Sustainable Crop Management Practices for Improving Production of Culinary Herbs in the Virgin Islands

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Abstract

Small-scale vegetable growers in the Virgin Islands rely on sales of culinary herbs as one major source of income. In spite of the economic importance, culinary herbs are available only in local markets and do not constitute a significant export crop. There is little research information on sustainable crop management practices to improve production and marketing of herbs in the Virgin Islands. This project was undertaken to develop sustainable soil and crop management practices for culinary herbs using crop rotation with green manures, application of composts, animal manures, and mulching. Over a four-year period (1997-2000), results indicated that although there were no significant differences in fresh and dry matter yield, culinary herbs grown in rotation with tropical green manure crops such as sunnhemp (*Crotolaria juncea*) and hyacinth bean (*Lablab purpureus*) tended to produce higher yields than those grown with cowpea (*Vigna unguiculata*) or fallow (no green manure) suggesting that without chemical fertilizers, legume green manure crops can sustain economic yield levels of culinary herbs in a crop rotation system. Organic mulches such as grass straw, wood chips and shredded paper were excellent alternatives to synthetic (plastic) mulch. Additionally, organic mulch suppressed weeds, increased irrigation water use efficiency, reduced soil surface erosion, and improved economic returns. Yield of thyme (*Thymus vulgaris)* was improved by application of chicken manure, but application of either cow manure or turkey litter did not influence yield of chive (*Allium schoenoprasum*), cilantro (*Coriandrum sativum),* parsley (*Petroselinum sativum*), sweet marjoram (*Majorana hortensis*) and thyme.

INTRODUCTION

Culinary herbs are aromatic plants grown and marketed fresh or dry, or dried for their extractable oils (Simon, 1990). Significant quantities of dried culinary herbs are imported annually into the U.S. Estimates by the USDA Foreign Agricultural Service showed that more than $349 million of dried condiments, seasonings and flavorings and $20 million of spice oleoresins were imported into the U.S. in 1988 (USDA, 1989). In recent years, consumption of culinary herbs and spices has steadily increased in the U.S. More Americans are consuming fresh, frozen, processed and dried culinary herbs and spices than before, and this trend will continue (Simon, 1990). Factors that account for increased consumption include interest in new foods and tastes, availability of more fresh herbs, advertising promotion by food services and institutional food chains, and expanding ethnic population demanding foods and flavorings of their homeland.

Although the U.S. Virgin Islands is part of the Caribbean region, domestic production of culinary herbs does not contribute significantly to exports into the U.S. mainland. Major exporting countries are Costa Rica, the Dominican Republic, Jamaica, Mexico and Trinidad. Culinary herbs are important horticultural crops in the U.S. Virgin Islands. In a 1988 survey, sales of herbs and spices constitute a major source of income for many small-scale growers in St. Thomas and St. Croix (Robles and French, 1988). In spite of their economic importance little research has been undertaken to improve field production, processing and marketing of herbs and spices. There are few research information and extension recommendation on efficient and sustainable cropping practices for growing herbs in the Virgin Islands. Some growers are already utilizing low-input management practices such as the use of organic manures and composts, however, most are still producing herbs using high inputs of chemical fertilizers and pesticides (Palada and Crossman, 1994). This management practice is neither ecologically sound nor sustainable since these inputs are not always available in a distant island. Furthermore, growers pay high costs for importing these inputs from the mainland due to added shipping costs. There is a demand from herb growers for information on recommended sustainable crop management practices, but is not met by extension service and the experiment station due to lack of research information. Information on sustainable and improved crop management practices for culinary herb production is scanty. Documented literatures on planting methods, fertilizer application, water requirement, weed, insect and disease control are few and limited. Some of the previous studies were focused on fertilizer application, irrigation and mulching. For example, integration of mulch with drip irrigation resulted in additional increase in water use efficiency and yield of basil (Palada et al., 1992; 1995). By adopting this system, herb growers can boost their income by 30 to 50 percent. Palada et al. (1993) reported that basil grown with organic mulch such as compost produced yields which were comparable or higher than synthetic (black plastic) mulch under drip irrigation. Davis (1994) found that the incidence of bacterial soft rot (*Erwinia spp*.) was highest in sweet and bush basil grown with wheat straw, but the disease was also high on sweet basil under black plastic mulch and bare ground.

