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Effect of Chemical Compositions of Seedling Media Prepared by Spent Mushroom Compost on Seedling Growth and Development of Kale and Broccoli

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The objective of this research was to determine the effect of chemical composition of seedling media prepared by spent mushroom compost on seedling growth and development of kale and broccoli. Spent mushroom compost (SMC), which was kept for 18 months in open field, conventional seedling medium (CSM) consisting of a mixture of decomposed farm-yard manure, sand and garden soil at a rate of 2:1:1, commercial peat (P), SMC + CSM (1:1, v/v) and SMC + P (1:1, v/v) were used. Seeds of broccoli (*Brassica oleracea* L. var. *italica* L. cv. Greenpeace F1) and kale (*Brassica oleraceae* L. var. *acephale* D.C. cv. Temel) were used. Some chemical and physical properties of different seedling media prepared by SMC were compared and their effects on days to emergence (DE), emergence percentage (EP), seedling height (SH), mean leaf area per seedling (LA) and total dry weight of seedling (DW) were determined. Correlation analyses were carried out to determine the relationships between chemical constituents of the seedling media and DE, EP, SH, LA and DW. The results revealed that SMC + P or SMC could be used as seedling media for both kale and broccoli.

Key Words: Spent mushroom compost, Kale, Broccoli, Seedling.

INTRODUCTION

Depletion of non-renewable resources such as peat and environmental deterioration arising from peat mining together with its high price in the market favoured the utilization of alternative materials as growth substrates[1]. Developing inexpensive and nutrient-rich organic media alternatives can not only eliminate environmental impacts, but it also means to reduce fertilization rates, irrigation rates and nursery costs[2].

A locally produced, renewable, contaminant free, material such as spent mushroom compost, could provide a low cost alternative to soilless media for vegetable transplant production. Spent mushroom substrate is discarded

as a waste, but also may be used as a soil amendment or potting material in agriculture, horticulture and environmental amelioration[3,4]. Some studies have been done on the use of spent mushroom substrate for this purpose[5-9].

Spent mushroom compost is a major solid waste product of the mushroom industry and is the material which remains, following the completion of growth of successive flushes of mushroom crops. The ingredients may vary among mushroom farms, but typically mushrooms are grown in a composted mixture of horse-bedded straw, wheat straw, hay, poultry manure, ground corn cobs, cotton seed hulls, brewer's grain, cottonseed meal, cocoa bean hulls and gypsum[10]. In addition to these bulk ingredients, it also contains some nutrient additives such as potash, urea and super phosphate[11].

Broccoli (*Brassica oleracea* L. var. *italica* L.) and kale are plants of the cabbage family, *Brassicaceae* (formerly *Cruciferae*). Broccoli is classified as the Italica Cultivar Group of the species *Brassica oleracea*. Broccoli is a cool season vegetable that may be grown early in the spring or late in the fall. It has a great economic importance due to its medicinal and dietetic values since ancient times. It is a high-quality vegetable for fresh use and is one of the more popular frozen vegetables. Broccoli is highly nutritious and has been deemed an anticancerous food by the American Cancer Society. This vegetable is a good source of Vitamin A, riboflavin (or vitamin B_2), calcium, phosphorous and iron[12].

Kale, known as *Brassica oleraceae* L. var. *acephale* D.C., is a leafy vegetable and is a part of the human diet all over the world. Kale is an excellent source of dietary carotenoids and has the highest concentration of lutein and β-carotene of any vegetable[13]. This type of kale grows in Southern Europe, the Black sea and Mediterranean coast. It is a main and traditional food in Turkey, especially in the Black Sea Region.

The objective of this research was to determine the effect of chemical compositions of seedling media prepared by spent mushroom compost on seedling quality of kale and broccoli.

EXPERIMENTAL

Spent mushroom compost (SMC), which was kept for 18 months in open field, conventional seedling medium (CSM) consisting a mixture of decomposed farmyard manure, sand and garden soil at a rate of 2:1:1, commercial peat (P), SMC + CSM (1:1, v/v) and SMC + P (1:1, v/v) were used in this study. CSM were regarded as the control medium. The experiment was carried out under greenhouse conditions. Seeds of kale cv. 'Temel' and broccoli cv. 'Greenpeace F1' were sown in modular seed trays containing cells (5 cm × 5 cm).

pH and electrical conductivity (EC) of seedling media were measured in a 1:10 water-soluble extract (w/v). Organic carbon (OC) was determined

after samples were ashed at 550 °C. Total nitrogen (N) in seedling media was determined by Kjeldahl method. P contents were analyzed in ash using UV-Visible spectrophotometer. Minerals (K, Ca, Mg, Fe, Mn, Zn and Cu) content of seedling media were also determined in ash by atomic absorption spectrophotometer[14]. C:N ratios were calculated. Some physical properties such as saturation, field capacity and permanent wilting point of seedling media were determined according to the methods of Demiralay[15]. Days to emergence (DE) and emergence percentage (EP) were determined as developmental parameters. Seedling height (SH), mean leaf area per seedling (LA) and total dry weight of seedling (sum of leaf, stem and root weight) (DW) were determined as growth parameters after 5 weeks of growth. Plants samples were dried at 80 °C for 48 h.

