American Journal of Plant Sciences, 2011, 2, 675-682
doi:10.4236/ajps.2011.25081 Published Online November 2011 (http://www.SciRP.org/journal/ajps)

Covering Tree Line with Black Poly Ethylene Sheets for Composting Fresh Animal Manures Reduces Weeds and Improves Tree Growth in Newly Established Orchards

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Received July 23rd, 2011; revised August 25th, 2011; accepted October 9th, 2011.

ABSTRACT

Three field experiments were carried out over two growing seasons to evaluate the response of weeds and the volume of fruit trees; peach, pear and olive to composting of manures at 10 $kg \cdot m^{-2}$. Planting holes were prepared early January. Animal manures from different sources; broiler, cow, layer and sheep were mixed in the top 20-cm of the soil surface over a 40-cm band X 2.5m row per treatment in the planting row then either non covered or covered with black polyethylene (BPE) sheets for six weeks or for the period from January to October. Trees were then planted late February. The same treatments were repeated in November of the next year. Weeds were significantly reduced and fruit trees were significantly larger in the treatments with manures in the BPE-covered treatments as compared to the non-covered treatment. Perennials; Cynodon dactylon (L.) Pers. and Cardaria draba L. in addition to Convolvulus arvensis L. and Sorghum halepense (L.) Pers. tolerated the composting process. Most annual weeds did not appear in composted manure subplots. Main annual weeds included; Amaranthus blitoides S. Wats. A. garacilis Desf. Sinapis arvensis L. Chenpodium album L. in addition to some weeds species belonging to Leguminosae and Caryphyllaceae.

Keywords**:** *Organic Farming, Crop Tolerance, Sustainable Agriculture, Environmental Safety*

1. Introduction

The use of composted organic matter, which contains essential nutrients for plants, reduces chemical use, thus reducing 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 animal source and 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, sheep and poultry manures are: 0.5%, 0.5%, 0.3%, 0.1%, 0.3%, 16.7%, 81.3%; 0.9%, 0.5%, 0.8%, 0.2%, 0.3%, 30.7%, 64.8%, and 0.9%, 0.5%, 0.8%, 0.4%, 0.2%, 30.7%, 64.8%; respectively [1]. 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 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, silt less susceptible to erosion, and it increases water holding capacity and cation exchange capacity of soil [2,3]. It was always looked upon manure favorably because of its fertilizing value since ancient times. However, raw manure generally releases nitrogen compounds and ammonia which may burn plant roots, young plants and interfere with seed germination. Application of fresh manures attracts large amount of plant pests and houseflies as manure is a favorable medium for the multiplication and propagation of various microorganisms and insects, including houseflies (*Musca domestica* L.) [4,5]. Surface application of manure, particularly liquid manure, may cause substantial losses of NH_3 by volatilization [2,3]. Most of the emitted NH_3 is deposited near the emission source which lowers soil pH and may lead to mobilization of aluminum ions, which disturbs the nutrient uptake by plants and enhances sensitivity to stress factors like drought and fungi. Besides its 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 [2]. Most of the odor comes from the anaerobic decomposition of manure due to the production of hydrogen sulphide and ammonia among other compounds. Thus, disposal of manures, without any further composting treatment, is a major environmental pollutant in agro-ecosystems.

Composting animal manures and recycling them in cultivated fields has been widely adopted in many countries [6] as it 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 [7,8] and lower housefly populations [9]. Composting of manure can also solve odor problems, recover nutrients and energy from manure, increase the fertilizer value, and decrease the pollution potential to allow safe discharge of the manure in the environment [10]. Manure management practices are strictly regulated and enforced in the developed countries to minimize pollution problems [10], but management of surplus manure in the animal production sector is far from satisfactory in developing countries where it is sold at low prices to farmers who spread raw manure on soil surface at rates ranging from 50 to 100 $t \cdot ha^{-1}$. Collected raw manure from grazing animal barnyards (goat and sheep) is normally contaminated with seeds of various plant species; as these animals, and to a lesser extent cattle, are normally allowed to graze crop remains and weeds after harvest [8]. Therefore, raw manure could increase the weed seed bank in receiving fields. Weeds are one of the most limiting factors in agricultural production, as weed infestations can result in serious yield losses compared to other constraints in crop production [11,12].

