Research Journal of Applied Sciences, Engineering and Technology 4(5): 387-392, 2012
ISSN: 2040-7467

Submitted: March 14, 2011 Accepted: July 18, 2011 Published: March 01, 2012

The Effects of Tillage Methods on Soil Penetration Resistance, Porosity and OkraYield

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Abstract: The effects of primary, minimum, conventional and ridging tillage on soil penetration resistance, porosity and the yield response of Okra (*Abelmoschus*) were investigated for a growing season in 2008, on a sandy loam soil. Experimental factors included tillage depths, tillage operations, and soil properties such, as soil resistance and porosity. Two different tillage depths of 0-150 and 150-300 mm were studied. Okra parameters investigated were plant height, plant leaf count and yield in terms of number of seeds per plot, number of fruits per plant, fruit weight, length and diameter of the fruits. The data obtained were statistically analyzed using ANOVA and regression analysis. Results showed that the highest porosity of 31.78% (v/v) was recorded on the ploughed + harrowed + harrowed plot, 30.35% (v/v) was recorded on ridged, while 29.76% (v/v) and 29.67% (v/v) were recorded in ploughed + harrowed plot and ploughed plot respectively. The results further showed that the highest soil penetration resistance of 1.13 KN was recorded in the ploughed plot, while the lowest value of 0.61 KN was obtained from the ridged plot. The other values were 1.08 and 1.05 KN for ploughed + harrowed plot and ploughed + harrowed + harrowed plot, respectively. Analysis of variance indicated no significant difference in soil porosity for depths, between plots and blocks at the 5% level of significance, while penetration resistance showed significant difference at the same level of significance. On the whole the mean highest okra yield was obtained from ploughing + harrowing + harrowing tillage operation. The values were 30.26 kg/ha for number of plant per plot, 5.27 kg/ha for number of fruits per plant, 1.76 kg for fruit weight, 68.2 mm fruit length and 31.5 mm for fruit diameter. This study has ploughing + harrowing + harrowing as the best operation suitable for efficient mechanization underlying the high labour productivity for Okra.

Key words: Okra, salient components, soil penetration resistance, soil porosity, tillage operations

INTRODUCTION

Soil tillage plays very important role in soil productivity as it creates optimum soil conditions for crop growth (Adamu *et al*., 2004, Nkakini *et al*., 2008). Soil aeration, infiltration, nutrient availability, soil erosion and root system proliferation are to a large extent influenced by tillage practices. Rashidi and Keshavazpour (2007) posit that soil tillage is among the important factors affecting soil physical properties and crop yield.

Conventional tillage practices modify soil structure by changing its properties such as soil penetration resistance and porosity. This decreases soil penetration resistance, improves soil porosities, and water holding capacity (Khan *et al*., 2001). Findings have shown that conventional tillage methods often result in decreased in soil pores, while soil strength is at increase (Bander *et al*., 1981). According to Kruger (1996), Franzen *et al*. (1994) and Ferreras *et al*., 2000, in No-till soil, greater soil penetration resistance level was observed, when compared with tilled soils. Pierce *et al*. (1994) observed that ploughing when compared with No-till increased micro porosity levels. From the study of Lampurlanes and Cantero-Martizez (2003), the most common variable used to assess soil strength in tillage studies are bulk density and soil penetration resistance. They are interrelated, and use of only for one of these variables may lead to misleading results (Campbell and Henshall, 1991). Soil penetration resistance is inversely related to total soil porosity which provides a measure of the porous space left in the soil for air and water movement (Carter and Ball, 1993). Generally, high porosity is associated with poor soil-root contact while low porosity reduces aeration and increases penetration resistance which limits roots growth (Cassel, 1982). Klepper (1990) reported that one of the most important soil physical properties affecting root growth is porosity. One of the goals of tillage is to increase soil porosity. Soil Penetration resistance or cone

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index of soil is mostly affected by factors like soil water content and bulk density. Penetration resistance increases with depth due to the increase in share friction and the values from the different soil depths which are correlated with each other (Franzen *et al*., 1994).