Experimental design was a completely randomized design with 15 replications. The statistical significance of obtained results was assessed with one-way Anova analysis, followed by the Duncan multiple range test. Correlation coefficients between chemical composition of the seedling media and DE, EP, SH, LA and DW were computed to test the significance of the relationships among them.

RESULTS AND DISCUSSION

Chemical and some physical properties of seedling media are presented in Table-1. Except for P, Ca, Mg and Fe contents of seedling media, significant differences were found among chemical properties of seedling media used in this study. pH values of SMC + P and P were lower than the others. The highest EC was determined in SMC and SMC + CSM, while the lowest EC was found in CSM. Total N content of SMC and SMC containing media was higher than those of P and CSM (control). Except for organic C content and C:N ratio, all investigated chemical properties of P medium were lower than those of SMC, SMC + P and SMC + CSM media (Table-1).

The present study revealed that chemical contents of mushroom compost were between 9600-10100 ppm for K, about 1.8 % for total N and 40 % for organic matter. It was reported that mushroom compost for agricultural practices should be contained at least 2000 ppm K, 0.6 % of total N and 30 % or more concentrations of organic matter[16]. Present study results were in agreement with the results mentioned above.

The analysis of variance showed that there were highly significant differences ($p < 0.01$) among investigated seedling characteristics with the exception of EP for kale. DE varied between 6.33 day in P and 12.00 day in CSM for kale. In all media, seedling was emerged in shorter time when compared with CSM media (Table-2). SH, LA and DW of seedlings obtained from SMC and SMC containing media were found to be lower than P. The EC of SMC and SMC containing media is higher than that in P (Table-1). However, correlations between EC and DE, EP, SH, LA and

TABLE-1
CHEMICAL AND PHYSICAL PROPERTIES OF SEEDLING MEDIA

	CSM	SMC	SMC + CSM	SMC + P	P
pH	8.60a**	7.50c	7.75b	7.05d	7.00d
$EC_{25°C}$ (dS m^{-1})	1.39e**	4.87a	4.31b	3.29c	2.08d
Total N (%)	0.37d**	1.52a	0.83c	1.24b	0.77c
Ash (%)	95.48a**	77.03b	86.59ab	57.82c	17.15d
Organic C (%)	2.61e**	12.65c	8.02d	24.07b	48.04a
C:N	7.05d**	8.32cd	9.66c	19.41b	62.39a
P (ppm)	600	1270	895	945	245
K (ppm)	18165b**	27160a	21080ab	2825c	3405c
Ca (ppm)	201	240	114	276	116
Mg (ppm)	155	195	200	155	180
Fe (ppm)	49	45	58	20	0
Mn (ppm)	861a**	729a	895a	452b	61c
Zn (ppm)	82c**	317a	100bc	127b	21d
Cu (ppm)	37b*	64a	38b	59ab	12c
Saturation (%)	23.50c**	84.50b	89.50ab	89.50ab	93.00a
Field capacity (%)	14.40e**	51.01c	36.01d	54.01b	55.81a
Permenant wilting point (%)	4.32e**	18.01d	27.01b	25.51c	27.91a

*Significant at 0.05 level; **Significant at 0.01 level. Values followed by the same letter are not significantly different according to Duncan's multiple range test (CSM: conventional seedling medium, SMC: spent mushroom compost, SMC + CSM (1:1), SMC + P (1:1), P: commercial peat).

TABLE-2
EFFECT OF DIFFERENT SEEDLING MEDIA ON DAYS TO EMERGENCE (DE), EMERGENCE PERCENTAGE (EP) AND SOME SEEDLING CHARACTERISTICS OF KALE

	DE (d)	EP (%)	SH (cm)	LA (cm^2)	DW (g $seedling^{-1}$)
CSM	12.00a**	83.33	9.52c**	26.25e**	0.10c**
SMC + CSM	9.00b	86.67	13.90b	55.38cd	0.20bc
SMC + P	8.67b	86.67	18.87a	94.78ab	0.39a
SMC	9.00b	90.00	15.17b	66.82bc	0.24b
P	6.33c	86.67	20.37a	118.79a	0.47a

*Significant at 0.05 level; **Significant at 0.01 level. Values followed by the same letter are not significantly different according to Duncan's multiple range test (CSM: conventional seedling medium, SMC: spent mushroom compost, SMC + CSM (1:1), SMC + P (1:1), P: commercial peat).

DW were found to be non-significant (Table-4). Ciavatta *et al.*[17] and Chong and Rinker[18] reported that high salt content limits SMCs suitability as a medium for plant growth. Higher EC values could be a limiting factor to plants sensitive to high salinity[19].

