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# Influence of Nitrogen Applications on Seed Yield and Chemical Ingredient of Winter Rapeseed

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In this experiment, it was purposed to investigate effects of different nitrogen applications on seed yield, oil and protein content and nutrient uptake of winter rapeseed grown at field conditions. Three cultivars of winter rapeseed (*Brassica napus* L.) askona, karola and silvia, were used. The nitrogen applications applied to the soil were 0, 60, 120 and 180 kg N $ha^{-1}$ as ammonium sulfate. Nitrogen concentration increased seed yield compared to untreated plants in all three cultivars. The highest seed yield was obtained from the plants received the highest nitrogen rate (180 kg N $ha^{-1}$) for all three cultivars. When compared to seed yield of cultivars, the highest seed yields was in cultivar, askona with 180 kg N $ha^{-1}$ and the lowest one was in the askona without nitrogen application too. The protein contents in all three cultivars were increased with the highest nitrogen content compared to untreated plants. However other nitrogen applications did not change protein content consistently. The changes in oil content were also not consistent among nitrogen levels and cultivars. Different nitrogen doses resulted in changes in nutrient levels in leaves of all three cultivars in some way. It can be revealed that nitrogen application at right doses can increase seed yield, oil and protein contents by increasing macro and micro nutrition of plants.

**Key Words: Rapeseed, Nitrogen application, Oil, Protein, Nutrient contents.**

## INTRODUCTION

Rapeseed (*Brassica napus* L.) is the third most important oil crop in the world. Its total acreage is expanding very fast especially in areas with moderate climatic conditions. In recent years, the production of rapeseed has undergone a rapid increase. With this development, the question arises whether such an increase might be enhanced by integrated N-management strategies[1].

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Mineral nitrogen fertilization is a crucial factor in rapeseed production[2,3]. Specific information on N-fertilization of rapeseed is reported in literature[4-9]. Compared to cereals, rapeseed requires a higher amount of nutrients and available nitrogen frequently restricts seed yield[10]. It is proposed that rapeseed has a higher critical N demand for biomass formation than wheat. Thus, a substantial amount of N is provided by conversion of previous crop residues and soil organic matter into soluble soil N, additional mineral N is a prerequisite for high yields[1]. For the production of 0.1 t of seeds, the whole rapeseed plant is expected to accumulate *ca.* 6 kg of N. Therefore, it is required to use of N sources in proper way to optimize the economic seed yield[11] and also minimize the potential risk for environmental pollution[12].

Optimizing the yield of rapeseed involves balancing the synthesis of oil and crude protein in the seeds, as well as the energy and carbon dioxide budget of the photosynthetic pool[1].

However, there seems to be little information on nitrogen effects on seed yield, oil and protein content of specific cultivars of rapeseed growing areas. Even though winter rapeseed is a heavy user of N and available N is the most limiting source in many areas of the world[13].

## EXPERIMENTAL

The investigation was conducted in the field condition in two success years of 2000 and 2001 using three winter cultivars of rapeseed, askona, karola and silvia. The experiment was carried out on the experimental area of the Agricultural Faculty, Department of Crop Science, Dicle University, Diyarbakir, Turkey. The field tests were conducted on the soil with pH 7.6 and a lime content of 11 %. Some of chemical and physical properties of soil were given in Table-1. The soil is generally lime alkaline and low in organic matter. The texture of soil was clay.

TABLE-1
CHEMICAL AND PHYSICAL CHARACTERISTICS OF THE SOIL USED IN THE EXPERIMENT

| Depth (cm) | T. Salt (%) | pH | $P_2O_5$ | $K_2O$ | Org. matter (%) | Lime |
|---|---|---|---|---|---|---|
| (0-90) | 0.05 | 7.6 | 2.8 | 71.2 | 1.88 | 11.0 |
| Cu | Mn | Fe | Zn | Clay (%) | Silt (%) | Text |
| 1.61 | 9.6 | 5.8 | 0.4 | 51.7 | 27.4 | Clay |

The experimental field is situated in the Southeast Turkey with an altitude of 650-700 m above the sea level and with an average daily temperature of 11 to 12 ºC. Annual precipitation varies from 381.9 to 605.3 mm distributed in two rain seasons. During the experiment, some of the climatic conditions were also given in Table-2.

