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Optimum Soil Conditioning for *Celosia Argentea* Propagation Subjected to Irrigation Scheduling

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ABSTRACT: *Celosia argentea* was planted on Agricultural and Environmental Engineering Department experimental field. The field was divided into nine plots of three different soil nutrient conditions (organic, inorganic, and control), labelled A_1, A_2, A_3; B_1, B_2, B_3; C_1, C_2, C_3, respectively. Plant growth parameters were measured and analyzed weekly starting from the third Week After Planting (WAP) to the sixth WAP when the crop was harvested. Growth parameters included height, stem girth, leaf area, and number of leaves. Maximum crop evapotranspiration rate based on Penman Montieth evapotranspiration equation were obtained using a CROPWAT 4 Windows Version 4.3 Software and subsequently, the irrigation amount required per day was determined. Measured data were analyzed statistically using the Generalized Linear Model (GLM) option of the Statistical Analysis System (SAS), Version 7.03. The results are presented in tables while the Duncan Multiple Range Test (DMRT) was used to separate the means based on their significant differences in order to determine the effects of variable water application rates and different nutrient conditions on growth parameters. It was concluded that *Celosia argentea* thrives better on soil with high content of organic matter, which retained more water than the inorganic soil nutrient condition and the control with no soil conditioning. Hence, under high economic pressure due to high poverty level in developing countries, application of organic fertilizer which is relatively cheaper than the inorganic chemical fertilizer can help maximize production with positive net returns and reduce environmental pollution from organic wastes produced mainly from the agricultural industry.
Key words: Soil Conditioner, Growth parameters, Statistical Analyses, Irrigation, *Celosia Argentea.*

INTRODUCTION

Sustainability of agriculture has become a major global concern since the 1980s. Soil organic matter is very important in the functions of soil inasmuch as it is a good indicator of soil fertility. A comparison of cultivated and uncultivated soils has demonstrated a reduction in soil organic matter with cultivation (Mann, 1986). Soil organic matter properties (e.g., C:N ratio and macro-organic matter) have been proposed as diagnostic criteria for soil health and performance. However, the importance of organic matter to crop production receives less emphasis, and its proper use in soil management is sometimes neglected or even forgotten. (Chong, 2005). Yields of crops grown in organic and conventional production systems can be the same (Stamatoados *et al.,* 1999). However, agriculture or agro-industries produce large quantities of organic wastes that are typically rich in nutrients, which can well be used in farming to conserve nutrients as well as reduce waste discharge and the use of chemical fertilizers.

Government policy in Nigeria strongly emphasized use of inorganic fertilizer through massive importation, and high levels of subsidization at the Federal level. However, small-scale farmers are disadvantaged in the highly competitive struggle to buy subsidized fertilizer without effective organizations, mutual trust, understanding of bureaucratic procedures or helpful contacts; they have little choice but to buy at exorbitant prices from the black market (Phillips-Howard and Lyon, 1994).

Poultry organic manure in the tropics comprise high levels of nitrogen (4%), phosphorous (1.56%) and potassium (2.32%) in addition to lesser quantities of Ca, Mg, Mn, Cu and Zn that are present in the poultry litter compared to other animal wastes (Fasina et al., 2006). Just like Inorganic (chemical) fertilizers, adequate organic fertilizer application supply the amount of plant nutrients needed to maximize crop production and net return. The mean net income earned per annum by poultry manure users was 1.40 times higher than that for non-users in South-western part of Nigeria. The difference in mean net income users and non-users of poultry manure constitutes an important land improvement technique capable of enhancing farm production and income levels (Bamire and Amujoyegbe, 2003).

Essentially, fertilization management makes certain that soil fertility is not a limiting factor in crop production. The major factors that affect the selection of the kind, rate, and placement of organic fertilizers are fertilizer characteristics, crop characteristics, soil characteristics and management, fertilizer placement, and carryover effects (Chong, 2005). Darwish *et al.* (1995) showed that at least 95% of total applied annual manure over 15 years was degraded. However, the ultimate purpose of applying organic fertilizer is to establish suitable soil organic matter content. A high initial application to build up organic pool and cut back in subsequent years is appropriate. Use of organic manure to fertilize agricultural lands is positive from the perspective of a recycling economy in terms of maintaining an adequate level of soil organic matter, a critical component of soil fertility and productivity.

The economic value of *Celosia argentea* is of immense importance in Nigeria. The potential of Nigeria flora as a veritable source of pharmaceuticals and other therapeutic materials have been emphasized, herbs have usually served as the repository of healing materials and have been acknowledged to be generally safe with or without minimum side effects (Ayodele, 1986). *Celosia argentea* also known as Lagos spinach has high nutritional value, and is diuretic and good for cough. *Celosia argentea* is a short duration growth plant and is mostly consumed in South Western Nigeria. It is a leafy vegetable that belongs to the family **Amaranthaceae**. *Celosia* is otherwise called Cock's comb and is locally known as 'Sokoyokoto'. Lagos spinach as it is commonly called in the South Western Nigeria has soft texture of its leaves when compared with amaranth leaves (Schippers, 2000).

