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Performance Evaluation of Drip Irrigation and Fertigation System for Sweet Maize and Telfairia Occidentalis

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Abstract. Studies were conducted to evaluate the performance of drip irrigation and fertigation system on the yields of sweet maize and telfairia occidentalis. Three treatments: watering once per week (6.38 litres) (W_1), twice (11.66 litres) (W_2), and thrice (17.16 litres) (W_3) were applied to sweet maize. Four treatments: 12 litres (W_1), 15.76 litres (W_2), 17.0 litres (W_3), 22.05 litres (W_4) and four fertigation levels: 54.6kg/ha (F_1); 68.06kg/ha (F_2); 81.92kg/ha (F_3) and 95.39kg/ha (F_4) were applied to telfairia occidentalis. Growth and yield of the crops were monitored. W_2 was optimum for sweet maize cultivation while (F_2W_2) was recommended for telfairia occidentalis.

Introduction

In most ecological zones of Nigeria, especially in arid and savanna, rainfall is both inadequate and non-uniformly distributed. The use of supplemental irrigation as an insurance against droughts therefore becomes paramount and imperative. In spite of the advances in irrigation systems development and practices to boost crop production, human population growth rate especially in developing countries override the seeming food production increase. [11] also reported that the continuous increase in earth's population coupled with the finite nature of the earth's renewable water resources pose challenges to intensive water management practices that will meet the water demands from various sectors of human economy. However, sudden shift to development of mechanized large-scale irrigation schemes in an effort to increase the production capacity of food especially in Nigeria without adequate and corresponding provision of drainage system has resulted into aggravated environmental instability and consequent pollution. Research conducted on high value drip irrigated horticultural and other crops such as tomato [3, 4, 11], potato [14] and squash [1] showed that the level of fertigation management for sustainable production exceeds what is found with other irrigation methods. Demand for horticultural crops in

Nigeria is increasing, however, as most horticultural crops and products are highly perishable, the commodities become very scarce during off season due to inadequate water supply thereby discouraging farmers from going to the farm. Drip irrigation and fertigation system therefore becomes the most viable alternative to farmer's water problems in the dry season to cope with increasing horticultural crop demands based on fewer drops per crop [2]. Studies on the use of drip irrigation and fertigation system for the production of sweet maize and telfairia occidentalis are very scarce. Sweet maize is shallow rooted and does not yield optionally if adequate soil water is not readily available. Reports have indicated that sweet maize is more sensitive to soil water suction during ear formation than any other time [10]. It is therefore essential that adequate moisture must be maintained at such sensitive growth stage especially from pollination to harvest. Telfairia occidentalis has a higher gestation period and the most sensitive period of water need is from fruit set to maturity. Telfairia occidentalis is a potential source of commercial vegetable oil used in homes in cooking preparation [13]. Telfairia is generally known to provide effective remedy against anemia ([12] when eaten as snack or milled as a seasoning for soups like egusi. The simplicity of design, minimum operational cost and minimal handling skill attract farmers to adopt the technology. This study will therefore investigate the performance evaluation of drip irrigation and fertigation on production potentials of sweet maize and telfairia occidentalis.

