EXPERIMENTAL COMPARATIVE ANALYSIS OF VARIOUS TRACTOR PARAMETERS ON SOIL PRODUCTIVITY

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Abstract

The research work examined various tractor parameters on soil productivity. Three tractor speeds (i.e. 4km/hr, 8km/hr and 11km/hr) powers, (i.e. 19kN, 40kN and 47kN) and tyre inflation pressure (i.e. 83kPa, 97kPa and 110kPa) with different implement load attached while tractor drawbar pull and soil resistance to cone penetrometer pressure were measured. It was observed that both drawbar pull and soil resistance to cone penetrometer pressure were found to increase from 0.72kN to 1.42kN and 0 to 163kPa (i.e. within 5 to 10cm soil depth) when the tractor power was increased from 19 to 47kN respectively ,implying that the compactibility of the soil increases thereby inhibiting the free flow of water and air into the soil which affect the productivity of the soil . Similarly, the drawbar pull was found to decrease from 9.7kN to 7.7kN when the tyre inflation pressure was increased from 83kPa to 110kPa but both tyre inflation pressure and speed of tractor with different implement loads attached did not have any effect on soil resistance to cone penetrometer pressure hence improve soil productivity.

Keywords: ***Tractor Power, Tyre Inflation, Pressure, Speed, Drawbar Pull, Soil, Resistance, Cone Penetrometer , Pressure, productivity.***

Introduction

Soil tillage can be described as the practice of modifying the state of the soil mechanically or otherwise in order to produce condition favourable to crop growth. It can also be the application of energy to change the soil physical condition from its present condition to that which is desired to achieve certain objectives e.g. preparation of suitable seed bed or root bed so as to facilitate rapid infiltration, good retention of moisture, provision of adequate air capacity, reduction of soil resistance to root penetration, minimize weed competition, check run-off, destruction of insects as well as their eggs, larvae, breeding places and optimize soil temperature. Other objectives include maintenance of soil productivity or fertility over a long period of time through soil and water conservation by maintaining soil organic matter at high level, preserving soil structure and pore stability (Anazodo, 1983).

Tillage in agriculture is further referred to as the mechanical stirring of soil to provide the soil conditions favourable for crop growth (Makanjoala, 1983). Vasey and Naylor (1958) compared six commercially available tyres of the same size in variety of field conditions and hardened surface. It was found that smooth tyre and industrial tyre types with low and closed centre thread design developed higher pull than all other tyres type on hardened surface. On the other hand increasing the height lugs beyond 20mm decreased tractive performance under poor and average soil condition (Gee-Cload and Mc Allister, 1977).

Drawbar pull which is a force

available at the drawbar can either be measured using a suitable instrument like the spring or hydraulic dynamometer or it can be estimated using such known variables like soil parameters, dynamic soil reaction on the drive wheels and tyre area of contact with the ground surface. At constant travel reduction, a decrease in tyre inflation pressure resulted to an increase in drawbar pull (Burt et al, 1982).

Cone penetrometer pressure of the soil was used as a means of testing strength of the soil. Cone index which is a term that indicates the strength of soil is simply a force per unit base area required to force a cone shaped probe into the soil at a steady rate. Gabrillides and Alexidedes (1963) on their study on soil resistance to cone penetrometer pressure, found out that the higher the moisture content of the soil the less the cone penetrometer pressure. It was found out that there was no significant difference in cone index due to soil type at a given depth but there was a measurable difference in cone index with depth for a given soil type (Hayes et al, 1981).

The aim of the study was to compare various tractor parameters on soil productivity while the objective of the study was to determine the effect of tractor speed, power and tyre inflation pressure on:

The measured drawbar pull

Soil resistance to cone penetrometer pressure under different implements load (i.e. an MF off-set disc harrow of 8.5kN, John Holt 3 Bottom disc ridger of 6kN and John Holt 2m wide tiller of 3.5kN) attached.

Materials and Methods

In this study, a complete randomized block designed was employed with each treatment replicated four times. The various tractor parameters investigated were the tractor powers, (i.e. 19HP Kubota, 40HP Fiat and 47 John Deere), speeds (i.e. 4km/hr, 8km/hr and 11km/hr), tyre inflation pressures (i.e. 83kPa, 97Pka and 110kPa) and type of implement loads (i.e. 8.5kN off-set disc harrow, 6kN John Holt 3 Bottom ridger and 3.5kN John Holt 2m-wide tiller) attached.

The experimental site was located at the Ahmadu Bello University Farm. The land was initially ploughed using a disc plough with three discs. The large soil clods formed were further reduced using an off-set disc harrow with seven discs per gang on a loamy soil of moisture content 12.6% dry basis.