The effect of organic and inorganic fertilizers on yield of Japanese mint was studied by Chattopadhyay et al. (1993). They reported that herbage, essential oil yield, nutrient uptake and soil available nutrients were significantly enhanced due to application of amended compost (mint-residue amended with starter nutrients, microbial culture and soil suspension) as compared to non-amended compost, farmyard manure and inorganic fertilizer. Organic fertilized soils maintained significantly higher available nutrients throughout the crop growth period compared to inorganic fertilizer soils. Palada et al. (1994) compared the effects of organic and inorganic N fertilizers on yield of thyme and found that urea and cow manure were superior to ammonium nitrate in terms of total plant fresh yield. They concluded that urea and cow manure are best sources of N fertilizer for thyme production.

This project was undertaken with the following objectives: 1) develop sustainable soil management practices for culinary herb production using crop rotation with green manures, application of composts, animal manures and other organic fertilizers; and 2) evaluate sustainable weed management methods for culinary herbs using organic mulches, cover crops, and biodegradable synthetic mulches.

MATERIALS AND METHODS

Field experiments were conducted during the project period from 1996 to 2000. Experiments were established on research stations and on farmer cooperators' farm.

Crop Rotation of Culinary Herbs with Tropical Legume Green Manures

Field experiments were conducted at the University of the Virgin Islands Agricultural Experiment Station on St. Croix. The soil is Fredensborg loamy, fine carbonatic, iso-hyperthermic, shallow, typic calciustoll. The initial soil had an analysis of pH=7.65, organic matter=1.4 %, 38 ppm N, 487 ppm K, 19 ppm P, and a CEC of 30 meq/100 g. The experimental design was randomized complete block with three replications. The green manures consisted of sunnhemp (*Crotolaria juncea*), cowpea (*Vigna unguiculata* var. *Sesquepedalis*), hyacinth bean (*Lablab purpureus*) and a natural grass/broadleaf fallow. The green manure crops were established in June, 1996 and 1997. In each year the green manure crops were mowed in October and incorporated into the soil with disk plowing. In the natural fallow plots, the area was mowed whenever the grass/broadleaf mix reached their reproductive growth stage. The final mowing and incorporation in the natural fallow plots were performed to coincide with the green manure plots. Plant samples of green manure crops were collected for determination of dry matter and nutrient yield. Seedlings of chive, basil, parsley, sage and cilantro were transplanted in December, 1996 and 1997. Plot size for each herb species was 1.5 m x 4 m, consisting of three rows spaced 0.5 m apart. Plants were spaced 0.30 m along the row. All plots were drip-irrigated to maintain soil moisture tension at -30 kPa. At harvest, data was collected on plant height (5 plants in center row). The same plants were sampled for data on fresh and dry weight. Plant samples were placed in an oven at 65 ^{o}C and dried to constant weight for dry matter determination. Data were analyzed using the Statistical Analysis procedures (SAS, 1988). Differences among treatment means were separated using the Duncan's Multiple Range Test.

Response of Culinary Herbs to Application of Animal Manures

Separate experiments were conducted to determine the yield response of chive, cilantro, sweet marjoram and thyme to animal manures. For chive, cow manure (2 % N, 1 % P and 2 % K) was applied at rates of 0, 10, 20 and 40 t ha^{-1}. Cilantro, sweet marjoram and thyme were applied with turkey litter at rates equivalent to 0, 50, 100 and 150 N kg ha^{-1}. In a separate on-farm trial, thyme was fertilized with dry chicken manure at rates of 0, 5 and 10 t ha^{-1}. All trials were established using a randomized complete block design with four replications. Plots consisted of three rows 3 m long. Data were collected on plant height at first harvest, number of slips (for chive), plant fresh and dry weight. Measurements were taken from 10 plants in the middle row. The experiments using turkey litter on chive, cilantro, sweet marjoram and thyme were conducted in farmers' field and on experiment station, while the trial on thyme applied with chicken manure was conducted on farmer's field.

Sustainable Weed Management Practices Using Organic and Synthetic Mulches

Over a four-year period, five separate experiments were conducted to evaluate the benefits of organic and synthetic mulches for culinary herbs. These trials evaluated various mulches including black fabric (weed barrier), silver-coated plastic, white-on-black plastic, grass straw, wood chips, and shredded paper on chive and parsley; black plastic, white-on-black plastic, grass straw, wood chip and weed block for basil; and grass straw, wood chips, shredded paper, and white-on-black plastic on thyme. For comparison, a bare (no mulch) control plot was included in all experiments. The trials were conducted both in farmers's field and on experiment station. All plots were drip irrigated to maintain a soil moisture tension of -30 kPa. Data on plant height, fresh and dry matter yields were collected at each harvest. Weed population and weed weight were determined before each weeding operation.

