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THE EFFECTS OF DIFFERENT NITROGEN DOSES ON YIELD AND NUTRIENT UPTAKE OF ROCKET (*ERUCA SATİVA*) PLANT

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Abstract

The present study was conducted to investigate the effects of different nitrogen doses on yield and nutrient uptake of rocket plant. The study has been carried out with three repetitions according to the experimental pattern of randomized plots in the plastic pots with the capacity of 3 kg under the greenhouse conditions. Nitrogen doses; 0 mg N kg^{-1}, 50 mg N kg^{-1}, 100 mg N kg^{-1}, 150 mg N kg^{-1}, 200 mg N kg^{-1}and were applied as $CaNO_3.4H_2O$ form. The rocket plant was harvested after 60 days of sowing and various traits like; shoot dry weight, macro- and micro-elements concentrations were determined. The results of the study have shown that the highest shoot dry weight was determined in 200 mg N kg^{-1}application with 4.45 g pot^{-1}. In addition, the highest N concentration (5.80 % N) wa sobserved in 200 mg N kg^{-1}application, P concentration in 50 mg N kg^{-1}application (0.34% P), K concentration in 100 mg N kg^{-1} application (7.01% K), Mg and Ca concentrations in 150 mg N kg^{-1} application (0.92% Mg, 1.35% Ca) were determined. Considering all treatments together, it was observed that increasing nitrogen doses increased yieldand macro and microelements concentrations of rocket plant.

Key words: *rocket, nitrogen, yield, nutrient uptake.*

INTRODUCTION

Rocket (*Eruca sativa*) is an endemic species of *Brassicaceae* family and a single year herbaceous plant. This species is widely cultivated such Mediterranean countries as Italy, Greece and Turkey in particular (Aegean, Marmara and Mediterranean regions) (Morales and Janick, 2002; Barlas et al., 2011; Baser, 2016). Fresh leaves of rocket plant have long been used in salads of Mediterranean cuisine (Başer, 2016). With the current increase in the consumption of green vegetables which are beneficial to human health, the economic potential rocket plant has steadily increased recently (Eşiyok et al., 2006).

In order for being able to harvest quality yield in plentitude in vegetable cultivation (Stewart et al., 2005), plant nutrients are emphasized in recent years (Adediran et al., 2004; Naeem et al., 2006). Plants need at least 17 plant nutritional materials or elements to achieve and demonstrate optimal growth and development (White, 2006; Gardiner and Miller, 2008; Fageria, 2009; Bolat and Kara, 2017). Nitrogen (N) is one of these nutritional materials and it is necessary for the formation of new cells in the plants. The growth rate of the plants declines due to the nitrogen deficiency. Particularly the vegetative development of the plants is negatively affected.

Leave and root systems of the plants is relatively weakened. Similarly, development of roots and particularly the branching of the roots is weakened. Flowering and fruit production rates decrease and fruits are relatively small in size (Foth, 1984; Aktaş and Ateş, 1998; Kantarcı, 2000; Boşgelmez et al., 2001; Güzel et al., 2004; Fageria, 2009; Kacar and Katkat, 2010; Bolat and Kara, 2017).

Although nitrogen is the main nutritient element, which is the most absorbed nutrient in comparison to other elements, it is one of the most deficient nutrient elements. A great part of soils on the Earth is subject to nitrogen deficiency.

