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Effects of Poultry Manure and Plant Spacing on the Growth and Yield of Waterleaf (*Talinum fruticosum* (L.) Juss)

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Abstract: Population density of a crop determines to a greater extent its performance in terms of growth and yield. The production of crop with organic fertilizer also plays a vital role in organic agriculture today. A study was conducted at Calabar, Nigeria to determine the effects of poultry manure and plant spacing requirement for optimum water leaf (*Talinum fruticosum*) production. The trial was a 3×5 factorial arranged in a randomized complete block design. Treatments included three levels of Poultry Manures (PM); 0, 5 and 10 t ha⁻¹ and five plant spacing namely; 3×5, 5×5, 5×8, 5×10 and 10×10 cm. These were replicated three times. PM at 10 t ha⁻¹ significantly increased plant height, number of leaves, leaf area, fresh and dry weights of waterleaf compared with the other levels. However, 10 t ha⁻¹ PM significantly increased the number of leaves in 2009 only. Plants with wider spacing (10×10 cm) grew taller, had more leaves besides having broader leaves. The fresh and dry weights were also significantly increased at close spacing (3×5 cm) when compared to wider spacing (10×10 cm). Wider spacing tended to increase the vigour of plants whereas close spacing gave higher fresh and dry weight. Moreover, waterleaf planted at spacing of 3×5 cm and which received 10 t ha⁻¹ of poultry manure had significant higher fresh and dry weights above those in other treatment combinations. Therefore planting waterleaf at 3×5 cm and the application of 10 t ha⁻¹ PM is recommended for optimum yield of waterleaf.

Key words: *Talinum fruticosum*, plant spacing, poultry manure, growth, fresh weight, dry weight, organic fertilizer, plant nutrients

INTRODUCTION

Water leaf (*Talinum fruticosum* (L.) Juss) is a perennial herb which is widely distributed in the warm tropics. The valuable parts of the crop are the leaves and succulent stems (Rice *et al.*, 1987). Water leaf is extensively grown in Southern Nigeria, particularly in Cross River and Akwa Ibom States and is used in soups and other delicacies in combination with other vegetables such as African jointfir (*Gnetum africanum*) (Welw); Bush apple (*Heinsia crinata*) (Afzel) G. Taylor and Fluted Pumpkin (*Telfaria occidentalis*) (Hook F.) (Etim and Udoh, 2006). The cultivation of water leaf is an important occupation and source of income of some peasant housewives. However, in the western part of Nigeria, water leaf is largely regarded as a weed (Akobundu, 1984).

Okhira *et al.* (1987) observed that plant spacing should be done in such a way not only to ensure that each crop has an equal chance to grow but also to simplify execution of field operation. The rate at which field operations are carried out, weed-crop competition and yield are influenced by the spatial arrangement on the field. Spatial arrangement interacts with other factors to

affect competition relationships (Zimdahl, 1980). Also Galanopoulou-Sendouka *et al.* (1980) showed that increasing plant density reduced individual plant growth, however, per unit land area, there is a higher total dry matter production in close spacing. Also close spacing allows less competition from weeds (Schipper, 2000). Baloch *et al.* (2002) observed that lowering plant densities increased the nutrient area per plant and this led to increase in morphological characters. Mortley *et al.* (1992) observed that stem diameter increased linearly as spacing between plants increased and that fresh weight yields are highest at closer within-row spacings. Pandey *et al.* (1996) observed the highest plant height in narrow spacing in tomato hybrids while wider spacing had the highest number of primary branches per plant. They attributed the higher plant height recorded in narrow spacing to greater competition for space and light and thereby forcing the plants to grow taller. Malik *et al.* (1999) also revealed that the closest spacing gave the highest plant height while, number of branches per plant were highest in the widest spacing in radish. Decreasing planting density significantly increased number of branches plant⁻¹ in

soybeans but increasing plant density increased significantly plant height and biological, straw (El-Badawy and Mehasen, 2012).

