8	96.2	102.8	0.0	264.9
Mean relative humidity (%)	Long years	63.2	59.0	56.5	52.1	45.1	55.2
	2017	59.6	49.8	55.7	58.3	38.4	52.4
Mean temperature (ºC)	Long years	6.4	11.5	16.2	20.3	23.8	15.6
	2017	8.1	11.2	15.7	20.3	25.5	16.2
Maximum temperature (ºC)	Long years	21.4	25.7	29.3	33.6	36.2	36.2
	2017	19.9	27.2	29.2	35.8	38.3	38.3
Minimum temperature (ºC)	Long years	-5.9	-0.8	4.1	8.1	11.4	-5.9
	2017	-1.5	-1.0	5.0	9.0	14.2	-1.5

Data were obtained from Ankara Meteorology Station (Anonymous, 2017a)

Table 2. Soil sample features belonging to the experimental area
Çizelge 2. Deneme alanına ait toprak örneklerinin özellikleri

Depth (cm)	Texture	Saturation content (%)	Total salt (%)	pH	Lime (%)	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Organic Substanc (%)
0-20	Clay loamy	56.0	0.025	7.81	5.3	93	1260	1.35
21-40	Clay loamy	56.0	0.025	7.81	5.2	105	2400	1.28
Mean		56.0	0.025	7.81	5.3	99	1830	1.32

Data were obtained from Soil Fertilizer and Water Resources Institute (Anonymous, 2017b)

3. Discussion and Conclusion

The different sowing dates referring to different weather conditions had a significantly different effect on the growth, development and yield performance of *B. nigra* genotypes. As shown in Table 3, significantly differences were noted among different sowing dates and genotypes were detected regarding characters. Day length data is shown in Table 4 that changed from 11 h 27 min to 13 h 26 min, 13 h 01 min to 14 h 37 min, 14 h 02 min to 15 h 35 min, 15 h 01 min to 15 h to 39 min and 15 h 00 min to 15 h 38 min during March, April, May, June and July 2017.

As demonstrated in Table 3, the maximum days to emergence (24.0 d) was noted on 10th May or long days sowing date and the minimum days to emergence (14.0 d) was observed on 10th April. The latest days to 50% flowering (75.2 d) was obtained on 25th March sowing date while the earliest days to 50% flowering (28.0 d) was detected on 10th May long days sowing date. The maximum days to 90% physiological maturity (32 d) was obtained on 10th April short day sowing date while the minimum days to maturity (30 d) was detected on 25th March long day sowing date (Table 3). Kayacetin et al. (2019) in their experiment showed that short day length with favorable low temperature, favorable soil moisture, relative humidity and precipitation induced rapid seed germination and growth. Contrary, long day length with increased temperature, low soil moisture and relative humidity and precipition induced seed dormancy and the seeds took more days to emerge from soil. Hence, the germinating seedlings took less days to emerge from soil. It is assumed that short day length, soil moisture in April, the most appropriate soil temperature and moisture at sowing played an significant role in seed germination and high emergence. In addition to first sowing on 25th March short day led to longest vegetative period to transform plants to generative period whereas last sowing on 10th May long day sowing had the shortest vegetative period to transform plants to generative phase (Angadi et al., 2003; Gawariya et al., 2015; Gupta et al., 2017).

Table 3. Effect of sowing dates on growth, development and yield of the black mustard genotypes
Çizelge 3. Siyah hardal genotiplerinin büyüme, gelişme ve verimi üzerine ekim zamanlarının etkisi