The main source of nitrogen in the soil is organic materials. Proteins, amino acids, nucleic acids, enzymes, chlorophylls, ATP, ADP are among significant organic materials

including nitrogen. As a result of the gradual decomposition of the organic materials, plants can make use of the nitrogen contained in these decomposed materials.
The soils of Turkey, which are particularly deficient in organic materials, are relatively poor in terms of nitrogen (Çepel, 1996; Aktaş and Ateş, 1998; Boşgelmez et al., 2001; Güzel et al., 2004; Gardiner and Miller, 2008; McCauley et al., 2009; Bolat and Kara, 2017). For this reason, chemical fertilizers which are commonly used for preventing nutritional imbalance in plants and satisfying needs of plants for nutritional elements are mainly composed of nitrogen content (Kacar and Katkat, 2010). Nitrogen has a significant effect on the plant quality.
The conducted research has demonstrated a direct correlation between nitrogen levels and quality of the plant yield. In accordance with the increase in the nitrogen dose applied to the plants, the N concentration in the plant grain and accordingly the grain quality also demonstrate increases (Marschner, 1997). However, in recent years, it has been detected that the remaining nitrogen in the soil from the high concentration nitrogen fertilizer applications results in environmental pollution (Zand-Parsa et al., 2006; Gollany et al., 2004; Beman et al., 2005) and leads to accumulation of materials in plants detrimental to human health (Ruiz and Romero, 1999).
For this reason, the management and programming of nitrogen in vegetable cultivation are of due significance (Adiloğlu et al., 2015).
The aim of the present study is determining the effects of administering nitrogen in varying quantities, which is a relatively significant nutrient element, on the productivity of and absorption of nutrient elements by rocket plant.

MATERIALS AND METHODS

This study was conducted at greenhouses of Plant and Animal Production Department of Cumhuriyet University Sivas Vocational Collage. Experiment was conducted in randomized plots design with 3 repetitions. Experimental soils were taken from 0-30 cm soil profile of experimental fields of the department. Soils were sieved through 2 mm sieve and 3 kg air-dried soils were placed in experimental pots.
Some physical and chemical characteristics of soil are provided in Table 1. Five levels of nitrogen; 0 mg N kg^{-1}, 50 mg N kg^{-1}, 100 mg N kg^{-1}, 150 mg N kg^{-1} and 200 mg N kg^{-1} (in $CaNO_3.4H_2O$ form) were applied. Before sowing, 100 mg kg^{-1} P and 125 mg kg^{-1} K (in the form of KH_2PO_4), 2.5 mg kg^{-1}Zn (in the form of $ZnSO_4.7H_2O$) and 2.5 mg kg^{-1} Fe (in the form of Fe-EDTA) were applied to each pot as basic fertilizers.

Plant analyses

Leaf samples were taken from the rocket plants 45 days after the sowing. Vegetative parts of the plants were washed through tap water, rinsed respectively through distilled water, 0.1 N HCl solution and twice though again distilled water. They were placed over coarse filter papers and excess water over them was removed.
Plant parts were then placed in separate paper bags and dried at 65°C until a constant weight. Following the measurement of dry weights, dry samples were ground in a plant mill. About 0.2 g of ground samples were wet digested in H_2O_2-HNO_3 acid mixture in a microwave oven. Resultant slurry was then completed to 20 ml with distilled water and filtered through blue-band filter paper. Samples were then subjected to P colorimetric K, Ca, Mg, Zn, Mn, Fe and Cu readings at 882 nm (Murphy and Riley, 1962) in an AAS (Atomic Absorption Spectrophotometer) (Shimadzu AA-7000) (Kaçar and İnal, 2008). N contents were determined with Kjeldahl distillation method (Bremner, 1965).

Data assessment

Experimental results were subjected to variance analyses (ANOVA) separately in accordance with randomized plots experimental design. SPSS 22.0 Windows software was used for statistical analyses. Means were compared with Tukey's test at $P<0.05$. Correlation analysis was performed to assess the relationships between the treatments.

Table 1. Some physical and chemical properties of soil

Soil Property	Depth (0-30cm)
pH	7.26
Lime (%)	17.0
Salt (%)	0.034
Organic matter (%)	1.38
Texture	SiCL
Total N (%)	0.087
Available P (kg ha^{-1})	47.3
Available K (kg ha^{-1})	744.8
Available Fe (mg kg^{-1})	3.11
Available Mn (mg kg^{-1})	1.04
Available Zn (mg kg^{-1})	0.41
Available Cu (mg kg^{-1})	1.22

RESULTS AND DISCUSSIONS

Effects of different nitrogen treatments on dry matter production of rocket plant were investigated and results are presented in Figure 1. The greatest dry matter production (4.45 g pot^{-1}) was obtained from 200 mg N kg^{-1} treatment (Figure 1).

