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PRODUCTION OF CULINARY HERBS IN ROTATION WITH GREEN MANURES IN THE VIRGIN ISLANDS[1]

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ABSTRACT. A study was conducted over two cropping seasons to evaluate the production of culinary herbs planted in rotation with legume green manure crops: cowpea (*Vigna unguiculata*), hyacinth bean (*Lablab purpureus*) and sunnhemp (*Crotolaria juncea*). Green manure crops were established in replicated plots in the summer of 1996 and 1997. In each year, the green manure crops were mowed in October and plots were disk-plowed to incorporate green manure residues into the soil. Two months later, plots were prepared for planting of culinary herbs including chive (*Allium schoenoprasum*), basil (*Ocimum basilicum*), parsley (*Petroselinum sativum*), sage (*Salvia officinalis*), and cilantro (*Coriandum sativum*). Each plot consisted of three rows, 4 m long. The trial used a randomized complete block design with three replications. Results in general showed that although there were no significant differences in plant fresh and dry matter yield, herbs grown in rotation with sunnhemp and hyacinth bean tended to produce higher yields than those grown with cowpea or fallow rotations. Basil and cilantro grown after sunnhemp and hyacinth bean produced taller plants than those grown after cowpea and fallow. Sage was benefitted by sunnhemp in terms of increased plant fresh and dry matter yield. The benefit of green manure rotations on growth and yield of parsley and chive was about the same. These results suggest that without chemical fertilizers, legume green manure crops, particularly sunnhemp and hyacinth bean, can increase yield of culinary herbs in a crop rotation system

INTRODUCTION

Green manures are crops which are grown either before or after the main crop. A green manure crop is a grass or legume which provides various benefits for soil improvement when incorporated into the soil at a certain growth stage. Green manures play an important role in sustainable agriculture and their use has been increasing in crop rotations. Green manures help protect against soil erosion, retain nutrients that might otherwise be leached from the soil, suppress germination and growth of weeds, recycle nutrients from the lower to the upper layers of the soil and in the case of legumes, contributes a considerable quantity of nitrogen (Coleman, 1989; Frye *et al.*, 1983; Palada *et al.*, 1983).

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The benefits of legume green manure crops have been widely recognized in major agronomic crops (Poincelot, 1986). For example, top yields of corn are possible with legumes supplemented by modest amounts of nitrogen fertilizer (Frye *et al.*, 1983). Yield increases of crops, cotton and maize in particular, have been reported when planted after various legumes (Roder *et al.*, 1989; Baldock and Musgrave, 1980; Hesterman *et al.*, 1986; Gakale and Clegg, 1987). The influence of legume green manure crops on culinary herbs has not been studied extensively. Culinary herbs might benefit when grown in rotation with green manure crops because their soil nutrient requirement is lower than major agronomic and vegetable crops. The use of green manures in crop rotation may appeal to organic herb growers who are reluctant to use chemical fertilizers. The objective of this study was to evaluate the production of major culinary herbs grown in rotation with legume green manure crops.

MATERIALS AND METHODS

Field experiments were conducted at the University of the Virgin Islands Agricultural Experiment Station on St. Croix. The soil is Fredensborg loamy, fine carbonatic, isohyperthermic, 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 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 were 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°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.

RESULTS AND DISCUSSION

Biomass and Nutrient Yield of Green Manure Crops. Significant differences were observed in dry matter yield of green manure crops in both years. As shown in Fig. 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 (Fig. 1). Both sunnhemp and hyacinth bean look promising as green manure crops in the Virgin Islands.

Data on Table 1 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 2), 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.

Green Manure Effect on Chive. The green manure treatments did not significantly influence plant height, fresh and dry matter yield (Table 2). However, data showed that in both years, fresh yield was highest for chive grown after hyacinth bean (1807 and 2786 g 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 2). It appears that green manures have potential for improving yield of chive.

Green Manure Effect on Sweet Basil. In 1997 no significant differences were obtained for plant height, 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. In 1998, significant differences in plant height was observed among green manure treatments. Tallest plants were observed when basil was grown after sunnhemp, however, this height was not significant compared with basil after fallow. 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.

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 4 indicate that plant height was not affected by green manure treatments in both types of parsley. Significant differences in fresh yield was only obtained in 1997 (Table 4). Highest yield (1803 g m^{-2}) was produced when parsley was planted after sunnhemp, while the lowest yield (1124 g 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 4). The data would suggest that parsley can benefit from green manure rotation.

Green Manure Effect on Purple Basil. There was no significant effect by green manure rotation on plant height, fresh and dry matter yield of purple basil on both years (Table 5). However, sunnhemp rotation consistently resulted in higher fresh and dry

matter yield than other rotation treatments. Purple basil planted after sunnhemp produced the highest fresh yield of 1065 and 1701 g m^{-2} in 1997 and 1998, respectively. Lowest yield was obtained from hyacinth bean rotation (Table 5). The data indicate that purple basil may benefit from sunnhemp rotation.

