Pak. J. Bot., **40(2): 807-813, 2008.**

THE EFFECT OF DIFFERENT NITROGEN DOSES ON SEED YIELD, OIL, PROTEIN AND NUTRIENT CONTENTS OF SPRING RAPE

DAVUT KARAASLAN

Southeast Anatolia Agricultural Research Institute,
21110 Diyarbakir, Turkey,

Abstract

In this two seasons experiment, it was aimed to investigate the effects of different nitrogen levels applied to the soil on seed yield, oil, protein content and nutrient uptake of oilseed rape grown under field conditions. Three cultivars of spring oilseed rape (*Brassica napus*) viz., Lirawell, Semu 86/225 Na and Westar were used. The nitrogen doses applied to the soil were 0, 60, 120 and 180 kg N/ha as ammonium sulfate. Nitrogen doses increased seed yield compared to untreated plants in all three cultivars. The highest seed yield was obtained from the plants which received nitrogen 180 kg N/ha for all three cultivars. The highest seed yield was in cultivar Semu 86/225 Na with 180 kg N/ha and the lowest one was in the Lirawell without nitrogen application. The protein contents in all three cultivars were increased with the highest nitrogen doses compared to untreated plants. However other nitrogen doses did not change protein content consistently. The changes in oil content were also not consistent among nitrogen doses and cultivars. Different nitrogen applications resulted in changes in nutrient levels in leaves of all the three cultivars.

Introduction

The production of oilseed rape (*Brassica napus* L.) has undergone a rapid increase recently. Given this development, the question arises whether such an increase might be enhanced by integrated N-management strategies (Rathke *et al.,* 2005).

Mineral N fertilization is a crucial factor in oilseed rape production (Dreccer *et al.,* 2000; Rathke & Schuster, 2001). Specific information on N-fertilization of oilseed rape is reported in literature (Bilsborrow *et al.*, 1993; Andersen *et al.*, 1996; Rathke, 1999; Behrens *et al.,* 2001; Behrens, 2002; Rathke *et al.,* 2006). When compared to cereals, oilseed rape requires more nutrients than the cereals, and available nitrogen frequently restricts seed yield of oilseed rape. Colnenne *et al.* (1998) proposed that oilseed rape has a higher critical N demand for biomass formation than wheat. While 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 (Rathke *et al.,* 2005). For the production of 0.1 t of seeds, the whole oilseed rape plant is expected to accumulate approximately 6 kg of N. Therefore, it is required to use the N sources in proper way to optimise the economic seed yield (Mason & Brennan, 1998) and also minimize the potential risk for environmental pollution (Aufhammer *et al.,* 1994).

Optimising the yield of oilseed rape 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 (Rathke *et al.,* 2005). However, there seems to be little information on nitrogen effects on seed yield, oil and protein content of specific cultivars of oilseed rape grown in the region. Even though winter oilseed rape is a heavy user of N and available N is the most limiting source in many areas of the world (Kessel, 2000; Rossato *et al.,* 2001). The present report gives an account of the effect of different nitrogen doses on seed yield, oil, protein and nutrient contents of spring rape.

Corresponding author: karaasland@yahoo.com, Tlf: (0090 412 3261326), Fax: (0090 412 3261324)

Materials and Methods

This research was carried out in the field condition in two successive seasons of 1999-2000 and 2000-2001 using three spring cultivars of oilseed rape viz., Lirawell, Semu 86/225 Na and Westar. The experiment was conducted on the experimental area of the Agricultural Faculty, Department of Crop Science, Dicle University Diyarbakir, Turkey. It is in 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. The field tests were conducted on the soil with pH 7.6 and a lime content of 11%. The soil is generally lime alkaline and low in organic matter. The texture of soil was clay.

Nitrogen was applied at the rate of 0, 60, 120 and 180 kg/ha 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 on October 15 and plants were harvested on June 10. Nitrogen was applied during growth period splitting three times, in sowing period, February and flowering stage, equally.

