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Productivity of irrigated gamba grass (*Andropogon Gayanus Kunth*) as influenced by flood irrigation and compost manure levels in zaria.

*** [1]Bello, S. S., [2]Amodu, J. T., [1]Hassan, M. R., [1]Abdu. S.B., [3]Bala, A.G., [1]Bello, I .U., [2]Ishiaku, Y. M. and [2]Ibrahim, H.**

[1]Department of Animal Science, Ahmadu Bello University, Zaria
[2]Feeds and Nutrition Research Programme, National Animal Production Research Institute, Ahmadu Bello University, Zaria.
[3] College of Agriculture and Animal Science, Ahmadu Bello University, Mando Kaduna State

*Corresponding author: email:sheyi4fact@gmail.com, Tel: +2347063461367

Abstract

A field experiment was conducted to evaluate the effect of varying levels of irrigation volume, irrigation frequency and compost manure application on growth components, forage yield and chemical composition of Gamba grass (Andropogon gayanus).The experimental design was a split- plot with 3×2×2 factorial arrangement, with three replications. There were three levels of irrigation volume (25, 50 and100L), under two irrigation frequencies (3 and 6 days) interval and two levels of compost (25 and 50t/ha), respectively. The result showed that stand count of Gamba grass was significantly affected (P< 0.05) by irrigation volume (335vs.243). Other growth components were significantly similar (P>0.05) in all the parameters measured. There was 8.2% significant increase (P< 0.05) in number of stands at 3days irrigation interval compared to that of 6 days. Compost levels applied had no significant effect (P>0.05) on number of stand and growth components in all the harvesting periods. The dry and fresh forage yields were significantly similar (P> 0.05) in all parameters measured. There were also no significant differences (P> 0.05) in all the interactions, except the values obtained from compost levels and age of maturity of gamba grass (P< 0.05) at different harvesting periods. The number of leaves at four weeks differed significantly (P< 0.05). Irrigation volume of 25L/day had the least (P<0.05) number of leaves (24) than other levels. However, all other parameters were not significant (P> 0.05). Interaction at 4 and 8 weeks were not significantly different (P>0.05) for plant height, except in the number of leaves at 12 weeks of age (P<0.05). It was therefore concluded that irrigation volume, frequency and levels of compost manure applied had effect on the productivity of gamba grass in Zaria, Nigeria. It is there recommended that, farmers could apply up to 100 liters of water per day to gamba grass at an irrigation interval of 3days and 25kg/ha of compost manure for better agronomic productivity of gamba grass in Zaria, Nigeria

Key words: Compost manure, gamba, irrigation, productivity, yield and quality.

Description of Problem

Natural grazing lands constitute the major feed resource, providing more than 90% of animal feed requirement, either in the form of grazing or conserved forages (1). These feed resources are categorized as high fibre, low protein feeds having organic matter digestibility between 30-45% and they include native grasses, crop residues and fibrous agro-industrial waste products (2). The three form the bulk of feeds consumed by small ruminants in tropical countries because they are produced in large quantities and are relatively cheap since they are not competed for by man. During the dry season when pastures, cereal crop residues and maize stover are in limited supply, malnutrition is often prevalent to many of the livestock farms (3). There is a clear need for alternative means of supplementing the year round forage requirements of livestock that will bridge the dry season shortage to ensure better performance and positive economic gain through high carrying capacity (4).

Gamba (*Andropogon gayanus*) is a tropical forage grass species often used in Brazil as pastures whenever drought stress is the most limiting factor (4*.,* 5). Being a cross-pollinated species, there are several cultivars and ecotypes available, which show a remarkable range of variation as to morpho-agronomic, seed and forage traits (6). Rapid spread of gamba grass has been observed from initial source paddocks in northern Australia and suggests explosive rates of spread analogous to highly invasive plants elsewhere (7). During the period of rapid growth the nutrient content of these natural grasses on average is about 25% dry matter, 10% crude protein, 6% ash, a fibre content of 35% and 43% acid detergent fibre (ADF). As the dry season advances and conditions become severe, their nutritional quality declines to the extent that crude protein could fall to as low as 2%. Ash values also decline to about 3 – 4% as a result of translocation of the root system, while fibre content increases in response to the process of lignifications and sometimes the crude fibre could be as high as 50% - 60% ADF (8). These grass species cannot meet the nutrient requirements of grazing livestock for most of the year. Even during the rains, they can only serve as maintenance requirements (8).

