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The Effects of Different Nitrogen Doses on Yield and Some Agricultural Characteristics of Castor Bean Plant (*Ricinus communis L.*)

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ABSTRACT: Castor bean (*Ricinus communis* L.) is an important medicinal and industrial plant used to obtain raw material for thousands of compounds. The present study was conducted to investigate the effects of different nitrogen doses (0, 50, 100, 150 kg ha^{-1}) on seed and oil yield and some agricultural characteristics (thousand seed weight, crude oil ratio and protein ratio) of five castor bean local varieties collected from different farmers of Western Azerbaijan, Iran. The experiment was laid out using factorial arrangement in randomized split-plot design with three replications under climatic conditions of Ankara in 2009. Among the local castor bean varieties LV4 and LV5 with performed the best at 100 kg ha^{-1} ammonium nitrate were found more suitable for growing under Ankara conditions.

Keywords: Castor bean , *Ricinus communis* L., nitrogen fertilization, seed yield, oil yield, crude oil ratio

Hintyağı (*Ricinus communis L.*) Bitkisinde Farklı Azot Dozlarının Verim Ve Bazı Tarımsal Özellikleri Üzerine Etkisi

ÖZET: Hintyağı (*Ricinus communis* L.) tıpta ve endüstride binlerce materyalin hammaddesini oluşturduğundan önemli bir bitkidir. Bu araştırma Ankara koşullarında, İran'ın Batı Azerbaycan bölgesinden toplanan beş lokal hintyağı varyetesi ve farklı azotlu gübre dozu (0, 50, 100, 150 kg ha^{-1}) uygulamalarının tohum ve yağ verimi ve bazı tarımsal özellikler (bin tohum ağırlığı, ham yağ oranı ve ham protein oranı) üzerine etkilerini belirlemek amacı ile yapılmıştır. Deneme 2009 yılında Ankara koşullarında faktöriyel düzeninde, tesadüf blokları bölünmüş parseller deneme desenine göre üç tekerrürlü olarak kurulmuştur. Lokal hintyağı varyeteleri arasında LV4 ve LV5, azot dozu olarak da 100 kg ha^{-1} amonyum nitrat uygulamasının Ankara koşullarında daha uygun olabileceği sonucuna varılmıştır.

Anahtar kelimeler: Hintyağı , *Ricinus communis*, azotlu gübreleme, tohum verimi, yağ verimi, ham yağ oranı

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INTRODUCTION

Castor bean (*Ricinus communis* L.), a member of Euphorbiaceae family, is one of the important industrial and medicinal plant, native to the Ethiopian region of tropical East Africa and has become naturalized in tropical and warm regions (Duke, 1986; Anonymous, 2009a). This plant has been cultivated for centuries for its oil (Anonymous, 2009b). The Egyptians burned castor oil in their lamps more than 4000 years ago (Poli et al., 2007). The seeds contain 5.1-5.6% moisture, 12–16% protein, 35 to 55% oil and are a rich source of phosphorus. The castor oil consist of ricinoleic, linoleic, oleic and stearic acids (Shafiee et al., 2009). Also three terpenoids and a tocopherol-related compound have been found in the aerial parts of *R. communis* (Onwuliri and Anekew, 2001).

Although the castor bean seeds contain high amount of oil, the seeds, leaves and stems of the plant contain ricin and ricinine, which are the poisonous to humans and animals (Knight, 1979; Moshkin, 1986). Eating of seed may cause nausea and death if used excessively (Anonymous, 2005), therefore castor bean oil cannot be used as edible oil.

Castor oil has been used as aircraft lubricants, hydraulic fluids, and in making of explosives (Duke, 1986; Onwuliri and Anekew, 2001). The oil is also used for the synthesis of soaps, linoleum, printer's ink, nylon, varnishes, enamels, paints and electrical insulations. Sulphonated castor oil is used for dyeing and finishing of fabrics and leather, preservation of leather and production of Rilson-polyamide nylon-type fiber (Ombrello, 2009). In addition, castor bean plant or oil can be used in biodiesel studies (Anonymous, 2009c).

