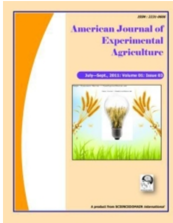

American Journal of Experimental Agriculture
3(1): 218-225, 2013

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Enhancing Dry Season Production of Indian Spinach (*Basella alba*) through Fertigation

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Authors' contributions

This work was carried out in collaboration between all authors. Author LSA designed the experiment and carried out field work, author OAA carried out analysis both author (Mrs) EAOD wrote and edited the paper. All authors read and approved the final manuscript.

Research Article

Received 7th November 2012
Accepted 5th January 2013
Published 27th February 2013

ABSTRACT

Optimum and qualitative production of vegetables in the depleted soils during the dry season are best achieved through irrigation. Two experiments were concurrently conducted in 2010 to determine the effect of irrigated poultry manure on the vegetative growth and nutritional quality of Indian Spinach (*Basella alba*) in South Western Nigeria. Poultry manure (P) rates at 0 (P_0+W), 5 (P_1+W), 10 (P_2+W), 15 (P_3+W) and 20 t ha^{-1} (P_4+W) were each irrigated with 6,000 litres of water per hectare (W) and the plots were arranged on a complete Randomized Block Design with four replications. The plot that had no manure but irrigated with 6,000 liters of water served as control. Compared with control, all the treatments significantly increased Basella height, leaf area (except P_1+W), wet leaf weight and dry matter yield. The percentage increases in the leaf area of *Basella alba* were P_1 + W (0.68%), P_2 + W (6.48%), P_3 + W (10%) and P_4 + W (25.95%). Accumulation of crude protein, fat and ash were highest in P_3 + W and were respectively 19.47, 4.34 and 13.49%. Crude fiber and dry matter yield were highest in P_4 + W with increase of 15.3 and 0.1% respectively. Treatment P_1+W had the highest carbohydrate with percentage increase of 18.51%. Compared with control, all the treatments significantly increased soil pH, OM, N, P, K and Ca. Fertigated poultry manure at 20 or 15 t ha^{-1} most increased basella growth, nutrient contents and soil chemical properties.

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Keywords: Poultry manure; moisture; crude protein; fat; carbohydrate.

1. INTRODUCTION

Vegetables attract higher prices during the dry season when they are in short of market supply than during the raining seasons termed glut season. Vegetables are naturally found everywhere as weeds during the wet season because of adequate moisture supply. Indian Spinach is one of the cherished but scarce vegetables during the dry season in southern Nigeria.

Among the importance of Indian spinach is its richness in vitamins A and C, low less calories or highness in calories compared with other vegetables [1]. It is very good as laxative; its high water content and fiber provide roughage for human diet. It sometimes used locally to treat hypertensive patients. The young leaves of Indian spinach are used to prepare salad.

It is advisable to grow Indian spinach during the dry season by farmers who intend to grow the crop for sale. The two major problems feared by farmers are the inherent low nutrients supply by the native soil and inadequate moisture supply. Fertilization and irrigation are the two agronomic measures that can be used to solve the problems of nutrients deficiency and shortage of water for the production of the crop. Hebber et al. [2] observed higher yield in tomato fruit through fertigation than irrigation alone.

Poultry manure could be an excellent source of nutrients for Bassella as it has been extensively used for the production of other crops such as maize, Amaranth and tomato [3,4]. Many researches have shown that poultry manure contains nutrients such as N, P, K and micronutrients that could be used to increase soil fertility [5]. In order to minimize cost and make the poultry manure readily soluble and effective as source of fertilizer; there is need to combine poultry manure with water for optimum vegetable production during the dry season. Hence, the objective of this work was to determine the effect of fertigation on the growth, vegetative yield and nutritional quality of Indian Spinach (*Basella alba*) in Southern Nigeria.

2. MATERIALS AND METHODS

Two experiments were concurrently carried out at Adeyemi College of Education and Fagun both located in Ondo (07º 05^1 and 04º 55ºN) southwestern Nigeria in October, 2010 to determine the effect of fertigation of poultry manure on growth and nutritional quality of *Basella alba*. Both soils are classified as Alfisol according to USDA classification system [6]

The initial soil chemical properties of the soil used for the study at the two locations and the nutrient composition of poultry manure were collected, sieved and analysed with the normal analytic procedures set out by Association of Analytical Chemist [7]. The poultry manure used for the experiment was collected from abattoir and kept in dry cool room in the laboratory.

