Earth-Kind® Vegetable Production in the Home Garden Using Mushroom and City Compost

Joseph G. Masabni^{1,3} and S. Alan Walters²

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SUMMARY. A field study was conducted in 2010 and 2011 to determine the suitability of Earth-Kind® production principles for home vegetable gardening. Earth-Kind® production encourages water and energy conservation, and reduction of fertilizer and pesticide use. Seven vegetable cultivars [Sweet Banana and bell pepper (*Capsicum annuum*); Celebrity and Juliet tomato (*Solanum lycopersicum*); Spacemaster cucumber (*Cucumis sativus*); Ichiban eggplant (*Solanum melongena*); Spineless Beauty zucchini (*Cucurbita pepo*)] were grown in mushroom compost (MC) or city compost (CC). Both composts were incorporated preplant into the soil with shredded wood mulch placed over them. In each year, nitrogen (N) fertilizer (15.5N-0P-0K from calcium nitrate) was applied preplant to CC plots to bring initial soil fertility levels similar to MC plots. No additional fertilizer was applied during the growing season. Drip irrigation was supplemented weekly. One application each of neem oil and pyrethrin (organic insecticides) and chlorothalonil (synthetic fungicide) was applied before harvest in 2010, but none was applied in 2011. Results indicated that Earth-Kind® technique could be effectively implemented in a home vegetable garden. MC is better suited for Earth-Kind® vegetable production than CC for some vegetables. Banana pepper, bell pepper, and zucchini had twice the yield in MC plots when compared with CC plots. No yield differences ($P > 0.05$) were observed between composts for tomato, eggplant, or cucumber. With proper irrigation and soil preparation practices such as addition of compost and mulch, Earth-Kind® vegetable gardening techniques can be used for selected vegetable crops without additional N fertilizer or pesticides. Furthermore, Earth-Kind® vegetable gardening can be successful as long as the home gardener understands that low yields may result from using this production method. However, often the home gardener is more concerned about producing vegetables using sustainable, environmentally friendly methods than maximizing yields.

Vegetable production on small-acreage farms has been gaining popularity in urban or near-large urban cities in recent years and account for 91% of all farms (U.S. Department of Agriculture, 2007). Low-input production practices are an attractive option for many vegetable growers as they can obtain premium prices for their products in the marketplace with lower overall operation costs. Several studies have compared high- and low-input vegetable production systems for profitability. Precheur et al. (2000) determined that reduced inputs for pumpkin (*Cucurbita maxima*) production can be profitable for wholesale markets, but not for retail markets where high-quality pumpkins are expected. For tomato, no differences were detected

in economic returns among systems at one location, although a higher return occurred in the conventional system at another location (Creamer et al., 1996). Reiners et al. (1992) also observed lower total tomato yield but greater fruit size in a transitional organic system, compared with either a high or reduced chemical input production system. Kaval (2004) indicated that some crops, such as eggplant, performed better in conventional production systems, while others, such as potato (*Solanum tuberosum*) and tomato, did better in organic systems.

Earth-Kind® concept

The concept of Earth-Kind® was pioneered by the Department of Horticultural Sciences at Texas A&M University. The objective of Earth-Kind® is to combine the best of organic and traditional gardening principles to create a horticultural system based on real world effectiveness and environmental responsibility. Earth-Kind® encourages water and energy conservation, and reductions in fertilizer and pesticide use, as well as reductions in the amount of wastes entering landfills. Extension publications on various topics addressing Earth-Kind® concepts are available at Texas A&M University Department of Horticultural Sciences Earth-Kind® website (Texas A&M University, 2013).

Earth-Kind home vegetable gardening

The popularity of Earth-Kind® rose (*Rosa* sp.) production and the parallel rise in vegetable gardening led to the evaluation of the Earth-Kind® production concepts for home vegetable gardening (Collart et al., 2010). However, most vegetables are annual crops and the principles of the multi-year protocol for Earth-Kind® rose production are not applicable in vegetables. Therefore, a new protocol was designed, adhering to the basic principles of Earth-Kind® including proper soil preparation and plant establishment, and reduced pesticide, water, and fertilizer inputs.

The protocol developed for Earth-Kind® vegetable production includes: 1) an annual soil test; 2) incorporating a 4 to 6-inch layer of compost before planting; 3) preferential use of organic pesticides, but chemical pesticides are accepted; 4) no pesticide application after the onset of harvest; and 5) chemical fertilizer use is accepted only as a preplant application to meet soil analysis recommendations.

