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Vegetable Crop Tolerance to Pre-plant Composting of Organic Matter

***Barakat Eid Abu Irmaileh*[*]✉ and Azmi Mohammad Abu Rayyan*[*]**

ABSTRACT

Several field and greenhouse experiments were conducted during the growing seasons of 2003 and 2004 to evaluate the response of some vegetable crops to pre-plant composting of organic matters at 10 $kg.m^{-2}$. Composting in field experiments was done under tight cover of polyethylene sheets in the planting row for six weeks. Organic matters included olive pomace, and animal manures from different sources; cow, poultry (broiler and layer), and sheep. The treatment with olive pomace was harmful to all crops except for onions; plants were stunted and leaf area was very much reduced compared with those in the control treatment. Cucumber was sensitive to layer manure. Muskmelon growth was not improved by the treatment with layer manure in as much as other manure treatments. The growth of all crops was significantly increased in the treatments with broiler, cow and sheep manures.

Keywords: Organic Farming, Crop Response, Sustainable Agriculture, Environmental Safety.

1. INTRODUCTION

It was always looked upon manure favorably because of its fertilizing value since ancient times. Before the introduction of inorganic fertilizers, manure was one of the few fertilizing materials with nutrients in a concentrated form available to plants. Raw manure generally releases nitrogen compounds and ammonia, which may burn plant, roots, and young plants and interfere with seed germination. Composting organic matter including animal manures and recycling them in cultivated fields has been widely adopted in many countries (Wang et al., 2005).

The use of composted organic matter, which contains essential nutrients for plants, reduces chemical fertilizer imports and or their manufacture. Animal manure supplies all major nutrients (N, P, K, Ca, Mg, S) necessary for plant growth, as well as micronutrients (trace elements), hence it acts as a mixed fertilizer. The chemical composition of fresh manures varies according to the type of feed and location. In general, the percentages of N, P_2O_5, K_2O, Ca, Mg, organic matter, and moisture in cow manure are: 0.5, 0.5, 0.3, 0.1, 16.7, 81.3 %, sheep manure are: 0.9, 0.5, 0.8, 0.2, 0.3, 30.7, 64.8% and poultry manure are: 0.9, 0.5, 0.8, 0.4, 0.2, 30.7, 64.8%, respectively (Anonymous a, 2007). Olive pomace consists of 1-1.5% polycohols, 0.5-7.5% proteins, 1-1.5% pectins and tannins, and 5-17%, polyphenols (Anonymous b, 2006). The contents of N, P and K in digested-fermented olive pomace in g kg^{-1} are 6.4 for total N, 0.97 for P_2O_5 and 6 for K_2O (Owen, 2006). In addition, a small fraction of the added organic material is transformed into humus or stable organic matter. Humus contributes to soil fertility by retaining

[*]Faculty of Agriculture, University of Jordan.
✉ Corresponding Author: A. Abu Rayyan, E-mail: aburayan@ju.edu.jo
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plant nutrients through adsorption. It also acts as binding material in the soil, thus improving soil structure. It is responsible for making clay less susceptible to compaction caused by heavy traffic and silt less susceptible to erosion, and it increases water holding capacity and cation exchange capacity of soil (Brandjes et al., 1996).

Application of fresh organic wastes involves addition of all of their components to the soil, and attracts large amount of plant pests and houseflies. Surface application of manure, particularly liquid manure, may cause substantial losses of NH_3 by volatilization (Brandjes et al., 1996). Most of the emitted NH_3 is deposited near the emission source which lowers soil pH and may lead to mobilization of aluminum (Al) ions, which disturbs the nutrient uptake of plants and enhances sensitivity to stress factors like drought and fungi. Besides the acidifying effect, NH_3 deposition accounts for a considerable N load to the environment, causing eutrophication problems and N enrichment of the soils in nature reserves, causing undesirable changes in species composition and biodiversity (Brandjes et al., 1996). Most of the odor comes from the anaerobic decomposition of manure due to the production of hydrogen sulfide and ammonia among other compounds.

