

ENHANCING DRY SEASON PRODUCTION OF INDIAN SPINACH (*BASELLA ALBA*) THROUGH FERTIGATION

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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 (P₀+W), 5 (P₁+W), 10 (P₂+W), 15 (P₃+W) and 20 t ha⁻¹ (P₄+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 P₁+W), wet leaf weight and dry matter yield. The percentage increases in the leaf area of *Basella alba* were P₁ + W (0.68%), P₂ + W (6.48%), P₃ + W (10%) and P₄ + W (25.95%). Accumulation of crude protein, fat and ash were highest in P₃ + W and were respectively 19.47, 4.34 and 13.49%. Crude fiber and dry matter yield were highest in P₄ + W with increase of 15.3 and 0.1% respectively. Treatment P₁+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.

Key words: 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 (07° 05¹ and 04° 55°N) 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 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 round the 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 cm². 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 65°C. The leaves were digested with 10ml of concentrated H₂SO₄ 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 flask and boiled gently with 1.25% H₂SO₄ and 1.25% of NaOH. The residue from the filtrate of the digest was dried in the oven at 105°C, cooled in desiccators and weighed. This was also placed in the muffle furnace at about 300°C 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.

118 3. RESULTS AND DISCUSSION

119 Before the start of the experiments, the soil nutrient status of Fagun showed that it had
 120 higher pH, organic manure, available P, K, Ca and Mg than the soil collected from Adeyemi
 121 College of Education. Adeoye and Agboola [10] recommended pH of 6 – 6.5, P (Bray's P)
 122 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
 123 2.34 C mol kg⁻¹ as critical levels for growing arable crops in southwestern Nigeria. Agboola
 124 and Sobulo [11] recommended 3% organic matter (OM), and total N 0.15% for arable crops
 125 in southwestern Nigeria. Tindal [12] recommended pH of 6.5 for vegetable production while
 126 Yamagichi [13] recommended pH value 5.0 – 7.0. Going by Tindal [12] and Yamaguchi [13]
 127 assertions, the pH of the two soils were adequate for Basella production. According to
 128 Agboola and Sobulo [11] and Adeoye and Agboola [10], the two soils were deficient in major
 129 nutrients hence; they needed additional supply of nutrients.

130 Table 1: initial soil analysis of the two sites

131

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

136

137 Analysis of poultry manure used for the conduct of the experiments showed that it contained
 138 1.85, 1.24, 3.95, 3.63, 0.92 and 0.64% for OC, N, P, K, Ca and Mg respectively. This
 139 showed that the poultry manure is likely to improve the nutrient status of the soil.

140 The effect of poultry manure at different rates combined with fixed water rate of 6,000 litres
 141 ha⁻¹ on growth, yield and nutritional quality of *Basella alba* were presented in Tables 2 and 3.
 142 Compared with control, P₁, P₂, P₃ and P₄ significantly increased (P<0.05) basella height, wet
 143 stem weight and wet root weight (Table 2). However, there was no significant difference in
 144 fresh root weight of basella among the treatments. All the treatments significantly increased
 145 leaf area except P₁.

146 The better performance of *Basella alba* fertigated with poultry manure and might be
 147 attributed to the adequate nutrients supplied by the poultry manure and the adequate water

148 supplied. Adequate nutrients, air and moisture are known to provide good medium of growth
149 for plants [14].

150 The major problem of vegetable during the dry season is inadequate supply of moisture.
151 Water also helps in the release of plant nutrients in the soil. The highest values in growth
152 parameters recorded by P₄ might be due to the adequate amount of nutrient released by
153 poultry manure. It was observed that treatments P₀, P₁ and P₃ showed similar leaf area while
154 P₂ and P₄ showed similar plant height. This inconsistency in the yield might be as a result of
155 nutrient imbalance or nutrient antagonism in the soil which might have led to the absorption
156 of certain nutrients at the expense of others. Inconsistency in the release of nutrients to the
157 soil by animal manures is one of the setbacks to their use as fertilizers.

158 The percentage increase in the leaf area of *Basella alba* compared with control were P₁
159 (0.68%), P₂ (6.47%), P₃ (10%) and P₄ (25.95%). The percentage change in the leaf area of
160 *Basella alba* fertigated compared with control indicated that application of 20 t ha⁻¹ poultry
161 manure mixed with 6,000 liters of water/ha could be recommended to the farmers since
162 buyers prefer the vegetables that have broad leaves. Though the economic analysis of the
163 yield of *Basella* was not evaluated in this experiment, application of 20t ha⁻¹ poultry manure +
164 6,000 litres of water (P₄) during the dry season might attract more prices than the *Basella*
165 fertilized with P₁, P₂ and P₃ since it had the broadest leaves which are likely to attract
166 buyers. This could be practiced where poultry manure is abundant like the urban cities of
167 southwestern Nigeria where poultry dung is dumped beside the road. This practice could
168 also serve as environmental sanitation.

