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Full Length Research Paper

The effects of different sowing time practices on Vitamin C and mineral material content for rocket (*Eruca vesicaria subsp. sativa* (Mill))

Funda Eryilmaz Acikgoz

Greenhouse Department, Corlu Vocational College, Namik Kemal University, Corlu - Tekirdag, Turkey.
E-mail: fundaea@yahoo.com.

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Salad rocket largely differs in composition and content for antioxidants such as Vitamin C together with a significant variability of bioactive compounds. Rocket encloses the highest Vitamin C content among the Brassicaceae vegetables used for salad. The content of Vitamin C and minerals in plants is affected by seasonal factors such as sowing time and the date of harvesting. The existence of Vitamin C and mineral materials in the content of green leaved vegetables are subject to different factors. The main factors are light and temperature. The aim of this study is to determine the values of antioxidant worthy Vitamin C and mineral material for rocket on different sowing times – fall and spring – that have different light and temperature conditions. Experiments were carried out in an unheated greenhouse in fall and spring growing period in Corlu, Turkey (41°11'N, 27°49'E). Results indicated that the rocket grown in fall sowing time has the maximum Vitamin C content as 57.41 mg 100 g $^{-1}$. Moreover, N, P and K values in fall sowing time are at the highest values as 3.69, 0.30 and 3.02% respectively. For rocket; Ca, Fe, Cu, and Zn contents reached at the highest values in fall sowing time; however, spring sowing time offered uppermost values for Mg and Mn contents in the research. In addition to its relatively short cultivating period, rocket has an easy growing vegetable. With its content of Vitamin C and mineral materials, it can be a good alternative crop for fall growing periods in an unheated greenhouse as well.

Key words: Rocket (*Eruca vesicaria subsp.sativa* (Mill)), different sowing time, vitamin C, mineral content.

INTRODUCTION

Increasing attention is paid to the role of diet in human health recently. Several studies indicate that a high intake of plant products is associated with a reduced risk of a number of chronic diseases and cancer (Podsedek, 2007; Gosslau and Chen, 2004; Gundgaard et al., 2003; Hashimoto et al., 2002; Kris-Etherton et al., 2002; Law and Morris, 1998; Temple, 2000; Jing et al., 2009).

The consumption of Brassica vegetables is related to human health and risk reduction of certain cancers and cardiovascular diseases (Francisco et al., 2010; Sies and Stahl, 1995; Traka and Mithen, 2009; Verhoeven, et al., 1997). Crucifers are rich in dietary antioxidants, that is, Vitamin E (tocopherol), Vitamin C, and carotenoids (Cao et al., 1996). They are also the richest source of the phytochemical glucosinolate in the human diet (Fahey et al., 2001). Moreover, mineral concentrations in crucifers present large variations depending on climate conditions (Rosa et al., 2002).

Rocket has been a very popular vegetable in 2000s. Between the years of 1926 and 2006, the number of academic papers related with rocket increased by 900% as from 2 to 20 (Anonymous, 2010).

Rocket (*Eruca vesicaria subsp.sativa* (Mill)) is a member of Brassicaceae (Cruciferae) family (Siedemann, 2005). *E. vesicaria subsp.sativa* (Mill) or commonly known as “garden rocket” is consumed as a salad vegetable in Southern Europe, forms an oilseed in India and is used for its fodder. Becoming a popular vegetable for salad in Western Europe, it is widely distributed across Southern Europe, North Africa, Western Asia and India (Dixon, 2007). Rocket remains very much valued currently in many countries of the Mediterranean region such as Italy, Greece and Turkey where it is consumed mainly in salads. It is generally sown directly in early

Table 1. Some chemical and physical characteristics of the research soil.

Depth (cm)	pH (%)	Salt (%)	Org. Mat. (%)	Total N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
0-10	7.03	0.016	1.69	0.544	8.21	291	4430	36.31	10.6	35.3	9.7	4.6
10-20	7.05	0.014	1.16	0.450	7.25	278	4480	36.73	10.2	32.4	6.9	3.8

Org. Mat.: Organic Material

winter or in early spring (FAO, 2009). It can be grown all year long, besides its fresh leaves can be consumed as salad or garniture (Esiyok, 1996; Elgin et al., 2004).

Humans necessitate Vitamin C as an essential component of any diet. Since Vitamin C exists in all green plants, it is not difficult to obtain for humans an adequate amount in their daily diet. For adults, dietary needs should be met by a minimum intake of 60 mg day^{-1} (Kim and Ishii, 2007).

