Effects of Different Sowing Dates on Oil Yield of Castor (*Ricinus communis* L.)

Ö. Öztürk, G. P. Gerem, A. Yenici, B. Haspolat

Abstract**—**Castor (*Ricinus communis* L.) is one of the important non-edible oilseed crops having immense industrial and medicinal value. Oil yield per unit area is the ultimate target in growing oilseed plants and sowing date is one of the important factors which have a clear role on production of active substances particularly in oilseeds. This study was conducted to evaluate the effect of sowing date on the seed and oil yield of castor in Central Anatolia of Turkey in 2011. The field experiment was set up in a completely randomized block design with three replications. Black Diamond-2 castor cultivar was used as plant material. The treatment was four sowing dates of May 10, May 25, June 10, June 25. In this research; seed yield, oil content and oil yield were investigated. Results showed that the effect of different sowing dates were significant on all of characteristics. In general; delayed sowing dates, resulted in decreased seed yield, oil content and oil yield. The highest value of seed yield, oil content and oil yield (respectively, 2523.7 kg ha^{-1}, 51.18% and 1292.2 kg ha^{-1}) were obtained from the first sowing date (May 10) while the lowest seed yield, oil content and oil yield (respectively, 1550 kg ha^{-1}, 43.67%, 677.3 kg ha^{-1}) were recorded from the latest sowing date (June 25). Therefore, it can be concluded that early May could be recommended as an appropriate sowing date in the studied location and similar climates for achieved high oil yield of castor.

Keywords**—**Castor bean, *Ricinus communis* L., sowing date, seed yield, oil content.

I. Introduction

CASTOR (*Ricinus communis* L.) belongs to the family *Euphorbiaceae*. Castor plant, although commonly referred to as "bean" is not a legume. Since castor is not a legume researchers should avoid the use of the term "castor bean" frequently found in the literature on this crop [1].

Castor is grown for its oil. Various varieties vary in oil content ranging from 40-60 percent, averaging about 47 percent [2]. It is a non-food oil seed crop, whose seed is inedible in the raw state. The oil extracted from the castor already has a demonstrated market, guaranteed by variety of 700 uses, ranging from medicines and cosmetics to replacing petroleum by bio-diesel, plastics and lubricants [3], [4].

Castor oil has unique physical and chemical properties among the vegetative oils and has found wide applications in modern technology. It is used in the production of medicines which cure skin problems. It is used to induce labor. It can offer you relief from pain and many other problems like indigestion, irregularities in menstruation, etc. It is used to manufacture anti-inflammatory and anti-fungal medicines, various cosmetics, lubricant in high-speed engines and aeroplanes, soaps, transparent paper, printing-inks, paints, plastics, brake fluids, varnishes,etc. [5]-[7]. Sulfonated (sulfated) castor oil, or Turkey Red Oil, was the first synthetic detergent after ordinary soap, and other forms of the oil became important for the treatment of leather, industrial lubricants, and other industrial uses. Castor oil is an excellent solvent of pure alkaloids and such solutions of atropine, cocaine, etc., as are used in ophthalmic surgery [8].

Castor oil is unique among vegetable oils because it is the only commercial source of a hydroxylated fatty acid (ricinoleic acid). This unique fatty acid comprises around 90% of the castor oil [1]. Ricinoleic acid has proven effectiveness in inhibiting the growth of various species of viruses, bacteria, yeasts and molds [3]. From an energy point of view, castor oil is the best vegetable oil for producing biodiesel (Castor methyl ester or Castor ME) because it does not require heat and the consequent energy that is needed when other vegetable oils are transformed into biodiesel. Long storage times are unproblematic under airtight conditions [8]. Biodiesel made from Castor oil still has a relatively high viscosity. In Brazil Castor ME was found too viscous to be used as such and is blended with biodiesel from other vegetable oils.