Improvement in ruminant production will therefore require increased effort in investigating the different possible ways and means of upgrading poor roughages through increasing their digestibility and voluntary intake (9). Although forages are not fertilized as heavily as cash crops, the trend is toward increased fertilization to maximize herbage production (26). Compost manure contributes significantly to the nutrient needs of plants microbial decomposition which directly releases N, P and S for use by plants. In addition, during the decomposition, CO_2 and other by products are released into the soil. A portion of the CO_2 released may be dissolved in the soil solution resulting in a decrease in the soil pH and increase the release of availability of several nutrients which include: P, Mn, Cu, Zn, B and Fe. By-products of compost manure decomposition may act as chelating agents in the soil, forming complexes with various nutrients. In the complexes state, these nutrients remain available to the plant rather than undergoing fixation by the soil particles (10).

Irrigation is becoming critically important to farm land for the purpose of agricultural production. Effective irrigation will influence the entire growth process from seedbed preparation, germination, root growth, nutrient utilization, plant growth and re-growth, yield and quality. Irrigation gives a powerful impetus to forage production and use by providing high quality feed in the dry season as trials by (11), (12), and (13) in the Savannah zone of Nigeria have shown that various grass and legume forages can be grown during the dry season with varying degree of success as farmers have a lot of control over how much water to supply and when to apply it. Nevertheless information on the Productivity and quality of Gamba grass under intensive flood irrigation in combination with compost manure is not well documented in Nigeria. Therefore, the present study was aimed at determine the effects of flood irrigation and rates of compost manure application on productivity components of Gamba grass in a small holder crop livestock system in Zaria, Nigeria.

Materials and Methods

Description of the experimental site

The experiment was conducted at the Irrigation Site of the Institute for Agricultural Research (IAR), Samaru, Zaria Kaduna State. Samaru is located on latitudes (11^0 and $11^{'}$N) and on longitudes (7^0 and $11^{'}$E) at an altitude of 686m above sea level in the Northern Guinea savanna of Nigeria (14). The maximum temperature for the period (February to April) recorded at Samaru, in Sabon Gari Local Government Area of Kaduna state showed the highest maximum temperature of about 30°C. The relative humidity in the months of February and AprilS is about 70 – 80%, during dry season (15).

Soil sampling and analysis

Composite soil samples were taken from the experimental site before land preparation using a Soil Auger at a depth of 15-20cm. The soil samples were bulked, and sub-samples taken and analysed for physical and chemical properties at the Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Experimental design and treatments

The experiment was laid out in a Split-Plot with 3×2×2 factorial arrangement, with three replications. There were three (3) levels of irrigation volumes (25, 50 and 100L), two irrigation frequencies (3 and 6-day intervals) and two levels of compost manure (25 and 50 kg/ha), respectively. Irrigation volumes were assigned as the main plots, while irrigation frequencies and compost were sub-plot factors. Soil moisture content was measured with a Tensiometer in each of the plots to determine the Volumetric Water Content. All the experimental plots received a uniform dose of 18kgha^{-1} NPK 15:15:15 fertilizer by broadcasting prior to sowing. A total of 36 plots measuring 2 m^2 with 1m inter-row path and watering channels, where used while the total area used for the experiment was 288 m.^{2} Prior to the forage establishment the field was cleared, ploughed and harrowed using hand hoes. Seeds of Gamba (*Andropogon gayanus*) at the rate of 10 kg/ha were broadcasted and compost manure were also applied by the same method in each plot perior to sowing.