Materials and Methods

This study was conducted at the experimental field of the National Horticultural Research Institute, Ibadan ($5^0$30'N, 7^0 26'E) between the months of November, 2004 and February, 2005 for Sweet maize and February 2005 to May 2005 for Telfairia occidentalis. Soil properties and irrigation water analysis were determined prior to the installation of irrigation and fertigation systems in 2004 using the method of (5). The soil topography was measured and the profile generated by SURFER [9, 7] Fig 1. The drip irrigation system for sweet maize consists of 100-litre delivery tank connected to the feeder tank with 18.5 mm plastic pipes (Fig 2). A ball valve was connected into the inner wall of the delivery tank as opening and closing device to regulate water flow from the feeder tank to the delivery tank. The delivery tank was connected at right angles to the mainline. The mainlines were in turn connected to the t-valve connectors at 180° on both sides. Lateral pipelines were connected appropriately. The mainlines were configured into three segments to conform to the three drip irrigation treatments using control valves. Fifteen emitters were connected on each lateral line of three lines per treatment. Installation was completed on the field on 17th November 2004. All forms of leakages were rectified prior to planting of sweet maize. Preliminary field-testing was effected by filling the tank with water and allowed to run for 10 minutes during which discharge per emitter was evaluated. The discharge was measured using graduated calibrated measuring cylinder. Treated seeds of sweet maize were planted three stands per hole at 0.75 m by 0.25 m spacing on 22nd November, 2004. Dead mulch at 3t/ha was applied uniformly on the plot on 25th November 2004. Fifteen emitter points were planted out to sweet maize per treatment. The whole plot was irrigated on 22nd and 25th November 2004 prior to the commencement of imposition of treatment to ensure uniform soil wetness. Irrigation water treatment started on 29th. November 2004. Drip irrigation water was applied once for treatment 1 (W_1), twice for treatment 2 (W_2) and thrice for treatment 3 (W_3) respectively at the rate of 0.0035 l/h, 0.0058 l/h and 0.0095 l/h for W_1, W_2, and W_3, in a split-plot design amounting to 6.38 litres, 11.66 litres, and 17.16 litres, for W_1, W_2, W_3, throughout the gestation (seedling stage to maturity) period. Water lifting to the tanks was effected from a nearby stream using 1.0 HP water pump. The drip irrigation system was modified to incorporate a separate fertigation system for telfairia occidentalis. This consisted of the feeder tank (1.500 litres), water delivery tank and the fertilizer tank connected to a mixer (Fig 3). The tanks were installed at relative ground levels one to another. The feeder tank was installed at 1.7 m above the ground level, the delivery tank at 0.7 m and the fertilizer tank, which is located 1.0 m above the soil surface. A motorized mixer was attached to the fertilizer tank to ensure homogeneous mixing of the fertilizer .The three tanks were networked to the main lines and controlled by a globe valve to ensure discriminate water or fertilizer injection when required. Seeds of telfairia occidentalis were planted out to the nursery on 2nd February 2005 and transplanted into the field 4 weeks after sowing (4WAS)) at average heights of 42.9 cm at 2 m by 2 m spacing. Water was applied to all 2 weeks after transplanting (2WAT). Drip irrigation treatment started 3 WAT. Mineral fertilizer (300 kg/ha) was added into the fertilizer tank for proper mixing prior to injection. Each treatment in the telfairia experiment consisted of fifteen driplets (4.2 mm diameter) and the distance between two sub plots was 1m. Irrigation water at the rate of 12 litres, 15.76 litres, 17.0 litres and 22.05 litres was applied as W_1, W_2, W_3, and W_4 at a uniform discharge rate of 2.9 cm^3/sec while fertilizer was applied at the level of 54.6 kg/ha, 65.06 kg/ha, 81.92 kg/ha and 95.39 kg/ha for F_1, F_2, F_3, and F_4 at the discharge rate of 1.3cm^3/sec. Experimental design was split-plot fitted into randomized complete block design with twelve replicates. Growth parameters of sweet maize were monitored. Plant height was measured with the aid of metre rule, number of leaves, was counted naturally, and stem diameter was measured using vernier calliper while the leaf area was evaluated with LI-3100 leaf area metre. Sweet maize cobs were harvested green and weighed with top loading balance. Root dry weights and above surface biomass was weighed using the