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.3048	ft	m	3.2808
9.3540	gal/acre	L·ha ⁻¹	0.1069
2.54	inch(es)	cm	0.3937
1.1209	lb/acre	kg·ha ⁻¹	0.8922
28.3495	oz	g	0.0353
33.9057	oz/yd ²	g·m ⁻²	0.0295
1	ppm	mg·L ⁻¹	1
6.8948	psi	kPa	0.1450
0.8361	yard ²	m ²	1.1960

¹Department of Horticultural Sciences, 2134 Texas A&M University, College Station, TX 77843-2134

²Department of Plant, Soil, and Agricultural Systems, Southern Illinois University, Carbondale, IL 62901-4415

³Corresponding author. E-mail: jmasabni@ag.tamu.edu.

In south-central Texas, two compost sources are available for homeowner use, namely MC and CC. Since the early 1990s, MC has been sold mostly to homeowners, as commercial vegetable growers find the price and transportation costs prohibitive. Since CC is most often developed from plant or tree debris, it is widely available near major cities and municipalities. The use of MC in vegetable production has been evaluated by Wang et al. (1984), Rhoads and Olson (1995), and Stephens et al. (1990), among others, and these studies generally indicate improved soil physical properties and increased crop yields with its application. Although past research has evaluated vegetable production using CC and MC, no study has evaluated integrating reduced inputs with MC or CC, or attempted to adopt the concept of Earth-Kind for vegetable production. Thus, the objective of this study was to determine the potential of Earth-Kind protocol for home vegetable gardening.

Materials and methods

A field study was conducted at the Texas A&M University Horticultural Farm in College Station (lat. 30°37'N, long. 96°22'W) in 2010 and 2011 on a Robco loamy fine sand (Loamy, siliceous, active, thermic Aquic arenic Paleustalfs). The field soil had a pH of 7.8, available N, phosphorus (P), and potassium (K) of 14, 1203, and 437 ppm, respectively, and an organic matter (OM) content of 1.8%. The experiment was set up as a split-plot design in a randomized complete block with three replications. Compost type (CC or MC) was the main plot and seven vegetable cultivars were subplots (cucumber, eggplant, banana and bell pepper, tomato, cherry tomato, and zucchini). The MC and CC were obtained from All American Stone and Turf, College Station, TX, and Brazos Valley Recycling, College Station, TX, respectively. Nutrient analyses of the two compost materials are presented in Table 1.

A well-tilled, clod-free seedbed was prepared by rototilling the field twice. A 4- to 6-inch layer of CC or MC was spread over the respective plots and incorporated twice to a depth of 6 to 7 inches to ensure proper mixing. After incorporating

the compost, six soil samples (one from each CC and MC main plot) were collected and sent to the Texas A&M University soil testing laboratory for analysis. Soil test results indicated that N levels were lower in the plots amended with CC than with MC, in both years of this study (Table 1). On the basis of available N and expected N release from OM (Garcia, 2008), an excess of 81 lb/acre N was calculated in soils amended with MC compared with CC (Table 2). Therefore, 81 lb/acre N from ammonium nitrate was broadcast and incorporated in the CC main plots, before planting, to equalize initial N fertility between the two compost treatments.

Fifteen centimeters high-raised beds with drip irrigation were prepared using a bedder/plastic layer (model 2212-D; Buckeye Tractor Co., Columbus Grove, OH). Center-to-center row spacing was 5 ft and individual plots were 11 ft long. The vegetable crop cultivars used in this research represent those commonly available at garden centers near College Station, TX (Table 3). Most vegetable crops were transplanted using a water-wheel setter (model 2216, Buckeye Tractor Co.), except for zucchini that was

seeded by hand. The in-row plant spacing was 4 inches for cucumber, 1 ft for pepper, and 2 ft for eggplant, tomato, and zucchini squash (Masabni, 2011a, 2011b, 2011c, 2011d; Masabni and Lillard, 2011). Plants were seeded/transplanted into the field on 31 Mar. 2010 and 9 Mar. 2011.