TABLE-2
METEOROLOGICAL DATA FOR THE FIELD SITE IN 2000 AND 2001

| Months | Mean temperature (ºC) | | Rainfall (mm) | | Mean relative humidity (%) | |
|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2000 | 2001 | 2000 | 2001 |
| October | 16.7 | 16.3 | 35.1 | 67.0 | 47.0 | 51.0 |
| November | 9.4 | 4.3 | 34.0 | 52.3 | 54.0 | 61.0 |
| December | 7.0 | 5.1 | 113.6 | 131.7 | 79.0 | 82.0 |
| January | 1.3 | 4.0 | 70.9 | 14.9 | 74.0 | 68.0 |
| February | 2.5 | 5.0 | 58.2 | 72.4 | 5.3 | 6.3 |
| March | 7.0 | 11.4 | 30.7 | 126.1 | 21.2 | 9.3 |
| April | 15.3 | 14.3 | 33.0 | 54.0 | 56.9 | 4.3 |
| May | 21.3 | 16.7 | 6.1 | 86.9 | 37.0 | 29.2 |
| June | 28.1 | 26.7 | 0.3 | 0.0 | 21.1 | 26.1 |
| Mean | 12.0 | 11.5 | – | – | 43.9 | 37.4 |
| Total | 108.6 | 103.8 | 381.9 | 605.3 | – | – |

Mean = Is the monthly mean for the whole growth period from planting to maturation; Total = Is the cumulative rainfall during seed development.

Nitrogen was applied at the rate of 0, 60, 120 and 180 kg ha$^{-1}$ as ammonium sulfate. The experiment was laid out as a randomized complete block design with three replications and a split-plot arrangement of the treatments, with cultivar as the main plot and N rate as the subplot. For each replicate, mini plot was designed. Seeds were sown in October 15 and plants were harvested in June 10. Nitrogen was applied during growth period splitting three times, in sowing period, middle February and flowering stage, equally.

**Extraction method of protein, oil and nutrient content:** Protein and oil concentrations were determined on a subsample taken from the yield samples. The oil content of seeds was determined by a soxhlet extraction method using *n*-hexane as solvent at 70 ºC for 6 h[14]. Protein content (N × 6.25) of rapeseed samples were determined according to the Kjeldahl procedure[15] by using a Tecator Kjeltec auto analyzer model 1030. Choosen plant 10 randomly from each plot at the period of the pod formation so as to determine the nutrient contents of the plants rapeseed were taken at the height of 40 cm from the ground cutting by a non-rusting steel scissors. The plant samples were analyzed according to the following methods. Total leaf N contents were determined by the Kjeldahl method and P by vanadate-molybdate yellow colorimetric method using spectrophotometer. The leaf content of K and Ca (%) and Fe, Mn, Zn and Cu (ppm) were assessed by atomic absorption spectrophotometer after ashing at 550 ºC and extraction in 10 % hydrochloric acid[16].

**Statistical analysis:** Statistical evaluation was carried out by using JMP package version 5.0.1a. A business unit of SAS. (Copyright 1989-2000. SAS Institute Inc.) with general linear model analysis of variance (Anova) with cultivars and N doses and years as the main treatment effects analyzed. Treatment means were separated by using least significant differences (LSD) at level a probability of 5 %.

## RESULTS AND DISCUSSION

**Seed yield:** Variation of seed yield between N doses was highly significant ($p < 0.001$). But cultivars and cultivars × N doses interaction effect were significant ($p < 0.01$). Seed yield increased with increasing N doses applied to the soil. The highest N applications (180 kg $ha^{-1}$) produced the highest seed yield in all three cultivars (Table-4). The economy of rapeseed cultivation is determined by the seed yield and less by the oil content. Processes of yield formation are highly variable and depend on genetic, environmental and agronomic factors as well as interactions between them[17]. Cropping of rapeseed is characterized by high N-surpluses resulting from N-fertilization exceeding the N-demand of seeds[2,8,18]. Yield components are affected by the application of N to the winter rapeseed crop with increases in seed yield resulting from an increase in the number of pods[19]. The positive effects of N on the seed yield of rapeseed have been mostly reported[1,6-9,20]. Nevertheless, some authors noted a stagnation or reduction in seed yield at high rates of N-fertilizer[21,22] illustrated that raising the rate of N from 80 to 200 kg N $ha^{-1}$ increased the seed yield of winter rapeseed from 3.21 to 3.84 mg $ha^{-1}$ corresponding to an increase of 0.63 mg $ha^{-1}$. Other authors also observed increased yield at N-doses of 80-160 kg N $ha^{-1}$, whereas there was only a small rise in yield[3] from 160 to 240 kg N $ha^{-1}$.

