Determination of Yield and Some Quality Characteristics of Winter Canola (*Brassica napus* ssp. *oleifera* L.) Cultivars

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Abstract**—**Canola is a specific edible type of rapeseed, developed in the 1970s, which contains about 40 percent oil. This research was carried out to determine the yield and some quality characteristics of some winter canola cultivars during the 2010-2011 vegetation period in Central Anatolia of Turkey. In this research; Oase, Dante, Californium, Excalibur, Elvis, ES Hydromel, Licord, Orkan, Vectra, Nelson, Champlain and NK Petrol winter canola varieties were used as material. The field experiment was set up in a "Randomized Complete Block Design" with three replications on 21 September 2010. In this research; seed yield, oil content, protein content, oil yield and protein yield were examined.

As a result of this research; seed yield, oil content, oil yield and protein yield (except protein content) were significant differences between the cultivars. The highest seed yield (6348 kg ha^{-1}) was obtained from the NK Petrol, while the lowest seed yield (3949 kg ha^{-1}) was determined from the Champlain cultivar was obtained. The highest oil content (46.73%) was observed from Oase and the lowest value was obtained from Vectra (41.87%) cultivar. The highest oil yield (2950 kg ha^{-1}) was determined from NK Petrol while the least value (1681 kg ha^{-1}) was determined from Champlain cultivar. The highest protein yield (1539.3 kg ha^{-1}) was obtained from NK Petrol and the lowest protein yield (976.5 kg ha^{-1}) was obtained from Champlain cultivar.

The main purpose of the cultivation of oil crops, to increase the yield of oil per unit area. According the result of this research, NK Petrol cultivar which ranks first with regard to both seed yield and oil yield between cultivars as the most suitable winter canola cultivar of local conditions.

Keywords**—**Cultivar, Oil yield, Rapeseed, Seed Yield.

I. INTRODUCTION

CANOLA (*Brassica napus* L.) is a very important oil seed crop in the world. It is a special type of rapeseed that was bred (using conventional breeding techniques) to have by definition less than 2 percent erucic acid in the oil and less than 30 micromoles per gram of glucosinolates in the oil-free meal [1], [2], and are often referred to as "double low" or "double-zero" varieties. These differences allow canola oil to be used for human consumption and the meal for a livestock feed protein supplement. Recently, canola oil has been proven to be an excellent feedstock for biodiesel production [3].

Canola varieties have been developed as both winter and spring annuals. Generally, winter types have a 20 to 30 percent yield advantage over spring types [3]. Winter canola is mainly cultivated in Europe, Asia, North America and Australia, but has a limited acreage in Turkey. Presently, over 50% of vegetable oil consumed in Turkey is imported from abroad [4]. To reduce oilseed production gap in Turkey, it is possible to grow alternative oilseed crops such as canola in crop rotation system with high oil percentage and oil quality; thus, increasing oilseed production will result in increasing vegetable oil and biodiesel production and decreasing import of vegetable oil and diesel oil [5].

Canola is a very good rotation product. In the field of agriculture, successively plantation of the same crops into the same grounds improves the soil and increases the diseases of the plants. Therefore, alternation must definitely be executed to get high performance in canola producing [6]. Growing winter canola is much like growing winter wheat. Winter canola and winter wheat are planted and harvested about the same time. Canola can be produced with small grains equipment, limiting the need for additional machinery and this is very great advantage. Production costs of canola are similar to those for winter wheat [7].

In Turkey, 75% of the arable land is devoted to cereals, of which 67% is occupied by wheat. Drought stress is also a serious abiotic stress factor limiting crop production in Turkey, especially in Central Anatolia, which covers nearly 45% (4.5 million ha) of the Turkish wheat-producing area. It is semiarid and the driest region in the country. Winter canola is a new and promising oilseed crop for many region of Turkey such as Central Anatolia. However, it achieved an important position due to fitting well in our cropping system. Although its production is still limited, this crop has large expansion possibilities in Turkey. It is an alternative principally in areas where wheat (*Triticum aestivum* L.) is the only winter crop or in marginal areas for this cereal. In Turkey, winter canola is usually cultivated in a crop rotation including winter wheat and winter barley (*Hordeum vulgare* L.) [4].