	Days to emergence (d)	Days to 50% flowering (d)	Days to 90% physiological maturity (d)	Plant height (cm)	Number of branches (branch plant^{-1})	Number of capsules (capsule plant^{-1})	Thousand seed weight (g)	Seed yield (g m^{-2})	Crude oil content (%)	Crude oil yield (g m^{-2})
Sowing dates										
25th March	17.8	75.2	30	111.4a	6.2a	189.1a	0.85a	28.4a	21.7a	6.1a
10th April	14.0	66.0	32	107.2a	4.9b	145.8b	0.68b	13.2b	20.4a	2.7b
25th April	16.0	50.0	31	93.0b	3.7c	65.8c	0.62c	4.7c	17.6b	0.8c
10th May	24.0	28.0	31	41.3c	1.8d	27.1d	0.44d	1.5d	11.9c	0.2c
Genotypes										
Izmir	18.0	54.8	31	94.2a	3.7b	106.4	0.69b	8.1cd	17.3	1.6cd
Ankara	18.0	54.8	31	94.9a	3.9b	106.8	0.61c	12.4b	17.6	2.6b
Sanlıurfa	18.0	54.8	31	92.6a	4.8a	108.2	0.50d	6.8d	18.1	1.4d
Tekirdag	17.0	55.8	31	87.7a	4.2b	105.7	0.58c	10.0bc	18.4	2.2bc
Kayseri	18.8	54.0	31	71.8b	4.1b	107.7	0.84a	22.4a	18.1	4.6a
Sowing dates×Genotypes										
25th March	Izmir			111.0b-e	4.7de	179.7abc	1.02a	22.7c	20.0	4.5cd
	Ankara			117.3abc	5.3d	182.7abc	0.92ab	31.7b	22.3	7.2b
	Sanlıurfa			129.0a	7.7a	210.7a	0.89b	15.0d	22.1	3.4de
	Tekirdag			115.8	6.3bc	173.3abc	0.88bc	23.1c	23.2	5.4c
	Kayseri			84.0ghi	7.2ab	199.3ab	0.87bc	49.3a	21.0	10.3a
10th April	Izmir			122.6ab	5.4cd	149.3abc	0.82bc	5.2efg	20.2	1.0fg
	Ankara			121.2ab	4.5def	152.7abc	0.78c	11.0de	19.5	2.2ef
	Sanlıurfa			108.0b-f	4.7de	127.3cd	0.65d	5.1efg	20.1	1.0fg
	Tekirdag			103.5c-f	5.3d	152.7abc	0.65d	10.5def	21.4	2.2ef
	Kayseri			80.8i	4.7de	147.0abc	0.60de	34.3b	20.9	7.1b
25th April	Izmir			98.4d-g	3.7fg	68.3de	0.59de	3.6g	17.0	0.6g
	Ankara			98.6d-g	4.0ef	62.7e	0.59de	5.4efg	17.1	0.9fg
	Sanlıurfa			95.2e-i	4.3ef	67.3de	0.57def	4.5g	18.0	0.8fg
	Tekirdag			91.5f-i	3.7fg	71.7de	0.53ef	5.3efg	17.1	0.9fg
	Kayseri			81.1hi	3.0g	59.0e	0.50efg	4.4g	18.8	0.8fg
10th May	Izmir			44.8j	2.0h	28.3e	0.50efg	0.9g	12.0	0.1g
	Ankara			42.6j	1.6h	29.3e	0.47fg	1.6g	11.7	0.2g
	Sanlıurfa			38.1j	2.0h	27.3e	0.40gh	2.5g	12.0	0.3g
	Tekirdag			39.8j	2.0h	25.0e	0.40gh	1.2g	12.0	0.1g
	Kayseri			41.2j	1.6h	25.3e	0.33h	1.5g	11.7	0.2g
$Fvalue_{SD}$				254.3**	263.9**	105.8**	199.8**	321.9**	76.4**	227.6**
$Fvalue_{G}$				18.1**	11.8**	0.02	89.3**	69.0**	0.6	42.6**
$Fvalue_{SD×G}$				4.1**	13.6**	0.5**	5.7**	24.7**	0.5	14.9**
CV(%)				8.9	10.1	25.9	7.2	21.7	10.8	27.9

***, P<0.01 significantly different according to the LSD. Data was the means of 3 replications*

Taking an average of sowing dates the maximum days to emergence and days to 50% flowering were determined as 18.8 d at Kayseri genotype and 55.8 d for Tekirdag genotype while the minimum days to emergence and days to 50% flowering were obtained as 17.0 d at Tekirdag genotype and 54.0 d for Kayseri genotype, respectively. The days to 90% physiological maturity were determined as 31 d for all genotypes. This can be owing to different genetic potentials of *B. nigra* genotypes and day length effects of photoperiod used in the study. Similar findings were noted by Kumar et al. (2004) and Tobe et al. (2013).