There were differences among cultivars in seed yield, the highest seed yield was obtained from cultivar, askona with the highest N application, the lowest one was from askona with no N application (Table-4). Rapeseed cultivars varies remarkably in yield and seed quality.

High progresses in plant breeding and molecular genetic research improved the developments of genotypes with improved characteristics under conditions of high N-supply[23]. Breeding and growing of N-efficient cultivars might contribute to improved N-use efficiency[24]. Genotypic variation in N-efficiency is attributed to high N-uptake and/or high N-utilization[25]. Cultivation of hybrid cultivars obtained from inbred lines improves seed yield up to 7 %. Those cultivars becomes obvious in unfavourable conditions due to the heterogeneous character of hybrids compared with conventional cultivars[26].

TABLE-3
ANALYSIS OF VARIANCE FOR AGRONOMIC TRAITS ON RAPESEED IN 2000 AND 2001

| Variation sources | D.F. | Seed yield (kg $ha^{-1}$) | Protein (%) | Oil (%) | P (%) | K (%) | Ca (%) | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 1 | ‡ | * | ns | ‡ | ‡ | ns | † | ‡ | ‡ | ns |
| Replication×year | 4 | * | ns | ns | † | * | ns | ns | ns | ns | ns |
| Cultivars | 2 | ‡ | ‡ | ‡ | ‡ | * | ns | * | † | ‡ | † |
| Years×cultivars | 2 | * | ‡ | ‡ | † | ns | ns | † | * | ns | ns |
| Rep.×cult. × year×rand. | 8 | ns | ns | ns | ns | ns | ‡ | ns | ns | ns | ns |
| N doses | 3 | ‡ | ‡ | ‡ | ‡ | ns | † | † | ‡ | ns | ns |
| Years×N doses | 3 | ns | ‡ | ‡ | ‡ | ns | † | † | † | * | ns |
| N doses × cultivars | 6 | † | ‡ | ‡ | ‡ | ns | † | ‡ | ‡ | ‡ | † |
| Year×N doses× cultivars | 6 | ns | ‡ | ‡ | † | ns | ‡ | ‡ | † | ‡ | ns |

ns = Non-significant, *Significant at $p < 0.05$, †Significant at $p < 0.01$, ‡Significant at $p < 0.001$.

TABLE-4
SEED YIELD, PROTEIN, OIL, PHOSPHORUS AND POTASSIUM CONTENTS OF THREE CULTIVARS OF RAPESEED GROWN AT DIFFERENT NITROGEN LEVELS

| Cultivars | N doses (kg N $ha^{-1}$) | Seed yield (kg $ha^{-1}$) | Protein (%) | Oil (%) | P (%) | K (%) |
|---|---|---|---|---|---|---|
| Askona | 0 | 214.60h | 18.21f | 43.51a | 0.22cd | 1.43d |
| | 60 | 310.83e | 19.48c | 43.70a | 0.19de | 1.65bcd |
| | 120 | 400.00b | 18.25f | 42.60b | 0.19e | 1.58cd |
| | 180 | 462.60a | 20.60a | 41.61cd | 0.19e | 1.80bc |
| Karola | 0 | 229.66gh | 17.51g | 42.66b | 0.23bc | 1.80bc |
| | 60 | 252.50fg | 17.03h | 42.88b | 0.23bc | 1.84bc |
| | 120 | 345.66cd | 19.11d | 41.96c | 0.25b | 1.72bcd |
| | 180 | 396.70b | 20.48a | 41.53d | 0.19e | 1.92abc |
| Silvia | 0 | 206.83h | 18.63e | 43.51a | 0.24bc | 1.96ab |
| | 60 | 270.7f | 17.98f | 42.66b | 0.20de | 1.80bc |
| | 120 | 316.96de | 20.10b | 41.83cd | 0.32a | 2.22a |
| | 180 | 372.73bc | 20.75a | 41.16e | 0.22cd | 1.83bc |
| LSD (5 %) | | 28.90 | 0.28 | 0.35 | 0.02 | 0.36 |
| F Value | | 5.51† | 66.85† | 6.69† | 9.93† | 1.77 |

†Significant at $p < 0.001$, F values are from one-way Anova using data for the year 2000 and 2001.