RESULTS AND DISCUSSION

Crop Rotation of Culinary Herbs with Tropical Legume Green Manures

Significant differences were observed in dry matter yield of green manure crops in both years. As shown in Table 1, sunnhemp was superior to hyacinth bean and cowpea, producing 10.97 and 13.12 t ha^{-1} in 1996 and 1997, respectively. Hyacinth bean produced significantly higher dry matter yield than cowpea in 1997. Sunnhemp produced a dry matter yield which was 50 to 75 % higher than hyacinth bean and cowpea (Table 1). Both sunnhemp and hyacinth bean look promising as green manure crops in the Virgin Islands.

Data on Table 2 show the nutrient content and contribution of green manure crops in 1997. In terms of nitrogen, sunnhemp produced significantly higher N yield (457 kg ha^{-1}) than cowpea and hyacinth bean. The N yield of hyacinth bean was also significantly higher than cowpea. Sunnhemp and hyacinth bean also produced higher P and K than cowpea. Highest calcium was obtained from hyacinth bean. No significant differences were observed for magnesium yield among the green manure crops (Table 3), but sunnhemp and hyacinth bean had a higher Mg yield than cowpea. The data suggest that sunnhemp and hyacinth bean may contribute significant amount of major nutrients for soil fertility improvement.

1. Green Manure Effect on Chive. The green manure treatments did not significantly influence fresh and dry matter yield (Table 3). However, data showed that in both years, fresh yield was highest for chive grown after hyacinth bean (1.81 and 2.79 kg m^{-2}, respectively). Chive grown after fallow (no green manure) produced the lowest fresh and dry matter yield, except in 1998 where chive grown after cowpea produced the lowest fresh yield (Table 3). It appears that green manures have potential for improving yield of chive.

2. Green Manure Effect on Cilantro. In one season trial, the effect of green manure rotation on fresh and dry matter yield was not significant (Table 3). However, it was apparent that both hyacinth bean and sunnhemp have positive effects on fresh and dry matter yield of cilantro. Yields from this rotation were higher compared to cowpea and fallow rotations. Cilantro planted after hyacinth bean and sunnhemp produced 20-50 % more fresh yield than cowpea and fallow rotation (Table 3). Hyacinth bean and sunnhemp are therefore promising green manures for cilantro production.

3. Green Manure Effect on Parsley. Two types of parsley were planted in the trial. In 1997, an upright stem parsley was used while a curled leaf parsley was planted in 1998. Data shown in Table 3 indicate significant differences in fresh yield in1997 but not in 1998. Highest yield (1.80 kg m^{-2}) was produced when parsley was planted after sunnhemp, while the lowest yield (1.12 kg m^{-2}) was obtained from cowpea rotation. No significant differences were observed in dry matter yield in 1997. In 1998, both fresh and dry matter yield of parsley were not affected by green manure rotation, however, all green manure crops resulted in higher fresh and dry matter yield of curled leaf parsley (Table 3). The data would suggest that parsley can benefit from green manure rotation.

4. Green Manure Effect on Sage. In one season trial, sage grown after sunnhemp produced significantly higher yield than the other rotation treatments (Table 3). Both fresh plant and dry matter yields of sage following sunnhemp were superior to cowpea, hyacinth bean and fallow rotations. Sunnhemp increased sage fresh yield by 50-60 % and dry yield by 39-54 % (Table 3). Sunnhemp therefore is the best green manure crop for rotation with sage.

5. Green Manure Effect on Sweet Basil. In 1997 no significant differences were obtained for fresh and dry matter yield of sweet basil as influenced by green manures (Table 3). However, basil grown after cowpea produced higher fresh yield than the other treatments. Hyacinth bean produced the lowest fresh and dry basil yield. Basil grown after hyacinth bean and sunnhemp produced the highest fresh and dry matter yield. This indicates that these green manure crops may have beneficial long term effects on basil production.

Response of Culinary Herbs to Application of Animal Manures

1. Chive Response to Cow Manure. Plant height, number of slips and fresh yield of chive were not significantly increased by application of cow manure at rates of 0, 10, 20 and 40 $t.ha^{-1}$ (Table 4). However, there was a tendency for plant height and number of slips to increase with increasing levels of cow manure.

