Journal of Global Biosciences
ISSN 2320-1355
Volume 5, Number 3, 2016, pp. 3699-3710
Website: www.mutagens.co.in
E-mail: submit@mutagens.co.in
researchsubmission@hotmail.com

Research Paper

STUDIES ON THE INTERACTIVE EFFECTS OF CULTIVARS, NPK FERTILIZER AND SEASONS ON THE GROWTH AND YIELD OF TARO [*Colocasia esculenta* (L.)] ON PLAINS OF NSUKKA, NIGERIA

Orji, K. O[1]., Ogbonna, P. E[2]. and Chukwu, L. A.[3]

[1]Department of Agronomy, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, Abia State
[2]Department of Crop Science, University of Nigeria, Nsukka, Enugu State
[3]Department of Agricultural Technology, Akanu Ibiam Federal Polytechnic, Unwana, Ebonyi State.

Abstract

A field trial was conducted in 2008 and repeated in 2009 cropping seasons at the Linkage Farm of the University of Nigeria, Nsukka with the aim of assessing the interactive effects of cultivars, NPK fertilizer and seasons on the growth and yield of taro [Colocasia esculenta (L.)] on Plains of Nsukka. The experiment was laid out in a 5 x 6 factorial in randomized complete block design (RCBD) with three replicates in which factor A is taro cultivars with five levels consisting of Nkpong, Odogolo, Nworoko, Cocoindia and Nach while factor B is NPK fertilizer with six levels comprising 0, 100, 150, 200, 250 and 300 kg/ha. Fisher`s Least Significant Difference was used to detect significant difference between two means at 5% probability level. The results indicated that annual mean rainfall for 2009 cropping season was higher that of 2008 by 11.3%. The soil was texturally clayey, moderately acidic with a pH of 5.0. There were significant interactions in the growth and yield parameters while seasons` effects were non-significant.

Key words: Cultivars, taro, fertilizer, growth, yield.

INTRODUCTION

Taro [Colocasia esculenta (L.)] belongs to the family of *Araceae* and subfamily of *Aroideae*. The genus *Colocasia* includes the taro, dasheen, eddoes, and *curcal* or old cocoyams (Morton, 1972). Other genera that belong to the same family and subfamily are Xanthosoma and Alocasia. It originates from South East Asia (Uguru, 2011).Taro is grown in the tropical and sub-tropical regions of the world, particularly Africa, Asia, Pacific and Oceania (Atiquzzaman *et al*., 2008). There are more than 200 cultivars of taro, selected for their edible corms and cormels, or their tropical looking ornamental foliage. The taro plant has a triple value in that the stem may be used as salads, the tubers provide easily digested starch, with the leaves are used as a green vegetable. Taro root is often used in a similar fashion to a potato, but in fact has better nutritional qualities than a potato. It has almost three times the dietary fiber, which is important for proper digestive health and regularity. Fiber can also fill you up and make you feel less hungry with fewer calories. Taro root has a low Glycemic Index, as opposed to potato which has a high Glycemic Index. A low GI means that taro effects blood sugar levels slowly, without the peaks and crashes of a high GI, which lead to increased hunger later on. Eating a diet of low GI foods can also help prevent diabetes. Taro is nutritious, and is an excellent source of potassium, which is an essential mineral for many bodily functions. Taro also contains some calcium, vitamin C, vitamin E and B vitamins, as well as magnesium, manganese and copper. Taro leaves contain good amounts of vitamins A and C, fiber and a relatively high amount of protein. Eating taro can lead to kidney stones and gout as well as other health complications if it is not prepared properly by boiling for the recommended amount of time. It can also be steeped in water overnight before cooking to further reduce the amount of oxalates. To absolutely minimize risk, milk or other calcium rich foods should be eaten with taro in order to block oxalate absorption. However, taro is a staple food for many people around the world and should not be considered a high risk food after it is cooked (Plant Guide, 2014). Colocasia esculenta is the fourteenth most consumed vegetable worldwide and comprises the diet of 300 million people (Brown, 1998). The use of inorganic fertilizer in cocoyam production is not common among the rural farmers. They depend more on farm yard manure and farm yard wastes. The quantities of these materials available may not be enough for large scale production. There is then the need to adopt the use of inorganic fertilizer by these farmers. However, Bashir *et al*. (1997) have noted that one of the problems facing rural farmers on the fertilizer usage is lack of information on what type of fertilizer and quantity that will suit their crops and soil types. Shabbier (2007) has noted that NPK fertilizers are an all in one source of plant nutrient for the individual crops and soils. The use of NPK fertilizer will provide balanced nutrient and enhance soil fertility, maximizes crop yield and ultimately will boost the agricultural economy (Shabbier, 2007). Onwueme (1978) reported that cocoyam requires a lot of potassium which in the additional farming system is formed in ash left after bush burning. Makinde *et al*. (2011) reported that seasonal weather variability has a direct influence on the quality and quantity of agricultural production particularly in Nigeria. Prolong moisture stress during vegetative period could inhibit vegetative growth due to the retardation of phytochemical and biochemical activities (Jordan and Sullivan, 1982; Boyer, 1976). Contrarily, excessive moisture during vegetative growth might reduce the final plant yield considerably by leaching the plant nutrients (Jatzold, 1977).The present study was undertaken to assess the interactive effects of cultivars, NPK fertilizer and seasons on the growth and yield of taro on Plains of Nsukka.

