



## The Effect of Different Nitrogen Doses on Yield and Quality of Some Winter Canola (*Brassica napus* L.) Cultivars\*\*

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### ABSTRACT

This research was carried out to determine the effect of different nitrogen doses on yield and yield components of winter canola cultivars in Konya conditions during the winter canola growing vegetation period of 2019-2020. Three winter canola cultivars (Linus, PR44W29, Es Neptune) were used as material and six different nitrogen doses (0, 50, 100, 150, 200, 250 kg N ha<sup>-1</sup>) were applied. The research was established according to the experimental design of split plots in randomized blocks. Half of the nitrogen fertilizer applications were given in the form of ammonium sulfate (21% N) at planting and the remaining half was given as urea (46% N) at the beginning of flowering. As a result of the study, it was determined that plant height, number of branch on the main stem, number of capsule per plant, capsule length, thousand seed weight seed yield, crude oil yield and crude protein ratio increased, while crude oil ratio decreased in winter canola varieties due to increasing nitrogen doses. As a matter of fact, the plant height values varied between 92.6 and 128.5 cm (respectively, LinusxN<sub>50</sub> and PR44W29xN<sub>250</sub>), number of branch (no. main stem<sup>-1</sup>) of 2.4-5.7 (LinusxN<sub>0</sub>-PR44W29xN<sub>250</sub>), number of capsule (no. plant<sup>-1</sup>) of 103.9-218.9 (Es-NeptunexN<sub>0</sub>-PR44W29xN<sub>150</sub>), capsule size of 5.3-6.6 cm (Es-NeptunexN<sub>0</sub>-LinusxN<sub>250</sub>), number of seeds in the capsule of 22.5-30.0 (Es-NeptunexN<sub>100</sub>-PR44W29xN<sub>250</sub>), thousand seed weight between 3.2 and 4.7 g (PR44W29xN<sub>0</sub>-LinusxN<sub>200</sub>), seed yield of 1361-5373 kg ha<sup>-1</sup> (Es-NeptunexN<sub>0</sub>-PR44W29xN<sub>250</sub>), crude oil yield between 547.0 and 2466.0 kg ha<sup>-1</sup> (Es-NeptunexN<sub>0</sub>-PR44W29xN<sub>150</sub>) and crude protein ratio values ranged of 16.2-23.9% (Es-NeptunexN<sub>0</sub>-LinusxN<sub>200</sub>). It was determined that there were increases in the values of these properties with increasing nitrogen doses in general. In terms of crude oil ratio, the lowest value was determined at PR44W29xN<sub>0</sub> with 39.2%, and the highest value was determined at PR44W29xN<sub>50</sub> with 46.3%. It has been determined that there are relatively decreases in crude oil ratios with increasing nitrogen doses. The main purpose of cultivation of oil seed crops is to increase the oil yield per unit area. From this point of view, it was concluded that PR44W29 cultivar among the cultivars considered in the study would be more suitable in terms of oil yield with 150 kg N ha<sup>-1</sup> application for the regions similar to the conditions in which the study was conducted.

### 1. Introduction

For an adequate and balanced diet, people need to meet the nutritional elements that contain a certain amount of protein, oil, carbohydrates, vitamins and minerals (Öztürk 2000). Among the nutrients, oils have a special importance in nutrition as an energy source. The daily calorie requirement of an adult person is 2800-3000. In a healthy and balanced diet, 30-35% (850-900

calories) of this energy should be taken from oils. 1 g of oil is 9.3 calories, an person needs 95 g of oil daily (Kılıç&Beycioğlu 2019). According to FAO, it is stated that a person's annual oil consumption should not be less than 17 kg, otherwise important health problems will occur (Gizlenci et al 2019).

World's total oil production is obtained 87% from plant-based oil seeds and 13% from animal sources. Since the commercial production of animal-derived oils

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\*\*It is the summary of Esra Yılmaz's Master Thesis

is expensive and these oils contain saturated fatty acids that have a harmful effect on human health, most of the fat needed is met from vegetable oils (Arioğlu et al 2010). Production of oilseed plants has increased greatly in recent years. While world oilseed production in 2012 was 466.9 million tons, according to FAO 2019 data, world total oilseed production reached 1 billion 101 million tons. Soybean takes the first place in the production of oil crops in the world with 333.8 million tons. This is followed by cotton seed with 82.6 million tons, canola with 70.6 million tons and sunflower with 56.1 million tons (Anonymous 2021).

Vegetable oils constitute an important part of oil production in Turkey. According to FAO data, a total of 6.390.412 tons of oilseeds were produced. Of this, 2.200.000 tons of cottonseed, 2.100.000 tons of sunflower, 1.525.000 tons of olive, 180.000 tons of canola, 169.328 tons of peanut and 150.000 tons of soybean, and 21.883 tons of safflower and other oilseed plants were obtained. Production of oil crops in our country follows a fluctuating course. While there is an increase in canola, sunflower and cotton, the production amount of oil crops such as safflower and flax decreases. For example; while the flax production in 2012 was 13 tons, there is no 2019 production value. While the amount of safflower production in 2015 was 70.0 thousand tons, there is a serious decrease as 21.3 thousand tons in 2020 (Anonymous 2021).

Although there has been an increase in the production of most oil crops over the years, the population in our country is increasing by almost 1.5% every year. For this reason, almost 70% of the needed oil is supplied by importing crude oil and oilseeds. As a result of this; our country has become foreign-dependent to meet the significant demand for vegetable oil, and billions of dollars of foreign currency are paid for imports. As a matter of fact, the amount of foreign exchange paid for oilseeds and their derivatives was 3.9 billion dollars according to 2020 figures (Kolsarıcı 2021). To meet our need for crude oil and oilseed plants; Planned agricultural policies are needed for the production and processing of oilseed plants (Perk Uçar 2011).

