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PRODUCTIVITY ASSESSMENT OF TWO DIFFERENT MANAGEMENT SYSTEMS IN SUB-DIVIDED FOUR DIFFERENT GRADIENTS

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ABSTRACT: *Watersheds are naturally productive but most ecologically vulnerable section of the landscape. Productivity assessment of two contrasting watershed were studied in Amawbia south east, Nigeria using amaranthus as test crop under field and pot experiments. The experiments were arranged in randomized complete block design (RCBD) and complete randomized design (CRD) respectively in managed and unmanaged system of the watershed with NPK at the rate of 150kg/ha. Findings from the study showed significant differences ($P < 0.05$) among the slopes, managements, slope and management as well as natural environment and NPK in all the parameters assessed. Higher values were recorded in managed system in all the parameters and values obtained from NPK were observed to be higher than the values obtained from natural environment. Natural environment of the four slopes studied in managed plot significantly recorded increased growth and yield of amaranthus than the unmanaged plots. Thus, the findings of the study are evidence that sustainable management of soil and water resources is based on the judicious and scientific management of all landscape units within a watershed. As land degradation beyond the point of no return, pollution and eutropication of water and environment are all traceable to poor and mismanagement of landscape units within a watershed.*

KEYWORDS: Amaranthus, ecosystem, fertilizer, management systems, natural environment, slope

INTRODUCTION

Amaranthus is an erect plant that has branching and occasional pubescent stem is a popular vegetable crop in Nigeria and south east in particular. It is a commonly grown leafy vegetable of the low land tropics in Africa and Asia. Amaranthus is of many species of which their cultivation have increased tremendously all over Nigeria and probably other parts of tropical Africa basically for its leafy material relevance in soup and stew making, salad, porridge etc. It is a source of dietary protein and like other leafy vegetables contains more Ca than meat. It's rich sources of vitamins B and C enhances its nutritional values (Ali 1999). Medically, the leaves can be used as alternative drug therapy for the hypertension and cardiovascular disease patients (Martiorosyan and Mirostinichen, 2007). The crop is a shallow rooted crop, sensitive to soil nutrients and water hence management practices affect the development and productivity of the crop. Amaranthus for instance, requires a fertile soil well supplied with organic matter for good productivity (Okoli and Nweke, 2015). Nitrogen has equally, proven to be the limiting soil nutrient in most situations (Weber, 1989) which has led to a study on the effect of nitrogen fertilizer on amaranthus in Nigeria (Ibrahim and Lawal, 2001). The crop is very tolerant to varying soil and weather conditions. Therefore, soils that should be used for effective production of the crop should be managed by conservation, though sustainable crop production in the face of ever increasing human population in Africa and Nigeria in particular with their expanding nutritional demands has made the environmental and social development a very big challenging issue.

Soil is the bedrock of food production and life, inappropriate management will affect the efficiency of its water and nutrient availability to plants. Bio-productivity is the amount and rate of production which occur in a given ecological system over a given time period. In agriculture for example the productivity is measured by the crop yield that is biomass x land area expressed in amount per hectare. Higher yield implies the use of less land to reach the same productivity. In the light of this the management and productivity of watershed ecosystem is very important as its structural and functional characteristics influence both human and natural communities within the ecosystem. Man is usually interested in the productivity of an ecosystem because it enhances the possibilities for exploiting the nature's resources. In some cases the exploitation can be harmful hence adequate land and water conservation practices are necessary for maximum exploitation and productive life of a watershed ecosystem. Adequate watershed management reduces or prevents the direct human impacts of resources extraction, land development and waste disposal. Such impacts according to Folke et al (2004) can reduce ecosystem resilience. Watershed management is aimed at improving the standard of living of the local people by increasing their productivity and earning capacity. Thus watershed management seeks to make the best use of soil water and vegetation within the constraint of a watershed's agro-climatic and topographic conditions to strengthen the natural resource base (soil, vegetation cover) and to increase agricultural productivity. The objective of this study therefore, was to use amaranthus crop to assess the productivity of two different management ecosystems.