Atwell (1993) and Gregory (1994) stated that root growth decreases as penetration resistance increase showing a linear, inverse or exponential relationship. Penetration values greater than 2 Mpa are generally reported to produce a significant root growth reduction (Atwell, 1993).

Okra (*Abelmoschus esculentus*) is an important vegetable crop whose immature leaves and fruits are rich sources of vitamins and minerals which are eaten in various forms. (Adeboye and Oputa, 1996). The fruits have pods. Their pods are also eaten directly and used as flavouring in preparing other food products. The fruits are mucilaginous and commonly used as a soup thickener in Nigerian. They are used in the making of fish lines, traps, salad dressings, ice-creams, cheese and candies. The essential and non-essential amino acids that Okra contains are comparable to that of soybean. Hence it plays vital role in human diet. The economic important of Okra cannot be over emphasized.

Presently, a wide range of tillage methods is being used in Nigeria without evaluating their effects on soil penetration resistances, porosities and crop performance. Therefore, this study investigates the effects of tillage methods on Okra (*Abel moschus, esculentus*) yield, soil penetration resistance and porosities during one growing season.

MATERIALS AND METHODS

The experiment was conducted during the 2008 growing season at the Research School Farm of Rivers State University of Science and Technology, Port-Harcourt, Nigeria. Port- Harcourt is on latitude of 0.5º 0.I N longitude of 0.6º57E, with an altitude of 274 mm above mean sea level. The study area is characterized by tropical rainforest vegetation,with a rainfall depth ranging frommm 2000-2484 mm/annum, of which70% occur between the months of May and August. The rest of the year is relatively dry. Mean temperature varies from 24 to 30ºC. The soil type is ultisol (USDA classification) and its texture is sandy loam (Ayotamuno *et al*., 2007). The treatment consisted of four tillage practices which were ploughing, ploughing + harrowing, ploughing + harrowing + harrowing and ridging. The tillage treatments were laid out in randomized complete block design and replicated three times. The experimental field was cleared manually. The dimension of the land was 16 m × 22 m. The land was divided into twelve comparative plots. Each plot measured 4 m × 4 m with 2 m apart from each tillage treatment. A headland of 10 m spacing from the entire areas of land was provided for tractor passage and implement hitching process.

Disc ploughing operation (primary) was carried out with a three-furrow disc plough mounted on STEYR SSF RUSU-5312. The disc ploughing was done to an average depth of 20 cm. Most of the existing weeds were inverted and buried in the ploughing operation.

A tractor-mounted disc harrow was used to pulverize the soil in the minimum tillage (ploughing + harrowing) operation, followed by conventional tillage and a tractor mounted ridger implement was used for ridging operations.

Soil samples were taken from each of the plots at three randomly selected locations before ploughing. Soil penetration resistance was measured by three insertions in each plot to the depth of 0-15 and 15-30 cm. A pocket cone penetrometer (T.207C. NTROLS MODEL) was used immediately after land clearing.

Soil porosity to the depths of 0-15 and 15-30 cm was determined by calculation based on the relationship between the bulk density and particle density. Okra variety (V-35) was planted at the rate of 2 kg/ha on May, 31st, 2008 (wet season). Three seeds/hole were sown by manual drilling to a depth of 3 cm at a spacing of 50-100 cm. No fertilizer was applied. Standard procedures were adopted for recording the data on various growth and yield parameters. Okra growth and yield performance assessed included, number of seeds per plot, number of fruits per plant, fruits weight (g) fruits length (cm) and fruit diameter (cm).

The data collected were analyzed statistically using analysis of variance and regression analysis.

RESULTS AND DISCUSSION

The study area is characterized by tropical rainforest vegetation, with a rainfall depth ranging from 2000-2484 mm/annum, of which 70% occur between the months of May and August. The rest of the year is relatively dry. Mean temperature varies from 24 to 30ºC. The soil type is ultisol (USDA classification) and its texture is sandy loam with composition of 71% sand, 8.47% silt and 17.94% clay from textural triangle reading.

