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Michelle Mbia
Prairie View A&M University

Eric Obeng
Prairie View A&M University

Aruna Weerasooriya
Prairie View A&M University

Peter Ampim
Prairie View A&M University

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Cover Page Footnote

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The Effects of Fertilizer Rate on the Growth of Egyptian Spinach in a Greenhouse

Michelle Noah Mbia[1], Eric Obeng[2], Aruna Weerasooriya[1,2] and Peter A.Y. Ampim[1,2]

[1]Department of Agriculture Nutrition and Human Ecology

[2]Cooperative Agricultural Research Center

College of Agriculture and Human Sciences, Prairie View &M University

Corresponding Author

Peter A.Y. Ampim

Department of Agriculture

Nutrition and Human Ecology

Prairie View A&M University

P.O. Box 519; MS 2008

Prairie View, TX 77446

paampim@pvamu.edu

Abstract

Egyptian spinach (Corchorus olitorius, L.) is an annual herb and a popular vegetable grown in the dry, semi-arid and humid regions of Africa. It belongs to the American basswood family and is very nutritious, and known to have medicinal properties as well. Introducing Egyptian spinach as a specialty crop in Texas requires examining and determining the best cultural practices needed for its successful production. The objective of this study was to determine the effects of three nitrogen fertilizer rates on the growth of Egyptian spinach grown under greenhouse conditions. We hypothesized that the yield of Egyptian spinach will increase with increasing nitrogen fertilizer rate. Seedlings of equal sizes were transplanted six weeks after planting into 15 cm plastic containers with Sunshine Professional Growing Mix. The plants were fertilized weekly with a micronutrient (i.e. boron, copper, iron, manganese, molybdenum and zinc) containing fertilizer, All Purpose MiracleGro fertilizer [24-8-16], (Scotts Miracle-Gro Products Inc., Marysville, OH) at 94, 188, and 376 kg N ha-1 for about 4.5 months. Weekly harvesting of the fresh shoots and weighing commenced nine weeks after transplanting and continued for approximately nine additional weeks. At the conclusion of the study, the results showed that the 94 kg N ha-1 rate of MiracleGro provided a significantly higher shoot biomass yield than the other treatments. The results imply that fertilizing Egyptian spinach at the 94 kg N ha-1 fertilizer rate is the best way to optimize yields under similar growing conditions. The results also suggest that optimizing field production of Egyptian spinach may require supplementing soils with micronutrients.

Introduction

Egyptian spinach (*Corchorus olitorius*, L.) also called Jews mallow or jute mallow, is a popular vegetable that grows in the wild and is also widely cultivated in parts of Africa (Oboh et al.,2009; Musa et al., 2010), Asia (Oboh et al., 2009) and the Middle East (Islam, 2013). It is an erect annual herb that can grow up to 150 cm.

The leaf, which is the edible part, is mucilaginous like okra. Egyptian spinach is nutrient-rich, containing iron, calcium, thiamin, riboflavin, niacin, folate, protein, and dietary fiber. It also contains magnesium, vitamin C, E and β-carotene, galactose, galacturonic acid, glucose, glucuronic acid, and rhamnose (Fondio and Grubben, 2004; Ndiovu and Afolayan, 2008).

Egyptian spinach has several medicinal uses. It is a diuretic, demulcent, and can improve bowel movements (Ogunrinde and Fasinmirin, 2011; Musa et al., 2010). Documentation of its use for treating chronic cystitis, fever, gonorrhea, and tumor also exists (Oyedele et al., 2006; Zakaria et al., 2006). Ionone glucoside extraction from the leaf may inhibit the activities of histamines (Grubben, 2004). In addition to its nutritional and medicinal attributes, it produces jute fiber.

Research has shown that introducing new crops can provide food options for the growing population and increase farmer income. Notwithstanding, the successful introduction of a crop is dependent on adaptation to local production conditions (Prohens et al., 2003). Hence the need for research to determine best production practices includes identification and optimization of nutrient requirements under local conditions. There is a market for Egyptian spinach in Texas and beyond. Consumers eat both the fresh and dry forms of the leaves of Egyptian spinach; hence there is an opportunity to reduce post-harvest losses by drying the leaves. The objective of this study is to determine the effect of three fertilizer rates on the growth of Egyptian spinach grown under greenhouse conditions. The hypothesis is that the yield of Egyptian spinach will increase with increasing nitrogen fertilizer rate. The knowledge gained from this study will facilitate field trials of Egyptian spinach, especially cultivation in containers and raised beds in urban areas.

