Agricultural Journal 2 (5): 596-601, 2007

Effect of Tillage Systems and Different Fertilizer Rates on Growth Parameters and Fruit Yield of Okra (Abelimoscus Esculentus)

S.O. Afolayan, O.A. Oladapo, O.A. Akintola and E.F. Muibi
National Horticultural Research Institute, Idi-Ishin, Ibadan, Nigeria

Abstract: The interactions between tillage techniques and fertilization play a major role in determining the sustainability of production of okra. Fields experimental were studied in 2004 and 2005, respectively to determine the effect of tillage methods and fertilizer application on crop growth and fruit yield of okra. Three different tillage methods: Ridging (R) Harrowing (H) and Bedding (B) in combination with three fertilizer sources: Control- no fertilizer-S_1, NPK (20-10-10) -S_2, Urea (45,0,0)-S_3 and 0rgano-mineral (2.25, 0.89, 2.01)-S_4 were considered for the first year. The second year experiment retained the tillage systems but adopted the best fertilizer source of the first year at four different rates 0 kg ha^{-1} (F_1), 200 kg ha^{-1} (F_2), 300 kg ha^{-1} (F_3) and 400 kg ha^{-1} (F_4). Soil properties were conducted before and after the experiments. Growth indices such as Number of Leaves (NL), Plant Height (PHT), Stem Diameter (SD) and Leaf Area (LA) were measured. Results obtained revealed that there were no significant differences ($p<0.05$) in bulk density (R = 1.29 gm cm^{-3}, p = 1.40 gmkm^3, H = 1.44 g km^3, B = 1.45 gm cm^{-3}) conducted after the first season. However, cone penetration resistances were greatly influenced by tillage methods (p = 0.065 kg s^{-1}, R = 0.93 kg s^{-1}, H = 0.93 kg s^{-1}, B = 0.95 kg s^{-1}). There were significant differences in all the crop growth and fruit yields of the two seasons. In the first year, S_4 fertilizer source in combination with R had the best mean leaf area followed by S_2 fertilizer source in combination with H. S_1R, S_2R and S_4R appeared most stunted in growth at $p<0.05$. Generally, S_3 fertilizer source combined with H tillage method (S_3H) recorded the highest mean yield at 2.4/ha followed by S_2H at 2.3t ha^{-1}. The second year experiment recorded significant differences ($p<0.05$) among the treatments in growth and fruit yield. F_3P produced the highest mean PHT (744.33 mm), F_2B had the best NL and F_3B producing best robust plants in terms of SD, F_1B appeared to be the treatment with the most luxuriant canopies respect to LA and F_2P having the highest mean yield at 5.53t ha^{-1}. Overall result showed that 200kg ha^{-1} of NPK fertilizer in combination with ploughing (F_2Pi) was suggested as the best treatment option for the sustainable cultivation of okra.

Key words: Tillage, fertilizer sources, fertilizer rates, fruit yield, plant height, growth parameters, Nigeria

INTRODUCTION

Tropical soils are prone to excessive loss of nitrogen and reduction in organic matter through intensive cultivation. On the other hand, assimilation of nutrients through the roots to the stem for photosynthetic activities stand hampered and defective except the soil attains optimum soil pulverization. It is therefore, imperative that there must be a compromise between sustainable environmental friendly tillage system adopted and level of fertilizer injected into the soil. Investigating some methods of tillage in combination with different rates of fertilization provides a unique opportunity to evaluate and quantify the possible effects of management practices on yield and environmental response. The interaction between soil-water-weather and plant in response to soil amendment using fertilizers plays a significant role in the choice of tillage practices. Earlier researchers (Lipiec *et al*., 2005; Meni and Shmuel, 2002; Jackson *at al*., 2004) reported that tillage practices lead to increase in the surface storage capacity of the soil with resultant effect on run off flow within and out of the field. It has been reported that root growth thrives better under a controlled temperature, adequate supply of water and air in the soil (Ashraful *et al*., 2001). Effective and sustainable tillage system will definitely enhance and promote better crop yield with little or no detrimental effect on soil depletion. However, uncontrolled or indiscriminate tillage application can aggravate soil erosion, nitrogen emission and leaching of the valuable nutrients (Neeteson and Carton, 2002). Fertilizer application is essential to tropical soils because of its general poor inherent status if vegetable production is to be sustained (Osiname, 2000). It is obvious that temperature has a deleterious effect on nematodes. At a very high temperature of greater than 40°C, these pests are inactivated. Although, the degree of hotness in