In contrast to conventional farming which includes the application of chemical pesticides for fast and efficient levels of pest and weed control, organic farming system rely on non-chemical approaches for the control of pests and weeds; i.e. biological means, various types of mulches and tillage. Most of the non-chemical methods are slow, costly, cumbersome, or less effective. Recent findings indicated that pre-plant composting of various organic manures in the planting rows for six weeks can effectively control weeds (Abu-Irmaileh and Abu-Rayyan, 2004; Abu-Rayyan and Abu-Irmaileh, 2004) including broomrapes (Abu-Rayyan and Abu-Irmaileh, 2004), and provide good nutrition to the crop (Janssen, 1993). Composted organic matter improves soil physical characteristics, lowers C: N ratio, thus reducing competition for nutrients between plants and microorganisms, and the high temperature produced during composting process reduces the viability of soil borne pests and weed seeds (L'Hermite et al., 1993).

Despite the many advantages of composted organic matter, it was observed that not all crops tolerate this process. The objective of this research is to study the tolerance of main vegetable crops grown in Jordan to certain composted manure types.

2. MATERIALS AND METHODS

a- Response of Some Vegetable Crops to Soil with Composted Organic Matter

Greenhouse pot experiments were conducted during 2003 growing season. Organic matters (cow, sheep, broiler, or layer manure or olive pomace) were composted in the field soil for six weeks. Composting was conducted manually by thoroughly mixing the organic material at a rate of 10 $kg \cdot m^{-2}$ with the soil to a depth of 25 cm. The soil was irrigated to field capacity by drip lines, and then the soil surface was covered tightly with black polyethylene (BPE) during the six-week period. The soil was moistened every two weeks during the composting period. Pots (30 cm in diameter) were filled with equal volume of soil and composted organic matter. The experiment consisted of six treatments; 1-5) soil with composted cow, sheep, broiler, or layer manures or olive pomace, 6) a control treatment which consisted of pots filled with field soil without composted organic matter. The experiment was conducted on one of the following crops using seedlings; cabbage (*Brassica capitata* L.), cauliflower (*Brassica botrytis* L.), cucumber (*Cucumis sativus* L.), eggplant (*Solanum melongena* L.), muskmelon (*Cucumis melo*

L.), pepper (*Capsicum annum* L.), or squash (*Cucurbita pepo* L.). For each crop, the treatments were arranged in a completely randomized design with seven replicate plants per treatment. The experiments were terminated two months after planting. Plant height, leaf area and number, and shoot dry weight was recorded.

Analysis of variance was conducted with the SAS program, (version 7, Statistical Analysis System, 1998) for CRD arrangement, and the means were separated by $LSD_{0.05}$ according to GLM procedure at $P \leq 0.05$ (SAS, 1998).

b- Effect of In-row Composting on Crop Performance

Field experiments were conducted to study crop responses to the pre-plant composting of organic matter in the planting rows. The experiments were carried out in the Agricultural Research Station – Jordan University Farm (longitude 35° 35.7´E, latitude 32° 05´N) in Jordan Valley during winter growing season of 2004. The soil was ostochreptic calciorthid. Composting was conducted manually by thoroughly mixing organic material with soil at a rate of 10 $kg \cdot m^{-2}$, in 40-cm bands along 2.5 m to a depth of 25 cm in the planting rows. The soil was heavily irrigated via drip lines which were laid to irrigate as needed thereafter. Soil surface was then covered with BPE during the six week period prior to planting. Each experiment was planted with beans(*Phaseolus vulgaris* L.), cauliflower, eggplant, lettuce(*Lactuca sativa* L.), squash, tomato(*Lycopersicum esculentum* Mill.), or onion(*Allium cepa* L.). Each experiment included five main treatments; 1-4) composted cow, layer, or sheep manure or olive pomace, and 5) a control treatment without composted organic matter. All plots were drip irrigated to field capacity once per week during the composting period and stopped during periods of rainfall.