Materials and Methods

This study was carried out in a greenhouse at the school farm of Prairie View A&M University. Egyptian Spinach (a West African variety) was planted in a flat tray in June 2015 and raised into seedlings for transplanting. Six weeks after planting, seedlings of equal size were selected and transplanted into pots (15 cm wide) containing Sunshine

Professional Growing Mix (Sungro Horticulture, Agawam, MA). The seedlings were treated with All Purpose MiracleGro (24-8-16) fertilizer (Scotts Miracle-Gro Products Inc., Marysville, OH) at four rates: 94 kg N ha^{-1} (half the label rate), 188 kg N ha^{-1} (label rate or the recommended rate), 376 kg N ha^{-1} (twice the label rate) and water control/no fertilizer treatment. The label rate for All Purpose MiracleGro (24-8-16) fertilizer, which is 188 kg N ha^{-1}, is equivalent to one tablespoon of 24-8-16 per 3.785 L (i.e. 1 gallon) of water. The fertilizer treatments were arranged in a completely randomized design. Each treatment had five replicates. As a result, the transplants assigned to the various fertilizer treatments were arranged accordingly on the same greenhouse bench. The fertilizer was applied weekly for about 4.5 months. An equal volume (250 ml) of the treatment solutions were applied to their respective pots on a weekly basis. Watering of Egyptian Spinach was done by applying the same volume (250 ml) of water to all treatments when needed. The same growing conditions were maintained in the greenhouse for all the treatments during the entire growing season.

Harvesting was done on a weekly basis after two months (starting in late August 2015) by cutting the apical tender parts of the plants including leaves (referred to as fresh shoot or biomass in this paper). Biomass harvested was weighed to obtain fresh weight. At the end of the study, each remaining plant was harvested and separated into roots and shoots. The shoots were weighed to obtain shoot biomass yield. The roots were washed, dried with a paper towel, and weighed as well. An analysis of variance (ANOVA) was completed using JMP software (SAS Institute, NC). Treatment effects were considered significant at $P \leq 0.05$.

Results

Treatment effect on fresh root weight and shoot yield of Egyptian spinach

Fresh root weight for the 94 kg N ha-1 (1/2X) rate was significantly different from the other treatments. The 188 kg N ha-1 (X) and 376 N ha-1 (2X) fertilizer rate treatments were statistically the same, but the 188 kg N ha-1 rate was different from the control (WC) [Fig.1]. Average fresh root weight for the 94 kg N ha-1 rate was 27%, 41% and 61% greater than 188 kgN ha-1, 376 kg N ha-1 rate and control (WC) respectively. Fresh root weight of the 188 kg N ha-1 (X) rate was 46% greater than the control.

