Effects of different growing media on seedling quality and nutrient contents in cabbage (Brassica oleraceae var. capitata L.)

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2 authors:

Halil Demir
Akdeniz University

Ersin Polat
Akdeniz University

WFL Publisher
Science and Technology
Meri-Rastilantie 3 B, FI-00980
Helsinki, Finland
e-mail: info@world-food.net

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Effects of different growing media on seedling quality and nutrient contents in cabbage (*Brassica oleraceae var. capitata* L.)

Halil Demır * and Ersin Polat

[1] *Korkuteli Vocational High School,* [2] *Department of Horticulture, Faculty of Agriculture, Akdeniz University 07800, Antalya, Turkey. *e-mail: hdemir@akdeniz.edu.tr*

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Abstract

This study was conducted with the aim of determining the effect of zeolite (clinoptilolite) on the seedling quality and plant nutrient contents of cabbage (*Brassica oleraceae var. capitata* L. cv. Brunswick). This trial was carried out in the research greenhouse located at the Seed Research and Development Center of Akdeniz University in Antalya, Turkey. Turf, clinoptilolite, perlite and various mixtures of these materials were used as growing media in this study. According to the results, clinoptilolite zeolite can be used as alternative material to perlite in the production of cabbage seedling together with turf. In the application of 30% zeolite, the growth criteria examined in cabbage seedling and the results of macro and micro element analyses were found to be similar to those of 30% perlite application. Therefore, 70% turf + 30% zeolite application is recommended as it was revealed that cabbage seedlings had a more balanced nutrition.

Key words: Zeolite (clinoptilolite), seedling, cabbage, turf, perlite.

Introduction

Use of seedlings in vegetable cultivation is quite essential. Recently, the use of high quality seedlings produced in facilities where climatic conditions are kept under control has increased [1]. While seedling production was common for vegetables such as tomato, pepper, cucumber and eggplant in the past, it has been being used for cabbage and lettuce-like vegetables in recent years.

In the production of seedling ready for planting, climatic conditions as well as seed sowing media have quite significant impacts on seedling development [2]. In vegetative production, seedling stage is an important stage that has influences on growth and development, early yield, total yield and fruit per plant. Seedling production with conventional methods causes stress in plants [3-5]. There are many kinds of materials which are used for seed sowing medium. Main characteristics desired in growing media are that they can be found easily, cheaply and abundantly, and it was also preferred that they are rich in nutrients, and have high water holding capacity and good aeration, and they must also be easy in transportation [1]. Peat is an important but expensive medium for seedling production [6]. In addition to the media of peat, perlite, vermiculite, pumice and cocopeat used in seedling production, zeolite has recently been getting a special attention.

Natural zeolites are among the minerals often used in attempts to develop new substrates for seedling production. Natural zeolites' strong sorption properties, high CEC and reach macro and micro nutrients content provide them with the advantage of being an desirable alternative to peat moss and other natural products used in the industrial production of substrates [7]. Zeolites consisting of aluminosilicate minerals are able to hold cations such as NH_4 and K [8]. Cations which are generally alkaline metals and water can be found in recesses [9] and high amounts of cations can be exchanged without causing any distortion in their structures [10]. These adsorption and ion exchange characteristics of zeolites make nutritional elements potentially beneficial in vegetative production [11].