MATERIALS AND METHODS

An on-farm research was conducted in 2008 and repeated in 2009 cropping seasons at the Linkage Farm of the University of Nigeria, Nsukka. Nsukka lies on longitude 6^0 45` E and latitude $7^0$ 12.5` N with altitude 447 m above sea level. Three cultivars of taro: *Nworoko*, *Odogolo, Nach* were sourced from the study area while two others of which were – *Nkpong* with accession number Nce005 and Cocoindia with accession number Nce001 were obtained from National Root Crop Research Institute (NRCRI), Umudike bringing the total number of cultivars to five. NPK 15: 15: 15 fertilizer was procured from Enugu State Agricultural Development Project station at Nsukka. A piece of land with a dimension of 11m x 45m was cleared with a matchet because it was a thick forest. The land was stumped with a hoe and the dried rubbish burnt to ash. It was ploughed, harrowed and ridged with tractor. The ridges were converted manually into plots of bed. Each plot of bed measured 2m x 3m in dimension with 0.5m spacing between two plots and 1.0 m spacing between two blocks. Cormels of equal size were planted on each plot with planting space of 0.5m x 1.0m in June each year. The experiment was laid out in 5 x 6 factorial in randomized complete block design (RCBD). Factor A forms five cultivars of taro namely: Nkpong, Odogolo, Nworoko, Cocoindia and Nach while factor B forms six levels of NPK 15: 15: 15 fertilizer thus: 0, 100, 150, 200, 250 and 300 kg/ha. There were a total of 30 treatment combinations with three replicates. Weeding was done twice. The first weeding was done at four weeks after planting (WAP) while the second was done at six WAP. Data were collected on plant height, plant girth, number of cormels/plant, weights of corms and cormels/plant and total yield/ha. The height of each of the four sampled plants per plot was measured with a meter rule from the ground level to the leaf apex in-situ while the plant girth was determined with a measuring tape. The number of cormels of each of the four sampled plant was counted while the weights of corms and cormels were measured with compression scale for each plot. The total yield/ha was determined by multiplying the sum of the weights of corms and cormels/plot by 10000 and dividing the result by the area of the plot. Soil samples were collected with an auger at the beginning of the planting season from six locations at the dephth of 0 – 20 cm. 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 characteristics of the soil. Particle size analysis was determined using hydrometer methods. 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 N0. 1method.The exchangeable bases were determined by leaching the soil sample with 1N ammonium acetate at pH 7.0 to extract the basic cations. The daily weather conditions on rainfall, temperature and relative humidity were also recorded. Statistical analysis of variance was done on the field data collected using Genstat 7.1 second Edition according to Obi (2001). Fisher`s Least Significant Difference (p=0.05) was used to detect significant difference between two treatment means.