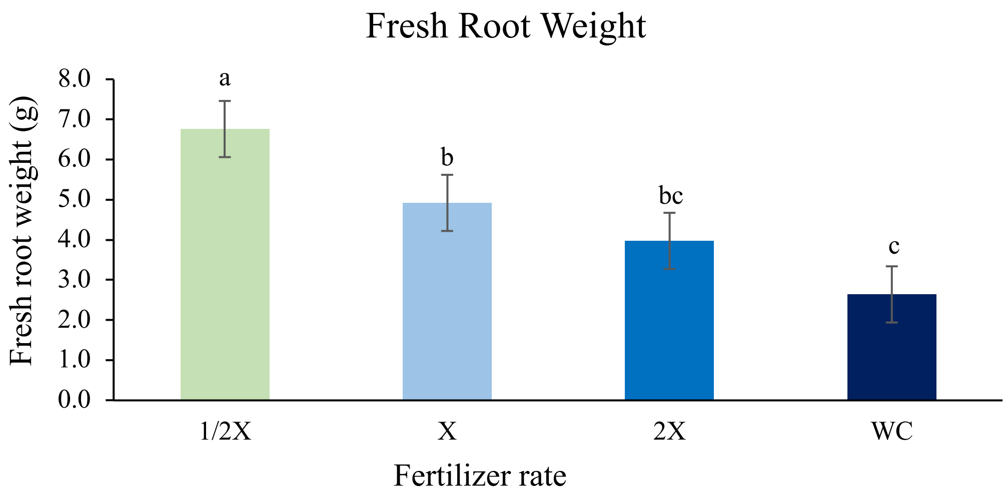

Figure 1. Effect of fertilizer rate on fresh root weight of Egyptian Spinach. *Each bar represents an average of five treatment replicates while the error bars represent standard errors of the mean. 1/2X = half the label rate (94 kg N ha^{-1}), X = label rate of fertilizer (188 kg N ha^{-1}), 2X = twice the label rate (376 kg N ha^{-1}), WC = water control or no fertilizer treatment. Bars with the same letter(s) are not significantly different from each other (P>0.05).*

The results for fresh shoot biomass followed a similar trend as fresh root weights. However, in this case, fresh shoot weights for all the treatments were significantly different from each other (Fig. 2). The 88 kg N ha^{-1} (1/2X) rate yielded 19%, 73% and 97% more shoot biomass than 188 kg N ha^{-1} (X) and 376 N ha^{-1} (2X) and control treatments respectively. Similarly, the average shoot biomass produced by the 188 kg N ha^{-1} (X) was 67% and 97% higher than the 376 N ha^{-1} (2X) and control treatments respectively. Compared to the control, the 376 N ha^{-1} (2X) rate produced 90% more shoot biomass.

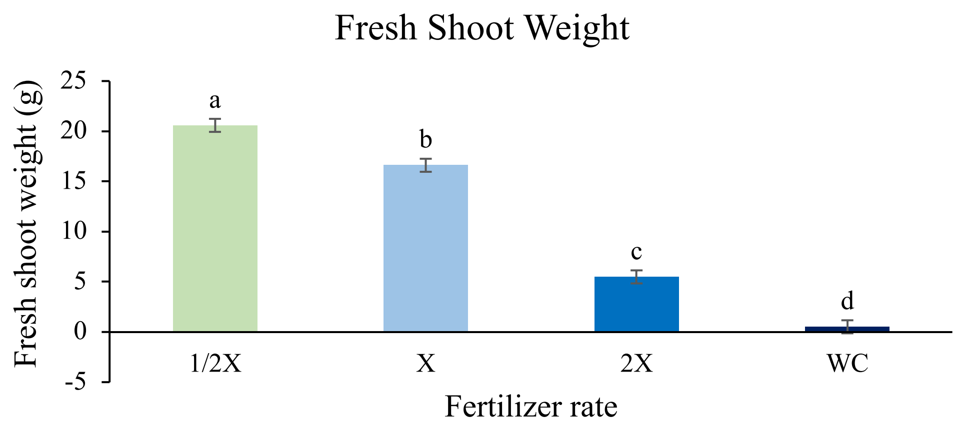

Figure 2. Effect of fertilizer rate on fresh shoot weight of Egyptian Spinach. *Each bar represents an average of five treatment replicates while the error bars represent standard errors of the mean. 1/2X = half the label rate (94 kg N ha-1), X = label rate of fertilizer (188 kg N ha-1), 2X = twice the label rate (376 kg N ha-1), WC = water control or no fertilizer treatment. Bars with the same letter(s) are not significantly different from each other (P>0.05).*

Fresh shoot biomass weights for the 94 and 188 kg N ha-1 rates were more than 3-fold greater than 376 kg N ha-1 rate and the control (Fig. 2). A significant correlation ($p = 0.0330$) was observed between root biomass and fresh shoot yield (Fig.3).