Corresponding Author: S.O. Afolayan, National Horticultural Research Institute, Idi-Ishin, Ibadan, Nigeria

Southwest of Nigeria is much less. However, with good soil pulverization using tractor will expose those soil pests (nematodes) to weather hazards thereby rendering them inactive. The combination of tillage methods and fertilizer constitutes two major factors of this study. Tillage is being practiced frequently in almost all the agro-ecological zones of Nigeria ranging from use of traditional tools to single passes with tractor mounted cultivators to multiple passes for weed control. Generally, fertilizer recommendation for most of the vegetables growth in Nigeria is between 50-100 kg N ha^{-1}, 20-60 kg$P_2$05 ha^{-1} and 60 kgK ha^{-1} (Babatola *et al*., 2002). Intensive research studies had been carried out on effects of tillage and fertilizer on crops (Adebayo and Adoun, 2002; Adesina *et al*., 2002; Akanbi *et al*., 2002; Olufolaji *et al*., 1998; Bermudez and Mallarino, 2003, 2004; Yin and Vyn, 2002; Alasiri *et al*., 1998). Little work is reported on growth and yield of okra (Abelmosues esculentus). The results of other authors (Fennimore *et al*., 2003; Hoyt *et al*., 1996; Hoyt, 1999; Johnson and Hoyt, 1999; Mundy *et al*., 1999) confirmed that soil biological, chemical and physical properties change with tillage systems. On the other hand, studies have also indicated that effect of soil tillage and management on crop yield and soil conditions are not consistent (Mc Garry *et al*., 2000; Ankeny *et al*., 1990; Rasmussen, 1999; Vervoor, 1993; Gomez *et al*., 1999). The overall objective of this study is to determine the combined effect of tillage systems and fertilizer on the yield of okra (Abelmoscus esculentus). Okra is used in cooking and as confectionaries in Nigeria. Despite the nutritional and economic value of the crop, its full potential is limited and unexploited by its current low production, which is predicated on poor agronomic knowledge of production techniques especially in terms of optimum tillage in combination with fertilizer requirement.

MATERIALS AND METHODS

This study was carried out at the vegetable Research Farm of the National Horticultural Research Institute in Ibadan (7°25'N and 3°52'E, 168m above seas level) in 2004 and 2005 cropping seasons. The site had experienced long-term cultivation for assorted vegetable production for more than ten years. Annual rainfall pattern is bimodal, with between 120 and 128 raining days delivering 1200 to 1400mm.Annual air mean, maximum and minimum temperatures are 24-29, 27-34 and 20-30°C, respectively with mean relative humidity of 64-83%. Rainfall data for 2004 and 2005 is shown in Table 1. Three tillage systems Ridging (R) Harrowing (H) and Bedding (B) in combination with three fertilizer sources: NPK (20-10-10), Urea (45-0-0) and Organ mineral (2.25, 0.89, 2.01) with control (no fertilizer) were evaluated in 2004. The absence of ploughing method was due to faulty equipment in the first season. However, four tillage methods: Ploughing (Pi), Ridging (R) Harrowing (H), Bedding (B) in combination with four rates of NPK (20-10-10) fertilizer, the most available and best rated in terms of performance in the first season and acceptable grade to the poor resource farmers at 0 kg ha^{-1}-F_1 (control), 200 kg ha^{-1}- F_2, 300 kg ha^{-1}- F_3 and 400 kg ha^{-1} – F_4 were investigated in 2005 to determined the effects of tillage and fertilizer on soil properties, growth and fruit yield of okra. Soil physical and chemical properties were conducted two times before the termination of the experiment according to FAO (2004) and IITA (2000).