In order to close our vegetable oil deficit and to reduce our foreign dependency, the only solution is to increase the cultivation area, unit area yields and oil production of oil plants. Canola is one of the most produced oilseed crops in the world after soybean and cottonseed. Today, canola can be produced wherever grain is produced in our country. In this case, canola ranks first among the oil crops that can fill our vegetable oil deficit.

World canola production in 2019 is 83.9 million tons on a 40.6 million ha area. The most important producing countries; Canada (18 million tons), China (13 million tons), India (9 million tons), France (3 million tons) and Ukraine (3 million tons). Our country ranks 28th in terms of production. While the world canola yield was 2070 kg/ha in 2019, it was determined as 3430 kg/ha in

our country. The provinces with the most common canola production in our country are; Tekirdağ, İstanbul, Konya, Edirne and Çanakkale (Anonymous 2021).

Canola is an important oil plant with winter and summer varieties belonging to the Cruciferae family, *Brassica* genus, with 36-50% oil and 16-24% protein in its seeds (Çorbacı 2011). The climate type, which is similar in our country as well as in countries with a continental climate, has the opportunity to be successfully grown in winter in regions with sufficient spring precipitation despite the low annual total precipitation and in soils with high water holding capacity (Öztürk 2000).

In canola, which has summer and winter varieties, summer varieties reach harvest maturity at the end of July and early August, and winter varieties at the end of June-early July. Most oil crops are not harvested during these periods. Thus, raw materials are provided to oil and feed factories operating at half capacity during these months. Another advantage of having an early maturation period is that it allows second crop farming.

High seed yield (2000-2500 kg ha<sup>-1</sup>) and oil rate (45-50 %) per unit area are obtained from canola compared to other oil crops. The whole cultivation technique until harvest is suitable for mechanization. Prevent the development of weeds by developing rapidly in spring. Leaves clean soil for the next crop.

In addition to all these, the rise and fluctuations in oil prices have increased the demand for vegetable oils in search of an alternative fuel. Since canola oil has the closest composition to diesel, 80% of biodiesel is produced from canola oil today (Arioğlu et al 2010).

When all these advantages are evaluated, canola is an important oil plant that will contribute to closing our current vegetable oil deficit. Fertilizer and water are the most important factors in canola cultivation, as in plant production. Fertilizer requirements, seed and oil yield of canola vary according to the amount of precipitation in the region or irrigation and plant cultivar. Determination of fertilizer forms suitable for the cultivar and region, as well as determination of agricultural costs and growing conditions are very important for seed and oil yield in canola.

As in most other plants, the most important plant nutrient in canola is nitrogen. Nitrogen requirement of canola is higher than grains. Nitrogen is a mobile element required at all stages of plant development. It contributes to the positive increase in yield factors such as plant height, number of branches, number of capsules, number of seeds and seed weight, and in parallel with all these, the yield per unit area also increases (Köymen 2018). However, excessive use of nitrogen fertilizers; when combined with soil and climatic factors, it causes high concentrations of nitrate and nitrite to accumulate in drinking, surface and underground waters, bringing human health and the environment to threatening levels. As a result of such unconscious practices, the sustainability of our lands is taking more risks every day and environmental pollution seriously threatens the life of living things (Kılıç&Korkmaz 2012).

The optimum amount of nitrogen needed by canola varies according to varieties (Öztürk&Ada 2009). As a matter of fact, the soil should have 200-250 kg ha<sup>-1</sup> N content for 2500 kg/ha seed yield (Schjoerring et al 1995). In Argentina, it has been reported that 150 kg/ha of nitrogen application increases the total dry matter and seed yield in a soil with normal soil fertility (Sarandón et al 1996). The amount of nitrogen in fertilization, which is one of the most important elements for a high-yield and quality agriculture, is very important in canola, as it is in most plants. It is necessary to reveal this subject by researching on different regions and varieties (Köymen 2018).

This research was carried out in Konya conditions in order to examine the effects of different nitrogen doses on the yield of some varieties of winter canola, which is a potential oil plant for the Central Anatolia Region, and to determine the most appropriate nitrogen dose for seed yield.

## 2. Material and Methods

### 2.1. Material

Table 1

Some Meteorological Values of the Average of Long Years and October 2019-2020 in the Canola Growing Period (September-June) in Konya Province\*

Months	Mean Temperature (°C)		Total Precipitation (mm)		Mean Relative Humidity (%)	
	Long Years	2019-2020	Long Years	2019-2020	Long Years	2019- 2020
September	18.6	15.7	11.3	16.3	46.1	48.5
October	12.4	12.9	29.7	5.5	58.5	60.8
November	5.5	8.2	39.0	30.1	70.1	69.2
December	1.3	1.6	43.9	86.6	76.5	86.3
January	-0.3	-3.1	30.8	53.1	76.0	94.7
February	0.6	-1.1	23.2	34.5	70.3	84.7
March	5.2	3.8	25.5	88.7	62.7	75.0
April	10.9	6.7	35.9	43.1	57.7	65.5
May	15.5	7.7	38.6	40.7	55.4	73.1
June	20.1	16.1	20.5	21.5	47.2	62.3
Total (mm)			298.4	420.1		
Mean	9.0	6.8			62.1	71.8

\*Values have been prepared from the records of the Devlet Su İşleri Genel Müdürlüğü.

Soil samples were taken and analyzed before the experiment was set up from a depth of 0-30 cm from the trial area where the research was conducted. The soil of the land has a clay-loam structure, rich in potassium, insufficient in terms of organic matter and phosphorus. The trial land has a slightly alkaline, unsalted and calcareous structure.

