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Evaluation of Mineral Contents of Greenhouse Plant Wastes in Antalya Region

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This study was carried out to determine the amounts of plant wastes coming out from tomato, pepper, cucumber and eggplant greenhouses which are widely grown in Antalya region at the end of the growing season and the mineral contents of plant wastes. For this purpose, plant samples were taken from the greenhouses in which tomato, pepper, cucumber and eggplant was grown in Antalya Region and separated from stem, leaf, fruit and root to analyze N, P, K, Ca, Mg, Fe, Mn, Zn and Cu contents. The fresh and dry weights of plant samples were determined. According to results, the fresh weights of tomato, pepper, cucumber and eggplant wastes at the end of growing season were determined as 584745, 48014, 89757 and 54605 tons ha^{-1}, respectively and it was determined to be total of 777112 tons ha^{-1} of plant wastes and to be wasted 7043 tons ha^{-1} nutrients with tomato plant wastes, 832 tons ha^{-1} nutrients with pepper plant wastes, 1435 tons ha^{-1} nutrients with cucumber plant wastes and 904 ton ha^{-1} nutrients with eggplant wastes. In addition, with these plant wastes, nutrients such as N, P_2O_5 and K_2O, which are equal to 7159 tons ha^{-1} in Antalya, were lost instead of being used as fertilizer. It was determined that use of these wastes by composting enables recycling of substantial amounts of nutrients and use of these composts especially on the soils which has low organic matter content may create important advantages. However, it was concluded that significant advantages in terms of both environment and economy could be acquired by the establishment of waste collecting and composting facilities enabling the recycling of the materials named as wastes.

Key Words: Greenhouse plants (tomato, pepper, cucumber and eggplant), Plant waste, Nutrients.

INTRODUCTION

Yield increase obtained from the increase of technological developments in agricultural areas and waste amounts increasing parallel to this in such dimensions as to damage ecology. Contrary to the increase of agric-

ultural waste amounts, disposal and recovery methods for them have been tried to be applied and developed for years. Today, the recycling and recovery methods have showed rapid development, agricultural wastes are used in biogas production, as the fertilizer by composting and as fuel in the form of biomass. The transformation of the wastes from harmful and problematic substances into useful products and economic gains by these kinds of recovery methods increases the attraction of the concept of the recovery of wastes.

Today, continuous vegetable demand and severe decrease of the production areas has turned greenhouse production into the best alternative in order to use the land and other resources more efficiently. In the greenhouse production, many plants are grown under partly or completely controlled conditions in order to obtain maximum yield and quality[1]. Increasing of life standards and population has made compulsory the increase of the amount and quality of the yield obtained from unit area. In addition to this, growing crops not only in spring and summer seasons which are suitable for the production but also throughout the whole year can be considered as a solution. Therefore, greenhouse production which enables farming in the seasons that are not suitable for production becomes common every other year[2].

Greenhouse production in Turkey started[3] in Antalya in 1940s and as of 2005 greenhouse production areas in Turkey have reached[4] an area of 46934.0 ha. Antalya is one of the regions in which greenhouse production is carried out most in Turkey. According to the data of 2005, a greenhouse production area of 24096.6 ha and 49.7 % of the greenhouse production areas of Turkey are in Antalya. Vegetables grown most in these greenhouse production areas are respectively tomato (11820.2 ha), cucumber (4140.1 ha), eggplant (2196.5 ha) and pepper (1803.7 ha). Those four important greenhouse vegetables which have a substantial production potential compose 82.2 % of the greenhouse production in Antalya Region[5].

Together with the increasing vegetable production, an increase is observed in the waste quantities. Anton *et al.*[6] stated that the most important problem in greenhouse production was the produced wastes. Kaplan *et al.*[7] pointed out that annually in Kumluca Region *ca.* 57500 tons and in Antalya Region 330625 tons of plant wastes from the tomato greenhouses were thrown in the environment randomly and eliminated by burning method. Kürklü *et al.*[8] reported that annual total amount of biomass waste produced from tomato and eggplant plants in the greenhouses were determined as 111480.99 and 15870.39 tons, respectively in Antalya. Haq *et al.*[9] reported that 491 million tons of biomass were formed annually in USA.