The results showed significantly (p<0.01) different effects sowing dates and genotypes on the agronomic parameters. Similarly, genotypes × locations also showed a significantly important interaction (p<0.01) on the agronomic characteristics. As shown in Table 3, the maximum plant height (111.4 cm), number of branches (6.2 branch plant^{-1}), number of capsules (189.1 capsul plant^{-1}), thousand seed weight (0.85 g), seed yield (28.4 g m^{-2}), crude oil content (21.7%) and crude oil yield (6.1 g m^{-2}) were obtained on 25th March short days while the minimum height (41.3 cm), number of branches (1.8 branch plant^{-1}), number of capsules (27.1 capsule plant^{-1}), thousand seed weight (0.44 g), seed yield (1.5 g m^{-2}), crude oil content (11.9%) and crude oil yield (0.2 g m^{-2}) were noted on 10th May long days sowing. A comparative analysis of each day length and prevailing environmental characteristics clearly show significant effects of

day length on yield and yield components. Overall, the results revealed that morphological characteristics decreased with delaying sowing dates. This can be due to as sowing date day length effects that changed from 11 hours 27 minutes to 15 hours 38 minutes in April to July hours before flowering (Table 4). The most delayed (long day) sown plants showed shorter vegetative phase and earlier transformation to generative phase with earlier flowering compared to those sown earlier (short days, short–long days, intermediate days) that long took start in day length more suitable to vegetative growth. Long or short maturation duration of the crop sown late induce undesired precocious maturity and entering into early reproductive phase. Long days photoperiod inhibited vegetative growth on the plants and forced plants to earlier generative phase resulting in poor plant height and reduced oil yield. On the grounds of favorable weather conditions, improvement in growth and yield, genotypes sown on 25th March short days produced considerably higher seed yield over subsequent sowings. Delayed sowing resulted in precocious induction of generative phase that decreased the dry matter production. 10th May long days sowing date had the minimum seed yield due to late sowing; when the plants were forced to induce precocious generative phase by lowering vegetative growth period and the plants had very short vegetative phase. This affected completion of seed formation and yield. Thus, the seeds were quite weak rudimentary and feeble (Kayacetin et al., 2018). These results are in conformity to those noted by Kar and Chakravarty (2000); Jat (2014) Singh and Lallu-Singh (2014); Gawariya et al. (2015); Muhal and Solanki (2016).

As an average of sowing dates, the maximum plant height was noted as 94.9 cm for Ankara genotype whereas the minimum plant height was obtained as 71.9 cm for Kayseri genotype. The maximum number of 4.8 branches plant^{-1} for Sanliurfa genotype whereas, the minimum number of 3.7 branches plant^{-1} were obtained for Izmir genotype. The maximum thousand seed weight was determined with 0.84 g Kayseri genotype while the minimum thousand seed weight was obtained for Sanliurfa genotype (0.5 g). The maximum seed yield was determined in Kayseri genotype (22.4 g m^{-2}) whereas the minimum seed yield was obtained for Sanliurfa genotype (6.8 g m^{-2}). The maximum crude oil yield was found for Kayseri genotype (4.6 g m^{-2}) while the minimum crude oil yield was noted for Sanliurfa genotype (1.4 g m^{-2}). The differences in the yield and yield components of *B. nigra* genotypes might be due to well adaptation and genetic potential of *B. nigra* genotypes under the existing agro-climatic conditions of Ankara. The findings under different environmental conditions of Pritchard et al. (2000); Angadi et al. (2003); Tripathi et al. (2005); Tobe et al. (2013); Kumar et al. (2018) also supported that changed plastic genetic potential of the genotypes.

Table 4. Monthly maximum and minimum photoperiod values (h)
Çizelge 4. Aylık en yüksek ve en düşük fotoperiyot değerleri (s)

Photoperiod (h)		Months				
		March	**April**	**May**	**June**	**July**
	Maximum	13 h 26 min	14 h 37 min	15 h 35 min	15 h 39 min	15 h 38 min
	Minimum	11 h 27 min	13 h 01 min	14 h 02 min	15 h 01 min	15 h 00 min

Data were obtained from Ankara Meteorology Station (Anonymous, 2018)

