Evaluation of Growth and Yield Responses of Some Taro (*Colocasia esculenta*) Cultivars to Plant Spacing on the Plains of Nsukka, Southeastern Nigeria

Orji, K.O.[1], Ogbonna, P.E.[2], Eze, C.E[1]

[1]Department of Agronomy, Michael Okpara University of Agriculture, Umudike, P.M.B. 7267, Umuahia, Abia State
[2]Department of Crop Science, University of Nigeria, Nsukka

Abstract: ***A field experiment was conduct in 2008 and repeated in 2009 crop season at the linkage farm of the Univesity of Nigeria, Nsukka to evaluate growth and yield responses of five cultivars of taro (Colocasia esculenta) to plant spacing on the plains of Nsukka with the objectives of identifying best performing cultivar and optimum plant spacing. The experiment was laid out in a 3 x 5 factorial in randomized complete block design (RCRD(with three replications in which factor A is plant spacing comprising 0.3m x 1.0m, 0.4m x 10m and 0.5m x 1.0m levels while factor B is taro cultivars consisting of Nkpong, Odogolo, Nworoko, Ugwuta and Nachi. F-LSD was applied to detect significant differences between two means at 5% probability level. The results show that the height and girth of cultivars were statistically the same for the two seasons except Ugwuta or Coco-India that indicated significant reduction in these growth parameters. Plant spacing also did not significantly influence the plant height and girth for the two seasons. Nworoko and Odogolo cultivars significantly produced the highest yield of 11.1tha-1 and 2.4tha-1 in 2008 and 2009 cropping seasons, respectively. In this vein, the close plant spacing (0.3mx1.0m) and maximum plant spacing (0.5mx10m) gave the highest yield of 11.9tha-1 and 2.3tha-1 in 2008 and 2009 cropping season, respectively.***

Keywords: *Colocasia esculenta*, factorial, cultivars, yield

1. Introduction

Taro (*Colocasia esculenta*) is a monocotyledonous crop that has the character of being an underground stem. It is different from yam as it is not a tuber but a corm. Cocoyams belong to the family of the plants called araceae or aroids with two genera – taro (*Colocasia esculenta*) and tannia (*Xanthosoma sagittifolium* (Uguru, 1996).

Taro is a staple food for many people in developing countries in Africa, Asia and the pacific (Agueguia, et al., 1992). The corm and cormels which are the major economic parts have a nutritional value comparable to sweet potato (Wang, 1983), while the young leaves used for food contains about 23% protein on a dry weight basis. It is also a rich source of calcium, phosphorus, iron, vitamin C, thiamine, riboflavin and niacin, which are important constituents of human diets (Onwueme, 1999; Ndon et al., 2003). Taro corms and cormels have a high economic value in urban markets. Its production provides employment to many people and the crop maintains good ground cover or canopy in the fields (Talwana, et al., 2009).

In spite of the advances made in cocoyam research, several factors remain as challenges to sustain cocoyam production in Nigeria. The ignorance of the nutritive value and diversities of food forms from cocoyam by a large percentage of the populace is a major limiting factor to general acceptability and extensive production of the crop. The notion that cocoyam is a poor man's crop is still prevalent and needs to be dispelled through the extension of proper information about the crop. The recycling of planting material year by year results in accumulation of pathogens in them and this translates to yield decline with time (FAO, 2001, 2004). The 11% drop in national production figure between 2000 and 2004 may not be unconnected with the phenomenon (FAO, 2001, 2004). At present, Nigeria and world at large are confronted with food crisis that demands an urgent attention through diversification of food forms of which taro is in a good position to meet these needs of mankind. The diversities of food forms of taro can help to them food insecurity and malnutrition in children and aged people since cocoyam (taro) can provide a good ground cover, so it can be grown as a cover crop for soil conservation particularly in an erosion prone ecological zone.

In view of the above reasons, the objectives of this study were: to identify the best-performing cultivar and optimum plant spacing for introduction in the plans of Nsukka.