Farmers in most developing countries remove weeds by manual hoeing [13]. In these countries chemical weed control is typically unaffordable, especially if more than one herbicide is required and if market economics limit profits. Nonchemical weed control practices, such as soil solarization with black polyethylene mulch during the hottest months of the year, are favored for the control of weeds and other pests [14]. Recent findings indicated that pre-plant composting of various organic manures in the planting rows for six weeks can effectively control weeds including broomrapes [8,15].

Good weed control is essential for rapid establishment and vigorous growth of young trees. Growth of fruit trees during the phase of orchard establishment is normally hampered by the presence of weeds. Weed control in young orchards is critical. Competition from smooth pigweed reduced tree growth of newly established trees by more than 40% [16], and Bermuda grass infestation can reduce fresh weights of peach trees by 87% after one year [17].

The objective of this research is to evaluate the impact of pre- and post-plant composting of different manures on weed infestation and tree growth in newly established olive, pear and peach orchards.

2. Materials and Methods

Three field experiments were conducted over two growing seasons (2009-2011) at the University of Jordan research stations, to study the growth response of three species of fruit trees; olive (*Olea europea*) cv. "Grosadi" (own rooted cuttings), peach *(Prunus persica*) cv. "Crimson Lady"/Montclar and pear (*Pyrus communis*) cv. "Cosia"/BA29 rootstock to composting treatments of four types of fresh manures in the tree line. Each manure type; cow, sheep, broiler and layer, was incorporated with the soil six weeks before planting the trees during January in the first growing season and during the fall period (November) in the second season. Planting holes were prepared before manure application in the first growing season, and manure was also mixed in the soil of the planting holes. The main treatments were: BPE6-composting by covering the tree line by black polyethylene (BPE) sheets for only six weeks before planting then the cover was removed, BPEC—as in the treatment BPE6, but BPE cover was retained for the whole growing season, NO BPE—treatment without BPE cover. Each main treatment included five sub treatments; cow, sheep, broiler, layer manures and a check (no-manure treatment). Each manure sub-treatment received a different source of manure in 40 cm bands, at the rate of 10 $kg \cdot m^{-2}$. Planting of fruit trees commenced at late February. Planting distances were 3 m within the tree lines which were 3 m apart. Each sub-treatment included three trees in plots of $3 \times 9\ m^2$. The area of each main treatment was $45 \times 3\ m^2$. The area of each experiment was $45 \times 9\ m^2$. The same set of treatments was also repeated during the second season in an open area nearby, in order to verify the effect of composting on weeds without interference of the shading effect of the tree canopies on weed growth. All experiments were drip irrigated to field capacity at weekly intervals except during the period of rainfall. No chemical fertilizers were added. Light pruning was carried out late autumn of the first growing season to remove the dead branches and suckers. The same treatments were repeated for the next growing season.

Each of the fruit tree species; olive, peach and pear, was planted separately to constitute an experiment by itself. Experiments were conducted at the Agricultural Research Station in Jubeiha, 32˚N, 35˚ longitude and 980 m above sea level. It was considered that the incorporated manure was composted in the soil when it was moistened under BPE during the covering period. The uncovered manure-treated soil was considered as a treatment without manure composting.

All experiments were arranged in a split plot design. The main plots were three composting methods; BPE cover for 6 weeks (**BPE6**), BPE cover for the whole growing season (**BPEC**) and no BPE cover (**NO BPE**) in each of the fruit tree types. Each main plot included five subplots; four different types of manure in addition to no-manure as a check. Three trees were planted in each subplot.

The initial tree volume was visually estimated for each tree by three researchers on a scale from 1 (for the smallest-sized tree) to 10 (for the largest-sized tree). Tree volumes were estimated during the period from mid-August to mid-October. The estimated tree size at planting for olive, peach, and pear was 2, 2 and 1; respecttively. Weeds were collected from the middle of each plot during spring and late summer. Weeds were identified and dried at 70˚C for three days in a drying oven. Weed dry weights were recorded.

Analysis of variance was conducted with the SAS program, version 7 for split-plot arrangement, and the interactive means were separated by least squared means according to GLM procedure [18]. Means were separated according to Duncan's Multiple Range Test at 5% level of probability.

