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Effects of Tillage Systems and Four Fertilizer Rates on Growth Parameters and Fruit Yield of Okra (*Abelmoscus esculentus*) and Pepper (*Capsicum annum*)

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ABSTRACT: The interactions between tillage systems and fertilizer play a significant role in determining sustainability of horticultural crop production. Field experiment were conducted to determine the effects of four tillage systems: Ploughing (T_1), ploughing plus ridging (T_2) and ploughing plus harrowing plus bedding (T_3) and ploughing plus harrowing (T_4), in combination with four rates of fertilizers: NPK (20, 10, 10)- at 0 kg/ha- (F_1), 80 kg/ha-(F_2), 120 kg/ha-(F_3) and 180 kg/ha-(F_4) on the growth and fruit yield of okra (*Abelmoscus esculentus*) and pepper (*Capsicum annum*). Growth indices such as number of leaves (NL), plant height (PHT), stem diameter (SD) and leaf area (LA) were measured. Fruit yield (YLD) of the two crops were determined. Soil properties before and after the experiments were conducted. Results obtained revealed that there was no significant difference ($p \leq 0.05$) in bulk density (T_1=1.29 gm/cm^3, T_2= 1.40 gm cm^{-3}, T_3 = 1.45 gm cm^{-3}, T_4 = 1.44 gm cm^{-3}). However, cone penetration values were greatly influenced by tillage systems (T_1=0.065 kg/s, T_2 = 0.97kg/s, T_3 =0.95 kg/s, T_4 = 0.93 kg/s). The differences among the tillage systems and fertilizer sources are more significantly ($p \leq 0.05$) pronounced in PHT, SD, LA and YLD, where F_3T_1 recorded the highest mean plant height (744.33 mm), F_2T_4, the best mean NL, F_2T_4 in SD, F_1T_4 in LA and F_3T_2 producing the highest mean YLD for okra. Similarly, F_3T_4, recorded the highest mean NL, with F_3T_3 having the best mean YLD in pepper. However, overall result based on the cost-benefit showed that F_3T_3, was more profitable cultivation techniques for pepper and F_3T_2, for okra production respectively. Considering the production inputs of the crops, F_3T_3 and F_2T_4 appeared to be the best options for pepper and okra productions respectively.

Key words: Tillage system · *Capsicum annum* · YLD · Cost benefit

INTRODUCTION

The relationship between soil pore structure and flow characteristics of solutes in the soil has been reported By Lipiec *et al*. [1]. Tillage obviously influences soil structure, which in turn affects agricultural activities to a large extent. Earlier researchers have discovered that tillage practices increase the surface storage capacity of the soil and also increase the run off flow within and out of the field [2]. However, uncontrolled or indiscriminate tillage application can result in soil erosion and fertilizer depletion. Afolayan *et al.* [3] reported that the capacity of the soil to sustain nutrient cycles, energy and water flow through soil aggregate and ability to recover from degradation or deterioration after intensive exploitation depends on the tillage techniques. Although, the rate of root growth depends on the temperature, water and air supply in the soil, roots perform better with adequate potentials for respiration by consuming oxygen and producing carbon dioxide [4]. Roots also perform better and develop faster in porous soils [5]. Porosity obviously is a function of pore size distribution, pore continuity and hydraulic conductivity functions [6], which is largely influenced by tillage systems. These properties evolving from soil pulverization depends on the type of tillage techniques adopted over the period. Aon *et al*. [7] confirmed that tillage quality exhibits a pronounced residual effect on saturated hydraulics conductivity and soil moisture retention characteristics. These variables are known to enhance suitable and sustainable soil structure. Studies have revealed that the effect of soil tillage and management has not been consistent on crop yield and soil characteristics [8-14]. However, effective and sustainable tillage system will

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promote and enhance better crop yield with little or no detrimental effect on soil depletion. Fertilizer application is essential to tropical soils because of its general poor inherent nutrient status if vegetable production is to be sustainable [16]. Generally, fertilizer recommendation for most of the vegetable grown in Nigeria is between 50-100 kgN/ha, 20-60 kgP_2O_5/ha and 40-60 kgK/ha [16]. However farmers' limited financial resources coupled with acute shortage of fertilizers compelled them to look elsewhere for substitute that will equally enhance their productivity with less input. Other sources of fertilizers such as organo-mineral, cow dung and poultry wastes are being explored. Much research studies had been carried out on effects of fertilizer and tillage on crops [17-27]. Little is reported on the effect of tillage systems and fertilizer levels on growth and fruit yield of pepper (*Capsicum annum*) and okra (*Abelmoscus esculentus*). Both okra and pepper are of numerous economic importances in Nigeria. Pepper (*Capsicum annum*) has nutritional veterinary and medical values. Pepper fruit (*Capsicum annum*) is being used by the rural folks in Nigeria to treat cold and catarrh. This crop can also be used in controlling the disease of pestes de petites ruminants (PPR) thereby controlling high mortalities among the small ruminants particularly within the first three months of birth. Okra is used in cooking and confectionaries in Nigeria. Inspite of the profitable use the crops are put into, their full potential are limited and under exploited by their current low production which are predicated on poor knowledge of production in terms of tillage and fertilizer requirements. The objective of this study is therefore to determine the combined effects of tillage systems and different sources of fertilizer on growth parameters and fruit yield of pepper (*Capsicum annum*) and okra (*Abelmoscus esculentus*).