Cheuk *et al.*[10] examined the product wastes under three categories *i.e.*, fruit wastes, plant pruning wastes and the whole plant part which was

uprooted at the end of the growing season. Also in their study, they reported that organic waste of 175 tons ha^{-1} $year^{-1}$ was produced in these greenhouses with tomato and pepper.

Sönmez *et al.*[2] reported that N, P_2O_5 and K_2O equivalent to that of 680 tons chemical fertilizers in the tomato-producing greenhouses with an area of 14275 da in Kumluca Region and in Antalya Region equivalent to that of 1910 tons of chemical fertilizers were wasted annually together with the vegetable wastes. However, they stated that it was possible to use these greenhouse plant wastes as organic fertilizer after being composted. Doran *et al.*[11] reported that the wastes of banana plant could be used in the same areas after being composted and in this way, mineral content of the plant increased.

With this study, waste amounts possible to occur in the end of growing season of tomato, cucumber, eggplant and pepper which are widely grown in the greenhouses in Antalya Region and, the mineral contents of these plant wastes were determined and some recommendations related to the evaluation possibilities of these plant wastes were made.

EXPERIMENTAL

Plant samples composing the research material were taken, in a way to represent the whole region, from 9 greenhouses (each for vegetables) where tomato, pepper, eggplant and cucumber, commonly grown vegetables in Antalya Region, are grown. Plant samples were taken together with roots at the end of the growing season of the year 2006. Plant samples taken were brought into the laboratories and then separated as the root, stem, leaves and fruits and their fresh weights were weighed. Plant samples were washed by distilled water and dried in a forced-air oven at 65 ºC to constant weight. After drying the leaf, stem and root dry weights were recorded. The leaf, stem and root samples were ground separately in a stainless mill to pass through a 20 mesh screen and kept in clean polyethylene bags for analysis. Dried plant samples (leaf, stem and root) of 0.5 g each were digested with 10 mL $HNO_3/HClO_4$ (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. Concentrations of K, Ca, Mg, Fe, Zn, Mn and Cu in the digestates were determined by using AAS[12]. Phosphorus was measured by spectrophotometry[13] and N was determined by a modified Kjeldahl procedure[12].

RESULTS AND DISCUSSION

Significant amounts of plant wastes at the end of growing season from tomato, pepper, cucumber and eggplant greenhouses, which are produced

most in Antalya, were formed. The amounts of fresh weights of plant wastes were found as a total of 49.47 tons ha^{-1} in tomato greenhouses, 26.62 tons ha^{-1} in pepper greenhouses, 21.68 tons ha^{-1} in cucumber greenhouses and 24.86 tons ha^{-1} in eggplant greenhouses. It was reported that 40-60 tons ha^{-1} $year^{-1}$ of plant wastes were formed in tomato production[14]. Di Blassi *et al.*[15] reported that 13 tons ha^{-1} (fresh weight) wastes were formed with the leaves and stem of the tomato. As a matter of fact, similar conclusions for tomato plants were obtained in this research. The fresh weights of the plant wastes differentiate from each other due to the organs (Fig. 1).

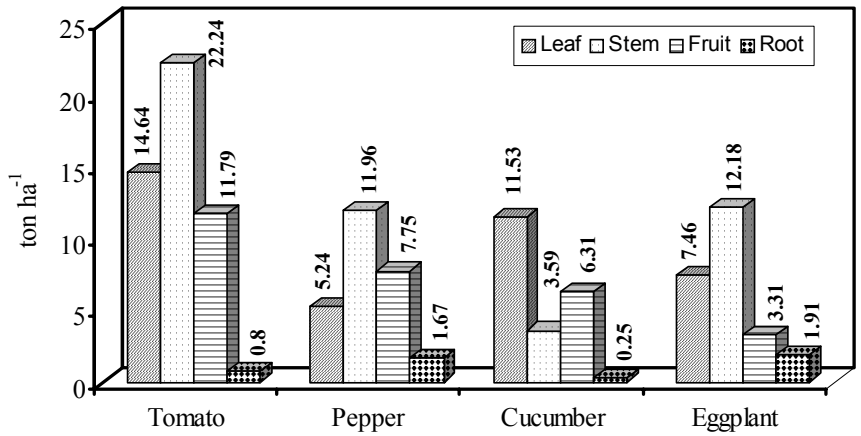

Fig. 1. Amounts of plant wastes on the basis of different organs of tomato, pepper, cucumber and eggplant vegetables at the end of growing season (fresh weight, tons ha^{-1})