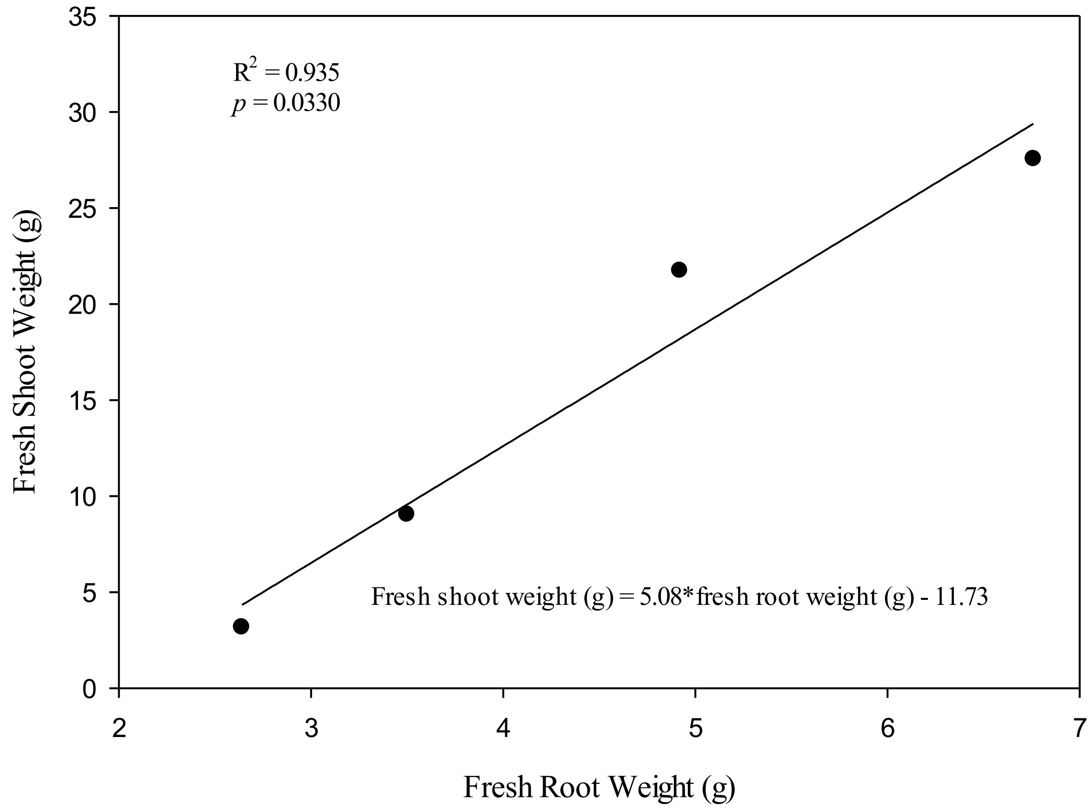

Figure 3. Correlation between fresh root weight and fresh shoot weight of Egyptian spinach grown at three nitrogen (N ha-1) rates.

Discussion

Egyptian spinach treated with 94 kg N ha^{-1} rate produced the highest shoot biomass yield compared to to the other treatments investigated (Fig.2). As a result, the hypothesis that the yield of Egyptian spinach will increase with increasing nitrogen fertilizer rate was rejected. The practical significance is that farmers can save money on fertilizer and, at the same time, get a better yield when the 94 kg N ha^{-1} rate is applied. The results also suggest that bigger plant roots can help improve yield probably because they help draw more water and nutrients for plant use, thereby improving nutrient use efficiency. The strong correlation between fresh root weight and fresh shoot weight (Fig.3) suggest that shoot biomass yield of Egyptian spinach could be predicted using root data for plants grown under similar conditions. Since the MiracleGro fertilizer used contained micronutrients, in addition to the macronutrients (nitrogen, phosphorus and potassium), it is likely the suite of micronutrients including boron, copper, iron, manganese, molybdenum and zinc in the fertilizer may have collectively influenced the results obtained from the study.

Conclusions

The yield of Egyptian spinach varied with fertilizer rate in this study, and root biomass was strongly related to shoot yield. Nitrogen applied at a 94 kg ha^{-1} rate produced the most yield and root biomass. Higher and more concentrated nitrogen rates reduced yield, suggesting Egyptian Spinach does not need a lot of nitrogen for growth and productivity. MiracleGro contains micronutrients; therefore, optimizing yield may involve adding these nutrients to fertilizer programs. The potential savings on fertilizer could make the productions of Egyptian spinach more economical and beneficial to small scale producers.

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