Castor is one of the most poisonous plants in the world due to ricin contained in the bean, stem and leaves [9]. Ricin is not found in the expressed oil but remains in the press cake. Its cake is used as manure and plant stalks as fuel or hatching material and for preparing paper pulp [10]-[14]. Just 4 to 8 beans can kill an adult person, a horse or an ox. However, cases of poisoning are rare. Animals sense the toxicity and avoid it [8].

Castor plant probably originated in North-East Africa from where it spread thousands of years ago to the Mediterranean, the Middle East and India. Today, castor is cultivated and growing in the wild throughout the drier tropical, warm-temperate and subtropical regions between 40° South to 52° North. It is found at altitudes from sea level to about 3,000 m in areas where there is no or only slight frost [8].

It is grown in 43 countries of the world and is cultivated on commercial scale in more than 30 countries. According to FAO (2012) statistics, the current total average world production of castor seeds stands at 1.958.334 metric tones per annum produced on an approximate area of 1.686.330 hectares with an estimated average yield of 1161.3 kg/ha. Among countries, India, China, Brazil, Mozambique, Ethiopia, Paraguay, Vietnam and Thailand are the major castor growing

Ö.Öztürk*, G. P. Gerem, A. Yenici, B. Haspolat are with Department of Field Crops, Faculty of Agriculture, Selcuk University, Konya, 42079 Turkey (*corresponding author phone: +90-533-4176804; fax: +90-332-2410108; e-mail: ozdenoz@ selcuk.edu.tr).

countries and account for 97 percent of the world's production [15]. Historically, Brazil, India and China have been the major castor cultivating countries to meet major part of the global market. In Turkey, castor grows naturally in the Mediterranean and Southeast regions (Adana, Aydın, Antalya, Bursa, Diyarbakır, Elazığ) and is used as ornamental plant [16], [17].

Although Turkey's climate and soil condition is suitable for castor, it is no cultivated on commercial scale. Turkeys castor import is 2075050 kg in 2006 and for this amount Turkey had to pay 1970587 US $ [18]. Turkey has imported castor products regularly during last ten years.

Sowing of crop at optimum time along with other agronomic factors is the key feature to get maximum production of any crop. Determining suitable planting date plays an important role in conformation of plant growth stages with desirable environmental conditions which results in maximum yield [19]. So, scientific works are needed to determine the proper sowing date in a particular zone for optimising quantitative and qualitative production of oil seeds. Castor should be planted in early May, about the same time as corn. Seedlings will emerge in 10 to 21 days [20].

Despite being an important crop, castor has never been realized as a commercial crop in Turkey and is not grown. The optimum sowing date and effects of sowing date on the oil yield of castor in Central Anatoila of Turkey is unknown. The objectives of this study, therefore, were to investigate the influence of sowing dates on seed and oil yield of castor in the Middle Anatolia irrigated conditions.

II. Materials and Method

The research was carried out in the Central Anatolia region (37^0 35' North p., 32^0 47' East m. at an altidute of 1013 m) of Turkey (at the Agricultural Experiment and Research Centre, Faculty of Agriculture, University of Selçuk, Konya) during the growing seasons in 2011. Soil samples (0-30 cm) were taken at seeding and analyzed for some parameters. The experimental soil was a clay loam with an organic matter content of 2.25% and a pH of 8.0. Total N content was 0.03 %, available phosphorus was 17.9 kg ha^{-1}, available potassium was 327.4 kg ha^{-1} and no salinity problems have been observed (Table I).

Monthly climatic data for 2011 and long term mean (1923-2010) during the castor vegetation period (May-October) are shown in Table II. As can be seen in Table II, rainfall, temperatures and relative humidity during the study period were similar to the 88-yr average for the area. The mean growing season rainfall, temperature and relative humidity from May to October were 120.6 mm, 18.8 ^{0}C and 49.6% respectively, for 2011.