Each of the tractor power of 19, 40 and 47kW were selected with tyre inflation pressure as recommended by the manufacturers was initially operated at full throttle and at selected gear with and without an implement load attached on a selected length of 50m on the field. Soil resistance to cone penetrometer pressure was measured on the selected 50m length of the field before and after operating each of the tractor power with and without an implement load attached. An even pressure was applied on the handle of the cone penetrometer pressure to measure the soil resistance to cone penetrometer pressure, while the cone advanced steadily into the soil up to the required depth of 5, 10, 15, 20 and 25cm respectively on the soil and readings on the scale were recorded. Four readings were taken randomly on the selected 50m length of the field.

The drawbar pull was measured using a spring dynamometer. The spring dynamometer was connected between two tractors while the implements were attached to the rear tractor. The measurement gave the approximate measured drawbar pull of the implement attached and the rear tractor. The difference in the measure drawbar pull when the load on the rear was disconnected gave approximately the required pull of the implement attached at the rear. The process was repeated four times and the results recorded.

The influence of speed and tyre inflation pressure on tractor measured drawbar pull and soil resistance to cone penetrometer pressure was determined by selecting a 40kW tractor. At each tractor speeds (i.e. 4km/hr, 8km/hr and 11km/hr) and tyre inflation pressures (i.e. 83kPa, 93kPa and 110kPa), the tractor was operated with and without an implement load attached and drawbar pull as well as soil resistance to cone penetrometer pressure were measured before and after treatment. The results were then recorded.

Results and Discussion

Table 1 - 6 showed the variation in soil resistance to cone penetrometer pressures with depth using different speed, power and tyre inflation pressure with different implement load attached. Table 1 and 2 showed that at high tractor speed, the implements load attached were operating at shallow soil depths. This might probably be traced to higher soil resistance to cone penetrometer pressure at higher tractor speed as compared to lower tractor speed. This was particularly true within the first 15cm soil depth. This shows that the compactibility of the soil was insignificant and does not affect the productivity of the soil.

Table 3 and 4 revealed that as the rear tyre inflation pressure increased, the contact area of tyre with soil decreased, hence resulting in higher cone penetrometer pressure. This was particularly true at shallow soil depth with no implement load attached to the tractor. It was shown that for a given range of soil depth, the resistance to cone penetrometer pressure was higher for higher tractor power than lower tractor power. This increases the soil compactibility as well affect the absorption of water by the soil and inhibit soil aeration. Table 5 and 6 reveal that the higher values of cone penetrometer pressure could be due to the higher static or dynamic load associated with higher tractor power. Large tractors developed more pull than smaller tractors as shown on Table 7. This increase in drawbar pull could be attributed to an increase in static load and area of contact of rear tyre with the soil as the tractor power increased. On the other hand as the tractor speed increases, the drawbar pull was observed to increase as shown on Table 8. This increase in drawbar pull could be due to the fact that at higher tractor speed, the implements were operating at shallow soil depth often less than 5cm.

Table 9 showed a decrease in drawbar pull as rear tyre inflation increases. This reduction in drawbar pull could be as a result of an increase in slippage as rear tyre inflation pressure increased. This could have been the cause of the reduction in drawbar pull. The findings of this study has a relationship with Shebi (1984), who reported that the performance of three agricultural tractors indicated a decrease in drawbar pull as the tractor inflation pressure was increased. This implies that there is a reduction of soil compactibility and hence enhances the productivity of the soil.

Conclusion and Recommendation

It was concluded that increasing the power of tractor from 19 47kW, the drawbar pull increased from 0-72 to 1.42kN. On the other hand the soil resistance to cone penetrometer pressure was increased by about 163kPa especially with no implement load attached as this affect soil compactibility and productivity. However, with implement load attached the result was different. Lower values of soil resistance to cone penetrometer was observed at soil depth of 5 10cm as compare to higher values observed at deeper soil depths of more than ten (10) cm.

With increase in tractor speed from 4 11km/hr, the measured drawbar was found to increase from 7.77 to 7.92kN while soil resistance to cone penetrometer pressure recorded a remarkable difference in readings hence no effect on the productivity of the soil.

As the rear tyre inflation pressure was increased from 83kPa to 110kPa, the measured drawbar pull decrease from 9.7 to 7.7kN while soil resistance to cone penetrometer pressure was not affected by an increase in tractor tyre inflation pressure.

It was recommended that different soil types and grassy surface as well as new tractors and implements be use to validate the findings of this research.

Table 1: Effects of Tractor Speed and Type of Implement attached on soil resistance to cone penetrometer pressure

Type of Implement Load Attached	Soil Depth (cm)	Average Cone Penetrometer Pressure kPa		
		4km/hr	8km/hr	11km/hr
	5	560	350	900
	10	725	606	1120
No Implement	15	AR	790	AR
	20	AR	AR	AR
	25	AR	AR	AR
	5	0	97	78
	10	17	208	317
	15	232	642	562
Off-set Disc Harrow	20	431	792	569
	25	649	724	632
	5	4	39	29
	10	34	69	100
	15	10300	174	606
	20	378	606	947
Bottom Mould board Ridger	25	558	AR	AR
	5	0	35	69
	10	23	52	327
	15	300	635	AR
	20	718	726	RA
2m-Wide Tiller	25	AR	334	R

