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Full Length Research Paper

Effects of spent mushroom compost on quality and productivity of cucumber (*Cucumis sativus* L.) grown in greenhouses

Ersin Polat[1]*, H. İbrahim Uzun[1], Bülent Topçuoğlu[2], Kubilay Önal[2], A. Naci Onus[1] and Mehmet Karaca[1]

[1]Akdeniz University, Faculty of Agriculture, Antalya, Turkey.
[2]Akdeniz University, Vocational School of Technical Sciences Antalya, Turkey

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This study was conducted to determine the effects of spent mushroom compost (SMC), which is a waste product of mushroom processing through a year, on greenhouse cucumber growth as an organic matter source for the soil. The effects of SMC on several yield related characteristics, such as total yield, fruit width, fruit length, total soluble solids, first quality fruit yield in total yield and nutrition content of the cucumber fruit were investigated. The effects of SMC on total yield and fruit width obtained during the whole vegetation period were statistically significant. On the other hand, no significant differences were determined among the SMC treatments for the first quality fruit yield, total soluble solids and fruit length. The highest total fruit yield was obtained at 40 ton ha^{-1} and it was followed by 80 and 20 ton ha^{-1} SMC applications. The highest values of fruit width and the nitrogen contents in cucumber were found at 80 ton ha^{-1} SMC application. Based on the present study it was concluded that as an organic material source and amendment of greenhouse soil application of at least 6 months waited SMC was very effective and beneficiary for cucumber growth, productivity and recycling the spent mushroom compost.

Key words: Spent mushroom compost, soil amendment, yield, nutrition content, cucumber.

INTRODUCTION

Soil productivity and reducing crop yield have reached to considerable levels in greenhouses due to decreased organic matter contents and increased soil salinity along with overmuch use of dense fertilizers and pesticides in agriculture. In order to overcome these problems, amendment or improvement of greenhouse soil may be considered (Abak and Çelikel, 1996).

Among the effective solutions for greenhouse soil, amendment or improvement of soil structure and better crop nourishment are much emphasized approaches. In Turkey agriculture as organic material combusted farm fertilizer (manure) is the most commonly used fertilizer in order to enrich soil and better yield. Well combusted farm fertilizers usually yield better crop production. However, high quality farm fertilizers increase the cost. This fact forces the farmers to emphasize alternative methods for development of an efficient and quality soil improvement approach (Özgüven, 1998).

Mushroom composts and turf materials, which are used as soil covering, are not used more than once due to loosing their desired properties and increased maintenance cost for mushroom production. It is known that even after being used the "waste" materials namely spent mushroom compost (SMC) and turf contain rich and valuable organic materials and are convenient for recycling in different forms (Danny, 1992; Tüzel et al., 1992; Szmidt and Convay, 1995).

Several properties of mushroom composts in terms of before and after usage in mushroom production have been reported. The used compost losses half of its weight, decreases nitrogen level below 1.5%, high level porosity and has approximately 6.5 - 7.0 pH value. Also excessive salinity in soil cover was reported by different researchers. It was also noted that long term storage of

*Corresponding author. E-mail: polat@akdeniz.edu.tr.

waste compost in outdoor altered the compost physical and chemical properties. Significant decrease in salinity of compost following first 6 months was emphasized (Tüzel et al., 1992; Söchtig and Grabbe, 1995; Szmidt and Convay 1995).

Abak et al. (1992) in one of their studies declared that 11B14 bell pepper and "Demre" pepper cultivars growing in four different soil mixtures consist of waste compost alone, compost + soil (1:1) and manure + soil (1:1) provided the highest yield per/m^2 in compost + soil for 11B14 and "Demre" pepper cultivar provided the highest yield per/m^2 in waste compost.

Polat et al. (2004) reported that there were statistically significant differences among different levels of spent mushroom compost applications in terms of total yield in lettuce growing as two and four tons/da spent mushroom compost applications gave the best result in terms of total and marketable yield.

Çelikel and Çağlar (1997) conducted a study utilizing cultures in soil, without soil but volcanic tuff, peat, spent mushroom compost (SMC), that either were used for tomato production in previous years or new ones for cucumber growth. Their study revealed that higher yield and earliness were found in mixtures of volcanic tuff, peat and SMC (1:1:1) that were previously utilized for two years. The lowest yield and earliness in cucumber growth were obtained in cultures with soil.