This research was established according to the split plots in randomized blocks experimental design with 3 replications. In the study, cultivars (Linus, PR44W29, Es Neptune) were placed on the main plots, and nitrogen doses were randomly placed on the sub-plots (0, 50, 100, 150, 200 and 250 N kg ha<sup>-1</sup>). Sowing was done by hand

The trial was established in Konya Province Karatay District Yarma Neighborhood land. Among the registered varieties obtained from Leading Farmer's Association and frequently cultivated in Konya conditions; winter canola cultivars Syngenta-Linus, Pioneer-PR44W29 and United Genetic-Es Neptune were used as material.

### 2.2. Method

This research, which was carried out to determine the effects of different nitrogen doses on yield and yield components of winter canola varieties in Konya conditions.

The temperature, precipitation and relative humidity values recorded in the growing season of the year (2019-2020) in which the experiment was conducted in Konya/Karatay district and the values of long-term averages are shown in Table 1. Total precipitation was 420.1 mm, average temperature was 6.8 °C and relative humidity was 71.8 % during the 2019-2020 growing period in which the research was conducted. Especially when the amount of precipitation falling in October of the trial year is 5.5 mm compared to the average of long years, irrigation was done for emergence and germination due to the insufficient rainfall.

on the rows opened with a 1 cm depth at 25 cm row spacing on 20.09.2019. Each sub-plot was arranged as 6 rows of 3 m long.

In the study, phosphorus fertilizer in the form of TSP at 90 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> was applied to all plots together with planting. Half of all doses except control (0 kg ha<sup>-1</sup> N) were planted in all sub-plots in the form of ammonium sulfate (21% N), and the remaining half was in the form of urea (46% N) at the beginning of flowering, to the determined nitrogen amounts (0, 50, 100, 150, 200 and 250 N kg ha<sup>-1</sup>). Apart from the emergence irrigation, sprinkler irrigation was applied during the flowering and seed setting periods during the trial period.

Before entering the winter, the plants were hand thinning to 5 cm intra row spacing when they had 3-4

leaves. The final thinning and single treatments were made in the early spring at the exit of winter to be 15 cm above the row (Öztürk 2000). Weeds seen in the plots in the spring were cleaned by hand. Hoeing was done by hand and the soil was softened by aerating between rows. In each sub-plot, one row from each side and 50 cm from the plot heads were removed as an edge effect, and the remaining area was harvested manually on 03-07.2020.

In this study; plant height (cm), number of branch (no. main stem<sup>-1</sup>), number of capsule (no. plant<sup>-1</sup>), capsule length (cm), capsules on the main stem, number of seeds per capsule (g), seed yield (kg ha<sup>-1</sup>), crude oil ratio (%), crude protein ratio (%) and crude oil yield (kg ha<sup>-1</sup>) were investigated and analyzed. Measurements of morphological characteristics were carried out on 10 randomly selected plants from each plot.

The values obtained as a result of the research were subjected to variance analysis in the "MSTAT-C" statistical program according to the split plots in randomized blocks experimental design. The mean values of the transactions, whose differences were determined by performing the F test, were grouped according to the LSD significance test.

### 3. Results and Discussion

#### 3.1. Plant Height

As could be seen from the examination of Table 2, the differences between cultivars, nitrogen doses and interaction of cultivar x nitrogen dose in terms of plant height were found to be statistically significant. In the study, plant height increased with increasing nitrogen doses in winter canola cultivars. As the average of nitrogen doses; the longest plant height was determined in Es-Neptune (112.6 cm) and PR44W29 (112.4 cm) cultivars, and the shortest in Linus (104.1 cm). Among the nitrogen doses considered as cultivar average, plant height was obtained from the longest 250 kg/ha nitrogen application (118.5 cm) and the shortest control plots (99.4 cm). In the study, the interaction of cultivar x nitrogen dose was statistically significant, and the longest plant height of 128.5 cm was determined in PR44W29, which applied 200 kg/ha of nitrogen. However, the differences between the values obtained in the interactions of PR44W29 x N<sub>250</sub> (126.8 cm), Es-Neptune x N<sub>200</sub> (123.8 cm) and Es-Neptune x N<sub>250</sub> (114.6 cm) were statistically insignificant and were included in the same group (a). The shortest plant height was determined as 92.6 cm with Linus in the plots where 50 kg/ha nitrogen was applied and formed the last group (e) (Table 2).

It is also stated in similar studies that increasing nitrogen doses increase plant height in winter canola. In the study conducted by Koç (2000) in Tokat conditions, it was reported that the shortest plant height was 87.5 cm in the control plots, and the longest 159.4 cm was obtained from 210 kg/ha N application. Başalma (1999) determined the plant height in the plots with the lowest nitrogen fertilizer application and the highest 160 kg/ha nitrogen application in the study conducted in Ankara. In other study conducted at different nitrogen doses in winter rapeseed varieties (Gürsoy et al 2019), it was determined that plant heights ranged from 125.40 cm (0 kg/ha N) to 131.02 cm (100 kg/ha N). Sana et al (2003) concluded that the variation in plant height of different varieties may be attributed to their genetic potential. Maestro (1995) and Reddy & Reddy (1998) reported that different brassica varieties differed significantly regarding their plant heights. With this study, it can be said that the differences reported in terms of plant height between the results of the research conducted by different researchers in different locations may have resulted from the climate, especially precipitation, temperature and soil conditions as well as the cultivar characteristics (Üstüner et al 2008; Öztürk 2000).

#### 3.2. Number of Branch on The Main Stem

In terms of the number of branch on the main stem, the differences between cultivars, nitrogen doses and cultivar x nitrogen dose interaction were found to be statistically significant (Table 2). The highest number of branch was determined in PR44W29 with 4.4 per main stem, but the difference between Es-Neptune (4.3) was not statistically significant. Both varieties were included in the same group (a). The lowest number of branch on the main stem was determined in Linus cultivar with 3.6 and formed the last group (b).