RESULTS

Data on meteorological table showed that the annual mean rainfall for 2009 cropping season was 11.3% greater than that of 2008 while other meteorological data 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) according to the rating of soil chemical and physical properties by Kparwang et al., (2001) (Table 2). Table 3 showed a significant interaction of cultivar x fertilizer x year effect in plant height with *Odogolo* producing the tallest plants at 200 kg/ha NPK fertilizer application in 2009 cropping season while the shortest plants were observed with Cocoindia where fertilizer was not applied in 2009 cropping season. There was also a significant interaction in plant girth with *Odogolo* producing the largest girth at 200 kg/ha NPK fertilization in 2009 cropping season. Cultivar x fertilizer x year interaction on the other hand produced significant reduction in plant girth with Cocoindia at zero fertilizer application in 2009 cropping season (Table 4). A significant interaction of cultivar x fertilizer x year effect was observed in the number of cormels/plant at harvest with *Nach* producing the highest number of cormels/plant at 200 kg/ha NPK fertilizer application in 2008 cropping season while a significant reduction of cultivar x fertilizer x year effect was observed in the parameter at 250 kg/ha NPK fertilizer application in 2009 cropping season (Table 5). Non-significant interaction of cultivars x fertilizer x year effect was observed in the weights of cormels and corms per plant at all levels of fertilizer application in both 2008 and 2009 cropping seasons (Tables 6 & 7). Data in Table 8 showed a significant interaction of cultivars x fertilizer x year effect with *Nkpong* producing the highest total yield of 51 tonnes per hectare at 200 kg NPK fertilizer application in 2008 cropping season.

Table 1: Weather records of Nsukka during the periods of the experiments

Month	Rainfall (mm)		Max. Temp(°C).		Min. Temp (°C)		R. H (%)	
	2008	2009	2008	2009	2008	2009	2008	2009
Jan.	0.00	53.59	31.39	31.90	20.32	21.45	56.03	71.39
Feb.	0.00	2.19	34.14	32.46	21.97	22.79	57.16	73.30
Mar.	61.23	0.00	33.77	33.61	22.87	23.32	74.13	72.81
Apr.	143.30	180.60	31.73	31.73	22.00	21.60	74.83	76.20
May	254.01	283.69	31.16	30.23	20.81	21.41	75.00	74.16
June	186.43	152.37	29.83	29.13	21.40	20.83	76.93	74.67
July	246.10	248.17	28.94	28.65	20.84	20.58	78.16	74.84
Aug.	203.20	260.33	27.81	27.48	20.68	20.84	79.55	75.84
Sept	326.02	175.76	27.60	27.87	20.80	20.63	78.67	74.67
Oct.	198.63	387.10	29.48	28.39	20.87	20.26	76.35	74.94
Nov.	08.38	103.18	31.10	29.83	22.00	19.30	74.35	63.80
Dec.	10.98	00.00	31.50	32.70	22.88	30.70	72.93	65.35
Mean	136.52	153.92	30.70	30.31	21.45	21.98	72.88	72.59

Table 2: Physico-chemical properties of the soil of the experimental site before planting

Parameter	Value
Sand (%)	16.00
Silt (%)	20.00
Clay (%)	64.00
pH (H_20)	5.00
pH (KCl)	4.60
Organic carbon (g/kg)	0.60
Organic matter (g/kg)	1.03
Total Nitrogen (g/kg)	0.05
Exchangeable bases (cmol/kg soil)	
Sodium	0.10
Potassium	0.09
Calcium	1.00
Magnesium	0.80
Cation Exchange Capacity (CEC)	6.00
Base Saturation (%)	33.00
Phosphorus (mg/kg)	2.60
Exchangeable Acidity (cmol/kg)	
EA	1.40
Al	1.00
H	0.40

Table 3: Effect of Cultivar X Fertilizer X Year interaction on plant height (cm) at 10 weeks after planting (WAP)

Cultivars	Fertilizer Rate(kg)	Year	
		2008	2009
Nkpong	0	59.83	58.58
	100	66.58	64.17
	150	72.42	73.58
	200	81.67	79.42
	250	70.17	72.92
	300	57.67	58.42
Odogolo	0	45.25	55.67
	100	74.58	74.83
	150	74.92	76.50
	200	70.67	89.42
	250	78.00	76.75
	300	64.25	67.17
Nworoko	0	55.67	54.17
	100	83.42	82.50
	150	79.25	77.58
	200	81.50	80.92
	250	58.42	72.75
	300	57.17	55.42
Ugwuta	0	51.67	25.75
	100	48.67	49.50
	150	50.33	54.58
	200	58.42	69.17
	250	38.58	39.25
	300	65.58	38.33
Nach	0	64.00	47.92
	100	80.17	79.67
	150	81.58	72.58
	200	73.58	75.83
	250	65.58	65.75
	300	63.33	65.83