MATERIALS AND METHODS

The study was conducted in Anambra State Market Garden, Amawbia. Amawbia is a sub-urban community within Awka Capital Territory, Anambra State, Nigeria. The area is a watershed, which lies between latitude 06°18 north and longitude 070°41 east. The temperature of the area is uniformly high with mean monthly minimum average of 26°C, maximum temperature of 30°C - 35°C ± 1°C is obtained in March but temperature may reduce to 24°C - 27°C. Amawbia receives an annual rainfall which ranges between 1500mm to 2500mm with its peak in the months of July and September. Part of this watershed in recent past has come under some kind of management programme initiated by Anambra State Government leaving the adjacent watershed area unmanaged. Hence, the watershed areas can be clearly categorized into managed and non-managed watershed systems. This study was carried out under these two management systems (i.e. management and non-management).The managed system was characterized with terraces separated by earth bunds and stabilised by permanent trees forming hedgerows. This plot was established in June, 1995, and has been under management for over 20 years. The non-managed system is neither terraced nor ridged for erosion control. The two management systems were subdivided in different slope gradients (slope 1, 34.8% gradient; slope 2, 29.6% gradient; slope 3, 23.8% gradient; slope 4 or plain, 0.52% gradient). Reclamation programme for the unmanaged system was conducted using pot experiment where by perforated polythene bags of dimension 25cm x 30cm containing soil sample weighing 5kg were used. Compost manure and poultry manure were applied at the rates of $0tha^{-1}$, $10tha^{-1}$, $20tha^{-1}$ and $30tha^{-1}$ and NPK was applied at the rate of $150kgha^{-1}$ (rate recommended for okra Singh, 1995) considering the low fertility status of the soil. Plant height, stem girth and leaf area were measured using ropes and ruler while fresh weight and dry weight were determined using electric oven and electric weighing balance. The field experiments were arranged in a randomized complete block design (RCBD) while the pot experiments were arranged in a completely randomized design (CRD). Results were subjected to analysis of variance (ANOVA) and significant differences among treatment means were separated using least significant difference (LSD).

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RESULTS

Effect of slope on Amaranthus

The result presented in Table 1 showed that slope had effect on the parameters of amaranthus studied. The values recorded for each of the parameter indicated increase in value as the slope gradients decreased, except for leaf area value where values of slope 4 decreased little relative to slope 3 values. Thus the highest value recorded for the parameters were obtained from slope 4 been the lowest gradient. The percentage increase in plant height, leaf area, fresh weight and dry weight of amaranthus in slope 4 relative to slope 1 were; 44.50%, 57.48%, 39.13% and 40.20% respectively.

Table 1 Effect of Slope on Amaranthus

Slope height (cm)	Plant girth (cm)	Stem Leaves	No. of (cm^2)	Leaf area weight (g)	Fresh (g)	Dry weight
1(34.8%)	54.64	2.73	61.25	48.34	365.30	233.70
2(29.6%)	84.28	2.80	68.67	84.38	520.10	328.30
3(23.8%)	69.98	3.55	106.30	114.30	556.20	326.0
4(0.52%)	98.45	3.63	121.0	113.70	600.60	390.80
LSD0.05	15.33	0.83	37.83	29.35	154.90	62.30

Effect of Management on Amaranthus

The impact of management on the amaranthus was effective as the result in Table 2 indicated significant differences ($P < 0.05$) in all the assessed parameters. The managed system recorded the highest value in all the parameters of amaranthus studied. The percentage decrease in value of plant height, leaf area and fresh weight in unmanaged system relative to the managed system were 65.91%, 31.32% and 20.19% respectively.

Table 2 Effect Management on Amaranthus

Management	Plant height (cm)	Stem girth (cm)	No. of Leaves	Leaf area (cm^2)	Fresh weight (g)	Dry weight (g)
Managed	95.88	3.64	109.80	102.40	557.20	361.50
Unmanaged	57.79	2.272	68.63	77.98	463.60	277.90
LSD0.05	28.48	0.83	52.58	36.08	79.95	64.80

Effect of treatment on amaranthus

The effect of natural environment and NPK fertilizer on the assessed parameters of amaranthus recorded in Table 3 showed significant differences ($P < 0.05$). Higher values were recorded in NPK compared to

the values of parameters obtained from natural environment. The percentage increase in value of plant height, leaf area, fresh weight and dry weight of amaranthus recorded in NPK relative to the values obtained in natural environment were 28.84%, 48.65%, 39.97%, 40.15% respectively.

Table 3 Effect Management on Amaranthus

Treatment	Plant height (cm)	Stem girth (cm)	No. of Leaves	Leaf area (cm^2)	Fresh weight (g)	Dry weight (g)
Natural Environment	63.89	2.60	59.42	61.21	382.90	239.40
NPK	89.78	3.75	119.0	119.20	637.90	400.00
LSD0.05	14.18	0.75	59.76	65.43	234.80	157.10

Combined effect of slope and management on amaranthus

The result of slope and management effect on the growth and yield components of amaranthus recorded in Table 4 indicated significant difference ($P < 0.05$) among the slope gradients and management systems studied. The value recorded for parameters, increased as the slope gradients decreased though in some of the parameters decreased values were observed as slope gradients decreased. Higher values were recorded in managed system compared to unmanaged system in all the slope gradients studied in Table 4 except for slope 4, for the result of stem girth , number of leaves, leaf area and fresh weight were the unmanaged system recorded higher values than the managed system. The percentage increase in these parameters stem-girth, number of leaves, leaf area and fresh weight in unmanaged system relative to managed system of slope 4 were; 29.74%, 13.85%, 21.71% and 30.92% respectively.