Irrigation of the forage crop was carried out 3 and 6 days interval.

Data collection

Agronomic data collection which includes phenological observations of the planted forage plant started at four weeks after sowing when plant leaves were fully developed. The plants were sampled at 4, 8, and 12 weeks post-emergence from five plants randomly selected per plot and carefully tagged for determination of various agronomic parameters using the Standard Procedure of (16). Parameters measured include the following:

Establishment counts

Seedling counts were carried out at 4 and 8 weeks after sowing to give an estimation of emergence.The total number of seedlings in each plot were also counted to determine plant density per square meter and estimate the soil cover.

Growth Parameters

Plant height (cm): The plant height was taken at weekly interval by measuring the height of the plant from the ground level to the tip of the plant using a meter rule.

Number of leaves, tillers and nodes (cm): These were also recorded at weekly intervals by counting and taking the average from 5 plant samples in each plot.

Leaf length (cm): The leaf length was taken from 5 randomly selected plant leaves in each plot and measured with a meter rule and the average was recorded.

Leaf breath (cm): The breath of the selected plant leaves was measured with a meter rule at weekly interval.

Leaf area index (LAI): Leaf Area Index was calculated at 8,10 and 12 weeks after emergence of the plant leaves by means of *planimetric* techniques, it measure the true leaf area and the machince flatten the leaves during measurement of Samples placed between the guides on the lower transparent belt and allowed to pass through the LI-3100C. As the sample travels under the fluorescent light source, the projected image is reflected by a system of three mirrors to a scanning camera. (17) However calibrations can be checked frequently by a simple formula

Area = K (Length × Maximum width)

The coefficient, K for grasses is 0.75 using the Li-30100C Planimeter (Leaf Area Meter) at the Crop Physiology Laboratory, Department of Agronomy, Faculty of Agriculture, Ahmadu Bello University, Zaria.

Fresh forage yield

The Gamba grass forage was cut at 10-15cm, above the ground from each plot at the end of the 12-weeks establishment period. Total fresh weight (Tot FW) of the material cut was weighed immediately in the field using a weighing balance to determine the fresh fodder yield.

Dry forage yield

A sample of 150–200g fresh material (FWss) was weighed, oven dried at 65°C for 48hrs and reweighed (DWss) to give an estimate of the dry-matter production during this period.

Dry-matter production was calculated as:

(Tot FW x (DW ss/FW ss) x 10 = dry matter kg/ha (16**)**

Where:

Tot FW = total fresh weight from 1 m^2 in g

DW ss = dry weight of the subsample in g

FW ss = fresh weight of the subsample in g

Chemical analysis

The proximate analysis for the nutrients composition of the forage ***was carried out at*** the Biochemistry Laboratory of the Animal Science Department, Ahmadu Bello University, Zaria. Samples collected were oven-dried to a constant weight at 105 ^{0}C to determine the dry matter and there after the sample was ground to pass through 1-mm sieve for later use. Crude protein, crude fibre, ether extract, Nitrogen free extract and ash content were determined with the Method of Association of Analytical Chemist (18). The crude protein was calculated by multiplying the Nitrogen value in feedstuffs by 6.25 protein co-efficient and the crude fibre component was determined by the method of (19). The dry matter (DW) was obtained after samples were oven-dried at 65^{o}C for 48hrs. The difference between the oven - dried weight and fresh weight was considered as the moisture content of the sample.