Method of oil and protein extraction: 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 70ºC for 6 h (Anon., 1987). Protein content (N x 6.25) of rapeseed samples were determined according to the Kjeldahl procedure (Anon., 1995) by using a Tecator Kjeltec Auto analyzer model 1030.

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 with cultivars and years as the main treatment effects and years, each analyzed seperately with one-way ANOVA. Treatment means were separated by using least significant differences (LSD) at 5% level of probability.

Results and Discussions

Seed yield: Variation of seed yield between N doses and N doses x cultivars interaction effect were highly significant ($p<0.001$) in two seasons, but cultivars effect was significant ($p<0.05$) for 2000-2001 season but not significant for season 1999-2000. Seed yield increased with increasing N doses. The highest N dose (180 kg/ha) produced the highest seed yield in all three cultivars (Table 1). The economy of oilseed rape 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 (Sidlauskas & Bernotas, 2003). Cropping of oilseed rape is characterized by high N-surpluses resulting from N-fertilization exceeding the N-demand of seeds (Dreccer *et al.,* 2000; Behrens, 2002; Lickfett, 2001). 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 (Scott *et al.,* 1973). The positive effects of N on the seed yield of oilseed rape have been mostly reported (Rathke, 1999; Behrens *et al.,* 2001; Behrens, 2002; Barlo´g & Grzebisz, 2004; Rathke *et al.,* 2005; Rathke *et al.,* 2006). Nevertheless, some authors noted a stagnation or reduction in seed yield at high rates of N-fertilizer (Gammelvind *et al.*, 1996). Sieling & Christen (1997) illustrated that raising the rate of N from 80 to 200 kg N/ ha increased the seed yield of winter oilseed rape from 3.21 to 3.84 Mg /ha corresponding to an increase of 0.63 Mg/ ha 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 from160 to 240 kg N ha^{-1} (Rathke & Schuster, 2001).

Table 1. Seed yield, protein and oil contents of three cultivars of oilseed rape grown at different nitrogen levels.

Cultivars	N doses Kg N/ha	1999-2000			2000-2001		
		S. yield kg/ha	**Protein %**	**Oil %**	**S. yield kg/ha**	**Protein %**	**Oil %**
Lirawell	0	1310 j	19.56 e	45.56 b	990 f	19.03 f	43.43 bcd
	60	3460 de	21.56 c	44.36 d	2326 d	21.13 c	44.86 a
	120	3230 f	20.66 d	43.06 ef	3552 a	22.43 b	43.23 bcd
	180	4700a	21.53 c	47.10 a	3776 a	23.33 a	44.93 a
Semu 86/225 Na	0	1960 i	20.73 d	42.0 g	1560 e	18.50 g	42.86 c-f
	60	2720 g	19.23 e	36.96 h	3040 b	21.16 c	43.86 abc
	120	3620 c	17.30 g	43.43 e	2931 b	19.70 e	42.46 def
	180	4810a	22.93 b	42.70 f	3776 a	22.23 b	43.06 b-e
Westar	0	2130 h	19.40 e	45.13 c	1448 e	19.16 f	43.26 bcd
	60	3300 ef	18.83 f	42.03 g	2618 cd	19.70 e	44.26 ab
	120	3560 cd	20.40 d	45.33bc	2845 bc	20.70 d	41.86 ef
	180	4400 b	23.70 a	45.03 c	3010 b	18.6 g	41.63 f
LSD (%5)		7.41	0.163	0.195	14.46	0.175	0.650
F-value		48.09***	169.40***	145.91***	13.70***	109.8***	2.38ns

***Significant at p<0.001; ns= Non-significant, The F-values are from one-way ANOVA using data for the year 2000 and 2001.