The effects of seedling media used in the study on DE and EP of broccoli were found non-significant. It was determined that seedlings obtained from P, SMC + P and SMC media were taller, had more LA and DW than SMC + CSM and control media. These media produced more quality seedlings (Table-3).

TABLE-3
EFFECT OF THE DIFFERENT SEEDLING MEDIA ON DAYS TO EMERGENCE, EMERGENCE PERCENTAGE AND SOME SEEDLING CHARACTERISTICS OF BROCCOLI

	DE (d)	EP (%)	SH (cm)	LA (cm^2)	DW (g $seedling^{-1}$)
CSM	9.67	90.00	11.89c**	41.13c*	0.17c*
SMC + CSM	9.33	90.00	13.32bc	48.72bc	0.21bc
SMC + P	9.00	96.67	17.07ab	76.59a	0.30ab
SMC	9.33	90.00	14.67abc	66.12ab	0.29ab
P	8.00	90.00	17.82a	84.66a	0.39a

*Significant at 0.05 level; **Significant at 0.01 level. Values followed by the same letter are not significantly different according to Duncan's multiple range test (CSM: conventional seedling medium, SMC: spent mushroom compost, SMC + CSM (1:1), SMC + P (1:1), P: commercial peat).

SH, LA and DW of seedlings obtained from CSM commonly used in seedling production were found to be lower than the other media in both kale and broccoli. CSM had lower saturation (23.50 %) and field capacity (14.40 %) than the other seedling media, especially P media (93.00 and 55.81 %, respectively) (Table-1).

Correlations between pH and SH, pH and LA, pH and DW, ash and SH, ash and LA, ash and DW, organic C and DE, K and SH, K and LA, K and DW, Fe and SH, Fe and LA, Fe and DW, Mn and SH, Mn and LA, Mn and DW were found to be negative and significant ($p < 0.01$). Positive and strong relationships were found between pH and DE, ash and DE, Mn and DE, organic C and SH, organic C and LA and organic C and DW. Whereas, correlations between C:N and SH, LA and DW were found to be positive and significant ($p < 0.01$), C:N showed negative significant correlations with DE. In addition, DW showed positive significant correlations with SH ($r = 0.955^{**}$) and LA (0.972^{**}). DE was also negatively correlated with SH, LA and DW (Table-4).

The physical, chemical and biological properties of SMC vary greatly depending on composting processes, cultivation techniques and weather conditions. SMC does not contain any pests or weed seeds, because of the high temperatures associated with the composting and pasteurization processes. In the present study, spent mushroom composts showed a wide

TABLE-4
CORRELATIONS BETWEEN CHEMICAL CONSTITUENTS OF THE SUBSTRATES AND DAYS TO EMERGENCE (DE), EMERGENCE PERCENTAGE (EP), SEEDLING HEIGHT (SH), LEAF AREA (LA) AND DRY WEIGHTS OF SEEDLING (DW)

	DE (d)	EP (%)	SH (cm)	LA (cm^2)	DW (g/seedling)
pH	0.697**	-0.200	-0.900**	-0.873**	-0.863**
EC	-0.186	0.059	0.076	0.054	0.003
Ash (%)	0.632**	-0.156	-0.842**	-0.840**	-0.862**
Organic C (%)	-0.645**	0.134	0.836**	0.842**	0.866**
Total N (%)	-0.316	0.114	0.408	0.397	0.366
C:N (%)	-0.573**	0.094	0.703**	0.718**	0.749**
P (ppm)	0.080	-0.160	-0.200	-0.176	-0.189
K (ppm)	0.387	-0.147	-0.688**	-0.657**	-0.679**
Ca (ppm)	0.114	-0.059	-0.019	-0.007	-0.004
Mg (ppm)	-0.210	-0.016	0.034	0.041	0.040
Fe (ppm)	0.496*	-0.043	-0.678**	-0.684**	-0.731**
Mn (ppm)	0.592**	-0.139	-0.832**	-0.831**	-0.862**
Zn (ppm)	0.101	-0.017	-0.167	-0.146	-0.175
Cu (ppm)	0.166	-0.054	-0.156	-0.164	-0.185
DE (d)	–	-0.082	-0.781**	-0.804**	-0.778**
EP (%)	-0.082	–	0.137	0.127	0.179
SH (cm)	-0.781**	0.137	–	0.977**	0.955**
LA (cm^2)	-0.804**	0.127	0.977**	–	0.972**
DW (g)	-0.778**	0.179	0.955**	0.972**	–

*Significant at the 0.05 level; **Significant at the 0.01 level.

range of physico-chemical and chemical parameters suitable for use as seedling media constituents for kale and broccoli. In Turkey, mushroom growing has developed in the last twenty years. Since such an increasing amount of waste, it can be used in preparing seedling media for different plant species, especially vegetables. As a result of the present study, it was concluded that SMC + P or SMC can be used as vegetable seedling media for both kale and broccoli.

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