169 Compared with control (P₀), treatments P₁+W, P₂+W, P₃+W and P₄+W significantly
170 increased crude protein, fat and fibre content of *Basella alba*. Fertigation had influence on
171 nutritional quality of *Basella alba*. Accumulation of protein, crude fat and ash were highest in
172 P₃+W were respectively 19.47, 4.34 and 13.49% while accumulation of carbohydrate was
173 highest in P₁+W with percentage increase of 18.51%.

174 Crude fiber and dry matter yield were highest in plots fertigated with 20 t ha⁻¹ poultry manure
175 while P₁ had the highest moisture (Table 3).

176 Adequate supply of N, P, and K, by 15 t ha⁻¹ poultry manure mixed with 6,000 t ha⁻¹ water
177 might have led to highest accumulation of protein and fat contents of *Basella alba* grown in
178 this medium. Makinde *et al* [15] observed that adequate supply of N, P, K, Ca and Mg
179 enhanced their uptake by *Amaranthus cruentus*. They also observed that organic manure

180 increased accumulation of protein, fat and crude fibre in *Amaranthus cruentus*. Grubben nad
 181 Dentus [1] observed that *Basella alba* thrives well in soils that are rich in organic manure.
 182 Zakaria and Vimala [16] and Sunassee [17] observed increase in yields of vegetables crops
 183 with application of poultry of manure.

184 Table2: Growth of *Basella alba* as affected by fertigation (ACE and Fagun sites)

185

186	Treatment	height (cm)	Leaf Area	Wet leaf weight	Wet root weight	Stover
187	Yield					
188		cm ²	----- g plant ⁻¹ -----			
189						
190	P ₀ +W	29.43d	19.00c	206.93d	15.70a	195.13d
191	P ₁ +W	52.13c	19.13c	214.23c	16.77a	202.37c
192	P ₂ +W	61.67b	22.23a	283.10a	21.67a	268.13a
193	P ₃ +W	65.23b	20.90b	278.10a	18.93a	263.20a
194	P ₄ +W	75.67a	23.93a	234.46b	16.17a	223.07b

195

196 *Means with the same letter in the same column are not significantly different at 5% using*
 197 *Duncam Multiple Range Test*

198 P = poultry manure

199 W = water

200

201

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204

205

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	16.79c	3.89b	17.38b	13.21a	43.25 c	9.46a	90.54a
P ₁ +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	45.99b	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 Duncan Multiple Range Test

P = poultry manure

W = water

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 (2010) 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, (1983). 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 P₂, P₃ and P₄ significantly increased soil pH, OM, P and K. (Table 4).

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

236

237	Treatment	pH	OM	N	P	K	Ca	Mg
238			-----%-----		mg kg ⁻¹		----- C mol kg ⁻¹ -----	
239								
240	P ₀ +W	5.9b	1.18b	0.06c	5.60b	0.14b	0.20c	0.20a
241	P ₁ +W	6.23ab	2.10ab	0.12b	5.66b	0.19ab	0.32b	0.20a
242	P ₂ +W	6.45a	2.88a	0.15a	6.32ab	0.21a	0.34b	0.24a
243	P ₃ +W	6.66a	2.90a	0.16a	6.95a	0.21a	0.37b	0.20a
244	P ₄ +W	6.65a	2.93a	0.16a	7.23a	0.23a	0.53a	0.24a

245 Means with the same letter in the same column are not significantly different at 5% using
 246 Duncam Multiple Range Test

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

248								
249	Treatment	pH	OM	N	P	K	Ca	Mg
250			-----%-----	mg kg ⁻¹	----- C mol kg ⁻¹ -----			
251								
252	P ₀ +W	6.10c	2.15c	0.13d	6.02c	0.18b	2.00d	0.80a
253	P ₁ +W	6.42b	3.20b	0.17c	6.80b	0.23ab	2.79c	0.83a
254	P ₂ +W	6.48ab	3.42b	0.19b	8.05a	0.27a	3.48b	0.87a
255	P ₃ +W	6.96a	3.92a	0.23a	6.20c	0.31a	6.73a	0.80a
256	P ₄ +W	7.10a	3.99a	0.26 a	7.00ab	0.30a	6.75a	0.83a

257

258 Means with the same letter in the same column are not significantly different at 5% using
 259 Duncam Multiple Range Test

260

261 4, CONCLUSION

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

268

269

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283 **COMPETING INTERESTS**

284

285 No competing interest arise

286 **AUTHORS' CONTRIBUTIONS**

287

288 Dr L.S Ayeni designed the experiment and carried out field work, Eng. O.A Adedeji carried

289 out analysis both Dr (Mrs) E.A Makinde wrote and edited the paper

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347 approved by the appropriate ethics committee and have therefore been performed in
348 accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.”

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