There were differences among cultivars in seed yield, the higher seed yield was obtained from cultivars Lirawell and Semu 86/225 Na with the highest N application, the lowest one was from Lirawell with no N application (Table 1). Oilseed rape cultivars have various distinguist differences between each others respect in yield and seed quality. High progresses in plant breeding and molecular genetic research improved developments of genotypes with improved characteristics under conditions of high N-supply (Snowdon & Friedt, 2004). Breeding and growing of N-efficient cultivars might contribute to improved N-use efficiency (Le´on & Becker, 1995). Genotypic variation in N-efficiency is attributed to high N-uptake and/or high N-utilization (Sattelmacher *et al.*, 1994). Cultivation of hybrid cultivars obtained from inbred lines improves seed yield upto 7%. Those cultivars becomes obvious in unfavorable conditions due to the heterozygous character of hybrids compared with conventional cultivars (Paulmann, 1993).

Oil and protein content: Variation of protein and oil contents between N doses were highly significant for two seasons. Variation of protein content between N doses and N doses x cultivar interaction effects were significant (p<0.001) for two seasons. Variation of oil content was significant between cultivars, N doses and N doses x cultivars interaction effects were significant for both of these two seasons too. In the most cases, the highest oil content was obtained by the highest N application. The Lirawell and Westar cultivars had high oil content compared to the Semu 86/225 Na cultivars. It has been reported that with the N-application at the beginning of re-growth in spring, oil content slightly increased (Behrens, 2002). In contrast, Dreccer *et al.*, (2000) indicated that the effect of N-supply on the oil content of oilseed rape was not significant.

There were also significant increases in protein content in three cultivars with increasing nitrogen application. Similarly, N-fertilization increased the protein content (Behrens, 2002; Rathke *et al.*, 2005; Rathke *et al.*, 2006).

Table 2. Some of macro-nutrient content in three cultivars of oilseed rape grown at different nitrogen levels.

Cultivars	N doses Kg N/ha	1999-2000			2000-2001		
		P	K	Ca	P	K	Ca
Lirawell	0	0.26a	1.57ab	1.84ef	0.24de	1.84abc	3.50 a
	60	0.16e	1.35e	1.86ef	0.31b	1.72cde	1.84 g
	120	0.12f	1.25fg	2.18cd	0.31b	1.53def	1.61 h
	180	0.17e	1.37de	3.17a	0.28bc	1.98ab	2.77 c
Semu 86/225 Na	0	0.23bc	1.33ef	1.63f	0.30bc	1.86abc	3.05 b
	60	0.21cd	1.38de	1.61f	0.37a	1.52def	2.03 f
	120	0.17e	1.49bc	1.80ef	0.30bc	1.38b	2.26 e
	180	0.12f	1.45cd	2.65b	0.30bc	1.52def	2.43 d
Westar	0	0.20d	1.42cde	2.00de	0.27cd	2.03a	3.45 a
	60	0.16e	1.16g	1.84ef	0.21e	1.96abc	2.47 d
	120	0.24ab	1.63a	2.44bc	0.22e	1.76bcd	3.06 b
	180	0.19d	1.47cd	2.17d	0.29bc	1.47ef	2.10 f
LSD (%5)		0.010	0.048	0.129	0.018	0.126	ns
F-value		36.7***	19.6***	11.6***	10.36***	4.71**	1.40ns

**Significant at p<0.01; ***Significant at p<0.001; ns= Non-significant, The F-values are from one-way ANOVA using data for the year 2000 and 2001.

Table 3. Some of micro-nutrient content (mg/kg) of three cultivars of oilseed rape grown at different nitrogen levels.