As it can be seen Table 2, the highest number of branch in terms of nitrogen doses was obtained in 150 kg and 250 kg nitrogen applications per hectare with 4.9. Statistically, both applications were in the same group (a). The lowest number of branch on the main stem was determined as 3.0 in 0 kg/ha N plots and formed the last group (c).

When the interaction of cultivar x nitrogen dose was examined in terms of the number of branch on the main stem (Table 2), the highest value was determined in PR44W29 cultivar with 250 kg/ha nitrogen applied with 5.7. This value formed the first group (a). The lowest value was obtained in Linus cultivar with 2.4 in control plots and formed the last group (i).

Table 2

Average values of the morphological characteristics of different nitrogen doses in winter canola cultivars and LSD test groups

Cultivars	Nitrogen Doses (kg/ha)						Mean
	N <sub>0</sub>	N <sub>50</sub>	N <sub>100</sub>	N <sub>150</sub>	N <sub>200</sub>	N <sub>250</sub>	
Plant Height (cm)							
Linus	92.7 e**	92.6 e	108.2 bc	111.4 bc	105.5 bcd	114.2 b	104.1b**
PR44W29	97.8 de	102.0 cd	104.7 bcd	114.3 b	128.5 a	126.8 a	112.4 a
Es-Neptune	107.9 bc	110.4 bc	107.2 bcd	111.6 bc	123.8 a	114.6 a	112.6 a
Mean	99.4 d**	101.7 cd	106.7 c	112.4 b	119.3 a	118.5 a	109.7
CV (%): 13.61    LSD <sub>Cultivar</sub> : 6.62    LSD <sub>Nitrogen Dose</sub> : 5.13    LSD <sub>CultivarXN Dose</sub> : 8.89							
Number Of Branch (no. main stem <sup>-1</sup> )							
Linus	2.4 i**	3.2 h	3.2 h	5.1 abc	3.4 gh	4.3 def	3.6 b**
PR44W29	3.5 fgh	3.6 fgh	4.1 d-g	5.4 ab	4.2 d-g	5.7 a	4.4 a
Es-Neptune	3.0 hi	4.4 cde	3.8 e-h	4.4 cde	4.6 cd	4.7 bcd	4.3 a
Mean	3.0 c**	3.7 b	3.7 b	4.9 a	4.0 b	4.9 a	4.1
CV (%): 7.62    LSD <sub>Cultivar</sub> : 0.44; LSD <sub>Nitrogen Dose</sub> : 0.40; LSD <sub>CultivarXNitrogen Dose</sub> : 0.69							
Number Of Capsule (no. plant <sup>-1</sup> )							
Linus	128.4 ef**	108.9 gh	114.8 fgh	151.8 bcd	124.3 efg	145.8 cd	129.0 b**
PR44W29	125.9 ef	205.3 a	144.9 cd	218.9 a	165.5 b	217.8 a	179.0 a
Es-Neptune	103.9 h	108.6 gh	153.8 bc	161.1 bc	146.8 cd	135.8 de	135.0 b
Mean	119.4 d**	140.9 c	137.8 c	177.2 a	145.5 c	166.4 b	147.9**
CV (%): 4.61    LSD <sub>Cultivar</sub> : 21.48; LSD <sub>Nitrogen Dose</sub> : 8.84; LSD <sub>CultivarXNitrogen Dose</sub> : 15.31							
Capsule Length (cm)							
Linus	6.4 ab**	6.2 bcd	6.4 ab	6.5 ab	6.5 ab	6.6 a	6.4 a**
PR44W29	5.9 cde	6.1 bcd	5.7 e	6.5 ab	6.2 bc	6.2 bcd	6.1 a
Es-Neptune	5.3 f	5.6 ef	5.6 ef	5.6 ef	5.6 ef	5.8 de	5.6 b
Mean	5.8 c**	5.9 bc	5.8 c	6.2 a	6.1 ab	6.2 a	6.1
CV (%): 2.63    LSD <sub>Cultivar</sub> : 0.366; LSD <sub>Nitrogen Dose</sub> : 0.205; LSD <sub>CultivarXNitrogen Dose</sub> : 0.35							
Number Of Seeds In Capsule							
Linus	26.5	26.5	26.6	28.4	27.0	29.4	27.4 a**
PR44W29	27.4	27.6	27.5	31.1	29.0	30.0	28.7 a
Es-Neptune	23.7	23.7	22.5	25.2	24.2	24.7	24.0 b
Mean	25.9 b**	26.0 b	25.4 b	28.5 a	26.7 ab	28.0 a	26.7
CV (%): 4.90    LSD <sub>Cultivar</sub> : 1.414; LSD <sub>Nitrogen Dose</sub> : 1.696							

\*\* Differences between the means shown with the same letters are not significant at the 1% level.

The high number of branch on the main stem in canola is an important feature that is desired because it increases the number of capsules in the plant and thus affects the seed yield and yield characteristics (Aytaç 2007). Variable number of branches per plant among different varieties, which have been related to be under genetic management control, has also been reported by Labana et al (1987) and Khehra & Singh (1988). As a result of this research; an increase in the number of branches was observed with increasing nitrogen ratios in winter canola. As a matter of fact, it supports our research; in the studies conducted by Başalma (1999), Koç (2000), Köymen (2018), it was reported that the highest number of lateral branches was obtained from the maximum nitrogen fertilizer dose.

### 3.4. Number Of Capsule Per Plant

In the study, in terms of the number of capsule per plant, the differences between varieties, nitrogen doses and cultivar x nitrogen interaction were found to be statistically significant (Table 2).

As a result of the study, the highest number of capsule in terms of cultivar average was determined in PR44W29 with 179.0 per plant and Linus with the lowest 129.0. However, the difference between Linus and Es-Neptune (135.0 per plant) was not found to be statistically significant and both cultivars were in the last group (b). In terms of nitrogen dose averages, the highest number of capsule per plant was determined at 177.2 with 150 kg/ha N application, and the lowest with 119.4 at 0 kg/ha N application (Table 2).

