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Seed Yield, Quality and Plant Characteristics Changes of Rocket Salad (*Eruca sativa* Mill.) under Different Nitrogen Sources and Vegetation Periods

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Abstract: Rocket salad is an ancient, under-utilized crop, which is either gathered from the wild or cultivated mainly as a leaf vegetable and oil crop in several European and Near East countries. The economic potential of rocket salad is steadily increasing in recent years. In this research effects of three sowing dates (1st day of November, January and March, 2002) and three nitrogen sources on plant height, number of branches per plant, number of siliqua per plant, number of seeds per siliqua, siliqua length (cm), 1000 seed weight (g), seed yield (kg/ha), and final germination (%) were determined. Results revealed that sowing dates statistically influenced on plant height, number of branches per plant, siliqua length, 1000 seed weight and seed yield, while nitrogen sources statistically influenced on the number of branches per plant, number of siliqua per plant, number of seeds per siliqua and seed yield. In general early sowings resulted higher seed yields than late sowing and also calcium nitrate application showed a higher seed yield comparable to organic manure and ammonium sulfate treatments. The highest seed yield obtained from November sowing (1364,4 kg/ha) and Calcium nitrate (1168,9 kg/ha) treatment.

Key words: *Eruca sativa* L., nitrogen sources, vegetation period, seed yield, seed quality

Farklı Azot Kaynakları ve Vegetasyon Dönemleri Altında Rokanın (*Eruca sativa* Mill.) Tohum Verimi, Kalite ve Bitki Özelliklerinin Değişimleri

Özet: Roka eski zamanlardan beri çeşitli Avrupa ve Yakın Doğu ülkelerinde gerek doğadan toplanan gerekse kültürü yapılan, yaprağı yenen veya yağ bitkisi olarak değerlendirilen bir ürün olarak kullanılmaktadır. Rokanın ekonomik potansiyeli son zamanlarda düzenli olarak artmaktadır. Bu araştırmada, 3 farklı tohum ekim zamanının (2002 yılı, Kasım, Ocak ve Mart aylarının 1. günü) ve 3 farklı azot kaynağının bitki boyu, bitki başına yan dal sayısı, bitki başına bakla sayısı, bakla başına tohum sayısı, bakla uzunluğu (cm), bin dane ağırlığı (g), tohum verimi (kg/ha) ve çimlenme oranı üzerine etkileri belirlenmiştir. Araştırmadan elde edilen sonuçlar, tohum ekim zamanının; bitki boyu, bitki başına yan dal sayısı, bakla uzunluğu, 1000 dane ağırlığı ve tohum verimi üzerine, farklı azot kaynaklarının ise; bitki başına yan dal sayısı, bitki başına bakla sayısı, bakla başına tohum sayısı ve tohum verimi üzerine istatistiki olarak etkili olduğunu ortaya koymuştur. Genel olarak erken tohum ekiminin geç tohum ekimine göre daha yüksek tohum verimi verdiği, kalsiyum nitrat uygulamasının ise, organik gübre ve amonyum sülfat uygulamalarına göre tohum verimini arttırdığı belirlenmiştir. En yüksek tohum verimi, Kasım ayındaki tohum ekiminden (1364,4 kg/ha) ve kalsiyum nitrat uygulamasından (1168,9 kg/ha) elde edilmiştir.

Anahtar kelimeler: *Eruca sativa* L., azot kaynakları, vejetasyon süresi, tohum verimi, tohum kalitesi

Introduction

Rocket is a circum mediterranean rural weedy species and a useful plant of steadily increasing economic potential (Padulosi, 1995). The rocket plant is referring to both *Diplotaxis tenuifolia* L. DC and the pungent form of *Eruca sativa* L. (syn. *Eruca vesicaria* L. Cav.) represents wild and cultivated rocket salad (Morales and Janick, 2002). Eruca comprises of 3 species, viz. *E. pinnatifida, E. sativa* and *E. vesicaria* (Hanelt, 2001). The distribution of these genera occurs in southern Europe, Central Asia and Mediterranean countries (Warwick et al., 2007) where they are used (either wild or cultivated) in many ways, as a condiment in salads (Kim et al., 2006), cooked vegetables, functional plants or for medicinal purposes as a stimulant, antiscorbutic, stomachic, and diuretic (Bhandari and Chandel, 1997). Rocket is an ancient under-utilized crop, which is consumed either by gathering from the wild or cultivated mainly as a leaf vegetable in several European and Near Eastern countries (Eşiyok, 1997; Pimpini and Enzo, 1997; Yaniv, 1997, Bozokalfa et al., 2011). In Turkey, rocket is generally grown for fresh consumption in the Southern and Western parts of Anatolia (Bozokalfa et al., 2009). It is also grown as an oil plant in India, Pakistan and China. The oil used for as human nutrition, medicinal and cosmetic properties, as lamp oil, as a lubricant (Yaniv, 1997; Warwick et al., 2007).