The land was cleared, harrowed, pegged and ridged. Poultry manure at the rates of 0, 5, 10, 15 and 20 t ha^{-1} were individually mixed with 6,000 L ha^{-1} of water (600ml of water) as suggested by Mathew and Karikari [8] were formulated as treatments. The treatments were split applied at three days interval. 150ml of the prepared stock solution (poultry manure mixed with water) was measured with measuring cylinder and directly applied to the root zone of each plant in a ring form before the treatments application; hole of about 3cm deep was dug around each plant in order to restrict the movement of the fertigated water within the root zone. Direct application of water to crop is a simulation of what the local farmers use in southwestern Nigeria where these experiments were carried out. The poultry manure used for the experiment was air dried ground with hammer mill and sieved through 2mm mesh before mixing with water. Twenty plots of size 5m x 5m with 1m discard area were made in each location. The experiment was laid out in a randomized complete block design. The five treatments were replicated four times to make a total sum of twenty ridges.

The seeds of Indian Spinach were collected from the local farmers. The seeds were sown directly in the field at a spacing of 1m x 1m, four seeds were sown per drill and thinned to one plant per stand. Each basella plant was staked.

Data such as plant height, leaf area, dry matter yield, fresh stem and root weight were determined two weeks after the completion of treatment application. The leaves were collected from each plant/plot and bagged in brown envelope for the determination of the nutritional quality of *Basella alba*. The leaf area was determined by graphical method and calculated in cm^2**.** Fresh leaf weight was determined by cutting the fresh leaf/plant weekly, weighed and recorded. The cumulative weight of the leaves per plot was used to determine the fresh leaf weight.

The fresh leaves were washed and rinsed with the distilled water and dried in the oven at 65ºC. The leaves were digested with 10ml of concentrated H_2S0_4 in the presence of selenium catalyst before the digestion and titration processes were carried out. The crude protein of *Basella alba* was determined by kjedahl method. The N content was determined and multiplied by 6.25 to get the crude protein [9,7].

The crude fibre content of *Basella alba* leaves was analyzed by weighting 5.0g of the sample into 500g conical flank and boiled gently with 1.25% H_2S0_4 and 1.25% of NaOH. The residue from the filtrate of the digest was dried in the oven at 105ºC, cooled in desiccators and weighed. This was also placed in the muffle furnace at about 300ºC for 30 minutes, cooled and re-weighed. Percentage crude fibre was calculated by deducting the weight of the crucible and the sample after furnace from the weight of crucible and wet sample divided by weight of the sample used and multiplied by 100. Soxhlet extraction method was used to extract crude fibre. The percentage crude fibre was calculated by subtracting weight of the sample after extraction from the weight of the sample used and multiplied by 100.

The total ash content of *Basella alba* was determined by ashing the leaves until the ash became whitish in colour. The crucible and its contents were re-weighed and calculated in percentage. The percentage moisture content was calculated by deducting oven dried weight of leaves from the fresh weight and multiplied by 100. Carbohydrate content of *Basella alba* was determined by deducting the sum of ash, protein, crude fibre and fat from 100 on dry matter basis.

Data on growth and nutritional quality of *Basella alba* were collected from each site, means of the two experiments were generated and computed since the plants' response to treatments application follow the same trend.

2.1 Statistical Analysis

The data obtained were subjected to analysis of variance and the means were separated by Duncam Multiple Range Test at 5% level of probability.

3. RESULTS AND DISCUSSION

Before the start of the experiments, the soil nutrient status of Fagun showed that it had higher pH, organic manure, available P, K, Ca and Mg than the soil collected from Adeyemi College of Education (Table 1). Adeoye and Agboola [10] recommended pH of 6 – 6.5, P (Bray's P) 10 – 16 mg kg^{-1} and exchangeable K 0.6 – 0.8 me Kg 100^{-1}, Mg 0.20 C mol kg^{-1} and Ca 2.34 C mol kg^{-1} as critical levels for growing arable crops in southwestern Nigeria. Agboola and Sobulo [11] recommended 3% organic matter (OM), and total N 0.15% for arable crops in southwestern Nigeria. Tindal [12] recommended pH of 6.5 for vegetable production while Yamagichi [13] recommended pH value 5.0 – 7.0. Going by Tindal [12] and Yamaguchi [13] assertions, the pH of the two soils were adequate for Basella production. According to Agboola and Sobulo [11] and Adeoye and Agboola [10], the two soils were deficient in major nutrients hence; they needed additional supply of nutrients.

