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The influence of vermicompost on plant growth characteristics of cucumber (*Cucumis sativus* L.) seedlings under saline conditions

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Abstract

Graded seeds of cucumber (*Cucumis sativus* L.), cv. Ekron F_1, were individually seeded in foam trays filled with different substrates: peat compost, vermin compost and a mixture (50% to 50%) of peat compost and vermin compost. Plants were equally irrigated, but no additional nutrient elements were supplied till the second true leaves appeared. Later, a sufficient number of 40 days old seedlings were transplanted in larger plastic pots filled with vermiculite, divided in three equal groups. In the two successive weeks all plants were periodically irrigated with equal amounts of the same nutrient solution (N 150, P 40 and K 200 mg L^{-1}), but differing from each other by the quantity of NaCl (0, 20 and 50 mM) added to the nutrient solution. The relative growth rate (RGR) and its components, net assimilation rate (NAR) and leaf area ratio (LAR) were computed. The relative stem elongation rate (RSER), the relative leaf expansion rate (RLER), root to whole plant dry weight ratio (RWR), root to shoot dry weight ratio (RSR) and the respective fractions of roots, stems and leaf dry mass against total plant weight (RMF, SMF, LMF) were also calculated. A significantly higher relative growth rate (RGR) was found for young seedlings grown in vermin compost compared to commercial peat compost, during the nursery stage. The same trend of RGR was kept during the stand establishment period, but while the morphological differences still existed, the differences regarding to physiological performance of transplanted seedlings were even more significant. The physiological efficiency of transplanted seedlings was drastically reduced due to the increase of nutrient solution salinity, but still relatively higher values were recorded in case of vermin and mixture composts. Higher dry matter per plant and higher relative leaf expansion rate were found for vermin compost prior to transplanting and end of stand establishment period, but no effect was found regarding to dry mass partitioning of young cucumber seedlings.

Key words: Vermicompost, cucumber seedlings, relative growth rate, net assimilation rate, dry matter partitioning, salinity stress.

Introduction

Salinity is one of the major abiotic stresses limiting crop productivity. Overcoming salt stress problems would have a positive impact on agricultural production [8]. It is a well known fact that the successful production of vegetable crops relies on the use of high quality transplants. Because slow recovery from transplant shock may delay early yields the commercial production of vegetable transplants has to provide a fast stand establishment coupled with enhancement in one or more attributes of earliness, uniform maturity and yield quantity and quality [6].

Developing new production practices to improve the stand establishment rate of transplanted vegetable seedlings under saline stress conditions is of a great interest. Actually, there is increasing interest in the potential use of vermicomposts as plant growth media and soil amendments [3]. On the other hand vermicomposting can be an economical alternative for livestock waste management[12], in order to reduce their negative effect on underground water quality. Vermicomposts are products of a nonthermophilic bio-degradation of organic materials through interactions between earthworms and microorganisms. They provide many benefits to agricultural soil, including increased ability to retain moisture, better nutrient-holding capacity, better soil structure and higher levels of microbial activity. The process of vermicomposting tends to result in higher levels of plant-availability of most nutrients than does the conventional composting process. Meantime, vermicompost stimulates further plant growth even when the plants are already receiving optimal nutrition. The aim of the study was to investigate the effect of peat and vermin compost on growth and dry mass partitioning of cucumber seedlings under saline conditions.

Materials and Methods

The influences of substrate composition on growth parameters and dry mass partitioning of cucumber (*Cucumis sativus* L.) seedlings were estimated in experiments conducted in a plastic greenhouse in Skenderaj, Kosovo. Graded seeds of cv. Ekron F_1 were individually seeded at March 4, 2008 in foam trays, filled with different substrates: sphagnum peat compost (a commercial Klassmann product), vermin compost (locally produced) and a mixture (50% to 50%) of peat compost and vermin compost. Seeded trays were placed for 48 hours in a germination room (25°C,

95% humidity). After germination, plants were placed in a non-heated greenhouse, without temperature and humidity control. Plants were periodically and equally irrigated, but no additional nutrient elements were supplied all nursery time. Of each experimental plot 25 plants were randomly selected each of two successive harvesting times. Each time (after the first and second true leaves appearance, respectively, at 2 and 12 of April 2008) roots, stems and leaf dry matter were weighed and stem length and plant leaf area were successfully measured.