In Fig. 1, it was seen that the stem composed an important part of waste amount of the vegetables except for cucumber. As a matter of fact, cucumber plant has a thinner and herbaceous stem in terms of its physiology. Another important issue that takes attraction is the fruit amounts wasted together with these plants at the end of growing season. The most important reason of this situation stems from the fact that the crops have lost their economic value at the end of the growing season. When the production areas of the vegetables are taken into consideration, the total amounts of these vegetable wastes formed at the end of growing season in Antalya are shown in Fig. 2.

As seen in Fig. 2, the attention was drawn to the fact that significant amounts of wastes were formed with tomato vegetable which was the first order in terms of production areas. A total of 777122 tons of vegetable wastes were formed in Antalya at the end of growing season regarding these four important greenhouse plants. In the distribution of these wastes

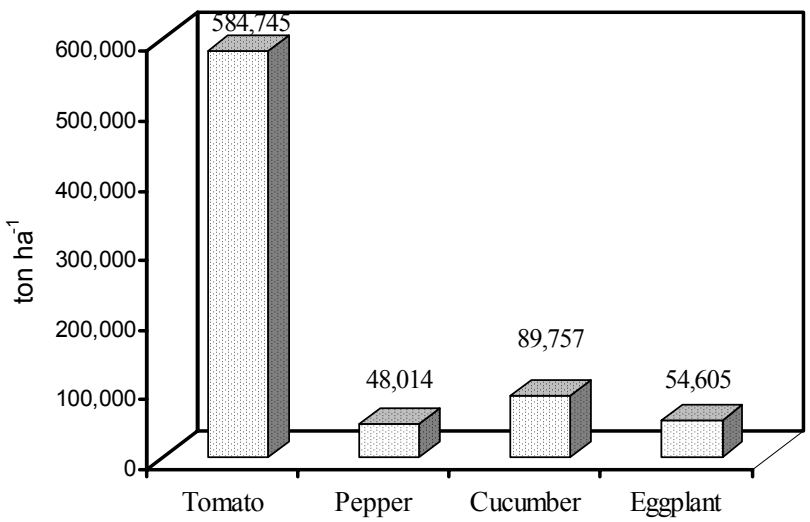

Fig. 2. Total amounts of vegetables wastes formed at the end of growing season (fresh weight, tons ha^{-1})

in terms of percentage, tomato was taken the first order with a value of 75.24 % with the largest production area and this was followed by cucumber with a value of 11.55 %, eggplant with the value of 7.03 % and pepper with a value of 6.18 %.

Average mineral contents, according to different organs of tomato, pepper, cucumber and eggplant which were obtained from the greenhouses in Antalya Region at the end of growing season were shown in Table-1. It was seen that these materials that are uprooted at the end of growing season and named as wastes contained an important amount of nutrients (Table-1). Average mineral contents which were uptake with different organs of tomato, pepper, cucumber and eggplant and which are wasted due to the disposal of these vegetables were shown in Table-2. In Table-2, it was seen that an important amount of nutrients were wasted together with greenhouse plants. It was determined that with tomato, pepper, cucumber and eggplant 594.5, 460.3, 346 and 410 kg ha^{-1} macro nutrient elements (N, P, K, Ca and Mg) and 1350, 994.2, 638.8 and 1404.3 g ha^{-1} micro nutrient elements (Fe, Mn, Zn and Cu) were wasted in Antalya Region, respectively. The mineral contents according to different plants and different organs of plants were given in Figs. 3 and 4 in terms of macro and micro elements. It was found that a high amount of nutrient element was wasted with tomato plant waste in terms of macro nutrient elements and with eggplant plant waste in terms of micro nutrient elements. By taking into consideration the production areas of important greenhouse plants in Antalya which were subject to the study, Fig. 5 was prepared for determining the amounts of the wasted nutrients