The site was previously cropped to wheat. Black Diamond-2 castor cultivar (Indian origin) was used as plant material. The field experiment was set up in a randomized plot design with three replications and four sowing dates [SD; May 10 (SD1), May 25 (SD2), June 10 (SD3), June 25 (SD4)] were assigned to the plots. The area of each plot was 21.0 m^2 consisting of six rows, 5 m long and 70 cm apart. Lines were drawn and seeds were sown by hand. Plants within rows were spaced 35 cm apart by thinning at 2 to 4 leaf stage.

Plots were basically fertilised with 80 kg ha^{-1} N, 70 kg ha^{-1} P_2O_5. Entire quantities of fertilizers were applied on bands by a driller during the sowing. The field was visited regularly and two hoeings were also carried out in order to provide optimum crop growth conditions. The slow emergence and early growth of castor means the plants in the first growth period are not strong competitors against weeds, so first hoeing were done when plant grew 20-25 cm and the second hoeing was done after one month.

The plots were irrigated three times using flood irrigation, a) after sowing, b) during flowering, and c) pod filling.

Plots were harvested by hand when all the capsules are dry and the leaves have fallen from the plants on 25-31 October 2011 after removing two outer rows at each plot. In this research; seed yield, oil ratio and oil yield were investigated.

Seed yield (kg ha^{-1}) was determined from the plants of the four ridges in each plot and the yield per hectare was calculated.

Seed oil ratio (%) was determined by using Soxhlet continuous extraction apparatus with petroleum either as an organic solvent according to A.O.A.C. [21].

Seed oil yield (kg ha^{-1}) was calculated by multiplying oil percentage with seed yield per ha. Analysis of variance was used to test the significance of treatment effects. Least Significant Difference (LSD) Test was used to compare treatment means using the computer program MSTAT-C [22].

TABLE I
Result of Some Chemical and Physical Analysis of Experimental Field Soil

Depth (cm)	pH	$CaCO_3$ (%)	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})
0-30	8.05	37.6	17.9	327.4
	Organic matter (%)	$EC^{25}x10^3$	Soil texture	
	2.25	0.85	Clay-loam	

TABLE II
Meteorological Data of the Experimental Region During the Test Growing Season and LTM [A] for Castor in Konya, Turkey

Month	Temperature (^{0}C)		Rainfall (mm)		Relative Humidity (%)	
	2011	LTM	2011	LTM	2011	LTM
May	15.7	15.8	41.1	45.5	69.6	56.0
June	19.9	19.9	22.6	25.0	55.1	50.0
July	23.3	23.2	7.9	6.5	36.9	42.0
August	22.8	22.8	5.7	4.4	38.2	42.0
September	18.4	18.2	10.9	11.4	37.8	48.0
October	12.4	12.3	32.4	29.3	60.2	60.0
Mean	18.8	18.7	-	-	49.6	49.7
Total	-	-	120.6	122.1	-	-

[a]LTM: represents the long-term (88-years) mean

III. Results and Discussion Seed Yield

The data regarding seed yield as influenced by sowing dates are presented in Table III. There was significant difference in seed yield between sowing dates (Table III). As can be seen in Fig. 1, early planting gave significantly higher yields than late planting, average seed yield ranged from 2523.7 kg ha^{-1} to 1550.0 kg ha^{-1}. Maximum seed yield (2523.7 kg ha^{-1}) was recorded for SD1 (May 10) followed by SD2 and SD3 with non-significant difference between SD1, SD2 and SD3. Minimum seed yield (1550.0 kg ha^{-1}) was obtained for SD4 (June 25). This result is in confirmatory with Reddy *et al.* [23] (2007), who reported that the castor crop sown at India during July gave higher seed yield over delayed sowing in August. The same trend was also observed by Patel *et al.* [24]. Similar studies of Jadhav *et al.* [25] also showed the highest yield with early sowing.

Sree and Reddy [26] reported that the first and foremost aspect among all the agronomic practices is sowing of castor at an appropriate time with a suitable cultivar that fits well in a given agro-climatic conditions. They found that yield attributes, seed and oil of castor were higher when the crop was sown on January 5 followed by December 20 in India. Delayed sowing of castor on January 20 reduced the seed yield by 14 and 11%, respectively, compared to January 5 and December 20 sown crop. Kumar *et al*. [27] concluded that higher castor yield can be obtained by sowing the crop early providing the crop conducive temperature and moisture conditions for growth. Early planting results in higher yield of primary spikes and lower yield of tertiary spikes compared to delayed planting and vice versa.