MATERIALS AND METHODS

Four Tillage Systems: Ploughing (T_1), Ploughing plus harrowing plus ridging (T_2), ploughing plus harrowing plus bedding (T_3) and ploughing plus harrowing (T_4), in combination with four rates of fertilizers: NPK (20, 10, 10)- at 0 kg/ha-(F_1), 80 kg/ha-(F_2), 120 kg/ha-(F_3) and 180 kg/ha-(F_4) were carried out and their effects determined on the growth parameters and fruit yields of pepper (*Capsicum annum*) and okra (*Abelmoscus esculentus*). The experiment was a split plot in randomized complete block design with three replications. Soil chemical properties were analyzed before and after the experiment according to standard procedure [28]. Soil physical properties were measured after the experiment. Land preparation was carried out on the 14th September, 2004. Pepper seeds were planted out into the nursery on the 12th August, 2004. Seedlings of pepper at average height of 35cm with the mean root depth of 10 cm were transplanted into the field on the 16th September, 2004. The plot size was 4 m by 1 m with standard recommended spacing of 50 cm by 50 cm. Okra seeds were sown directly on 18th September, 2004. Soil bulk density and cone penetrometer resistance were determined using oven dry method at constant moisture moisture at 105°C and cone penetrometer, respectively. Initial basic growth parameters were measured prior to imposition of fertilizer treatment weekly starting from two weeks after transplanting pepper (2WAT) and direct sowing of okra (2WADS). Application of fertilizer was effected 3WAT of pepper and 3WADS of okra. Agronomic practices such as manual weeding using traditional hoes were carried out 4WAT of pepper and 4WADS of okra. Spraying with insecticides using cymbush at the standard specification was applied 5WAT and 6WAT of pepper and 6WADS of okra. Harvesting commenced 8WAT of pepper and continued at regular intervals until 15WAT of pepper (*Capsicum annum*) and 14WADS of okra (*Abelmoscus esculentus*). Other growth parameters were measured. Cost benefit of the crops beginning for initial land preparation to harvesting was calculated. Generated growth and yield data were analyzed using SAS (scientific analytical software) (1999).

RESULTS AND DISCUSIONS

Table 1 shows the meteorological elements during the experimental period. Mean rainfall amounts recorded for the experimental months were 69.6mm. This quantity was below the recommended values(100 cm) for vegetable production [29]. However, the months of November to December, 2004 and January to February 2005 were supplemented with irrigation. This becomes necessary because moisture being the main constituent of plant tissue and reagent in photosynthesis is regarded as the medium by which chemicals and nutrients are carried from soil to the various parts of crops [30]. Soil temperature as recorded in Table 1 is within the threshold values recommended for vegetable crops. Although high temperatures are generally not destructive to crops as low temperatures, provided the moisture supply is adequate to prevent wilting [30]. Table 2 and 3 presented the chemical and physical properties of the soil conducted

Table 1: 2004/05 Meteorological Data for the Experimental Period

	2004						2005		
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	March
Rainfall (mm)	115.6	68.3	131.9	167.4	7.8	0.0	0.0	53.8	82.6
R. Humidity (%)	86.0	86.0	87.0	84.0	83.0	81.0	59.0	79.0	80.0
Air Temperature (°C)	25.0	25.0	26.0	27.0	27.4	28.0	25.2	28.2	29.0
Sunshine hours (hr)	2.9	1.1	2.5	2.2	2.7	5.2	4.7	5.1	5.8
Evaporation (mm)	2.8	2.7	4.0	4.0	4.0	4.8	5.9	5.6	5.5
Wind run (km)	56.0	66.2	52.4	36.6	44.4	48.5	55.3	68.3	39.0
Radiation	276.0	259.4	296.0	303.3	309.9	315.3	314.0	318.8	333.4

Table 2: Soil properties conducted before the experiment

Sample elements	Values
EC (mm hos/cm @ 250C)	0.13
OC (%, W/ W)	0.48
N (%, W / W)	0.57
Mehlich P (ppm)	9.00
Ca (cmol/kg)	8.06
Mg (cmol/kg)	1.81
K (cmol/kg)	0.74
Na (cmol/kg)	0.26
Mn (ppm)	377.18
Fe (ppm)	334.82
Zn (ppm)	6.03
Cu (ppm)	1.53