All experiments were arranged in a randomized complete block design with four replications. Each plot consisted of two rows for all crops except for lettuce for which plots consisted of four rows. Plot size was 2.5 m X 1.5 m with 0.5 m alleys on all sides.

Average plant fresh weights (g) were recorded for cauliflower and lettuce. Total yield in ton per hectare was recorded for onion and average yield per bean, eggplant and tomato plant (g) were taken from the middle three plants of each row. Data were subjected to ANOVA analysis (SAS, 1998).

3. RESULTS

a- Response of Some Vegetable Crops to Soil with Composted Organic Matter

Cruciferous Crops (Cabbage and Cauliflower)

For both crops, plant growth in composted manures was increased over the control but was significantly reduced by the composted olive pomace; the plants were stunted, and leaf area and shoot dry weight were the lowest (Tables 1 and 2). Leaf area, plant height and shoot dry weight were the highest for composted cow manure. Different manures affected growth parameters differently in both crops. Cabbage dry weight and plant height were the highest in cow and sheep manure treatments, but leaf area was the highest in cow and layer manure treatments (Table 1). However, cauliflower growth parameters were the highest in cow manure treatment, and plant height was the highest in broiler and sheep manure treatments (Table 2).

Table (1): Average plant height, leaf area and shoot dry weight of cabbage in different compost treatments*.

Treatment	Plant height (cm)	Leaf area (cm^2)	Shoot dry weight (g)
Cow	29.1 a	2936.6 a	14.9 a
Broiler	25.9 b	2339.8 b	11.9 b
Sheep	28.9 a	2223.5 b	14.2 a
Layer	27.6 ab	2826.8 a	13.7 ab
Olive pomace	6.0 d	769.0 c	3.2 d
Control	9.1 c	2125.9 b	9.5 c
$LSD_{0.05}$	1.97	264.0	1.9

*Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Table (2): Average plant height, leaf area and shoot dry weight of cauliflower in different compost treatments*.

Treatment	Plant height (cm)	Leaf area/plant (cm^2)	Shoot dry weight (g)
Cow	32.9 a	2460.0 a	14.2 a
Broiler	32.0 a	2197.2 b	12.0 b
Sheep	31.0 a	1835.9 d	12.3 b
Layer	28.6 b	1992.6 bc	11.5 b
Olive pomace	7.1 d	680.5 e	3.8 d
Control	10.7 c	1499.9 d	9.3 c
$LSD_{0.05}$	2.1	228.4	1.9

*Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Cucurbit Crops (Cucumber, Muskmelon and Squash)

Cucurbits varied in their responses to amendments of composted organic matter. The treatment with composted broiler or cow manure improved all growth parameters in squash over composted olive pomace. Leaf area and shoot dry weight were significantly higher in broiler and cow manure than in the control treatment, while plant height was not significantly different. Composted sheep and layer manures improved squash dry weight compared to either composted olive pomace or the control treatments (Table 5). Cucumber dry weight and leaf area responded positively to composted cow, broiler or sheep manures as compared with other treatments. The lowest value of plant height was obtained in the layer manure treatment. The plants also had the least shoot weight as compared with the values in the other manure treatments (Table 3). Muskmelon growth parameters were better in broiler, cow or sheep manure compared to the control or pomace treatments. The dry weight was the highest in cow manure treatment (Table 4). The treatments with composted layer manure or olive pomace brought about lower values of the growth parameters than the control treatment, even though not significantly. In spite of the significant increase in plant height and leaf area of muskmelon in the composted layer manure treatment over those in the control, the values were less than those in the other composted manures. In general, composted olive pomace was harmful to all cucurbits tested, as their growth parameters were less than those in the control, even though not significantly different.

Table (3): Average plant height, leaf area and shoot dry weight of cucumber in different compost treatments*.