Culp [28], Domingo and Crooks [29] and Prisemina [30] reported that reduction in the length of average growing season resulted in lower castor yield, seed weight and oil content. Williams and Kittock [31] reported that higher seed yields were associated with early planting, adequate moisture availability and early harvest after frost.

In present study, castor sown on SD3 and SD4 was badly affected by drought which indicates that delayed sowing should be avoided. The seed yield results of this investigation would therefore favour the adoption of May 10 sowing date for castor under irrigated conditions in Central Anatolian of Turkey.

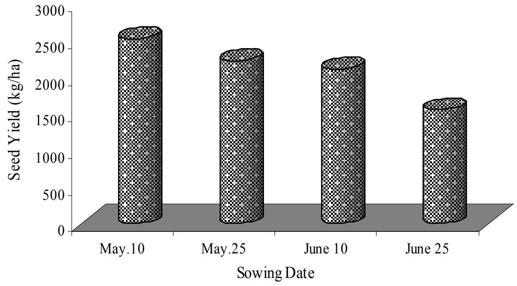

Fig. 1 Effect of sowing dates on seed yield (kg/ha) of castor

TABLE III
EFFECT OF SOWING DATE ON SEED YIELD (KG HA^{-1}), OIL CONTENT (%) AND OIL YIELD (KG HA^{-1}) OF CASTOR

Sowing Date (SD)	Seed Yield (kg ha^{-1})	Oil Content (%)	Oil Yield (kg ha^{-1})
May 10 (SD1)	2523.7 a**	51.18 a**	1292.2 a**
May 25 (SD2)	2223.0 a	50.18 ab	1116.1 a
June 10 (SD3)	2111.0 a	48.78 b	1029.9 a
June 25 (SD4)	1550.0 b	43.67 c	677.3 b
Mean	2101.9	48.40	1028.6
LSD	502.0	1.907	271.1

*** $P<0.01$*

B. Oil Content

The data of oil content as influenced by sowing date are presented in Table III. Significant differences were found among all the sowing dates for oil content. The sowing date of May 10 (SD1) produced higher oil content (51.18%) followed by SD2 and SD3. The lowest oil content (43.67%) was observed for SD4 (Fig. 2). Oil content percentage in oilseed crops is of enormous importance as more oil increases the economic importance of crop and provides more return to the farmer. In total, seed oil content is mainly determined by climatic conditions, variety and planting date so that late planting will decrease the oil content and oil yield [32]. The difference for oil content among sowing dates may be because of different temperature and moisture levels as oil content is greatly influenced by temperature and moisture during seed development and oil formation period.

Unger and Thompson [33] have reported higher oil content at higher temperature, supporting the results of our studies. Results of our study relate to the observations recorded by Nagabhushanam and Raghavaiah [34], who described that the early seeding (October) of castor crop induced significantly higher oil content as compared to the crop sown late in November.

Our findings are in line with Reddy *et al*. [23] who reported that castor crop sown during July gave the highest oil content as compared to the crop sown in August. In some similar studies, the amount of crude oil in different castor cultivars were between 50 and 60% [17], [35]-[39]. On the other hand, Deligiannis et al. [40] in a research obtained 40.3% oil in castor cultivars.