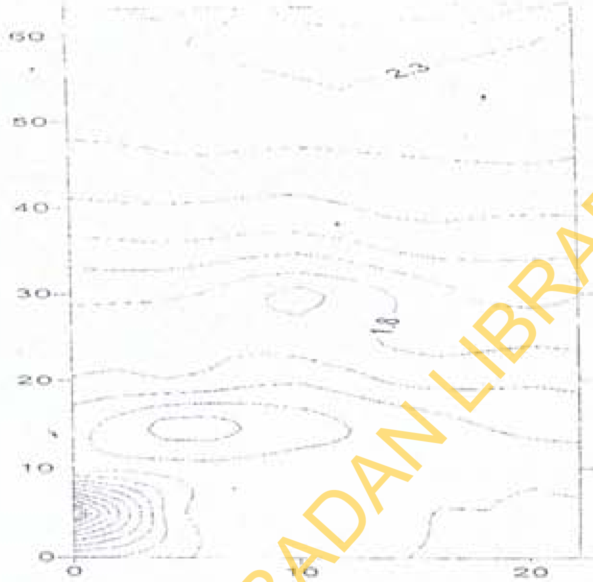

Fig 1: Topography of the Experimental field

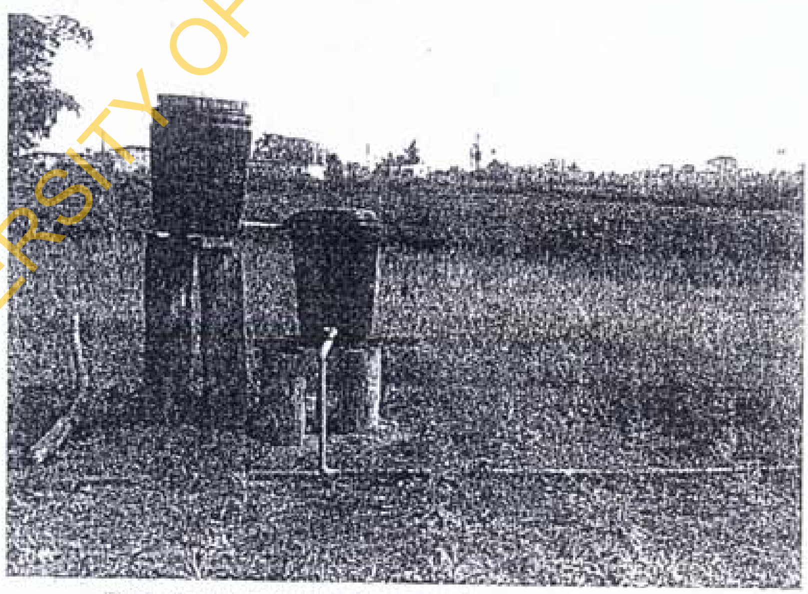

Fig 2: Drip Irrigation for Sweet maize

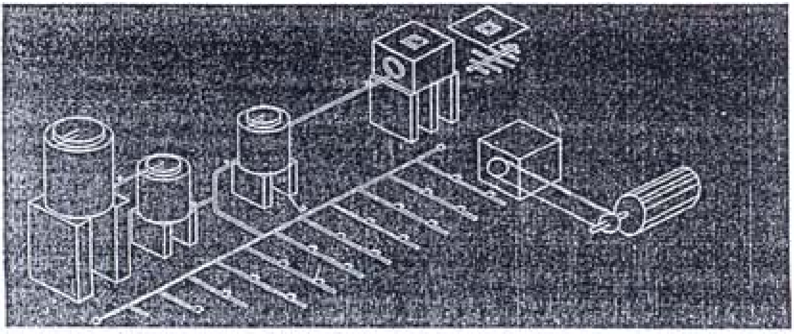

Fig 3: Design Layout of drip irrigation and fertigation system for *telfairia occidentalis*

standard weighing balance. Plant heights of sweet maize 7WAS, 9WAS and 12WAS were measured, while the amount of water applied at each stage was recorded. Telfairia growth parameters were measured accordingly.

Results and Discussion

Results of the chemical analysis of the water used for irrigation were presented in Table 1. The result appears favourable for agricultural activities bearing in mind the general acceptance that the quality of irrigation water is less than that of drinking water [8]. Table 2 shows the chemical and physical properties of the soil indicating sandy loamy soil of Alfisol (Egbeda Series) of the South of Nigeria. The amount of drip irrigation water applied to sweet maize was 6.38, 11.67 and 17.16 litres for W_1, W_2, and W_3, respectively. The water requirements for sweet maize ranged between 6.38 litres and 17.16litres. The average height of sweet maize ranged from 79.1 8 cm (W_1) to 109.76 cm (W_2) to 121.40 cm (W_3) respectively with gestation period of 78, 80 and 80 days for W_1, W_2, and W_3. The observed differences in height among the plants suggested that plants under W_1 suffered some level of water stress thereby leading to premature termination of plant growth and development. It was also observed that plants under W_2, and W_3 tasseled much earlier than W_1. Table 3 presents the effect of drip irrigation on growth performance of sweet maize. Plants under W_3 appeared significantly more luxurious ($P<0.05$) in leaf area, plant height and root weight than others. This result is not strange in the sense that generally plants respond more favorably to moisture availability at early stage especially when the critical level has not been exceeded. However, yield performance was best ($P<0.05$) under W_2. This result could be suggestive of array of plants utilizing water available in different ways. While some utilize the moisture available for early vegetative development leaving less moisture for other physiological growth, others delay till the late period of plant development under the same weather conditions. This phenomenon presents plants as unique living organisms capable of exhibiting different responses to photoperiodicity and moisture availability.