Ayenigbara (2000) reported on the need to consider application of organic matter to ensure soil management for improved crop yield. Asiegbu (1987) attributed the superiority of organic matter to the slow release of balanced nutrient resources during decomposition. This makes organic waste of greater residual beneficial effect distributed over a longer period than inorganic fertilizers (Obi *et al.*, 2005). However, the slow release of nutrient may make them not available to crop in the year of application and thus short season crops may not fully benefit from organic manure if applied shortly before planting (Muoneke and Asiegbu, 1997). Mineral fertilizers assure only rapid short term growth and yield improvements (Ware and Mc Collum, 1980) and may not ensure sustainability of agricultural production (Titiloye *et al.*, 1985; Verchuur, 1993). Poultry manure, an efficient organic fertilizer is an important source of plant nutrients; its average nutrient content is 3.03 N, 2.63 P₂O₅ and 1.4% K₂O (Reddy and Reddi, 1995) and in addition to releasing nutrients, it is rich in organic matter improves the physical properties of soil (Ayeni, 2011). Poultry manure has frequently been found to increase the yields of pastures and crops including vegetable. The positive yield response from chicken manure treatment is attributed to increased nitrogen nutrition. (Hochmuth *et al.*, 1993; Opara and Asiegbu, 1996). In addition to its value as an organic N source, poultry manure has also been shown to increase soil organic matter content and to effectively reduce root knot nematode populations and root galling in vegetables (Cheung and Wong, 1983; Babatola, 1989; Chindo and Khan, 1990).

The superiority and richness of poultry manure over other manures has been confirmed in many experiments (Asiegbu, 1987; Maynard, 1991; De Lannoy and Romain, 2001) reported that the yield of each of the nine crops (except lettuce) fertilized with 5 t ha⁻¹ poultry manure was equal to or greater than those obtained with inorganic fertilizer. Asiegbu (1987) also showed the superiority in the application of 10 t ha⁻¹ poultry manure over 50 kg N, 22 kg P and 60 kg K ha⁻¹. Application of 10 tonnes per hectare of poultry manure gave a significantly greater number of fresh pods and fresh pod weight in okra when compared with 50 kg N+22 kg P+60 kg K ha⁻¹.

Also, the fact that mineral fertilizers are expensive and not easily affordable (FTTC, 1997) and its attendant hazards to the soil and crop injuries (Stopes *et al.*, 1988) make the use of organic manure a good option. Also, the use of poultry manure promotes organic farming and

enhances soil fertility management for the resource-poor farmers in the rural communities of most parts of the developing world.

Interest in water leaf research is still at its infant stage in South Eastern Nigeria. The cultivation of water leaf is predominantly an occupation of peasant housewives who do not adopt any recommended agronomic or specific spacing arrangement. This study was therefore carried out to determine the effects of poultry manure application and the beneficial spacing requirement for optimum yield of water leaf.

MATERIALS AND METHODS

Site information: This study was conducted at the Teaching and Research Farm of University of Calabar, Calabar in the early cropping seasons of 2006 and 2007. Calabar is located in the south eastern rainforest zone of Nigeria (4°57' N, 8°19' E) with annual rainfall in the range of 3000 to 3500 mm and mean annual temperature of 27 to 35°C.

Experimental design and field layout: The experiment was a 3×5 factorial experiment laid out in a randomized completed block design. It comprised two factors which included three levels of Poultry Manure (PM) (0, 5 and 10 t ha⁻¹) and five different planting distances including; 3×5 cm (6,666, 666.66 plants ha⁻¹), 5×5 cm (4,000,000 plants ha⁻¹), 5×8 cm (2,500,000 plants ha⁻¹), 5×10 cm (2,000,000 plants ha⁻¹) and 10×10 cm (1,000,000 plants ha⁻¹). The experimental site was ploughed and raised seed beds measuring 2.0 by 1.0 m were made.

Soil sampling and laboratory analysis: Soil samples were collected at random from 0-15 cm depth from the study site and bulked, air-dried, sieved to pass through a 2 mm mesh and kept for routine physico-chemical analysis. A sub-sample was taken for laboratory analysis to determine the physical and chemical properties of the soil of the site using suitable laboratory analytical procedures as follows; the particle size analysis was done using Bouyoucos hydrometer method (Sheldrick and Wang, 1993). The soil was chemically analysed following procedures outlined by Carter (1993). The soil pH was determined using a ratio of 1:2 in soil-water medium and read with a digital pH meter (Ibitoye, 2006). Organic carbon content was determined by Walkley-Black dichromate oxidation method (Nelson and Sommers, 1996). Organic matter was obtained by multiplying total carbon by a factor of 1.724 while available phosphorus was determined by Olson method (Emteryd, 1989). Total N was determined by the micro-Kjeldahl method (Bremner, 1996).