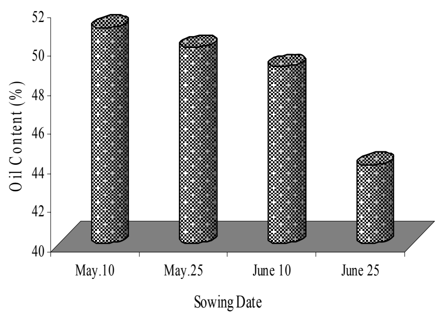

Fig. 2 Effect of sowing dates on oil content (%) of castor

C. Oil Yield

Oil yield as product of seed yield and oil concentration was expressed in kg/ha. The data pertaining to the oil yield as influenced by sowing dates are presented in Table III. Comparatively higher oil yield (1292.2 kg ha^{-1}) was obtained from SD1 (Fig. 3) which was non-significantly different from SD2 and SD3 but significantly different from SD4. The lowest oil yield (677.3 kg ha^{-1}) was recorded with SD4 which probably was due to the lower seed yield and lower oil content with SD4.

Oil yield obtained from composition of seed yield and oil amount so can be concluded that delayed sowing date reduce seed yield and oil content, to cause of oil yield will be reduced [41], [42]. On the other hand, climatic conditions especially high temperature and water stress during the flowering and the formation of oil can be deleterious effects on oil yield [43].

At the end of research, our results are in agreement with the findings of De La Vega and Hall [44] and other researchers [45]-[47] who claimed that planting date was the main source of variation for oil yield and with delay in planting, percent of seed oil decreased.

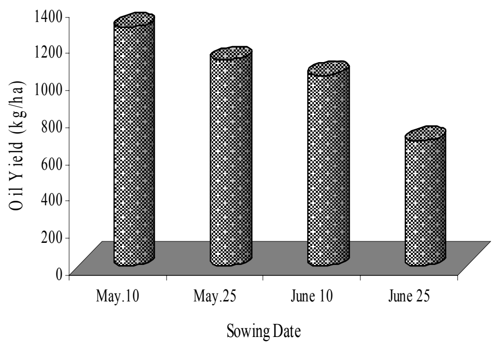

Fig. 3 Effect of sowing dates on oil yield (kg/ha) of castor

IV. CONCLUSION

The experiment was conducted at different sowing dates under irrigated conditions. The results indicated significant differences among different sowing dates for seed yield, oil content and oil yield with the highest from crop grown on May 10 (SD1). This is probably due to different moisture and temperature conditions at sowing and seed development stage. As a result of this study, it was concluded that sowing date affected seed and oil yield of castor. Delayed sowing date decreased seed and oil yield per unit of area. The higher seed yield, oil content and of course oil yield was obtained the earliest sowing. By planting castor earlier, plants are able to get the full benefit of soil moisture and nutrients during the extended growing season, allowing more total seeds capsul^{-1} to form because of sufficient time to fill. Consequently, among the sowing dates, May 10 proved to be the most appropriate sowing date resulting in the maximum seed and oil yield. Therefore, May 10 sowing is recommended for high seed and oil yield in castor production under irrigated Middle Anatolia type environments.

ACKNOWLEDGMENTS

The authors would like thank to Coordinating Office of Scientific Research Projects of Selcuk University (BAP) for the financial support for this work.