Tillage effect on soil porosity: Table 1 shows the values of porosity and their mean at different tillage depths. It can be seen from the Table that the highest level of porosity was observed to be 31.78%v/v on the plough + harrowed + harrowed plot which is due to looseness of the soil at a depth of 0-300 mm. The ploughed plot recorded a porosity of 29.67%v/v, at the same depth, clearly showing that porosity was highest on the ploughed + harrowed + harrowed plot and lowest on the ploughed plot.

Table 1: Mean of soil porosity at different tillage levels

Depth of samplings (Mm)	T_1 plough plot	T_2 plough +	T_3 Plough + Harrow + Harrow plot	T_4 Ridging plot P_4
0-150 m	32.26	29.81	25.20	31.23
	25.00	32.98	39.77	26.29
	35.25	31.29	33.08	39.44
Mean	30.84	31.36	32.68	32.32
150-300 mm	32.51	24.71	30.04	34.21
	28.33	31.99	34.08	24.13
	24.62	27.78	27.84	26.79
Mean	28.49	28.16	30.88	28.38
Total mean	29.67	29.76	31.78	30.35

Table 2: ANOVA for tillage treatment on soil porosity

Sources of variance (S.V)	d_f $^{n-1}$ (–1)	SS	M_S	Cal_f	$Table_f$
Total variance 8	7	65.23	9.32	0.32	
Total treatment 4	3	5.71	1.90	0.07	6.94 NS
Depth 2	1	15.93	15.93	0.55	6.94 NS
Block 3	2	0.03	0.03	0.05	6.94 NS
Error total variance	3	- 86.87	28.96	1.00	

-(Treatment + Depth) (D_f); NS: Not significant ($p \leq 0.05$)

Table 3: Mean effect of tillage treatments on soil penetration resistance at different levels. (KN)

Depth of samplings (cm)	T_1 Plough plot	T_2 Plough + harrow plot	T_3 Plough + Harrow + Harrow plot	T_4 ridging plot
0-15 cm	1.04	0.92	0.98	0.52
15-30 cm	1.22	1.22	1.11	0.70
Total mean	1.13	1.08	1.05	0.61

Table 4: ANOVA for tillage treatment on soil penetration resistance at different levels

Sources of variance (S.V)	d_f $^{-1}$ (n–1)	SS	M_S (ss/df)	Cal_f	$Table_f$
Total variance 8	7	0.43	0.06	20	
Total treatment 4	3	0.35	0.12	40	6.94 SS
Depth 2	1	0.07	0.07	23	6.94 SS
Block 3	2	0.03	0.03	55	6.94 SS
Error total variance -(Treatment + Depth) (df)	3	0.01	0.003		

SS: Significant ($p \geq 0.05$)

This might be due to the fact that when compared with these other tillage methods, ploughing only had the potential of reducing the free flow of air and water into and within the soil profile. It could be also of the fact that the disc created more space in the soil with its inversion of bigger clods. This agreed with findings of Nwagu and Oluka (2006), Nkakini *et al*. (2008) reporting that the lowest value of porosity was obtained in zero- tillage and that ploughing alone gave higher value of porosity than ploughing plus harrowing as compared with other tillage methods. Similarly, Adamu *et al*. (2004), reported that soil porosity was lowest with no-tillage and highest with conventional in the first - two weeks after planting

The statistical results of the study indicated no significant differences in porosities among the tillage treatments and depths in the plots at 5% level of significance (Table 2). Similar result was reported by Nkakini *et al*. (2008), Nwagu and Oluka (2006).

Tillage effect on soil penetration resistance: The effect of tillage on soil penetration resistance is presented in Table 3.The lowest soil penetration resistance of 0.61KN was obtained from the ridging plot. This might be due to soil loosening effect of primary, secondary and ridging implements used. This result is in line with that reported by Khurshid *et al*. (2006) which stated that soil of the conventional tillage treatment had lower soil penetration resistance than other treatments. The highest soil penetration resistance of 1.13 KN was obtained for the ploughed treatment. This agrees with the findings of Rashidi and Kesharovpour (2007).