Table 2: Effect of Tractor speed and type of implement load attached on Soil resistance to Cone Penetrometer pressure at 5 percent soil depth

Source of Variation	Sum of Square	DF	Mean Square	F- Value	Significance
Mean effects	308.611	4	77.153	1.559	NS
A	227.556	2	113.778	2.299	NS
B	81.056	2	40.528	0.819	NS
AB	73.444	4	18.361	0.371	NS
Explained	382.056	8	47.757	0.965	
Residual	1336.250	27	49.491		
Total	1718.318	35	49.094		

Table 3: Effect of Tyre Inflation Pressure and Implement load attached on Soil resistance to cone penetrometer pressure

Type of Implement Load Attached	Soil Depth (cm)	Average Cone Penetrometer Pressure (kPa)		
		83kPa	97kPa	110kPa
No Implement	5	252	287	272
	10	906	516	367
	15	AR	AR	AR
	20	AR	AR	AR
	25	AR	AR	AR
Off-set Disc Harrow	5	0	14	0
	10	83	25	115
	15	880	172	AR
	20	AR	723	AR
	25	AR	627	AR
Bottom Mould boar Ridger	5	0	0	0
	10	69	126	0
	15	321	264	115
	20	872	847	255
	25	AR	AR	356
2m Wide Tiller	5	0	23	0
	10	69	388	184
	15	805	AR	663
	20	AR	AR	1102
	25	AR	AR	AR

Table 4: Effects of tyre inflation pressure and type implement load attached on Soil resistance to Cone Penetrator pressure at 5cm Soil depth

Source of Variation	Sum of Square	DF	Mean Square	F- Value	Significance
Mean effects	111186 9.833	5	222373.967	40.613	*
A	8478.712	2	42390.361	7.742	*
B	1027089.111	3	342353.037	62.528	*
AB	301620.339	6	50270.065	9.181	*
Explained	1413490.22	11	128499.111	23.468	
Residual	131409.330	24	5475.309		
Total	1544899.556	35	44139.989		

* = Significance at 5 percent confidence level
A = Tractor tyre inflation pressure
B = Type of implement load attached

Table 5: Effect of tractor power and type of implement load attached on soil resistance to cone penetrometer pressure

Type of Implement Load Attached	Soil Depth (cm)	Average Cone	Penetrometer	Pressure kPa
		19kW	40kW	47kW
No Implement	5	781	578	408
	10	AR	AR	499
	15	AR	AR	752
	20	AR	AR	972
	25	AR	AR	1293
	5	18	77	272
Offset Disc Harrow	10	109	207	422
	15	216	525	487
	20	AR	499	732
	25	AR	677	AR
-Bottom Mould board Ridger	5	43	17	663
	10	121	34	AR
	15	516	305	AR
	20	AR	878	AR
	25	AR	AR	AR
	5	166	34	556
	10	523	236	AR
2mWide Tiller	15	AR	508	AR
	20	AR	792	AR
	25	AR	AR	AR

Source: Field survey, 2012

Table 6: Effects of tractor power and type of implement load attached on Soil resistance to Cone Penetrator pressure

Source of Variation	Sum of Square	DF	Mean Square	F- Value	Significance
Mean effects	12116.29	5	2423.258	3.223	*
A	8838.875	2	4419.437	5.378	*
B	3277.417	3	1092.472	1.453	NS
AB	9828.958	6	1638.160	2.179	NS
Explained	21945.250	11	1995.023	2.653	
Residual	27068.00	36	751.889		
Total	49013.23	47	1042.835		

* = Significance at 5 percent confidence level
NS = Not Significant at 5 percent confidence level
A = Tractor power
B = Type of implement load attached

Table 7: Effect of tractor power on measured drawbar pull

Type of Implement Load Attached	Averaged	Measured Drawbar	Pull (kN)
	19kW	40kW	47kW
Off-set Disc Harrow	9.73	10.32	10.4
3-Bottom Mouldboard Ridger	6.69	7.35	7.40
2m-Wide Tiller	4.8	5.4	5.4

Source: Field survey, 2012

Table 8: Effect of Tractor speed on Measure Drawbar Pull

Type of Implement Load Attached	Averaged	Measured D rawbar	Pull (kN)
	4km/hr	8km/hr	11km/hr
Off-set Disc Harrow	10.22	10.23	10.22
3-Bottom Mouldboard Ridger	7.06	7.36	7.46
2m-Wide Tiller	5.02	5.26	5.09

Source: Field survey, 2012

Table 9: Effect of tyre inflation pressure and Measured Drawbar Pull

Type of Implement Load Attached	Averaged Measured	Drawbar Pull (kN)	
	83kPa	97kPa	110kPa
Off-set Disc Harrow	17.06 2	10.52	10.34
3-Bottom Mould board Ridger	8.06	7.98	7.61
2m-Wide Tiller	5.52	5.25	5.17

Source: Field survey, 2012

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