DM (%) = 100 - Moisture content

Statistical analysis

Data collected were analyzed using Analysis of Variance (ANOVA) of the General Linear Model (GLM) Procedure of Statistical Analysis System (SAS) version 9 (20). Data on growth components, proximate and mineral compositions were analyzed using repeated measure ANOVA. The treatment means were separated and compared by Dunnet's Test for Split Plot Design. The model for this design is:

$$Y_{ijkl} = \mu + A_i + B_j + C_{K+} (ABC)_{ijK} + \varepsilon_{ijk}$$

where:

Y_{ijkl} = observation l in level i of factor A with level j of factor *B and level k of factor c*

μ = the overall mean

A_i = the effect of level i of factor (A) *irrigation volume (25, 50,100)*

B_j = the effect of level j of factor B *irrigation frequencies*

C_k = the effect of level k of factor C

$(ABC)_{ijk}$ = *the effect of level* ijk^{th} *interaction of* A x B x C

ε_{ijk} = the split-plot error with mean 0 and *variance* σ^2

Also, $\mu_{ijk} = \mu + A_iB_j + C_K + (ABC)_{ijK}$ = **the mean of** ijk^{th} A **x** B **x C interaction**

where

i = 3, ..., a indexes the main plot levels, irrigation (25, 50 and 100l),

j = 2 , ... , b indexes the subplot levels irrigation frequencies (3 and 6-day) and compost (25 and 50kg/ha)

Therefore the model assumed that main plot and split plot errors are independent.

Results and discussions

Soil Sampling and analyses

The physical and chemical characteristics of the composite soil samples taken from 15-20cm depths at the experimental site are presented in Table 1. The pH value of 6.3 obtained from the soil samples of the experimental site at the commencement of this study indicated that it was a fairly neutral soil. Total nitrogen (0.91%) and available phosphorus (25.2mgkg^{-1}) showed that the soil was low in these nutrients which were required for good growth and quality of forage plants. The low level of these nutrients has been reported to be responsible for the poor productivity of crops, especially forage plants on tropical soils (21).

The organic carbon content of the soil (0.9%) was low, hence there is need to enhance the quality of the soil through fertilization to increase productivity of forages at this location.

Table 1: Physical and Chemical Properties of the Soil at the Experimental Site

Properties		Values
Physical (%)		
Clay		22
Silt		22
Sand		56
SChemical		
P^H (H_20)		6.3
P^H ($Cacl_2$)		5.7
Exchangeable cations (CMolkg)		
Sodium	(Na)	0.96
Potassium	(K)	1.13
Calcium	(Ca)	4.20
Magesium	(Mg)	1.47
Total N(%)		0.91
Available P(ppm)		25.2
Organic Carbon (%)		0.9
Cations exchange capacity (Meq/100g)		8.4
Exchangeable acidity (CMol/kg)		
H+ Al		0.6

The effect of varying levels of irrigation volume, frequency and compost application on stand count and growth components of gamba grass at 12 weeks of age are presented in Table 2. The result show a 31% increase ($P < 0.05$) in number of stands with increase in irrigation volume. The highest stand count was recorded in the highest irrigation volume followed by the moderate and lowest irrigation volumes. This shows that soil moisture availability was highest at higher irrigation volume which might be the reason for higher germination percentage and hence the stand count. Irrigation water provides suitable moist environment to crops leading to optimum yields and maintenance of soil productivity (22).Water is the most important input for crop production especially in fodder crops where the maximum vegetative growth is desired within a short period of time (23). Provision of irrigation allows the maximum utilization of resources for intensive forage production, which is very important in countries with small land holdings.

Varying irrigation volumes had no significant effects on other parameters measured. There was 8.2% significant increase ($P < 0.05$) in number of stands at 3 days Irrigation (290.41) interval compared to 6 days irrigation interval. (266.63) delayed irrigation of (6 days) in gamba could results in water stress, particularly at growing stages of the plant. However, the rate of compost applied did not affect ($P>0.05$) both stand counts and growth components throughout the harvesting period. The result indicated that farmers could use either 25 kg/ha of compost without negative effect on growth components of the plant. Results obtained in this study are similar to the report of (24) that addition of minocopal waste compost to agricultural soils has beneficial effects on crop development and yield by improving soil physical and biological properties. According to these authors, compost help to improve the cation exchange capacity of soils, enabling them to retain nutrients longer. It will also allow crops to more effectively utilize nutrients, while reducing nutrient loss by leaching. For this reason, the fertility of soils is often tied to their organic matter content. They further opined that improving the cation exchange capacity of sandy soils by adding compost can greatly improve the retention of plant nutrients in the root zone.