Table 4 Combined effect of Slope and Management on Amaranthus

Slope	Management	Plant height cm	Stem girth cm	No. of leaves	Leaf area cm^2	Fresh weight g	Dry weight g
1(34.8%)	Managed	81.85	3.50	88.50	78.05	449.40	292.80
	Unmanaged	27.43	1.95	34.0	18.55	281.10	174.70
2(29.6%)	Managed	116.95	3.70	96.83	94.95	654.20	428.70
	Unmanaged	51.60	1.90	40.0	73.80	386.0	227.90
3(23.8%)	Managed	85.95	4.35	142.0	136.60	634.80	403.70
	Unmanaged	54.0	2.75	70.50	92.05	477.50	248.30
4(0.52%)	Managed	98.75	3.00	112.0	99.90	490.30	321.0
	Unmanaged	98.50	4.27	130.0	127.60	709.80	460.60
LSD 0.05		29.63	0.91	14.75	66.04	36.05	94.58

Combined effect of slope and treatment on amaranthus

The result of slope and treatment effect on amaranthus presented in Table 5 indicated significant differences ($P < 0.05$) among the slope gradients and treatments studied. In most of the parameters value recorded increased as the slope gradients decreased. In each slope gradient NPK treatment recorded the highest value in all the parameters compared to the natural environment. Slope gradient (4) and NPK in

comparison to other slope gradients and treatment gave the highest value in plant height, number of leaves, fresh weight and dry weight; while slope gradient 3 and NPK recorded highest value in stem girth and leaf area. The percentage decrease in value of fresh weight and dry weight of amaranthus in natural environment relative to NPK in slope gradient 1 were 189.19% and 209.19% respectively.

Table 5 Combined effect of Slope and treatment on Amaranthus

Slope	Treatment	Plant height	Stem girth	No. of leaves	Leaf area	Fresh weight	Dry weight
		cm	cm		cm^2	g	g
1(34.8%)	Natural Envt	43.18	2.40	45.83	36.95	187.64	114.30
	NPK	66.10	3.05	76.67	59.64	542.80	353.40
2(29.6%)	Natural Envt	71.15	2.30	40.0	44.58	386.90	245.30
	NPK	97.40	3.30	96.83	124.20	653.40	411.30
3(23.8%)	Natural Envt	52.90	2.45	63.0	62.50	465.85	286.40
	NPK	87.05	4.65	149.50	166.20	646.50	383.60
4(0.52%)	Natural Envt	88.35	3.27	88.83	100.90	491.50	330.10
	NPK	105.55	4.0	153.20	126.60	708.70	451.50
LSD 0.05		43.81	0.89	45.01	23.62	190.90	92.28

Combined effect of management and treatment on Amaranthus

The management and treatment effect on amaranthus were not effective except for number of leaves, fresh weight and dry weight (Table 6), that showed significant difference ($P < 0.05$) among the treatments and management systems studied. Higher values were recorded in managed system compared to unmanaged system in all the parameters assessed. Also NPK treatment recorded higher values in all the parameter compared to the values obtained from natural environment. The combined effect of managed system and NPK recorded the highest values in all the assessed parameters of amaranthus compared to other management and treatment effect considered in this study. The percentage decrease in value of plant height, leaf area, fresh weight, and dry weight in natural environment of unmanaged system relative to natural environment of managed system were 93.16%, 47.32%, 55.01% and 64.68% respectively.

Table 6 Combined effect of Management and Treatment on Amaranthus

Management	Treatment	Plant height	Stem girth	No. of leaves	Leaf area	Fresh weight	Dry weight
		cm	cm		cm^2	g	g
Managed	Natural Envt	84.20	2.90	74.83	72.97	465.50	297.90
	NPK	107.55	4.38	144.80	131.90	648.90	425.10
Unmanaged	Natural Envt	43.59	2.31	44.0	49.53	300.30	180.90
	NPK	77.0	3.13	93.25	106.50	626.80	374.80
LSD 0.05		NS	NS	26.17	NS	23.85	152.60