Among the agronomic factors, which affect the yield of a crop, cultivars with high yield potential play a pivotal role in increasing the yield per unit area [8], [9]. Because winter canola is a relatively new crop for the Turkey, the suitable cultivars for winter canola have not yet been established for this region. Therefore, the objective of this study was to determine the best suitable winter canola cultivars in Central Region of Turkey.

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II. Materials and Method

This research was carried out to determine the yield and some quality properties of some winter canola cultivars in the Central Anatolia region (37^0 35' North p., 32^0 47' East m. at an altidute of 1013 m) of Turkey (in the Konya Soil, Water and Combating Desertification Research Station Management) during the 2010-2011 vegetation period. Experiment area is 1016 meters above sea level. The city in which experiment carried out, is located southern part of the Central Anatolia and it has a terrestrial climate. Winters are harsh, cold, and snowy, summers are hot and rainless.

Soil samples (0-30 cm, 30-60 cm) were taken at sowing and analyzed for some parameters. The experimental soil was a clay loam with 1.10-0.82 % organic matter content and pH of 7.78-7.74. Available P was 28.9-13.2 kg ha^{-1}, available K was 55.0-39.0 mg kg-1, and no salinity problems were observed (Table I).

The average and minimum temperatures, monthly rainfall and relative air humidity data for 2010-2011 and long term mean (1975-2010) during the canola vegetation period (September-June) are shown in Table II. In trial year, mean and minimum temperature (respectively, 10.1 and -1.0^0C) was higher than the 35 yr average values (respectively, 9.0 and -12.2^0C). There was considerable variability in rainfall amounts and distribution from year to year. The amount of rainfall and average relative air humidity were more suitable for plant growth in trial year than in long term average. Rainfall received during the vegetation period (September-June) in 2010-2011 was 491.8 mm, which was higher than long-term average (298.4 mm) and had an erratic distribution. The mean long-term relative air humidity (62.1%) was below to trial year (70.1%).

The field experiment was set up in a randomized complete block design with three replications on 21 September 2010. In this research; Oase, Dante, Californium, Excalibur, Elvis, ES Hydromel, Licord, Orkan, Vectra, Nelson, Champlain and NK Petrol winter canola varieties were used as trial material. Sowing was done with hand.

Plots were overseeded and subsequently thinned to final plant density of about 50 plants m-2 at seedling stage. Area of each plot was 7.2 m^2 consisting of six rows, 4 m long and 30 cm apart. A 1.0-m alley was left around each plot. 60 kg ha^{-1} P_2O_5 and 120 kg ha^{-1} nitrogen applied to each plot. All plots received P as Diamonnium phosphate before sowing. Nitrogen was applied as split in two applications; half was drilled into the soil before sowing (Amonnium sulphate) and the remaining half was topdressed at the flower-bud-visibility stage as amonnium nitrate form [10]. Weeds were controlled by hand as needed. Plots were irrigated once at sowing to allow an immediate and homogeneous emergence during growing seasons. Plots were hand-harvested at technological maturity stage on 29 June-2 July 2011 after removing two outer rows at each plot.

In this research, seed yield, oil content, oil yield, protein content and protein 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. Subsamples were dried at 105ºC for moisture determination. Seed yield was adjusted to 9% moisture content [11], and all other measurements were reported on a dry weight basis. Seed oil content was determined by Soxhlet extraction technique, using diethyl ether [12], and seed N concentration by the Kjeldahl procedure, N was multiplied by 6.25 to convert to protein content [13]. Oil yield (kg ha^{-1}) and protein yield (kg ha^{-1}) were calculated by multiplying crude oil and crude protein percentage with seed yield per ha. Statistical analysis was conducted using the MSTAT-C statistical package. Differences among treatments were tested by ANOVA and compared using Least Significant Difference (LSD) test at 0.01 and 0.05 levels of significance.