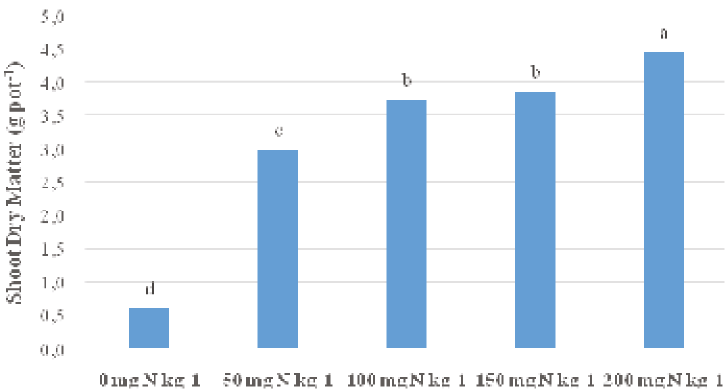

Figure 1. Effects of different nitrogen fertilizer on shoot dry matter of rocket plant

This treatment was followed by 100 mg N kg^{-1} and 150 mg N kg^{-1} treatments respectively with 3.86 g pot^{-1} and 3.75 g pot^{-1} dry matter productions which were placed in the same statistical group. The lowest dry matter production was observed in control treatment (0 mg N kg^{-1}) with 0.61 g pot^{-1}. Increasing dry matter production of rocket plants were observed with increasing N doses. Haag and Minami (1988) applied four different nitrogen doses (0, 100, 200, 300 kg ha^{-1}) to rocket plants and made harvests in June, July and August. It was reported that marketable product quantity increased from 4.4 ton ha^{-1} to 8.3 ton ha^{-1} (about doubled) with N treatments. Eşiyok et al. (1998) investigated the effects of different nitrogenous fertilizers on yield and nutrient uptake of rocket plants. Yield and nutrient uptakes varied with nitrogen doses and the greatest yield was obtained from 160 kg ha^{-1} nitrogen treatment. Researchers also reported decreasing leaf nitrogen, phosphorus, potassium and other nutrient contents with the aging of the leaves as compared to young leaves harvested at early periods. Demiral et al. (2009) investigated the effects of N treatments on plant growth and nitrate (NO_3^-) accumulation of four different winter vegetables including chard (*Beta vulgaris* cv. Chard), rocket (*Eruca sativa*), lettuce (*Lactuca sativa*) and spinach (*Spinacia oleracea*). Researchers applied three different N doses (110, 175 and 240 mg l^{-1}) to the plants in 4 replications and indicated improved plant growth with the experimental treatments. Hanaka et al. (2016) applied two different nitrate (0.3, 0.6 g N dm^{-3} of medium) and 3 different potassium (0.3, 0.6, 0.9 g K dm^{-3} of medium) doses to rocket plants and reported dry matter productions under experimental treatments as between 9.2-10.1 g.

Table 2. Effects of different nitrogen fertilizer on N, P and K concentrations of rocket plant (%)

Treatments	N	P (%)	K
0 mg N kg^{-1}	1.91 ±0.02d	0.15 ±0.01d	3.09 ±0.05e
50 mg N kg^{-1}	2.75 ±0.25c	0.34 ±0.02 a	4.40 ±0.02 d
100 mg N kg^{-1}	4.97 ±0.18 b	0.28 ±0.01 b	7.01 ±0.11 a
150 mg N kg^{-1}	5.16 ±0.04 b	0.28 ±0.03 b	6.71 ±0.04 b
200 mg N kg^{-1}	5.80 ±0.06 a	0.22 ±0.00 c	5.51 ±0.29c

$P<0.05$

Considering the effects of different nitrogen treatments on N concentration of the rocket plants, the greatest value (5.80% N) was obtained from the greatest nitrogen dose of 200 mg N kg^{-1} treatment.