3. Results and Discussion

3.1. Effect of Main Treatments of Manure Composting on Weed Control

The grand means of dry weights of weeds collected from the main treatments with BPE cover for 6 weeks (**BPE6**), or with BPE cover for the whole growing season (**BPEC**), were significantly lower than in the uncovered treatment (**NO BPE**) in all fruit tree types (**Table 1**).

When the BPE cover was removed after 6 weeks, weeds that tolerated the treatments under the BPE cover grew to the end of the season, but their dry weights remained significantly lower compared to those in the main treatment **NO BPE**, except in the pear experiment. This was related to the fact that weed populations in the pear experiment were mixed with perennial weeds that tolerated the BPE cover treatment, namely; *Cynodon dactylon* (L.) Pers. and *Cardaria draba* L. in addition to *Convolvulus arvensis* L. and *Sorghum halepense* (L.) Pers. which appeared sporadically. When BPE cover was removed after 6 weeks, the treatment-tolerant weeds grew in the absence of weed interference from the weeds that did not tolerate the treatments. Most annual weeds did not appear in composted manure subplots. Main annual weeds included; *Amaranthus blitoides* S. Wats. *A. garacilis* Desf. *Sinapis arvensis* L. *Chenpodium album* L. in addition to some weeds species belonging to Leguminosae and Caryphyllacea. A second factor that may have contributed to such result is that pear branching was mostly upright compared to that in peach and olive where the tree line was mostly shaded, thus discouraged weed growth as compared to pear. No weeds were collected from the main treatment **BPEC** as the BPE cover was retained on the surface of the planting line for the whole season.

The impact of different treatments on weed dry weights varied among experiments, depending on the dominating weed types in each. The overall impact of composting manures on weed dry weights was apparent during summer, especially in peach as weed dry weights in the check plots (the no-manure subplots) were significantly lower (**Table 2**). Weed dry weights in the olive experiment had the same trend, but only weed weights in the check plots were significantly lower than those that received sheep and broiler manures. No significant differences appeared in weed dry weights either in pear or in the open area experiment.

All subplots with manure had higher weed dry weights within the main treatment without BPE cover, **NO BPE**, compared to treatment with BPE cover for six weeks, **BPE6**, and with continuous BPE cover, **BPEC** (**Table 3**). This was an expected result as manures are organic fertilizers; in addition to the untreated manures are normally contaminated with weed seeds, depending on the types of feed lots or the grazing areas [8]. Weeds continued to grow faster in most of the subplots which received manure application than the weeds in the no-manure subplots across all experiments. When weed dry weight measurements were carried out late summer, about 5 - 6 months after PBE removal in the main treatment **BPE6**, weed dry weights in the no-manure subplot (check) was either significantly lower than those in the check subplots of the **NO BPE** in peach and olive experiments, but were similar to those in the pear and the open area experiments. The different weed population in the pear experiment resulted in almost equal dry weights of weed masses across all subplots compared to those in peach and olive experiments. Annual weeds that dominated peach and olive areas were mostly annuals, while the pear and the open areas were dominated by perennials,

Table 1. Grand means of weed dry weights in the main treatments.

Main treatment	Weeds dry weight (g)*							
	First growing season						Second growing season	
	Peach		Pear		Olive		Open area	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
BPE6	5 b	116 b	12 b	407 a	9 b	201 b	11 b	82 b
BPEC	0 c	0 c	0 c	0 b	0 b	0 c	0 c	0 c
NO BPE	102 a	605 a	84 a	446 a	115 a	681 a	39 a	130 a

*Means within columns carrying the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test.

Table 2. Grand means of weed dry weights in various manure treatments.

Manure types	Weeds dry weight (g)*							
	First growing season						Second growing season	
	Peach		Pear		Olive		Open area	
	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
Sheep	39 ab	284 a	35 a	269 a	27 b	320 ab	15.8 ab	73.6 a
Broiler	33 b	262 a	33 ab	276 a	43 ab	353 a	15.5 ab	46.7 b
Cow	32 b	220 a	34 a	282 a	38 b	233 c	14.9 b	45.4 b
Layer	41 a	300 a	28 b	273 a	38 b	311 ab	15.8 ab	63.5 ab
Check	34 b	134 b	32 ab	322 a	62 a	251 bc	21.7 a	59.6 ab

*Means within columns carrying the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test.