Among more than 40 types of natural zeolites, clinoptilolite is the most common zeolite used in agricultural production [12]. In terms of ion exchange, clinoptilolite prefers large cations like NH_4^+ and K^+ to other ions [11]. Zeolite is highly economical in terms of reducing fertilizer use and preventing environmental pollution by reducing the washing of the elements [13]. Two types of peats, ready substrate, compost and enriched zeolites (Zeoplant) were evaluated for tomato and pepper seedling production. Best quality seedlings were reported to be obtained from the mixture of peat and enriched zeolites (Zeoplant), and also from the growing media mixed with enriched zeolites [5]. Tomato seedlings were grown in a medium (turf + vermiculite, 2:1) supplemented with zeolite. Stem diameter, leaf area, total dry weight and seedling index increased with increasing content of zeolite in the growing medium. Photosynthetic pigment content, photosynthetic parameters and root growth were affected at various degrees [14]. In a trial, turf, clinoptilolite and perlite media were used in different ratios for pepper seedling cultivation and recommended mixtures of 60% turf + 40% clinoptilolite, 50% turf + 25% clinoptilolite + 25% perlite and 80% turf + 20% clinoptilolite, considering seedling quality criteria such as germination ratio, seedling height, stem diameter, number of leaves and fresh weight [1]. In another study, mixtures of turf, perlite and clinoptilolite were used for tomato seedling cultivation, and 80% turf + 40% clinoptilolite mixture was recommended in terms of number of leaves and seedling height and 80% turf + 20% clinoptilolite mixture was recommended in terms of seed germination ratio, seedling height and fresh weight [15].

The present study aimed at evaluating the effect of clinoptilolite used in agriculture on the seedling quality and nutritional contents in cabbage (*Brassica oleraceae var.capitata* L. cv. Brunswick) plants.

Materials and Methods

This study was carried out in the research greenhouse located at the Seed Research and Development Center of Akdeniz University (36°53' N, 30°39' E) in Antalya ,Turkey. The plant material used in the study was seeds of *Brassica oleraceae var. capitata* L. cv Brunswick. The seeds were sown into the viols filled with various growing media, and the study ended after ~45 days, when they came into the planting size (~8 cm high). In this study which was planned with 4 replicates, 45 seeds were sown into each growing medium. In the present study, peat, perlite, natural zeolite containing clinoptilolite and their mixtures were used as seedling growing media. There were seven different growing media in the experiment (Table 1).

Table 1. Growing media in experiment.

Z	100% Zeolite
T	100% Turf
P	100% Perlite
7T+3Z	70% Turf + 30% Zeolite
7T+3P	70% Turf +30% Perlite
7T+2P+1V	70% Turf + 20% Perlite + 10% Vermiculite
7T+2Z+1V	70% Turf + 20% Zeolite +10% Vermiculite

The clinoptilolite used in the study was supplied from the mines in the mountain of Manisa-Gördes located in Aegean District of Turkey. The analysis results of peat, perlite and zeolite (clinoptilolite) are also given in Table 2.

Table 2. Analysis results of peat, perlite and zeolite (clinoptilolite) used in the study.

Components	Turf	Perlite	Zeolite (Clinoptilolite)
pH	4.8	6.0	7.4
EC (µS/cm)	695	86.0	986
Lime (%)	0.8	-	-
Humidity (%)	67	-	-
Water-Holding capacity	568	638	83
Organic mater	89	-	-
Ash (%)	11	-	-
Total N (%)	0.162	-	0.07
Available P (ppm)	121.6	0.59	1.67
Available K (ppm)	351.3	19.49	289
Available Ca (ppm)	706.5	82.5	676
Available Mg (ppm)	219.4	5.78	248.5
Available Fe (ppm)	0.775	0.695	0.01
Available Mn (ppm)	0.125	0.105	0.09
Available Zn (ppm)	0.155	0.11	0.035
Available Cu (ppm)	0.03	0.015	0.01

Seedling trays were regularly irrigated with tap water in order to maintain humidity suitable for plant growing. The cabbage seedlings were evaluated in terms of germination ratio (%), height (cm), number of leaves (number plant^{-1}), stem diameter (mm) between root collar and just below cotyledon leaves, fresh and dry weight (%) per plant. Macro- and microelement analyses of the plants that have reached planting stage were also done.

Plant samples were washed by distilled water and dried in air-forced oven at 65°C to reach constant weight. After drying; dry weight of seedlings was recorded. The seedlings were ground separately in a stainless mill to pass through 20 mesh screen and kept in clean polyethylene bags for analysis. Dried seedling samples of 0.5 g each were digested with 10 ml $HNO_3/HClO_4^{-1}$ (4:1) acid mixture on a hot plate. The samples were then heated until a clear solution was obtained. The same procedure was repeated several times. The samples were filtered and diluted to 100 ml using distilled water. Total N was measured by modified Kjeldahl method [16]; the other elements in wet-digested extracts were determined by spectrophotometry for P [17] and atomic absorption spectrophotometry for K, Ca, Mg, Fe, Cu, Zn and Mn [16].