In the end of nursery period, a sufficient number of 40 days old seedlings were transplanted in larger plastic pots filled with vermiculite. The total number of transplanted seedlings was divided in three equal groups. In the following two weeks all plants were periodically irrigated with equal amounts of the same nutrient solution (N 150, P 40 and K 200 mg L^{-1}) but differing from each other by the quantity of NaCl (0, 20 and 50 mM) added to the nutrient solution. In the end of the two-week period, similarly to the end of the nursery stage, 10 plants were randomly selected and stem length and plant leaf area were measured and root, stem and leaf dry matter weighed.

Based on the primary data, the relative growth rate (RGR) and its components, net assimilation rate (NAR) and leaf area ratio (LAR) were computed [5] for each period; the nursery stage and transplanting time. The root to whole plant dry weight ratio (RWR) and root to shoot dry weight ratio (RSR) [10] and the respective fractions of roots, stems and leaf dry mass versus total plant weight (RMF, SMF, LMF) [13] were calculated. For each experimental plot, the relative stem elongation rate (RSER) and the relative leaf expansion rate (RLER) were also individually calculated. Analysis of variance was conducted for each experimental parameter and means were separated by least significant differences test (LSD) at 5% significance level.

Results and Discussion

The influence of vermin compost on seedling characteristics and dry matter partitioning: Cucumber seedlings grown in vermin compost were characterized by a better performance in terms of growth rate and final weight. At the second true leaf stage, the cucumber seedlings grown in vermin compost showed a higher dry matter compared with peat grown seedlings (Table1). The differences were statistically significant and similar with results received by Golchin *et al.* [7] testing the effect of vermin compost on pistachio seedlings.

Fifteen days after transplanting, the seedlings grown in pure vermin compost substrate or in mixture substrate (50% vermin compost + 50% peat) kept the advantage of a significantly higher dry matter weight, compared with pure peat grown seedlings. Though the seedlings dry matter was gradually decreased by the increase of nutrient solution salinity (0, 20 and 50 mM NaCl), still heavier plants compared with peat grown seedlings were recorded in case of mixture substrate and vermin compost grown seedlings. Talking about root dry matter of plants the above trend was even more visible and highly significant (Table 1). Higher leaf area per plant was recorded in case of vermin compost grown seedlings, but no difference was found between peat and vermin compost grown seedlings according to plant height. During the nursery stage, both the relative leaf expansion rate (RLER) and the relative stem elongation rate (RSER) were significantly higher for vermin compost grown seedlings. A higher RLER was also recorded after transplanting for vermin and mixed compost (Table 1), but no difference was found regarding RSER (data not shown).

These differences could be explained by assuming the presence of specific ingredients which promote the faster growth of vermin compost grown seedlings. Indeed, according to Muscolo *et al.*[11], vermicomposts are comprised of large amounts of humic substances, some of the effects of which on plant growth are similar to those of soil-applied plant growth regulators.

The way the growing substrate influences the photosynthetic products partitioning between the different plant parts, namely leaves, stems and roots, is of an utmost importance for the quality parameters of vegetable seedlings. Basically this is a question of the trade-off between biomass investment in leaves, which would increase the supply of photosynthates and in roots would stimulate the uptake of nutrients and water [13]. Practically, the substrate composition had no effect on the dry matter partitioning of cucumber seedlings. The root:whole plant dry matter ratio (RWR) and root:shoot ratio (RSR) showed the same value despite of compost type. Similar results were obtained by Huang *et al.* [8] in case of salt-treated and control (no NaCl added) cucumber seedlings. Similar results were found regarding to root, stems and leaves mass fractions (Table 2). Generally speaking, the root share was very small compared with stems and especially leaf fraction and obviously vermin compost had no effect increasing the cucumber seedling root weight.

