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Effects of Planting Distance on Bitter Leaf Plant *(Vernoniaamygdalina)* Growth and Yield

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Abstract
Bitter leaf (Vernoniaamygdalina) is a very important indigenous vegetable in Africa especially Nigeria. It is a leafy vegetable use for food, feeds and medicinal purposes but it is not grown in commercial scale and regular cropping system. Hence studies were carried out in 2019 and 2020 cropping seasons to determine effects of planting distance on growth and yield of the crop. Seven planting distances: 90x40cm, 90x60cm, 90x80cm, 1mx50cm, 1mx1m, 1mx1.5m, and 1mx2m inter andintra row respectively, replicated three times. Growth aid yield of bitter leafplant was significantly affected by planting distance. Lager leaf area index values (2.95, and 3.316) and tallest plant height (497.5 and 476.8)cm were obtained with 90x40cm planting distance at 30 weeks after planting (WAP) in 2019 and 2020 seasons respectively. Wider planting distance (1mx1.5m) had more laves , branches, fresh and dry matter yield per plant. The highest fresh leaves weight (3.89g and 3.88) t/h and dry leaves yield (0.793 and 0.786) t/ha per hectare were produced by 90x40cm spacing at 35 WAP in 2019 and 2020 season respectively. Farmers are advised to cultivate bitter leaf plant at 90x40cmand or 1m x 50cm yield.

Key Words: *Bitterleaf, (Vernoniaamygdalina) planting distance, growth, yield*

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I. Introduction

Bitter leaf (V*ernoniaamygdalina)* belong to family compositaceae. It is called*ewuro*in Yoruba and*onugbu* in Ibo,*etidot* (Efik),*shuwaka* or *chusardoki*(Hausa). It is a small shrub that grows predominantly in the tropical Africa and Nigeria the plant is locally called bitter-leaf due to it bitter taste.

In Nigeria the leaves are used as staple vegetables in soups and stews of various cultures.

Leaves are also used in place of Hops to brew local beer(Nwanjo, 2005))

The aqueous extract from leaves, stem and root are use to reduce glycerol levels and diabetic in traditional medicine, it reduces cancer risk due to it anti – cancer properties like andandrographolide compounds(*Appiah, Kwame (2018).*(Ijeh andEjike ,2011).

In Nigeria a lot of persons usebitter-leaf (*Vernoniaamygdalina*) either as soup, stew ingredient or medical purposes. Some even use the stem and branches as chew – sticks

The large scale (commercial quantity) production of bitter-leaf in Nigeria is militated by some factors (lack of literature on it fertilizer rates,planting date, spacing among others).

The crop has not yet been incorporated into the farming system either as sole or mixed cropping. A few peasant women that grow the crop, plant it behind their compounds, close to their kitchen or as a hedge.

Inspired of the economics importance of bitter-leaf, there is paucity of literature on the cultivation and the agronomic technique required for the commercial scale production to ensure regular supply of the crops whenever it is needed

Literature shows that spacing or planting distance have significantly effects on the growth and yield of crops.

Adequate inter and intra row planting distance increase growth and yield component of crops (Adams, *et al;*2013). Evenly distributed plants have less nutrient stress. Widely spaced crops arelarger plants as a result of reduced competition for growth factors (Umar *et al;*2017).

The agronomic technique of bitter-leaf (fertilizer application, planting distance, weeds control, and planting date among others) for optimum growth and yield is lacking. Theses consideration form the bases of this work. Hence, the objective of this study was to determine the effect of different planting distance on the growth and yield of bitter-leaf in central Cross River State, Nigeria.

2. Materials and Method

Experimental Site.

Two experiments were carried out in the Department of Agronomy Teaching and Research farm, Faculty of Agriculture and forestry, Obubracampus University of Cross River, South, Nigeria. The situation of Obubra at

the global map lies between longitude 08°15" E and latitude 05°59" N of the equator (Cross River Agricultural Development Project (CRADP, 1992)

The studies were carried out in 2019 and 2020 cropping season between April and November respectively the average temperature range is 26°C – 32°C and annual rainfall of 2000 - 2500mm (CRADP,1992) in the humid tropical rainforest.

Land Preparation

Experimental Site was cleared, ploughed, harrowed manuallyand divided into four block on 5th April, 2019 and 2020. Each block was divided into seven (7) plots of 8mx4m ($32m^2$) separated by 0.5m path way and 1.0m between each block.