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

Depth cm	PH	EC x10^3 mmhos/ cm	Available P_2O_5 kg ha^{-1}	Available K_20 kg ha^{-1}
0-30	7,78	0,05	28,9	550,0
30-60	7,74	0,04	1,32	39,00
Depth cm	**Organic Matter %**	**$CaCO_3$ %**	**Soil Texture**	
0-30	1,10	18,37	Clay- loam	
30-60	0,82	18,34		

TABLE II
Meteorological Data of the Experimental Region During the Test

Month	Mean Temperature ^{0}C		Minimum Temperature ^{0}C		Rainfall mm		Relative Humidity %	
	2010-11	LTM	2010-11	LTM	2010-11	LTM	2010-11	LTM
Sept.	21.8	18.6	10.4	1.2	0.8	11.3	41.1	46.1
Oct.	12.9	12.4	0.3	-7.6	75.2	29.7	72.7	58.5
Nov.	10.1	5.5	-0.2	-20.0	2.8	39.0	63.6	70.1
Dec.	5.2	1.3	-4.0	-22.4	85.2	43.9	86.4	76.5
Jan.	1.5	-0.3	-5.8	-25.8	46.5	30.8	88.8	76.0
Feb.	2.0	0.6	-11.4	-25.0	52.2	23.2	77.9	70.3
March	5.2	5.2	-8.7	-15.8	35.4	25.5	73.8	62.7
April	9.4	10.9	-1.8	-8.6	67.1	35.9	71.6	57.7
May	13.9	15.5	1.1	-1.2	64.0	38.6	69.6	55.4
June	19.3	20.1	9.7	3.2	62.6	20.5	55.1	47.2
Total	-	-	-	-	491.8	298.4	-	-
Mean	10.1	9.0	-1.0	-12.2	-	-	70.1	62.1

[a]LTM: represents the long-term (35-years) mean

III. Results and Discussion

A. Seed Yield

The data regarding seed yield of different canola cultivars given in Table III. As can be seen in Table III, seed yield was significantly affected by cultivars. Average seed yield ranged from 6348.0 kg ha^{-1} to 3949.0 kg ha^{-1}. Maximum seed yield was produced be variety NK Petrol, minimum seed yield was obtained by Champlain (Fig. 1).

Genotype is one of the most important factors affecting growth and yield of crops. A Romanian investigation with 50 rapeseed cultivars showed significant differences regarding the grain yields [14]. The maximum seed yield produced by NK Petrol may be attributed to the combined effect of yield components such as more number of siliquas per plant and maximum number of seeds per siliqua, over the other varieties. Khehra and Singh [15] studied 29 genotypes of *Brassica napus* L. and reported significant differences for seed yield, number of siliqua, number of secondary branches and plant height. Similarly, several investigators [16]-[20] compared different mustard and canola cultivars and reported that all cultivars differed significantly for seed and oil yield.