Table 3. Effect of interactive combination of manure amendment x manure type on mean weed dry weights.

Main treatments	Manure types	Weeds dry weight (g)*							
		First growing season						Second growing season	
		Peach		Pear		Olive		Open area	
		Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer
NO BPE	Sheep	110 ab	737 a	95 a	397 ab	73 c	703 b	15 bcd	115 abc
	Broiler	92 c	670 ab	78 bc	517 a	120 b	857 a	7 cd	56 cd
	Cow	90 c	543 b	92 a	390 ab	105 bc	530 c	9 cd	68 cd
	Layer	121 a	783 a	72 c	383 ab	105 bc	737 b	8 cd	92 abc
	Check	99 bc	291 c	86 ab	543 a	172 a	577 c	17 bcd	79 bc
BPE6	Sheep	5 d	117 d	10 ef	410 ab	7 d	257 d	33 abc	155 a
	Broiler	7 d	117 d	21 d	310 b	8 d	203 d	39 ab	115 abc
	Cow	7 d	118 d	10 ef	457 ab	10 d	170 d	36 ab	98 abc
	Layer	4 d	117 d	13 de	437 ab	9 d	197 d	40 ab	140 ab
	Check	4 d	110 d	9 ef	423 ab	13 d	177 d	48 a	139 ab
BPEC	Sheep	0 d	0 d	0 f	0 c	0 d	0 e	0 d	0 d
	Broiler	0 d	0 d	0 f	0 c	0 d	0 e	0 d	0 d
	Cow	0 d	0 d	0 f	0 c	0 d	0 e	0 d	0 d
	Layer	0 d	0 d	0 f	0 c	0 d	0 e	0 d	0 d
	Check	0 d	0 d	0 f	0 c	0 d	0 e	0 d	0 d

*Means within columns carrying the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test.

namely; *Cynodon dactylon* (L.) Pers. and *Cardaria draba* L. in addition to *Convolvulus arvensis* L. and *Sorghum halepense* (L.) Pers. which appeared sporadically in **BPE6**.

Weeds which were removed at the end of summer each growing season in the uncovered main treatment, **NO BPE**, mainly included *Cardaria draba* L., *Cynodon dactylon*, *Chenopodium vulvaria* L., *C. murale* L., *Amaranthus blitoides* S. Wats., *A. retroflexus* L., *Sonchus oleraceous* L., *Malva sylvestris* L. The main weeds which appeared in the main treatment **BPE6** were *Cardaria draba* L., *Cynodon dactylon*, while *Cynodon dactylon* appeared in the holes around the trees in the main treatment **BPEC**. Weed species that were effectively controlled included *Chenopodium murale*, *C. album*, *Amaranthus retroflexus*, *Sonchus oleraceous*, *Polygonum aviculare*, and *Sisymbrium irio*.

The impact of composting each type of manure in the treatment **BPE6** on weed dry weights taken three months after PBE removal during spring time was not significant compared to the check. However, weed dry weights of the different sub-treatments in **BPE6** were significantly lower than the corresponding sub-plots in the **NO BPE** main treatment. The variations in weed dry weights among and within each experiment was due to variations in weed populations dominating each site. Such variation could not be controlled under normal field weed infestations. This indicated that the main significant effect of treatment **BPE6** was due to the PBE covering rather than to the manure composting.

Unlike the obtained results here, it was reported that composting manure and other organic matter prior to planting under PBE cover reduced weed population in vegetables in warmer regions [15] as composting manures resulted in warming up the soil besides the production of volatile compounds which are retained under BPE cover in high concentrations, such as ammonia, which enhanced detrimental effects on weed growth.. Such effect was not evident in the relatively cooler regions where this research was carried out. However, weed seeds can be killed during composting even though lethal temperatures are not reached [19]. The efficacy of the composting process for controlling soil borne living propagules is not necessarily dependent on simply raising soil temperatures. For instance, imbibed weed seeds have been reported to be killed faster than non imbibed weed seeds at typically sub lethal soil temperatures when under mulch [20]. But, some weed species and other soil borne pest propagules may not be controlled effectively if BPE cover is applied during the winter months.