Table 1. Initial soil analysis of the two sites

	pH	OM	N	P	K	Ca	Mg
		------%-----		mg kg^{-1}	-------- C mol kg^{-1} --------		
ACE	5.92,	1.92	0.09	6.23	0.12	0.27	0.19
Fagun	6.0,	2.35	0.16,	6.38	0.14	2.13	0.83

Analysis of poultry manure used for the experiments showed that it contained 1.85, 1.24, 3.95, 3.63, 0.92 and 0.64% for OC, N, P, K, Ca and Mg respectively. This showed that the poultry manure is likely to improve the nutrient status of the soil.

The effect of poultry manure at different rates combined with fixed water rate of 6,000 litres ha^{-1} on growth, yield and nutritional quality of *Basella alba* were presented in Tables 2 and 3. Compared with control, P_1, P_2, P_3 and P_4 significantly increased ($P<0.05$) basella height, wet stem weight and wet root weight (Table 2). However, there was no significant difference in fresh root weight of basella among the treatments. All the treatments significantly increased leaf area except $P_{1.}$

The better performance of *Basella alba* fertigated with poultry manure could be attributed to the adequate nutrients supplied by the poultry manure and the adequate water supplied. Adequate nutrients, air and moisture are known to provide good medium of growth for plants [14].

The major problem of vegetable during the dry season is inadequate supply of moisture. Water also helps in the release of plant nutrients in the soil. The highest values in growth parameters recorded by P_4 might be due to the adequate amount of nutrient released by poultry manure. It was observed that treatments P_0, P_1 and P_3 showed similar leaf area while P_2 and P_4 showed similar plant height. This inconsistence in the yield might be as a result of nutrient imbalance or nutrient antagonism in the soil which might have led to the absorption of certain nutrients at the expense of others. Inconsistence in the release of nutrients to the soil by animal manures is one of the setbacks to their use as fertilizers.

The percentage increase in the leaf area of *Basella alba* compared with control were P_1 (0.68%), P_2 (6.47%), P_3 (10%) and P_4 (25.95%). The percentage change in the leaf area of *Basella alba* fertigated compared with control indicated that application of 20 t ha^{-1} poultry manure mixed with 6,000 liters of water/ha could be recommended to the farmers since buyers prefer the vegetables that have broad leaves. Though the economic analysis of the yield of Basella was not evaluated in this experiment, application of 20t ha^{-1} poultry manure + 6,000 litres of water (P_4) during the dry season might attract more prices than the Basella fertilized with P_1, P_2 and P_3 since it had the broadest leaves which are likely to attract buyers. This could be practiced where poultry manure is abundant like the urban cities of southwestern Nigeria where poultry dung is dumped beside the road. This practice could also serve as environmental sanitation.

Compared with control (P_0), treatments P_1+W, P_2+W, P_3+W and P_4+W significantly increased crude protein, fat and fibre content of *Basella alba.* Fertigation had influence on nutritional quality of *Basella alba*. Accumulation of protein, crude fat and ash were highest in P_3+W were respectively 19.47, 4.34 and 13.49% while accumulation of carbohydrate was highest in P_1+W with percentage increase of 18.51%.

Crude fiber and dry matter yield were highest in plots fertigated with 20 t ha^{-1} poultry manure while P_1 had the highest moisture (Table 3).

Table 2. Growth of *Basella alba* as affected by fertigation (ACE and Fagun sites)

Treatment	Height (cm)	leaf area	Wet leaf weight	Wet root weight	Stover yield
	cm^2	------------------- g plant-^{1}	---------------------------		
P_0+W	29.43d	19.00c	206.93d	15.70a	195.13d
P_1+W	52.13c	19.13c	214.23c	16.77a	202.37c
P_2+W	61.67b	22.23a	283.10a	21.67a	268.13a
P_3+W	65.23b	20.90b	278.10a	18.93a	263.20a
P_4+W	75.67a	23.93a	234.46b	16.17a	223.07b

Means with the same letter in the same column are not significantly different at 5% using Duncam Multiple range test

P = poultry manure W = water

Table 3. Mean nutritional quality of *Basella alba* as influenced by fertigation at ACE and Fagun sites (%)

Treatment	Protein	Fat	Crude Fibre	Total Ash	Carbohydrate	Leaf Moisture Content	Dry Matter
P_0+W	16.9c	3.89b	17.38b	13.21a	43.25c	9.46a	90.54a
P1+W	13.38d	3.76b	19.13a	12.62a	51.21a	9.57a	90.43a
P_2+W	17.92b	4.05a	18.86ab	13.18a	45.99a	9.39a	90.61a
P_3+W	19.47a	4.34a	19.61a	13.49a	43.09c	9.51a	90.49a
P_4+W	18.65a	3.95ab	20.08a	12.76a	44.56bc	9.37a	90.63a