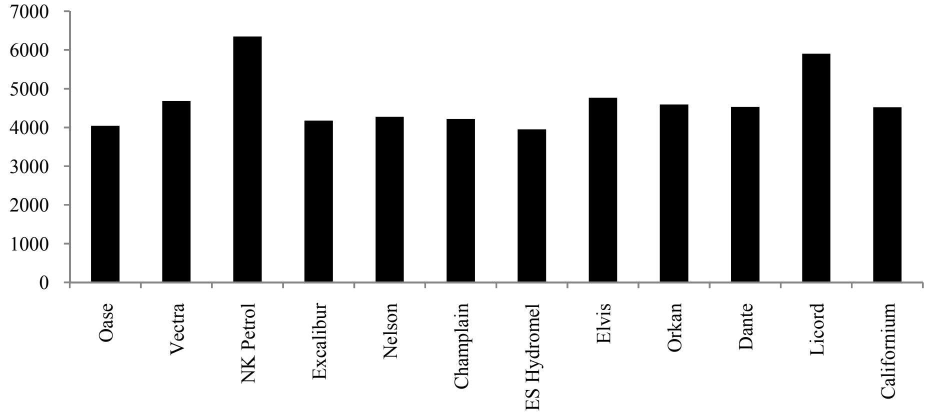

Fig. 1 Effect of cultivars on seed yield (kg ha^{-1}) of winter canola

TABLE III
EFFECT OF WINTER CANOLA CULTIVARS ON SEED YIELD, OIL CONTENT, OIL YIELD, PROTEIN CONTENT AND PROTEIN YIELD

Cultivars	Seed Yield kg ha^{-1}	Oil Content %	Oil Yield kg ha^{-1}	Protein Content %	Protein Yield kg ha^{-1}
Oase	4042.0 cd*	46.73 a**	1898.0 bc*	25.1	1070.2 c**
Vectra	4684.0 bcd	41.87 d	1962.0 bc	22.9	1074.3 c
NK Petrol	6348.0 a	46.27 ab	2950.0 a	24.4	1539.3 a
Excalibur	4174.0 cd	45.33 abc	1898.0 bc	24.6	1017.7 c
Nelson	4217.0 cd	43.03 bcd	1819.0 c	23.3	989.0 c
Champlain	3949.0 d	42.43 cd	1681.0 c	24.7	976.5 c
ES Hydromel	4765.0 bcd	44.20 a-d	2119.0 bc	22.5	1068.3 c
Elvis	4592.0 cd	45.00 a-d	2070.0 bc	24.3	1112.3 bc
Orkan	4528.0 cd	43.67 a-d	1978.0 bc	24.4	1106.7 bc
Dante	5903.0 ab	42.87 cd	2533.0 ab	23.3	1377.3 ab
Licord	4520.0 cd	42.67 cd	1924.0 bc	23.7	1074.0 c
Californium	5259.0 abc	43.00 bcd	2263.0 bc	23.1	1210.0 bc
Mean	4749.0	43.92	2091.0	23.9	1129.6

P<0.05,P<0.01*

B. Oil Content

An oilseed crop rich in oil content of high quality is the ultimate goal of a grower. The quality of a canola seed is determined from its oil content. As can be seen in Table III, significant difference in oil content (%) recorded between cultivars. Among the varieties, maximum oil content (46.73 %) was found in Oase whereas minimum oil content (41.87 %) was obtained in Vectra (Fig. 2).

Oil content of canola depends on many factors such as variety, growth environment, agrotechnics and fertilization [21]. These results are in accordance with the findings of [22] who reported 9% difference between two varieties of winter canola, while [23] observed 2.3% difference between different *Brassica carinata* lines for seed oil content. Such similar reports have made by [24]-[28] which confirmed our results.

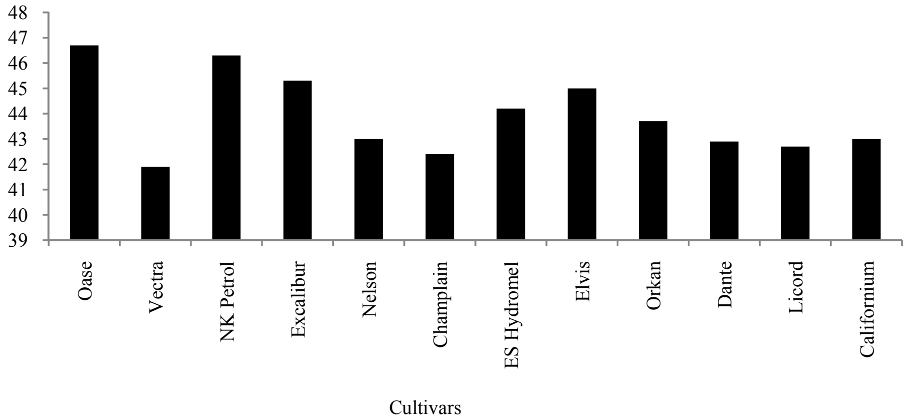

Fig. 2 Effect of cultivars on oil content (%) of winter canola

C. Oil Yield

The oil yield of a crop is the combined expression of seed oil content and seed yield of a variety. The oil yield was significantly affected by different cultivars (Table III).