REFERENCES

[1] Severino et al., 2012. A Review on the Challenges for Increased Production of Castor.Agronomy Journal. Volume 104, Issue 4, 853-880.
[2] Clans, E. D. 1959. Pharmacognasy. Lea and Febriger Philadelphia. Pp. 179-181.
[3] Anonymous. 2003. Castorbean (*Ricinus communis*) an international botanical answer to bio-diesel production and renewable energy. Dove Biotech Ltd pp.1-26.
[4] Cheema, N.M. 2011. Yield and chemical composition castor bean (*Ricinus communis* L.) as influenced by environment. Thesis of doctor. Department of Agronomy Faculty of Crop and Food Sciences Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi Pakistan.
[5] Hattam, M. and G. Q. Abbasi. 1994. Oil seed crops. Crop production. National Book Foundation Islamabad. pp. 362-366.
[6] Martin, J. J., W. H. Leonard and D.L. Stamp. 1967. Principles of field crop production. Mcmillan Publishers Ltd. 3: 930-984.
[7] Weiss, E. A. 1971. Castor, Sesame, Safflower, Leonard Hill London. 94, 291-308.
[8] Nielsen, F., B. Hill and J.J., FACT-Arrakis. 2011. Castor (*Ricinus communis*) potential of castor for bio-fuel production. FACT Project no: 146/WW/001.
[9] De-La-Cruz, R. R., A. M. Pastor and J. M. Pelgado-Garela. 1995. The neurotoxic effects of *Ricinus communis* agglutinin-II Journal Toxicol. Toxin-REV. Dep. Fisoil. Boil. Amin., fac. Boil., Univ. Sevilla, E-41012 Sevilla, Spain. . 12(1): 1-46.
[10] Khaleq-Uezzaman, M. 1990. Studies on the consumption and utilization of castor leaves by larvae of eri-silkworm, *Samia Cynthia ricini* (Biosduval). Pak-JZool. Silk worm Res. Lab. Dep. Zool. Rajshahi Univ. Rajshahi-6205, Bangladesh. 22(2): 149-157.
[11] Bhattacharjee, S. K. 1998. Hand Book of Medicinal Plants. Pointer Publishers Jaipur, 302003, India. pp. 300-302.
[12] Reddy, D. N. and K. C. N. Swamy. 1999. Effect of Hort. On the consumption rate, leaf-cocoon and leaf-egg Ratio of Eri-Silkworm, Samia Cynthia ricini. Boisduval Entomon Dep. Of Sericulture, College of Agric., Univ. of Agric. Science. Banglore, 560065 India. 24(1): 67-70.
[13] Govindan, R., B. Sannappa, V. P. Bharathi, M. A. Shankar, M.P. Singh and D.M. Hegde. 2002. Growth and yield parameters of some castor genotypes as influenced by date of sowing under rainfed condition. Environment and Ecology, 20(4): 970-975.
[14] Sannappa, B., M. Jayaramaiah and D. Chandrappa. 2002. Influence of castor genotypes on consumption indices of eri silkworm Samia Cynthia ricini Boisdual (*Lepidoptera: Saturniidae*). Environment and Ecology. 20(4): 960-964.
[15] FAOSTAT. 2012. Food and Agriculture Organization of United Nations. (http/faostat.fao.org).
[16] Anonymous, 2009. Castor bean (*Ricinus communis*) an international botanical answer to biodiesel production & renewable energy. http://www.dovebiotech.com/pdf/castor%20bean%20 ricinus %20 communis %20-%20biodiesel. pdf.
[17] Pashazadeh, M., D. Başalma. 2012. The Effects of Different Nitrogen Doses on Yield and Some Agricultural Characteristics of Castor Bean Plant (*Ricinus communis* L.). Iğdır Univ. J. Inst. Sci. & Tech. 2(2): 83-92.
[18] Demirel, E. 2007. Hintyağından değerli kimyasalların elde edilmesi. Anadolu Üniversitesi Fen Bilimleri Enstitüsü Kimya Mühendisliği Bölümü, Yüksek Lisans Tezi, Eskişehir.
[19] Siadata,S.A. and S.S. Hemayatib. 2009. Effect of sowing date on yield and yield components of three oilseed rape varieties. Plant Ecophysiology. 1: 31-35.
[20] Koutroubas, S., D, D. K.Papakosta and A. Doitsinis. 2000. Water Requirements For Castor Oil Crop (*Ricinus communis* L.) in a Mediterranean Climate. Journal of Agronomy and Crop Science 184 (1), 33–4.
[21] A.O.A.C. 1975. Official Methods of Analysis (12th Edition), William Sterwetzled, Published by A.O.A.C., Washington D.C., pp. 506-508.

[22] MSTAT-C,1991. A Software Program for the Design, Management and Analysis of Agronomic Research Experiments. Michigan State University, East Lansing, MI.

[23] Reddy, U. V. B., G. P. Reddy and D. S. Reddy. 2007. Yield and oil content of castor varieties as influenced by planting dates. Indian J. Dryland Agri. Res. Dev., 22(1): 114-116.