Table 2. Dry matter partitioning of cucumber seedlings in different substrates during the nursery stage.

Substrate type	RWR	RSR	RMF	SMF	LMF
Peat	0.14	0.16	0.14	0.39	0.47
Peat+Vermicomp.	0.13	0.14	0.13	0.39	0.46
Vermicompost	0.14	0.16	0.14	0.39	0.47

RWR root:whole plant ratio, RSR root:shoot ratio, RMF root mass fraction, SMF stem mass fraction, LMF leaf mass fraction.

The influence of vermin compost on seedling growth rate: Growth intensity is an important quality parameter of vegetable seedlings. The relative growth rate (RGR) can be used as a comprehensive indicator for the evaluation of different growing conditions influence on seedling growth. A significantly higher relative growth rate (RGR) was found for cucumber seedlings grown in vermin compost compared to commercial peat compost,

Table 1. Growth parameters of cucumber seedlings in different substrates during the nursery stage and stand establishment period.

Substrate type	Nursery period				Stand establ.period		
	W	LA	RLER	RSER	W	RW	RLER
Peat	0.52[b]	70.77[b]	0.120[b]	0.057[c]	2.88[b]	0.49[c]	0.038[b]
Peat + Vermicomp.	0.54[b]	76.00[b]	0.125[b]	0.067[b]	3.27[a]	0.59[b]	0.045[a]
Vermicomp.	0.59[a]	80.53[a]	0.156[a]	0.075[a]	3.29[a]	0.70[a]	0.045[a]

W dry matter, LA leaf area, RLER relative leaf expansion rate, RSER relative stem elongation rate, RW root dry matter. Mean values, different letters indicate significant difference at $P<0.05$.

for the period between the first and second true leaf stages (Table 3). Though not statistically significant, relatively higher RGR was also recorded for both mixture and vermin compost grown seedlings after transplanting, despite the significant reduction on the relative growth rate under salinity stress conditions (Table 3). The significant increase in soil enzyme activities such as urease, phosphomonoesterase, phosphodiesterase and arylsulphatase [1], solubilization of nutrients [14] and production of growth hormones, like 1-aminocyclopropane-1-carboxylate (ACC) deaminase [4], thanks to specific chemical properties of vermicompost, seems to be a realistic explanation for these differences.

No differences were found among different types of composts on net assimilation rate (NAR) during the nursery stage, while there was a significant difference on the leaf area ratio (LAR). The vermin mixture compost provided larger values of LAR compared with peat compost. Consequently, the higher relative growth rate of vermin compost grown cucumber seedlings, up to transplanting time, was mostly due to the morphological differences (LAR) among the experimental plots. Vermin compost provides a faster expansion of plant leaf area, and consequently a higher amount of sun radiation intercepted and transformed to plant organic matter.

A slightly different view was obtained after transplanting (stand establishment period). The morphological differences still existed, but significant differences were also found regarding to physiological performance of transplanted seedlings. During that period, vermin and mixture substrate provided significantly higher values of NAR compared to peat compost (Table 3). The plants' physiological activity was drastically reduced due to the increase of nutrient solution salinity (Table 4), but still relatively higher values were recorded in case of vermin and mixture composts (Table 5). According to Azarmi *et al.* [2], application of vermicompost increased available K in the respective treatments. Obviously, a higher rate of salt tolerance due to lower accumulation of Na^+ and/or Cl^- in the leaves [8] because of increased available K^+ in the growing substrate should be the explanation for the enhanced plant physiological efficiency (NAR) of vermicompost grown cucumber seedlings during the stand establishment period.