Rocket is directly seeded in the most of Mediterranean countries and Turkey. During cultivation, soil type, fertilizer applications, environmental conditions and vegetation period exert an overall effect on plant growth. In addition to environmental conditions during seed formation and maturation have remarkable effects on subsequent seed germination and dormancy (Gutterman, 1992; Wulff, 1995; Perez-Garcia, 1997).

The rocket plant was grown on a range of soil types and deficit in N for maximum seed yield production. Sowing date may play an important role in determining seed yield in winter condition. Particularly continued very low temperatures inhibit seed germination and emergence, decreased plant growth and increased plant vegetation period. Direct seeding method is commonly used for fresh leaf and seed production and most of N fertilizer is applied near or at the sowing of the seed. Leafy vegetables required considerable high amount of N fertilizer most often it enhances the accumulation of nitrates in their edible parts (Wierdak, 2009). Therefore, adequate use of N fertilizers is required for optimum economic yield (Mason and Brennan, 1998) and 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 (LAI), and the number and weight of pods and seeds per plant in oil seed rape (Allen and Morgan, 1972). Furthermore N fertilizer operates gradually due to their chemical composition (Rathke et al., 2006) and N is applied as mineral fertilizer rather than organic fertilizer while some farmers prefer to use organic manure as N sources for lower input costs. In addition organic manure can increase soil biological activities and the use of organic manure instead of inorganic fertilizer can result in equal or even higher yield in maize (McKyes et al., 1986; McLaughlin et al., 2000)

In this study, the effects of several nitrogen sources and sowing dates on seed yield and quality of rocket (*Eruca sativa* Mill.) were investigated.

Materials and Methods

A field experiment and seed quality tests were conducted at the Ege University, Faculty of Agriculture, Department of Horticulture in Bornova (Izmir province), Turkey. Rocket seeds were sown directly in open field condition with one month intervals on 1st day of November, February and March, 2002 which have recommended and widely apply sowing period to obtain maximum seed yield in Aegean Region, in Turkey (Table 1.). Three different nitrogen forms as manure (100 tons/ha), calcium nitrate [$Ca(NO_3)_2$ 15,5% N] (1,5 tons/ha), and ammonium sulphate [$(NH_4)_2SO_4$ 21% N] with 1,5 tons/ha were applied at the time of sowing. In addition 1,2 tons/ha phosphorus (43% P_2O_5) and 1,8 tons/ha (K_2SO_4 50%) were applied to the plots at the sowing time. The optimum application doses are revealed by previous research result, which is unpublished. Some chemical and physical properties of soil in an experimental location were given in table 2.

The experiment was conducted as a randomized complete block with a split plot arrangement with three replicates of 2 m^2 plot size for each treatment. The main plots were the duration of vegetation period, and the subplots were three nitrogen sources (organic manure, ammonium sulfate and calcium nitrate) and all the recommended agronomic practices were done during the growing season. Plants were harvested by hand in May and June when the color of siliqua had turned to brown, just before siliqua cracking. After drying the plants under shade, seeds were extracted by hand and blowed at laboratory seed air blower (Seedburo Equipment Co., Des Plaines, IL, USA). Plant height, number of branches per plant, number siliqua per plant were determined on twenty randomly selected plants and also siliqua length and number of seed per siliqua were determined on 30 randomly selected siliqua for each treatment. Using the plot seed yield data seed yield per hectare was calculated as kg/ha. Thousand seed weight and germination tests were carried out according to the ISTA rules (ISTA, 1996). Four replicates of 100 seeds were sown on top of two filter papers in 120 mm petri dishes and filter paper was moisturized with 4 ml of distilled water. Petri dishes were covered with stretch film to avoid moisture loss from germination media and then were kept at 20^{o}C incubator for 7 days. At the end of the germination test final germination of rocket seeds determined as a percentage according to 2mm criteria.

Data were subjected to analysis of variance (ANOVA) using SPSS software (SPSS Inc., USA). Means were compared using Fischer's protected least significant difference (LSD) test at p (0.05 level of probability.