Table 2: Effects of varying levels of irrigation volume , frequency and compost manure application on growth co mponents of Gamba grass at 12 weeks of planting.

Treatments	Stand count (no.)	Plant height (cm)	No of leaves (no.)	No of tillers (no.)	LAI
Irrigation volume(L)					
100	335.00[a]	82.23	30.34	13.52	0.12
50	231.92[b]	80.23	31.46	12.21	0.21
25	263.30[b]	81.04	23.70	9.48	0.14
Irrigation (interval)					
3	290.41[a]	83.57	28.69	12.19	0.17
6	266.63[b]	79.04	29.08	11.68	0.14
Compost manure (kg/ha)					
25	268.16	80.28	28.18	10.48	0.13
50	288.71	82.18	29.71	13.54	0.19
SEM	10.82	4.06	3.36	2.33	0.37

[abc] means with different superscripts along the column differed significantly (P <0.05) SEM= Standard error of means , LAI = Leaf Area index.

Table 3 shows the effects of varying levels of irrigation volume, frequency, compost and their interactions on fresh and dry forage yield of gamba grass at 12 weeks of age. The dry and fresh forage yields were significantly similar (P > 0.05) in all the harvesting periods (25.82, 25.05 t/ha) fresh forage yield while. However, there was a significant interaction (P< 0.05) between levels of compost and age of harvest of the forage at dry forage yield (C×A) t/ha .This indicates that compost requirements of gamba grass varies with age of the plant .Irrigaton volume and frequencies had no effect on forage yield.

Table 4 shows the effects of varying levels of irrigation volume, frequency and compost and their interaction on plant height and number of leaves of Gamba forage at 4, 8 and 12 WAS. There was a significant increase (P< 0.05) in the number of leaves at 4 WAS in all irrigation volumes with 50 L volume having the highest number of leaves (31.46) but not significantly higher (P > 0.05) than (30.34) recorded for 100 L. The present finding is in agreement with the report of (26) who concluded that most sorghum plants had high water

Table 3: Effects of varying levels of irrigation volume, frequenc y and compost manure on fresh and dry forage yields of Gamba grass at 12 weeks of age.

Treatments	Fresh forage yield (t/ha)	Dry forage yield (t/ha)
Irrigation volume (L)		
100	26.85	6.84
50	26.31	7.79
25	22.40	5.99
Irrigation (Interval)		
3	25.82	7.00
6	25.05	6.91
Compost manure (kg/ha)		
25	24.58	6.56
50	26.35	7.39
SEM	3.32	2.04
Interactions		
V×A	NS	NS
C×A	NS	*
F×A	NS	NS
V× F× C×A	NS	NS

[abc] means with different superscripts along the column differed significantly (P <0.05), SEM= Standard Error of Means.VA= Volume × Age, CA= Compost manure × Age, FA= freq × Age, VFC A= Volume × frequency × compost manure × Age

Table 4: Effects of varying levels of irrigation volume, frequency and compost manure, and their interaction on plant height and number of leaves of Gamba at 4,8 and12 weeks after sowing.

Treatments	Plant height (cm)			No of leaves (no)		
	4	8	12	4	8	12
Irrigation volume (L)						
100	19.41	29.24	82.23	30.34[a]	10.92	16.85
50	19.18	26.99	80.24	31.46[a]	11.88	21.97
25	18.44	29.90	81.04	23.70[b]	11.23	20.72
Irrigation (Interval)						
3	19.48	27.99	83.57	10.99	18.65	28.69
6	18.44	29.16	79.04	28.69	10.99	18.65
Compost manure (kg/ha)						
25	19.14	27.99	80.28	28.69	11.04	18.65
50	18.96	28.49	82.18	29.71	11.75	20.71
SEM	1.48	2.75	4.06	3.36	1.79	3.17
Interactions						
V×A	NS	NS	*	*	*	*
C×A	NS	NS	NS	*	*	*
F×A	NS	NS	*	NS	NS	*
V× F× C×A	NS	NS	NS	NS	NS	*

