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GROWTH AND YIELD OF CHIVE AND PARSLEY GROWN IN ROTATION WITH TROPICAL GREEN MANURE CROPS IN THE VIRGIN ISLANDS

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ABSTRACT. A study was conducted to evaluate growth and yield response of chive (*Allium schoenoprasum*) and parsley (*Petroselinum sativum*) planted in rotation with three green manure crops: Cowpea (*Vigna unguiculata*), hyacinth bean (*Lablab purpureus*) and sunnhemp (*Crotolaria juncea*). Green manure crops were established in replicated plots in June, 1996 and mowed in October, 1996. Samples were taken to determine biomass yield. A natural fallow (grass/broadleaf) treatment was also included. Plots were disk plowed to incorporate green manures into the soil. Two months later (December, 1996), plots were prepared and seedlings of chive and parsley were transplanted into three rows, 4 m long. No fertilizer was applied to any of the plots. Plots were drip irrigated to maintain a soil moisture tension of 30 kPa. The trial used a randomized complete block design with 3 replications. Sunnhemp produced a significantly ($p<0.009$) higher dry biomass yield (10.97 $t.ha^{-1}$) than hyacinth bean (4.11 $t.ha^{-1}$) and cowpea (2.55 $t.ha^{-1}$). The data for the third harvest showed that parsley plants from the sunnhemp and hyacinth bean plots were significantly taller (22 cm) and the sunnhemp plots were also more productive (619 g/m^2) than from the cowpea and natural fallow plots. There were also significant differences for the total weight of parsley. No significant differences were observed between green manures as to their influence on plant height, fresh and dry matter yield of chive, however, the data showed that fresh yield was highest for chive grown after hyacinth bean (1807 g/m^2) and lowest for the cowpea (1247 g/m^2) treatment. Green manure crops had a significant effect on some yield parameters of both crops. This study indicates that during the initial stage, some culinary herbs can benefit when grown in rotation with green manure crops.

INTRODUCTION

Only a small percentage of the culinary herbs used in the U.S. are domestically produced. Most of the herbs consumed are imported from the Mediterranean region, Africa, Latin America and the Caribbean. The U.S. Virgin islands are a part of the Caribbean region, but domestic production of culinary herbs does not contribute to exports into the U.S. mainland. The major exporting countries are Costa Rica, Dominican Republic, Jamaica, Mexico and Trinidad.

The prospect of culinary herb production for fresh, frozen, processed and dried products is bright and there is potential for production in the U.S. Virgin Islands to meet local, regional and international demands. The U.S. Virgin Islands are an extremely popular tourist destination, hosting about 2 million tourists annually. It is predicted that attractively packaged, affordable local products like bush teas and bath herbs will appeal to many of the tourists. Other potential markets for culinary herbs are local restaurants, resort hotels and supermarkets. Expansion of herb and spice production through a greater understanding of production constraints and incorporation of appropriate sustainable management practices will economically benefit farmers, contribute to the viability of the local economy and satisfy consumer needs in the Caribbean and the U.S.

There is little documented literature on planting methods, fertilizer application, water requirements, and pest (weed, insect and disease) control. Fertilizer recommendations for culinary herbs are lacking and some recommendations are based on other crops which have similar growth characteristics. Simon (1987) suggested rates of 100-150 kg N/ha for leaf crops and 50-100 kg N/ha for seed crops. Other research with herbs has shown the need to apply fertilizer based on the specific plant needs and final product requirements (Bernath, 1986; Franz, 1983: Ruminska, 1978).

Results of fertilizer response studies conducted at the UVI Agricultural Experiment Station have established a range optimum N application rates for thyme, basil and marjoram grown in calcareous soils (Crossman and Collingwood, 1991; Collingwood et al., 1991; Palada and Crossman, 1994). The source of nitrogen was found to influence the production of thyme in the Virgin islands (Palada et al., 1994). Urea and cow manure were found to be the best sources of nitrogen for thyme production.

Agriculture is sustainable when it can evolve indefinitely toward greater human utility, greater efficiency of resource use, and a balance with the environment that is favorable both to humans and to most other species (Harwood, 1990). Sustainability has become a significant issue in the U.S. and internationally Brady (1990). There are concerns with the dangers of excessive chemical fertilizer and pesticide use. There is also a focus on the problems of soil and water conservation.