Analysis of variance used to determine the significant difference among variables is shown in Table 4. The results of the analysis of variance indicate that there is significance difference in soil penetration resistance among the tillage treatments and depths in the plots at 5% level of significance. This is because, soil penetration resistance varies both in treatment and depth.

Okra yield performance: Okra growth measured as plant height was affected by different tillage treatments (Table 5). The height of Okra on 19/07/08 are 126.7, 150, 106.7 and 63.3 mm for ploughed, ploughed + harrowed, ploughed + harrowed + harrowed, and ridging plots respectively.

Table 5: Response of Okra plant height at different tillage treatment plots (mm)

Periods of collection (two weeks interval)	Ploughed plot	Ploughed + Harrowed Plot	Ploughed +Harrowed +Harrowed Plot	Ridging plot
21/06/08	51.3	41.3	41.7	40.7
5/07/08	70.0	66.7	51.7	53.0
19/07/08	126.7	150.0	106.7	63.3

Table 6: ANOVA for tillage treatment on plant height at different levels

Sources of variance/S.V	$d_f^{\,n-1}$ (n–1)	SS	M_S (ss/df)	Cal_f	Table
Total variance 12	11	144.30	13.12	4.13	
Total treatment 4	3	21.73	7.24	2.28	6.94 NS
Depth 2	1	100.31	100.31	31.54	6.94 SS
Block 3	2	0.03	0.03	0.05	6.94 NS
Error total variance -(Treatment - Depth) (df)	7	22.26	3.18	1.00	

NS: Not significant ($p \leq 0.05$); SS: Significant ($p \geq 0.05$)

From Table 6 of analysis of variance on plant height, the result showed that there was no significant difference in height of plant among the treatment plots at ($p \leq 0.05$) but a significant difference at ($p \geq 0.05$) among the depths in the plot. According to Adamu *et al*. (2004) the result of the effect of tillage on plant height for Soyabean was significantly higher with no-tillage than disc ploughing and conventional. This could be as a result of the beneficial effect of the plant residue left on the soil surface in the no-tillage treatment.

Table 7 presents Okra plant leaf count at different periods of growth. It can be seen that the highest leaf counts of 5.77 was obtained from ridged plot, while leaf count of 5.22, 5.33 and 5.33 were recorded from ploughed, ploughed + harrowed and ploughed + harrowed plots, respectively.

Table 8 is the analysis of variance which showed no significant difference at ($p \leq 0.05$) in number of leaf per plant among the treatment and block plots However there is a significant difference at ($p \geq 0.05$) in the number of leaf per plant among the depths.

From Table 9, the effects of different tillagetreatments on okra yield kg/ha, showed that the number of plant per plots, number of fruits per plant, fruit weight (kg), fruit length (mm), fruit diameter (mm), affected yield during the season. Rashidi and Keshavarzpour (2007) reported similar findings in yields of watermelon.

The overall analysis for Okra yield showed that conventional treatment plot had the highest value in all ramifications as the best treatment for Okra production. Ridged treatment plot had the lowest value of yield characteristics with poor or rather low yield performance. These results are in agreement with those of Khan *et al*. (2001) who concluded that conventional tillage methods produces a favorable environment for crop growth, nutrient use and crop yield.

In Table 10, is shown the regression equations for the relationships between soil porosity, soil penetration resistance and different tillage treatments on Okra yield performance.

From the regression correlation analysis, it was observed that the plough+ harrow + harrow treatment plot has the highest yield properties, while the plough treatment has the lowest yield requirement for profitable okra production.

Different tillage treatments significantly affected Okra yield performance during this year of study in terms of Okra plant height, plant leaf and okra yield (Table 5, 7 and 9).