Treatment	Plant height (cm)	Leaf area (cm^2)	Shoot dry weight (g)
Cow	11.9 ab	2718.5 a	7.5 a
Broiler	12.9 a	2905.9 a	6.3 a
Sheep	13.3 a	2589.8 a	7.5 a
Layer	3.0 c	965.7 b	1.2 b
Olive pomace	8.6 b	905.5 b	1.4 b
Control	10.3 ab	1278.1 b	2.2 b
$LSD_{0.05}$	3.5	509.9	1.4

*Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Table (4): Average plant height, leaf area and shoot dry weight of muskmelon in different compost treatments *.

Treatment	Plant height (cm)	Leaf area (cm^2)	Shoot dry weight (g)
Cow	54.4 a	2638.0 a	6.9 a
Broiler	47.1ab	2792.3 a	3.4 b
Sheep	55.4 a	2509.8 ab	4.2 b
Layer	35.7bc	1684.6 bc	3.5 b
Olive pomace	17.3 d	1178.3 c	0.8 c
Control	20.7cd	1246.3 c	1.4 c
$LSD_{0.05}$	17.0	905.9	1.9

*Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Table (5): Average plant height, leaf area and shoot dry weight of squash in different compost treatments*.

Treatment	Plant height (cm)	Leaf area (cm^2)	Shoot dry weight (g)
Cow	14.1 a	3034.3 a	12.9 ab
Broiler	13.7 a	2038.9 b	14.3 a
Sheep	11.3 ab	1343.9 c	10.3 b
Layer	12.4 ab	2114.7 b	11.7 ab
Olive pomace	9.7 b	840.7 d	2.4 c
Control	12.7 ab	1096.4 cd	5.7 c
$LSD_{0.05}$	3.7	502.7	3.6

*Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Solanaceous Crops (Eggplant and Pepper)

Plant growth in the composted olive pomace treatment was significantly reduced in both crops than that in the control treatment (Tables 6 and 7). This treatment brought about significant reduction in leaf area and plant dry weight values in both crops, and eggplant and peppers were stunted. Both crops responded positively to composted manures compared to the plants in the control treatment. However, different growth parameters responded differently to different treatments. While plant height and shoot dry weight in eggplants were significantly doubled or tripled in response to treatments of either composted cow or broiler manure, leaf area value was the largest (Table 6). Plant height and shoot dry weight of pepper were better in broiler, cow and sheep manures than in composted layer manure, but leaf area value was largest in cow manure (Table 7).

Table (6): Average plant height, leaf area and shoot dry weight of eggplants in different compost treatments [*].

Treatment	Plant height (cm)	Leaf area (cm^2)	Shoot dry weight (g)
Cow	46.3 a	2497.4 ab	14.1 a
Broiler	44.4 ab	2311.7 bc	13.5 a
Sheep	40.9 c	2188.4 c	11.1 b
Layer	42.4 bc	2601.5 a	12.5 ab
Olive pomace	11.3 d	766.1 e	1.7 d
Control	13.6 d	1752.5 d	5.4 c
$LSD_{0.05}$	3.4	213.5	2.2

[*]Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Table (7): Average plant height, leaf area and shoot dry weight of pepper in different compost treatments [*].

Treatment	Plant height (cm)	Leaf area (cm^2)	Shoot dry weight (g)
Cow	37.7 b	2756.3 a	10.6 b
Broiler	39.6ab	2103.3 b	12.2 a
Sheep	43.2 a	2274.2 b	10.5 b
Layer	31.1 c	2296.1 b	6.7 c
Olive pomace	17.3 e	1166.2 d	2.2 e
Control	22.6 d	1752.3 c	3.8 d
$LSD_{0.05}$	4.1	313.2	1.2

[*]Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

b- Effect of In-Row Composting of Organic Matter on Crop Performance in the Field

Composted cow, layer and sheep manures increased bean yield significantly over control and olive pomace treatments (Table 8). Composted olive pomace brought about drastic yield reductions in eggplant as compared with cow and layer composted manures. Tomato yield was significantly better in composted cow, layer and

sheep manures than in pomace treatment. The highest tomato yield was obtained from composted layer treatment. Eggplant and tomato yields with composted sheep manure were not significantly different from the yield in the control treatment.