Cultivars	N doses KgN/ha	1999-2000				2000-2001			
		Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Lirawell	0	70.3de	25.5cd	9.9a	3.2bc	112.1c	25.4fg	12.4fg	3.8a
	60	64.1ef	22.2e	3.1e	3.3ab	130.6ab	30.3abc	18.6ab	3.4ab
	120	72.0cde	16.5f	8.2ab	1.6e	101.4d	32.6a	19.7a	1.5d
	180	80.3bc	22.8e	4.7cde	3.3ab	85.3ef	28.6cde	15.6cd	3.3abc
Semu 86/225 Na	0	85.0b	23.9de	6.5bc	3.0c	104.8cd	24.9g	17.2bc	3.1bc
	60	94.6a	26.3c	6.3c	3.2bc	129.3b	25.8efg	13.1efg	3.1bc
	120	71.3de	26.7c	5.2cd	3.4a	87.86e	26.5d-g	18.3ab	3.4ab
	180	70.9de	26.5c	5.3c	3.4a	76.2fg	26.9d-g	17.41b	3.4ab
Westar	0	85.8ab	34.9b	5.6c	2.7d	111.0cd	31.6ab	11.9b	2.7c
	60	59.3f	22.3e	3.4de	1.6e	66.9g	21.6h	8.2h	1.6d
	120	84.4b	45.4a	9.9a	3.2abc	139.6a	28.2cdf	13.8ef	3.2abc
	180	74.0cd	35.0b	6.4c	3.1c	107.5cd	28.8bcd	14.6de	3.1bc
LSD (%5)		4.202	0.991	0.849	0.936	4.772	1.428	0.817	0.309
F-value		16.7***	86.4***	13.3***	116.9***	6.81***	11.07***	21.37***	13.60***

***Significant at p<0.001; ns= Non-significant, The F-values are from one-way ANOVA using data for the year 2000 and 2001.

Table 4. Correlation coefficients for seed yield, protein and oil and nutrient contents of usıng data for the Year 1999-2000 and 2000-2001

	S. yield	Protein %	Oil %	P	K	Ca	Fe	Mn	Zn	Cu
S. yield	1,0000	0,5886	0,1497	-0,3589	-0,3722	-0,1040	-0,3744	0,0639	-0,2450	-0,0331*
Protein%	0,5886	1,0000	0,3014	-0,0069**	-0,0330*	-0,0081**	-0,0792	0,1402	0,0992	0,0598
Oil %	0,1497	0,3014	1,0000	-0,0054**	0,1814	0,1864	-0,1733	0,2096	-0,0301*	0,0496*
P	-0,3589	-0,0069	-0,0054	1,0000	0,3639	-0,0017	0,6049	0,2737	0,8031	0,2021
K	-0,3722	-0,0330	0,1814	0,3639	1,0000	0,6068	0,3779	0,2231	0,4364	0,1124
Ca	-0,1040	-0,0081	0,1864	-0,0017***	0,6068	1,0000	0,2200	0,0157	0,1682	0,1787
Fe	-0,3744	-0,0792	-0,1733	0,6049	0,3779	0,2200	1,0000	0,2207	0,5968	0,2743
Mn	0,0639	0,1402	0,2096	0,2737	0,2231	0,0157*	0,2207	1,0000	0,2091	0,2006
Zn	-0,2450	0,0992	-0,0301	0,8031	0,4364	0,1682	0,5968	0,2091	1,0000	0,0875
Cu	-0,0331	0,0598	0,0496	0,2021	0,1124	0,1787	0,2743	0,2006	0,0875	1,0000
Na	-0,0227	0,0183	-0,0606	0,4580	0,5136	0,4044	0,4982	-0,0720	0,6929	0,0854

*Significant; at p<0.05; **Significant; at p<0.01; ***Significant; at p<0.001.

Nutrient content: Generally, variation of nutrient content was significant between cultivars, N doses and N doses x cultivars interaction effect ($p<0.05$, $p<0.01$, $p<0.001$). High N application reduced P content in Lirawell and Semu 86/225 Na cultivars, but did not change that in Westar cultivar. There were decreases in K content in Lirawell cultivar, but no significant change in the other cultivars with N application. However, Ca increased with increasing N application in Lirawell and Semu 86/225 Na cultivars, but in Westar cultivar, there seems to be no consistence results in Ca content (Table 2).