3.2. Effect of Main Treatments of Manure Composting on Tree Volume

Despite the fact that there were no significant negative impact of manure composting on weed dry weights compared to the no-manure composting in both main treatments; **BPE6** and **BPEC** (**Table 2**), tree growth was very much improved by manure composting process. In addition to the positive effects of composting [2,3], it enhances microbial activity and accelerates rates of decomposition, leading to a humification effect through which the unstable organic matter is oxidized and stabilized [21].

The response of tree volume to the main treatments varied among fruit tree species (**Table 4**). Tree volumes were significantly increased within four to five months of planting in peach and pear in the first growing seasons in **BPE6** and **BPEC**, and in response to the main treatment **BPEC** in olives as compared to **NO BPE**, but were numerically higher in the **BPE6**. Greater tree volumes were due to the BPE cover in addition to the manure composting effect.

The response of tree volume to different manure treatments (**Table 5**) was evident during summer in all tree species, but significantly larger in peach and olives, and was numerically smaller in the check subplots. However, pear branching was more upright and the trees grew in height rather than in width.

The response to composting each manure type was much more variable among the tree species, but there was no clear trend in response to specific manure in any of the tree species among the main treatments. In general, subplots where manure was composted produced larger tree volumes than the check subplots with no-manure application (**Table 6**).

In conclusion, covering the tree line at planting with BPE reduces weeds and improves tree growth, especially if BPE cover was retained during spring and summer after planting. Composted fresh animal manures under BPE cover increased tree growth. If the applied fresh manures were not composted, the weed growth will be increased tremendously. The variable response of different tree species to different treatments of manure composting is more likely to be due to the variability of different species nutrient requirements and or growth habit. Olives, as evergreen species with relatively longer growing season, may require larger amounts of nutrients and water compared to peach and pear. It is also due to the different interference levels from different weed populations. As not all weeds are sensitive to either BPE cover with or without manure, certain weeds tolerate this treatment and continue to grow at faster rates in the absence of interference of the BPE cover-sensitive weeds.

The positive effects of manure application on the growth of trees is a common phenomenon, as manures provide nutrients [22] to the trees and increase the soil aggrega-

Table 4. Grand means of tree volumes in response to BPE covers.

Main treatments	Tree volume estimates*					
	Peach		Pear		Olive	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
BPE6	7.2 a	8.1 b	5.1 b	5.8 b	6.2 ab	7.7 ab
BPEC	7.9 a	8.8 a	7.0 a	7.9 a	6.8 a	7.8 a
NO BPE	5.0 b	7.1 c	3.9 c	4.4 c	6.0 b	7.1 b

*Means within columns carrying the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test.

Table 5. Grand means of tree volumes in various manure treatments.

Manure types	Tree volumes estimates*					
	Peach		Pear		Olive	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sheep	6.8 a	8.4 ab	5.1 bc	5.9 a	6.4 a	8.0 a
Broiler	6.9 a	9.0 a	5.6 ab	6.1 a	6.7 a	8.0 a
Cow	6.2 a	8.0 b	5.2 bc	6.1 a	6.6 a	8.0 a
Layer	7.2 a	8.6 ab	6.0 a	6.4 a	6.5 a	8.0 a
Check	6.4 a	6.2 c	4.8 c	5.8 a	5.5 b	6.4 b

*Means within columns carrying the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test.

Table 6. Effect of interactive combination of manure amendment X manure type on mean tree volumes.