Statistical analysis: The study was carried out according to completely randomized design as four replicates. Analysis of variance was performed using The SAS packet program and means were compared using the LSD test at $p \leq 0.01$.

Results

The effects of different media on germination of seeds (%), height (cm), stem diameter (mm), number of leaves (number plant^{-1}), fresh and dry weight (%) in seedlings are given in Table 3.

According to the results of the statistical analysis, there were significant differences at $p<0.01$ level between the media in respect of the germination ratio in seeds (%), seedling height (cm), stem diameter (mm), leaf number (number/plant), fresh and dry weight (%). Germination ratio was highest in P medium with a percentage of 87.50% followed by T (85.15%) and 7T+2P+1V (82.03%), respectively. The lowest germination ratio was also determined in 7T+3Z (66.40%) mixture.

The effect of media on seedling height was significant and the highest value was obtained from T medium (7.58 cm) and it was followed by 7T+2P+1V (7.18 cm) and 7T+2Z+1V (6.66 cm). The shortest seedlings were measured in P (1.38 cm) medium. On account of stem diameter of cabbage seedlings, the highest values were obtained from 7T+2P+1V media with a diameter of 2.82 mm and these media were followed by 7T+3Z (2.63 mm) and 7T+3P (2.63 mm) that were in the same group statistically. The lowest stem diameter was determined in P (1.43 mm) medium.

In the seedlings that have reached planting stage, the greatest leaf numbers were recorded in T (5.66 number/plant) and 7T+3Z (5.59 number/plant) and the seedlings with the lowest leaf number was from the P (2.69 number/plant) medium. The fresh weight amounts according to the media were measured to be highest in 7T+3Z (85%) and were followed by T (81%), Z (80%) and 7T+2Z+1V (80%), respectively. The lowest fresh weight was determined in P medium (77%). According to media, the highest amount of dry weight was determined in P (23%) and was followed by 7T+3P (21%) and 7T+2P+1V (21%) that were in the same group statistically. The lowest dry weight was measured in 7T+3Z (15%) mixture.

The effects of different growing media on macro element contents in cabbage seedlings are given in Table 4.

Cabbage seedlings grown in different media were analysed in respect of N (%), P (%), K (%), Ca (%) and Mg (%) contents, and there were significant differences at $p<0.01$ level. Nitrogen content was highest in Z (5.60%) medium and it was followed by P (2.58%) and 7T+3Z (2.464%) media that were in the same group statistically. The lowest contents also were found in 7T+3P (1.624) and 7T+2P+1V (1.624) mixtures. When the analysis results were evaluated in respect of P, the highest P in cabbage seedlings was

Table 3. Effects of different media on germination of seeds, and height, stem diameter, leaf number, fresh and dry weight in seedlings.

Growing media	Germination (%)	Height (cm)	Stem diameter (mm)	Leaf number (number plant^{-1})	Fresh weight (%)	Dry weight (%)
Z	72.65 f	2.77 e	1.90 c	3.48 d	80 bc	20 b
T	85.15 b	7.58 a	2.69 ab	5.66 a	81 b	19 b
P	87.50 a	1.38 f	1.43 d	2.69 e	77 d	23 a
7T+3Z	66.40 g	6.31 d	2.63 b	5.59 a	85 a	15 c
7T+3P	75.78 e	6.31 d	2.63 b	4.75 c	79 c	21 ab
7T+2P+1V	82.03 c	7.18 b	2.82 a	5.30 b	79 c	21 ab
7T+2Z+1V	76.56 d	6.66 c	2.73 ab	4.69 c	80 bc	20 b
LSD $_{1\%}$	0.2855*	0.3253*	0.1336*	0.1951*	1.5262*	2.7066*

*Different letters within columns indicate statistical differences ($p \leq 0.01$).