Available P was extracted by the Bray-1 method and determined by Molybdenum blue calorimetry (Frank *et al.*, 1998). Exchangeable Ca, K, Mg and Na were extracted with 1.0 N NH_4OAc using a soil: solution volume ratio of 1:10. The K and Na in the extract were read using a flame photometer, while Ca and Mg were determined by EDTA titration method (IITA, 1989). Exchangeable acidity was determined from 1.0 N KCl extract and titrated with 1.0 N HCl (Hendershot and Lalonde, 1993). Effective cation exchange capacity was determined by the summation of NH_4OAc -extractive cations and KCl-exchange acidity.

The poultry manure was incorporated into the prepared seed bed two weeks before planting. Prior to application, the chicken manure was analyzed for pH, organic carbon, P, K, Ca and Mg. The pH was determined using a saturated paste. Organic carbon content was measured by a modified Walkley-Black method (Nelson and Sommers, 1996). Bray 2 method was used to determine available P (Olsen and Sommers, 1982). Exchangeable Ca, Mg and K were determined with a NH_4OAc , pH 7 extract and an atomic absorption spectrophotometer (AOAC, 1990).

Field planting and maintenance: Fresh water leaf stem cuttings locally obtained from waterleaf farms in Calabar was planted at one cutting per stand. Each cutting measured at least 10 cm long. Weeds were manually removed as they appeared to avoid competition with the newly sprouted waterleaf plant.

Collection of data: First harvesting was done at four Weeks After Planting (WAP) and subsequently at 3 weekly intervals. Field data other than the fresh and dry weights were obtained by randomly sampling fifteen plants from each experimental plot before each harvest (cutting). A total of four cuttings were done during the study. Data were collected on plant height (cm), number of leaves per plant, number of branches per plant, leaf area (cm^2), fresh weight (t ha^{-1}) and dry weight expressed weight by weight in percentage.

Data analysis: These data were subjected to statistical analysis. Analysis of Variance (ANOVA) at 0.05 probability level was used to test for significance of treatment and significant means were separated using Fisher's Least Significant Difference (FLSD) at 5% level of probability as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The results of the experiment indicated a positive response of the test crop to increasing levels of poultry

manure. The highest level of application (10 t ha^{-1}) was the best in growth enhancement and dry matter yield. Although, wider spacing ($10 \times 10 \text{ cm}$) promoted individual plant vigor, the highest fresh and dry matter yields were obtained with the highest plant density ($3 \times 5 \text{ cm}$). Also, the combination of 10 t ha^{-1} PM with a spacing of $3 \times 5 \text{ cm}$ resulted in the highest growth enhancement of waterleaf and dry matter yield.

The soil texture at the experimental site was classified as a sandy loam (Table 1). The pH was very low and exchangeable acidity was high in both years. Nitrogen and potassium contents were low whereas phosphorus content was high. The calcium and magnesium content were also low but with a medium base saturation.

The growth of water leaf was significantly ($p \leq 0.5$) increased with Poultry Manure (PM) amendment compared with the control in both years (Table 2, 3). The plants fertilized with 10 t ha^{-1} PM was significantly taller than the other PM levels. A decrease in plant population significantly enhanced water leaf growth. Plants in the $10 \times 10 \text{ cm}$ plots were significantly taller than the other spacing arrangements. The results followed a similar trend for both years. Similarly, branching was significantly increased with increase in PM level while the reverse was the case with increase in plant population for both years (Table 2, 3). However, leaf production was similar ($p > 0.05$) among the different PM levels in 2006 but increased significantly with increase in PM level in 2007. The number of leaves produced per plant was significantly increased with increase in plant population. Plants spaced at $3 \times 5 \text{ cm}$ had significantly the highest number of leaves; 19.00 and 21.86 for 2006 and 2007, respectively. For the two years of trial, successive increase in PM level significantly ($p \leq 0.05$) increased the leaf area of water leaf and highest leaf areas (37.37 and 36.46 cm^2) were obtained at 10 t ha^{-1} PM in 2006 and 2007, respectively. Similarly, increasing plant spacing significantly ($p \leq 0.05$) produced broader leaves for both years. The enhancement in

Table 1: Physical and chemical properties of the soil at the experimental site in 2006 and 2007

