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GROWTH AND YIELD RESPONSE OF MALABAR SPINACH TO LEVELS OF DEHYDRATED COW MANURE APPLICATION

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ABSTRACT. A field experiment was conducted to determine growth and yield response of Malabar spinach (*Basella alba* L.) to various levels of cow manure application. Malabar spinach seedlings were transplanted in plots containing three rows 5.0 m long. Spacing was 1.0 m between rows and 0.5 m between plants in the row. Dehydrated cow manure (2%N, 1%P, 2%K) was soil-incorporated before planting at rates of 0, 10, 20, and 40 $t.ha^{-1}$. The trial used a randomized complete block design with four replications. Data on number of stems harvested, length of longest stem, total plant fresh and dry weights, leaf and stem fresh and dry weights, and leaf area index (LAI) were collected from each of the five harvests. All data were taken from a sample of five plants at each harvest. Results indicated significant response to levels of cow manure in terms of all measured parameters. Highly significant ($P<0.0001$) linear and quadratic responses to cow manure levels were observed in stem number and length, total plant, leaf, and stem fresh and dry weights. LAI response was both linear ($P<0.001$) and quadratic ($P<0.01$). Edible leaf fresh yield increased from 110.4 g $plant^{-1}$ at 0 t ha^{-1} to 306.8 g $plant^{-1}$ at 40 t ha^{-1} cow manure application. Optimum cow manure application rate for leaf yield is between 10 to 20 t ha^{-1}.

INTRODUCTION

Malabar spinach (*Basella spp.* L.) is also known as Ceylon spinach, vine spinach or Malabar nightshade of the family *Basellaceae*. It is a climbing perennial plant, mostly cultivated as an annual vegetable against a support of home gardens, but in some areas as a vine-like market vegetable without staking (Martin *et al.*, 1998; Oomen and Grubben, 1978; Winters, 1963). There are two common species of Malabar spinach, the red stem and leaves (*Basella rubra* L.) and the green leaves and white stem (*Basella alba* L.). Malabar spinach is not a true spinach, but its leaves, which form on a vine, resemble spinach and are used in the same way. The plant is native of India or Indonesia, and spread throughout the tropics, and is even used in the temperate zone as an annual crop. It is particularly abundant in India, Malaysia, and the Philippines, but is also seen throughout tropical Africa, the Caribbean, and tropical South America.

Malabar spinach has thick tender stems and the leaves are almost circular to ovate, alternate, and short petioled. They are thick, rugose, succulent, and colored from green to purple (Martin *et al.*, 1998; Winters, 1963). The flowers are borne on axillary spikes or branching peduncles are bisexual and inconspicuous. The fruits are fleshy and purplish black and the juice are sometimes used as a dye. The succulent young and mature leaves, and the stems are eaten. The most common method of cooking is as a pot herb, mixed with stew or other vegetables. On cooking, the green stem/leaf species retains its fresh green color. The red species loses much pigment to the water and is less attractive. The leaves have mild flavor or are almost tasteless. The stems may be somewhat bitter, and become gelatinous or mucilaginous especially when overcooked. Malabar spinach is a good source of vitamins A and C, calcium and iron (Martin *et al.*, 1998; Oomen and Grubben, 1978; Winters, 1963).

Although Malabar spinach is adapted to many soils, a sandy loam is most suitable. It can thrive under conditions of moderate soil fertility, but is quite responsive to nitrogen fertilizer. At the Agricultural Experiment Station's loamy soils, nitrogen application rate of 100 kg ha^{-1} can produce edible leaf yield of 344-385 g m^{-2} (Palada *et al.*, 1996; Palada and Crossman, 1998). In spite of its popularity as a leaf vegetable in many countries of the tropics, little research and development work have been focused on Malabar spinach. Not much studies have been reported on the response of Malabar spinach to organic and chemical fertilizers. Concerns about increasing nitrate accumulation in soil and plant tissues due to application of high levels of nitrogen from chemical fertilizers have prompted some vegetable growers to use organic fertilizers with relatively lower N content. Recommended levels or rate of cow manure application for Malabar spinach have not been established in the Virgin Islands. The objective of this study was to determine the growth and yield response of Malabar spinach to levels of cow manure application.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Experiment Station, University of the Virgin Islands on St. Croix (Lat. 17°42'N and long. 64°48'W). The soil is Fredensborg loamy, fine carbonatic, isohyperthermic, shallow, typic calciustolls. The initial soil analysis showed a soil pH of 7.60, organic matter content of 2.40%, 24 ppm total N, 17 ppm P, 462 ppm K, and a CEC of 26 meq/100 g. This analysis indicated low to medium N, low P, and very high K. The average annual rainfall is 1016 mm, but evapotranspiration exceeds precipitation resulting in a negative water balance.

Seeds of Malabar spinach (*Basella alba* L.) were sown in 72-cell Styrofoam trays containing Promix-BX. Seedlings were raised in greenhouse for 30 days and field planted on 18 May 1998. Dehydrated cow manure (2-1-2) was broadcast and incorporated into the soil three days before planting. Cow manure was applied at rates of 0,10, 20, and 40 t ha^{-1}. These rates are equivalent to 0,200, 400, and 800 kg N ha^{-1}; 0, 100, 200, and 400 kg P ha^{-1} and 0, 200, 400, and 800 kg K ha^{-1}. With a nitrogen release efficiency (NRE) rate of 50% for cow manure during the first year of application (Parnes, 1990), these rates correspond to 0, 100, 200, and 400 kg N ha^{-1}.

Plots were arranged in a randomized block design with 4 replications. Each plot had 3 rows, 5 m long. Rows were spaced 1 m and plants within rows were 0.50 m apart. All plots were drip-irrigated and soil moisture tension maintained at 30 kPa as determined by soil tensiometers installed 15 cm depth in each block.