In sustainable agricultural crop production a popular method of providing nutrients to the crop is by using animal manures. A reluctance to the use of these materials is that they have to be transported and applied in large quantities, requiring high labor and energy costs. An alternative to animal manures can be the use of green manures which eliminates the need for transportation of bulky materials and can be easily incorporated into the soil.

When broadleaf crops are integrated into a cropping rotation they are believed to provide a number of productivity and sustainability benefits over the sole use of cereals and pastures (Lockie, et al., 1995). Crop rotations including leguminous species should be a basic component of any sustainable cropping system.

There is a general agreement that legumes contribute nitrogen to a succeeding crop. Two types of legumes can be used to improve soil fertility, primarily through nitrogen contribution: annual seed legumes and perennial forages used as green manure crops (Francis and Clegg, 1990). Yield increases of crops, cotton and maize in particular, when planted after various legumes have been reported by a number of researchers including Roder et al., 1989; Baldock and Musgrave, 1980; Hesterman et al., 1986; Gakale and Clegg, 1987.

The objectives of this study were to determine the effect of three green manure crops on the growth and yield of chives and parsley.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Experiment Station, University of the Virgin Islands on St. Croix. The soil is a Fredensborg loamy, fine carbonatic, isohyperthermic, shallow, typic calciustoll. The initial soil had an analysis of pH of 7.65, organic matter 1.4%, 38 ppm N, 487 ppm K, 19 ppm P, and a CEC of 30 meq/100g. The experimental design was randomized complete blocks with three replications. The green manures consisted of three legumes, sunnhemp (*Crotolaria juncea*), cowpea (*Vigna unguiculata* var. Sesquepedalis), hyacinth bean (*Lablab purpureus*) and a natural grass/broadleaf follow.

The green manure crops were established in June, 1996 then mowed and incorporated into the soil in October, 1996. In the natural fallow plots the area was mowed whenever the grasses reached their reproductive growth stage. The final mowing and incorporation in the natural fallow plots were performed to coincide with the green manure plots. The selected species of herbs were transplanted in December, 1996. The plot sizes for each herb species were 1.5 m x 4 m, consisting of three rows spaced 0.5 m apart. Plants were spaced 0.3 m along the rows. All plots were drip irrigated to maintain soil moisture tension at 30 kPa.

At harvest the height of 5 plants from the center row of each plot was measured. No inorganic fertilizer was applied to any of the plots. The parsley plants were cut back and the fresh weight of the leaves and petioles was determined. The entire plants of the chives were harvested and weighed, the number of tillers per plant was also recorded. All chive plots were immediately replanted with individual tillers following the harvest of the first crop of chive. The harvested materials of both chives and parsley were then placed in an oven at 65 °C and dried to constant weight for dry matter determination.

Table 1. Total fresh and dry matter yield (biomass) of three legume green manure crops grown in rotation with culinary herbs ($t.ha^{-1}$).

Green Manure	Total fresh yield	Total dry yield
Cowpea (*Vigna unguiculata*)	14.5	2.55 b [x]
Hyacinth bean (*Lablab purpureus*)	25.2	4.11 b
Sunnhemp (*Crotolaria juncea*)	29.2	10.97 a

[x] *Within columns, means followed by the different letters are significantly different by Duncan's multiple range test (P# 0.05).*

RESULTS AND DISCUSSION

Green Manure Crops: The data in Table 1 shows that the fresh yield of biomass produced by the green manure crops ranged from 29.2 $t.ha^{-1}$ (sunnhemp) to 14.5 $t.ha^{-1}$ (cowpea). Sunnhemp produced a significantly ($p<0.009$) higher dry biomass yield (10.97 $t.ha^{-1}$) than hyacinth bean (4.11 $t.ha^{-1}$) and cowpea (2.55 $t.ha^{-1}$). Biomass production was consistent with the size of the various green manure species.