Table1: Chemical analysis of the irrigation water compared with acceptable standard

Chemical properties	Drinking water	Standard
P^{H} (H20)	7.1	7.0
Ec (mm hc/cu)	1.1x10-2	5.4x10-3
Ca (ppm)	217.421	200
Mg (ppm)	70.203	123
Na (ppm)	0.34	7.6
K (ppm)	0.89	3
$S04^{2}$ (ppm)	31.95	2.50
$HC03^{2}$ (ppm)	3.36	50.0
$P04^{3}$ (ppm)	48.80	-
$P04^{3}$ (ppm)	1.19	10
$NO3^{2}$ (ppm) Sulphur	7.04	10
Cu (ppm)	10.17	-
Zn (ppm)	0.026	1.01
Mn (ppm)	0.213	0.01
Fe (ppm)	0.005	15
Fe (ppm)	5.999	0.2
Salinity hazard	0.9	-
Alkalinity	13.8	77.0

Table 2 Chemical and physical properties of experimental soil

Ec	0.4
SAR ($meql^{-1}$	$4.8x10^{2}$
N (%)	0.135
C/N ratio	11
P (mg/kg)	3.06
Mg (cmol/kg)	1.07
K (cmol/kg)	0.19
Na (cmol/kg)	0.20
Mn (ppm)	194.09
Zn (ppm)	9.37
Cu (ppm)	093
Sand (%)	55.2
Clay (%)	22.0
Silt (%)	32.8

Table 3: Effect of Drip Irrigation on crop growth and cob yield of sweet maize

Trt	LA (cm^2)	PHT (cm)	RDT (cm)	BLWT (kg/ha)	COYLD (t/ha)	STD (cm)	STWT (t/ha)	RTWT (t/ha)
W_1	1435.1	79.18	9.52	61.40	14.72	3.70	39.89	2.95
W_2	1308.8	109.76	12.21	113.0	28.18	8.0	71.13	5.10
W_3	1628.5	121.40	1371	111.30	27.67	7.15	62.19	7.05
LSD (5%)	1305.4	26.72	4.42	55.28	20.26	2.96	37.23	6.27

Table 4 displays the effect of drip irrigation on total biomass production. Cob and the root dry matter performed better under W_2, although W_3 was best for stem dry matter. Generally, result obtained indicated that W_2 was optimum for sweet maize production. The result of the analysis of variance (ANOVA) for telfairia growth is presented on Table 5. Average plant heights, stem diameter and number of leaves responded more significantly ($P<0.05$) to moisture and fertilizer levels under irrigation rates of 15.76 litres and fertilizer level of 65.06 kg/ha (W_2F_2) in terms of growth performance. However, yield responded more positively to irrigation rates of 22.05 litres and fertilizer level of 95.39 kg/ha (W_3F_3) closely followed by W_2F_2 although there were no significant differences among the treatments.

Table 4: Effect of Drip irrigation on Biomass production.

Trt	Cob Weight (t/ha)	Root Weight (kg/ha)	Stem Weight (t/ha)
W_1	1.36	5.46	14.37
W_2	3.11	13.14	21.54
W_3	2.79	12.14	24.74
LSD (5%)	1.06	2.59	2.06

LA=Leaf Area (cm2); Plant height (cm); RDT=Root depth, (cm); BLWT=Bulk weight (kg); COYLD=Cob Yield (kg); STD=Stem diameter (cm); STWT=Stem weight (kg); RTWT=Root weight (kg).

Table 5: Effects of Drip irrigation rates and fertilizer levels on crop growth and yield of Telfairia occidentalis EF

Treatment	Plant Height/plant	Stem diameter Per plant (cm)	No leaves	Yield/plant
R_1F_1	149.15	7.8	13	22.0
R_2F_2	238.50	9.9	24	35.3
R_3F_3	209.10	8.9	22	20.8
R_4F_4	269.70	9.9	22	40.8
LSD (5%)	37.2	0.86	Ns	

R_1F_1-Drip irrigation of 12 litres and 54.6kg/ha of fertilizer
R_2F_2-Drip irrigation of 15.76 litres with 66.00kg/ha fertilizer
R_3F_3-Drip irrigation 17.0 liters and 81.92kg/ha fertilizer
R4F4-Dripirrigation of 22.05 litre and 95.39kg/ha

Considering the amount of water involved and the magnitude of fertilizer required to produce almost the same quantity of telfairia occidentalis under W_2F_2 and W_4F_4, W_2F_2 is preferable as it minimizes the amount of water applied and quantity of fertilizer for cultivation. Irrigation rates of 11.67 litres (W_2) and 15.76 litres in combination with fertilizer level of 65.06kg/ha (W_2F_2) are suggested for the cultivation of sweet maize and Telfairia occidentalis respectively.

Conclution:

Water resources are fast diminishing, the conventional irrigation systems are not only water and energy wasting but are also difficult to manipulate by poor farmers who earn their living by small farming activities. Sprinkler irrigation systems, the most currently used encourage pathogen infestations and spread. Environmental implications are not well addressed in the conventional systems. Drip irrigation and fertigation methods of water and fertilizer application are known to control all these problems associated with conventional irrigation systems and are cost effective.

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