As it can be seen Table 2, the highest number of capsule in terms of cultivar x nitrogen dose interaction was determined in the PR44W29 cultivar with 150 kg/ha nitrogen applied with 218.9 per plant. This value formed the first group (a). The lowest was detected in Es-Neptune cultivar with 103.9 per plant and 0 kg/ha N applied and formed the last group (h).

In the study conducted by Öztürk&Ada (2009) on examining the relationship between different nitrogen doses and yield and morphological characteristics in summer rapeseed, it was determined that the relationship between seed yield and the number of capsule per

plant and nitrogen dose was positive and important. It has been stated that the number of capsules per plant has a high and positive direct effect on the seed yield.

In the study carried out in Ordu ecological conditions, the number of capsule was determined at the lowest dose of 186.17 per plant and 0 kg/ha N dose, while the highest dose was determined at 242.61 per plant and 200 kg/ha N dose (Köymen 2018). In the study conducted by Çorbacı (2011), in Tekirdağ conditions, the highest number of capsule (206.3 per plant) was determined in the plots where 150 kg/ha N was applied, and the lowest (158.5 per plant) in the control plots. These values are higher than our values and it can be said that the differences may be caused by the climate, soil structure and cultivar of the location where the studies are carried out.

### 3.5. Capsule Length

In terms of capsule length; between cultivars, nitrogen doses and cultivar x nitrogen interaction were found to be statistically significant. As the average of the winter canola cultivars used in the research, the highest capsule length was determined as 6.4 cm in Linus and 6.1 cm in PR44W29 cultivars, which are in the same statistically group (a). The shortest was determined in Es-Neptune with 5.6 cm and formed the other group (b). Among the nitrogen doses used as the average of the cultivars in the study, the longest capsule length was 6.2 cm, and the plots with 150 kg and 250 kg nitrogen per hectare were determined and formed the first group (a). The shortest is 5.8 cm with control and 100 kg/ha nitrogen applications were determined and formed the last group (c) (Table 2).

In terms of cultivar x nitrogen dose interaction, the highest capsule length was determined in Linus cultivar applied with 250 kg nitrogen per hectare with 6.6 cm(a), and the shortest capsule length was determined in Es-Neptune cultivar with 5.3 cm(f) in control plots (Table 2).

Çorbacı (2011) stated that the lowest capsule length varies between 5.31-6.03 cm in the control plots, and the capsule length increases with increasing fertilizer doses. In the study carried out by Başalma (1999) to examine the effect of nitrogen fertilization on yield and yield components of rapeseed in Ankara conditions, the average capsule lengths showed values varying between 5.67-6.69 cm, and it was determined that the average capsule length increased with the increase in nitrogen fertilizer doses. The values obtained as a result of this research regarding the capsule size were similar to the findings of the researchers mentioned above.

### 3.6. Number of Seeds in Capsule

Differences between cultivars and nitrogen doses in terms of the number of seeds in the capsule were statistically significant however the interaction of cultivar x nitrogen dose was found to be insignificant. In the study, the highest number of seeds in the capsule among the varieties was determined in PR44W29 with 28.7. However, the value was statistically in the same group (a) as

Linus (27.4 seed/capsule). The lowest value was determined in Es-Neptune with 24.0 seed/capsule and formed the other group (b) (Table 2).

Among the nitrogen doses, the highest number of seeds in the capsule was determined in the application of 150 kg nitrogen per hectare, with 28.5 seeds. However, the difference between the value obtained from 250 kg/ha nitrogen application (28.0 seed/capsule) was not found to be statistically significant and they were included in the same group (a). The lowest was determined in the application of 100 kg nitrogen per hectare with 25.4 seed/capsule, but the difference between the control (25.9 seed/capsule) and 50 kg/ha nitrogen application (26.0 seed/capsule) was not found to be statistically significant, and they were in the same group (b).

As can be seen from the Table 2, although the interaction of the cultivar x nitrogen dose is insignificant in terms of the number of seeds in the capsule, the highest value was determined in PR44W29xN<sub>150</sub> with 31.1 and Es-NeptunexN<sub>100</sub> application with the lowest (22.5).

Koç (2000) reported that the number of seeds in the capsule varied between 18.33-28.33, Köymen (2018) 17.15-20.95, Başalma (1999) 27.8-25.4. The seed number values in the capsule found as a result of this study (between 22.5 and 31.1) are generally similar to the studies on this subject. It can be said that some differences may be due to varieties and climatic characteristics.

### 3.7. Thousand Seed Weight

As can be seen in Table 3, cultivars, nitrogen doses and cultivar x nitrogen interaction in terms of thousand seed weight were found to be statistically significant. Between the cultivars were determined with the highest 4.1 g in Linus and Es-Neptune, and they were in the same group (a). The lowest value was determined in PR44W29 with 3.7 g and formed the other group (b).

In terms of nitrogen doses, the highest thousand seed weight was determined with 4.2 g at 150 kg/ha and 200 kg/ha nitrogen applications. The difference between the values (4.0 g) obtained from the application of 50 and 250 kg nitrogen doses per hectare was not found to be statistically significant and they were all in the same group (a).

In terms of cultivar x nitrogen dose interaction, the highest thousand seed weight was determined in Linus (a) applied 200 kg nitrogen per hectare, the lowest in PR44W29 planted in control plots (h) with 3.2 g (Table 3).