In 2010, 70% neem oil at 0.78% v:v (Green Light Neem Concentrate; Scott's Miracle-Gro Co., Marysville, OH) and pyrethrin at 0.26% v:v (Bonide 857 Pyrethrin Spray Concentrate; Bonide Products, Oriskany, NY) were applied on 13 and 20 Apr., respectively. Only one application of nonorganic fungicide chlorothalonil at 0.26% [v:v (Bravo WeatherStick, Syngenta Crop Protection, Greensboro, NC)] was applied on 30 May 2010. Because of the dry weather conditions in 2011, no pesticides were deemed necessary. Pesticides were applied using a carbon dioxide (CO₂)-pressurized backpack sprayer with a four-nozzle boom using 11002 flat-fan spray tips (TeeJet Technologies, Wheaton, IL) at 30 psi in 24 gal/acre.

Plots were irrigated several times per week using drip irrigation (10.7 and 21.6 inches of water was applied by 1 July 2010 and 2011, respectively).

Table 1. Nutrient content of mushroom and city compost treatments used in the Earth-Kind® vegetable crop evaluation in College Station, TX, during 2010. Similar nutrient values were obtained in 2011.

Nutrient	Mushroom compost	City compost
	(ppm) ^z	
Nitrate	90	67
Phosphate	912	603
Potassium	683	1,565
Calcium	3,770	5,239
Magnesium	338	358
Sulfur	106	557
pH	6.7	7.4
Organic matter	16.1%	14.3%

^z1 ppm = 1 mg·L⁻¹.

Table 2. Nitrogen (N) amounts required to equalize soil nitrogen content between mushroom and city compost treatments before transplanting vegetable crops in College Station, TX, during 2010.

N amount	Available N		Excess available N in mushroom	
	Mushroom compost	City compost	compost (lb/acre)	
	(ppm) ^z	(lb/acre) ^z	(ppm)	(lb/acre)
Available N	90	180	67	134
ENR ^y	—	322	—	287
Total available N		502		421
				81

^z1 ppm = 1 mg·L⁻¹, 1 lb/acre = 1.1209 kg·ha⁻¹.

^yEstimated N release (ENR) = organic matter [OM (%)] × 20 lb/acre N (Garcia, 2008); mushroom compost = 16.1% OM, city compost = 14.3% OM.

No additional fertilizer was applied during the growing season. Crops were harvested multiple times during the growing season in both years. The experiment was harvested between 20 May and 1 July 2010, and 2 May and 12 July 2011. The bell pepper plants were harvested 8 and 9 times during 2010 and 2011, respectively; the plants for 'Celebrity' tomato were harvested 7 and 14 times in 2010 and 2011, respectively; and 'Juliet' cherry tomato plants were harvested 9 and 18 times during 2010 and 2011, respectively. The other vegetable crops had the same number of harvests for both years, namely, 'Sweet Banana' pepper (10 harvests), 'Spacemaster' cucumber (12 harvests), 'Ichiban' eggplant (14 harvests), and 'Spineless Beauty' zucchini (14 harvests).

For each vegetable crop, fruit number and weight (grams) per plot were collected at each harvest. Data were subjected to analysis of variance followed by Student's *t* test at $P \leq 0.05$ using JMP software (version 10.0; SAS Institute, Cary, NC) appropriate for a split-plot experimental design to determine the effects of the compost treatments on yield of the seven vegetable crops. Data were not pooled across years for analysis since statistical interactions between year and compost treatments were detected ($P \leq 0.05$). For each crop, Student's *t* test was used to separate treatment differences at $P \leq 0.05$.

Results and discussion

YEAR EFFECT. The 2011 growing season was extremely hot and harvest began earlier compared with 2010; however, no differences ($P > 0.05$) in fruit number or weight were observed between the 2 years for most vegetable crops evaluated, except for 'Juliet' cherry tomato with higher fruit number and weight in 2010 and 'Spacemaster' cucumber with higher fruit weight in 2011 (Table 3). Fruit pollination in tomato is reduced at elevated night temperatures (Levy and St. Clair, 1992; Peet and Sato, 2000), which is the likely cause for lower 'Juliet' cherry tomato yields in 2011. 'Juliet' cherry tomato appears more sensitive to hot, dry summers than 'Celebrity' tomato. Both fruit number and weight of 'Juliet' cherry tomato were significantly lower in 2011 than in 2010. However, fruit number and weight of 'Celebrity' tomato did

not differ between the 2 years. There was no effect of temperature on pollination or fruit set in cucumber in 2011 since that growing season provided higher fruit weights compared with 2010.