Low soil fertility has been identified as a critical constraint to agricultural productivity in Africa, where use of inorganic fertilizer is comparatively small (McIntyre *et al.,* 1992) and usually restricted to cash crops (Pingali *et al.,* 1987). The problem for small-scale farmers in Africa is how, under high economic pressure due to poverty to intensify production with extremely scarce resources. This paper attempts to examine the benefits and effects of the use of organic and inorganic fertilizer on crop yield subjected to the same water application rates. Dry season farming is chosen because of the high demand for vegetable crops during this season. Also, nutrients leeching as a result of infiltration and percolation can be controlled due to artificial application of water through irrigation. Furthermore, removal of nutrients from the soil by surface runoff due to heavy rainfall is eliminated.

Irrigation practice is highly imperative to sustain plant growth in dry seasons in Nigeria. Over 80% of the fresh weight of many plants, and over 90% of some plant parts is water. Yet more remarkable is the appetite of plants for water (Forbes and Watson, 1992). Irrigation is imperative in crop production because plants remove water, the soil water content decreases with a decrease in total soil water potential. At the same time the conductivity of the soil decreases (James, 1993).

Calculating Crop Evapotranspiration and Crop Coefficient Values: The method for computing crop ET employs the equation;

$$ET = K_{c.\,X}\ ET_o \qquad (1)$$

Where; ET is the evapotranspiration for a specific crop; ET_o is the reference crop evapotranspiration and, K_c is the crop coefficient that relates the actual rate at which a crop uses water. Values of K_c for field and vegetable crops generally increase from an initial plateau to a peak plateau and then decline as the plant progresses through its growth stages. K_c values for celosia argentea at growth stages, from K_c initial, K_c mid and K_c end are 0.70, 1.00, 0.95 respectively. This is for single crop coefficients K_c, and mean maximum plant height for non-stressed, well-managed crops in semi humid climates for use with FAO Penman-Montieth ET_o is 3m (FAO, 1998).

MATERIAL and METHOD

Collection of Soil Data: Experimentation was conducted in Ibadan, Nigeria at latitude: 7.26^0 N, longitude: 3.50^0 E and 228 m above msl altitude. Soil used was from two different locations; Abadina Poultry Farm (APF) which contains accumulated broiler and layer droppings on unpaved area over a period of 2 years as organic manure, and Department of Agricultural and Environmental Engineering Farm (AEEF). However, inorganic fertilizer (NPK 15-15-15) was applied to a part of the soil from AEEF, while the other portion was referred to as the control, with no soil conditioning added.

Hence, the determination of the textual class of the soil from the aforementioned locations was obtained by determining the particle size distribution (Mechanical Sieve Analysis) through the bouyoucos hydrometer method. A sample of air - dried soil of 50g was passed through a 2mm sieve and poured into a dispersion cup. 20ml of 5% Sodium hexametaphosphate (Calgon) was added and a 350ml of water was also added, and stirred mechanically for at least 5 minutes to cause the soil particles dispersed.

The experimental field was 6m X 8m, with each part A, B, C of 3m x 3m in size. Each part was divided into 9 plots of 1m x1m size and labeled A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3. The planting of *Celosia argentea* seeds was carried out in the evening on 28th November, 2006. Planting was done by the drilling rows with 30cm spacing apart. This was done since under real conditions farmers always adopt either broadcasting or drilling method.

Water application for *Celosia argentea* was carried out daily for 45 days. Daily application of water was done with the use of CROPWAT program to calculate the daily evapotranspiration rate. The daily evapotranspiration rate determines the amount of moisture lost from both soil structure and the respective vegetable stands. Five stands were considered for measurement on each plot. Agronomic parameters such as plant heights were measured (from the base of plant to the top of the terminal bud). Centimeter rule was used to carry out each measurement. Also measured was the leaf area. The stem girth was measured using a veneer caliper and the number of leaves by counting the green leaves on the stem of the vegetable stands.

Crop Water Requirements: To determine the crop water requirement or consumptive use, weather data used in this project was obtained from the International Institute of Tropical Agriculture, Ibadan, Nigeria, which is approximately 1.5km from the experimental sites. These were imputed into a CROPWAT 4 Windows Version 4.3 Software. Using the crop coefficient K_c value of 0.7 for an initial growth period and ET_O value of 3.51 for day one; water application rates were determined as follows from equation 1:

ET = 2.46mm/day = 2.46litres/day

Therefore, 100% -, 75% - and 50% - of 2.46litres of water were applied per irrigation for the three different water application rates (Table 1). The various growth variables measured was done weekly starting from the third Week After Planting (WAP) until the sixth week. Analysis of data was carried out using the Generalized Linear Model (GLM) option of the Statistical Analysis System (SAS), version 7.03. Duncan Multiple Range Test (DMRT) was used to separate the means based on their significant differences.