F-LSD (P=0.05) for comparing two C X F X Y means= 14.45

Table 4: Effect of cultivar X fertilizer X year interaction on plant girth (cm) at 10 WAP

Cultivar	Fertilizer Rate (kg/ha)	Year 2008	Year 2009
Nkpong	0	16.67	15.50
	100	18.83	18.08
	150	13.25	20.00
	200	23.00	23.25
	250	19.33	21.67
	300	17.92	19.00
Odogolo	0	11.58	15.25
	100	21.00	19.50
	150	20.83	20.25
	200	23.50	25.08
	250	22.17	23.08
	300	19.50	22.58
Nworoko	0	19.25	17.17
	100	22.50	22.58
	150	20.67	21.17
	200	21.33	19.25
	250	17.67	22.25
	300	18.08	16.67
Ugwuta	0	10.67	09.42
	100	16.67	16.92
	150	17.58	18.67
	200	20.43	20.50
	250	14.67	12.83
	300	14.25	13.75
Nach	0	15.00	14.08
	100	21.33	22.08
	150	22.67	18.75
	200	22.92	23.33
	250	21.08	22.50
	300	16.58	17.75

F-LSD (P=0.05) for comparing two C X F X Y means= 5.18

Table 5: Effect of cultivar x fertilizer x year interaction on the number of cormels/plant at harvest

Cultivar		**Year**	
	Fertilizer Rate (kg/ha)	**2008**	**2009**
Nkpong	0	0.32	0.13
	100	2.79	0.15
	150	3.37	0.20
	200	5.01	0.23
	250	3.35	0.23
	300	2.95	0.14
Odogolo	0	0.16	0.18
	100	3.15	0.27
	150	3.82	0.31
	200	3.64	0.30
	250	3.03	0.29
	300	1.93	0.26
Nworoko	0	0.12	0.15
	100	3.78	0.26
	150	3.20	0.31
	200	4.08	0.29
	250	3.14	0.27
	300	1.97	0.24
Ugwuta	0	0.24	0.02
	100	2.32	0.18
	150	2.95	2.66
	200	4.41	0.71
	250	2.50	0.10
	300	2.37	0.04
Nach	0	0.16	0.17
	100	2.58	0.32
	150	3.91	0.34
	200	5.07	0.24
	250	3.01	0.22
	300	3.92	0.26

F-LSD (P=0.05) for comparing two C x F x Y means = 1.47[NS]

Table 6: Effect of cultivar x fertilizer x year interaction on the weight of (kg) cormels/plant at harvest

Cultivar	Fertilizer Rate (kg)	Year 2008	2009
Nkpong	0	0.08	0.05
	100	0.45	0.09
	150	0.64	0.13
	200	0.01	0.11
	250	0.57	0.14
	300	0.50	0.07
Odogolo	0	0.12	0.08
	100	4.67	0.16
	150	0.71	0.21
	200	0.67	0.18
	250	0.65	0.12
	300	0.37	0.14
Nworoko	0	0.05	0.06
	100	0.70	0.08
	150	0.58	0.11
	200	0.75	0.11
	250	0.57	0.09
	300	0.36	0.15
Ugwuta	0	0.08	0.04
	100	0.41	0.17
	150	0.56	0.12
	200	0.56	0.05
	250	0.86	0.12
	300	0.44	0.03
Nach	0	0.08	0.08
	100	0.42	0.16
	150	0.68	0.13
	200	0.99	0.09
	250	0.56	0.08
	300	0.84	0.14

F-LSD (P=0.05) for comparing two C x F x Y means = 1.77^{NS}

Table 7: Effect of cultivar x fertilizer x year interaction on the weight (kg) of corm/plant