2. Materials and Methods

The field experiments were conducted in 2008 and 2009 cropping season at the linkage farm of the University of Nigeria, Nsukka. Nsukka lies on longitude 6o451E and altitude 7o12.51N with altitude 447m above sea level. Three local cultivars of taro: *Nworoko, Nachi* and *Odogolo* were sourced from the study area while two others of which were Nkpong with accession number NCE005 and Ugwuta (Coco-India) with accession number NCE 001 were obtained from National Root Crops Research Institute, Umudike bringing the total number of cultivars to five.

NPK 15:15:15 fertilize was purchased from Enugu State Agricultural Development project station at Nsukka. A piece of land with a dimension of 11m x 32m was cleared with matchet, because it was a thick forest. It was stumped with hoe and the dried rubbish burnt to ash. The land was ploughed and harrowed with tractor. The ridges were prepared manually into beds/plots. Each plot measured 2m x 3m in dimension with 0.5m spacing between two plots and 1.0m spacing between the blocks. 20, 15 and 12 equal, sized cormels were planted on each of the forty-five plots with plant spacing of 0.3m x 1.0m, 0.4m x 1.0m and 0.5m x 10m, respectively. All farm operation took place between 10th April and 6th December, for 2008 and 2009 cropping season. The experiment was laid out in a 3 x 5 factorial in Randomized Complete Block Design (RCBD). Factor A is plant spacing with three levels; 0.3m x 1.0m, 0.4m x 1.0m while factor B is five cultivars of taro: nkpong, *Odogolo*, *Nworoko*, ugwuta and nach. There was a total of 15 treatments combination with three replicates. Weeding was done twice. The first weeding was done at four weeks after planting (WAP), while the second was carried out at 6 WAP. 200kg/ha of N.P.K. of 15:15:15 fertilizer was applied to each plot at 8WAP to increase the soil nutrients. Soil samples were collected with an auger at the beginning of planting from six locations at the depth of 0-20cm.

The samples were properly mixed to get a composite sample from which a subsample was used for laboratory analysis to determine both the physical and chemical properties of the soil. Particle size analysis was determined using hydrometer method. Soil pH was determined in calcium chloride in soil solution ratio 1:2.5 using a glass electrode pH meter. Organic carbon by wet oxidation method while total nitrogen was determined by Kjidehal method. Available phosphorus was determined by Bray and Kurtz No.1 method. The exchangeable bases were determined by leaking the soil sample with IN ammonium acetate at pH 7 to extract the basic cation (Ca, Mg, K and Na). K and Na were determined by flame photometer while Ca and Mg were determined using EDTA titration method. The daily weather conditions on rainfall, temperature and relative humidity were also collected and recorded. Statistical Analysis of Variance (ANOVA) was done on the field data collected using Genstat 7.1 second edition according to Obi (2002). Fishers Least Significant Difference (P=0.05) was used to detect significant difference between two treatment means.

3. Results

Data on rainfall indicated that the mean rainfall for 2009 planting season was higher compared to 2008 while other meteorological parameters were relatively the same (Table 1). The soil was texturally clayey and moderately acidic with a pH of 5.0. The soil also was low in organic carbon, organic matter, calcium, phosphorus and with moderate Cation Exchange Capacity (CEC) (Table 2).

Table 3 shows that "*Odogolo*" cultivar produced the tallest plant while "ugwuta" (coco-Idia) produced the shortest ones in both 2008 and 2009 planting seasons. Other cultivars were statistically the same. Planting spacing did not significantly influence the plant height in both planting seasons, though the maximum plant spacing (0.5m x 1.0m) produced the tallest plant. Tallest plants were also observed where "*Odogolo*" was combined with a minimum plant spacing (0.3m x 1.0m) in both 2008 and 2009 farming season. Ugwuta contrarily produced the short plants but at the same minimum plant spacing. From the mean table, *Odogolo* and *Nworoko* were statistically the same in plant girth in dual seasons. Nevertheless, *Nworoko* had the biggest plant girth in 2009 while *Odogolo* produced the biggest plant girth in 2008 cropping season. Significant plant spacing effect was not observed in plant girth for both cropping season although the plant spacing of (0.4m x 1.0m) produced the biggest girth in 2008 and 2009 planting seasons (Table 3). Cultivar by planting spacing interaction was not significant in 2008 but significant in 2009 with *Nworoko* producing the biggest plant girth at 0.4m x 1.0m plant spacing.