Castor oil is purgative popular for the treatment or prevention of many ailments. The leaves have been used for treatment of rheumatic pains and as antibacterial and anti-inflammatory (Bonjean, 2002; Luseba et al., 2007). Castor oil is used in mainstream medicine as a way to deliver chemotherapy drugs to cancerous tumors (Fjällskog et al., 1994; Fetrow and Avila, 1999).

Castor bean total production during 2008 was 1209756 ton. Although, India, China and Brazil are the major world producers of castor oil, the plants are grown commercially in many other countries, including the United States (New Mexico, Texas and the Midwestern United States), Philippines and Thailand. EU, China, Philippines, Paraguay, Brazil and Unites States are the major consumer in the world (FAO, 2009).

Castor bean is very important multi usage plant and lot of foreign exchange is being spent to import castor oil or related products. In Turkey, castor beans grows naturally in the Mediterranean and Southeast regions (Adana, Aydın, Antalya, Bursa, Diyarbakır, Elazığ) and is used as ornamental plant (Anonymous 2009 c). Although Turkey's climate and soil condition is suitable for castor bean, it is no cultivated on commercial scale. Turkeys castor bean import is 2075050 kg in 2006 and for this amount Turkey had to pay 1970587 US $ (Demirel, 2007). Turkey has imported castor bean products regularly during last ten years.

Castor bean is successfully cultivated in tropical and sub tropical regimes. This plant grows as an annual in cold and arid areas. But in the tropics and sub tropics, the castor bean plant is a perennial (Cherry, 2009). Castor bean requires a loamy soil of medium texture, also this plant do well on either alkaline or acid soils, as long as the subsoil is permeable and there is good drainage. Seed will not set if soil moisture is inadequate. Castor beans should not be planted in an area that is subject to erosion (Vashist and Ahmad, 2011). Castor bean growing season is 140 to 180 days. Germination is slow. Seedlings will emerge 10 to 21 days after planting (Vwioko and Fashemi, 2005). The most important factor in fertility level is the supply of nitrogen in the soil (Kalimantan, 2011). If the soil is deficient in nitrogen, 90 to 135 kg ha^{-1} of nitrogen usually are needed for maximum yields. Also, Alternaria leaf spot (disease) is more severe in nitrogen-starved plants (Dufour et al., 2003). N nutrient is still one of major factors limiting crop yield. Although adequate supply ofNto crops is fundamental to optimize crop yields, mismanagement of N, such as excessive N application, can result in contamination of groundwater (Jaynes et al., 2001).

In the experiment was conducted at Iran four nitrogen levels (0, 40, 80 and 120 kg ha^{-1}) were used. Means comparison showed that highest seed yield, biological yield and oil yield were achieved under application of 80 kg ha^{-1}, highest seed thousand weight was achieved under 120 kg ha^{-1} and highest oil percent was achieved under 40 kg ha^{-1} nitrogen application. The results of this experiment showed that oil percent decreased under increase of nitrogen application *(*Farahani and Aref, 2008).

Different amount of castor bean fertilization depend on soil and climate of different countries. For example Shams et al., (1967) in a research under Egyptian condition showed that 30 kg ha^{-1} nitrogen as best dose for *R. communis.* Whereas, Pohlmeier (2007) found the suitable nitrogen dose as 50 kg ha^{-1} under Belgium conditions.

As previously described, castor bean generally is grown by self-cultivation in Turkey and lack of research on this subject. The aim of this research was to evaluate different local castor bean varieties and nitrogen doses on growth, yield and quality parameters under climatic conditions of Ankara.

MATERIALS AND METHODS

The experiment was carried out at the Experimental Field Area of Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Turkey in 2009.

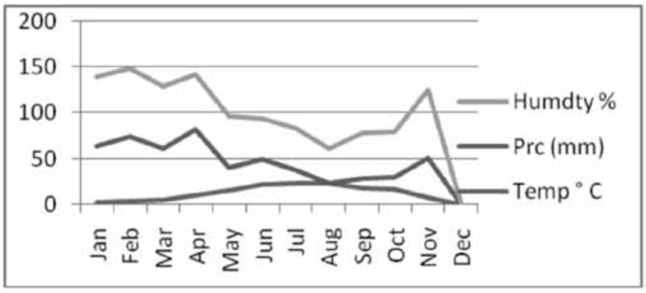

Figure 1. Climate data of Ankara in 2009.