Cauliflower yield was significantly increased over the control in both composted cow and layer manures (Table 8). Cauliflower yield was not significantly different from the control, composted sheep manure or olive pomace.

Lettuce fresh weight was significantly the least in the olive pomace treatment (Table 8). Other treatments brought about non-significant increases in plant fresh weights.

Table (8): Average field yield in different compost treatments*.

Treatment	Yield.Plant^{-1} (g)			Plant fresh weight (g)		Yield (t·ha^{-1})
	Beans	Eggplants	Tomato	Cauliflower	Lettuce	Onions
Cow	132.9 b	1211.5 a	788.0 b	3891.7 a	1167.9 a	35.5 b
Layer	145.8 a	1201.0 a	1197.0 a	4394.4 a	1160.1 a	44.3 a
Sheep	120.8 c	678.5 ab	663.0 bc	3375.0 ab	999.6 a	27.6 c
Pomace	80.5 d	252.8 b	328.1 d	2429.2 b	542.2 b	42.8 ab
Control	87.7 d	403.0 b	552.5 c	2641.7 b	937.5 a	15.3 d
$LSD_{0.05}$	8.5	584.8	216.7	1029.9	356.2	7.57

*Within each column, means having different letters are significantly different at the 5% level of probability according to LSD Test.

Onion bulb yield was significantly increased with composted organic matters, including olive pomace as compared with the control (Table 8). Onion yield was significantly better in composted cow and layer than in sheep manure treatment.

4. DISCUSSION

The results indicated that pre-plant composting of fresh organic matter, especially poultry, cow, and sheep, in the planting row, increased the values of the growth parameters that were tested either in the field or the greenhouse experiments in some crops. Such results were expected, as the composted manures provided fertilizing materials with nutrients as animal manure supplies all major nutrients (N, P, K, Ca, Mg, S,) as well as micronutrients necessary for plant growth (Wang et al., 2005).

However, application of fresh organic matter involves the addition of all of their components to the soil, and attracts large amount of plant pests and may cause substantial losses of NH_3 by volatilization (Brandjes et al., 1996). The heat produced during manure degradation would make manure hot enough to burn sensitive plants (Owen, 2006). On the other hand, composting organic matter improves soil physical characteristics, lowers C: N ratio, thus reducing competition for nutrients between plants and microorganisms, and reduces the viability of soil borne pests and weed seeds by the effect of the high temperature produced during composting process (L'Hermite et al., 1993).

Variation in growth responses to preplant-composting of different organic matter is mainly due to the differences in their contents of nutrients (Amirante and Pipitone, 2002; Clemente et al., 1997), C/N ratio and contents from other compounds that might be toxic to plant growth such as phenolic compounds which are normally found in olive pomace (Amirante and Pipitone, 2002), or to the production of by-products during composting, including ammonia at

higher concentration that could not be tolerated by certain crops (Mitchell and Donald, 2006). Except onion, the growth response of other crops tested to composted olive pomace was drastically negative, either in the greenhouse or in the field. Composted olive pomace, which was refined from pomace oil, was tried as an organic fertilizer, or organic mulch (Anonymous b, 2006). The pomace used in this research was not refined. It proved to be harmful as a fertilizer. In addition to the polyphenols, which might be toxic to plant growth, olive pomace contains difficult-to-biodegrade compounds including lignin, tannins, and an unbalanced nutrient content (Anonymous b, 2006).