Means with the same letter in the same column are not significantly different at 5% using Duncam Multiple range test

P = poultry manure, W = water

Adequate supply of N, P, and K, by 15 t ha^{-1} poultry manure mixed with 6,000 t ha^{-1} water might have led to highest accumulation of protein and fat contents of *Basella alba* grown in this medium. Makinde et al. [15] observed that adequate supply of N, P, K, Ca and Mg enhanced their uptake by *Amaranthus cruentus*. They also observed that organic manure increased accumulation of protein, fat and crude fibre in *Amaranthus cruentus*. Grubben nad Dentus [1] observed that *Basella alba* thrives well in soils that are rich in organic manure. Zakaria and Vimala [16] and Sunassee [17] observed increase in yields of vegetables crops with application of poultry of manure.

Application of fertigated poultry manure at all rates significantly increased ($p< 0.05$) soil pH organic matter (OM), N, P, K and Ca at ACE site (Table 4) and Fagun site (Table 5). The increase in soil nutrients by fertigated poultry manure than the unmanured soil shows the ability of poultry manure to improve soil chemical properties. Also, the increase in soil pH compared to the control shows the liming effect of poultry manure. Ayeni [18] observed that poultry manure could be used as liming material. The soil nutrients status of Fagun were higher than ACE after the harvest of basella. This might be because the fertility status of the soil before the start of the experiment was higher than the soil located in ACE. The soil pH of treatment P4 in Fagun was higher than the critical level according to Yamaguchi, [13]. This shows that caution must be exercised in applying huge amount of manures to avoid nutrient imbalance. It is noted in this experiment there were sharp increase in soil exchangeable Ca when the fertigated poultry manure was increased to 15 and 20 t ha^{-1} with corresponding decrease in soil available P.

Relative to control, all the treatments significantly increased soil N and Ca in ACE site. Treatments P_2, P_3 and P_4 significantly increased soil pH, OM, P and K. (Table 4).

Table 4. Effect of fertigated poultry manure on soil chemical properties at ACE site

Treatment	pH	OM	N	P	K	Ca	Mg
		-------------%---------		mg kg^{-1}	------------C mol Kg^{-1}----------		
P_0+W	5.9b	1.18b	.0.06c	5.60b	0.14b	0.20c	.20a
P1+W	6.23ab	2.10ab	0.12b	5.66b	0.19ab	0.32b	0.20a
P_2+W	6.45a	2.88a	0.15a	6.32ab	0.21a	0.34b	0.24a
P_3+W	6.66a	2.90a	0.16a	6.95a	0.21a	0.37b	0.20a
P_4+W	6.65a	2.93a	0.16a	7.23a	0.23a	0.53a	0.24a

Means with the same letter in the same column are not significantly different at 5% using Duncam Multiple range Test
P = poultry manure W = water

Table 5. Effect of fertigated poultry manure on soil chemical properties at Fagun site

Treatment	pH	OM	N	P	K	Ca	Mg
		-------------%-----------		mg kg^{-1}	-------------- Cmol kg^{-1} ------------		
P_0+W	6.10c	2.15c	0.13d	6.02c	0.18b	2.00d	0.60a
P1+W	6.42b	3.20b	0.17c	6.80b	0.23ab	2.79c	0.83a
P_2+W	6.48ab	3.42b	0.19b	8.05a	0.27a	3.48b	0.87a
P_3+W	6.96a	3.92a	0.23a	6.20c	0.31a	6.73a	0.80a
P_4+W	7.10a	3.99a	0.26a	7.00ab	0.30a	6.75a	0.83a

Means with the same letter in the same column are not significantly different at 5% using Duncam Multiple range test
P = poultry manure W = water

4. CONCLUSION

The experiment conducted in southwestern Nigeria on the effect of combined application of poultry manure and water during the dry season showed that fertigated poultry manure increased growth components and nutritional quality of *Basella alba.* Application of 20 t ha^{-1} combined with 6, 000 L ha^{-1} of water recorded the highest agronomic parameters as well as nutritional quality of Basella. This could be used by local farmers to grow Basella and where the poultry manure is not adequate 10 or 15 t ha^{-1} could be used.

ACKNOWLEDGEMENTS

A brief acknowledgement section may be given after the conclusion section just before the references. The acknowledgments of people who provided assistance in manuscript preparation, funding for research, etc. should be listed in this section. All sources of funding should be declared as an acknowledgement. Authors should declare the role of funding agency, if any, in the study design, collection, analysis and interpretation of data; in the writing of the manuscript. If the study sponsors had no such involvement, the authors should so state.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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