Land preparation for 2004 experiment was carried out in September 14, 2004 at the effective height of 7.7, 6.3 and 9.1 cm for R, H and B, respectively. Seeds of okra (Abelmoscus esculentus) were sown on the field in 18th September 2004 and 14th October 2005, respectively a day after land preparation to maintain freshness in soil tilts. Each plot contained 20 plants at 5 plants per m^2 with 50 cm by 50 cm spacing. The experiment was arranged as a split-plot fitted into a randomized complete block with three replications. The main plot was tillage systems while fertilizer at different rates constitutes subplot. Fertilizer treatment was imposed 3 WAS for 2004 and 5 WAS for 2005, respectively at average plant height of 380, 300 , 350 and 360 mm for P, R, H and B. The experiments were carried out under rain fed-condition but supplemented with irrigation during the dry spell. Insects were controlled with foliar spray of cymbush at the recommended rate 5 WAS and 6 WAS, respectively. Weeds were controlled manually with traditional hoes at 4 WAS and at Two Weeks Interval (2WI). Growth parameters such as Number of Leaves (NL), Plant Height (PHT), Stem Diameter (SD), Leaf Area (LA) were determined 6 WAS and at two (2WI) till the termination of the experiment. Fruit yields were evaluated 6, 7, 8 and 9 WAS. Generated data were subjected to analysis of variance using SAS-GLM procedures (SAS Institute, 1999). Treatment differences were separated using the probability of difference for source of variation determined to be significant at ($p<0.05$). Means were compared using multiple range test and least significant differences.

RESULTS AND DISCUSSION

Climate: The first cropping season (September-November, 2004) recorded higher mean monthly rainfall (Table 1) than the optimum expected for vegetables

Table 1: 2004/2005 Meteorological data for the experimental seasons

	2004						2005					
	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	March	Oct.	Nov.	Dec.
Rainfall (mm)	115.6	68.3	131.9	167.4	7.8	0.0	0.0	53.8	82.6	235.8	20.5	82
R. Humidity (%)	86.0	86.0	87.0	84.0	83.0	81.0	59.0	79.0	80.0	8.4	8.2	82
Air temperature (°C)	25.0	25.0	26.0	27.0	27.4	28.0	25.2	28.2	29.0	27.0	28.0	27.2
Sunshine hours (h)	2.9	1.1	2.5	2.2	2.7	5.2	4.7	5.1	5.8	4.6	7.2	6.1
Evaporation (mm)	2.8	2.7	4.0	4.0	4.0	4.8	5.9	5.6	5.5	4.4	4.7	4.3
Wind rum (km)	56	66.2	52.4	36.6	44.4	40.5	55.3	68.3	39.0	45.0	29.0	61.0
Radiation	276	259.4	296	303.3	309.9	325.3	314.0	318.8	333.4	*	*	*

•=Missing data

(Willock, 1983) in the months of September and October 2004. The month of November was relatively dry month hence the need to supplement with irrigation to ensure longer gestation period and encourage longer harvesting period. This trend tallies with the routine practices of the vegetable growers in the Southwestern Nigeria. The second season (October-December 2005) (Table 1) had more than sufficient rainfall in the month of October, while the months of November and December were relatively dry, however, supplemental irrigation was applied during the months to guarantee effective absorption of the nitrogen component of the fertilizer, being the most important and crucial nutritional element affecting crop yield and quality, environmental safety and economic consideration (Fageria and Baligar, 2005; Compbell *et al.*, 1995; Grant *et al.*, 2003).