Not all crops tolerated the treatment with composted manures at the same level. Even though all manures were composted for six weeks prior to planting, cucumber plants were very sensitive to composted layer manure. This was probably due to various factors; of which is that soil temperature was not low enough for cucumber seed germination to proceed normally. The average soil temperature at 15 cm depth during the 6th week of composting layer manure might be higher than 40 ºC (Abu-Irmaileh and Abu-Rayyan, 2004), at which cucumber seed germination drops to less than 50% (Anonymous d, 2006). Optimum soil temperature for cucumber seeds ranges between 25-30 ºC at the planting depth (Anonymous c, 2006). Then, composting period of layer manure should be extended until soil temperature would be low enough for proper seed germination. Cucumber plants were stunted, and the leaves were very small.

It is also probable that the concentration of the produced ammonia from this treatment was high enough to affect cucumber plants. Ammonia production under anaerobic condition is normally the highest from layer manure as compared with other manure types (Brandjes et al., 1996). Since manure composting was under tight polyethylene sheet, which does not allow free aerobic condition to prevail, it is suspected that ammonia production during the composting process is high. Ammonia is known to be extremely toxic to cucurbits (Kessel, 2003). However, such speculations require verification.

Plant growth of other crops, such as muskmelon and pepper, in the composted layer manure treatment was less than that in the treatment with other composted manures. Other crops including cauliflower, cabbage, eggplants, and squash tolerated the treatment with composted layer manure, and their growth was improved significantly. In the field, plant growth of beans, cauliflower, eggplants, tomatoes, and onions was improved and their yields were increased by the treatment with composted layer manure.

Under field condition, the numerical values of crop growth parameters in composted sheep manure were lower than in other composted manures (Table 8). It is speculated that this was due to the high carbon content in sheep manure (Wang et al., 2005). Sheep in Jordan either graze grasses and straw remains from cereal fields, or fed straw in barnyards. Thus, the percent C is suspected to be high. Degrading microorganisms utilize the available nitrogen content in the manure, and reduce the available nitrogen to the plants.

In conclusion, pre-plant composting of organic matters at rates of 10 kg·m^{-2} had different effects on the growth of different crops. Composted olive pomace was harmful to most crops included in this experiment. Not all crops tolerated the treatment with composted layer manure, which brought about significant improvement in the growth of some crops. Cucumber did not tolerate layer manure. Pre-plant composting of sheep manure improved growth of all crops, but to a lesser level than the composted cow or broiler.

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استجابة بعض المحاصيل الخضرية لمعاملات تدبيل مواد عضوية مختلفة قبل الزراعة

بركات عيد ابو رميلة وعزمي محمد ابو ريان**

ملخـص

تم إجراء تجارب مختلفة في البيوت الزجاجية والحقل خلال موسمي الزراعة 2003 و 2004 لاختبار مدى تحمل محاصيل خضرية مختلفة لمعاملات تدبيل مواد عضوية مختلفة (جفت الزيتون، روث حيواني من مصادر متنوعة - دواجن، بقر أو غنم) بمعدل 10 كغم. م$^{-2}$ (0.4 X 2.5 م 2) تحت غطاء بلاستيكي محكم لمدة ستة أسابيع في سطر الزراعة. كانت المعاملة بجفت الزيتون ضارة بجميع المحاصيل ما عدا البصل، حيث كانت النباتات مقزمة وكانت المساحة الورقية صغيرة جدا بالمقارنة مع الشاهد. أظهرت نباتات الخيار حساسية عالية للمعاملة بزرق الدجاج البياض، حيث كان النمو ضعيفا، وظهرت بقع احتراق على الأوراق. ولم يتحسن نمو نباتات الشمام في المعاملة بزرق الدجاج البياض بقدر تحسن النمو في معاملات الروث الأخرى. لقد ازداد نمو المحاصيل المختلفة بشكل معنوي بمستويات متفاربة في معاملات روث الدجاج اللاحم والبقر والغنم.

الكلمـات الدالـة: الزراعة العضوية، الزراعة المستدامة، سلامة البيئة واستجابة المحاصيل.

*كلية الزراعة، الجامعة الأردنية، عمان، الأردن.

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