During the growing season, 391.8 mm precipitation (April-September) was recorded with mean temperature of 18.95 °C, this amount is low for the castor bean that grows in tropical areas but in the growing season the monthly temperature (July-August) is ideal for growing castor bean (23.6-23.3 °C). Also the climate data of Ankara in 2009 was given in Figure 1. Soil type was loam, medium alkali (pH: 8.20) with low level of salt and contained 3.8 % organic matter.

Five different local varieties of castor bean (LV 1, LV 2, LV 3, LV 4 and LV 5) were obtained from nature of Western Azerbaijan, Iran. Local castor bean varieties general physiologic characters were given in Table 1.

Different doses of nitrogen (N_0: 0 kg ha^{-1} Control, N_1: 50 kg ha^{-1}, N_2: 100 kg ha^{-1} and N_3: 150 kg ha^{-1} N) were applied at two different time (sowing time and start of flowering). Ammonium nitrate (NH_4NO_3) fertilizer (33% N) was used as source of nitrogen. Seeds were treated with Thiram (Tetramethylthiuram disulfide) before sowing because there is a risk of low spring temperatures and high soil moisture immediately after planting. Thiram is the only registered seed treatment fungicide for use on castor beans.

The experiment was performed using randomized split-plot design containing three replications. Local castor bean varieties were planted 100 cm apart keeping distance of 50 cm between rows. The main plot size was 3 m x 20 m = 60 m^2 and sub plots sizes are**:** 3 m x 4 m = 12 m^2. Planting was done manually. Castor bean seeds were sown in 5 May 2009. The slow emergence and early growth of castor beans 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. During the experimental period, the plants were irrigated 4 times. First irrigation was done soon after sowing followed by second irrigation after one month

Table 1. Some physiological characters of local castor bean varieties

Local Varieties	Emergence Time	Flowering Time	Harvest Time	Plant Height (cm)	Number of Branch in Plants	Number of Capsule in a Cluster	Seed Yield (kg ha^{-1})	1000 Seed Weight (g)	Crude Oil Ratio (%)	Crude Protein Ratio (%)	Oil yield (kg ha^{-1})
LV 1	17	67	112	170	13	68	2834	241	42	18	751.2
LV 2	16	69	100	194	12	106	1733	241	42	14	766.4
LV 3	19	69	113	185	11	97	1825	290	41	15	748.0
LV 4	18	65	120	172	12	122	1641	251	45	17	931.6
LV 5	18	64	111	205	14	59	3111	391	51	16	1203

of sowing using sprinkler irrigation method. Approximately 35 mm water was applied during each irrigation. The third and fourth irrigation were made at the time of first flowering and cluster formation by flood irrigation system using approximately 100 mm water each. The reason of less use of water during later irrigations was excessive precipitation (391.8 mm) during growing season (2009).

The castor bean crop was ready for harvesting when all the capsules were dry (100–120 day after sowing). The earliest harvesting time was 100 days with LV 2 and the latest harvest time in 120 days was observed in LV 4 (Table 1). Harvesting was done by hand. In order to found plot yield, harvested seeds were combined and weight. Thereafter, plot yields were converted to hectare kg ha $^{-1}$. After harvesting, the thousand seed weight (g) was determined by weighing seeds that obtained from each plot.

Data pertaining to plant height (cm) and number of capsules in a cluster was measured by sampling 10 plants selected randomly from each plot. Whereas, crude oil (%) were measured by Soxhlet method (10 g per samples), protein content (%) (0.25 g per sample) were measured by Kjeldahl method. Oil yield was obtained by multiple of seed yield and crude oil ratio. Data were analyzed using Mstat- C computer program (Michigan State University) and means were separated using comparisons based upon the Least Significant Difference (LSD) test.

RESULT AND DISCUSSION

Nitrogen is a macronutrient that all plants need because this fertilizer is an integral component of amino nucleic acids, proteins, nucleotides, chlorophyll, chromosomes, genes, ribosome and is also a constituent of all enzymes. This wide range of different nitrogen containing plant compounds explains the important role of nitrogen for plant growth (Blumenthal et al., 2008). Also, it is the basis for proteins in plants and animals, especially in plants, nitrogen present in the chloroplasts, which are the molecules within plants that perform photosynthesis, making food. If plants do not have enough nitrogen, they turn yellow, in part because the chloroplasts are not functioning properly (Narits, 2010).