COMPOST EFFECT. Mushroom compost resulted in higher fruit number and weight for the two pepper cultivars and zucchini compared with CC (Table 4). Several studies have indicated that the application of MC in vegetable production has generally increased yields (Rhoads and Olson, 1995; Stephens et al., 1990; Wang et al., 1984). However, no yield differences were detected between MC and CC plots for cucumber, eggplant, or either tomato cultivar. Considering that initial soil nitrogen fertility levels were equal between MC and CC treatments, it appears that other factors may have contributed to the higher yields of pepper and zucchini.

A possible cause is that N may have been released more slowly from the MC throughout the growing season, which was more advantageous for the pepper and zucchini, while the CC released most of the available N in a larger initial dose.

Conclusion

This research provided a home vegetable gardening protocol using Earth-Kind® principles. This protocol was developed to allow the home vegetable gardener to become more environmentally responsible and sustainable through input reduction and soil quality improvement. Earth-Kind® vegetable gardening is a concept developed for home vegetable gardening with a focus on reducing pesticide and fertilizer applications. Water reductions are generally not feasible in Earth-Kind® vegetable gardening as yields are strongly influenced by volume of

Table 3. Effect of growing season on total fruit number and weight for seven vegetable crops at College Station, TX, combined for both mushroom and city compost treatments.

Vegetable crop	Fruit (no.) ^z		Fruit wt (g) ^z	
	2010	2011	2010	2011
'Sweet Banana' pepper	12.6 a ^y	10.5 a	220 a	193 a
Unknown bell pepper	3.6 a	3.9 a	179 a	203 a
'Celebrity' tomato	3.9 a	3.5 a	522 a	493 a
'Juliet' Cherry tomato	52.9 a	30.5 b	817 a	456 b
'Spacemaster' cucumber	7.4 a	7.9 a	1006 b	1405 a
'Ichiban' eggplant	3.0 a	2.7 a	290 a	332 a
'Spineless Beauty' zucchini	2.8 a	2.1 a	845 a	902 a

^zYields are based on 3-yard² (2.5 m²) plots; 1 g per 3-yard² plot = 0.4 g·m⁻² = 0.0118 oz/yard², 1 g = 0.0353 oz. Depending on the specific vegetable, crops were harvested between 7 and 14 times in 2010, and 9 and 18 times in 2011.

^yWithin vegetable cultivar, means followed by the same letters are not significantly different at $P < 0.05$ using Student's *t* test.

Table 4. Effect of mushroom compost or city compost on total fruit number and weight per harvest of seven vegetable crops at College Station, TX, combined over 2010 and 2011.

Vegetable crop	Fruit (no.) ^z		Fruit wt (g) ^z	
	Mushroom compost	City compost	Mushroom compost	City compost
'Sweet Banana' pepper	14.3 a ^y	8.8 b	269 a	144 b
Unknown bell pepper	4.5 a	3.0 b	247 a	134 b
'Celebrity' tomato	3.7 a	3.6 a	499 a	516 a
'Juliet' Cherry tomato	47.9 a	5.5 a	726 a	550 a
'Spacemaster' cucumber	7.7 a	7.6 a	1189 a	1222 a
'Ichiban' eggplant	3.2 a	2.5 a	345 a	277 a
'Spineless Beauty' zucchini	3.2 a	1.6 b	1170 a	578 b

^zYields are based on 3-yard² (2.5 m²) plots at each harvest; 1 g per 3-yard² plot = 0.4 g·m⁻² = 0.0118 oz/yard², 1 g = 0.0353 oz. Depending on the specific vegetable, crops were harvested between 7 and 14 times in 2010, and 9 and 18 times in 2011.

^yWithin vegetable cultivar, means followed by the same letters are not significantly different at $P < 0.05$ using Student's *t* test.

water applied (Doorenbos and Kassam, 1979; Stockle et al., 1994). Adhering to Earth-Kind® vegetable gardening concept by reducing fertilizer use is possible with MC. Vegetable crop yields in MC, without any initial addition of nitrogen fertilizer, were similar to or higher compared with those grown in CC. Bell and banana peppers, as well as zucchini, had higher yields when grown with MC than in CC. It is also important to note that pesticide use was minimal in this experiment with no significant disease or insect outbreaks occurring. It is important to remember that the cultivars used in this experiment are old standards or open pollinated cultivars, commonly sold at garden centers, and do not have the potential yield of new hybrids used by commercial growers. Earth-Kind® vegetable gardening can be successful as long as home gardeners understand that low yields may result from using this production method. Home gardeners must decide whether reduced yields due to reduced inputs are acceptable to their needs. Home gardeners often times are more concerned about producing vegetables using sustainable, environmentally friendly methods than maximizing yields. Also, most home gardeners are more concerned about producing vegetables from their garden as a hobby rather than an income potential. Furthermore, Behe et al. (2013) determined that consumers are becoming more interested in and purchasing products that are locally grown and/or ecologically friendly.