However, the highest response of Okra plant height of 150 mm at different tillage treatment was obtained in ploughed + harrowed plot, while ridging had the lowest plant height of 63.3 mm, which might be due to the rate of the infiltration and moisture retention in the tillage treatment. This agrees with the reports of Adamu *et al*. (2004) on plant height for soybean being significantly higher with no-tillage than disc ploughing and conventional tillages.

Table 7: Okra plant leaf count at different periods of growth

Period of collection (two weeks interval)	Ploughed plot	Ploughed +Harrowed Plot	Ploughed +Harrowed +Harrowed	Plot Ridging plot
21/06/08	4.33	4.33	4.00	4.44
05/07/08	5.33	5.67	6.00	5.33
19/07/08	6.00	6.00	6.00	7.67
Total mean	5.22	5.33	5.33	5.77

Table 8: ANOVA for tillage treatments on Okra plant leave count at different levels

Sources of variance (S.V)	$d_f^{\,n-1}$ (–1)	SS	M_S	Cal_f	$Table_f$
Total variance 12	11	12.07	1.10	3.93	
Total treatment 4	3	0.54	0.18	0.64	6.94 NS
Depth 2	1	9.58	9.58	34.21	6.94 SS
Block 3	2	0.03	0.03	0.05	6.94 NS
Error total variance -(treatment - depth) (df)	7	1.95	0.28	1.00	

NS: Not significant ($p \leq 0.05$); SS: Significant ($p \geq 0.05$)

Table 9: Effect of different tillage treatments on Okra yield performance (mean of replicates)

Treatments	No. of plant per plot	No. of fruits per plant)	Fruit length (mm)	Fruit diameter (mm)	FuFruit weight (Kg)	Okra yield (Kg/Ha)
T_1 Ploughed plot	22.52	3.40	52.8	27.2	0.94	4.53
T_2 Ploughed +	27.24	4.35	61.7	30.0	0.23	7.50
Harrowed Plot	30.26	5.27	68.2	1.76	3.15	17.69
T_3 Ploughed +						
Harrowed +						
Harrowed Plot						
T_4 ridged plot	19.12	3.04	53.7	3.57	2.28	3.47

Table 10: Regression table

Treatments	a	b	r	Y (kg/ha)
T_1 ploughed plot	3.43	0.17	0.82	4.53
T_2 Ploughed +	4.88	0.04	0.87	7.50
Harrowed Plot				
T_3 Ploughed +				
Harrowed +	5.97	0.23	0.96	17.69
Harrowed plot				
T_4 Ridged plot	2.77	0.20	0.80	3.47

Table of analysis of variance for okra plant leaf count showed no significant difference among the treatment and block plots, but a significant difference among the depths. The highest yield of 17.69 kg/ha was obtained in the ploughed+harrowed + harrowed plot treatment and lowest of 3.47 kg/ha in the ridged plot treatment. Rashidi and Keshavarzpour (2007) reported similar findings in yields of watermelon.

CONCLUSION

This study evaluated the effect of ploughing, ploughing+harrowing, ploughing+harrowing+harrowing and ridging on soil porosity, soil penetration resistance and okra yield performances. Soil penetration resistance is one of the common variables used to assess soil strength in tillage. Reduced soil penetration resistance increased soil porosity.

Different tillage treatment had no significant effect on soil penetration resistance and porosity. Tillage methods significantly affected crop yield of okra in the order of T3>T2>T1>T4. The highest amount of okra crop yield obtained in ploughed + harrowed + harrowed might be due to moderately reduced soil penetration resistance and increased porosity which enhanced seed-soil contact. From this research, (ploughed + harrowed + harrowed) conventional tillage was discovered as the best for okra production.

REFERENCES

Adamu, S., C. A. Ezeaku and S.G. Mshelia, 2004. Response of soybean (Glycine Max) to three tillage system at Bauchi. Proceedings of 5th International Conference and 26th Annual General meeting of the Nigerian . Institution of Agricultural Engineers held at Kwara Hotels Limited, Ilorin, Nigeria. 28th Nov-2nd Dec.