Table 1. Sowing-harvest dates and duration of the vegetation periods

Sowing dates	Harvest dates	Vegetation periods (days)
01 November 2002	22 May 2002	203
01 February 2002	05 June 2002	126
01 March 2002	12 June 2002	104

Table 2. Some chemical and physical properties of soil in experimental location

	Depth (cm)					Depth (cm)		
Parameters	0-10	10-30	20-30		Parameters	0-10	10-20	20-30
pH	7,57	7,58	7,68	Available ($mgxkg^{-1}$)	P	9,24	8,56	4,44
Salt (%)	0,065	0,064	0,062		K	318	294	338
Org. matter (%)	1,76	1,24	1,16		Ca	4391	4591	4741
$CaCO_3$ (%)	1,81	2,12	1,34		Mg	37,12	37,76	35,12
Sand (%)	68,2	66,2	66,2		Na	20	28	21
Clay (%)	15,64	15,64	15,64		Fe	10,9	10,5	10,8
Silt (%)	16,16	18,16	18,16		Cu	11,7	7,2	13,8
Texture	Sandy loam	Sandy loam	Sandy loam		Zn	5,2	4	5
Total N (%)	0,63	0,56	0,602		Mn	37,3	34,5	39,1

Results and Discussion

The analysis of variance showed significant differences among vegetation period and the effect of the sowing time on plant growth, branching pattern and silk characteristics in rocket plant are given in table 3. Sowing dates affected plant height, number of branches per plant, siliqua length, 1000 seed weight and seed yield significantly; but did not have any significant effect on number of siliqua per plant, number of seeds per siliqua and final germination rate. A similar response was also reported by facile et al. (2010) who showed that a combined application of sulphur and nitrogen in general, did not significantly affect the number of seeds per siliqua in rocket plant.

The different nitrogen source treatments were exhibited statistically significant influence on number of branch per plant, number of siliqua per plant, number of seeds per siliqua and seed yield. But among several nitrogen sources such effects were found statistically non-significant in plant height, siliqua length, 1000 seed weight and final germination. The interaction between seed sowing dates and nitrogen sources was not statistically significant for any of the parameters evaluated. The variation in plant height is also reported by Degenhardt and Kondra (1981) and Özer (2003) who showed that delaying sowing date increased plant height in rapeseed. Late sowing date reduced plant height and the maximum plant height (94.46 cm) is obtained from the early sowing. It is mainly related to weather temperatures which is warmer temperatures may inhibit plant growth in later sowing dates in rocket plant. The study showed that main effects of sowing dates and nitrogen application were significant and the maximum number of branches per plant is obtained in February sowing (7.03) and fertilization with calcium nitrate (5.89). Number of siliqua per plant and seed number per siliqua did not vary statistically with the sowing date, whereas nitrogen source significantly affected both parameters. Nitrogen fertilization improving seed yield and protein concentration while reduce oil concentration of rapeseed (Farahbakhsh et al., 2006). Inorganic nitrogen sources resulted in higher siliqua numbers per plant and seed number per siliqua. Yadav (2002) determined the seed number per siliqua values as 28.20 seeds/siliqua for mutant taramira (*Eruca sativa* Mill.), similarly in common rocket plant cultivation.

Sowing date exhibited significant influence on siliqua length and highest siliqua length was obtained at 2.59 cm from November sowing date. Delayed sowing dates decreased seed size and reduced 1000 seed weight and seed yield. The highest 1000 seed weight (1.70 g) and seed yield (1364.4 kg/ha) was obtained in November sowing. Seed yield reduction was observed with delaying sowing dates which can be explained by lower 1000 seed weight. During the winter months particularly from December to March average air temperature was changed between 5.9^{0}C and 13.8^{0}C and those temperatures reduced plant growth rate during the cultivation period. A similar observation was stated in rapeseed (Özer et al., 1999; Degenhardt and Kondra, 1981) and explained the result of declining plant growth, leaf area and faster maturation (Mckay and Schneiter, 1990). Inorganic fertilization increased seed yield compared with organic manure and fertilization with nitrate nitrogen resulted in the highest seed yield (1168.9 kg/ha). Not only sowing dates but also nitrogen sources did not affect final germination.