II. Experimental Design

The design of the experiment was a randomized complete block design (RCBD). There were seven (7) planting distances (90cmx40cm), (90cm x60cm),(90cmx80cm), (1mx50cm), (1mx1m), (1mx1.5m), (1mx2m), inter and intra row respectively used as treatments for the studies.Table of random numbers was used to allocate the seven treatment that had four replications.

Planting of Bitter-leaf (*Vernoniaamygdalina*)

Bitter leaf (*Vernoniaamygdalina*) was planted using vegetative method of propagation using stem (young stems cuttings of 8 – 12 cm with 4-5 nodes) were cut from the mature bitter-leaf plant tie in bundles and taken to the experimental farm for planting according to the seven planting distance of the experimental treatments. Planting was alone on the 10thApril,2019 and 2020 respectively. The stem cutting were collected from a peasant woman who cultivated the crop in her compound behind the kitchen.

Cultural Practices.

Weed control was done manually with a small weeding hoe at five times in each year 2019 and 2020 to keep the farm clean.

Data Collection

Vegetative growth parameters data were collected on vegetative growth : (Numbers of leaves branches per plant, height (cm) , and dry matter weight).

Ten plants were chosen at random from the middle row of plot tag and used for measurements: numbers ofbranches and leaves per plant was by physical counting the branches and leaves of the chosen plants and their mean calculation to the meanest whole number.

Leaf area was determined using the leaf area meter model (Model – MK - 2)

Leaf area index was calculated from the measured leaf area using the formula outlined by shortfall shown below

$LAI = Y \times N \times Ax(AP)^{-1}$

Where

Y = Leaf Area Index

N = Average number of leaves per plant

A = Average area per leaf

AP = Area of plot

Plant height was determined using meter rule that measured height from soil level to Apex top of 10 selected plant and mean taken as the plant height (cm).

Girth (stem diameters) was measured using venire calipers in (mm).

Dry matter of leaves and stem

Destructive sampling of one plant per plot was done.

The plant was oven dried in label envelop papers in oven at 80°C to a constant weight for three days and the weight recorded.

These data were collected at 8 weeks after planting (WAP), 16WAP and 32WAP in 2019 and 2020 cropping seasons respectively.

Crop Growth Rate:

Analysis of crop growth rate was conducted to measure bitter leaf (*Vernoniaamygdalina*) growth rate at four growth rate at four stages (5-10 WAP,10-15WAP, 15-20WAP, 20-35WAP in 2019 and 2020 cropping seasons respectively through destructive sampling of one plant per plot and oven dried to content weight. The crop growth rate was determined by the formula for growth analysis techniques described by Shortal and lie bard (2000) shown below.

Crop Growth Rate

$$CGR = \frac{W_2 - W_1}{SA\ (t_2 - t_1)}$$

Where

CGR = Crop growth rate (gm^2/days)

$W_2 – W_1$ = dry weight of sampled matter mater at the beginnings and end of the growth interval (1 and 2)
SA = the area occupied by the plant at sampling.

Harvesting

The economic harvestable part of bitter-leaf is the fresh leaves and shoots that were cut manually at 15WAP, 21WAP, 26WAP, and 35WAP, in both 2019 and 2020 cropping seasons

Electronic weighing balance was used to measure the fresh weight of the harvest per plant and hectare during each harvest.

Statistical Analysis

Data collected were statistically analyzed using analysis of variance (ANOVA) procedures as outlined by Gomez and Gomez (1986). Treatment that showed significant difference were separated using fisher least square difference (F LSD) at 0.05% probability level.

III. Result And Disscusion

Bitter leaf (*Vernoniaamygdalina*) responded significantly ($p<0.05$) to planting distance (Table 1). Plant spacing of 90x40cm gave the tallest plant height of 497.5cm in 2019 and 476.8cm in 2020 with highest leaf area index (LAJ) (2.954 and 3.316) at 30 WAP in the two cropping season respectively. Stem girth (diameter) differ significantly as affected by planting distance. Largest girth mean values of 54.25mm in 2019 and 56.53 in 2020 were recorded at 30WAP (Table 1)

This result of this present study corroborated the works of Kanton*et al* (2013) who reported significant effect of planting distance on girth, Leaf area index and height of crops.