Soil properties: Table 2 presents the soil physical and chemical properties at the initial stage of the experiment. Sand fraction accounted for about 90% of the textural quality suggesting high porous soil profile with low water holding capacity and high vulnerability to surface run-off. The clay content is below the critical level showing soil with weak structural stability and high erosive index (Horgies, 1983). Exchangeable Ca, Na, Mg and K according to Marcos and Gonzalez (1994) followed the natural order of Ca> Mg> Na> K for all agricultural soils (Table 2). Of the six essential micronutrients for plant growth, deficiencies of only three Zn, Fe and Bo have been shown to have some economic importance in Nigeria (Osiname, 2000). However, high exchangeable Ca in the soil suppresses B uptake by plants (Osiname, 2000) thereby resulting into distortion of leaves and stunted roots (FDALR, 2004). The low value of Ca (0.64) is indicative of high pH, a condition unsuitable for most plants (Veldkamp, 1992) Available Mn, Zn, Cu and Fe were above the thresh hold levels (Verloo, 1983). Organic matter content of the soil was 0.83 g kg^{-1} with C: N ratio of about 7. This was considered grossly deficient when compared with the reports of (Sanchez *et al.*, 1992) showing poor decomposition of organic matter status although crops do not need SOM, except in maintaining

Table 2: Soil physical and chemical properties conducted before the experiment

Sample elements	Values
EC cmmhos cm^{-1} @ 25°C	0.13
OM (%, w w^{-1})	0.83
N (%, W W^{-1})	0.124
Mehlich P (ppm)	4.26
Ca (c mol kg^{-1})	0.64
Mg (c mol kg^{-1})	0.44
K (c mol kg^{-1})	0.11
Na (c mol kg^{-1})	0.23
Mn (ppm)	377.18
Fe (ppm)	334.82
Zn (ppm)	6.03
Cu (ppm)	1.53
Sand (%)	88.4
Silt (%)	6.0
Clay (%)	5.6
Porosity (%)	46.0
Bulk density (gcm^{-3})	1.53

soil fertility by providing nutrients through decomposition, retention of soil moisture and maintaining soil structure (Vanlauwe, 2000). Generally, the experimental soil has naturally low fertility as indicated by the low content of total N, P and organic matter in line with the report of Soumare *et al.* (2002) for tropical soils. In view of the low soil fertility, fertilizer application will be very necessary to rejuvenate the soil to enhance production. Table 3 shows the soil properties conducted at the end of the second season experiment. The bulk density values decreased appreciably in all the tillage treatments though with B recording the highest. Mean bulk density values of R, H and B were very close. This trend is expected bearing in mind that while P was subjected to only one tractor pass, R, H and B were exposed to multiple tractor runs, which possibly could have affected the soil compaction. Results of soil analysis conducted after the second season showed changes in all the major and trace elements. Cu, P, OM appreciated in all the tillage treatments while Mn, Fe, N, Mg, Ca, K, Na, Zn depleted from the initial values to lower. The degree of appreciation for Cu, P and OM was more pronounced in ploughing respect to Cu and OM, ridging respect to P, although the values were below the critical level thereby suggestive of nutrient deficiencies (FDALR, 2004). This development might not be unconnected with the extent of

Table 3: Soil properties conducted after the experiment

Tillage systems	Values												
	Cu	Mn	Fe	OM	N	P	Ca	Mg	K	Na	Zn	Bd	Cone
Pi	3.75	259.19	160.97	1.03	0.056	5.0	1.19	0.88	0.26	0.11	4.29	1.29	0.06c
R	3.56	216.35	135.3	0.95	0.045	5.3	1.12	0.51	0.23	0.08	4.83	1.40	0.77a
H	3.82	253.05	129.85	1.2	0.068	2.5	1.14	0.57	0.19	0.12	5.65	1.43	0.95a
B	3.90	251.99	134.71	0.83	0.045	3.5	1.18	0.60	0.16	0.12	5.19	1.44	0.93ab
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	

Table 4: Effects of tillage and fertilizer ources on growth parameter and fruit yield of okra (Abelmoscus esculentus)-2004

Tillage systems	NL	PHT (mm)	LA (mm^2)	YLD t ha^{-1}
S_1R	11	26.0	120.6	0.42
S_2R	8	23.4	182.3	0.30
S_3R	17	26.4	211.0	0.84
S_4R	15	33.1	779.4	0.69
S_1H	24	47.8	137.0	1.01
S_2H	26	46.0	283.5	2.3
S_3H	42	67.0	180.5	2.43
S_4H	44	88.1	194.6	1.26
S1B	18	64.8	34.2	0.69
S_2B	18	47.1	71.3	0.72
S_3B	21	64.6	38.1	0.75
S_4B	16	58.0	33.3	0.57
LSD (5%)	19.8	36.5	0.35	0.42