Most of the measured plant parameters such as plant height, number of capsules in a cluster, seed yield, thousand seed weight and protein contents were statistically significant among local castor bean varieties. However, nitrogen applications had no significant affect on most of the investigated plant parameters, except for number of capsules in a cluster and protein content. Effects of different nitrogen doses on some plant characteristics of local castor bean varieties are given in Table 2.

Plant Height: Analysis of variance results showed that plant height significantly varied among local castor bean varieties ($p> 0.01$) (Table 2).

Maximum plant height (196.8 cm) was recorded in LV5. Whereas, minimum plant height (166.5 cm) was recorded as in LV1 (Table 3).The results are in line with Ilisulu (1973), Babagiray (1984) and Oplinger et al. (1990), who also reported 72–300 cm plant heights in castor bean. On the other hand, interaction of LV and nitrogen applications resulted in plant height ranged from 90.9 to 173.7 cm (Rehm and Espig, 1991). Similarly, Öğütçü (1980) observed plant height differences between 120 -150 cm in local castor bean varieties.

Table 2. Variance analysis for the effect of different nitrogen doses on various plant characteristics of local castor bean varieties

		Mean square						
Source of Variation	**d. f.**	**Plant Height**	**Number of Capsules in a Cluster**	**Seed Yield**	**1000 Seed Weight**	**Crude Oil Content**	**Protein Content**	**Oil Yield**
Blocks	2	229.2	48.0	375.7	157.4	30.7	10.8	132517.4
Nitrogen Doses (A)	3	1945.6	745.6*	6725.7	24.6	42.3	7.4*	247352.5*
Error 1	6	4306.9	80.4	2146.2	29.8	27.3	1.4	51980.5
LV (B)	4	1995.3**	3629.6**	6317.5**	660.8**	60.9	5.5*	305766.9**
AxB	12	401.4	700.8**	5566.2**	27.2	55.6	3.7	50193.7**
Error 2	32	356.7	106.3	714.5	47.3	36.0	1.8	27380.8
Total	59	------	------	--------	------	------	------	------

$^*P \leq 0.05$, $^{**}P \leq 0.01$

Table 3. Effect of different nitrogen doses on plant height (cm) in local castor bean varieties

	Nitrogen Doses (kg ha^{-1})				
Local Varieties	**N_0 (0)**	**N_1 (50)**	**N_2 (100)**	**N_3 (150)**	**Means**
LV 1	170.0	173.3	150.0	172.7	166.5 $_{b2}$
LV 2	194.0	182.9	140.8	196.3	178.5 $_{ab2}$
LV 3	184.5	165.1	152.9	172.0	168.6 $_{b2}$
LV 4	171.9	168.1	151.9	175.8	166.9 $_{b2}$
LV 5	204.8	182.1	203.7	196.6	196.8 $_{a1}$
Means	185.0	174.3	159.9	182.7	

*Means fallowed by different small letters are significantly different at 0.05 level of significance
**Means fallowed by different numbers are significantly different at 0.01 level of significance
$LSD_{(LV)}$ 0.01= 21.12, 0.05= 15.71

Number of Capsules in a Cluster: Interactive effect of LV x nitrogen doses was found significant on number of capsules per cluster ($p \leq 0.01$). Also significant differences among local castor bean varieties ($p \leq 0.05$) were found. Similarly, nitrogen doses affected number of capsules per cluster ($p \leq 0.05$) (Table 2). Results clearly showed the variable response of LV to nitrogen doses. Results further showed that LV 5 (62.3) response to nitrogen doses was very poor compared to other local castor bean varieties and LV 4 (110.9) was obtained the high number of capsule.

Maximum number of capsules per cluster (143.7) were determined in LV 4 at 100 kg ha^{-1} nitrogen dose (Table 4). After 100 kg ha^{-1} nitrogen doses with increasing nitrogen doses, the number of capsules in a cluster decreased. In comparison to nitrogen doses the number of capsules in a cluster were the maximum amount in 100 kg ha^{-1} and minimum in 50 kg ha^{-1}. Ilisulu (1973) who reported 50 to 350 numbers of capsule in a cluster.

