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Influence of Irrigation and Fertilizer Application Methods on Yield of Green Amaranth

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Abstract:- This study evaluated the effects of methods of urea fertilizer application and the different irrigation methods on yield of green amaranth. This was with the view to establishing the best combination of urea fertilizer method of placement and irrigation method for green amaranth production in Southwestern Nigeria.The experiment was carried out in two agroecological zones (rainforest and derived savanna) in the dry season. The experiment was laid out in Randomized Complete Block Design with four replicates. The treatments were: (i) broadcasting + sprinkler, (ii) fertigation + sub-irrigation (iii) spot + sprinkler, (iv) drilling + sprinkler and (v)fertigation + sprinkler. Soil samples were collected from each plot at 0-15 cm depth before and after the experiment for routine laboratory analyses. The above-ground biomass of green amaranth was harvested and tissue samples were taken for the determination of dry matter yield and total tissue nitrogen. Nitrogen uptake, nitrogen use efficiency and nitrogen recovery of green amaranth were estimated. The data collected were subjected to analysis of variance and differences in treatment means were separated using Tukey test at 5% level of probability.Dry matter yield and nitrogen uptake from broadcast were significantly lower than that of sub-fertigation, spot, drilling and surface fertigatonin both rainforest and derived savanna zones. Nitrogen use efficiency and nitrogen recovery efficiency under broadcast were significantly lower than other fertilizer application methods in the two locations. The dry matter yield, nitrogen uptake, nitrogen use efficiency and nitrogen recovery efficiency were similar under the two irrigation methods in the derived savanna zone. However, these parameters were greater ($p < 0.05$) with capillary irrigation compared to sprinkler irrigation in the rainforest zone.It was concluded that either sub-fertigation, spot, drilling or surface fertigation fertilizer application method was best for optimum yield and Nitrogen use efficiency of green amaranth. Capillary irrigation produced better yield and Nitrogen Use Efficiency in the rainforest than sprinkler irrigation but not in derived savanna.

Keywords:- Fertigation, Capillary, Dry matter yield.

I. INTRODUCTION

The absolute farmers' dependence on the seasonal March to September rains for cultivating crops and imbalanced use of fertilizers over the years have resulted to low crop yield in Nigeria (Shaheen*et al.*, 2010; Adepetu*et al.*, 2014). Improper farm management practices even where fertilizers and irrigation facilities are present have been found to account for nutrient loss also leading to low crop yield.

Water is an important climatic factor which affects or determines plant growth and development. Its availability or scarcity can mean a successful harvest or reduction in yield or total failure (FAO, 2011). When rainfall is not enough, the plants must receive additional water from irrigation. Various methods used to supply irrigation water to plants can be divided broadly into gravity watering (this result from water that is applied above the soil surface) and capillary watering (involves sub-irrigation or other systems that rely on wicking action). Capillary irrigation has been found to be more advantageous than its counterpart gravity in the following ways- improved crop quality, reduction of soil evaporation, surface runoff and deep percolation, and greater savings of water, nutrients and labour (Najafi and Tabatabaei, 2007).

Nutrients supply is also an important factor required for plants' growth and survival. The beneficial effect of adding mineral elements (such as plant ash or lime) to soils to improve plant growth has been known in agriculture for more than 2000 years. Nevertheless, even up till date it is still a matter of scientific controversy deciding the appropriate mineral fertilizers application rates and methods for optimum plant growth.

Nitrogen in urea fertilizer when applied to soil for green amaranth growth is lost through various means due to improper farm management practices. Therefore, innovative actions are required to improve fertilizer use efficiency to mitigate the problem of nutrient loss associated with conventional methods of fertilizer application and irrigation.One of the innovations developed by the Microveg Project is the capillary irrigation device which has been proven to be water saving. However, its effectiveness in improving crop yield has not been tested, hence this study.

Amaranthusviridis is an annual herb with nutritional, economical and health values. It contains all the classes of food and it is a source of income for farmers.*Amaranthusviridis* has high resistance to adverse weather conditions, fast growth rate and most importantly high nutrient responsiveness especially affecting the leaf growth, thereby making it the appropriate test crop for this experiment. The key constraints to its production are low moisture content, emergence of multiple nutrient deficiencies, low use and imbalanced use of fertilizers (Shaheen*et al.,* 2010).

The specific objectives of the study were to evaluate the effects methods of urea fertilizer application on dry matter yield (DMY) of green amaranth; andevaluate the effects of different irrigation methods on DMY of green amaranth.