Data regarding mean values obtained in the experiment for plant height and 1000 seed weight are in agreement with the results of Ilısulu (1973), who reported that plant height of ‘Izgın’ (*Eruca sativa* L.) was between 30-70 cm and 1000 seed weight is approximately 1 g. Results also show that number of siliqua per plant is a major factor to increase seed yield and early sowing date improve the number of siliqua and seed yield in rapeseed (Mendham et al., 1981). In the present research number of silica per plant was not affected by sowing date while increasing with mineral fertilizing. A similar observation was reported by Fazili et al. (2010) who indicated that S (sulphur)

Table 3. Effects of sowing date and nitrogen sources on plant characteristics and seed quality

	Treatments	Plant height (cm)	Branch number/plant	Number of siliqua/plant	Seed number/siliqua	Siliqua length (cm)	1000 seed weight (g)	Seed yield (kg/ha)	Germination (%)
Sowing Dates (A)	November	94,46	4,14	55,54	20,93	2,59	1,70	1364,4	97,11
	February	86,43	7,03	55,94	20,29	2,49	1,16	841,9	98,66
	March	73,26	4,84	47,72	20,66	2,33	1,11	750,4	96,11
	LSD $_{0.05}$	***9,76**	***1,77**	**ns**	**ns**	***0,17**	****0,23**	***102,40**	**ns**
Nitrogen Sources (B)	O. Manure	84,17	4,52	48,53	19,08	2,41	1,29	715,3	96,11
	A. Sulphate	88,17	5,60	51,06	21,23	2,45	1,34	1053,8	97,89
	C. Nitrate	84,17	5,89	59,61	21,56	2,56	1,35	1168,9	97,89
	LSD$_{0.05}$	**ns**	***0,99**	****6,68**	****2,07**	**ns**	**ns**	***102,40**	**ns**
AxB	**LSD$_{0.05}$**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**

*, ** Significant at $p \leq 0.05$ and $p \leq 0.01$ probability level, respectively.

and N (nitrogen) fertilization improved lower seed yield of oilseed crop in case of *E. sativa* Mill. (Taramira).

According to our results, sowing dates and different nitrogen sources are effective on rocket salad seed yield, some plant characteristics and seed quality parameters. Early sowing resulted longer vegetation periods and better-developed plants, and consequently better seed yield. Using nitrogen in nitrate form did not increase the plant height, but the number of branches per plant, number of siliqua per plant and number of seeds per siliqua increased, which consequently increased the seed yield.

As a conclusion, to get high seed yield in rocket salad, early sowing dates and also calcium nitrate application as a nitrogen sources are recommended.

References

Allen, E.J. and Morgan, D.G. 1972. A quantitative analysis of the effects of nitrogen on the growth development and yield of oilseed rape. J. Agric. Sci. Camb. 78, 315- 324.

Bhandari, D.C. and Chandel, K.P.S. 1997. Status of rocket germplasm in India: research accomplishment and priorities. In: Padulosi S. and Pignone D. (eds), Rocket: a Mediterranean crop for the world. Report of a workshop, 13-14 December 1996, Legnaro (Padova), Italy. IPGRI, Rome, Italy. pp 67-75.

Bozokalfa, M.K., Yağmur B., İlbi, H., Eşiyok, D. and Kavak, S. 2009. Genetic variability for mineral concentration of *Eruca sativa* L. and Diplptaxis tenuifolia L. accessions. Crop Breed. App. Biotech. 9, 375-381.

Bozokalfa, M.K., Eşiyok, D., İlbi, H., Kavak, S. and Kaygısız Aşçıoğul, T. 2011. Evaluation of phenotypic diversity and geographical variation of cultivated (*Eruca sativa* L.) and wild (*Diplotaxis tenuifolia* L.) rocket plant. Plant Gen. Resour. Charac Util. 9(3), 454-463.

Degenhardt, D.F. and Kondra, Z.P. 1981. The influence of seeding date and seeding rate on seed yield and yield components of five genotypes of *Brassica napus*. Can. J. Plant Sci. 61, 175-183.

Eşiyok, D. 1997. Marketing and utilization of rocket in Turkey. In: Padulosi S. and Pignone D. (eds), Rocket: a Mediterranean crop for the world. Report of a workshop, 13-14 December 1996, Legnaro (Padova), Italy. IPGRI, Rome, Italy, pp. 86-90.

Farahbakhsh, I., Pakgohar N. and Karimi, A. 2006. Effects of nitrogen and sulfur fertilizers on yield, yield components and oil content of oilseed rape (*Brassica napus* L.). Asian J. Plant Sci. 5:112–115.