Main treatments	Manure Types	Mean tree volumes estimates*					
		Peach		Pear		Olive	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
BPE6	Sheep	7.2 ab	9.4 a	5.8 cde	6.3 cdef	6.0 ab	7.4 abc
	Broiler	7.9 ab	9.2 a	6.1 bcd	6.6 cde	6.2 ab	8.6 ab
	Cow	7.1 ab	7.7 bcde	4.8 def	5.8 defg	6.6 a	8.2 abc
	Layer	7.1 ab	8.6 abc	4.4 ef	5.0 fgh	6.3 a	7.7 abc
	Check	6.6 abc	5.7 f	4.6 ef	5.4 efg	6.0 ab	6.8 cd
BPEC	Sheep	8.2 ab	8.9 ab	6.0 cd	7.6 bc	7.0 a	8.9 a
	Broiler	7.8 ab	9.3 a	6.9 bc	7.4 bc	6.7 a	7.3 abcd
	Cow	7.2 ab	9.2 a	7.4 ab	8.1 ab	7.1 a	7.8 abc
	Layer	8.5 a	9.7 a	8.7 a	9.2 a	7.3 a	8.6 ab
	Check	7.7 ab	7.1 cdef	6.0 cd	7.1 bcd	5.9 ab	6.7 cd
NO BPE	Sheep	4. 9 cd	6.9 ef	3.6 e	3.7 h	6.2 ab	7.8 abc
	Broiler	4.9 cd	8.4 abcd	3.9 e	4.3 gh	7.2 a	8.0 abc
	Cow	4.2 d	7.0 def	3.3 e	4.3 gh	6.1 ab	7.1 bcd
	Layer	6.1 bcd	7.6 bcde	4.8 cde	5.1 efgh	5.9 ab	7.2 abcd
	Check	4.8 cd	5.8 f	3.8 e	4.8 gh	4.7 b	5.7 d

*Means within columns carrying the same letter are not significantly different at 5% level of probability according to Duncan's Multiple Range Test.

tion, improve soil structure and texture and improve water holding capacity [2,3]. However, if fresh manures were applied to the soil without composting process, the local environment would suffer from the side effects such as increasing weed populations and intensifying competition with the trees for the essential growth resources [13], and increasing housefly problems [23]. Preplant or autumn composting of fresh manures without being covered with BPE offer a solution as nutrient source, and alleviate the problem of weeds, houseflies and other ill effects that application of fresh manure may bring about [5].

REFERENCES

[1] A. Clemente, R. Sánchez-Vioque, J. Vioque, J. Bautista and F. Millán, "Chemical Composition of Extracted Dried Olive Pomaces Containing Two and Three Phases," *Food Biotech*, Vol. 11, 1997, pp. 273-291. doi:10.1080/08905439709549936

[2] P. J. Brandjes, J. de Wit, H. G. van der Meer and H. Van Keulen, "Environmental Impact of Animal Manure Management," International Agriculture Centre, Wageningen, 1996. http://www.fao.org/WAIRDOCS/LEAD/X6113E/x6113e05.htm#2%20Manure%20management%20and%20effects%20of%20manure%20on%20the%20environment

[3] P. L'Hermite, P. Sequi and J. H. Voorburg, "Scientific Basis for Environmentally Safe and Efficient Management of Livestock Farming," *Report of the Scientific Committee of the European Conference Environment*, Agriculture and Stock Farming in Europe, European Conference, Mantova, Mantua, 1993.

[4] R. W. Crosskey and R. P. Lane, "House-Flies, Blowflies, and Their Allies (Calyptrate Diptera)," In: R. P. Lane and R. W. Crosskey, Eds., *Medical Insects and Arachnids*, Chapman and Hall, London, 1993, pp. 403-428. doi:10.1007/978-94-011-1554-4_11

[5] A. M. Abu-Rayyan, B. E. Abu-Irmaileh and M. M. Akkawi, "Manure Composting Reduces House Fly Population," *Journal of Agricultural Safety and Health of ASABE*, Vol. 16, No. 2, 2010, pp. 99-110.

[6] M. A. Ross and C. A. Lembi, "Applied Weed Science," 2nd Edition, Prentice Hall, New Jersey, 1999, pp. 1-22.

[7] K. H. Linke, M. C. Saxena, J. Sauerborn and H. Masri, "Effect of Soil Solarization on the Yield of Food Legumes and on Pest Control," In: J. E. De Vay, J. J. Stapleton and C. L. Elmore, Eds., *Soil Solarization, Proceedings of the* 1*st International Conference on Soil Solarization*, Amman, 19-25 February, 1990, *FAO Plant Production and Protection Paper* # 109. Rome, 1991, pp. 139-154.