II. MATERIALS AND METHODS

This study was carried out at the Obafemi Awolowo University Teaching and Research Farm (OAUT&RF), Ile-Ife, Osun State (rainforest ecological zone of Southwestern Nigeriaof Latitudes between 7º 32´ 39´´ N and 7º 38´ 36´´ N and Longitudes between 4º 33´ 29´´ E and 4º 33´ 30´´ E) and National Biotechnological Development Agency (NABDA) station, Ogbomoso, Oyo State (derived savannah ecological zone of Southwestern Nigeria of Latitudes between 8º 6 ´35´´ N and 8º 6´ 46´´ N and Longitudes between 4º 18´ 41´´ E and 4º 18´ 42´´ E).

The experiment which included four fertilizer application methods and two irrigation methods were combined differently (representing different farm management practices) and laid out in randomized complete block design with five treatments in four replicates. The treatments are: broadcasting + sprinkler, fertigation + sub-irrigation, spot + sprinkler, drilling + sprinkler and fertigation.

Planting was done in the dry season at both locations. Seedlings of *Amaranthusviridis* were raised in the nursery and later transplanted into the main plots. About 40 litres of water was added to each plot every other day and this was done using different irrigation methods as indicated in the experimental design. Urea was applied two weeks after transplanting and subsequently applied immediately after each harvest according to design. Three cycles of harvest were carried out at each location before termination and harvesting was done by cutting the above ground biomass at about one centimeter from the ground surface.

Soil samples were collected from each plot at 0 - 15 cm depth, air-dried, gently crushed and passed through a 2 mm sieve. The soil samples were labelled and taken to the laboratory for routine analyses.Plant tissue samples were also collected at each harvest, rinsed, weighed and oven dried at 65 ºC to constant weight. The oven-dried tissues were weighed, ground, bagged and labelled and used for total nitrogen analysis. The dry matter yield, nitrogen use efficiency(NUE) and nitrogen recovery efficiency(NRE) were estimated using the formulae below:

$$\text{Dry matter yield (kg/ha)} = \frac{dry\ matter\ weight\ (kg)}{\text{area of harvested land (ha)}}$$

$$\text{NUE (kg/ha)} = \frac{(YN - YO)}{\text{Nr}}$$

Where,
Y_N = Dry matter yield with inorganic fertilizer
Y_O = Dry matter yield without inorganic fertilizer
N_r = Amount of inorganic fertilizer applied (Eivazi and Habibi, 2013)

$$\text{NRE (\%)} = \frac{(a-b)}{c} \text{ x } 100$$

Where,
a = total N uptake from treated plots (kg/ha)
b = total N uptake from the control (kg/ ha)
c = total N applied (kg / ha) (Vanlauwe*et al.,* 2001).

Data collected were subjected to Analysis of Variance using the PROC GLM procedure in Statistical Analysis System (SAS) software version 9.0 (SAS institute, 2001) and where significant, means were separated using Tukey test.

III. RESULTS AND DISCUSSION

The textural classification of soils in both locations is sandy loam (Table 1). The pH (in $CaCl_2$ solution) of soil in Ife ranged from 4.8 to 5.9 and that of Ogbomoso ranged from 5.5 to 5.9 (Tables 2 and 3). The soil pH ranging from 4.0-5.4 is classified as medium acidic and 5.5-5.9 as slightly acidic (Adepetu*et al.,* 2014). The organic carbon and available P of the soil at Ife have values ranging from 3.61-5.56 g/kg and 6.07-7.73 mg/kg respectively while the organic carbon and available P of Ogbomoso soil have values ranging from 12.3-16.5 g/kg and 12.1-15.9 mg/kg, respectively. The organic carbon of Ogbomoso soil (derived savanna) was higher than that of Ife soil (rainforest) which is expected and this is because of the fibrous root system in grasslands which ramifies the soil, leading to high deposition of organic matter. It may also be due to the fact that the soil in the NABDA site has not been subjected to continuous use as that in the OAUT&RF. The ranges of exchangeable calcium, magnesium and potassium of the locations can be seen in Tables 2 and 3.

In rainforest and derived savanna zones, dry matter yield (DMY) and nitrogen uptake (NU) of green amaranth obtained from broadcast was significantly lower than those from sub-fertigation, drilling and spot(Tables 4 and 5). The result was in line with the report by Kucey (1986) which observed no difference in yield and nitrogen uptake in barley among three different banded fertilizer application methods. In derived savanna zone, the dry matter yield and nitrogen uptake values were higher than the rainforest. The trend was similar to what was obtained for soil organic matter content in the zones.