The highest oil yield (2950.0 kg ha^{-1}) was obtained in NK Petrol, while the lowest oil yield (1681.0 kg ha^{-1}) was Champlain (Fig. 3). The highest oil yield in NK Petrol might be on account of maximum seed yield and seed oil content than the other varieties. Seed oil concentration is purely genetically controlled character and plays vital role in determining total oil yield per unit area [29]. Also, climatic conditions especially high temperature and water stress during the flowering and the formation of oil can be deleterious effects on oil yield [30].

These findings are in lines with those [31], [32] who found differences in oil yields of different brassica species.

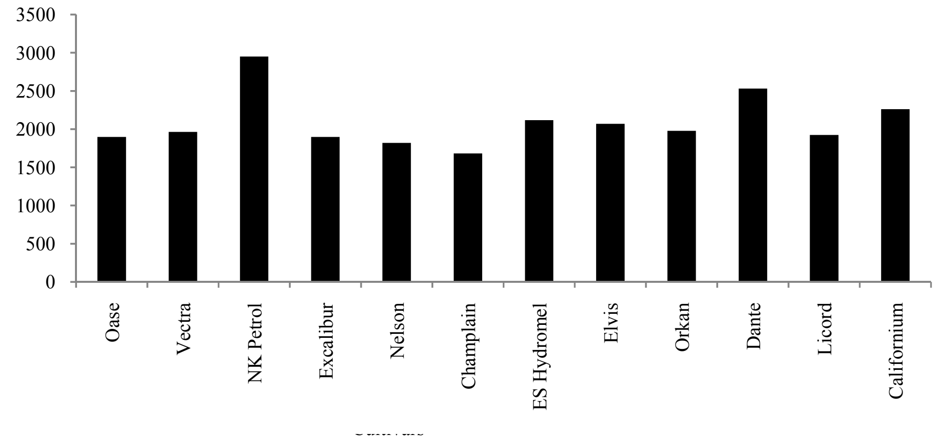

Fig. 3 Effect of cultivars on oil yield (kg ha^{-1}) of winter canola

D. Protein Content

Protein content of canola was not influenced between cultivars (Table III). However, Oase cultivar recorded higher seed protein content (25.1 %) as compared to others (Fig. 4). Canola is not only an oilseed crop, but also contains a relatively high seed protein concentration (> 400 g kg-1 oil-free meal) and its meal is used as a protein supplement for animals and possibly will be for humans in the near future [33]. Oil content is negatively correlated with protein [34]. The protein contents of the varieties used in the study varied between 22.5 % and 25.1%. Weiss [35] reported that protein content in canola seeds was 25% on average. As some researches [36]-[39] stated, although protein content may be affected by environmental conditions, they vary to a great extent depending on the genetic properties of variety. These results are consistent with those reported [40], [41].