soil pulverization each treatment was subjected to. While Ploughing (Pi) was subjected to only one traffic pass, riding, harrowing and bedding experienced multiple runs thereby exposing soil microorganisms responsible for soil rejuvenation to weather hazards and render them inactivated. Nutrients depletion was observed for Mn, Fe, N, Mg, Ca, K, Na and Zn. The degree of depletion was inconsistent with tillage treatments (Table 3). Generally, ploughing (Pi) suffered the least depletion in terms of soil nutrient status after the second plantation season. Obviously, the degree of tractorization was less in ploughing compared to the rest tillage treatments. However, there were no significant differences in all the elements among the tillage treatments at 50% probability level. Bulk density values were similar among the tillage treatments (Table 3). However, cone penetration resistance was signficantly ($p<0.05$) highest in Harrowing (H) while Ploughing (Pi) was least showing differential compaction which could have been possibly initiated by the number of tractor traffic passes during cultivation.

Crop growth and fruit yield: The crop growth and fruit yield response to tillage systems and fertilizer are shown in Table 4 for 2004. There were significant differences ($p<0.05$) in all the growth parameters among the treatments. Numbers of leaves, plant heights were best under S_4H. Mean values of leaf area were significantly more luxurious under S_2H than other treatments. Fruit yield was best under S_3H, followed by S_4H and S_2H. The observed significant differences in the tillage and fertilizer sources could be attributed to the nature of

Table 5: Effects of tillage systems and fertilizer rates on growth and fruit yield of okra (Abelmosues esculentus)-2005

Tillage system	NL	PHT (mm)	SD (mm)	LA (mm^2)	YLD t ha^{-1}
S_1Pi	12	469.22	11.59	1234.33	1.27
S_2Pi	15	570	13.48	1496.11	1.85
S_3Pi	14	541	14.51	1485.11	3.01
S_4Pi	12	384.56	10.06	797.67	0.51
S_1R	16	562.33	14.33	2459.99	1.51
S_2R	16	454.44	14.26	1398.56	5.53
S_3R	14	744.33	15.82	1591.78	2.58
S_4R	15	471.78	11.99	2260.67	0.59
S_1H	15	372.78	10.0	1393.44	0.85
S_2H	18	466.67	12.89	1248.33	1.17
S_3H	15	699.44	14.02	1221.89	1.46
S_4H	17	403.11	11.80	3042.67	0.76
S1B	13	420.56	12.17	4818.22	1.81
S_2B	21	483.44	15.74	1548.44	0.89
S_3B	18	619.44	16.59	1513.44	2.66
S_4B	20	427.22	13.68	908.89	0.77
LSD (5%)	4	98.45	1.61	298.66	0.34

organic fertilizer sources to undergo initial mineralization before availability to plant. Okra, being a short gestation crop (47 days) could have almost reached the harvest stage at which level the crop's physiological ability to utilize the nutrients for fruit production would have been late. However, considering availability and ease of accessibility of fertilizers at the time of the second season cropping and the degree of soil depletion, S_2H (NPK+harrowing) was adjudged the best treatment for sustainable production of okra in the first season. Table 5 presents the effects of tillage systems and fertilizer rates on growth and fruit yield of okra (Abelmoscus esculentus) for 2005 planting season.

There were significant differences in all the growth parameters. Mean values of number of leaves were significantly higher ($p<0.05$) in F_2B, plant height in F_3Pi, stem diameter in F_3B, Leaf area in F_1B, respectively. The observed significant difference in number of leaves is expected as F_4B received the highest fertilizer rate. Obviously, fertilizer application at threshold values will definitely enhance better vegetative development and possibly with higher yield. The result of the plant height could be suggestive of greater interaction between fertilizer and tillage treatment. Less compacted soil profile has the tendency of benefiting plant root dynamics as in the case of ploughing (Table 4). The higher value in stem diameter might not be unconnected with the nature of raised seedbed with less restriction to root growth at the initials stage but could not sustain further development due to induced soil compaction during tractor traffics below the plough layer where most roots are concentrated. Leaf areas were more significantly ($p<0.05$) luxurious in F_1B though with low fruit yield. This is indicative of the fact that luxurious canopy characteristics do not necessarily compliment crop yield. This suggests that more of the soil nutrients could have been utilized during canopy formation in F_1B with corresponding delay till fruiting in F_2Pi. Overall results suggested that fertilizer rates of 200kg ha^{-1} in combination with ploughing treatment (F_2H) was best for sustainable production of okra.