Plant N concentration of the control (0 mg N kg^{-1}) treatment was 1.91% N. As it was in dry matter productions, increasing plant N concentrations were observed with increasing nitrogen doses. Similarly, Hanaka et al. (2016) also reported increasing leaf N concentrations of rocket plants with increasing N doses (especially when combined with S).

The greatest P concentration (0.34% P) was observed in 50 mg N kg^{-1} treatment and plant P concentrations decreased after this N dose. The greatest K concentration (7.01% K) was obtained from 100 mg N kg^{-1} treatment. K concentrations decreased after this dose. All nitrogen doses significantly increased % N, % P and % K concentrations of rocket plants as compared to the control treatment. Nurzyńska-Wierdak (2015) applied different nitrogen and potassium doses to rocket plants and reported % P concentrations of the plants as between 0.51-0.61% P and % K concentrations as between 5.30-6.76% K. Barlas et al. (2011) in a survey study, collected rocket plants from 30 different fields and reported %N concentrations as between 2.94-5.23% N, % P concentrations as between 0.12-0.27% P and K concentrations as between 3.99-5.98% K.

Table 3. Effects of different nitrogen fertilizer on Ca and Mg concentrations of rocket plant (%)

Treatments	Ca (%)	Mg
0 mg N kg^{-1}	0.54 ±0.02 e	0.63 ±0.03 bc
50 mg N kg^{-1}	1.08 ±0.01 c	0.88 ±0.07 ab
100 mg N kg^{-1}	1.22 ±0.03 b	0.90 ±0.03 a
150 mg N kg^{-1}	1.35 ±0.02 a	0.92 ±0.03 a
200 mg N kg^{-1}	0.93 ±0.03 d	0.59 ±0.03 c

$P<0.05$

Considering the Ca concentrations of the rocket plants, the lowest value (0.54% Ca) was obtained from the control (0 mg N kg^{-1}) treatment and the greatest value (1.35% Ca) was obtained from 150 mg N kg^{-1} treatments (Table 3). Barlas et al. (2011) reported leaf Ca concentrations of rocket plants as between 2.20-3.55% Ca. Bukhsh et al. (2007) reported the Ca concentration as 1900 µg g^{-1} Ca in seeds of rocket plants and as 700 µg g^{-1}. Ca in the leaves of rocket plants. Similar to Ca concentrations, the greatest Mg concentration (0.92% Mg) was obtained from 150 mg N kg^{-1} treatment. This treatments was followed by 100 mg N kg^{-1} treatment (0.90% Ca) which was placed in the same statistical group. In previous studies, Mg concentrations of rocket plants were reported as between 37-41 mg 100 g^{-1} (Haag and Manami, 1998) and as 46 mg 100 g^{-1} (Bianco, 1995). Eşiyok et al. (2006) reported Mg content of organic fertilizer-treated rocket plants as between 0.19-0.23% Mg.

Table 4. Effects of different nitrogen fertilizer on Fe, Zn, Mn and Cu concentrations of rocket plant

Treatments	**Fe**	**Zn** (mg kg $^{-1}$)	**Mn**	**Cu**
0 mg N kg^{-1}	73.4 ±1.31 d	10.9 ±0.48 c	26.8 ±1.05 d	4.4 ±0.04 c
50 mg N kg^{-1}	163.4 ±14.07 a	30.2 ±2.86 a	27.7 ±0.53 cd	5.5 ±0.32 b
100 mg N kg^{-1}	133.6 ±12.52 b	24.6 ±0.01 b	29.4 ±0.23 c	5.9 ±0.08 b
150 mg N kg^{-1}	151.3 ±5.23 a	24.6 ±0.10 b	35.7 ±0.21 b	6.3 ±0.16 ab
200 mg N kg^{-1}	97.6 ±1.39 c	12.1 ±0.07 c	42.9 ±2.18 a	7.1 ±0.71 a