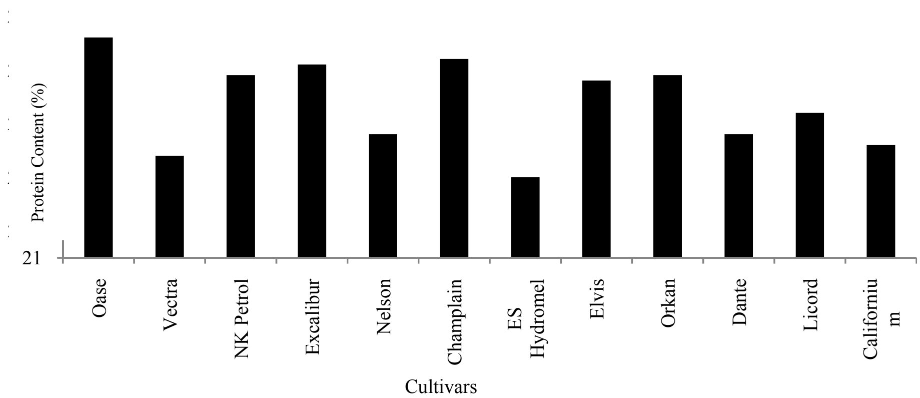

Fig. 4 Effect of cultivars on protein content (%) of winter canola

E. Protein Yıeld

Differences were important among the cultivars in terms of protein yield was $p<0.05$ (Table III). The highest yield was obtained from NK Petrol as 1539.3 kg ha^{-1} and the lowest from Champlain as 976.5 kg ha^{-1} (Fig. 5).

Canola meal is a high-protein animal feed used by the dairy, cattle and poultry industries. It is a byproduct of oilseed extraction that consists of the solids left after oil is extracted from seeds [42]. Protein yield as protein concentration and product of seed yield was expressed in kg/ha. At the end of research, our results were similar to the findings of [43]-[45].

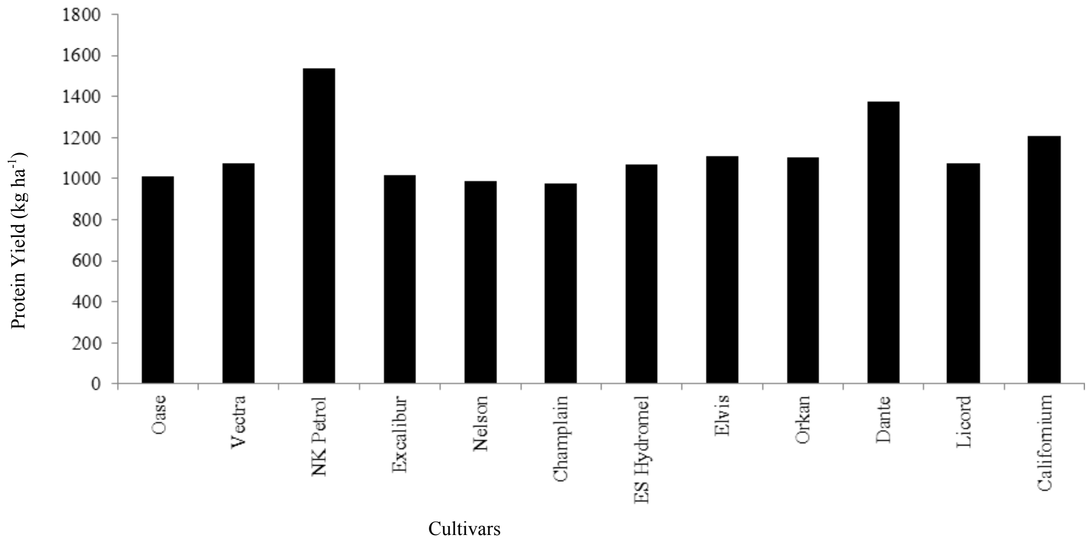

Fig. 5 Effect of cultivars on protein yield (kg ha^{-1}) of winter canola

IV. Conclusion

Cultivar selection is perhaps the most important decision that is made in growing a canola crop. Therefore, producers should carefully review cultivar characteristics and choose cultivars that match their management style.

The production of seed yield, oil content, oil yield, protein content and protein yield were studied in 12 winter canola cultivars in Central Region of Turkey climate conditions. Favourable climate conditions are very important for canola, because they certainly influence both seed production and oil content [46]. Based on meteorological data (Table II), it can be concluded that the general weather course in 2010-2011 growing seasons was favourable for all the important stages of ontogenetical development within the growth cycle of sowing, flowering and seed maturation. High values of seed yield, oil yield and protein yield were obtained in the cultivar NK Petrol.

Choosing a variety is one of the most important decisions a producer makes in raising a successful crop. A variety's performance may differ from year to year and location to location due to changing environmental conditions. Considering all the studied parameters, it was concluded that NK Petrol cultivar, is ideally suited to Central Region of Turkey type climate conditions.

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