Combined effect of slope, management and treatment on amaranthus

The effect of slope, management and treatment on amaranthus presented in Table 7 showed significant differences ($P < 0.05$) in all the parameters studied. The result of plant height in both managed and unmanaged systems as well as natural environment and NPK increased as slope gradients decreased though the value decreased in slope 3, but increased again in slope 4 (plain). Stem girth result showed that its value in the natural environment of managed system decreased as the slope gradients decreased though an increased value was observed in slope 4 relative to slope 3, while NPK value of managed

system showed increased value as slope gradients decreased, though decreased value was recorded in slope 4 relative to slope 3. In the case of unmanaged system, the stem girth value in natural environment and in NPK did not follow any particular order of increase or decrease in relation to the slope gradients studied. Number of leaves and leaf area result indicated that highest value was recorded in NPK of managed system in slope 3 compared to other management, treatment and slope gradients studied. Fresh and dry weight value of amaranthus showed increased value in both natural environment and NPK treatment of managed system and unmanaged system as slope gradients decreased. Unmanaged system and NPK of slope 4 gave the highest value of fresh weight (764.20g) and dry weight 469.0g relative to other treatments, management and slope gradients studied.

Table 7 Combined effect of Slope, Management and Treatment on Amaranthus

Slope	Management	Treatment	Plant height cm	Stem girth cm	No. of leaves	Leaf area cm^2	Fresh weight g	Dry weight g
1(34.8%)	Managed	Natural Envt	66.10	3.20	77.67	61.28	265.30	175.0
		NPK	97.60	3.80	99.33	94.92	633.50	410.0
	Unmanaged	Natural Envt	20.22	1.60	14.0	12.76	110.0	52.60
		NPK	34.60	2.30	54.0	24.41	452.20	297.0
2(29.6%)	Managed	Natural Envt	113.70	3.0	68.0	76.40	648.0	422.0
		NPK	120.20	4.40	125.70	113.50	660.40	435.0
	Unmanaged	Natural Envt	28.60	1.60	12.0	12.78	125.70	68.20
		NPK	74.60	2.20	68.0	134.90	646.40	388.0
3(23.8%)	Managed	Natural Envt	72.30	2.60	82.0	75.80	621.30	387.0
		NPK	99.60	6.10	202.0	197.50	648.50	421.0
	Unmanaged	Natural Envt	33.50	2.30	44.0	49.23	310.50	150.0
		NPK	74.50	3.20	97.0	134.90	644.50	346.0
4 (0.52%)	Managed	Natural Envt	84.70	2.80	71.67	78.27	327.40	208.0
		NPK	112.80	3.20	152.30	121.60	653.20	435.0
	Unmanaged	Natural Envt	92.0	3.73	106.0	123.50	655.40	453.0
		NPK	104.30	4.80	154.0	131.60	764.20	469.0
LSD 0.05			22.38	0.93	7.17	29.97	43.91	38.30

DISCUSSION

The productivity of amaranthus was observed to be higher in the four different slopes of the managed plot in the natural environment and with NPK. Slope 2 of the managed plot was found to have recorded the highest plant height on their natural environment with NPK. While slope 3 of managed plot with NPK recorded the highest value in stem girth, number of leaves, leaf area, fresh weight and dry weight respectively. This result scenario might be in connection with the vegetation cover provided by the hedgerows in the managed plot that encouraged evenly distribution and maintenance of available soil nutrients throughout the four slopes of the watershed unlike the unmanaged plot that had more concentration of nutrients only in slope 4 with little or no nutrients in other slopes. This was confirmed by the studies conducted by Lal, (1989); Kang and Ghuman, (1991) and Nweke (2020) which demonstrated significant positive effect of alley cropping on soil fertility parameters such as organic carbon levels, total N and extractable P levels over a range of climatic and soil conditions. Nitrogen has proven to be the limiting soil nutrients in most situations of amaranthus production (Weber, 1989) as was evidence in reduced yield and yield components observed in both natural environment of managed and unmanaged system compared with their NPK application. On the other hand, the plant through its relatively increased yield in some parameters in unmanaged system tends to agree that the plant can tolerate varying soil and climatic conditions. Furthermore, Hauser (1990) found higher concentration of N, K, Ca and Mg in the surface soil than in the sub-soil under hedgerows. This he attributed to leaf litter fall and nutrients uptake by the trees from the subsoil. Also that in the entire of the alley plots the reverse situation occurred with lower nutrients level in the surface soil due to crop uptake and higher levels in

the subsoil due to leaching. This scenario might have been responsible for the increased values in the parameters recorded in the managed system of the watershed. The result shows that hedgerows in managed system can reduce the downward movement and displacement of soil nutrients.

CONCLUSION

The result of the study showed that natural environment of the managed watershed showed significantly higher productivity in all the growth and yield parameters of amaranthus compared with unmanaged systems. The findings from the study simply attest that proper watershed design and management are critical factors in the sustainable exploitation of our land resources.

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