$P<0.05$

Considering the micro element concentrations of rocket plants (Table 4), the greatest Fe concentration was obtained from 50 mg N kg^{-1} treatment (163.4 mg kg^{-1}). This treatment was followed by 150 mg N kg^{-1} (151.3 mg kg^{-1} Fe). As compared to control treatment, all nitrogen doses increased plant Fe concentrations. Zn concentrations of the rocket plants also increased with increasing nitrogen doses.

The lowest Zn concentration (10.9 mg kg^{-1} Zn) was obtained from 0 mg N kg^{-1} control treatment and the greatest Zn concentration (30.2 mg kg^{-1} Zn) was obtained from 50 mg N kg^{-1} treatment. As it was in P concentrations, Zn concentrations of rocket plants decreased after 50 mg N kg^{-1} treatments. Increasing nitrogen doses also increased Mn and Cu concentrations of the plant. The greatest Mn and Cu concentrations were obtained from 200 mg N kg^{-1} treatment. While the greatest Mn concentration was 42.9 mg kg^{-1}Mn, the greatest Cu concentration was observed as 7.1 mg kg^{-1} Cu. Bukhsh et al. (2007) reported Fe concentration of rocket plants as 60.62 µg g^{-1} Fe, Zn concentration as 56.1 µg g^{-1} Zn, Mn concentration as 19.0 µg g^{-1}Mn and Cu concentration as 32.0 µg g^{-1} Cu; reported leaf Fe concentration as 37.5 µg g^{-1} Fe, leaf Zn concentration as 1.12 µg g^{-1} Zn, leaf Mn concentration as 10.6 µg g^{-1}Mn and leaf Cu concentration as 21.0 µg g^{-1} Cu. In a survey study, Fe concentration of rocket plants was reported as 350.78 mg kg^{-1} Fe, Zn concentration as 64.86 mg kg^{-1} Zn, Mn concentration as 40.58 mg kg^{-1}Mn and Cu concentration as 5.37 mg kg^{-1} (Barlas et al., 2011).

Table 5. Correlation values of parameters evaluated in the study

Parameters	SDW***	N	P	K	Mg	Ca	Fe	Zn	Mn	Cu
SDW	1									
N	.907**	1								
P	.536*	.194	1							
K	.818**	.850**	.468	1						
Mg	.295	.197	.613*	.631*	1					
Ca	.767**	.640*	.780**	.882**	.781**	1				
Fe	.498	.188	.949**	.508	.768**	.834**	1			
Zn	.335	.029	.948**	.421	.730**	.755**	.948**	1		
Mn	.545*	.398	.138	-.015	-.468	.004	.007	-.148	1	
Cu	.913**	.891**	.293	.678**	.113	.586*	.282	.077	.661**	1

*Significant at $P<0.05$ **Significant at $P<0.01$ ***SDW=Shoot Dry Weight

Considering the correlations among investigated parameters, it was observed that SDW had significant positive correlations with N, K, Ca and Cu ($P<0.01$); there was significant positive correlation between P and Mn ($P<0.05$) (Table 5). There was significant positive correlations also between N and K, between Ca and Cu; P had positive correlations with Mg, Ca, Fe and Zn; there were positive correlations between K and Mg, between Ca and Cu; and Mg had significant positive correlations with Ca, Fe and Zn ($P<0.01$); Ca positively correlated with Fe, Zn and Cu; there were positive correlations between Fe and Zn and between Mn and Cu.

CONCLUSIONS

The present study was conducted to investigate the effects of different nitrogen doses on yield and nutrient uptake of the rocket plants.