2. Response of Cilantro, Sweet Marjoram and Thyme to Turkey Litter. Application of turkey litter at rates equivalent to 0, 50, 100 and 150 kg N ha^{-1} did not significantly influence the yield of cilantro, sweet marjoram and thyme (Table 5). However, for sweet marjoram there was a tendency for yield to increase with N application up to 150 kg ha^{-1}. For cilantro and thyme maximum yield was attained with turkey litter application equivalent to 100 kg ha^{1}.

The absence of significant response to animal manures can be attributed to the relatively high soil organic matter content (>4 %) and residual nutrient levels in the VI Department of Agriculture plots where the trials were conducted.

3. Effect of Chicken Manure on Yield of Thyme. The response of thyme to application of chicken manure under farmer's field conditions was significant (Table 6). Thyme plant fresh weight, dry weight, leaf and stem dry weight were significantly increased with application of 10 t ha^{-1}. At this application rate, fresh and dry weight of plants, leaves and stems were significantly higher than 0 and 5.0 t ha^{-1} application rate. It appears that chicken manure is favorable for thyme.

Sustainable Weed Management Practices Using Organic and Synthetic Mulches

1. Parsley. Parsley plant height was significantly affected by application of mulches. Plants in the straw mulch were consistently taller than other mulch treatments. Data on Table 7 show that plants in grass straw mulch produced significantly taller plants than other mulch treatments except the control. Significant differences in yield were observed during the third harvest (Table 7). Parsley grown with grass straw mulch produced a significantly higher fresh (811 g m^{-2}) and dry (141 g m^{-2}) compared to parsley grown under black fabric (weed barrier) and white plastic mulch, respectively. However, differences in total fresh and dry weight were not significant, although parsley under grass straw maintained higher fresh and dry weight than all other treatments (Table 7).

Weed population was significantly higher in bare soil (no mulch) treatment than all mulched plots (Table 8). Fresh and dry weed biomass (weight) were almost similar for all mulch treatments, but significantly lower than the control (bare soil). The plots were weeded on a regular basis which prevented weeds from getting big enough to accumulate any appreciable biomass.

A combination of rainfall and high temperature caused the mulch to lose its silver coating on a large percentage. This caused light penetration through the transparent areas of the mulch and contributed to a high weed population under the plastic mulch. The mulch also started to deteriorate before the trial was terminated. A root knot nematode problem also developed during the latter stages of the trial. The loss of plants caused by this pest ranged from 40 % (silver mulch) to 17 % in the straw and bare soil (no mulch) treatments. This higher nematode infestation in the synthetic mulch would probably indicate that these mulches create a micro-environment that is ideal for the development of nematodes.

2. Chives. All types of mulch were effective in controlling weeds (Table 9). Differences in weed count, fresh and dry weight of weeds between mulched plots and the bare soil (control) were significant, indicating that mulches are very effective in reducing weed growth. Significant differences were also observed in plant height and fresh yield of chive (Table 10). Chives grown under grass straw mulch were taller and have higher yield than those grown with other mulches. All mulching materials maintained integrity except for the silver film. Deterioration of the silver plastic film was observed similar to that in the parsley trial. This indicates that towards the end of the trial its effectiveness in controlling weeds may be reduced.

3. Sweet Basil. Basil plants grown in plots with grass straw mulch were significantly taller than plants grown with other mulch types (Table 11). Plant fresh weight of basil under grass straw mulch was superior to other treatments and significantly higher than plants with no mulch (Table 11). Leaf fresh yield of basil with grass straw mulch was also significantly greater than other mulch types except the weed block. Differences in dry weight of plants and leaf were also significant among mulch types with grass straw showing the highest dry weight (Table 12). All types of mulch significantly reduced the number and biomass of weeds compared with the no-mulch (bare) treatment (Table 13). Among mulch types, wood chips was the most effective in controlling weeds in terms of number and biomass. Grass straw mulch was as effective in controlling weeds as synthetic mulches.

CONCLUSIONS

Based on the results from studies conducted over the four-year period, the use of green manures grown in rotation with culinary herbs demonstrates their potential for improving yield without the need for fertilizer application. In nutrient-poor soils, animal manures are good alternatives to chemical fertilizers and will have an economic impact for small-scale herb growers in the Virgin Islands. Promising results from the use of organic mulches will have a greater impact on weed control thereby reducing labor input mainly by hand weeding. The studies demonstrated the benefits of using sustainable crop management practices for culinary herb production such as utilization of local resources for management of soil fertility, reducing crop-weed competition and decreasing irrigation water use. Further research is needed on pest management addressing major insect pests and diseases of culinary herbs.