[24] Patel, K. S., G. N. Patel, M. K. Patel, H. C. Pathak and B. S. Patel. 2005. Seed yield of castor, *Ricinus communis L.* hybrids as influenced by different dates of sowing. Journal-of-Oilseeds-Research; 22(1): 204-205.

[25] Jadhav, K. T., M. V. Dhoble and N. B. Rathod. 2006. Studies on castor seed yield and plant density relationship. Pune, India: Journal of Maharashtra Agricultural Universities; 31(3): 281-283.

[26] Sree, P. S. S and B. B Reddy. 2004. Effect of sowing date on performance of castor (*Ricinus communis*) cultivars during summer in rice (*Oryza sativa*) fallows. Indian Journal of Agronomy, 49(3): 189-191.

[27] Kumar, P. V., Y. S. Ramakrishna, B. V. Ramana Rao, U. S. Victor, N. N. Srivastava and A. M. Subba Rao. 1997. Influence of moisture, thermal and photoperiodic regimes on the productivity of castor beans (*Ricinus communis* L.). Agricultural and Forest Meteorology., 88(1-4): 279-289.

[28] Culp, T. 1945. Investigation with the castor bean plant: II. Rate of planting and date of planting tests. J. Am. Soc. Agron., 37: 812-820.

[29] Domingo, W.E. and D.M. Crooks. 1945. Investigation with the castor-bean plant. I. Adaptation and variety tests, *J. Am. Soc. Agron.* 37: 750–762.

[30] Prisemina, Z. P. 1929. The biochemical variability of the seeds of the castor oil plant due to geographical factors. Bull. Appl. Bot. Genetics and Pi. Breeding 21: 427-436.

[31] Williams, J. H. and D. L. Kittock. 1969. Management factors influencing viability of castorbean (*Ricinus communis* L.) seed. Agron J., 61: 954-958.

[32] Jasinska, Z. 1987. The influence of sowing dates and sowing rates on the development and yield of winter rape varieties. Proc. 7th Int. Rapeseed Cong. Poznan.Poland. 886-92.

[33] Unger, P. W. and T. E. Thompson. 1982. Planting date effect on sunflower head and seed development. Agron. J., 74:389-395.

[34] Nagabhushanam, U. and C. V. Raghavaiah. 2005. Seding date and irrigation effects on the productivity and oil quality of post monsoon grown castor, *Ricinus communis* L. in Alfisols. J. Oilseeds Res., 22(1): 206-208.

[35] Shams, A., Moursi, M. A. and Ahmed, S.S. 1967. Effects of nitrogen and spacing on castor bean in sandy soils in Egypt. Cairo University. U.A.R. National Research Centre and Faculty of Agriculture, pp. 61-64.

[36] Blanckenburg, D. and Creaner, H.D. 1971. Handbuch der Landwirtschaft uncl Ernaehrung in der Entwicklungslaender. Band 2. Ulmer. Stuttgart. P 355.

[37] Armstrong, W.P. 1982. The Castor bean. http://waynesword.palomar.edu/plmar99.htm

[38] Brigham, R.D. 1993. Castor, return of an old crop. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York. pp. 380-383.

[39] Labalette, F., A. Estragnat and A. Messéan. 1996. Development of Castor Bean Production in France. Progress in New Crops, ASHS Press, Alexandria, VA, pp. 40-342.

[40] Deligiannis, A., G.Anastopoulos, L. Karavalakis, D. Mattheou, F. Karonis, S. Zannikos and E.Stournas, 2009. Castor (*Ricinus communis* L.) seed oil as an alternative feedstock for the production of biodiesel. Proceeding of the 11th International Conference on Environmental Science and Technology. Chania, Crete, Greece.

[41] Breidenbach, R. W., A. Kahn and H. Beevers. 1968. Characterization of glyoxysomes from genotype of castor bean endosperm. Plant Physiol. 43: 705- 713.