Fazili, I.S., Masoodi, M., Ahmad, S., Jamal, A., Khan, J.S. and Abdin, M.Z. 2010. Interactive effect of sulfur and nitrogen on growth and yield attributes of oilseed crops (*Brassica campestris* L. and *Eruca sativa* Mill.) Differing in Yield Potential. J. Plant Nutr. 33:1216-1228

Gutterman, Y. 1992. Maturation dates affecting the germinability of *Lactuca serriola* L. achenes collected from a natural population in Negev highlands. Germination under constant temperatures. J. Arid Environ. 22:353-362

Hanelt, P. (ed) (2001) Mansfeld's Encyclopedia of Agricultural and Horticultural Crops. Springer.

Ilısulu, K. 1973. Yağ bitkileri ve ıslahı. Beyoğlu-İstanbul Çağlayan Kitabevi, 312-320. (In Turkish)

ISTA, 1996. International Rules for Seed Testing. Seed Science and Technology, vol. 24, Supplement, Rules.

Kim, S.J., Kawaharada, C. and Ishii, G. 2006. Effect of ammonium nitrate nutrient ratio on nitrate and glucosinolate contents of hydroponically-grown rocket salad (*Eruca sativa* Mill.). Soil Sci. Plant Nutr. 52,387–393.

Mason, M.G. and Brennan, R.F. 1998. Comparison of growth response and nitrogen uptake by canola and wheat following application of nitrogen fertilizer. J. Plant Nutr. 21 (7), 1483–1499.

Mendham, N.J., Shipway, P.A. and Scott, R.K. 1981. The effects of delayed sowing and weather on growth, development and yield of winter oil-seed rape (*Brassica napus*). J. Agric. Sci. Camb. 96, 389- 416.

McKay, K.R. and Schneiter, A.A. 1990. Response of spring canola and crambe to several dates of planting (In: 1990 Agronomy abstracts). ASA, Madison WI.

McKyes, E., Owen, G. and Kelly, J. 1986. Energy analysis model of various tillage and fertilizer treatments on corn silage production. Canadian J. Agric. Eng. 28 (2)101–105.

McLaughlin, N.B., Hiba, A., Wall, G.J. and King, D.J. 2000. Comparison of energy inputs for inorganic fertilizer and manure based corn production. Can. J. Agric. Eng. 42 (1)2.1–2.14.

Morales, M. and Janick, J. 2002. Trends in new crops and new uses. In Janick J. and Whipkey A. (ed) ASHS Press, Alexandria, VA.

Padulosi, S., 1995. The rocket genetic resources network. Report of the First meeting. 13-15 November 1994. Lisbon, Portugal. IPGRI, Rome, Italy

Perez Garcia, F. 1997. Germination of *Cistus Ladanifer* seeds, in relation to parent material. Plant Ecol. 133, 57-62.

Pimpini, F. and Enzo, M. 1997. Present status and prospects for rocket cultivation in the Veneto region. In: Padulosi S. And Pignone D.(eds), Rocket: a Mediterranean crop for the world. Report of a workshop, 13-14 December 1996, Legnaro (Padova), Italy. IPGRI, Rome, Italy. 51-66.

Rathke, G.W., Christen, O. and Diepenbrock, W. 2006. Effects of nitrogen source and rate on productivity and quality of winter oilseed rape (*Brassica napus* L.) grown in different crop rotations. Field Crop Res. 94:103-113.

Özer, H., Oral, E. and Dogru, U. 1999. Relationships between yield and yield components on currently improved spring rapeseed cultivars. Tr. J. Agric. For. 23, 603-607.

Özer H. 2003. Sowing date and nitrogen rate effects on growth, yield and yield components of two summer rapeseed cultivars. Eur. J. Argon. 19:453-463.

Warwick, S.I., Gukel, R.K., Gomez-Campo, C. and James, T. 2007. Genetic variation in *Eruca vesicaria* (L.) Cav. Pl Gen Res: Charac Util 5(3), 142-153.

Wierdak, N.R. 2009. Growth and yield of garden rocket (E*ruca sativa.* Mill.) affected by nitrogen and potassium fertilization. Acta Sci. Pol., Hortorum Cultus 8(4), 23-33.

Wulff, R.D. 1995. Environmental maternal effects on seed quality and germination. In: Kigel J and Galili G. (eds), Seed Development and

Germination. Marcel Dekker Inc., New York, pp. 491-505.

Yadav, Y.P. 2002. Siliqua mutant in taramira (*Eruca sativa* Mill.) Cruciferae Newsl. 24, 21-23.

Yaniv, Z. 1997. Traditions, uses and research on rocket in Israel. In: Padulosi S. and Pignone D.(eds), Rocket: a Mediterranean crop for the world. Report of a workshop, 13-14 December 1996, Legnaro (Padova), Italy. IPGRI, Rome, Italy, pp. 76-80.