**Protein and oil content:** Variation of protein and oil content between N doses, cultivars and N doses × cultivars interaction effects were highly significant at ($p < 0.001$). In most cases, the highest oil content was obtained from askona and silvia cultivars with no N application and askona with 60 kg N $ha^{-1}$ application. The askona cultivar had high oil content compare to the karola and silvia cultivars. It has been reported that the N-application at the beginning of re-growth in spring the slightly increased oil content[8]. In contrast[2], it is indicated that the effect of N-supply on the oil content of rapeseed was not significant.

There were also significant increase in protein content in three cultivars with increasing nitrogen application. Similarly, N-fertilization increases the protein content[1,8,9].

**Nutrient content:** Generally, variation of nutrient content was significant between cultivars, N doses and N doses × cultivars interaction effect ($p < 0.05$, $p < 0.01$, $p < 0.001$). High N application reduced P content in karola and silvia cultivars, but did not change in askona cultivar. There were decreases in K content in askona and karola cultivars, but no significant change in the silvia cultivar with N application.

However, Ca increased with increasing N application in askona and karola cultivars, but in silvia cultivar, there seems to be no consistence results in Ca content (Table-5). Changes in Fe contents were not consistent with different nitrogen applications. For example, in askona cultivar, Fe content increased with application of nitrogen at 180 kg $ha^{-1}$, but it decreased in silvia and karola cultivars with same application of nitrogen.

Furthermore, in karola and silvia, Fe content increased with application of N at 120 kg $ha^{-1}$ compared to no nitrogen application (Table-5). There were no consistency in results in Mn concentration obtained with nitrogen applications. The highest Mn content was obtained from askona cultivar at no nitrogen application, but the lowest Mn content was obtained from silvia with 60 kg N $ha^{-1}$ nitrogen doses. Mn concentration was lowered by the highest N application in silvia cultivar, but was increased by the same N application in karola cultivar.

In askona cultivar, there seems to be no consistency in result of Mn concentration with different N application. Nitrogen applications reduced Zn concentration in karola and silvia cultivars. Changes in Zn concentrations were not consistent between N doses and cultivars. There seems to be no change in Cu concentration with N application in most cases. But askona and silvia given the highest Cu content in no nitrogen applications.

**Correlation analysis:** Correlation analysis was performed to explore the trend of associations between seed yield, protein and oil contents and individual nutrient contents showed in Table-6. The data presented that

TABLE-5
SOME OF NUTRIENT CONTENT OF THREE CULTIVARS OF RAPESEED GROWN AT DIFFERENT NITROGEN LEVELS

| Cultivars | N doses kg N ha$^{-1}$ | Ca (%) | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) |
|---|---|---|---|---|---|---|
| Askona | 0 | 2.13c | 86.38cdef | 36.97a | 11.97bc | 3.36a |
| | 60 | 2.20c | 91.73cde | 27.02e | 8.73ef | 3.39a |
| | 120 | 2.79ab | 84.75def | 28.42de | 8.84ef | 2.53cdef |
| | 180 | 2.97a | 104.75ab | 27.58e | 11.99bc | 2.67cde |
| Karola | 0 | 2.50bc | 93.08cde | 33.33bc | 9.10ef | 1.89g |
| | 60 | 2.34c | 95.86bcd | 26.93e | 7.97f | 2.28defg |
| | 120 | 2.13c | 105.08ab | 31.82cd | 9.64de | 2.00fg |
| | 180 | 2.99a | 96.35bc | 35.52ab | 9.55e | 2.72bcde |
| Silvia | 0 | 2.21c | 115.01a | 25.46ef | 11.16c | 3.03abc |
| | 60 | 2.22c | 79.80f | 23.25f | 12.95ab | 2.13efg |
| | 120 | 2.39c | 112.43a | 31.87cd | 13.90a | 3.33ab |
| | 180 | 2.20c | 84.40ef | 26.49ef | 11.16cd | 2.79abcd |
| LSD (5 %) | | 0.39 | 11.45 | 3.47 | 1.52 | 0.62 |
| F Value | | 4.83† | 11.66‡ | 9.22‡ | 9.18‡ | 6.06† |

†Significant at $p < 0.01$, ‡Significant at $p < 0.001$, F values are from one-way Anova using data for the year 2000 and 2001.

seed yield had a significantly positive correlation with the protein and Ca content, in contrast had a significantly negative correlation with oil, P, K, Fe, Mn, Zn and Cu content. Protein content had a positive correlation with all the traits without oil and Fe and P content. Oil content had a positive correlation with Mn and Cu content and had a negative correlation with seed yield, protein, P, K, Ca, Fe and Zn contents. Therefore, P content had a positive correlation with K, Fe, Zn and Cu contents, but had a negative correlation with seed yield, protein and oil, Ca and Mn contents. K had a positive correlation with protein content and P, Ca, Fe and Zn, but had a negative correlations with seed yield, oil content, Mn and Cu contents.