Cultivar	Fertilizer Rate (kg/ha)	Year 2008	Year 2009
Nkpong	0	0.18	0.08
	100	0.29	0.09
	150	0.27	0.15
	200	0.33	0.15
	250	0.29	0.13
	300	0.31	0.08
Odogolo	0	0.04	0.11
	100	0.23	0.12
	150	0.25	0.18
	200	0.23	0.15
	250	0.14	0.18
	300	0.12	0.12
Nworoko	0	0.07	0.06
	100	0.25	0.12
	150	0.22	0.15
	200	0.27	0.13
	250	0.22	0.09
	300	0.14	0.09
Ugwuta	0	0.17	0.01
	100	0.17	0.08
	150	3.49	0.02
	200	7.85	0.01
	250	0.26	0.04
	300	0.16	0.02
Nach	0	0.08	0.07
	100	0.19	0.13
	150	0.30	0.14
	200	0.30	0.14
	250	0.29	0.12
	300	0.25	0.13

F-LSD (P=0.0‿) for comparing two C x F x Y means = 2.99^{NS}

Table 8: Effect of cultivar x NPK fertilizer x year interaction on the total yield (t/ha) at harvest

Cultivar		**Year**	
Fertilizer Rate (kg/ha)		**2008**	**2009**
Nkpong	0	3.30	1.30
	100	7.90	1.60
	150	33.90	2.00
	200	51.80	2.40
	250	33.50	2.30
	300	29.60	1.50
Odogolo	0	1.70	1.90
	100	31.50	2.70
	150	38.20	3.10
	200	36.40	3.00
	250	30.40	3.00
	300	19.30	2.60
Nworoko	0	1.20	1.60
	100	37.90	2.50
	150	32.10	3.20
	200	40.80	3.00
	250	31.40	2.70
	300	19.70	2.50
Ugwuta	0	2.50	0.20
	100	23.30	1.80
	150	29.30	26.70
	200	44.10	0.10
	250	25.00	1.00
	300	23.80	0.50
Nachi	0	1.60	1.70
	100	25.80	3.30
	150	39.10	3.50
	200	50.70	2.50
	250	30.10	2.20
	300	39.30	2.60

F-LSD (P=0.) for comparing two C x F x Y means = 1.47

DISCUSSION AND CONCLUSION

The agro-meteorological data in table1 showed that there was a remarkable difference in the average rainfall while relative humidity and temperature were relatively the same. There was 12.7% reduction in the mean rainfall in 2008 and 21.4% reduction in the average rainfall between August and September in 2009 during which taro establishment takes place. The variations in these climatic factors might have resulted in the variations expressed in the growth parameters in 2009 farming season. The result agreed with the result obtained by Daniells *et al.* (2008) who reported that radiation, temperature and water availability affect the total growth, yield and the time taken to reach maturity. The influence of climatic factors on growth and yield of crops as expressed in photosynthesis, enzyme activation, photorespiration, transpiration, etc cannot be overemphasized in crop production. Application of NPK fertilizer to the soil was necessary due to its low fertility in order to increase the crop growth and productivity which was in agreement with the results obtained by Shiyam *et al.,* (2007), Mare and Modi, (2009). A crop response to fertilizer is higher in soil with low nutrient contents than soil with high nutrient reserve (Tisdale and Nelson, 1975). Significant effects on the growth parameters and total yield of the cultivar (Tables 3, 4 & 8) could be attributed to the maximum ecological factors which triggered high photosynthetic activities to produce enough photosynthates deposited in the sink in the two seasons. This agreed with the result obtained by Ahmed *et al*. (2009) who reported significant interaction effect between cultivars x bio-P and fertilizer x mineral P on growth parameters but with chickpea cultivars. Burhan Kara (2010) also reported significant effects from Altay-2000 with cultivar x late season N interaction in the second season but with wheat cultivars. Non-significant interaction effects on the yield components of taro cultivars x NPK fertilizer x year could be as a result of the data shown in (Tables 5, 6 & 7) were statistically the same in both seasons.

Conclusively, I would recommend that more analytical field experiments with second order interactions need to be done on taro by more field researchers to confirm my report.

REFERENCES

Ahmed, M.A and Badr, E.A.2009. Effect of Bio- and mineral Phosphorus fertilizer on the growth, productivity and nutritional value of some chickpea cultivars (*Cicer arietinum* L.) in newly cultivated land. Australian Journal of Basic and Applied Sciences, 3 (4) :4656-4664

Ahmed, M.K. 1981. Optimum Plant Spacing and Nitrogen Fertilization of Sweet pepper in the Sudan Gezira. Soil and Crop Sc.fla.proc. 32:85-96.