Changes in Fe contents were not consistent with different nitrogen applications. For example, in Lirawell cultivars, Fe content increased with application of nitrogen at 180 kg/ha, but it decreased in Westar and Semu 86/225 Na cultivars with same application of nitrogen. Furthermore, in Semu 86/225 Na cultivar, Fe content increased with application of N at 120 kg/ha compared to no nitrogen application (Table 3). There were no consistence results in Mn concentration obtained with nitrogen applications.

Manganese concentration was lowered by the highest N application in Lirawell cultivar, but was increased by the same N application in Semu 86/225 Na cultivar. In Westar cultivar, there seems to be no consistent result in Mn concentration with different N application. Nitrogen applications reduced Zn concentration in Lirawell and Semu 86/225 Na cultivars but no change in Westar cultivar. Changes in Zn concentrations were not consistent in both years. There seems to be no change in Cu concentration with N application in most cases.

Correlation analysis: Correlation analysis was performed to explore the trend of associations between seed yield, protein and oil contents and individual nutrient contents shown in Table 4. The data presented that seed yield had a significantly negative correlation with the P, K, Ca, Fe, Zn and Cu in contrast had a significantly positive correlation with protein and oil contents and Mn. Protein content had a positive correlation with seed yield, oil content, Mn, Zn and Cu nutrient content, but had a negative correlation with P, K, Ca and Fe.

Oil content had a positive correlation with seed yield, protein content and K, Ca and Mn and had a negative correlation with P, Fe and Zn. Therefore, P content had a positive correlation with K, Fe, Mn, Zn and Cu content, but had a negative correlation with seed yield, protein and oil content and Ca.

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

References

Anderson, M.N., T. Heidman and F. Plauborg. 1996. The effect of drought and nitrogen on light interception, growth and yield of winter oilseed rape. *Acta Agric. Scand. Sect. B Soil Plant Sci.,* 46: 55-67.

Anonymous. 1987. *Standard Methods for the Analysis of Oils, Fats, and Derivatives*, (7th Ed.): Bleckwell Jevent Publishers: Oxford, U.K., Method 1, 123.Chemists: Arlington, VA, Method 953.33.

Anonymous. 1995. *Official Methods of Analysis*, 16th ed. Association of Official Analytical Aufhammer, W., E. Kübler and M. Bury. 1994. Nitrogen uptake and nitrogen residuals of winter oilseed rape and fallout rape. *J. Argon. Crop Sci.*, 172: 255-264.

Barlog, P. and W. Grzebisz. 2004a. Effect of timing and nitrogen fertilizer application on winter oilseed rape (*Brassica napus* L.). I. Growth dynamics and seed yield. *J. Agron. Crop Sci.*, 190: 305-313.

Behrens, T. 2002. Stickstoffeffizienz vonWinterraps (*Brassica napus* L.) in Abha¨ngigkeit von der Sorte sowie einer in Menge. In: Zeit und Form variierten Stickstoffdüngung, Cuvillier Verlag, Gottingen.

Behrens, T., W.J., Horst and F. Wiesler. 2001. Effect of rate, timing and form of nitrogen application on yield formation and nitrogen balance in oilseed rape production. In: *Plant Nutrition: Food Security and Sustainability of Agro-Ecosystems through Basic and Applied Research*. (Eds.): W.J. Horst, *et al*., Kluwer Academic Publishers, Dordrecht, pp. 800-801.

Bilsborrow, P.E., E.J. Evans and F.J. Zhao. 1993. The influence of spring nitrogen on yield, yield components and glucosinolate content of autumn-sown oilseed rape (*Brassica napus*). *J. Agric. Sci. Camb*., 120: 219-224.

Colnenne, C., J.M. Meynard, R. Reau, E.J. Justes and A. Merrien. 1998. Determination of criticle nitrogen dilution curve for winter oilseed rape. *Ann. Bot.,* 81: 311-317.