This study has shown that organic mulches such as grass straw and wood chips were similarly effective in controlling weeds as synthetic mulches. Mulching with organic mulches, therefore, has the potential of increasing marketable yield.

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Tables

Table 1. Dry matter yield of tropical green manure crops grown in rotation with culinary herbs.

Green Manure	Total Dry Matter (t ha^{-1}) 1996	1997
Cowpea (V. unguiculata)	2.55 b	3.54 c
Hyacinth Bean (Lablab purpureus)	4.11 b	7.79 b
Sunnhemp (Crotolaria juncea)	10.97 a	13.12 a

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.0.5$).

Table 2. Nutrient yield of green manure crops.

Green Manure	Nutrient Yield (kg ha^{-1}) N	P	K	Ca	Mg
Cowpea	125 c	6.69 b	65.9 b	110.5 b	17.5 a
Hyacinth Bean	277 b	13.37 ab	155.65 a	229.9 a	25.9 a
Sunnhemp	457 a	16.74 a	181.39 a	151.2 b	33.5 a

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.05$).

Table 3. Fresh and dry weight of culinary herbs grown in rotation with tropical green manures.

Green Manure	Basil Fwt Dwt	Chive Fwt Dwt	Cilantro Fwt Dwt	Parsley Fwt Dwt	Sage Fwt Dwt
1997	kg m^{-2}	kg m^{-2}	kg m^{-2}	kg m^{-2}	kg m^{-2}
Cowpea	2.32a 0.32a	1.68a 0.24a	- -	1.12b 0.18a	- -
H. bean	1.88a 0.24a	1.81a 0.25a	- -	1.35ab 0.21a	- -
Sunnhemp	2.13a 0.27a	1.65a 0.21a	- -	1.80a 0.24a	- -
Fallow	2.04a 0.28a	1.25a 0.16a	- -	1.49ab 0.23a	- -
1998	kg m^{-2}	kg m^{-2}	kg m^{-2}	kg m^{-2}	kg m^{-2}
Cowpea	3.59a 0.58a	2.24a 0.54a	0.92a 0.14a	0.29a 0.07a	0.37b 0.07b
H. bean	4.16a 0.82a	2.79a 0.45a	1.14a 0.16a	0.44a 0.10a	0.47b 0.09b
Sunnhemp	4.14a 0.63a	2.42a 0.45a	1.37a 0.19a	0.37a 0.08a	0.84a 0.15a
Fallow	3.96a 0.62a	2.47a 0.39a	0.79a 0.12a	0.22a 0.05a	0.41b 0.08b

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.05$).

Table 4. Response of chive to levels of cow manure application. VI Department of Agriculture, St. Croix.

Cow manure (t ha^{-1})	Plant height (cm)	Number of slips per plant	Fresh yield (g/plot)
0	52	4.18	1490
10	53	3.88	1541
20	54	4.98	1479
40	56	5.33	1462

Table 5. Yield response of cilantro, sweet marjoram and thyme to levels of turkey litter application. VI Department of Agriculture, St. Croix.

Nitrogen ($kg\ ha^{-1}$)	Cilantro*** (yield, g/plot)	Sweet Marjoram* (yield, g/plot)	Thyme** (yield, g/plot)
0	5454	1457	5873
50	5931	1436	5985
100	6131	1509	6043
150	6019	1632	5924

* 1 harvest; ** 2 harvests; *** 3 harvests.

Table 6. Response of thyme to chicken manure in farmer's field. Estate Bordeaux, St. Thomas, Virgin Islands.

Chicken manure ($t\ ha^{-1}$)	Fresh wt. (g/plt)	Dry wt. (g/plt)	Leaf dry wt. (g/plt)	Stem dry wt. (g/plt)
0	12.93 b	4.40 b	2.99 b	1.24 b
5	17.68 b	5.95 b	4.13 ab	2.05 ab
10	25.33 a	8.70 a	5.40 a	3.09 a

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.05$).

Table 7. Plant height, fresh and dry weight of parsley grown with various mulches in the Virgin Islands, 1997.