RESULTS and DISCUSSION

The following tables presents the results of analysis of data of the effects of water application rates at different nutrient conditions on *Celosia Argentea* during vegetative growth period. Only the effects of water application rates on leaf area and number of leaves which forms the edible weight are discussed (Tables 2 and 3) at 3 and 6WAP. This is because the economic value of the crop under consideration is assessed based on its edible weight as it is sold per unit weight. There is no significant difference on the effect of water application rates at 50% and 75% on number of leaves with inorganic and control nutrient conditions at 3WAP. However with organic nutrient condition at 50% and 75% water application rates, the numbers of leaves were significantly different. Similar results were obtained in organic and inorganic nutrient condition at 6WAP for the number of leaves (Table 3). Also at 3WAP, leaf area at 50% were significantly different from 75% and 100% application rate for organic nutrient condition while it was not significant for the inorganic and control nutrient condition. This is an indication to the fact that water retention in soils with inorganic fertilizer application is poor. Hence more water will be required in inorganic than in organic nutrient condition to produce the same crop biomass yield if all conditions are the same.

Considering Tables 4 and 6 which is at 3 and 6WAP, it was observed for the growth parameter plant height and stem girth that Duncan Multiple Range Test (DMRT) shows that there is no significant difference in the effect of 75 and 100% water application rate. However, there are significant differences in leaf area for the three levels of water application rates. Initially for the number of leaves at 3WAP, only 100% water application rate was significantly different from the 50% and 75% application rate. At harvest in table 6 (6WAP), there are significant difference in number of leaves for the various water application rates.

Generally there are significant differences in nutrient conditions at 3 and 6WAP (Tables 5 and 7). The exception is girth at 6WAP which shows no significant difference between inorganic and the control nutrient condition. Duncan Multiple Range Test (DMRT) shows clearly that the crop growth parameters performed best with the organic nutrient condition.

CONCLUSIONS

The organic soil nutrient conditions recorded much significant difference in the growth parameters (height, girth, leaf area, and number of leaves) as compared with the application of inorganic soil conditioner when water is not limiting. This shows that the organic nutrient conditions would conclusively be appropriate as a soil conditioning for the growth of *celosia argentea* in field situation.

Application of organic soil conditioner helped to retain more water in the soil for longer period than the inorganic and the control (no soil conditioner) nutrient condition. Hence, under high economic pressure due to high poverty level in developing countries, application of organic fertilizer which is relatively cheaper than the inorganic chemical fertilizer can help maximize production with positive net returns and reduce environmental pollution from organic wastes produced mainly from the agricultural industry.

This project work serves as a prototype for a field situation where all important land preparation practices have been met, crop agronomy and data reviewed, and crop evapotranspiration rate determined in order to apply the actual crop water requirement. However this research work has been carried out in the dry season. This means that full irrigation was practiced, and that the results are particularly useful in the dry season or in the northern regions of Nigeria where little rainfall is recorded annually.

Table 1. Crop Water and Irrigation Requirements

DATE	ETo (mm/d)	Crop K_C	Effective Rain (mm)	Irr. Reqd (l/d)
28/11/06	3.51	0.70	0	2.46
29/11/06	3.43	0.70	0	2.40
30/11/06	3.34	0.70	0	2.34
1/12/06	3.51	0.70	0	2.46
2/12/06	3.16	0.70	0	2.21
3/12/06	3.49	0.70	0	2.44
4/12/06	3.42	0.70	0	2.39
5/12/06	3.44	0.70	0	2.41
6/12/06	3.82	0.70	0	2.67
7/12/06	3.51	0.70	0	2.46
8/12/06	3.50	0.70	0	2.45
9/12/06	3.55	0.70	0	2.49
10/12/06	3.56	0.70	0	2.49
11/12/06	3.40	0.70	0	2.38
12/12/06	3.39	1.00	0	2.37
13/12/06	3.33	1.00	0	3.33
14/12/06	3.44	1.00	0	3.44
15/12/06	3.42	1.00	0	3.42
16/12/06	3.17	1.00	0	3.17
17/12/06	3.18	1.00	0	3.18
18/12/06	3.42	1.00	0	3.42
19/12/06	3.14	1.00	0	3.14
20/12/06	3.25	1.00	0	3.25
21/12/06	3.24	1.00	0	3.24
22/12/06	3.33	1.00	0	3.33
23/12/06	3.44	1.00	0	3.44
24/12/06	3.56	1.00	0	3.56
25/12/06	3.39	1.00	0	3.39
26/12/06	3.39	1.00	0	3.39
27/12/06	3.13	1.00	0	3.13
28/12/06	3.46	0.95	0	3.29
29/12/06	3.19	0.95	0	3.03
30/12/06	3.18	0.95	0	3.02
31/12/06	3.03	0.95	0	2.88
1/1/07	3.64	0.95	0	3.46
2/1/07	3.13	0.95	0	2.97
3/1/07	3.44	0.95	0	3.27
4/1/07	3.74	0.95	0	3.55
5/1/07	3.75	0.95	0	3.56
6/1/07	3.42	0.95	0	3.25
7/1/07	3.60	0.95	0	3.42
8/1/07	3.39	0.95	0	3.22
9/1/07	3.13	0.95	0	2.97
10/1/07	3.25	0.95	0	3.09
11/1/07	3.36	0.95	0	3.19
Total	**152.57**			**134.42**