Dreccer, M.F., A.H.C.M. Schapendonk, G.A. Slafer and R. Rabbinge. 2000. Comperative response of wheat and oilseed rape to nitrogen supply: absorption and utilisation efficiency of radiation and nitrogen during the reproductive stages determining yield. *Plant Soil*, 220: 189-205.

Gammellvind, L.H., J.K. Schjöerring, V.O. Mogensen, C.R. Jensen and J.G.H. Bock. 1996. Photosynthesis in leaves and siliques of winter oilseed rape (*Brassica napus* L.). *Plant Soil,* 186: 227-236.

Kessel, B. 2000. Genetische variation und vererbung der Stickstoff- Effizienz bei Winter raps (*Brassica napus* L.). Cuvillier Verlag, Gottingen.

Leon, J. and H.C. Becker. 1995. Rapeseed—genetics. In: Physiological potentials for yield improvement of annual oil and protein crops. Blackwell Science, Berlin, Vienna, pp. 53-80.

Lickfett, T. 2001. Effects of reduced tillage intensity on soil Nmin dynamics following oilseed rape cultivation. In: *Plant Nutrition: Food Security and Sustainability of Agro-Ecosystems through Basic and Applied Research*. (Eds.): W.J. Horst *et al*., Kluwer Academic Publishers, Dordrecht, pp. 872-873.

Mason, M.G. and R.F. Brennan. 1998. Comparision of growth response and nitrogen uptake by canola and wheat following application of nitrogen fertilizer. *J. Plant Nutr*., 21(7):1483-499.

Paulmann, W.1993. Stand der Entwicklung von Hybridsorten bei Raps. *Raps*., 11: 43-46.

Rathke, G.W. 1999. Auswirkung von vorfrucht und stickstoff (N)-düngung auf die energiebilanz des winterrapsanbaus. Cuvillier Verlag, Göttingen.

Rathke, G.W. and C. Schuster. 2001. Einfluss der düngerformauf ertrag und ölgehalt von winterraps. In: Gestaltung der anbauverfahren landwirtschaftlicher kulturpflanzen. (Ed.): W. diepenbrock, Shaker verlag Aachen, berichte aus der landwirtschaftlicher, pp. 1-3.

Rathke, G.W., O. Christen and W. Diepenbrock. 2005. Effects of nitrogen source and rate on productivity and quality of winter oilseed rape (*Brassica napus* L.) grown in different crop rotations. *Field Crops Research*, 94: 103-113.

Rathke, G.-W., O. Christen and W. Diepenbrock. 2006. Welchen Beitrag leisten Vorfrucht und Stickstoffdu¨ngung fu¨r den Ertrag vonWinterraps? (with English summary). UFOP-Schriften Heft 29, Öl- und Proteinpflanzen, OIL 2005, 149-156.

Sattelmacher, B., W.J. Horst and H.C. Becker. 1994. Factors that contribute to genetic variation for nutrient efficiency of crop plants. *J. Plant Nutr. Soil Sci.,* 157: 215-224.

Scott, R.K., E.A. Ogunremi, J.D. Irvins and N.J. Mendham. 1973. The effect of fertilizers and harvest date by growth and yield of oilseed rape sown in autumn and spring. *J. Agric. Sci. Camb.,* 81: 287-293.

Sidlauskas, G. and S. Bernotas. 2003. Some factors affecting seed yield of spring oilseed rape (*Brassica napus* L.). *Agron. Res.,* 1(2): 229-243.

Sieling, K., O. Christen, B. Nemati and H. Hanus. 1997. Effect of previous cropping on seed yield and yield components of oilseed rape (*Brassica napus* L.). *Eur. J. Argon.,* 6: 215-223.

Snowdon, R.J. and W. Friedt. 2004. Molecular markers in Brassica oilseed breeding: current status and future possibilities. *Plant Breed.,* 123: 1-8.

(Received for publication 7 December 2007)