REFERENCES

Adesina, O.I., G.C. Ndukwu and C.C. Onyeje, 2002. influence of NPK fertilizer on growth and yield of egg plant/garden egg (Solanum Melongena). Proc. Hortson, pp: 67- 68.

Adebayo, O. and J. Adoun, 2002. Effect of Organic manure and spacing on the yield and yield component of Amaranthus cruentus. Proc. 16th Ann. Conf. Hortson, pp: 63-67.

Akanbi, W.B., O.A. Togun, J.O. Akinfasoye and R.A. Baiyewu, 2002. Nutrient uptake and yield of okra (*Abelmoscus esculentus*) as affected by variety and nitrogen mixed fertilizer. Proc. 16th A Conf. Hortson, pp: 145-150.

Alasiri, K.O., F.O. Olaniyan, A. Salami, 1998. Growth and yield of plantain as influenced by the application of organic and mineral fertilizer. Proc. 16th Ann. Conf. Hortson, pp: 107-111.

Ankeny, M.D., C.K. Kaspar and R. Horton, 1990. Characterization of Tillage effects on unconfined infiltration measurement. Soil. Sci. Ann., 54: 487-840.

Ashraful, H., R.I. Sacker, A. Murshed, 2001. Effect of Soil strength on root growth of rice crop for different dry land tillage methods. Agricultural Mechanization in Asia, Africa and Latin America (AMA), 32: 23-26.

Babatola, L.A., O.B. Adebayo and O.I. Lawal, 2002. Effect of different rates of poultry manure and NPK fertilizer on performance of Celosia argentia. Proc. Hortson, pp: 55.

Bermudez, M. and A.P. Mallarino, 2003. Yield and early growth responses to starter fertilizer in no-till corn assessed with precision agricultural technologies. Agron. J., 94: 1024-1033.

Bermudez, M. and A.P. Mallarino, 2004. Corn responses starter fertilizer and tillage across and within fields having no till management histories. Agron. J., 96: 776-785.

Campbell, C.A., R.J. Myers and D. Curtin, 1995. Managing nitrogen for sustainable crop production. Fert. Res., 42: 277-296.

FAO (Food and Agriculture Organization) 2004. FAO agricultural data base (http: www.fao.org). FAO, Rome, Italy.

FDALR (Federal Department of Agricultural Land Resources), 2004. Handbook on Soil Test-Based Fertilizer Recommendations for Extension workers. National Special Programme for Food Security, pp: 37.

Fagera, N.K. and V.C. Baligar, 2005. Enhancing Nitrogen use efficiency in crop plants. Adv. Agron., 88: 1-185.

Fennimore, S.A. and L.E. Jackson, 2003. Organic Amendment and tillage effects on vegetable field weed emergence and seed banks. Weed Tech., 17: 42-50.

Gomez, J.A., S.V. Giraldez, M. Pastor and E. Fereres, 1999. Effects of tillage methods on soil physical properties infiltration and yield in an olive orchard. Soil and Tillage Res., 53: 167-175.

Grant, C.A., G.A. Peterson and C.A. Campbell, 2003. Nutrient consideration for diversified cropping systems in the northern Great Plains. Agronomy, 94: 186-198.

Hoyt, G.D., A.R. Bonanno and G.C. Parkeri, 1996. Influence of tillage and herbicides on yield and quality of cabbage. Weed Tech., 101: 50-54.

Hoyt, G.D., 1999. Tillage and cover Residue: Effects on Vegetable yields. Hort. Tech., 9: 351-358.