Table 3: Soil Properties conducted after the experiment

Tillage	Values												
System	Cu	Mn	Fe	C (%w/w)	%N	P	Ca	Mg	K	Na	Zn	BD(gmcm^{-3})	CONE (kg/s)
T_1	3.75	259.19	160.97	0.6	0.056	5	1.19	0.88	0.26	0.11	4.29	1.29	0.06
T_2	3.56	216.35	135.13	0.55	0.045	5.3	1.12	0.51	0.23	0.08	4.83	1.40	0.97
T_3	3.82	251.99	134.71	0.7	0.068	2.5	1.14	0.57	0.19	0.12	5.65	1.45	0.95
T_4	3.9	253.05	129.85	0.48	0.045	3.5	1.18	0.6	0.16	0.12	5.19	1.44	0.93

BD = bulk density; CONE = cone penetration resistance

before and after the experiment,respectively. The initial value of the percent organic carbon was below the standard (1.4%) [31]. This trend implies inadequate soil fertility since organic carbon or organic matter as the case may be is a source and a sink for nutrient elements that form organic elements like nitrogen, phosphorus and sulphur. Organic carbon contains charge properties for ion exchange thereby facilitating aggregation with mineral particles particularly clays and in turn modify soil physical structure and activating soil water regimes [31]. Mean values of the chemical properties conducted did not reflect any appreciable differences among the treatments (Table 3). However, in the trace element reserves, T_1 was the least for Zn and T_2 for Cu and Mn. Generally, the variations among the treatments were marginal for any differential positive effects on crops. Effects of tillage system and fertilizer rates on growth and fruit yields of okra (*Abelmoscus esculentus* and pepper (*Capsicum annum*) are presented on Tables 4 and 5. Okra plants under most of the treatments had mean number of leaves (NL) above thirteen (13), except F_4T_2 and F_1T_2 that were 40% below the mean highest value (21). However, F_2T_4 produced the highest mean value at 5% significant differences. Mean values of PHT range from 400 mm to

Table 4: Effects of tillage systems and fertilizer levels on growth and fruit yield of okra (Abelmoscus esculentus)

Treatments	NL	PHT (mm)	SD (mm)	LA (mm^2)	YLD (t/ha)
F_1T_1	16	562.33	14.33	2459.89	1.51
F_1T_2	12	469.22	11.59	1234.33	1.27
F_1T_3	15	372.78	10	1393.44	0.85
F_1T_4	13	420.56	12.17	4818.22	1.81
F_2T_1	16	454.44	14.26	1398.56	1.53
F_2T_2	15	570	13.48	1496.11	1.85
F_2T_3	18	466.67	12.89	1248.33	1.17
F_2T_4	21	483.44	15.74	1548.44	0.89
F_3T_1	14	744.33	15.82	1591.78	2.58
F_3T_2	14	541	14.51	1485.11	3.01
F_3T_3	15	699.44	14.02	1221.89	1.46
F_3T_4	18	619.44	16.59	1513.44	2.66
F_4T_1	15	471.78	11.99	2260.67	0.59
F_4T_2	12	384.56	10.06	797.67	0.51
F_4T_3	17	403.11	11.86	3042.67	0.76
F_4T_4	20	427.22	13.58	908.89	0.77
LSD (5%)	4	98.45	1.61	298.66	0.34

Table 5: Effects of tillage systems and fertilizer levels on growth and fruit yield of pepper (Capsicum annum)

Treatments	NL	PHT (mm)	SD (mm)	LA (mm^2)	YLD (t/ha)
F_1T_1	103	279	5.46	239.16	0.92
F_1T_2	175	373.67	7.28	242.35	1.12
F_1T_3	167	502.33	7.56	323.81	0.76
F_1T_4	210	444.33	7.7	390.58	0.93
F_2T_1	124	368.89	6.4	172.09	0.48
F_2T_2	112	300.78	6.14	219.86	0.43
F_2T_3	109	371.67	7.02	133.2	1.26
F_2T_4	141	292.56	6.11	293.74	0.69
F_3T_1	205	407	7.66	397.85	1.12
F_3T_2	165	397.44	7.5	450.72	1.02
F_3T_3	228	444.56	8.22	359.76	2.07
F_3T_4	247	488	9.61	514.77	1.03
F_4T_1	123	330.89	7	320.7	0.82
F_4T_2	107	327.56	5.13	534.04	0.82
F_4T_3	155	306.11	6.46	256.93	1.04
F_4T_4	91	236.78	4.54	420.25	1.19
LSD (5%)	41	63.97	0.99	56.13	0.29