Green Manure Effect on Cilantro. The effect of green manure rotation on cilantro plant height, fresh and dry matter yield was not significant (Table 6). 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 6). Hyacinth bean and sunnhemp are therefore promising green manures for cilantro production.

Green Manure Effect on Sage. Sage grown after sunnhemp produced significantly higher yield than the other rotation treatments (Table 7). 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 7). Sunnhemp therefore is the best green manure crop for rotation with sage.

CONCLUSIONS

This study has shown that green manures grown in rotation with culinary herb have the potential of improving yields. Sunnhemp and hyacinth bean are green manure crops that showed positive benefits on basil, cilantro, and sage. Chive and parsley did not significantly benefit from green manures as indicated by almost similar plant fresh and dry matter yield. However, there was a consistent increase in yield when hyacinth bean and sunnhemp were grown in rotation with chive and parsley. The significant effect of sunnhemp and hyacinth bean on yield of culinary years can be attributed to their greater biomass production and nutrient contribution compared to cowpea and fallow rotations. Additional research is needed to determine the long term effect of green manures on soil fertility and crop yields.

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Table 1. 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 by Duncan's Multiple Range Test (p=0.05).

Table 2. Plant height, fresh and dry matter yield of chive grown in rotation with tropical green manures, 1997-98.

Green Manure	Plant Height (cm)		Fresh Yield (g m^{-2})		Dry Yield (g m^{-2})	
	1997	1998	1997	1998	1997	1998
Cowpea	44	28	1681 a	2244 a	235 a	542 a
Hyacinth Bean	45	35	1807 a	2786 a	252 a	450 a
Sunnhemp	44	36	1652 a	2416 a	214 a	447 a
Fallow	40	28	1247 a	2472 a	158 a	390 a

Mean separation by Duncan's Multiple Range Test (p=0.05).

Table 3. Plant height, fresh and dry matter yield of sweet basil grown in rotation with green manures, 1997-98.

Green Manure	Plant Height (cm)		Fresh Yield (g m^{-2})		Dry Yield (g m^{-2})	
	1997	1998	1997	1998	1997	1998
Cowpea	45	39 b	2319 a	3588 a	320 a	575 a
Hyacinth Bean	43	38 b	1876 a	4158 a	240 a	820 a
Sunnhemp	45	46 a	2132 a	4135 a	268 a	625 a
Fallow	48	41 ab	2044 a	3957 a	281 a	618 a

Mean separation in columns by Duncan's Multiple Range Test, (p=0.05).

Table 4. Plant height, fresh and dry matter yield of parsley grown in rotation with green manures, 1997-98.

Green Manure	Plant Height (cm)		Fresh Yield ($g\ m^{-2}$)		Dry Yield ($g\ m^{-2}$)	
	1997	1998	1997	1998	1997	1998
Cowpea	29	12.6	1124 b	298 a	179 a	65.8 a
Hyacinth Bean	30	12.9	1345 ab	442 a	206 a	98.8 a
Sunnhemp	27	12.5	1803 a	372 a	236 a	84.9 a
Fallow	30	12.7	1498 ab	215 a	229 a	49.6 a

Mean separation in columns by Duncan's Multiple Range Test, (p=0.05).

Table 5. Plant height, fresh and dry matter yield of purple basil grown in rotation with green manures, 1997-98.

Green Manure	Plant Height (cm)		Fresh Yield ($g\ m^{-2}$)		Dry Yield ($g\ m^{-2}$)	
	1997	1998	1997	1998	1997	1998
Cowpea	30	32	965 a	1504 a	121 a	264 a
Hyacinth Bean	31	30	915 a	1407 a	101 a	239 a
Sunnhemp	31	33	1065 a	1701 a	128 a	296 a
Fallow	31	33	940 a	1463 a	111 a	239 a

Mean separation in columns by Duncan's Multiple Range Test, (p=0.05).

Table 6. Plant height, fresh and dry matter yield of cilantro grown in rotation with green manures, 1998.

Green Manure	Plant Height (cm)	Fresh Yield ($g\ m^{-2}$)	Dry Yield ($g\ m^{-2}$)
Cowpea	22	924 a	135 a
Hyacinth Bean	25	1141 a	163 a
Sunnhemp	24	1374 a	191 a
Fallow	21	797 a	120 a

Mean separation in columns by Duncan's Multiple Range Test, (p=0.05)

Table 7. Plant height, fresh and dry matter yield of sage grown in rotation with green manures, 1998.

Green Manure	Plant Height (cm)	Fresh Yield ($g\ m^{-2}$)	Dry Yield ($g\ m^{-2}$)
Cowpea	20	365 b	68 b
Hyacinth Bean	19	473 b	91 b
Sunnhemp	21	835 a	149 a
Fallow	20	409 b	79 b