Horgies, N., 1983. Contribution a letude de la fertilite potentielle des sols allaviaa-a u Shaba-Perimetre de Mangomba, Zaire. Travaax de fim detude. Facuite des Sciences. Agronomiques de Combloux., pp: 27.

IITA, 2000. International Institute for Tropical Agriculture Laboratory Manual.

Jackson, L.E., I. Ramirez, R. Yekota. S.A. Fennimore, S.T. Koike, O.M. Henderson, W.E. Chaney, E.J. Caldaron and K. Klonsky, 2004. On-farm assessment of organic matter and tillage management on vegetable yield, soil, weeds, pests and economics in California. Agric., Ecosys. Environ., 103: 443-463.

Johnson, A.M. and G.D. Hoyt, 1999. Changes to soil environment under conservation Tillage Hort Tech., 9: 380-393.

Lipiec, J., J. Kus, J.A. Slowinka and A. Nosalewicz, 2005. Soil Porosity and water infiltration as influenced by tillage methods. Soil and Tillage Research. Article in Press.

Marcos, M.L.P. and A.P. Gonzalez, 1994. Cation leachieg from two soils located in Lysimeters since 1989-1990 in a long-term experiment. Agrochemical, 38: 341-354.

Mc Garry, D., B.J. Bridge and B.J. Radford, 2000. Contrasting Soil Physical properties after Zero and traditional tillage of an alluvial soil in the semi and subtropical soil: Tillage Res., 53: 105-115.

Meni, Ben-Hur and Slimuel Assoulins, 2002. Tillage Effects on water and salt distribution in vertisol during affluent irrigation and rainfall. Agron. J., 94: 1295-1304.

Mundy, C., N.G. Creamer, C.R. Crozier, L.G. Wilson and R.D. Morse, 1999. Soil physical properties and potato yield in no till, subsurface and conventional-till systems. Hort Tech., 9: 240-247.

Neeteson, J.J. and O.T. Carton, 2002. The Environmental Impact of Nitrogen in Field Vegetable Production. ISHS Acta Horticulture, 563: 2.

Olufolaji, A.O., O.B. Adebayo and F.O. Omotaajo, 1998. Response of grain amaranth (Amaranthus Grantus) to difference times of N and P fertilizer application. Proc. 16th Ann. Conf. Hortson, pp: 80-84.

Osiname, A.O., 2000. Soil fertility in Nigeria: My experience. Agronomy in Nigeria, University of Ibadan, pp: 183-186.

Rasmussen, K.J., 1999. Impact of ploughless soil tillage yields and soil quality: A Scandinavian review soil: Tillage Res., 57: 69-82.

Sanchez, P.A., W. Canto and S.W. Buol, 1992. The fertility capacity of soil classification systems: Interpretation, applicability and modification. Geodermics, 27: 283-304.

SAS Statistical Analysis Systems, 1999. SAS/STAT Users Guide, Version 8. Statistical Analysis Systems Institute, Cary, Nc., pp: 3884.

Soumare, M., A. Deneyar, F.M. Tack and M.G. Verloo, 2002. Nutrient availability in the surface horizons of Focus Tropical Agricultural Soils in Mali. Tropicultural, 20: 49-57.

Vervoor, 1993. Importance of micronutrient in multiple cropping systems. Food aid Agricultural Organization of the United Nations. Roma Fert and plant Nutr., 5: 74-83.

Veldkamp, T., 1992. Fertilite du sol. Agromisa B.P.4. Wageningen Pays Bas Agrodok, 2: 2-8.

Verloo, M.G., 1983. Importance of micronutrients in multiple cropping systems. Food and Agricultural Organization of the United Nations, Rome Fert. Plant. Nutr., 5: 74-83

Willcock, B. Dennis, 1983. Water Engineering. Evans Brothers (Nigeria Publisher) Ltd., Jericho, Ibadan.

Vanlauwe, B., 2000. Soil Organic matter and crop production in West African context. Agronomy in Nigeria, University of Ibadan, pp: 202-207.

Yin Xinhua and J. Vyn Tony, 2002. Soyabean responses to potassium placement and tillage alternatives following no-till. Agron. J., 94: 1367-1374.