Table 4. The effects of different growing media on macro element contents in cabbage seedlings.

Growing media	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Z	5.600 a	0.149 c	3.101 a	2.849 b	0.829 b
T	2.016 c	0.328 a	1.162 b	2.473 c	0.516 c
P	2.580 b	0.161 c	1.700 d	3.646 a	1.124 a
7T+3Z	2.464 b	0.253 b	2.473 b	1.990 de	0.504 c
7T+3P	1.624 e	0.249 b	1.109 f	2.129 d	0.423 c
7T+2P+1V	1.624 e	0.271 b	1.471 e	2.126 d	0.493 c
7T+2Z+1V	1.820 d	0.234 b	2.334 c	1.870 e	0.452 c
LSD $_{1\%}$	0.1438*	0.0556*	0.1371*	0.1687*	0.1286*

*Different letters within columns indicate statistical differences ($p \leq 0.01$).

in T (0.328%) followed by 7T+2P+1V (0.271%), 7T+3Z (0.253%), 7T+3P (0.249%) and 7T+2Z+1V (0.234%) mixtures that were in the same group statistically. The lowest phosphorus contents were in P (0.161%) and Z (0.149%) media.

The highest potassium content was analysed in seedlings which were grown in Z medium with a ratio of 3.101% followed by T (1.162%) and 7T+3Z (2.473%) that were in the same group. The lowest potassium content was found in 7T+3P mixture with a ratio of 1.109%. While calcium content was the highest in cabbages grown in P (3.646%) media, other highest values were recorded in Z (2.849%) and T (2.473%) media and the lowest values were found in 7T+2Z+1V (1.87%) mixture. The content of Mg was the highest in P (1.124%) medium and this was followed by Z (0.829%) while other applications were in the same group statistically.

The effects of different growing media on microelement contents in cabbage seedlings are given in Table 5.

Table 5. The effects of different growing media on microelement contents in cabbage seedlings.

Growing media	Zn (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)
Z	78.30 a	75.20 d	47.60 a	4.00 b
T	37.60 b	113.30 a	27.20 d	1.80 c
P	28.80 d	80.90 c	14.80 f	5.40 a
7T+3Z	38.80 b	86.90 b	33.80 b	1.90 c
7T+3P	34.70 c	45.40 f	25.30 e	1.50 c
7T+2P+1V	34.10 c	47.20 e	28.60 c	1.60 c
7T+2Z+1V	30.00 d	113.20 a	27.40 d	1.80 c
LSD $_{1\%}$	1.2943*	0.343*	0.3011*	0.4879*

*Different letters within columns indicate statistical differences ($p \leq 0.01$).

According to the results of the statistical evaluation, there were significant differences between microelement contents that were found in cabbage seedlings grown in different media (*p<0.01*). The highest zinc content was in Z (78.30 ppm) medium while the lowest contents were recorded in 7T+2Z+1V (30.00 ppm) and P (28.80 ppm) media that were in the same group statistically. While the iron contents were the highest in T (113.30 ppm) and 7T+2Z+1V (113.20) media that were in the same group, the lowest value was found in 7T+3P (45.40 ppm) mixture. In evaluation of results for manganese, the highest value was found in Z (47.60 ppm) medium and this was followed by 7T+3Z (33.80 ppm) mixture. The lowest content was also analysed in P (14.80 ppm). Copper was the highest in P (5.40 ppm) medium and it was followed by Z (4.00 ppm) medium. These media were followed by other seedling media that were in the same group statistically.