Taking an average of sowing dates × genotypes, the maximum plant height was noted as 129.0 cm on 25th March × Sanliurfa genotype whereas the minimum plant height was obtained as 38.1 cm on 10th May × Sanliurfa genotype. The maximum number of 7.7 branch plant^{-1} on 25th March × Sanliurfa genotype whereas, the minimum number of 1.6 branch plant^{-1} were obtained on 10th May × Ankara and Kayseri genotypes. The maximum number of 210.7 capsule plant^{-1} on 25th March × Sanliurfa genotype whereas, the minimum number of 59.0 capsule plant^{-1} were obtained on 10th May × Ankara and Kayseri genotypes. The maximum thousand seed weight was determined with 1.02 g on 25th March × Izmir genotype while the minimum thousand seed weight was obtained on 10th March × Kayseri genotype (0.33 g). The maximum seed yield was determined on 25th

March × Kayseri genotype (49.3 g m^{-2}) whereas the minimum seed yield was obtained for Izmir genotype (0.9 g m^{-2}). The maximum crude oil yield was found on 25th March × Kayseri genotype (10.3 g m^{-2}) while the minimum crude oil yield were noted on 10th May × Izmir and Tekirdag genotypes (0.1 g m^{-2}).

The findings clearly illustrate that each day length and prevailing environmental characteristics clearly show significant effects of

sowing dates on morphological and phenological characteristics. The crop at early sowing dates (short day length) demonsrated increased yield and yield components compare to the crop late sowing (long day length). The long days or short maturation duration of the crop sown late induce undesired precocious maturity and entering into early reproductive phase.

The research demonstrates that 25th March short days sowing date and the genotype Kayseri proved the best in performance in terms of growth, development and yield performance. Keeping in view the photoperiod or day length requirements of *B. nigra* genotypes provision of short day length in late March sowings are more desirable for increased yield under Dsa type climate of Ankara.

References

Akan, H., Bakir, Y., 2015. Kâhta (Adiyaman) Merkezi ve Narince Koyunun Etnobotanik Acidan Arastirilmasi. BEU Fen Bilimleri Dergisi, 4 (2): 219-248.

Akgul, A., 1993. Spice Science and Technology. Selcuk University, Faculty of Agriculture, Food Science and Technology, Food Technology Publications No: 15, Ankara. p: 85-88.

Angadi, S. V., Cutforth, H. W., McConkey, B. G., Gan, Y., 2003. Early Seeding Improves the Sustainability of Canola and Mustard Production on the Canadian Semiarid Prairie. Canadian Journal of Plant Science, 84 (3): 705-711.

Anonymous, 2017a. Ankara Meteorology Station, Ankara.

Anonymous, 2017b. Soil Fertilizer and Water Resources Institute, Ankara.

Anonymous, 2018. https://en.climate-data.org 2018.

Anonymous, 2019. Bizimbitkiler.org.tr (accessed 08.06.2019).

Anonymous, 2020. Turkish Plants Data Service. http://194.27.225.161/yasin/tubives/index.php?sayfa=dizin&&familya=Acanthaceae (accessed 10.07.2019).

Darwesh, D. T. D., 2017. Plant Biodiversity and Ethnobotanical Properties of Various Plants in Choman (Erbil–Iraq) (Doctoral dissertation. 130 pp, MSc, Sutcu Imam University, Kahramanmaras Turkey.

Gawariya, S. C., Chopra, N. K., Chopra, N., Harika, A. S., 2015. Effect of Date of Sowing and Crop Geometry on Growth and Yield Parameters of Forage Mustard (Var. Chinese Cabbage). African Journal of Agricultural Research, 10 (33): 3292-3295.

Guner, A., Aslan, S., Ekim, T., Vural, M., Babac, M. T., 2012. Türkiye Bitkileri Listesi (Damarli Bitkiler). Nezahat Gökyigit Botanik Bahcesi Yayinlari Flora Dizisi I, Istanbul.

Gupta, M., Sharma, C., Sharma. R., Gupta V, Khushu MK., 2017. Effect of Sowing Time on Productivity and Thermal Utilization of Mustard (*Brassica juncea* L.) Under Sub-Tropical Irrigated Conditions of Jammu. Journal of Agrometeorology, 19 (2): 137-141.

Jat, J., 2014. Influence of Different Sowing Dates on Growth, Development and Yield of Indian Mustard [*Brassica juncea* (L.) Czernj and Cosson] Varieties Under Irrigated Condition. M.Sc. Thesis. JNKVV. Jabalpur (M.P.).

Kar, G., Chakravarty, N. V. K., 2000. Phenological Stages and Growth Dynamics of Brassica as Influence by Weather. J. Agromet, 2 (1): 39-46.