Plants were harvested on 18 June, 14 July, 3 August, and 26 August, 1998. Harvest samples were taken from middle rows consisting of 5 plants each. For each harvest, number of stem harvested and length of the longest stem were measured. Total plant fresh weight was determined and leaves were separated from stem. Fresh weight of leaves and stem were recorded. Leaf area from 5 plants was measured using the CI-202 Area Meter (CID, Inc., Vancouver, WA). Data on leaf area were used to determine leaf area index (LAI). Stem and leaf samples were oven-dried to constant weight for determination of dry matter. Data were analyzed using the Statistical Analysis procedures (SAS, 1989) general linear model (GLM).

RESULTS AND DISCUSSION

Number and Length of Stem. Data on Table 1 show that the number of stems harvested and the length of the longest stem was significantly influenced by levels of cow manure application. The number of stems per plant increased from 4.64 at 0 t ha^{-1} to 10.72 at 40 t ha^{-1} cow manure application. This response was both linear ($P<0.0001$) and quadratic ($P<0.001$). The increase in the number of stems was greater from 0 to 20 t ha^{-1} application than from 10 to 20 t ha^{-1}. Additional application of 20 t ha^{-1} resulted in a slight increase in stem number. Similar response was observed for the length of the longest stem (Table 1). Stem length increased with increasing cow manure application up to 20 t ha^{-1}. The longest stem (107.9 cm) was measured at 40 t ha^{-1} application.

Plant, Leaf and Stem Fresh Weight. Total plant, leaf and stem fresh weight increased with increasing cow manure application (Table 1). Highest total fresh weight (582 g/plant) was attained at cow manure application of 40 t ha^{-1}. The response was both linear ($P<0.0001$) and quadratic ($P<0.0001$). Similar response was observed with leaf and stem fresh weight (Table 1). Highest leaf and stem fresh weight (306.8 and 275.5 g/plant, respectively) was attained at the highest rate of cow manure application. Generally, leaf fresh weight is higher than stem fresh weight resulting in a leaf/stem ratio >1. Although there is a significant linear and quadratic response to cow manure application the data suggest that optimum rate for fresh leaf production is between 10 and 20 t ha^{-1}. This rate is equivalent to 10-20 kg per 10 m^2 plot.

Plant, Leaf and Stem Dry Weight. Dry weight of plant, leaf and stem responded significantly to levels of cow manure application (Table 1). The response for these three parameters were both linear and quadratic. The increasing trend is similar to plant, leaf and stem fresh weight and leaf dry weight is higher than stem dry weight. Percent dry matter of leaf is greater than stem (data not shown) indicating that Malabar spinach stems are more succulent than leaves.

Leaf Area Index (LAI). The relationship between levels of cow manure application and leaf area index is shown in Table 1. There was a highly significant linear ($P<0.001$) response to cow manure application. LAI increased from 0.2909 at 0 t.ha^{-1} cow manure application to 0.6930 at 40 t ha^{-1} (Table 1). However, highest LAI of 0.7110 was attained at cow manure application of 10 t ha^{-1}. Application of cow manure significantly increased leaf area which in turn resulted in increased edible leaf fresh yield per unit area.

Leaf vegetables like Malabar spinach contain a large quantity of nutrients, which indicates that they remove large quantities of N, P, K and other minerals like Mg, Ca, and Fe. For example, a well-grown bed (10 m^2) of amaranth producing 25 kg of leaves and tops in 4 to 6 weeks may take up 125 g N, 25 g P, 290 g K, 75 g Ca, and 40 g Mg. This quantity of minerals can be replenished by adding one kg of dry cow manure, 15 kg of swine manure, 20 kg of municipal waste or 25 kg of compost (Oomen and Grubben, 1978). The rates of dehydrated cow manure used in our study are within the levels mentioned in the literature. However, our present study did not perform leaf tissue analysis for nutrient content which was beyond the scope of this study.

CONCLUSIONS

This study has shown that Malabar spinach responded to levels of cow manure application. Significant linear and quadratic responses were observed in number of stems harvested, length of longest stem, fresh weight of plant, leaf and stem as well as dry weight of plant, stem and leaf. Leaf area index significantly increased with increasing rate of cow manure application. For optimum fresh leaf yield and production an application rate of 10-20 t ha^{-1} is recommended for Virgin Islands. For small garden plots this is equivalent to 10-20 kg dry cow manure per 10 m^{-2} plot area.

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Table 1. Growth and yield response of Malabar spinach to levels of cow manure application.

Cow Manure (t ha^{-1})	Number of Stems per plant	Length of longest stem (cm)	Total Fresh Wt. (g/plant)	Fresh Wt. Leaves (g/plant)	Fresh Wt. Stem (g/plant)
0	4.64	55.7	175.1	110.4	66.5
10	8.64	90.0	462.2	247.6	221.0
20	10.20	107.9	550.4	285.0	264.3
40	10.72	105.0	582.3	306.8	275.5
Linear	***	***	***	***	***
Quadratic	**	***	***	***	***
Cubic	NS	NS	NS	NS	NS

Cow Manure (t ha^{-1})	Dry Wt. Leaves (g/plant)	Dry Wt. Stem (g/plant)	Total Dry Wt. (g/plant)	LAI
0	41.1	34.1	67.8	0.2909
10	83.5	72.9	153.1	0.7110
20	96.1	92.3	189.3	0.6185
40	97.2	92.7	191.0	0.6930
Linear	***	***	***	**
Quadratic	***	**	**	*
Cubic	NS	NS	NS	*

*** = Pr>F=0.0001; **=Pr>F=0.001; *=Pr>F=0.01; NS=not significant