Rocket contains mineral materials and Vitamin C. Salad rocket largely vary in the composition and content for antioxidants with a significant variability of bioactive compounds. Among the Brassicaceae vegetables used for salad, rocket supplies the highest Vitamin C content and it offers a considerable potential for healthy and leafy salads by its content of antioxidants (Martinez et al., 2007; Martinez et al., 2008). The content of Vitamin C and minerals in plants is under effects of seasonal factors such as light, temperature, sowing time and the date of harvesting (Kim and Ishii, 2007; Okiei et al., 2009).

Climatic conditions including light and average temperature have a strong impact on the chemical composition of horticultural crops (Klein and Perry, 1982). According to Lee and Kader (2000), temperature has influences on the composition of plant tissues during growth and development. Total available heat and the extent of low and high temperatures are the most significant factors that determine growth rate and chemical composition of horticultural crops.

Rocket is very sensitive to ecological conditions. In the conditions where the temperature is below 10°C, the germination of the seeds and plant development decelerate. In such circumstances, the aromatic material percentage rises and the quality of eating decline for the leaves that are seen as vegetable. Similarly, the development of the plants is negatively affected in summer months. Plants develop very well and high quality products can be collected in fall and spring, under conditions where temperature is not very low or very high, and in the periods when enough humidity exists in soil and air (Vural et al., 2000).

Content of Vitamin C and mineral materials depend on different factors. The main factors are light and temperature. The aim of this study is to determine the values of antioxidant worthiness for vitamin C and mineral material for rocket on different sowing times in which diverse light and temperature conditions exist.

MATERIALS AND METHODS

The research was conducted in conditions of an unheated greenhouse in Corlu, Tekirdag. The experiment was conducted according to random blocks experimental design with three repetitions. Seeds of cv. Sky Rocket (Chilternseeds Co.) used in the experiment were sown on the 1st of October for fall and on the 1st of March for spring season. Sowing was realized by scattering 2 g of seed on each 2 m^2 portion of research area (Esiyok et al., 2006).

All cultural treatments were neatly executed throughout the research. There was no need for using herbal medicines, since no disease or pest was traced. Plant samples harvested were dehydrated in drying oven on 65°C after being washed with distilled water. Then those dry samples were ground and prepared for the analysis.

In the experiment, the following characteristics were studied: Ascorbic acid (Vitamin C) in fresh samples (mg 100^{-1} g) and mineral content (%, ppm).

Ascorbic acid content of fresh samples was estimated by using titrimetric method. Nitrogen content of the plant samples was determined by Kjeldahl system; Vanadat-Molibdat phosphoric yellow color method and Eppendorf colorimeter were used for P value; Eppendorf flame photometer was read for total K and Ca values; and total Mg, Fe, Cu, Zn, and Mn values were read on Perkin Elmer 2380 atomic absorption spectrophotometer (Kacar, 1972).

The results of physical and chemical analysis for the research soil are given in Table 1; and average temperatures of the research area are presented in Table 2.

Statistical analysis

Data obtained was subject to the analysis of variance by using SPSS statistical software (v.16.0 for Windows OS) and the differences between practices were compared by using LSD test.

RESULTS AND DISCUSSION

Vitamin C

The effect of different sowing times on Vitamin C was determined as 57.41 mg 100g^{-1} for fall sowing time and found to be statistically significant (Table 3).

Cruciferous vegetables are relatively good sources of abundant antioxidants such as Vitamin C and there is a substantial and significant variation between the subspecies. Moreover, variances exist in genotype for the antioxidant phytochemicals. Vitamin C content is affected by seasonal factors such as sowing time and harvesting date (Singh et al., 2007; Kim and Ishii, 2007; Podsedek, 2007).

Table 2. Average temperature values of the unheated greenhouse.

Months	Average temperature (°C)	Maximum temperature (°C)	Minimum temperature (°C)	Average humidity (%)
October	8.2	16.9	4.6	90
November	8.9	17.0	4.5	87
December	8.0	16.2	4.1	89
January	9.5	16.2	4.1	90
February	10.0	19.0	4.1	89
March	10.2	20.1	4.2	89
April	12.7	21.4	6.3	87
May	15.0	22.1	8.1	89

Table 3. The effect of different sowing time practices on vitamin C content and yield.