A high thousand seed weight is an indication that the seeds are large. Therefore, in terms of seed yield and oil rate, it is desirable to have a high seed weight of thousand seed. It is thought that the higher the thousand seed weight, the higher the seed yield and oil content (Mert 2009). In the study carried out by Eryiğit (2005) in Şanlıurfa conditions, the weight of one thousand seeds in canola varied between 2.82-2.96 g. The highest thousand seed weight was 200 kg/ha N, and the lowest was determined in the control plots. It was stated that with

increasing nitrogen dose, thousand seed weight increased and there was a linear relationship between nitrogen doses and thousand seed weight. As a matter of fact, in this study, one thousand seed weight increased with increasing nitrogen doses, and it is thought that the differences between the studies may be due to the differences in the cultivar used, climate and cultural practices. Thus, several investigators (Munir & McNeilly 1992, Hashem et al 1998, Om et al 1998, Sana et al 2003, El-Nakhlawy & Bakhshwai 2009) found significant differences for 1000-seed weight among different brassica varieties.

### 3.8. Seed Yield

In terms of seed yield, the differences between cultivars, nitrogen doses and cultivar x nitrogen dose interactions were found to be statistically significant. In the study, among the winter canola varieties, the highest seed yield was found in PR44W29 with 3498 kg/ha, and the lowest in Es-Neptune with 2437 kg/ha (Table 3). Among the nitrogen doses, the highest seed yield was determined at 4162 kg/ha in 250 kg nitrogen application per hectare, and the lowest 1630 kg/ha in control plots. As can be seen in Table 3, the highest seed yield in terms of cultivar x nitrogen dose interaction was determined in PR44W29 cultivar with 250 kg/ha nitrogen applied with 5373 kg/ha, while the lowest 1361 kg/ha was determined in the control application of Es-Neptune cultivar.

Nitrogen (N) fertilizer increases yield by influencing a variety of growth parameters such as the number of

branches per plant, the number of pods per plant, the total plant weight, the leaf area index. Also, it increases the number and weight of pods, seeds and flowers per plant, and overall crop assimilation, contributing to increased seed yield (Wright et al 1988 and Al-Barrak 2006). Reddy & Reddy (1998) and Khoshnazar et al (2000) found significant differences in seed yield among different varieties of brassica species. The significant and insignificant differences between the studied canola varieties in yield and yield components might be due to the genetic  $\times$  environment interaction effects. Khoshnazar et al (2000), Kolte et al (2000) and Stringam et al (2000) compared different mustard and rapeseed cultivars and reported that all cultivars differed significantly for seed oil yields (El-Nakhlawy & Bakhshwai 2009). In the study conducted by Köymen (2018), a seed yield of 1410.6 kg per hectare was obtained from the control plots that were not applied nitrogen. It has been reported that the seed yield increased with increasing nitrogen doses and the highest figure was reached at 1977.0 kg per hectare and 200 kg/ha nitrogen application. Similarly, in the study conducted by Başalma (1999), it was stated that the lowest seed yield was obtained from the N<sub>0</sub> dose with 2443.7 kg/ha and the highest N<sub>120</sub> dose with 2904.9 kg/ha. As a matter of fact, in this study, there was an increase in seed yield with increasing nitrogen doses. The differences between the results of the research in terms of yield values; ecological factors, cultivars used, cultural practices and nitrogen doses are thought to be caused by differences.

Table 3

Average values of thousand seed weight (g) and seed yield (kg/ha) at different nitrogen doses in winter canola cultivars and LSD test groups

Cultivars	Nitrogen Doses (kg/ha)						Mean
	N <sub>0</sub>	N <sub>50</sub>	N <sub>100</sub>	N <sub>150</sub>	N <sub>200</sub>	N <sub>250</sub>	
Thousand Seed Weight (g)							
Linus	4.1 bcd**	4.3 abc	3.6 e-h	4.2 bcd	4.7 a	3.9 c-g	4.1a**
PR44W29	3.2 h	3.5 fgh	3.4 gh	4.3 abc	3.6 fgh	4.2 abc	3.7b
Es-Neptune	3.9 c-f	4.2 abc	3.7 ab	4.2 abc	4.5 ab	4.0 cde	4.1a
Mean	3.7b**	4.0a	3.6b	4.2a	4.2a	4.0a	3.9
CV (%): 4.57    LSD <sub>Cultivar</sub> : 0.097; LSD <sub>Nitrogen</sub> : 0.235; LSD <sub>CultivarxNitrogen Dose</sub> : 0.407							
Seed Yield (kg/ha)							
Linus	2099 1**	1522 j	3185 def	2972 efg	3563 cd	4844 b	3031b**
PR44W29	1430 j	2940 efg	2720 fgh	40.6 c	4521 b	5373 a	3498a
Es-Neptune	1361 j	2617 gh	3042 efg	2105 1	3232 de	2268 h1	2437c
Mean	1630e**	2360d	2982c	3027c	3772b	4162a	2989
CV (%): 12.77    LSD <sub>Çeşit</sub> : 213.7; LSD <sub>Azot Dozu</sub> : 262.2; LSD <sub>ÇeşitxAzot Dozu</sub> : 454.2							

\*\* Differences between the means shown with the same letters are not significant at the 1% level.

### 3.9. Crude Oil Ratio

In terms of crude oil ratio, the differences between cultivars, nitrogen doses and cultivar x nitrogen dose interaction were found to be statistically significant (Table 4). In the study, the highest crude oil ratio was obtained in Linus (43.8%). However, the difference between PR44W29 (43.2%) was found to be statistically insignificant and both varieties were in the same group (a). The lowest value was determined in Es-Neptune with 41.6% and formed group (b). In terms of different nitrogen doses in winter canola cultivars, the average crude oil rate

was found to be the highest with 44.3% in the application of 50 kg nitrogen per hectare. The differences between the values obtained from the plots applied 100 kg and 150 kg nitrogen per hectare (44.1% and 43.7%, respectively) were insignificant and were included in the same group (a). The lowest oil rate was determined as 41.1% in the control plots. However, the difference between the crude oil ratio values obtained in N<sub>200</sub> and N<sub>250</sub> doses (42.1% and 42.0%, respectively) was found to be statistically insignificant and they were in the same group (b) (Table 4).