Number of leaves and branches per plant were significantly higher in wilder planting distance than shorter ones at 30WAP, 1mx1.5m spacing gave the highest number of leaves per plant (71.2 and 74.4) in 2019 and 2020 respectively(Table1).The observed increase in number of leaves and branches per plant with increase in planting distance could probably be due to the wider spacing that showed more potential to realize more leaves and branches due to more growth resources available per individual plant which enhance higher growth and development. Maury (2013) reported higher number of leaves per plant in wider row planting distance of maize.

Similarly, Umar *et al* (2017) pointed out that some growth parameters especially stem girth, plant height, branches and leaves number were significantly increase in wider intra – row spacing.

Result indicated higher dry matter of leaves and stem per plant in wide row planting distance than narrow spacing (Table 2). The 1m x 1.5m spacing gave higher leaf dry meter per plant (20.75/g and 20.813g) and stem (31.523 and 30.787g) at 30Wap in 2019 and 2020 seasons respectively (Table 2).

Bitter leaf crop growth rate measured as dry matter accumulation in leaf and stem increased significantly slowly at 5.10WAP (Table 3). However at 20 – 30WAP dry matter accumulation rate increased drastically with the highest leaf growth rate values of (6.459 and 6. 299) g/m^2/day in the two cropping seasons (2019) and (2020) Tables 3). The observed increasing in growth rateand dry matter accumulation in Bitter leaf crop leaves and stems in wide planting distance in this study might probably be as a result of the wide intra – row spacing that reduce competition for light, water and nutrients in the plots. This findings is in line with result of Maurya*et al;* (2013) that recorded significantly higher dry matter weight in leaves of crop in wider than narrow spacing.

Remarkable increased in fresh and dry leaves yield per plant was observed as planting distance was increased (Table 4). On the per plant basis wider planting distance of 1mx 1.5m gave higher fresh and dry leaves yield than narrow spacing.

However, on per hectare basis, narrow row planting distance produced significantly higher fresh and dry leaves yield per hectare as compare with wider row spacing (Table 4) .

The highest fresh leaf (3.89 and 3.88) t/ha) and dry leaf (0.73 and 0.786) t/ha yield per hectare was obtained at 35 WAP in 2019 and 2020 cropping seasons respectively.

This findings were in accordance with Falodun and Ogedegbe, (2016) who obtained higher leaf yield per hectare of crops in narrow than under intra row spacing.Urman (2017) obtained similarly results where okra plants in wider intra – row planting distance produced significantly higher fresh and dry leaves yield per hectare as compare with wider – row spacing (Table 4)

IV. Conclusion And Recommendation.

Bitter leaf crop is a very essential indigenous vegetables use for soup, spice, medicinal and raw material for pharmaceutical industry in most African countries. It commercial scale production is yet to be achieved. Famers and Researchers are therefore recommended to cultivate Bitter leaf crop at a spacing of 90 x 40 or 1mx 1.5 for maximum growth and yield in sandy loan soils.

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Table 1 : Effects of Planting Distance on Plant Height (cm), Number of Leaves, per plant, leaf area index and girth (stem diameter) (mm) of bitter leaf (*vernoniaamydalina*) in 2019 and 2020cropping seasons