Present findings revealed increasing dry matter productions, N, Mn and Cu concentrations of rocket plant with increasing nitrogen doses and 200 mg N kg^{-1} treatment was found to be prominent with regard to these parameters. On the other hand, 150 mg N kg^{-1} treatments were found to be prominent with regard to Ca, Mg and Fe. Considering the entire findings together, it was concluded that nitrogen treatments significantly increased dry matter yields and nutrient uptake of the rocket plant as compared to the control treatment.

Present findings revealed that nitrogenous fertilizers play a significant role in green vegetables like rockets with increasing consumptions.

REFERENCES

Adediran A.J., Taiwo B.L., Akande O.M., Sobule A.R., Idowu J.O., 2004. Application of organic and inorganic fertilizer for sustainable maize and cowpea yields in Nigeria, J. Plant Nutr., 27: 1163-81.

Adiloğlu S., Açıkgöz F.E., Adiloğlu A., 2015. The effect of increasing doses of N application on some agronomic characteristics, vitamin C, protein and mineral content of mibuna (*Brassica rapa* var. *nipposinica*) and mizuna (*Brassica rapa* var. *japonica*) plants. Ziraat Fakültesi Dergisi, Uludağ Üniversitesi, 29 (2), 1-11.

Aktas M., Ates A., 1998. Reasons and Determination of Nutritional Disorders in. Nurol Press. A.Ş.Ostim-Ankara-Turkey (in Turkish).

Barlas N.T., Irget M.E., Tepecik M., 2011. Mineral content of the rocket plant (*Eruca sativa*). Afr. J. Biotechnol., 10 (64): 14080-14082.

Başer K.H.C., 2016. Roka (*Eruca sativa* Mill.). Bağ-Bahçe (68) 26-27.

Beman J.M., Arrigo K., Matson P.M., 2005. Agricultural runoff fuels large phytoplankton blooms in vulnerable areas of the ocean, Nature, 434: 211-214.

Bianco V.V., 1995. Rocket an ancien tunder utilized vegetable crop and its potential, Rocket genetic resources network. Repot of the first meeting, 13-15 November, Libson, Resources Institue, Rome, Italy, pp: 35-37.

Bolat İ., Kara Ö., 2017. Plant Nutrient Elements: Sources, Functions, Toxicity and Disorders. Journal of Bartin Faculty of Forestry, 19 (1), 218-228 (in Turkish).

Boşgelmez A., Boşgelmez İ.İ., Savaşçı S., Paslı N., 2001. Ecology - II (Soil), Baskent Klise Press., Kızılay-Ankara/Turkey (in Turkish).

Bremner J.M., 1965. Total nitrogen. Methods of soil analysis. Part 2. Chemical and microbio-logical properties. (methods of soil anb), 1149-1178.

Bukhsh E., Malik S.A., Ahmad S.S., 2007. Estimation of nutritional value and trace elements content of C*arthamus oxyacantha, Eruca sativa* and *Plantago ovata.* Pak. J. Bot., 39 (4): 1181-1187.

Çepel N., 1996. Toprakilmi. İÜ Yayın No 3945, Orman Fakültesi Yayın No: 438. İstanbul.

Demiral M.A., Ay M., Soral F., Tekin M., 2009. Effect of nitrogen on growth and nitrate accumulation of some leafy vegetables. ADÜ Ziraat Fakültesi Dergisi, 6 (2): 3-7.

Eşiyok D., Oktay M., Yağmur B., 1998. Farklı azot seviyelerinin rokanın topraktan kaldırmış olduğu besin maddeleri ve verimi üzerine etkisi. 2. Sebze Tarımı Sempozyumu, 28-30 Eylül, Tokat, 240-248.

Eşiyok D., Ongun A.R., Bozokalfa K., Tepecik M., Okur B., Kaygısız T., 2006. Organik Roka Yetiştiriciliği. VI. Sebze Tarımı Sempozyumu. Eylül 2006. Kahramanmaraş.