CropWat 4 Windows Ver 4.3

Table 2. Effects of water application rate on growth parameters of *Celosia Argentea* at different nutrient conditions (3WAP)

Nutrient condition	Water application rate (%)	Height (cm)	Girth	Leaf Area (Cm^2)	Number of leaves
Organic	50	8.83a	0.30b	13.33b	7.667c
	75	9.33a	0.40ab	27.33a	11.67b
	100	9.10a	0.47a	29.33a	15.67a
		4.97	*0.12*	*8.81*	*3.07*
Inorganic	50	2.43b	0.13b	8.67b	7.67b
	75	4.17b	0.20ab	13.33ab	7.67b
	100	6.0a	0.23a	22.00a	12.00a
		1.75	*0.08*	*8.68*	*2.00*
Control	50	2.0a	0.10a	1.90b	4.00a
	75	2.17a	0.133a	3.83ab	4.33a
	100	2.67a	0.133a	6.00a	4.00a
		3.53	*0.12*	*3.26*	*1.77*

Table 3. Effects of water application rate on growth parameters of *Celosia Argentea* at different nutrient conditions (6WAP)

Nutrient condition	Water application rate (%)	Height (cm)	Girth	Leaf Area (Cm^2)	Number of leaves
Organic	50	19.0b	0.60a	29.67b	16.67b
	75	45.33a	1.0a	41.67ab	25.33a
	100	50.67a	1.27a	52.83a	29.33a
		17.90	*0.85*	*21.01*	*5.68*
Inorganic	50	8.67b	0.30b	12.0b	9.67b
	75	27.33a	0.40ab	18.67b	11.67b
	100	35.0a	0.53a	36.33a	19.67a
		8.73	*0.22*	*10.67*	*3.21*
Control	50	2.83b	0.10b	2.57b	6.67b
	75	13.33a	0.40a	11.83a	12.0a
	100	14.67a	0.27ab	14.0a	13.33a
		5.13	*0.18*	*2.64*	*1.85*

Table 4. DMRT showing significant difference in water application rate at 3WAP

Water application rate (%)	Height (cm)	Girth	Leaf Area (Cm^2)	Number of leaves
50	4.422b	0.178b	7.967c	6.444b
75	5.222ab	0.244a	14.833b	7.889b
100	5.922a	0.278a	19.111a	10.556a
	3.70	*0.13*	*9.93*	*3.89*

Table 5. DMRT showing significant difference in nutrient conditions at 3WAP

Nutrient Condition	Height (cm)	Girth	Leaf Area (Cm^2)	Number of leaves
Organic	9.090a	3.889a	23.333a	11.667a
Inorganic	4.200b	0.189b	14.667b	9.111b
Control	2.778c	0.122c	3.911c	4.111c
	3.42	*0.06*	*6.76*	*2.71*

NUMBERS IN ITALICS FOR TABLES 2-7 ARE FOR THE LEAST SIGNIFICANT DIFFERENCE LSD (0.05) Means with the same letter are not significantly different

Table 6. DMRT showing the significant difference in water application rate at 6WAP

Water application rate (%)	Height (cm)	Girth	Leaf Area (Cm^2)	Number of leaves
50	10.167b	0.333b	14.744c	11.000c
75	28.667a	0.600a	24.056b	16.333b
100	33.444a	0.688a	34.389a	20.778a
	13.74	*0.39*	*14.96*	*6.49*

Table 7. DMRT showing the significant difference in nutrient conditions at 6WAP

Nutrient Condition	Height (cm)	Girth	Leaf Area (Cm^2)	Number of leaves
Organic	38.333a	0.956a	41.389a	23.778a
Inorganic	23.667b	0.411b	22.333b	13.667b
Control	10.278c	0.256b	9.467c	10.667c
	12.37	*0.27*	*10.47*	*4.89*

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