TABLE-1
AVERAGE MINERAL CONTENTS ACCORDING TO DIFFERENT ORGANS OF GREENHOUSE PLANTS (DRY MATTER)

Plant	Organs	Nutrients								
		%					mg kg^{-1}			
		N	P	K	Mg	Ca	Fe	Mn	Zn	Cu
Tomato	Leaf	1.93	0.19	3.68	2.14	4.15	125.10	56.71	53.34	14.36
	Stem	1.36	0.18	4.33	0.71	1.62	32.90	16.24	100.00	15.78
	Fruit	2.06	0.34	3.74	0.23	0.31	47.56	9.29	42.23	13.06
	Root	1.36	0.15	1.88	0.44	1.60	1123.30	32.60	93.34	16.35
Pepper	Leaf	4.33	0.59	4.49	1.13	3.59	84.89	63.27	100.00	27.07
	Stem	1.50	0.26	3.37	1.60	1.87	22.23	22.90	62.23	19.68
	Fruit	3.08	0.64	3.92	0.27	0.50	36.00	18.40	55.56	21.75
	Root	2.11	0.21	1.94	0.48	1.84	615.10	28.36	128.9	33.75
Cucumber	Leaf	2.56	0.40	1.56	1.91	8.08	70.12	76.49	93.34	19.44
	Stem	2.09	0.37	2.91	1.03	2.32	23.67	28.52	53.40	22.44
	Fruit	4.35	0.80	3.60	0.60	1.31	63.50	23.30	102.30	25.70
	Root	2.25	0.28	1.84	0.50	1.16	410.8	22.50	93.33	23.65
Eggplant	Leaf	3.96	0.36	4.95	0.61	4.36	107.00	119.10	75.56	16.10
	Stem	1.54	0.16	3.10	0.38	1.63	35.78	37.87	100.00	13.00
	Fruit	3.13	0.45	3.42	0.41	0.72	62.80	32.50	46.70	16.80
	Root	1.75	0.21	1.32	0.44	1.76	694.2	60.10	146.70	24.50

TABLE-2
AVERAGE MINERAL CONTENTS UPTAKEN WITH DIFFERENT ORGANS OF GREENHOUSE PLANTS (DRY MATTER)

Plant	Organs	Nutrients								
		kg ha^{-1}					g ha^{-1}			
		N	P	K	Mg	Ca	Fe	Mn	Zn	Cu
Tomato	Leaf	44.4	4.0	87.4	50.8	96.4	295.9	124.7	129.5	32.8
	Stem	41.9	5.7	138.2	22.5	51.8	47.2	51.3	318.8	50.4
	Fruit	13.7	2.3	22.9	1.6	2.0	31.4	5.8	30.7	9.2
	Root	2.2	0.3	3.0	0.7	2.7	199.4	5.7	14.5	2.7
Pepper	Leaf	31.6	5.6	37.7	13.1	42.3	65.5	72.4	92.0	22.6
	Stem	36.5	6.7	84.5	41.3	47.2	59.6	55.4	148.9	50.5
	Fruit	33.1	6.7	42.6	2.9	5.0	34.1	18.9	59.6	23.9
	Root	7.50	0.7	6.9	1.7	6.7	218.6	10.4	49.6	12.2
Cucumber	Leaf	43.9	6.9	30.7	29.5	146.3	112.0	140.9	143.3	33.5
	Stem	13.5	2.9	25.9	5.2	17.8	16.2	20.8	36.2	15.2
	Fruit	8.9	1.6	7.0	1.3	2.5	12.4	4.7	17.4	5.3
	Root	0.70	0.1	0.7	0.2	0.4	13.6	0.7	2.9	0.7
Eggplant	Leaf	44.5	4.0	58.7	6.7	61.4	129.1	178.5	87.6	22.6
	Stem	41.9	4.2	81.2	10.5	45.7	94.6	115.4	239.3	48.9
	Fruit	9.20	1.4	10.5	1.2	1.9	18.7	10.2	13.1	5.8
	Root	8.00	1.1	6.8	2.1	9.0	337.4	30.1	60.7	12.3