740 mm. F_3T_1 was significantly superior in crop development than other treatments. The mean leaf area, which is an index of canopy characteristics, was significantly ($P<0.05$) more luxuriant under F_1T_4 than the rest. Most importantly, the mean yield value was best under F_3T_2 treatment for okra and F_3T_3 for pepper. The trend observed in the physiological pattern of the growth parameters might not be unconnected with the interactions between tillage, fertilizer application (180 kg/ha) and moisture availability (100 cm). Above and below soil moisture optimum level with the optimum level of fertilizer and tillage systems, plants physiological response to chemicals and nutrients assimilation for development will be affected. Below the threshold level, plants will wilt and die and above the threshold,

Table 6: Cost-Benefit effect for pepper (Capsicum annum) cost/ha.

Tillage Treatment	LP	FER	BEN (N/ha)	TE (N/ha)	PRT (N/ha)
F_1T_1	3706.6	-	140000	3706.6	136293.4
F_1T_2	6177.6	-	56000	6177.6	49822.4
F_1T_3	8648.7	-	140000	8648.7	131351.3
F_1T_4	6177.6	-	68000	6177.6	61351.3
F_2T_1	3706.6	2400	168000	6106.6	161893.4
F_2T_2	6177.6	2400	56000	8577.6	47422.4
F_2T_3	8648.7	2400	172000	11048.7	160951.3
F_2T_4	6177.6	2400	76000	8577.6	67422.4
F_3T_1	3706.58	3600	144000	7306.6	136693.4
F_3T_2	6177.6	3600	40000	9777.6	30222.4
F_3T_3	86118.7	3600	160000	12248.7	447751.3
F_3T_4	6177.6	3600	48000	9777.6	38222.4
F_4T_1	3706.6	5400	100000	9106.6	90893.4
F_4T_2	6177.6	5400	164000	11577.6	152422.4
F_4T_3	8648.7	5400	336000	14048.7	321951.3
F_4T_4	6177.6	5400	132000	11577.6	120422.4

Table 7: Cost-Benefit effect for Okra (Abelmoscus esculentus) cost/ha.

Tillage Treatment	LP	FER	BEN (N/ha)	TE(N/ha)	PRT(N/ha)
F_1T_1	3706.6	-	107800	3706.6	104093.4
F_1T_2	6177.6	-	105600	6177.6	99422.4
F_1T_3	6177.6	-	48400	6177.63	42222.4
F_1T_4	8648.7	-	215600	8648.7	206951.3
F_2T_1	3706.6	2400	105600	6106.6	99493.43
F_2T_2	6177.6	2400	125400	8577.6	116822.4
F_2T_3	6177.6	2400	41800	8577.6	33222.4
F_2T_4	8648.7	2400	250800	11048.7	239751.3
F_3T_1	3706.6	3600	136400	7306.6	129093.4
F_3T_2	6177.6	3600	52800	9777.6	43022.4
F_3T_3	6177.6	3600	63800	9777.6	54022.4
F_3T_4	8648.7	3600	213400	12248.7	201151.3
F_4T_1	3706.6	5400	81400	9106.6	72293.4
F_4T_2	6177.6	5400	59400	11577.6	47822.4
F_4T_3	6177.6	5400	69400	11577.6	57822.4
F_4T_4	8648.7	5400	114400	14048.7	100351.3

soil pores are filled thereby resulting to water logging, eventually, the crops will die. F_3T_2 (120 kg/ha) of fertilizer in combination with ploughing and ridging (T_2) ensures the required quantities of fertilizer and the tillage system. T_2, in addition to supporting roots development; it also guarantees drainage and controls soil erosion. Similarly, F_3T_3 (120 kg/ha + bedding) had the best mean value for pepper production. The differences in results can be attributed to the ability of the seeds to adjust to soil tilt or structural characteristics. Raised flat seedbeds produced by bedding treatment seem to favour pepper production while conical shaped seedbed as in harrowing favours okra production. Tables 6 and 7 showed the cost of production for both okra and pepper. Combining all inputs or indices of production, F_3T_3 was found more profitable than others in pepper (*Capsicum annum*) while F_2T_4 in okra (*Abelmoscus esculentus*) productions, respectively.

CONCLUSION

Tillage enhances soil pore structures thereby influencing crop yield while fertilizers are required to urgument-depleted soils typical of tropical soil conditions. Pepper (*Capsicum annum*) under fertilizer rates of 120 kg/ha, in combination with ploughing plus harrowing plus bedding tillage system produced the best mean yield, while fertilizer rate of 80 kg/ha in combination with ploughing plus harrowing produced the best in okra (*Abelmoscus esculentus*). This will assist the farmers in their acquisition of implement capable of pulverizing the soil into desired tilth and reduce investments in capital machine that will not work to its full capacity.

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