A study of Dallon (1988) indicated that NO_3-N, K and Mg contents of SMC was considerably higher than normal greenhouse soil. The same study also showed that soluble salts and Ca content of SMC was also too high. Wisniewska and Pankiewiez (1989) found that SMC treatment in soil elevated the P, K, Ca and Mg contents in soil.

This study was conducted to determine the effects of spent mushroom compost (SMC) on cucumber (*Cucumis sativus* L.) growth as an organic matter source for greenhouse soil. The effects of SMC on several quality and quantity parameters such as yield, fruit width, fruit length, total soluble solids, nutrition content of the cucumber fruit and first quality fruit amount in total yield were studied.

MATERIALS AND METHODS

This study was conducted in a greenhouse at Faculty of Agriculture, Akdeniz University in Turkey. In the experiment cucumber plant was grown in different amounts of SMC provided from private companies dealing with mass mushroom production. Upon receiving the SMC, it was left in a mass in an open environment and kept for 6 months. Sixth months old SMC and soil samples from the greenhouse, where the cucumber plant were grown, were analyzed according to the Jackson (1962). The results of analyses showing some of the physical and chemical properties of spent mushroom compost and greenhouse soil classified in Red Mediterranean big soil group are shown in Table 1.

In summary, soil texture and $CaCO_3$ (%) were determined using a hydrometer method (Bouyoucos, 1951) and calsimeter (Çağlar, 1949), respectively. The pH of SMC and greenhouse soil was measured using a pH meter after 1:2.5 dilutions according to Grewelling and Peech (1960). Conductivity test was obtained using an E.C. meter according to Hızalan and Ünal (1966) in saturated soil. Organic matter was determined using Walkley-Black wet burning method reported in Jackson (1962); Kjeldahl method (Bremmer, 1965) was applied to determine total nitrogen content. Available phosphorous and exchangeable K, Ca, Mg and Na were measured using $NaHCO_3$ extraction (Olsen et al., 1954) and neutral ammonium acetate extraction (Pratt 1965), respectively. Finally available Fe, Cu, Zn and Mn were determined using the DTPA extraction method (Lindsay and Norwell, 1978).

Experiments were conducted using completely randomized design (CRD) with three replications. Plots were designed according to 100 - 50 x 35 cm planting distances in double rows and plot sizes were 5.25 m^2.

SMC was mixed with greenhouse soil before planting in the amount of 0 (control), 20, 40 and 80 ton ha^{-1}. The amount of SMC was calculated based on their dry weights. Fertilization of the greenhouse soil was implemented using 824 kg ha^{-1} potassium sulphate, 455 kg ha^{-1} ammonium sulphate before planting and 165 kg ha^{-1} mono ammonium phosphate and 455 kg ha^{-1} ammonium nitrate were provided in the drop irrigation system during the crop growth.

Plant material of the study was "Santana" cucumber cultivar, which is commonly grown both in spring and fall for the Mediterranean region. A total of 3820 seedlings/da were planted. Each plot had a total of 20 seedlings. Greenhouse soil was irrigated using drop irrigation system based on the field soil capacity. Common production practices were applied through out the growth.

A total of 20 harvests were performed during growing period. Total soluble solids (TSS), fruit length and width were measured in a total of 3 different harvest periods as first, middle and final harvests. Yield components such as total yield (kg m^{-2}) and first quality fruit yield (%) and monthly yield (kg m^{-2}) were determined.

Length and weight of harvested fruits, yield (kg $plant^{-1}$-kg m^{-2}), fruits per plants, monthly yield, and earliness (50% of total yield) were determined based on fruit quality classification. Total soluble solids values were measured using a hand refractometer. Variance and Least significant differences (LSD) analyzes of data were performed using MSTATC statistic program.