The nitrogen use efficiency (NUE) in the rainforest zone from broadcast was significantly lower than sub-fertigation and spot which may be due to loss of nitrogen through volatilization from the urea broadcast, thereby reducing its efficiency (Table 4). Urea fertilizers according to Jones *et al.* (2013) have high potential for volatilization. Rapid volatilization from the broadcast urea may also be due to irrigation because volatilization of surface-applied urea increases linearly as soil water increases (A-Kanani*et al*.,

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1991). Sweeny *et al.* (1987) reported 36% recovery from urea buried beside plants and just 18% from the urea broadcast which is similar to result of nitrogen recovery (17.44%) from broadcast in the rainforest zone. This recovery from broadcast was significantly lower than sub-fertigation and spot which had recoveries of 28.46% and 22.92% respectively. Similarly, in the derived savanna the nitrogen use efficiency and nitrogen recovery efficiency from broadcast were significantly lower than the other application methods. Spot which was buried beside plants had the highest recovery of 33.41% while broadcast had 14.75%.

Dry matter yield of green amaranth from capillary irrigation was significantly higher than that of sprinkler irrigation in rainforest but the two irrigation methods had no significant effect on DMY in the derived savanna zone (Table 6). The nitrogen uptake of green amaranth from capillary and sprinkler irrigation were not significantly different from each other in the two zones (Table 6). The higher dry matter yield of green amaranth with capillary irrigation in rainforest zone can be related to the study done by Ayars*et al.* (1999) that recorded higher yield of tomato, cotton and sweetcorn with capillary irrigation than surface irrigation.

Tables 7 shows the soil chemical properties after harvesting of the vegetable at Ife and Ogbomoso, respectively. The last row on each table shows the mean values of the antecedent chemical properties and there was little or difference between the antecedent and post-harvest chemical properties but the post-harvest organic carbon in Ogbomoso had reduced appreciably which was probably responsible for the higher yield in this zone.

	Ife	**Ogbomoso**
Sand (g/kg)	739	732
Silt (g/kg)	115	157
Clay (g/kg)	146	111
Textural class	Sandy loam	Sandy loam

Table 1: Soil particle size distribution of Ife and Ogbomoso experimental site

Trt	pH($CaCl_2$)	OC (g/kg)	Avail.P (mg/kg)	Ca	Exchangeable Mg (cmol/kg)	K	Na
1	5.9a	5.0a	7.7a	1.1a	0.88a	0.15a	0.031a
2	4.8a	3.6a	6.8a	1.1a	0.96a	0.16a	0.025a
3	5.7a	4.8a	6.5a	1.4a	0.81a	0.17a	0.050a
4	5.6a	4.8a	7.1a	1.0a	0.87a	0.16a	0.045a
5	5.7a	4.8a	6.1a	1.4a	0.95a	0.16a	0.027a
6	5.8a	5.6a	7.6a	1.2a	0.93a	0.16a	0.041a

Table 2: Antecedent chemical properties of the soil (0-15 cm) at Ife

Means in a column with similar letter(s) are not significantly different (p<0.05) according to Tukey test. Where 1= 80 kg N/ha (farmers' practice) + broadcasting + sprinkler, 2= 40 kg N/ha (microdose) + fertigation + sub-irrigation, 3= Microdose + spot + sprinkler, 4= Microdose + drilling + sprinkler, 5= Microdose + fertigation + sprinkler, 6= 0 kg N/ha + sprinkler (control), Trt= treatments, OC= organic carbon

Trt	pH($CaCl_2$)	OC (g/kg)	Avail.P (mg/kg)	Ca	Exchangeable Mg (cmol/kg)	K	Na
1	5.9a	12a	12a	1.4a	0.45a	0.14a	0.048a
2	5.6a	13a	14a	1.5a	0.45a	0.14a	0.045a
3	5.7a	15a	14a	1.4a	0.42a	0.14a	0.017a
4	5.7a	15a	16a	1.4a	0.39a	0.14a	0.008a
5	5.9a	14a	13a	1.4a	0.46a	0.14a	0.045a
6	5.5a	17a	13a	1.4a	0.43a	0.14a	0.020a