There was no significant effect in the number of cormels/stand in 2008, although ugwuta produced the highest number of cormels per stand. Nach cultivar differed significantly in the number of cormels per stand in 2009 cropping season while other cultivars were statistically the same (Table 3). Minimum plant spacing (0.3 x 1.0m) produced a significant reduction in the number of cormels per stand in 2008 and least number of cormels was also produced by it in 2009, although not significant. Highest number of cormels was produced with a combination of nkpong and minimum plant spacing in 2008 while nach cultivar in combination with 0.4m x 1.0m plant spacing produced the highest number of cormels/stand in 2009. Nkpong in combination with maximum plant spacing gave the least number of cormels in 2008 while the least number of cormels was obtained where ugwuta was combined with minimum plant spacing (Table 3).

Taro cultivar here did not differ significantly in the weight of cormels. Nevertheless, "*Nworoko*" gave the cormel with greatest weight in 2008 while in 2009 cropping season "nach" significantly produced cormels with greatest weight (Table 4). Plant spacing different significantly in cormels weight as it decreased from the minimum plant spacing to the maximum in 2008. In 2009 cropping season, plant spacing means were statistically the same: signifant cultivar by plant spacing interaction was observed in the weight of cormels, where *Nworoko* was combined with the minimum plant spacing (0.3m x 1.0m) in 2008 to produce cormels of greatest weight while "nach" significantly produced cormels of greatest weight in 2009 cropping season (Table 3). "Nkpong" and "*Odogolo*" cultivar significantly produced the highest weight of corms in 2008 and 2009, respectively. The means of plant spacing were statistically the same in 2008 and 2009 cropping seasons, although the minimum and maximum plant spacing gave the highest weight of corms in 2008 and 2009, respectively (Table 4). Significant cultivars by plant spacing interaction were also observed where "nkpong" and "*Odogolo*" combined with 0.4m x 1.0 and 0.5m x 1.0m in 2008 and 2009, respectively. Nonsignificant cultivar effect was seen in the total yield per hectare, nevertheless, *Nworoko* cultivar produced the highest total yield in tonnes of 11.13tha-1 in 2008 while in 2009, and "*Odogolo*" cultivar significantly produced the highest total yield of 2.37tha-1. Minimum plant spacing (0.3m x 1.0m) and maximum plant spacing (0.5m x 1.0m) produced the highest total yield of 11.9tha-1and 2.3tha-1 in 2008 and 2009, respectively. Cultivar by plant spacing interaction did not differ significantly; nevertheless, highest total yield of 13tha-1 was observed where *Nworoko* was combined with 0.3m x 1.0m plant spacing in 2008. Contrarily, a combination of nach and 0.5m x 1.0m planting spacing gave the highest total yield of 3tha-1 in 2009 (Table 4).

4. Discussion

The agro-meteorological data in table 1 show that there were remarkable differences in the rainfall and temperature. There was 19.4% reduction in the average rainfall in 2005 and 23.2% reduction in the average rainfall between August and September in 2009 during which cormelization takes place. The variations in these climatic factors might have resulted in the variations expressed in the agronomic traits measured within the cropping season particularly in 2009 cropping season in which yield components were adversely affected. Moreover, the outbreak of taro leaf blight (TLB) in 2009 which destroyed cocoyam farms worldwide immensely attacked the yield traits resulting in poor yield. The closeness of the weeding interval was as a result of smothering ability of the cocoyam on weeks which was similar to the results obtained by (Onwueme, 1978). Significant plant spacing effect was observed at close plant spacing (0.3m x 1.0m), in total yield in this study which agreed with Zarate, et al., (2004); Ogbonnaya, (1983); Osundare, (2007). The biotic and abiotic stresses of which taro leaf blight disease is of prime factor might have contributed to the yield decline in 2009 cropping season which was in tandem with the assertion made by Cox and Kasiamani (1988) that taro leaf blight disease caused by *Phytophtora colocasia* is estimated to cause up to 50% losses in corm yield.