Mulch Type	Plant ht. (cm)	Fresh wt.[1] ($g\ m^{-2}$)	Dry wt.[1] ($g\ m^{-2}$)	Total Fresh wt. ($g\ m^{-2}$)	Total Dry wt. ($g\ m^{-2}$)
Bare	24.4 ab	639 ab	127 ab	1589	296
Black Fabric	23.7 b	321 b	79 ab	1266	243
Silver Plastic	23.2 b	479 ab	94 ab	1264	226
Grass Straw	27.5 a	811 a	141 a	1895	317
White Plastic	23.8 b	394 ab	48 b	1209	207

[1] Third harvest only. Within columns, means followed by different letters are significantly different by Duncan's Multiple Range Test ($P \leq 0.05$).

Table 8. Weed population and biomass in parsley plots as affected by types of mulching material, St. Croix, Virgin Islands, 1996-97.

Mulch Type	Weed Count (no.m^{-2})	Fresh Weight (g m^{-2})	Dry Weight (g m^{-2})
Bare	154 a	560 a	139 a
Black Fabric	19 b	39 c	6 b
Silver Plastic	39 b	197 b	40 b
White Plastic	16 b	22 c	5 b
Grass Straw	30 b	56 bc	11 b

Mean separation in columns by Duncan's Multiple Range Test ($P \leq 0.05$).

Table 9. Weed count, weed fresh and dry weight from chive plots grown with various mulches. St. Croix, Virgin Islands.

Mulch Type	Number of weeds (no. m^{-2})	Weed fresh weight (g m^{-2})	Weed dry weight (g m^{-2})
Bare	256 a	936 a	233 a
Black fabric	32 c	65 c	11 b
Silver Plastic	62 b	329 b	67 b
Grass straw	48 bc	94 bc	19 b
White Plastic	27 c	38 c	7 b

Mean separation in columns by Duncan’s Multiple Range Test, ($P \leq 0.05$).

Table 10. Plant height, number of tillers and fresh yield of chive grown under various types of mulching materials. St. Croix, Virgin Islands, 1996-97.

Mulch Type	Plant Height (cm)	No. of tillers/plant	Fresh Yield (t.ha^{-1})
Bare	43.6 c	6.05 a	8.63 b
Black Fabric	49.4 ab	8.20 a	12.31 ab
Silver Plastic	46.0 bc	7.75 a	11.81 ab
White Plastic	40.7 c	7.95 a	9.83 b
Grass Straw	51.8 a	7.40 a	15.17 a

Within columns, means followed by different letters are significantly different by Duncan's Multiple Range Test, ($P \leq 0.05$).

Table 11. Plant height, total fresh weight of plants and leaves of sweet basil as influenced by mulch type. Farmer's field, St. Thomas, Virgin Islands.

Mulch Type	Plant height (cm)	Total fresh weight (t ha^{-1})	Leaf fresh weight (t ha^{-1})
Grass straw	42.0 a	28.01 a	18.78 a
Black fabric	34.8 b	20.86 ab	13.88 b
Wood chip	34.7 b	20.91 ab	13.50 b
Weed block	33.7 b	22.60 ab	14.72 ab
White plastic	33.0 b	20.15 ab	13.72 b
Bare	31.8 b	14.85 b	10.15 b

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.05$).

Table 12. Sweet basil plant, leaf and stem dry weight as influenced by mulch type. Farmer's field, St. Thomas, Virgin Islands.

Mulch Type	Plant dry weight (kg ha^{-1})	Leaf dry weight (kg ha^{-1})	Stem dry weight (kg ha^{-1})
Grass straw	4485 a	2702 a	1783
Black fabric	3667 ab	2484 ab	1183
Wood chip	3799 ab	1905 b	1894
Weed block	4096 ab	2484 ab	1612
White plastic	3126 ab	1865 b	1261
Bare	2812 b	1684 b	1126

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.05$).

Table 13. Weed population and biomass in sweet basil plots as affected by mulch type. Farmer's field, St. Thomas, Virgin Islands.

Mulch Type	Weed count (no. m^{-1})	Weed fresh weight (g m^{-2})	Weed dry weight (g m^{-2})
Bare	869 a	1449 a	291 a
Black fabric	180 bc	496 b	31 b
White plastic	220 b	216 b	38 b
Weed block	124 bc	80 b	18 b
Grass straw	14 c	524 b	84 b
Wood chip	7 c	16 b	4 b

Mean separation in columns by Duncan's Multiple Range Test, ($P \leq 0.05$).