Treatment	Number of leaves per plant						Leaf Area Index						Plant Height (cm)						Stem in girth (mm)					
	2019			2020			2019			2020			2019			2020			2019			2020		
	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP
90 X40cm	12.3	22.1	31.2	11.1	20.3	29.4	0.134	0.289	2.954	0.151	0.297	3.32	1	2.1	3.21	1	2.01	3.13	3.13	53.2	239.8	497.5	60.19	241.6
90 X60cm	15.2	28.3	42.1	14.2	25.1	41.3	0.132	0.274	2.761	0.142	0.281	2.82	1.01	2.21	3.32	1.01	3.12	3.21	3.21	48.3	214.6	474.7	51.63	222.3
90X60cm	19.1	32.4	48.2	20.1	30.3	46.1	0.128	0.259	2.572	0.131	0.257	2.43	1.02	3.13	4.13	1.03	3.11	3.11	4.15	45.4	185.5	381.5	45.11	201.2
1mx50cm	24.3	36.2	51.3	23.3	34.2	50.2	0.124	0.247	2.185	0.127	0.243	2.01	1	3.21	5.21	1.11	3.14	3.14	5.23	39.5	167.9	353.3	40.26	172.4
1mx1m	27.1	41.3	63.1	26.2	42.1	61.3	0.121	0.228	1.455	0.122	0.225	1.32	1.01	4.01	6.11	1.1	4.11	4.11	6.12	36.3	148.7	271.5	35.8	145.3
1m x1.5m	31.2	48.1	71.2	30.4	49.3	74.1	0.117	0.215	1.231	0.118	0.213	1.23	1.1	4.12	6.21	1.02	4.13	4.13	6.21	32.4	115.8	258.4	33.3	118.5
1m x 2m	34.1	53.3	65.3	35.1	50.3	67.2	0.113	0.212	1.115	0.112	0.114	1.12	1.11	5.01	6.21	1.12	5.02	5.02	6.31	30.7	101.4	221.6	30.6	105.6
LSD(0.05)	0. 4	2.1	3.2	0.5	1.6	2.5	0.001	0.003	0.02	0.001	0.003	0.02	NS	0.01	0.54	NS	0.01	0.01	0.53	1.21	4.3	6.5	1.1	3.4

WAP=Weeks after planting

Table 2: Effect of planting distance on dry matter of bitter leaf (*Vernoniaamygdlina*in 2019 and 2020 cropping seasons)

Treatments	Leaf dry weight per plant (g)						Stem dry weight per plant (g)						Root dry weight per plant					
	2019			2020			2019			2020			2019			2020		
	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP	9 WAP	15 WAP	30 WAP
90 x 40 cm	0.134	2.411	4.234	0.129	2.352	4.312	1.243	3.152	10.061	1.156	3.234	10.106	0.0561	1.124	3.598	0.0498	1.126	3.499
90 x 60 cm	0.153	2.832	5.093	0.162	2.715	5.111	1.516	3.435	11.343	1.481	3.568	11.259	0.0893	1.413	4.137	0.0875	1.357	4.227
90 x 80 cm	0.192	3.357	6.115	0.196	3.189	6.214	1.923	5.224	13.121	1.799	5.157	13.224	0.0979	1.725	5.348	0.0934	1.689	5.456
1m x 50 cm	0.236	4.104	8.394	0.227	4.213	8.178	2.131	9.105	11.611	2.254	9.114	16.378	0.133	2.009	6.256	0.125	2.361	6.342
1m x 1m	0.268	5.232	12.113	0.273	5.146	11.596	3.042	9.734	22.812	3.115	9.681	21.956	0.164	2.346	7.119	0.179	2.415	7.235
1m x 1.5m	0.315	7.415	20.751	0.321	7.231	20.813	3.431	14.511	31.523	3.348	14.997	30.787	0.196	2924	8.234	0.194	2.879	8.346
1m x 2m	0.526	7.213	15.812	0.518	7.344	16.421	3.359	14.359	29.434	3.277	14.125	28.513	0.199	2.547	8.110	0.198	2.485	8.121
LSD(0.05)	0.01	0.321	1.21	0.01	0.31	1.13	0.11	1.41	2.12	0.11	1.32	2.03	0.001	0.02	1.11	0.001	0.02	1.12

Table 3: Effects of planting distance on the growth Rate (g/m^2/day) of Bitter leaf plant in 2019 and 2020 Cropping Seasons