Atiquzzaman, M., Ali, M. M.,Mondal, M. A., Begun, M. Z. F. A. and Akther, Q . Y. 2008. Effect of spacing on the growth and yield of Mukhikachi. J. Agrofor. Environ. 2(1): 1 – 6

Bashir, J. S., Aliyu, A. and Shaibu, B.1997. Nigeria National Agricultural Research Strategy Plan: 1996- 2010, Federal Ministry of Agricultre and National Resources (FMANR).

Boyer, J.S. 1976. Water Deficit and Photosynthesis. In: Water Deficit and Plant Growth, Kozlowski, T.T. (Ed.). Academic Press, New York, pp: 153-190.

Brown, W.H. 1951. Useful plants of the Philippines, Vol.1 (Tech, Bul.10). Phil.Dept. Agric and National. Res.,Manila

Burhan, K. 2010. Influence of late- season nitrogen application on grain yield , nutrient use efficiency and protein content of wheat under Isparta ecological conditions. Turkish Journal of Field Crops, 15 (1): 1-6

Daniells, J.W., Hughes, M., Traynor, M., Vawdery, L. and Astridge, D. 2008. Taro Industry Development: *The first step. RIRDL Publication* no 09/066.

Jatzold, R.1977. Humid month isolines as an aid in agricultural planning. Tubingen Applied Sci. Dev., 9: 140-158.

Jordan, W.R. and C.Y. Sullivan, 1982. Reaction and resistance of grain sorghum to heat and drought. In: Sorghum in the Eighties, House, L.R., L.K. Mughogho and J.M. Peacock (Eds.). ICRISAT, Patancheru, India, pp: 131-142.

Kpamwang, T., Raji, B.A., Odunze, A.C and V.O. chude, 2001. properties, classification and Agricultural potentials of ustults and Tropepts on a sedimentary Toposequence in the bemic Nigeria, *Journal of Soil Research* 2:58-85.

Makinde, A.A., Bell, N.J.,Olasantan, F.O., Adebisi, M.A., and Adeniyi, H.A., 2011. Seasonality and crop combination effects on growth and yield of two sorghum (Sorghum bicolor) in sorghum/maize/okra intercrop in a Forest Savanna Transition Zone of Nigeria. Agricultural Science Journal, 6 (3) : 92-99

Mare, R. and Modi, A.T., 2009. Influence of planting date and organic fertilization on growth and yield of taro landraces. African Crop Sci. Conf. Proc. 9: 179-189

Morton, J.F. 1972. Cocoyams (Xanthosoma caracu, X. Atrovirens and X. nigrum), ancient root – and leaf- vegetables, gaining in economic importance. Proc. Of Florida State Horticultural Society 85:85-94

Obi, I.U. 2001. Introduction to factorial Experiments, for Agricultural, Biological and social sciences Research (2nd Ed).Optinal publisher Ltd Nigeria. Vii + 9 2p.

Onwueme, I.C.1978. The Tropical Tuber crops. New York, U.S.A. John Willey and Sons.

Plant Guide , 2014. <http: //plant materials. Nrcs.usda.gov

Shabbier, H.R. 2007. Effect of Nutrient availability and photoperiod on growth and yield of Taro (*Colocasia esculenta* (L) Schott). Proceedings of workshop on Taro and Tanier modelling, Ext. ser. 136. College of Tropical Agric and Human Res., Univ. of Hawaii, Honolulu.

Shiyam, J.O., Obiefuna, J.C., Ofoh, M. C., Oko, B. F. D. and Uko, A.E. 2007. Growth and corm yield response of upland cocoyam (*Xanthosoma sagittifolium* L.) to sawdust mulch and NPK 20:10:10 fertilizer rates in the humid forest zone of Nigeria. Continental J. Agronomy 1:5 – 10

Tisdale, S.A. and Nelson, W.L.1975. Soil Fertility and Fertilizers. Macmillian Publ.Co. Inc. 3rd edn. New York. 694p

Uguru, M.I. 2011. Crop Production Tools, Techniques and Practice, Rev. ed. Full Pub. Com. 55-57pp