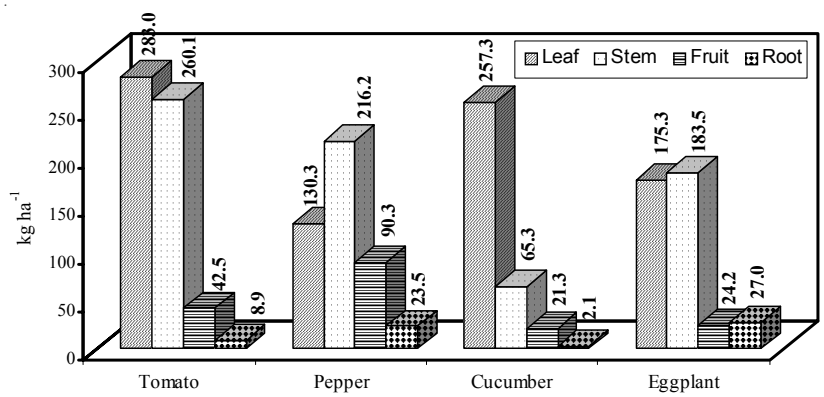

Fig. 3. The contents of total macro nutrients (N, P, K, Ca and Mg) according to different plants and different organs of plants

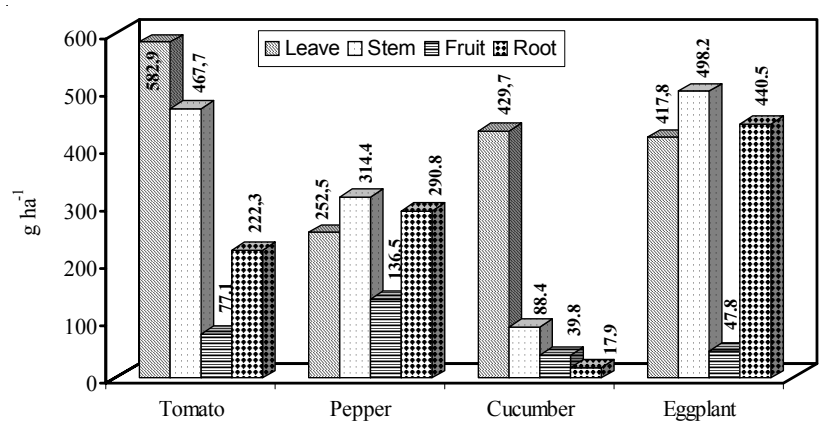

Fig. 4. The contents of total micro nutrients (Fe, Mn, Zn and Cu) according to different plants and different organs of plants

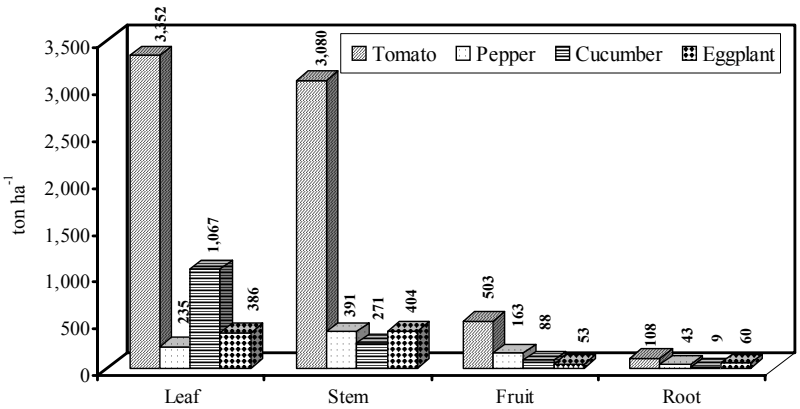

Fig. 5. Total amount of wasted nutrients with greenhouse plants in Antalya region

according to different organs of the vegetables. As can be seen from Fig. 5, 7043, 832, 1435 and 904 tons of nutrients 'a total of 10214 tons', respectively from tomato, pepper, cucumber and eggplant were wasted without being used for any end.