Treatments	Leaf Growth Rate (g/m^2/day)								Stem Growth Rate (g/m^2/day)							
	2019				2020				2019				2020			
	5-10 WAP	10-15 WAP	15-20 WAP	20-35 WAP	5-10 WAP	10-15 WAP	15-20 WAP	20-35 WAP	5-10 WAP	10-15 WAP	15-20 WAP	20-35 WAP	5-10 WAP	10-15 WAP	15-20 WAP	20-35 WAP
90 x 40 cm	0.00198	0.0342	1.019	3.012	0.00174	0.0326	1.017	3.014	0.0251	0.138	1.309	2.516	0.0245	0.136	1.233	2.342
90 x 60 cm	0.00233	0.0567	1.023	3.245	0.00235	0.0578	1.025	3.153	0.0463	0.171	1.534	2.886	0.047	0.165	1.671	2.863
90 x 80 cm	0.00347	0.0675	2.079	3.716	0.00411	0.0711	1.0361	3.648	0.0821	0.234	2.055	3.0191	0.0852	0.241	2.168	3.025
1m x 50 cm	0.00685	0.0788	2.486	4.354	0.00668	0.0823	2.063	4.265	0.0999	0.357	2.367	3.785	0.0977	0.368	2.293	3.674
1m x 1m	0.00774	0.0857	2.486	4.896	0.00729	0.0957	2.378	4.776	0.127	0.418	2.611	4.217	0.131	0.423	2.571	4.138
1m x 1.5m	0.00835	0.1469	2.837	6.459	0.00975	0.1521	2.851	6.299	0.135	0.511	3.023	5.858	0.142	0.521	3.111	5.019
1m x 2m	0.00987	0.1871	3.615	5.346	0.00998	0.1723	3.411	5.178	0.156	0.635	3.656	4.186	0.154	0.642	3.578	4.075
LSD(0.05)	0.001	0.003	0.02	0.22	0.001	0.003	0.02	0.23	0.01	0.02	0.11	0.31	0.01	0.02	0.11	0.30

Table 4: Effects of planting distance on fresh and dry leaf yield of Bitter leaf plant in 2019 and 2020 cropping seasons.

Treatments	Fresh leaf yield per plant (g)								Dry leaf yield per plant (g)								Fresh leaf yield per hectare (t/ha)								D leaf yield per hectare (t/ha)							
	2019				2020				2019				2020				2019				2020				2019				2020			
	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP	15 WAP	21 WAP	26 WAP	35 WAP
90 x 40 cm	22.31	36.27	52.11	69.36	23.15	35.46	51.93	62.45	10.13	21.24	30.14	42.37	9.84	22.15	45.74	61.59	0.34	0.89	2.76	3.89	0.33	0.87	2.81	3.88	0.191	0.295	0.577	0.793	0.189	0.294	0.581	0.786
90 x 60 cm	27.45	41.34	58.52	68.25	26.59	42.15	57.78	67.19	14.35	24.17	34.22	47.16	13.67	25.23	55.36	68.23	0.21	0.76	2.51	3.67	0.23	0.77	2.53	3.65	0.153	0.261	0.382	0.617	0.164	0.273	0.393	0.638
90 x 80 cm	32.18	48.26	63.78	72.14	33.23	27.35	62.51	73.56	19.42	27.35	41.51	53.28	21.34	28.14	65.18	72.48	0.18	0.67	1.97	3.24	0.19	0.68	1.89	3.26	0.122	0.183	0.355	0.539	0.135	0.192	0.346	0.527
1m x 50 cm	38.43	53.12	71.34	80.23	37.35	52.45	73.18	81.79	25.16	31.22	45.17	57.35	26.18	32.35	72.33	80.53	0.15	0.53	1.69	3.07	0.17	0.54	1.67	3.08	0.111	0.165	0.286	0.482	0.158	0.168	0.279	0.479
1m x 1m	46.24	58.72	79.15	91.54	45.86	57.64	77.41	90.89	29.34	38.51	50.33	62.17	28.56	39.24	78.15	93.47	0.13	0.41	1.51	2.42	0.14	0.43	1.52	2.41	0.091	0.143	0.248	0.371	0.141	0.147	0.245	0.362
1m x 1.5m	49.15	66.39	88.26	113.11	48.59	64.85	87.83	115.75	35.17	43.21	61.74	70.85	33.41	45.36	86.75	114.81	0.11	0.38	1.38	2.25	0.12	0.39	1.39	2.24	0.084	0.125	0.169	0.248	0.079	0.124	0.176	0.253
1m x 2m	42.33	64.28	80.41	101.31	43.18	62.32	81.52	103.28	31.21	40.32	57.24	65.73	30.73	41.16	41.16	102.37	0.08	0.23	1.16	1.36	0.09	0.22	1.15	1.35	0.073	0.104	0.124	0.201	0.065	0.103	0.123	0.212
LSD(0.05)	1.2	2.1	3.2	4.1	1.5	2.0	3.1	3.4		1.0	2.2	3.1	1.6	2.1	3.0	3.4	0.001	0.01	0.02	0.03	0.001	0.01	0.02	0.03	0.001	0.002	0.004	0.006	0.001	0.002	0.004	0.006

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