References

[1] Agueguia, C.A., Fatokum and Hahn, S.K. (1992). Protein Analysis of Ten Cocoyam, Xanthosoma sagittifolium (L) Schott genotypes, Root Crop for Food Security in Africa Proceedings of the Fifth Triennial Symposium, Kampala, Uganda. 348p.
[2] Cox, P.G. and Kasimani, C. (1988). Control of Taro Leaf Blight (TLB) using Metalaxyl. Tropical Pest Management. 34(1): 81 – 84.
[3] Food and Agricultural Organization (FAO) 2001, 2004. FAOSTA Tbase http:www.fao.org.
[4] Kpannwang, T., Raji, B.A., Odunze, A.C., and V.O. Chide (2001). Properties, Classification and Agricultural Potentials of Ustults and Tropepts on a Sedimentary Toposequence in the Benin Nigeria. Journal of Soil Research, 2: 58pp.
[5] National Root Crops Research Institute (NRCRI) (2009). Umudike – Cocoyam Programme. http:www.nrcri.gov.ng/pages/cocoyam.htm
[6] Ndon, B.A., Ndulaka, N.H. and Ndaego, N.U. (2003). Stabilization of Yield Parameters and Some Nutrient Components in Cocoyam Cultivars with time in Uyo, Southern Nigeria. Global Journal of Agricultural Science. 2: 74 – 78.
[7] Obi, I.U. (2001). Introduction to Factorial Experiments. For Agricultural, Biological and Social Sciences Research (2nd Ed). Optimal Publishers ltd. Nigeria. Vii 92P.
[8] Ogbonnaya, J.C. (1983). Effect of Plant Spacing and Time of Planting on Growth and Yield of Taro (*Colocasia esculenta*i var. antiquorum) Schott in the derived savanna belt of Nigeria. B.Sc. Project: Department of Crop Science, UNN. 18pp.
[9] Onwueme, I.C. (1978). The Tropical Tuber Crops. New York, U.S.A. John Willey and Sons.
[10] Onwueme, I.E. (1999). Taro Cultivation in Asia and in Pacific, RAP Publication. Food and Agricultural Organization of the United Nations Reg. office for Asia and the Pacific Bangkok, Thailand.
[11] Osundare, B. (2007). Effect of Fertilizer Types and Varying Population on the Performance of Cocoyam. Moor Journal of Agriculture Research 5(1): 7PP
[12] Talwana, H.A., Serem, A.R.I., Ndaikunze, B.K., Nwachi, J.O.M.I., Tumuhimbise, R.I., Kaweesi, T., Chumo, E.C. and Palapala, V. (2009). Production Status and Prospects of Cocoyam (*Colocasia esculenta* Schott) for improving food and income security in East Africa. Journals of Food Crops. 35: 98P.
[13] Ugwu, M.I. (1996). Crop Production Tools, Techniques and Practices. Full. Pub. Com. Nsukka, 48.
[14] Wang, J.I. (1983) (Ed). Taro – A review of Cococasia esculenta and its potentials. University of Hawaii Press, Honolulu
[15] Zarate, N.A.H., M. Doc, Vierra, E.J., Rosa Junior and J.C. Alves (2004). Effect of Plant Population and N-rates on Macequino Taro Rhizome yield Gliencia Agrotechnologia 28: 1190P

Table 3: Effect of cultivars, plant spacing and their interaction on plant height, girth, number and weights of cormels/stand in 2008 and 2009 cropping seasons