Table 4

Average values of crude oil ratio (%), crude oil yield (kg/ha) and crude protein ratio (%) at different nitrogen doses in winter canola cultivars and LSD test groups

Cultivars	Nitrogen Doses (kg/ha)						Mean
	N <sub>0</sub>	N <sub>50</sub>	N <sub>100</sub>	N <sub>150</sub>	N <sub>200</sub>	N <sub>250</sub>	
Crude Oil Ratio (%)							
Linus	43.8 bc**	45.7 a	43.1 bc	44.4 abc	43.1 bc	42.5 cd	43.8 a**
PR44W29	39.2 e	46.3 a	43.7 bc	43.4 bc	42.5 cd	43.8 bc	43.2 a
Es-Neptune	40.2 e	40.8 de	45.1 ab	43.1 bc	40.8 de	39.5 e	41.6 b
Mean	41.1 b**	44.3 a	44.1 a	43.7 a	42.1 b	42.0 b	42.8
CV (%): 1.89    LSD <sub>Cultivar</sub> : 1.565    LSD <sub>Nitrogen Dose</sub> : 1.051    LSD <sub>CultivarxNitrogen Dose</sub> : 1.820							
Crude Oil Yield (kg/ha)							
Linus	918 fg**	696 gh	1373 cd	1322 cde	1536 c	2058 b	1317 b**
PR44W29	561 h	1364 cd	1192 de	2466 a	1923 b	2351 a	1643 a
Es-Neptune	547 h	1071 ef	1372 cd	908 fg	1319 cde	899 fg	1018 c
Mean	675 e**	1043 d	1312 c	1565 b	1593 b	1768 a	1326
CV (%): 8.06    LSD <sub>Cultivar</sub> : 73.6    LSD <sub>Nitrogen Dose</sub> : 138.6    LSD <sub>CultivarxNitrogen Dose</sub> : 240.1							
Crude Protein Ratio (%)							
Linus	16.9 gh**	17.3 fg	19.4 e	23.2 ab	23.9 a	22.8 b	20.6 a**
PR44W29	16.4 h	16.8 gh	19.6 e	20.9 cd	21.2 cd	21.6 c	19.4 b
Es-Neptune	16.2 h	16.6 gh	17.7 f	21.5 cd	20.7 d	21.1 cd	19.1 b
Mean	16.5 d**	16.9 c	18.9 b	21.8 a	21.9 a	21.8 a	19.7
CV (%): 1.73    LSD <sub>Cultiva</sub> : 0.4680    LSD <sub>Nitrogen Dose</sub> : 0.4396    LSD <sub>CultivarxNitrogen Dose</sub> : 0.7614							

In the study, in terms of cultivar x nitrogen dose interaction, the highest crude oil rate was determined with 46.3%, PR44W29 and 50 kg/ha nitrogen application. There was no statistical difference between the value (45.7%) obtained from the 50 kg/ha nitrogen application of Linus and they formed the first group (a). The lowest value was determined with 39.2% in PR44W29 and 0 kg/ha nitrogen application. The difference between this value and the value determined in Es-Neptune cultivar (40.2%) at 0 kg/ha nitrogen application was not statistically significant and formed the last group (e) (Table 4).

Since canola is an oil crop, the main purpose of its cultivation is to obtain crude oil. For this reason, it is an important factor that is desirable that the oil rate in the seed is high.

In order to determine the effects of different nitrogen fertilizer doses applied to rapeseed cultivars on yield and yield components, Gürsoy et al (2019), it was reported that there were decreases in oil ratios with increasing nitrogen doses. The lowest crude oil rate was obtained in the control with 34.10%, and the highest was obtained with a nitrogen dose of 38.09% at 100 kg/ha. As a result of the study carried out by Koç (2000) for two years in Tokat conditions, the lowest oil rate was determined at 41.43% at 0 kg/ha, and the highest at 43.81% with 140 kg nitrogen per hectare plots. In the study conducted by Başalma (1999) in Ankara conditions, it was determined that increasing nitrogen doses caused reductions in oil ratios. In the study, the highest oil rate was determined with 51.17% in the application of 80 kg nitrogen per hectare, and the lowest in the control plots with 37.07%.

As a matter of fact, in this study, it was determined that there were fluctuations in oil ratios depending on the cultivars with increasing nitrogen doses in general. It

was observed that the oil ratios decreased with increasing nitrogen doses after N<sub>150</sub> in Linus and N<sub>100</sub> in Es-Neptune. In the PR44W29 cultivar, it was determined that the oil ratio followed a fluctuating course after the N<sub>50</sub> dose. It can be said that the differences seen in oil ratio between this study and other research results may be due to the differences between the cultivars used, the ecologies in which the research was conducted, and the nitrogen doses used. Similarly, Fernandez et al (1986) reported that nitrogen rates of 0-150 kg/ha had no appreciable effect on oil content but rates higher than 200 kg/ha reduced oil content by 8-9%.

### 3.10. Crude Oil Yield

In terms of crude oil yield, the differences between cultivars, nitrogen doses and cultivar x nitrogen dose interaction were found to be statistically significant. As an average of nitrogen doses, the highest crude oil yield was determined in PR44W29 with 1643 kg/ha in terms of cultivars and formed the first group (a). The lowest was detected in Es-Neptune with 1018 kg/ha and formed the last group (c) (Table 4).