Seed Yield: With respect to seed yield per hectare, the significant interaction between LV x nitrogen doses was found ($p \leq 0.01$) and varied between 1614-3108 kg ha^{-1} (Table 4). The maximum seed yield (3108 kg ha^{-1}) was obtained from LV 5 with 100 kg ha^{-1} nitrogen. Whereas, minimum seed yield (1614 kg ha^{-1}) was recorded in LV3 at control (0 kg ha^{-1} N). Furthermore, seed yield was significantly affected by different local castor bean varieties ($p \leq 0.01$) and the highest seed yield was 2566 kg ha^{-1} from LV 5 (Table 5). Studied the effect of varied levels of nitrogen on seed yield of castor and found significant increase in seed yield with an increase in the nitrogen level between 0, 60 and 120 kg N ha^{-1}. The highest was recorded in the treatment supplied with 120 kg N ha^{-1} (Taylor et al., 2005; Sawana et al., 2007). The increase in growth characters and yield components with the increase in nitrogen levels might be due to the role in nitrogen in stimulating vegetative growth (Al-Thabet, 2006).

According to the regression analysis, the highest seed yield was observed with 100 kg/ha after that seed yield started declining (Figure 2).

These values are in line with previously reported by Kittoch and Williams (1967), Blanckenburg and Creaner (1971), Babagiray (1989), Oplinger et al., (1990), Labalette et al., (1996) and Rastegar (2005). Castor bean seed yield in another research done by

Table 4. Effect of different nitrogen doses on number of capsules per cluster in local varieties (number/ per cluster)

	Nitrogen Doses (kg ha^{-1})				
Local Varieties	**N_0 (0)**	**N_1 (50)**	**N_2 (100)**	**N_3 (150)**	**Means**
LV 1	68.0 g-ı 5-7	79.3 d-h 3-7	97.0 c d 2-4	90.0 c-f 3-5	83.6 b 2
LV 2	105.7 b c 2,3	75.7 e-ı 4-7	95.3 c-e 4,3	83.3 d-g 3-7	90.0 b 2
LV 3	97.3 c d 3,4	87.3 c-g 3-6	80.3 d-h 3-7	95.3 c-e 3,4	90.1 b 2
LV 4	121.7 b 1,2	96.3 c d 3,4	143.7 a 1	82.0 d-g 3-7	110.9 a1
LV 5	58.7 I 7	57.7 I 7	61.3 h ı 6,7	71.7 f-I 4-7	62.3 c 3
Means	90.3 a b	79.3 c	95.5 a	84.5 b c	

*Means fallowed by different small letters are significantly different at 0.05 level of significance
**Means fallowed by different numbers are significantly different at 0.01 level of significance
$LSD_{(Ax B)}$ 0.01= 23.05, 0.05= 17.15 $LSD_{(Nitrogen)}$ 0.05 = 8.016 $LSD_{(LV)}$ 0.01= 11.53, 0.05= 8.574

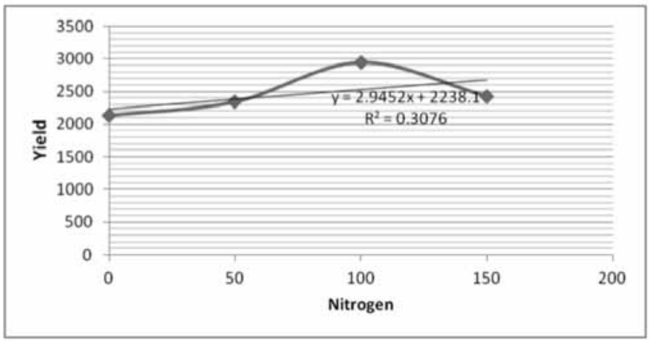

Figure 2. Effect of nitrogen doses on castor bean seed yield.

Baldwin and Robert (2009) in four location of USA, ranged between 89-1954 kg ha^{-1}.