Plant Height (cm)												
Cultivars												
Plant Spacing	Nkpong		*Odogolo*		*Nworoko*		Ugwuta		Nach		Mean	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
0.3m x 1.0m	68.50	68.50	83.20	80.90	82.20	84.40	51.90	53.60	75.70	75.90	72.10	77.72
0.4m x 1.0m	75.70	75.30	80.00	79.20	76.70	78.20	52.70	54.10	75.00	84.80	72.00	72.30
0.5m x 1.0m	78.00	83.10	77.30	79.00	76.50	73.50	51.80	54.30	78.70	77.60	72.50	73.50
Mean	74.10	75.60	79.80	79.70	78.50	78.70	52.10	54.00	72.20	76.10		
Plant Girth (cm)												
0.3m x 1.0m	21.25	20.92	23.33	24.33	22.67	23.42	19.00	19.67	22.17	22.83	21.68	22.23
0.4m x 1.0m	22.33	22.83	23.00	23.17	23.58	26.58	19.08	20.08	22.25	22.42	22.05	23.02
0.5m x 1.0m	22.00	23.33	20.92	22.68	20.17	20.58	18.83	20.08	21.17	22.25	20.63	21.67
Mean	21.86	22.36	22.42	23.19	22.14	23.53	18.97	19.94	21.86	22.50		
Number of Cormels /Stand												
0.3m x 1.0m	18.00	3.58	16.58	4.17	16.25	3.83	16.58	1.42	16.26	4.50	5.20	3.50
0.4m x 1.0m	9.83	2.75	14.58	4.17	14.50	4.08	14.92	3.42	13.58	6.40	13.48	4.08
0.5m x 1.0m	9.50	2.92	10.42	4.92	12.08	5.17	15.08	4.50	11.33	4.73	11.68	4.01
Mean	12.44	3.08	12.94	4.42	14.39	4.36	15.42	3.11	13.83	5.08		
Weight (kg) of Cormels/Stand												
0.3m x 1.0m	0.90	0.10	0.82	0.12	0.98	0.11	0.78	0.05	0.88	0.11	0.87	0.10
0.4m x 1.0m	0.66	0.08	0.72	0.11	0.72	0.15	0.07	0.06	0.66	0.14	0.80	0.14
0.5m x 1.0m	0.56	0.06	0.52	0.15	0.67	0.12	0.75	0.12	0.64	0.17	0.63	0.12
Mean	0.71	0.08	0.69	0.13	0.79	0.13	0.73	0.08	0.77	0.14		

	Plant HE		Plant Girth		No. of Cormel/Stand		Weigh of Cormel/Stand	
	2008	2009	2008	2009	2008	2009	2008	2009
F-LSD (0.05): Cultivars (C):	9.04	8.08	2.39	2.61	3.71	1.43	0.22	0.04
F-LSD (0.05): Spacing (S):	7.00	6.26	1.85	2.02	2.88	1.11	0.17	0.03
F-LSD (0.05): C x S	15.66	14.00	4.14	4.53	6.53	2.47	0.38	0.08

Table 4: Effect of cultivars, plant spacing and their interaction on weight (kg) of corm/stand and total yield tha-1 for 2008 and 2009 cropping seasons

Weight (kg) of Corm/Stand												
Cultivars												
Plant Spacing	Nkpong		*Odogolo*		*Nworoko*		Ugwuta		Nach		Mean	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
0.3m x 1.0m	0.36	0.09	0.42	0.09	0.32	0.12	0.18	0.04	0.27	0.09	0.31	0.09
0.4m x 1.0m	0.38	0.10	0.26	0.10	0.31	0.04	0.19	0.04	0.33	0.08	0.29	0.07
0.5m x 1.0m	0.34	0.11	0.25	0.14	0.34	0.08	0.25	0.08	0.27	0.13	0.29	0.11
Mean	0.36	0.10	0.31	0.11	0.32	0.08	0.20	0.05	0.29	0.10		
Total Yield (t ha-1)												
0.3m x 1.0m	12.60	1.90	12.40	2.10	13.00	2.30	9.60	0.90	11.50	2.00	11.90	1.84
0.4m x 1.0m	10.40	1.80	9.80	2.10	10.30	1.90	2.60	0.03	9.90	2.20	10.75	1.61
0.5m x 1.0m	9.00	1.70	7.70	2.90	10.10	2.00	10.00	2.00	9.10	3.00	9.18	2.32
Mean	10.65	1.80	9.97	2.37	11.13	2.07	7.40	0.98	10.17	1.00		

	No. of Cormel/Stand		Weigh of Cormel/Stand	
	2008	2009	2008	2009
F-LSD (0.05): Cultivars (C):	0.11	0.05	1.01	0.06
F-LSD (0.05): Spacing (S):	0.09	0.04	0.79	0.05
F-LSD (0.05): C x S	0.19	0.08	1.79	0.11