Soil property	2006	2007
pH (H_2O)	3.60	3.85
Organic carbon (g kg^{-1}) (%)	2.01	2.15
Total nitrogen (g kg^{-1}) (%)	0.14	0.11
Available P (mg kg^{-1})	58.61	59.66
Exchangeable K (Cmol kg^{-1})	0.29	0.25
Exchangeable Ca (Cmol kg^{-1})	1.20	1.18
Exchangeable Mg (Cmol kg^{-1})	0.65	0.70
Exchangeable Na (Cmol kg^{-1})	0.34	0.35
Exchangeable acidity (Cmol kg^{-1})	3.08	3.04
ECEC	6.42	6.58
Base saturation (BS)	52.60	54.10
Sand (%)	79.50	80.60
Silt (%)	13.10	13.25
Clay (%)	7.40	6.15
Textural class	Sandy loam	Sandy loam

Table 2: Effects of poultry manure and plant spacing on the growth and yield of water leaf (*Talinum fruticosum*) in 2006

Parameters treatments	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm ²)	Fresh weight (t ha ⁻¹)	Dryweight(%)
Poultry manure (PM) in (t ha⁻¹)						
0	20.47	2.91	16.90	30.50	0.93	16.43
5	22.90	3.63	16.70	35.27	1.13	17.43
10	23.45	3.85	16.40	37.37	1.21	19.43
LSD _(0.05)	0.35	0.14	NS	0.52	0.05	0.30
Spacing (S) in (cm)						
3×5	19.03	2.68	19.00	26.40	1.35	21.69
5×5	21.38	3.15	17.11	30.29	1.12	17.76
8×5	23.02	3.43	16.28	34.30	1.08	17.24
10×5	23.63	3.78	15.78	37.80	0.99	16.38
10×10	24.29	4.26	15.17	43.11	0.92	15.77
LSD _(0.05)	0.21	0.08	0.33	0.32	0.03	0.18

Table 3: Effects of poultry manure and plant spacing on the growth and yield of waterleaf (*Talinum fruticosum*) in 2007

Treatments	Plant height (cm)	No. of branches	No. of leaves	Leaf area (cm ²)	Fresh weight (t ha ⁻¹)	Dry weight (%)
Poultry manure (PM) in (t ha⁻¹)						
0	20.85	3.10	17.54	29.84	1.00	16.84
5	23.13	3.78	18.03	34.23	1.17	18.52
10	23.52	3.92	18.73	36.46	1.25	20.38
LSD _(0.05)	0.23	0.09	0.43	0.58	0.04	0.46
Spacing (S) in (cm)						
3×5	18.88	2.80	21.86	25.58	1.44	22.76
5×5	22.12	3.33	18.61	29.06	1.20	19.11
8×5	22.87	3.62	17.69	33.71	1.10	17.98
10×5	23.98	3.89	16.49	36.91	1.01	16.78
10×10	24.66	4.37	15.86	42.30	0.96	16.29
LSD _(0.05)	0.14	0.05	0.26	0.35	0.03	0.28

growth attributes in water leaf due to increase in PM level may have been related to the direct addition of limiting plant nutrients. Poultry manure has high N content as well as other nutrients which are gradually released to the plant (Khalil *et al.*, 2005; Awodun, 2007; Ewulo, 2005). It can be adduced that increasing level of PM could have resulted in an increase in the amount of nitrogen made available to the plants through mineralization and nitrogen is known to stimulate growth in plants (Anyaegebu *et al.*, 2010). The better growth performance due to application of Poultry manure can be attributed to the lower C:N ratios (Maerere *et al.*, 2001). The results also indicated that increase in plant spacing led to an increase in growth, leaf area and branch formation but with a decrease in leaf production. Plant with ample space will compete less for environmental factors (Baloch *et al.*, 2002). This observation also corroborates the report by Galanopoulou-Sendouka *et al.* (1980) that increase in plant density reduces individual plant performances especially morphological growth attributes. Also the more healthy and robust waterleaf plants produced by widely spaced plants as opposed to the closely spaced ones can be attributed to less competition for nutrients as also observed by Philip *et al.* (2010). Also Morrison *et al.* (1990) explained further that well spaced plant received more solar radiation and are therefore more photosynthetically efficient than closely spaced ones. Dense spacing also increases competition for water and fertilizers which results in inadequate vegetative growth