Thousand Seed Weight: Analysis of variance results showed the significant differences in local castor bean varieties ($p \leq 0.01$) (Table 2) and ranged 240.4 g to 420.2 g. The maximum thousand seed weight (420.2 g) was recorded on LV 5. Whereas, minimum thousand seed weight (240.4 g) was recorded from LV 1 (Table 6).

When the previous parameters were analyzed, the results show that, the least amount of capsule in a cluster was produced by LV5, while the maximum seed yield and thousand seed weight was noted in LV 5. It means that, number of capsule in a cluster and thousand seed weight are inversely related.

Thousand seed weight in cotton significantly increased by adding the high N-rate Sawana et al. (2007). This may be due to increased photosynthetic activity that increases accumulation of metabolites, with direct impact on seed weight (Reddy et al., 1996).

These finding are in agreement with Babagiray (1984), who reported 120.8 to 530.2 g thousand seed weight using different nitrogen doses and various local castor bean varieties. Contrarily, Shams et al., (1967) and Öğütçü (1980) reported lesser thousand seed weights in castor bean plant which might be due to different plant material and environmental conditions in this study.

Crude Oil Ratio: Crude oil ratio was affected by none of the parameters (Table 2). In the current study, the crude oil content varied between 35.3 and 51.4%

Table 5. Effect of different nitrogen doses on seed yield (kg ha^{-1}) in local castor bean varieties

	Nitrogen Doses (kg ha^{-1})				
Local varieties	**N_0 (0)**	**N_1 (50)**	**N_2 (100)**	**N_3 (150)**	**Means**
LV 1	2041 e-i 5-7	2273 d-g 3-7	2828 a-c 1-3	2098 e-i 4-7	2310 a 1
LV 2	1843 f-i 5-7	2172 e-h 3-7	2992 a b 1,2	2206 e-h 3-7	2303 a 1
LV 3	1614 i 7	2513 b-e 1-5	1815 g-i 5-7	1997 f-i 6,7	1985 b 2
LV 4	1735 h i 6,7	1879 f-i 5-7	2742 a-d 1-4	1905 f-i 5-7	2065 b 1,2
LV 5	2361 c-f 2-6	1988 f-I 5-7	3108 a 1	2805 a-c 1-3	2566 a 1
Means	1919	2165	2697	2202	

*Means fallowed by different small letters are significantly different at 0.05 level of significance
**Means fallowed by different numbers are significantly different at 0.01 level of significance
$LSD_{(LV)}$ 0.01= 29.88, 0.05= 22.23 $LSD_{(Ax B)}$ 0.01= 59.77, 0.05= 44.46

Table 6. Effect of different various doses of nitrogen on thousand seed weight (g) in local varieties

Local Varieties	Nitrogen Doses (kg ha^{-1})				**Means**
	N_0 (0)	**N_1 (50)**	**N_2 (100)**	**N_3 (150)**	
LV 1	240.5	230.8	240.7	240.6	240.4 b 2
LV 2	240.6	310.6	230.9	240.3	260.1 b 2
LV 3	290.1	330.8	270.1	240.6	280.6 b 2
LV 4	250.5	240.2	240.5	250.5	240.9 b 2
LV 5	390.5	400.8	480.0	400.4	420.2 a 1
Means	280.6	300.8	290.7	270.9	

*Means fallowed by different small letters are significantly different at 0.05 level of significance
**Means fallowed by different numbers are significantly different at 0.01 level of significance
LSD $_{(LV)}$ 0.01= 7.69, 0.05= 5.720

Table 7. Effect of different nitrogen doses on crude oil ratio (%) in local varieties

Local Varieties	Nitrogen Doses (kg ha^{-1})				Means
	N_0 (0)	N_1 (50)	N_2 (100)	N_3 (150)	
LV 1	42.5	39.2	45.1	35.7	40.6
LV 2	42.2	45.1	44.6	35.3	41.8
LV 3	40.8	46.9	45.6	48.4	45.5
LV 4	45.3	45.3	40.8	38.3	42.4
LV 5	51.4	45.9	42.2	46.9	46.6
Means	44.4	44.5	43.7	40.9	

Table 8. Effect of different nitrogen doses on crude protein ratio (%) in local varieties