[abc] means with different superscripts along the column differed significantly (P <0.05) SEM= Standard Error of Means. VA= Volume × Age CA= Compost manure × Age FA= freq × Age VFCA= Volume × frequency × compost manure ×Age.

demands during the first week of establishment and irrigation should be emphasized at early stages and any time in which the soil water is below wilting point. However they were significantly higher ($P< 0.05$) than 23.70 leaves per plant in 25 L irrigation volume. The number of leaves per plant although there were no significant differences ($P> 0.05$) between the periods and the irrigation levels.(27) reported that plant height generally depends on internodes expansion, which caused an increase in height with increase in water depth, resulting in taller plants and functional characteristics changes continuously with relative age (28).

Conclusion and Application

It could be concluded from the results of this study that:

1. Productivity of *Andropogon gayanus* Gamba is influenced by irrigation volume, frequency and level of compost manure application. Farmers should plant gamba grass when the soil moisture content reaches field capacity (250 000 L/ha moisture content) for better stand count and leaf productivity.
2. The level of compost to be applied to gamba should not exceed 2.5 t/ha in Northern Guinea Savanna of Nigeria. However, irrigation frequency of 3days is adequate for better agronomic performance of gamba grass in Northern Guinea savanna of Nigeria.

References

1. Tolera, A . and Abebe, A.(2007). Livestock production in pastoral and agro-pastoral production systems of Southern Ethiopia .*Livestock Research for rural Development*,19-17.
2. Ajiji, I., Nyako, H. D., and Ashom, S .A. (2013). Performance of Yankasa Rams fed *Andropogon gayanus* (Gamba Grass) hay supplemented with *Faidherbia albida* (Acacia) Pods *Journal of Biology, Agriculture and Healthcare Vol.3(13)*
3. Amodu, J.T., and Kallah, M.S. (2008). A guide to hay making .Extension guide published by National Animal Production Research Institute, Shika Zaria.
4. Buldgen, A., Francois, J. and Falla, J. (1995*).* Seedling establishment *of Andropogon gayanus var. bisquamulatus* under dry conditions*. Tropical Grasslands*, **29**: 248–256.
5. Garcia, R., Pereira, O. G., Altuve, S.M. and Alvarenga, E.M. (1998). Effect of water potential on seed germination of three tropical forage grasses. *Brazilian Journal of Animal Science,* 27 (1): 9-15.
6. Usberti , R., Alcantara, P. B. and Tsuhako, A. T . (2008). Relationship among seed parameters and flowering cycles of three gamba grass (*Andropogon gayanus)* segregating populations. *International Grassland Congress Proceedings*, 11 360.
7. Petty, A. M., Setterfield, S.A.,

Ferdinands, K.B. and Barrow, P. (2012). Inferring habitat suitability and spread patterns from large-scale distributions of an exotic invasive pasture grass in north Australia .*Journal of Applied Ecology,* 26(64): 2012-2028.