The Ca had a positive correlation with seed yield, protein, K, Fe and Mn content, in contrast had a negative correlation with oil content, P, Zn and Cu contents. Hence Fe showed a positive correlation with P, K, Ca, Zn and Cu contents, but showed negative correlation with seed yield, protein, oil and Mn contents. Mn showed a positive correlation with protein, oil, Ca and Cu contents, but had a negative correlations with seed yield, P, K, Fe and Zn contents. In addition, Zn had a positive correlation with protein, P, K, Fe and Cu contents, but had a negative correlation with seed yield, oil, Ca and Mn contents. In the end Cu had a positive correlation with most of the traits without seed yield, K and Ca contents.

TABLE-6

CORRELATION COEFFICIENTS FOR SEED YIELD, PROTEIN AND OIL AND NUTRIENT CONTENTS OF USING DATA 2000 AND 2001

| | S. Yield | Protein (%) | Oil (%) | P (%) | K (%) | Ca (%) | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|
| S. Yield | 1.0000 | 0.5467 | -0.5800 | -0.2842* | -0.0913 | 0.2915* | -0.0031 | -0.0024 | -0.1065 | -0.0446 |
| Protein (%) | 0.5467‡ | 1.0000 | -0.3969 | -0.0771 | 0.0818 | 0.2163 | -0.1260 | 0.0665 | 0.0099 | 0.1822 |
| Oil (%) | -0.5800 | -0.3969† | 1.0000 | -0.0912 | -0.2050 | -0.2131 | -0.1343 | 0.0455 | -0.1763 | 0.1277* |
| P (%) | -0.2842 | -0.0771 | -0.0912 | 1.0000 | 0.6264 | -0.1893 | 0.3327 | -0.1622 | 0.7522 | 0.0020 |
| K (%) | -0.0913 | 0.0818 | -0.2050 | 0.6264‡ | 1.0000 | 0.0048 | 0.2574 | -0.2995 | 0.6256 | -0.0736 |
| Ca (%) | 0.2915 | 0.2163 | -0.2131 | -0.1893† | 0.0048* | 1.0000 | 0.0128 | 0.0993 | -0.0101 | -0.0288 |
| Fe (ppm) | -0.0031 | -0.1260 | -0.1343 | 0.3327† | 0.2574* | 0.0128 | 1.0000 | -0.0108 | 0.3040 | 0.1568 |
| Mn (ppm) | -0.0024 | 0.0665 | 0.0455 | -0.1622 | -0.2995* | 0.0993 | -0.0108 | 1.0000 | -0.3033 | 0.1389 |
| Zn (ppm) | -0.1065 | 0.0099 | -0.1763 | 0.7522‡ | 0.6256‡ | -0.0101 | 0.3040† | -0.3033† | 1.0000 | 0.0106 |
| Cu (ppm) | -0.0446 | 0.1822 | 0.1277 | 0.0020 | -0.0736 | -0.0288 | 0.1568 | 0.1389 | 0.0106 | 1.0000 |

*Significant at $p < 0.05$, †Significant at $p < 0.01$, ‡Significant at $p < 0.001$.

## Conclusions

The highest seed yield was obtained from the highest nitrogen rate (180 kg N $ha^{-1}$) for all the three cultivars. The highest seed yield was obtained from aksona in the highest nitrogen doses (180 kg N $ha^{-1}$) with 462.60 kg N $ha^{-1}$. The differences in oil content were also not consistent among nitrogen doses and cultivars. The highest oil content was obtained from no nitrogen application and 60 kg N $ha^{-1}$ doses. The protein contents in all three cultivars were increased with the highest nitrogen levels compared to untreated plants. The highest protein content were obtained from the askona (20.60 %) and karola (20.48 %) at the highest nitrogen doses (180 kg N $ha^{-1}$). On the other hand different nitrogen applications resulted in changes in nutrient levels in leaves of all three cultivars in some way.

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