By taking the production areas into consideration; N, P_2O_5 and K_2O amounts of the nutrients (wasted with the plants wastes at the end of growing season) equivalent to that of chemical fertilizer were determined. With tomato, pepper, cucumber and eggplant vegetables, nutrients equivalent to chemical fertilizer containing 5108, 649, 705 and 696 tons of N, P_2O_5 and K_2O, respectively are wasted. When all the plants were examined on the basis of elements; N, P_2O_5 and K_2O equivalent to a total of 7159 tons of fertilizer containing 1909 tons N, 577 tons P_2O_5 and 4673 tons K_2O is wasted together with the plant wastes at the end of the growing season. N, P_2O_5 and K_2O amounts for each greenhouse plants were given in Fig. 6.

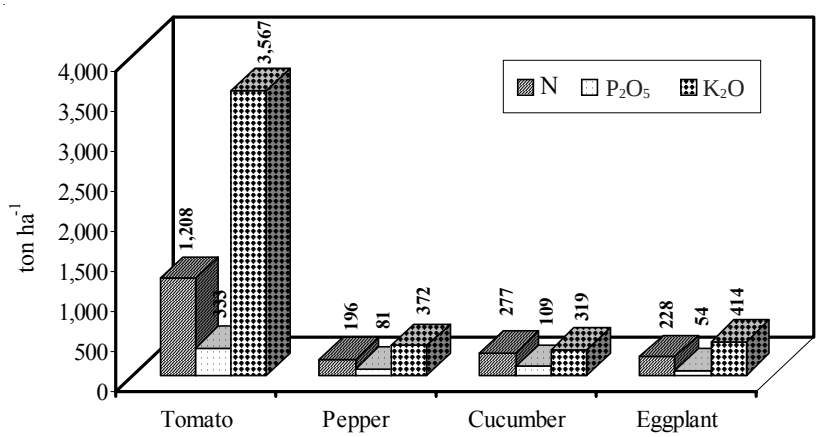

Fig. 6. N, P_2O_5 and K_2O amounts wasted with greenhouse plants in Antalya Region

As can be seen from Fig. 6, vegetable materials coming out at the end of growing season and large amounts of nutrients, primarily potassium, were wasted with the disposal of these wastes. However, it is possible to compost those greenhouse plant wastes and use them as organic fertilizer. Abou-Hadid *et al.*[16] found that N concentrations in the cucumber fruits were shown an increase of 34 and 48 %, respectively in waste compost and organic fertilizer and 86 and 80 % in the harvest in a study carried out on the composted cucumber plant wastes and their application on the soil and its comparison with poultry manure. An increase of 73 and 36 %, was determined when compared with the control in terms of waste compost

and organic fertilizer in the P content of the fruit. Manios[17] reported that the wastes of cucumber plant (50 %) and the wastes of olive vegetable pruning (50 %) could be composted successfully. Lo *et al.*[18] pointed out that the compost obtained from greenhouse plant wastes contained high amounts of nutrients and shown good physical characteristics and also could be used as a high-quality grown media.

Conclusion

Today, the number of researches on the evaluation and amount of the wastes coming out as a result of agricultural activities gradually increases. As a matter of fact, increasing plant production leads to an increase in the plant waste amount. Especially the plant wastes coming out at the end of growing season in greenhouse production and evaluation of these wastes have a special importance.

The insufficiency of soil organic matter is one of the most important problem encountered in greenhouse production in Antalya Region. Composition and re-use of these wastes in the same areas in this region, where such dense production is carried out, provides important benefits for soil characteristics and especially in terms of organic matter and it is also highly important for recycling of their nutrients. Also in this research, nutrient losses have occurred at incontrovertible amounts together with these wastes. Those valuable materials which are referred as wastes by farmers are burnt at the end of the growing season or thrown away randomly and therefore cause air and environmental pollution. In order to recycle these materials, establishment of waste collection facilities in local areas and brought of the materials by the farmers to these facilities should be ensured. These collected wastes should be composted under technical conditions and re-introduced to the use of the farmers. By this way, soil characteristics of the areas where greenhose production is carried out will partly be protected and nutrients contained by these materials will be recycled. As a result, economic benefit as well as environmental benefit will be ensured through recycling.

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