(Knave, 1988). The interaction between plant spacing and PM application was significant ($p \leq 0.05$) for leaf area in both years, while significant interaction between the two factors with respect to plant height and number of branches was observed only in 2006 (Table 4, 5). With moderate (5×5 cm) to wider spacing arrangement (10×10 cm), there was a significant increase in leaf area of water leaf with successive increase in PM level. A similar trend was observed with plant height, however, for branching, a decrease in plant density only increased the branching significantly with application of 5 t ha⁻¹ PM relative to control. There was no significant difference in branching between plants treated with 5 t ha⁻¹ and 10 t ha⁻¹ PM and spaced at 5×10 and 10×10 cm (Table 5). It could be inferred from these results that increasing rate of PM at reduced plant density could lead to wastage of plant nutrients through inefficient utilization of the applied organic manure. Successive increase in the PM level significantly ($p \leq 0.05$) increased the fresh weight and dry matter accumulation of water leaf plants in both years of the trial. Conversely, increase in spacing significantly ($p \leq 0.05$) reduced fresh weight and dry matter production for the two years (Table 2, 3). The interaction between spacing and PM application was significant for percentage dry weight in 2006 (Table 4). At any spacing, dry matter accumulation in water leaf was significantly higher with 10 t ha⁻¹ relative to other rates. At each PM level, there was significant decrease in dry matter production as plant spacing was increased up to 5×10 cm.

Table 4: Interactions between poultry manure application and plant spacing on leaf area (cm²) and dry weight (%) of *Talinum fructicosum* in 2006

Treatment	3×5 cm	5×5 cm	5×8 cm	5×10 cm	10×10 cm
Leaf area					
0	24.30	25.73	30.17	34.87	37.43
5	27.07	31.53	35.60	38.17	44.00
10	27.83	33.60	37.13	40.37	47.90
LSD _(0.05)	1.57				
Dry weight					
0	20.33	16.07	15.57	15.00	13.63
5	21.73	17.37	16.37	15.63	15.57
10	23.00	19.23	19.00	18.50	18.10
LSD _(0.05)			0.91		

Table 5: Interactions between poultry manure application and plant spacing on plant height (cm), number of branches per plant and leaf area (cm²) of *Talinum fructicosum* in 2007

Treatment	3×5 cm	5×5 cm	5×8 cm	5×10 cm	10×10 cm
Plant height in cm					
0	17.10	20.07	20.87	22.70	23.50
5	19.70	23.07	23.67	23.37	24.83
10	19.83	23.22	24.07	24.87	25.63
LSD _(0.05)	0.69				
Number of branches per plant					
0	2.43	2.83	3.00	3.23	4.00
5	22.87	3.55	3.80	4.17	4.53
10	3.10	3.60	4.07	4.27	458.00
LSD _(0.05)	0.27				
Leaf area (cm²)					
0	22.20	25.10	30.03	33.93	36.93
5	26.37	29.30	34.70	37.20	43.60
10	27.17	32.77	36.40	39.60	46.37
LSD _(0.05)	1.74				

However, with the control plot (10 t ha⁻¹ PM), there was significant reduction in dry matter as spacing was increased 5×10 to 10×10 cm. The highest dry matter production was obtained with the highest plant density (3×5 cm) and 10 t ha⁻¹ PM treatment. Close spacing appeared to have favoured dry matter production. Wider spacing could have favoured individual's plant performance morphologically but densely populated plants produced greater mass per unit area compared with less dense plots. Other researches on vegetables have shown that yields increase linearly when the inter-row plant spacing is reduced (Huitron-Ramirez *et al.*, 2009; Ban *et al.*, 2011). The result also indicated that widely spaced plants had higher moisture content than their closely spaced counterparts. The metabolic activities of an economic plant are reflected in its dry matter content and growth.

CONCLUSION

There was a general improvement in the growth and yield of waterleaf due to application of poultry manure but the degree of such improvement increased with rate of application. Also narrow spacing was found to promote dry matter accumulation in waterleaf and the wider

spacing positively increased various growth attributes considered in the study. Thus, it can be concluded that for the optimum biomass yield of water leaf, the plant may be densely cultivated at a spacing of 3×5 cm with 10 t ha⁻¹ of poultry manure amendment.

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