RESULTS AND DISCUSSION

Some of the physical and chemical properties of spent mushroom compost (SMC) and greenhouse soil are shown in Table 1. Greenhouse soil was argillaceous loam, light alcali, high level limy and reasonable level of salt. Organic matter and nitrogen contents of the greenhouse soil were in an inadequate level according to Chapman (1966). On the other hand greenhouse soil contained adequate amount of available P according to Olsen et al. (1954), high level exchangeable K, Ca, Fe, Cu, Zn and Mn according to Jackson (1962). The trace or microelements of the greenhouse soil had sufficient level. Analyses of SMC indicated that it was light acidic, rich in salt and organic matter, nitrogen and available nutrients (Table 1).

Effects of SMC on total yield (kg m^{-2}), first quality fruit amount in total yield (%), total soluble solids (%), fruit width (cm) and length (cm) are shown in Table 2. As seen in the table, the effects of SMC on total yield and fruit width were statistically significant during entire growth. On the other hand, the effects of SMC on first quality fruit yield in total yield; total soluble solids and fruit

Table 1. Some physical and chemical properties of spent mushroom compost (SMC) and greenhouse soil.

Property	SMC	Greenhouse Soil
Textured	-	Argillaceous loam
pH	6.8	7.7
EC (michos cm^{-1})	7156	331
$CaCO_3$ (%)	-	12.1
Organic matter (%)	66.6	1.17
Total N (%)	2.17	0.021
Available P (mg kg^{-1})	25	12
Changeable K (me 100 g^{-1})	1.48	1.26
Changeable Ca (me 100 g^{-1})	5.14	21.6
Changeable Mg (me 100 g^{-1})	3.16	2.04
Available Fe (mg kg^{-1})	25.3	12.7
Available Cu (mg kg^{-1})	5.75	1.01
Available Zn (mg kg^{-1})	7.74	1.04
Available Mn (mg kg^{-1})	31.76	5.33

Table 2. Influence of spent mushroom compost (SMC) on yield, fruit width, fruit length and total soluble solids in cucumber

Treatment	Total yield (kg m^{-2})	FCFA (%)	TSS (%)	Fruit width (cm)	Fruit length (cm)
Control	12.20 c	91.70	3.3	2.76 b	17.81
20 (ton ha^{-1})	13.23 b	94.02	3.3	2.76 b	17.82
40 (ton ha^{-1})	14.40 a	91.10	3.4	2.80 b	17.74
80 (ton ha^{-1})	13.30 b	90.40	3.4	2.87 a	17.81
$LSD_{5\%}$	0.744	NS	NS	0.050	NS

Control: Without SMC; FCFA: First Class Fruit Amount in total yield; TSS: Total Soluble Solids; NS: Not significant.
Values in a column followed by different letters are significantly different ($p < 0.05$).

length values were not statistically significant.

SMC treatment of 40 ton ha^{-1} provided the highest statistically significant effects and it was followed by 80 and 20 ton ha^{-1} SMC treatments, which were in the same statistical group, for the total yield ($p<0.05$). In another word the effects of all the SMC treatments were statistically significant in comparison to control for the total yield. For the fruit width the 80 ton ha^{-1} SMC treatment resulted with the highest effect ($p<0.05$). Finding of this study is in accordance with previous studies. For instance Stewart et al. (1998a) pointed out that SMC treatments positively affected crop yield and plant nutrition uptake due to reducing the volume weight, soil clod and slide layer formation, and increasing infiltration rate, water holding capacity. In another study, Li et al. (1998) found that crop yield dramatically increased in SMC and vermiculite ratio of 2 to 1 in tomato and cucumber in a comparison to that of the control. Rhodas and Olson (1995) suggested that optimum SMC was 44.8 ton ha^{-1} for many crops and they postulated that increased yield was due to the nitrogen availability which was resulted with SMC treatments.

Effects of spent mushroom compost on monthly yield (kg m^{-2}) and first quality fruit amount in total yield (%) for cucumber growth are shown in Table 3. Based on the variation analysis conducted for each month yield, there were higher yield in all the SMC treatments ($p<0.05$). This was expected since SMC leaded to rapid increase of inorganic N concentration in soil and resulted with yield increase as previously reported by Stewart et al. (1998b). However, the study showed that there were no significant differences between total yield and first quality fruit yield for March ($p<0.05$). Total yields of April and May different; however, there were not statistical significant differences between the first quality fruit amount between these months ($p<0.05$). As shown in Table 3, total yields of all the SMC treatments were higher in comparison to that of the control for April ($p<0.05$). In May, the highest total yield of 7.163 kg m^{-2} was provided in 40 ton ha^{-1} treatment of SMC and it was followed with 6.60 kg m^{-2} yield in 20 ton ha^{-1} treatment of SMC. Remarkable yield increase in May took a place following temperature in-crease and that probably enhanced the yield up. How-ever, when the

Table 3. Effects of spent mushroom compost on monthly yield (kg m^{-2}) and First Class Fruit Amount in total yield (FCFA) (%).