Local Varieties	Nitrogen Doses (kg ha^{-1})				Means
	N_0 (0)	N_1 (50)	N_2 (100)	N_3 (150)	
LV 1	17.7	15.5	17.2	17.0	16.8 a
LV 2	14.2	17.5	16.8	16.8	16.3 a b
LV 3	14.7	16.8	17.8	18.9	17.1 a
LV 4	16.8	17.5	17.9	17.2	17.4 a
LV 5	15.5	14.7	16.9	15.4	15.5 b
Means	15.8 b	16.4 a b	17.4 a	17.1 a	

*Means fallowed by different small letters are significantly different at 0.05 level of significance
**Means fallowed by different numbers are significantly different at 0.01 level of significance
$LSD_{(LV)}$ 0.05= 1.127, $LSD_{(Nitrogen)}$ 0.05= 1.067

Table 9. Effect of different nitrogen doses on crude oil yield (kg ha^{-1}) in local castor bean varieties

Local varieties	Nitrogen Doses (kg ha^{-1})														
	N_0 (0)			N_1 (50)			N_2 (100)			N_3 (150)			Means		
LV 1	751.2	e	12	887.9	de	8	1196	a-c	5	736.5	e	12	893	b	3
LV 2	766.4	e	11	826.7	e	9	1191	a-c	5	785.6	e	10	892.5	b	3
LV 3	748.0	e	12	1141	a-d	7	1168	a-d	6	955.1	b-e	7	1003	b	2
LV 4	931.6	c-e	7	1230	ab	4	1185	a-c	5	965.2	b-e	7	1078	b	2
LV 5	1203	a-c	4	1283	a	2	1327	a	1	1297	a	2	1277	a	1
Means	905 b			1074 ab			1213 a			948 ab					

* Means fallowed by different small letters are significantly different at 0.05 level of significance
**Means fallowed by different numbers are significantly different at 0.01 level of significance
$LSD_{(LV)}$ 0.01= 311.0, 0.05= 187.6 $LSD_{(Ax B)}$ 0.01= 412.7, 0.05= 294.4 $LSD_{(Nitrogen)}$ 0.05= 264.9

among interaction of LV and nitrogen doses. LV means ranged 40.6-46.6% whereas, nitrogen doses ranged 40.9- 44.5% (Table 7). In general, high nitrogen rates reduced oil content at all oil crops (Malidarreh, 2010).

In some similar studies, the amount of crude oil in different castor bean cultivars were between 50 and 60%, Shams et al. (1967), Blanckenburg and Creaner (1971), Armstrong (1982), Brigham (1993) and Labalette et al. (1996). On the other hand Deligiannis et al. (2009) in a research obtained 40.3% oil in castor bean cultivars.

Crude Protein Ratio: Variance of analysis result showed significant differences between the local castor bean varieties and nitrogen doses on protein contents ($p \leq 0.05$) (Table 2). The maximum protein content (17.4%) was recorded from LV 4. Whereas, protein contents ranged 15.8 and 17.4% with respect to different nitrogen doses by using 100 kg ha^{-1} nitrogen (Table 8).

Nitrogen is a constituent of the proteins, nucleic acids and nucleotides that are essential to the metabolic function of a plant (Salisbury and Ross, 1994). This study confirm previous finding by Viola et al. (2001), who also reported protein ratio range between 14.14 and 20.77% in castor bean.

Oil Yield: With respect to oil yield per hectare, the significant interaction between LV x nitrogen doses was found ($p \leq 0.01$) and varied between 736.5-1327 kg ha^{-1}. The maximum seed yield (1327 kg ha^{-1}) was obtained from LV 5 at 100 kg ha^{-1} N. Furthermore, oil yield was significantly affected by different local castor bean varieties ($p \leq 0.01$) and the highest seed yield was 1277 kg ha^{-1} from LV 5, also The effects of nitrogen doses on the oil yield were significant in ($P<0.05$) and between 905-1213 kg ha^{-1} (Table 9).

CONCLUSION

On the average, evaluation of local castor bean varieties show that most of the investigated plant parameters such as seed yield, thousand seed weight and protein ratio were significantly affected by different N application under Ankara conditions. The results also show that LV 4 and LV 5 of castor bean were more suitable for cultivation. Moreover, 100 kg N ha^{-1} application was found the most suitable N application that can be suggested for castor bean in Ankara.

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