[8] B. E. Abu-Irmaileh and A. Abu-Rayyan, "In-Row Preplant Manure Composting Reduces Weed Populations," *HortScience*, Vol. 39, No. 6, 2004, pp. 1456-1460.

[9] S. J. Brown, "Manure Composting: A Solution to Dealing with Stricter Environmental Regulations," *Sustainable Farming*: *Resource Efficient Agricultural Production*, Ste-Anne-de-Bellevue, McGill University, Ecological Agriculture Projects, Quebec, 1995. http://www.eap.mcgill.ca/MagRack/SF/Winter%2095%20E.htm

[10] E. Hammill and M. Murphy, "Alternate Methods of Manure Treatment and Utilization," *Guidelines for Management for Prince Edward Island*, P.E.I. Department of Agriculture and Forestry and P.E.I. Department of Technology and Environment, Manitoba, 1999. <http://www.gov.mb.ca/agriculture/livestock/pork/swine/bah11s01.html

[11] B. E. Abu-Irmaileh and A. S. El Kady, "Some Factors Affecting Pest Control in Jordan," *Arab Journal of Plant Protection*, Vol. 15, No. 1, 1997, pp. 24-30

[12] S. E. Azrag, "Future Trends in Agricultural Production within the Arab Countries," *Proceedings in FAO Improved Weed Management in the Near East*. *Proceedings of FAO Expert Consultation on Improved Weed Management in the Near East*, *FAO Plant Production and Protection Paper* #80, Nicosia, 30 October-1 November 1985, pp. 5-15.

[13] R. Parker and B. E. Abu-Irmaileh, "Weed Control Manual for the Jordan Valley," University of Jordan Publication, Amman, 1987.

[14] B. E. Abu-Irmaileh and U. A. R. Saghir, "Components of Successful Weed Management with Special Reference to Vegetable Growers in the Near East," *FAO Plant Protection Bulletin*, *Paper No*. 30, 683/B, Vol. 42, No. 4, 1994, pp. 191-200.

[15] A. M. Abu-Rayyan and B. E. Abu Irmaileh. "Efficiency of Fermenting Poultry Manure for Weed Control in Organically Grown Eggplants (*Solanum melongena* L.)," *Arab Journal of Plant Protection*, Vol. 22, No. 1, 2004, pp. 35-40.

[16] B. A. Majek, P. E. Neary and D. F. Polk, "Smooth Pigweed Interference in Newly Planted Peach Trees," *Journal of Production Agriculture*, Vol. 6, No. 2, 1993, pp. 244-246.

[17] S. C. Weller, W. A. Skroch and T. J. Monaco, "Common Bermuda Grass (*Cynodon dactylon*) Interference in Newly Planted Peach (*Prunus persica*) Trees," *Weed Science*, Vol. 33, 1985, pp. 50-56.

[18] S. A. S. "Statistical Analysis System," Version 7, Licensed to North Carolina State University, Site # 0027-585007, SAS Institute. Inc., Cary, 1998.

[19] E. Bahman and G. W. Lesoing, "Viability of Weed Seeds Following Manure Composting," Tektran, USDA-ARS, 1999. http://www.nal.usda.gov/ttic/tektran/data/000010/47/0000104751.html.

[20] L. C. Standifer, P. W. Wilson and R. Porche-Sorbet, "Effects of Solarization on Soil Weed Seed Population," *Weed Science*, Vol. 32, 1984, pp. 569-573.

[21] C. Elvira, L. Sampedro, E. Benitez and R. Nogales, "Vermicomposting of Sludges from Paper Mill and Dairy Industries with *Eisenia Andrei*," *A Pilot-Scale Study*, *Bioresource Technology*, Vol. 63, 1998, pp. 205-211. doi:10.1016/S0960-8524(97)00145-4

[22] F. M. Bradley and B. W. Ellis, "Rodale's All-New Encyclopedia of Organic Gardening. The Indispensable Resource for Every Gardener," Rodale Books, Emmaus, 1993.

[23] N. A. Romiah and H. M. Elmosa, "A Cultural Method for Controlling the House Fly *Musca domestica* (Diptera: Muscidae) and Studying Certain Aspects of Its Biology in the Jordan Valley," MSc. Thesis, University of Jordan, Amman, 1996.