Parsley: The data for the third harvest showed that parsley plants from the sunnhemp and hyacinth bean plots were significantly taller (22 cm) than from the cowpea and natural fallow plots (17 cm). The mean plant height for the four harvests was however, statistically similar for all treatments (Table 2). The taller parsley plants harvested from the sunnhemp plots during the third harvest were also more productive. This treatment had a fresh yield of 619 g/m^2 which was significantly higher than the yields from the natural fallow and cowpea plots of 342 and 294 g/m^2, respectively (Table 3). The data also shows (Table 3), that the total weight of fresh parsley produced (from all 4 harvests combined) was significantly higher from the sunnhemp treatment (1803 g/m^2) than from the cowpea plots, which produced 1124 g/m^2.

Table 2. Plant height (cm) of parsley grown in rotation with tropical green manure crops.

Green Manure	Harvest #1	Harvest #2	Harvest #3	Harvest #4	Mean Height
Cowpea	29	24	17 b^x	17	22
Fallow	30	25	17 b	15	22
Sunnhemp	27	27	22 a	18	24
Hyacinth Bean	30	26	22 a	15	23

^{x} *Within columns, means followed by the different letters are significantly different by Duncan's multiple range test (P# 0.05).*

The overall yield pattern for all treatments showed an increase from the first to the second harvest followed by a decline through the third and fourth harvests. The sunnhemp treatment however, continued the pattern of increased yields through the third harvest and the decline was also not as drastic for the hyacinth bean as for the fallow and cowpea treatments (Table 3). Even though there were significant differences in fresh yield, the dry matter produced by the parsley plants was not significantly influenced by the green manure treatments but the sunnhemp treatment tended to have a higher yield.

The higher amount of biomass incorporated into the soil from the sunnhemp in particular, possibly contributed to the sustained yields obtained through 3 harvests.

Table 3. Fresh weight (g/m^2) of parsley grown in rotation with tropical green manure crops.

Green Manure	Harvest #1	Harvest #2	Harvest #3	Harvest #4	Total Weight
Cowpea	308	391	294 b^x	131	1124 b
Fallow	414	514	342 b	228	1498 ab
Sunnhemp	342	572	619 a	270	1803 a
Hyacinth Bean	329	485	410 ab	121	1345 ab

^{x} *Within columns, means followed by the different letters are significantly different by Duncan's multiple range test (P# 0.05).*

Chives: The green manure treatments did not significantly influence plant height, fresh weight or dry matter yield of chives, however, the data (Table 4) showed that fresh yield was highest for chives grown after hyacinth bean (1807 g/m^2) and lowest for the cowpea (1247 g/m^2) treatment. The percent dry matter (13.7 %) of the first crop of chives from the cowpea treatment was significantly higher than for all of the other treatments. This did not result in a higher dry matter yield because of the low fresh yield obtained from the cowpea treatment. The number of tillers per plant (Table 5) from the second crop of chives in the sunnhemp plots (8.7) was significantly higher than from the fallow treatment (4.7). However, this did not translate into a significantly higher yield of chives from the sunnhemp when compared to the fallow treatment.

Table 4. Mean plant height (cm), total fresh and total dry weight of chives grown in rotation with tropical legume green manures (total of two harvests g/m^2).

Green Manure	Plant height	Total fresh wt.	Total dry wt.
Cowpea	44	1681	235
Fallow	40	1247	158
Sunnhemp	44	1652	214
Hyacinth bean	45	1807	252

Table 5. Number of tillers per plant produced by chives grown in rotation with tropical legume green manure crops.

Green Manure	Harvest #1	Harvest #2	Mean
Cowpea	6.8	6.3 ab [x]	6.6
Fallow	4.8	4.7 b	4.7
Sunnhemp	5.6	8.7 a	7.1
Hyacinth bean	6.3	5.3 ab	5.8

[x] *Within columns, means followed by the different letters are significantly different by Duncan's multiple range test (P# 0.05).*

The green manure crops had a significant effect on some yield parameters of both crops. The crop responses indicate that sunnhemp, which produced the highest biomass yield, has the potential to increase the production of fresh parsley particularly during the latter harvests of the crop. The relatively low production and lack of plant vigor in the second crop of chives was clearly evident that the green manure crops did not provide enough nutrients to sustain proper plant growth. There was clearly a need for supplemental fertilizer for this crop. The parsley also showed some symptoms of nutrient deficiencies during the latter harvests. This study has provided some good indications of how some culinary herbs can benefit in the initial stages when grown in rotation with green manure crops.

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