As can be seen from the examination of Table 4, in terms of nitrogen doses, the highest crude oil yield was determined at 1768 kg/ha and 250 kg nitrogen application per hectare, and it was determined in the first group (a), while the lowest 675 kg/ha was determined in the control plots and formed the last group (e). In terms of cultivar x nitrogen dose interaction, the highest crude oil yield was determined in PR44W29 with 2466 kg/ha and 150 kg/ha nitrogen application, and with this value, 250 kg/ha nitrogen application was obtained in PR44W29. There was no statistical difference between 2351 kg/ha, which is the value obtained, and they formed the first group (a). The lowest crude oil yield was determined in



Es-Neptune planted in control plots as 547 kg/ha, and there was no statistical difference between this value and the value determined in PR44W29 (561 kg/ha) in nitrogen application at 0 kg/ha, and both values were combined. they formed the last group (h).

As a matter of fact, similar to the results of this research, in the study conducted by Eryiğit (2005) in Şanlıurfa conditions, it was found that increasing nitrogen doses increased the crude oil yield, the highest oil yield was 1108.6 kg/ha and 200 kg/da N application, the lowest 676.6 kg/ha control. reported from the plots. In the study carried out by Çorbacı (2011) for two years, the highest crude oil yield was found in the fertilizer application plots, and the lowest in the control plots. A similar result was reported in the study conducted by Öztürk (2010) to determine the effects of nitrogen ratios on yield and quality in winter rapeseed varieties.

### 3.11. Crude Protein Ratio

In terms of crude protein ratio, the differences between cultivars, nitrogen doses and cultivar x nitrogen dose interaction were found to be statistically significant (Table 4). As a result of the research, the highest crude protein ratio was determined in Linus with 20.6% in terms of varieties and formed the first group (a). The lowest value was determined in Es-Neptune with 19.1%, there was no statistical difference between this value and the value determined in PR44W29 (19.4%) and they formed the last group (b). In terms of nitrogen doses, the highest crude protein ratio was determined as 21.9% in 200 kg/ha nitrogen application. According to the LSD test, there was no statistically significant difference between the values determined at 250 kg/ha N and 150 kg/ha N doses (21.8% and 21.8%, respectively), and these three nitrogen doses together formed the first group (a). The lowest crude protein ratio was found in the control plots with 16.5% and formed the last group (d) (Table 4).

In the study, the highest crude protein ratio was found in Linus with 200 kg N application per hectare with 23.9% in terms of cultivar x nitrogen doses and formed the first group (a). The lowest was determined in the Es-NeptunexN<sub>0</sub> interaction with 16.2%, and there was no statistical difference between this value and the value (16.4%) obtained from the PR44W29xN<sub>0</sub> interaction and they formed the last group (h) (Table 4).

Başalma (1999) in Ankara conditions, it was reported that the protein ratio increased with increasing nitrogen ratios and these values ranged between 32.93% and 28.40%. Eryiğit (2005) conducted in Şanlıurfa conditions for two years, reported that with the increase of nitrogen dose, the protein ratio increased in both years, and the highest protein ratio was 21.65% in 200 kg nitrogen application per hectare, and the lowest 18.36% in control plots. As a matter of fact, as a result of this study carried out by us, it was determined that the protein ratio increased as the nitrogen doses increased.

It is a known fact that there is a negative relationship between oil ratio and protein ratio in oil crops (Atakişi 1999). Ilisulu (1973) reported that after oil, the most

abundant substance in canola seeds is protein and it covers one-fifth of it overall. In our study, crude protein ratio according to the cultivars and nitrogen doses varied between 16.5% and 21.9%, and these values are in agreement with the values reported by Öztürk (2010) as 20.36-23.0% and by Eryiğit (2005) as 18.31-21.58%. As a matter of fact, although the effect of increasing nitrogen ratios on the crude oil ratio in our study was not very significant, the highest crude oil ratio was determined at the dose of 100 kg/N per hectare, while the highest protein ratio was obtained at the dose of 200 kg/N per hectare. In the studies conducted by Başalma (1999), Öztürk & Ada (2009), and Eryiğit (2005), it was reported that with increasing nitrogen doses, there was a decrease in the fat ratio, while the protein ratio increased. These results confirm the findings obtained as a result of this research conducted by us.

## 4. Conclusion

For both seed yield and oil yield, nitrogen fertilizer use is frequently preferred in canola as in all field crops. As a matter of fact, canola is an oil crop that increases yield in parallel with the use of fertilizers. Determining the correct nitrogen dose is very important in canola cultivation. It is very important to determine the optimum nitrogen ratio in canola when the high nitrogen application is evaluated in terms of the damage it causes to the country's economy due to the deterioration of the soil and environmental structure and increasing the producer cost.

As a result of the research, it was observed that increasing nitrogen fertilizer doses in winter canola caused significant increases in plant height, number of branches on the main stem, number of capsules per plant, number of seeds per capsule, capsule length and seed yield, but less increase in thousand seed weight. While the crude oil ratio in the cultivars changed inversely with increasing nitrogen doses, the protein ratio increased in parallel with the nitrogen doses.

The highest seed yield was determined in PR44W29xN<sub>250</sub> application with 5373 kg/ha, crude oil ratio in PR44W29xN<sub>50</sub> with 46.3%, crude oil yield in PR44W29xN<sub>150</sub> application with 2466 kg/ha and LinusxN<sub>200</sub> application with 23.9% crude protein.

According to the results of this research carried out on winter canola; in terms of both seed yield and oil yield; It was determined that PR44W29 was the most suitable cultivar for local conditions. In the study, it was determined that the cultivars showed different responses to increasing nitrogen doses in terms of seed yield and oil yield, and the interaction between cultivars and nitrogen doses was found to be significant.

The main purpose in the cultivation of oil crops is to increase the oil yield per unit area. As a result, it was concluded that for the regions similar to the conditions in which the study was carried out, planting with the PR44W29 cultivar in the form of 150 kg nitrogen application per hectare would be more appropriate in terms

of seed yield. However, this study is only one year, and the necessity of repeating the study in different years and locations should not be overlooked in terms of the reliability of the results.

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