Adeboye, O.C. and C.O. Oputa, 1996. Effects of galex on growth and fruit nutrients composition of Okra (*Abelmoschus esculentus*). Ife J. Agric., 18(1-2): 1-9.

Atwell, B.J., 1993. Response of roots to mechanical impedance. Environ. Exp. Bot., 33: 27-40.

Ayotamuno, M.J., K. Zuofa, A.S. Ofori and B.R. Kogbara, 2007. Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. Afri. J. Biotechnol., 6(5): 509-515.

Bander, J. W., G .W. Randall and J.B. Swan, 1981. Effect soff our continuetill age systemson mechanical impedance of a clay-loam soil. Sci. Soc. Amer., 45: 802-806.

Campbell, D.J. and J.K. Henshall,1991. Soil Analysis; Physical Methods, Bulk Density. In: Smith, K.A. and C.E. Mullins (Eds.), MarcelDekker, New York, pp: 329-366.

Carter,M.RandBall, B. C. (1993). Soil Sampling Methods of SoilAnalysis. Soil Porosity. In: Carter, M.R. (Ed.), Lewis publ, Boca Raton, FL. pp: 581-588.

Cassel, D.K., 1982. Tillage Effects on Soil Bulk Density and Mechanical Impedance. In: Unger P.W. and D.M. Van-Doren, (Eds.), ASA Spec Publ., 44 Madison, W.I. pp: 45-67.

Ferreras, L.A., J.L. Costa, F.O. Garciaand, C. Pecorari, 2000. Effect of no-tillage on some soil physical properties of a structural degraded petrocalcic paleudoll of the Southern “Pampa” of Argentina. Soil Tillage Res., 54: 31-39.

Franzen, H., R. Lal and W. Ehlers, 1994. Tillage and mulching effects on physical properties of a tropical Alfisol. Soil Tillage Res., 28: 329 -346.

Gregory, P.J.,1994. Root Growth and Activity. In: Boote, K.J., J.M. Bennett, T.R. Sinclair and G.M. Paulsen, (Eds.), Physiocology and Determination of Crop Yield. ASA, CSSA and SSSA, Madison. W.I., pp: 65-93.

Khan F.U.H., Tahir A.R. and Yule I.J. 2001. Intrinsic implication of different tillage practices on soil penetration resistance and crop growth. Int. J. Agric. Biol., 3: 23-26.

Khurshid, R., M. Igbal, M.S. Arif and A. Nawaz, 2006. Effect of tillage and mulch on soil physical properties and growth of maize. Int. J. Agric. Biol., 5: 593-596.

Klepper, B., 1990. Root Growth and Water Uptake. Irrigation of Agricultural Crops. In: Stewart, B.A. and D.R. Nielsen, (Eds.), Agron. Monogr. 30. ASA, CSSA and SSSA, Madison, W.I., pp: 281-322.

Kruger, H., 1996. Soil compaction in haplustolls from the south western part of Buenos Aires, Argentina, Scienc. Suelo., 14: 104-106.

Lampurlanes, J. and C. Cantero-Martirez, 2003. Soil bulk density and penetration resistance under different tillage and crop management system and their relationship with Barley root growth. Am. Soc. Agron. J., 95: 526-536.

Nkakini, S.O., A.J. Akor, I.J. Fila and J. Chukwumati, 2008. Investigation of soil physical property and Okra emergence rate potential in sandy loam soil for three tillage practices. J. Agric. Eng. Technol., 16(2): 34-43.

Nwagu, A.N. and S.I. Oluka, 2006. Optimum tillage system for okra production in an ultisol of South Eastern Nigeria. J. Agric. Eng. Technol., 14: 79-85.

Pierce, F.J., M.C. Fortin and M.J. Staton, 1994. Periodic plowing effects on soil properties in a no-till farming system. Soil Sci. Soc. Am. J., 58: 1782-1787.

Rashidi M. and Keshavarzpour F. 2007. Effect of different tillage methods on grain yield and yield components of maize (Zea mays L.). Int. J. Agric. Biol. 9: 274-277.