8. Smith, O.B. (1992). Small ruminant feeding systems for small scale farmers in humid West Africa. In: Stares, J.E.S, Said, A.N. and Kategile, J.A. (Eds). *The complementarity of feed resources for animal production in Africa.* Proceedings of the joint Feed resources networks workshop held in Gaborone, Botswana, 4-8 March 1991. Africa Feeds research Network. ILCA(International livestock Centre for Africa). Addis Ababa, Ethiopia . Pp. 363-376.
9. Fadel Elseed, A.M.A. (2004). Effect of supplemental protein feeding on ruminal characteristics and microbial production in sheep fed treated rice straws. *Small Ruminant Research*, 57: 11-17
10. Schulte, E.E. (1995). Recommended Soil Organic Matter Tests. *In*: Soil Testing Procedures for the Northeastern United States. 2nd edition. Northeastern Regional Bull No., 493. University of Delaware. Newark, DE.
11. de Leeuw, P. N. (1971). The Establishment of *stylosanthes humilis* in Nigerian Savanna. Paper presented at the *12th International Grassland*. Congress Held in Moscow, Pp: 839- 850
12. Akinola, J.O. (1975). A preliminary assessment of forage legumes grown under irrigation for out of season dry matter and crude protein production. *Samaru Agriculture News*, 17 (2):62-64.
13. Kallah, M.S. (1988). Forestry and Economic Development*, India Journal of Agricultural Economics,* 43(3): 237-257
14. Ovimaps,(2014). Ovilocation map;ovi Earth Imaginary accessed on 21, February,2014.
15. Institute for Agricultural Research (I. A. R). Ahmadu Bello University (A. B. U.) weather station, 2015.
16. Tarawali, S. A., Tarawali, G., Larbi, A. and Hanson J. (1995). *Methods for the evaluation of legumes, grasses and fodder trees for us as livestock feed. ILRI Manual1.*ILRI International Livestock Research Institute), Nairobi, Kenya. Pp. 1-12.
17. Daughtry, C.S.T. (1990). Direct measurements of canopy structure. *Remote Sensing Reviews,* 5: 45-60.
18. Association of Official Analytical Chemist- AOAC, (2004). Association of Officials Analytical Chemist, 20th Edition, Washington D. *C., U. S. A*
19. van Soest, J.P. (1991). The use of detergents in the analysis of fibrous feeds. Determination of plant constituents. *Journal of Association of Agriculture Chemistry. 50 : 50 -55.*
20. SAS (2002). Statistical Analysis system User's guide, release 9.0 Institute Inc, SAS Circle, cary,

North Carolina, U.S.A.

21. Mohamed - Saleem, M.A. (1972). Productivity and chemical composition of *Cynodon* Ib8 as influenced by level of fertilization, soil pH and height of cutting. PhD Thesis, Department of Agronomy, University of Ibadan, and Ibadan, Nigeria.
22. Food and Agriculture Organization (FAO), (2006). United Nations, Irrigation and drainage paper No 56. Rome, Italy. Pp.173.
23. Fatondji, D., Tabo, R., Bationo, A., Fosu, M. and Sawadogo, S. (2011). Enhancing rain water and nutrient use efficiency for improved crop productivity, farm income and rural livelihood in the Volta Basin .CPWF Project Report. Colombo, Sri Lanka:CGIA Challenge Program on Water and Food http://hdl.handle.net/10568/37 68.
24. Zheljazkov, V.D. and Warman, P.R. (2004). Source-separated municipal solid waste compost manure application to Swiss chard and Basil. *Journal of Environmental Quality*, 33, 542-552
25. Lawrence, D.M., Slater, A.G., Romanovsky, V.E and Nicolsky, D. J. (2008). Sensitivity of a model projection of near surface permafrost degradation to soil column depth and inclusion of soil organic matter, *Journal of Geophysics ResearchS*, 113, 2011: 10.1029 / 2007 00781
26. Mastrorilli, M., Katerji, N. and Rana, G. (1999). Productivity and water use efficiency of sweet sorghum as affected by soil water deficit occurring at different vegetative growth stages. *Europe Journal of Agronomy*, 11: 207–215
27. Hazrat, E.W.I., Sulaiman, A.Z.B., Sakinah, A.M.M. (2004). Assessment of heavy metals tolerance in leaves stems and flowers of *Stevia rebaudiana* plant. *Proscenia Environment Science*, 20: 386–393.
28. Niinemets, U., Loreto, F. and Reichstein, M. (2004). Physiological and physicochemical controls on foliar volatile organic compound emissions, *Trends Plant Science*, 9: 180 – 186.