Sowing time	Vitamin C (mg 100 g^{-1})	Yield (kg da^{-1})
Fall (1st October)	57.41	1250
Spring (1st March)	55.51	1100
LSD	1.06**	12.20**

**significant as $p < 0.01$

Branca (1994) and Bianco (1994) stated that *E. sativa* appeared to be rather rich in fibre, iron and particularly in Vitamin C than other leafy vegetables. Additionally, the amount of Vitamin C was determined as 110 mg 100 g^{-1} in rocket leaves and it is stated that this value was affected by sowing time and growing conditions. Esiyok et al. (2006) also found the value of Vitamin C in fall as 58.13 mg 100 g^{-1} as greater than the value of spring sowing time and therefore it is coherent with the findings of this study. Francke (2004) provides that the shorter the days and the lower the temperature, the higher the value of Vitamin C would be. In addition, this is concordant with the finding of fall sowing time in the research. According to Fraszczak (2006), the length of day has the weakest effect on the content of Vitamin C in rocket; this explains well the decline of the Vitamin C content in spring sowing.

Yield

The yield was determined as (1.25 t 0.1 ha-1 or 1250 kg da-1) for fall sowing time and found to be statistically significant (Table 3). Musnicki et al. (1999) stated that some environmental and agronomic factors might significantly change the yield.

Bianco (1994) stated that the sowing time of 10th October gave the highest yield for *E. sativa* as 1.1 t 0.1 ha^{-1} compared with the 25th September and 9th December. Francke (2004) offered that the autumn yield was, on average, 4 times higher than the yield obtained in the spring sowing. Freitas et al. (2009) also stated that after using two sowing times for rocket as June/August and September/October; as a result, the best agronomic performances of rocket were observed in the September/October planting times as 1.97 t 0.1 ha^{-1} that is similar to the findings of this research. Wierdak (2006) suggested that it was possible to cultivate garden rocket in autumn in an unheated greenhouse. This finding is in agreement with the results of the paper as well.

Mineral material content

The effect of different sowing times on mineral material content was statistically found to be significant in fall sowing time for N, P, and K values and not significant for Ca, Mg, Fe, Mn, Cu, and Zn values (Table 4).

According to Collins and McCoy (1997) and Ventrella et al. (1993); when the short biological cycles are considered, a high rate and extent of N revealed. For this research, depending on the sowing time, the highest values determined in the leaves of rocket for fall sowing time for N was 3.69, 0.30 for P and 3.02% for K. Those data were found as 3.80; 0.41 and 3.13% respectively for N, P, and K in Esiyok et al. (2006) and were relatively similar to the results of this study. Collard greens have more N, P, and K in fall than in spring; and air temperature affects N uptake by salad greens (Gent, 2002).

According to Rosa and Heaney (1996); for some *Brassica* species, exception of Ca, the contents of all minerals investigated were higher in fall sowing time than in spring sowing time and mineral contents of plants responded to environmental changes.

The results of the analysis for fall sowing time gave 1.40% Ca; 102.4 mg kg^{-1} Fe; 25.3 mg kg^{-1} Cu; 34.18 mg

Table 4. The effect of different sowing time practices on mineral material content.

Sowing time	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})
Fall(1st October)	3.69	0.30	3.02	1.40	0.13	102.4	100.2	25.3	34.18
Spring (1st March)	3.08	0.25	2.81	1.33	0.14	98.1	113.7	24.1	33.72
LSD	0.07**	0.01**	0.12**	ns	ns	ns	ns	ns	ns

ns: Not significant, ** Significant as $p < 0.01$.

kg^{-1} Zn as the highest values; spring sowing reached to the highest values for Mg as 0.14% and for Mn as 113.7 mg kg^{-1}. For fall sowing time, Esiyok et al. (2006) had found those data at highest for Ca 1.50%; Fe 113.7 mg kg^{-1}; Cu 25.5 mg kg^{-1}; Zn 44.29 mg kg^{-1} together with Mg 0.24% and Mn 123.9 mg kg^{-1} in spring and they are therefore concurrent with the data of this research.

Consequently, the content of Vitamin C, mineral materials, and yield in rocket differs depending on the main factors of light and temperature. Thus, the rocket grown in fall sowing time had the maximum vitamin C content as 57.41 mg 100 g^{-1} and N; P; and K values in fall sowing time were at their highest levels as 3.69; 0.30; and 3.02% respectively. In rocket; Ca, Fe, Cu, and Zn contents in fall sowing time; however, Mg and Mn contents reached at their greatest values in spring sowing time in the research. The yield was determined as (1.25 t 0.1 ha^{-1}) for fall sowing time. Besides its relatively short cultivating period, rocket is an easy growing and it can be a good alternative crop for fall growing periods in an unheated greenhouse for this region with its content of Vitamin C and mineral materials.

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