Fageria N.K., 2009. The Use of Nutrients in Crop Plants. CRC Pres, Boca Raton, Florida, New York.

Foth H.D., 1984. Fundamentals of Soil Science. 7th Edition, John Wiley and Sons, New York.

Gardiner D.T., Miller R.W., 2008. Soils in Our Environment. 11th Edition, Pearson/Prentice Hall, Upper Saddle Hill, New Jersey, USA.

Gollany H.T., Molina J.E., Clapp C.E., Allmaras R.R., Layese M.F., Baker J.M., Cheng H.H., 2004. Nitrogen leaching and denitrification in continuous corn as related to residue management and nitrogen fertilization, Environmental Management, 33: 289-298.

Güzel N., Gülüt K.Y., Büyük G., 2004. Soil Fertility and Fertilizer. Cukurova University, Agricultural Faculty Publish Nr: 246, Lecture Book Nr: A-80, Adana/Turkey (in Turkish).

Haag H.P.,Minami K., 1988. Nutriçao mineral de hortilicas. LXXVII. Demanda de Nutrient spor de Rucula, Annl. Esc. Sup. Agric. Luiz de querioz Piracicaba, Vol:45 (2): 589-595.

Hanaka A., Dresler S., Nurzyńska-Wierdak R., 2016. Biochemical and physiological responses of Eruca Sativa Mill. To selected nutrient conditions. ActaSci. Pol. Hortorum Cultus, 15 (4): 147-160.

Kacar B., İnal A., 2008. Bitki Analizleri, Nobel Yayınları: Ankara, Turkey, p. 1241.

Kacar B.,Katkat V., 2010. Bitki Besleme. 5. Baskı, Nobel Yayın Dağıtım Tic. Ltd. Şti, Kızılay-Ankara.

Kantarcı M.D., 2000. Soil Science, Istanbul University, Soil Science and Ecology Department Press Nr: 4261, Forestry Faculty Nr: 462, 420 pp. İstanbul/Turkey (in Turkish)

Marschner H., 1997. Mineral Nutrition of Higher Plants. 2nd Edition. Academic Press, London 889 p.

McCauley A., Jones C., Jacobsen J., 2009. Nutrient Management. Nutrient management module 9 Montana State University Extension Service. Publication, 4449-9, p.1–16.

Morales M., Janick J., 2002. Arugula: A promising specialty leaf vegetable. In: Trends in New Crops and New Uses. Janick J, Whipkey A. (eds.). Alexandria, VA: ASHS Press, pp. 418-423.

Murphy J., Riley J.P., 1962. A modified single solution for the determination of phosphate in natural waters. Analtica Chemica Acta. 27, 31-36.

Naeem M., Iqbal J., Bakhsh M.A.A., 2006. Comparative study of inorganic fertilizers and organic manures on yield and yield components of mung bean (*Vigna radiata* L.), J. Agric. Soc. Sci., 2: 227-9.

Nurzyńska-Wierdak R., 2015. Nutritional and energetic value of *Eruca sativa* Mill. leaves. Acta Sci. Pol. Hortorum Cultus, 14 (4): 191-199.

Ruiz J.M., Romero L., 1999. Cucumber yield and nitrogen metabolism in response to nitrogen supply, Scientia Horticulturae, 82: 309-316.

Stewart M.W., Dibb W.D., Johnston E.A., Smyth J.T., 2005. The contribution of commercial fertilizer, Nutrients to Food Production. Agron. J., 97: 1-6.

White R.E., 2006. Principles and Practice of Soil Science: The Soil as a Natural Resource. 4th Edition, Wiley-Blackwell Scientific Publication, London, United Kingdom.

Zand-Parsa S., Sepaskhah A.R., Ronaghi A., 2006. Development and evaluation of integrated water and nitrogen model for maize, Agricultural Water Management, 81: 227-256.

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