Table 3. Relative growth rate, net assimilation rate and leaf area ratio of cucumber seedlings in different substrates during the nursery stage and stand establishment.

Substrate type	RGR (mg $g^{-1}day^{-1}$)		NAR (g $m^{-2}day^{-1}$)		LAR ($m^2 kg^{-1}$)	
	Nursery	Transpl.	Nursery	Transpl.	Nursery	Transpl.
Peat	91.5 ^{b}	69.8 ^{b}	0.013 ^{a}	0.036 ^{b}	13.04 ^{b}	7.03 ^{b}
Peat+Vermicomp.	97.4 ^{ab}	75.2 ^{a}	0.013 ^{a}	0.042 ^{a}	14.28 ^{a}	7.98 ^{a}
Vermicompost	106.4 ^{a}	75.8 ^{a}	0.014 ^{a}	0.041 ^{a}	14.64 ^{a}	7.68 ^{a}

RGR relative growth rate, NAR net assimilation rate, LAR leaf area ratio. Mean values, different letters indicate significant difference at $P<0.05$.

Table 4. Relative growth rate, net assimilation rate and leaf area ratio of cucumber seedlings in different NaCl concentrations of nutrient solution during the stand establishment period.

NaCl (mM)	RGR (mg $g^{-1}day^{-1}$)	NAR (g $m^{-2}day^{-1}$)	LAR ($m^2 kg^{-1}$)
0	78.02 ^{a}	0.044 ^{a}	6.98 ^{c}
20	72.95 ^{b}	0.039 ^{b}	7.30 ^{b}
50	69.83 ^{c}	0.036 ^{b}	8.42 ^{a}

Mean values, different letters indicate significant difference at $P<0.05$.

Table 5. Growth of cucumber seedlings in different combinations of substrate and NaCl concentration of nutrient solution during the stand establishment period.

Substrate	NaCl (mM)	W (mg pl^{-1})	RW (mg pl^{-1})	RGR (mg $g^{-1}day^{-1}$)	NAR (g $m^{-2}day^{-1}$)	LAR ($m^2 kg^{-1}$)
Peat	0	3.21^{ab}	0.57^{ab}	74.5 ^{ab}	0.041 ^{b}	6.15 ^{f}
	20	2.89^{ab}	0.45 ^{b}	70.7 ^{bc}	0.036 ^{d}	7.08 ^{e}
	50	2.55 ^{b}	0.43 ^{b}	64.2 ^{c}	0.031 ^{c}	7.88 ^{c}
Peat +	0	3.60 ^{a}	0.67^{ab}	79.9 ^{a}	0.046 ^{a}	7.63 ^{cd}
Vermicomp.	20	3.14^{ab}	0.56 ^{b}	72.7^{abc}	0.040 ^{b}	7.35 ^{de}
	50	3.06^{ab}	0.54 ^{b}	72.9^{abc}	0.039^{bc}	8.96 ^{a}
Vermicomp.	0	3.59 ^{a}	0.87 ^{a}	79.6 ^{ab}	0.045 ^{a}	7.16 ^{de}
	20	3.24^{ab}	0.65^{ab}	75.4 ^{ab}	0.041 ^{b}	7.46^{cde}
	50	3.04^{ab}	0.56 ^{b}	72.2^{abc}	0.037^{cd}	8.41 ^{b}

W plant dry matter, RW root dry matter, RGR relative growth rate, NAR net assimilation rate, LAR leaf area ratio. Mean values, different letters indicate significant difference at $P<0.05$.

Conclusions

Vermicompost is an appropriate growing media for vegetable seedling propagation, used alone, or in mixture compound with sphagnum peat. It provides a higher growth rate and higher dry matter of cucumber seedlings during the nursery period. A higher growth rate was also provided during the stand establishment time under salinity stress conditions, mostly thanks to enhanced plants' physiological efficiency.

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