Table 3: Antecedent chemical properties of the soil (0-15 cm) at Ogbomoso

Means in a column with similar letter(s) are not significantly different (p<0.05) according to Tukey test. Where 1= 80 kg N/ha (farmers' practice) + broadcasting + sprinkler, 2= 40 kg N/ha (microdose) + fertigation + sub-irrigation, 3= Microdose + spot + sprinkler, 4= Microdose + drilling + sprinkler, 5= Microdose + fertigation + sprinkler, 6= 0 kg N/ha + sprinkler (control), Trt= treatments, OC= organic carbon

TRT	DMY	NU (kg/ ha)	NUE	NR (%)
Broadcast	1090c	40.32c	11.63b	17.44c
Sub-fertigation	2022a	62.62a	21.61a	28.46a
Spot	1984a	55.96ab	20.97a	22.92b
Drilling	1788ab	58.17ab	18.71ab	24.76ab
Surface fertigation	1666b	52.31b	16.36ab	19.87bc

Table 4: Effects of fertilizer application methods on dry matter yield, nitrogen uptake, nitrogen use efficiency and nitrogen recovery of green amaranth in rainforest zone

Means in a column with similar letter(s) are not significantly different ($p<0.05$) according to Tukey test. Where TRT= treatments, DMY= dry matter yield, NUE= nitrogen use efficiency, NU = nitrogen uptake, NRE= nitrogen recovery.

TRT	DMY	NU (kg/ ha)	NUE	NR (%)
Broadcast	1717b	54.75b	11.26b	14.75b
Sub-fertigation	2528ab	66.58ab	19.96ab	23.05ab
Spot	2464ab	79.07a	22.84a	33.41a
Drilling	2735a	74.87a	22.89a	29.09ab
Surface fertigation	2408ab	76.02a	23.48a	30.92ab

Table 5: Effects of fertilizer application methods on dry matter yield, nitrogen uptake, nitrogen use efficiency and nitrogen recovery of green amaranth in derived savanna zone

Means in a column with similar letter(s) are not significantly different ($p<0.05$) according to Tukey test. Where TRT= treatments, DMY= dry matter yield, NUE= nitrogen use efficiency, NU = nitrogen uptake, NRE= nitrogen recovery.

	Rainforest		Derived savanna	
	Capillary	Sprinkler	Capillary	Sprinkler
DMY (kg/ha)	2022a	1666b	2527a	2408a
NU (kg/ha)	62.62a	52.31a	66.58a	76.02a
NUE (kg/ha)	21.61a	16.36b	19.96a	23.48a
NR (%)	28.46a	19.87b	23.05a	30.92a

Table 6: Effects of irrigation methods on dry matter yield, nitrogen uptake, nitrogen use efficiency and nitrogen recovery of green amaranth in rainforest and derived savanna zones

Means in a row with similar letter(s) are not significantly different ($p<0.05$) according to Tukey test. Where TRT= treatments, DMY= dry matter yield, NUE= nitrogen use efficiency, NU = nitrogen uptake, NRE= nitrogen recovery.

Trt	pH($CaCl_2$)	OC (g/kg)	Ca	Exchangeable Mg	K	Na
			(cmol/kg)			
1	5.7a	8.3a	1.9a	0.32a	0.15a	0.028a
2	5.6a	7.2a	1.7a	0.32a	0.14a	0.025a
3	6.1a	6.9a	1.8a	0.32a	0.16a	0.050a
4	6.3a	5.4a	1.9a	0.31a	0.16a	0.045a
5	6.1a	6.6a	1.8a	0.31a	0.16a	0.025a
6	5.8a	5.9a	1.9a	0.31a	0.14a	0.048a
Ante.	5.6	4.8	1.2	0.42	0.16	0.037

Table 7: Post-harvest chemical properties of the soil (0-15 cm) at Ife

Means in a column with similar letter(s) are not significantly different ($p<0.05$) according to Tukey test. Where 1= 80 kg N/ha (farmers' practice) + broadcasting + sprinkler, 2= 40 kg N/ha (microdose) +fertigation + sub-irrigation, 3= Microdose + spot + sprinkler, 4= Microdose + drilling + sprinkler, 5= Microdose + fertigation + sprinkler, 6= 0 kg N/ha + sprinkler (control), Trt= treatments, OC= organic carbon, Ante. = antecedent

IV. CONCLUSION AND RECOMMENDATION

In conclusion, dry matter yield, nitrogen use efficiency and nitrogen recovery of green amaranth were optimum with sub-fertigation, spot and drilling fertilizer application methods and should be recommended to green amaranth farmers for increased fertilizer use efficiency, optimum yield. Capillary irrigation produced a better result in the rainforest zone than sprinkler irrigation but were not significantly different from each other in the derived savanna.

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