[42] Gorttappeh,A,H., S. Najafi, M.Z. Manesh and M.Najafi. 2012. Yield, Yield Components and Oil of Castor Bean Genotypes. Tıbbı ve Aromatik Bitkiler Sempozyumu (13-15 Eylül), Tokat. 481-487.

[43] Kittock, D. L., J. H. Williams, and D. G. Hanway. 1967. Castor bean yield and quality as influenced by irrigation schedules and fertilization rates. Agron. J. 59: 463-467.

[44] De La Vega AJ and A.J. Hall. 2002. Effect of planting date, genotype, and their interaction on sunflower yield. II. Components of oil yield. Crop Science. 42: 1202-1210.

[45] Sreedhar, C. 2001. Influence seeding time on castor genotypes under irrigated conditions. M.Sc. (Ag) thesis submitted to Acharya N.G. Ranga Agricultural Univesity, Hyderabad.

[46] Rezvani Mogaddam, P., Z. Rezazade., A. A. Mohammad Abadi and A. Sharif. 2008. Effect of planting date and different treatments fertilizer on yield, yield components and percent of grain oil of castor bean plant. Iranian j. Field Crops Res. 6: 2. 303-313

[47] Gahannavard, SH., M. Tagbakhsh and A. Bernosi. 2009. Effect of different planting dates and plant densities on oil and protein yields of castor bean crop. National Congress of oilseed plants of Esfahan University, Iran. Pp: 359-361.

Öztürk Özden was born in Konya-Turkey. She received the B.E.E. from Selçuk University, M.Sc. and Ph.D. degrees from Institute of the Natural and Applied Sciences Selcuk University, Turkey, in 1991, 1994 and 2000, respectively. Dr. Öztürk' recent studies have been primarily concerned with oilseed crops especially on sunflower, rapeseed and safflower plants.

She became a Research Assistant in Department of Field Crops, Faculty of Agriculture, Selcuk University in 1992 and currently working as Assoc. Prof. Dr. at the same place.

- Çalışır,S., T. Marakoğlu, H. Öğüt, and **Ö. Öztürk.** 2005. Physical Properties of Rapeseed (*Brassica napus oleifera* L.), *Journal of Food Engineering*, 69, 61-66.
- **Öztürk, Ö.,** A. Topal, F. Akınerdem and N. Akgün. 2008. Effects of sowing and harvesting dates on yield and some quality characteristic of crops in sugar beet/cereal rotation system. *Journal of the Science of Food and Agriculture*, 88, 141-150.
- **Öztürk, Ö.** and H. Günlü. 2008. Determining relationships amongst morphine, capsule and oil yield using path coefficient analysis in poppy (*Papaver somniferum* L.). *Asian Journal of Chemistry*, 20 (4), 2979-2988.
- Ceyhan, E., M. Önder, **Ö. Öztürk,** M. Harmankaya, M. Hamurcu and S.Gezgin. 2008. Effects of application boron on yields, yield component and oil content of sunflower in boron-deficient calcareous soils. *African Journal of Biotechnology*, 7 (16), 2854-2861.
- **Öztürk, Ö.** and R**.** Ada. 2009. Correlation and Path Coefficient Analysis of Yield and Quality Components in Some Sunflower (*Helianthus annuus* L.) Cultivars. *Asian Journal of Chemistry,* 21 (2), 1400-1412.
- **Öztürk, Ö.,** S. Soylu, R.Ada, S. Gezgin and M. Babaoğlu. 2010. Studies on differential response of spring canola cultivars to boron toxicity. *Journal of Plant Nutrition.* 33(8), 1141-1154.
- **Öztürk, Ö.. 2010.** Effects of form and rate of nitrogen fertilizer on yield, yield components and quality of winter rapeseed (*Brassica napus* L.). *Chilean Journal of Agricultural Research*. 70 (1), 132-141.
- **Öztürk, Ö.** And O. Şaman.2012. Effects of different plant densities on the yield and quality of second crop sesame. *World Academy of Science, Engineering and Technology (WASET) International Conference. Oral Presentation*. Issue 69, 958-964. Berlin.