Literature cited

- Behe, B.K., B.L. Campbell, C.R. Hall, H. Khachatryan, J.H. Dennis, and C. Yue. 2013. Consumer preferences for local and sustainable plant production characteristics. *HortScience* 48:200–208.
- Collart, A.J., M.A. Palma, and C.R. Hall. 2010. Branding awareness and willingness-to-pay associated with the Texas Superstar™ and Earth-Kind™ brands in Texas. *HortScience* 45:1226–1231.
- Creamer, N.G., M.A. Bennett, B.R. Stinner, and J. Cardina. 1996. A comparison of four processing tomato production systems differing in cover crop and chemical inputs. *J. Amer. Soc. Hort. Sci.* 121:559–568.
- Doorenbos, J. and A.H. Kassam. 1979. Yield response to water. Food and Agricultural Organization of the United Nations, Rome, Italy.
- Garcia, R. 2008. Integrated cropping systems and water management handbook (AGRO-76). Section 9i-Developing a basic Nitrogen Budget. 18 Jan. 2013. <http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/NM_IWM_Field_Manual/Section09/9i-Developing_basic_Nitrogen_Budget.pdf>.
- Kaval, P. 2004. The profitability of alternative cropping systems: A review of the literature. *J. Sustain. Agr.* 23(3):47–65.
- Levy, J.G. and D.A. St. Clair. 1992. Pollen viability and vigor in tomato plants under high temperatures. *HortScience* 27:683 (abstr.).
- Masabni, J.G. 2011a. Bell pepper. 4 Apr. 2013. <<http://aggie-horticulture.tamu.edu/vegetable/files/2011/10/pepper-Bell.pdf>>.
- Masabni, J.G. 2011b. Eggplant. 4 Apr. 2013. <<http://aggie-horticulture.tamu.edu/vegetable/files/2011/10/eggplant.pdf>>.
- Masabni, J.G. 2011c. Squash. 4 Apr. 2013. <<http://aggie-horticulture.tamu.edu/vegetable/files/2011/10/squash.pdf>>.
- Masabni, J.G. 2011d. Tomato. 4 Apr. 2013. <<http://aggie-horticulture.tamu.edu/vegetable/files/2011/10/tomato.pdf>>.
- Masabni, J.G. and P. Lillard. 2011. Cucumber (slicing). 4 Apr. 2013. <<http://aggie-horticulture.tamu.edu/vegetable/files/2011/10/slicers.pdf>>.
- Peet, M.M. and S. Sato. 2000. Physiological factors limiting tomato fruit set at moderately elevated temperatures. *HortScience* 35:497–498.
- Precheur, R.J., B. Bergefurd, T. Harker, R.M. Riedel, and C. Welty. 2000. Comparison of high- and low-input production schemes in pumpkins. *HortScience* 35:440 (abstr.).
- Reiners, S., R.G. Brumfield, and D.J. Probst. 1992. Three alternative tomato production systems. *HortScience* 27:662–663.
- Rhoads, F.M. and S.M. Olson. 1995. Crop production with mushroom compost. *Proc. Soil Crop Sci. Soc. Fla.* 54:53–57.
- Stephens, J.M., D.L. Bennett, B.F. Castro, and G.C. Henry. 1990. Mushroom compost as a soil amendment for vegetable gardens. *Proc. Florida State Hort. Soc.* 102:108–111.
- Stockle, C.O., S.A. Martin, and G.S. Campbell. 1994. CropSyst, a cropping systems simulation model: Water/nitrogen budgets and crop yield. *Agr. Syst.* 46(3):335–359.
- Texas, A&M. University. 2013. Earth-Kind® landscaping. 4 Feb. 2013. <<http://aggie-horticulture.tamu.edu/earthkind>>.
- U.S. Department of Agriculture. 2007. Small farms. 13 Feb. 2013. <http://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Fact_Sheets/Farm_Numbers/small_farm.pdf>.
- Wang, S.H.L., V.I. Lohr, and D.L. Coffey. 1984. Spent mushroom compost as a soil amendment for vegetables. *J. Amer. Soc. Hort. Sci.* 109:698–702.