Treatments	Total yield (kg m^{-2})	FCFA (%)
March		
Control	1.03	96
20 (ton ha^{-1})	1.163	97
40 (ton ha^{-1})	1.163	96
80 (ton ha^{-1})	1.110	96
LSD $_{5\%}$	NS	NS
April		
Control	5.056 b	95.6
20 (ton ha^{-1})	5.663 a	94.6
40 (ton ha^{-1})	6.073 a	94.0
80 (ton ha^{-1})	6.053 a	94.0
LSD $_{5\%}$	0.5278	NS
May		
Control	6.120 c	87.6
20 (ton ha^{-1})	6.610 b	89.6
40 (ton ha^{-1})	7.163 a	88.0
80 (ton ha^{-1})	6.140 c	86.3
LSD $_{5\%}$	0.3628	NS

Control: Without SMC; NS: Not significant.
Values in a column followed by different letters are significantly different ($p < 0.05$).

Table 4. Influence of spent mushroom compost (SMC) on plant nutrition content (as dry matter) in cucumber fruit.

Treatments (ton ha^{-1})	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe mg (kg^{-1})	Zn mg (kg^{-1})	Mn mg (kg^{-1})	Cu mg (kg^{-1})
Control	3.92 b	1.257	3.75	0.11	0.24	62	52	22	7
20 (ton ha^{-1})	4.12 b	1.363	4.43	0.11	0.26	66	46	22	6
40 (ton ha^{-1})	4.09 b	1.135	3.75	0.12	0.21	61	65	19	6
80 (ton ha^{-1})	4.57 a	1.305	4.29	0.13	0.20	66	75	18	7
LSD; $_{\%5}$	0.25	NS	NS	NS	NS	NS	NS	NS	NS

Control: Without SMC; NS: Not significant.
Values in a column followed by different letters are significantly different ($p < 0.05$).

all data analyzed SMC treatment of 80 ton ha^{-1} resulted in similar yield with that of control ($p<0.05$). This was probably due to the salinity introduced with higher amount of SMC to soil in comparison to other lo-wer SMC treatments; therefore, the higher salinity within 80 ton ha^{-1} SMC treatment might have negatively affected the yield.

One of the most important findings of the present study demonstrated that higher amount salt in SMC negatively affected SMC treatments. This problem can be overwhelmed by keeping the SMC outside for longer time. However, this would enhance another problem of loosing some nutrient values of SMC. Maher (1991) indicated that keeping the SMC outside longer time 94% potassium, 33% phosphorous, 15% nitrogen were lost. Influence of spent mushroom compost (SMC) on plant nutrition contents in cucumber fruit are shown in Table 4. As seen in the table, the effects of SMC on plant nutrition contents in cucumber fruit were no statistically significant except the nitrogen ($p<0.05$). SMC treatment of 80 ton ha^{-1} provided the highest statistically significant effects in the cucumber nitrogen content; it was followed by the other SMC treatments which were in the same statistical group ($p<0.05$). It is also understood that 80 ton ha^{-1} application increased the fruit width as shown in Table 2 ($p<0.05$).

In conclusion, all of the spent mushroom compost treatments resulted in higher yield than control treatment. The highest total fruit yield was obtained at 40 ton ha^{-1} and it was followed by 80 and 20 ton ha^{-1} SMC applications ($p<0.05$). When the effects of SMC application on fruit width were investigated, the highest values were found at 80 kg ha^{-1} SMC application ($p<0.05$). Based on the present study it was concluded that as an organic material source and amendment of greenhouse soil application of at least 6 months kept SMC was very effective and beneficiary for cucumber production, quality and recycling the spent mushroom compost.

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