Kayacetin, F., Onemli, F., Yilmaz, G., Kinay, A., Hatipoglu, H., Kivilcim, M. N., Kara, N., Kose, A., Sefaoglu, F., 2018. Effect of row spacing on yield, yield components and crude oil of autumn and spring sowed mustard (*Sinapis arvensis* L.) in eight locations of Turkey. Journal of Agricultural Sciences 24 (4): 483-499.

Kayacetin, F., Onemli, F., Yilmaz, G., Khawar, K. M., Kinay, A., Hatipoglu, H., Kivilcim, M. N., Kara, N., Kose, A., Sefaoglu, F., Ozaydin, K. A., 2019. Growing Degree Day and Seed Yield Relationships in Mustard (*Brassica juncea* L.) Under Different Sowing Seasons and Locations of Turkey. Journal of Agricultural Sciences, 25 (3): 298–308.

Kayacetin, F., 2019. Morphological Characterization and Relationship Among Some Important Wild and Domestic Turkish Mustard Genotypes (Brassica spp.). Turkish Journal of Botany, 43 (4): 499-515.

Kokcu, B., Esen, O., Uysal, I., 2015. Medicinal Plants Sold in Canakkale/Turkey City Center Herbalists. Biological Diversity and Conservation, 8/3: 80-91.

Kottek, M., Grieser, J., Beck, C., Rudolf, B., Rubel, F., 2006. World Map of the Koppen-Geiger Climate Classification Updated. Meteorologische Zeitschrift, 15 (3): 259-263.

Kumar, A., Lal, M., Mohan, N., Kumar, M., Kumar, N., 2018. Effect of different sowing dates on yield and yield attributes of Indian mustard (*Brassica juncea* L.) genotypes. Int. J. Pure App. Biosci. 6(2): 848-853.

Kumar, A., Singh, B., Ashpal, Y., Yadava, J. S., 2004. Effect of Sowing Time and Crop Geometry on Tetra Loculor Indian Mustard Under Southwest Haryana. Indian Journal of Agriculture Science, 74 (11): 594-596.

Laureti, D., Fieri, S., 2001. Fodder and Industrial Rape in Marche. Informatore Agrario, 51 (42): 121-122.

Major, D. J., 1987. Photoperiod Response Characteristics Controlling Flowering of Nine

Crop Species. Can. J. Plant Sci., 60 (3): 777-784.

Muhal, S., Solanki, N. S., 2016. Effect of Seeding Dates and Salicylic Acid Foliar Spray on Growth Yield Phenology and Agrometeorological Indices of Brassica Species. Journal of Oilseed Brassica, 1 (1): 183-190.

Oguz, F., 2017. Yuksekova (Hakkâri) Yoresinde Halk Tababetinde Kullanılan Bitkiler ve Kullanım Alanları. Turkish Journal of Weed Science, 20 (2): 28–37.

Palle–Reisch, M., Wolny, M., Cichna–Markl, M., & Hochegger, R. (2013). Development and Validation of a Real–Time PCR Method for the Simultaneous Detection of Black Mustard (*Brassica nigra*) and Brown Mustard (*Brassica juncea*) in Food. Food Chemistry, 138: 348–355.

Pritchard, F. M., Eagles, H. A., Norton, R. M., Salisbury, S. A., & Nicolas, M. (2000). Environmental Effects on Seed Composition of Victoriana Canola. Australian Journal of Experimental Agriculture, 40: 679-685.

Singh, M. P., Lallu-Singh, N. B., 2014. Thermal Requirement of Indian Mustard (*Brassica juncea*) at Different Phonological Stages Under Late Sown Condition. Ind J Plant Physiol, 19 (3):238-243.

Tobe, A., Hokmalipour, S., Jafarzadeh, B., Darbandi, M. H., 2013. Effect of Sowing Date on some Phenological Stages and Oil Contents in Spring Canola (*Brassica napus* L.) Cultivars. Middle-East Journal of Scientific Research, 13 (9): 1202-1212.

Tripathi, M., Singh, D., Rao, V., Singh, R., 2005. Biomass Partitioning in Indian Mustard (*Brassica juncea* L.) Under Different Growing Environments. Haryana Journal Agronomy, 21(2): 179-182.

Uhl, S. R.. 2000. Handbook of Spices Seasonings and Flavourings. Technomic Publishing Co Inc Lancaster pp. 132–6.