Discussion

Since initiating vegetable production with seedlings contributes to growth, development, early and total yield [3, 5], labour and finally to economy, it is an important stage in production process. Consequently, seedling sector is becoming more important as the use of seedlings is an inseparable part of today's production processes. There have been numerous studies on different materials in seedling production and these studies are still continuing. Aside from producing quality seedlings, it is also aimed to find inexpensive materials, such as turf [6], which can be supplied easily, are rich in nutrients and have high water holding and cation exchange capacity [18]. Perlite has a very widespread use in seedling sector in Turkey, however, various studies have been carried out on alternative materials in respect of both the quality of seedlings produced and other characteristics. One of such materials is zeolite, which is found very abundantly in Turkey. Recently, the studies conducted on zeolites that have high water holding capacity and cation exchange capacity are on the rise [9, 10].

In this study, the figures obtained from zeolite (clinoptilolite) mixtures in terms of germination ratio, seedling height, seedling length and stem diameter were not the highest. The highest germination ratio among the applications was found in P (87.50%), whereas the lowest was obtained from 7T+3Z (66.40%), in which the weak development of seedlings adversely affected the seedling height. The highest seedlings were found in T medium, while the lowest ones were determined in P medium. The highest value in terms of stem diameter of seedlings was in 7T+2P+1V medium, whereas the lowest one was in Z. Owing to the high water holding and cation exchange capacity of seedlings [9, 10] while developing, the second and third highest values were obtained from 7T+2Z+1V and 7T+3Z in terms of stem diameter (Table 2). The highest value in terms of number of leaves per plant was found in 7T+3Z medium. Results obtained in terms of stem diameter and number of leaves per plant are similar to those of Demir *et al.* [1] and Sönmez *et al.* [15]. The highest value in terms of fresh weight of seedlings was found in 7T+3Z application. The lowest fresh weight was also recorded in 100% perlite medium and it was not possible to obtain seedlings in normal planting stage in this medium. The results on fresh weight conform to a study conducted on turnip in media such as clinoptilolite and turf [19].

Clinoptilolite is very efficient in quality seedling production because of its features such as ion exchange and water holding capacity. As a result of the experiment, when the plants were analysed, it was seen that the highest N and K content of seedlings were obtained from Z medium (Table 4). The zeolites are very effective in increasing the N and K in plant tissues. Particularly, clinoptilolite has a notable selectivity for cations, such as ammonium and potassium [13]. This feature has been made use of in the preparation of slow-release chemical fertilizers [20]. While the highest P content of cabbage seedlings was obtained in T, the highest Ca and Mg contents were found in P medium.

While the highest values for Zn and Mn contents of cabbage seedlings were obtained in Z, Cu content was highest in P (Table 5). It is estimated that the high micronutrient uptake of seedlings in experiment may be explained by having a high CEC value in zeolites. Zeolites are known to have a very high CEC value and stability in comparison to other materials utilized [21]. P (100% perlite) caused the contents of seedlings to increase in high amount. The highest Cu content values of cabbage plant were associated with perlite and fertilizer use together [22]. The highest Fe content was also found in T medium. Different results may be obtained from studies conducted with different zeolite types. In a study, chabazite (powder 1-3 mm) zeolite did not lead to a significant increase in the quality of lettuce, tomato and melon seedlings [23].

Conclusions

Clinoptilolite, which is a kind of zeolite, was mixed into the mentioned substrates due to its high cation exchange capacity. Turkey has in the possession of approximately 50 billion tons zeolite reserves. Zeolite has a very restricted use currently, although it can be supplied abundantly and cheaply and used as a soil regulator and a growing media without a significant preparation process. It has properties that are close to, or even superior than, perlite and other mineral plant growing substrates that are preferred due to their economical, physical and chemical properties. Zeolite is the name of a mine group and there are approximately 40 natural zeolite types. Perlite is the most widespread material that is used for vegetable seedlings in greenhouses and tunnel growing in Turkey.

According to the results of this study that was conducted in order to find an alternative material to perlite, clinoptilolite zeolite can be used in the production of cabbage seedling together with turf because the growth criteria and macro and micro-element analysis results examined on cabbage seedlings were found similar to those in 30% zeolite and 30% perlite application and it was revealed that cabbage seedling had a more balanced nutrition. Therefore, 70% turf and 30% zeolite application is recommended.

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