Nigerian Journal of Engineering
Faculty of Engineering
Ahmadu Bello University
Samaru - Zaria, Nigeria

Vol. 26, No. 3, December 2019
ISSN: 0794 - 4756

EFFECTS OF SOIL COMPACTION AND FERTILIZERS ON PERFORMANCE OF MAIZE (*Zeamays*) PLANTED IN A SANDY LOAM SOIL IN YOLA, ADAMAWA STATE, NIGERIA

T. S. K. Tya*[1] and A. W. Gundiri[1]

[1]Department of Agricultural and Environmental Engineering,
Modibbo Adama University of Technology, Yola, Nigeria
***Corresponding Author's Email: tsktya@gmail.com**

ABSTRACT
An appropriate levels of soil compaction and fertilizers is necessary to create an optimum seed bed condition for optimum crop growth and yield. Experiment was carried out to investigate the performance of maize (Zeamays) in terms of stem diameter, crop height and yield when planted in sandy loam soil incorporated with organic manure (cow dung) and inorganic fertilizer N.P.K. at different levels of soil compaction. A sandy loam soil was subjected to compaction of different tractor traffic of 0,5,10, and 15 passes of MF 180 tractor with tyre inflation pressure of 31 kpa before crop sowing in a complete randomized block design experiment. The crop was sown to depths of 5 cm at 30 cm between raw and 40 cm within row. The fertilizers were applied to the plots at the rate of 120 kg/ha. Plant heights and stem diameter of the crop were measured at an interval of two weeks after planting till the time of harvest. Results indicate that the crop stem diameter and height vary throughout the growing period of the crop for the various levels of soil compaction and the fertilizers incorporated in the soils. Highest mean crop stem diameters, heights and yields of 15.45 and 18.74 mm, 103.50 and 134.86 cm, 2.90 and 4.02 t/ha were obtained for zero tractor pass (control) in the study area, respectively. Generally, for this study, maize performance decreases with increase in soil compaction. There was a high significant difference between the crop stem diameters, heights and yields even for the same treatment in the study area. N.P.K. fertilizer performed better than cow dung in improving the yield of maize planted in sandy loam soil for the various levels of soil compaction.
Keywords: *Maize, compaction, stem, height, yield, cow dung, NPK fertilizer.*

INTRODUCTION

In Nigeria, most soils used for growing crops are light soils ranging from sandy loam to sandy clay. The inadequate availability of nutrients in these soils for crops use to enhance growth and yields has made farmers keep demanding for inputs especially Nitrogen, Phosphorous and Potassium (NPK) fertilizer to improve soil fertility. Unfortunately, the price of this NPK fertilizer is in many cases beyond the reach of peasant farmers who are the majority in providing food for the nation. The use of organic materials as alternatives in providing adequate nutrients to the soil is gaining ground among researchers and farmers.

Maize which is botanically called (*Zeamays* L) belongs to the family Grammineae. It is a cereal monoecious shrub. Most maize species grow well where the annual rainfall ranges from 400 cm - 900 cm and temperature of 20^{o}C to a height of 4.5 m. The range of time from planting to maturity varies between 3 to 4 months, depending on the variety use. Maize thrives best on well aerated, viable working soil rich in humus. Maize grow successfully in northern part of Nigeria, the grain contains higher percentage of carbohydrate with little protein and fat of all cereal, maize has the largest amount of oil, the average chemical composition is starch 68-70%, protein 10% and 3.6-5% (Solomon *et al*., 2012).

Maize is the third most important cereal after wheat and rice (Jones, 1997). In Nigeria, maize is an important food, fodder and industrial crop, grown both commercially and at subsistence level. Maize is used for the production of indigenous and commercial food products that are relished for their unique and distinctive flavours. It is eaten fresh, or milled into flour and serves as a valuable ingredient for baby food, cookies, ice cream, pan cake mix, biscuits and livestock feed and a variety of traditional beverages (Eleweanya, 2005).

Efforts aimed at obtaining a high yield of maize would necessitate the segmentation of the nutrients status of the soil to meet the crop requirement for optimum productivity and maintain soil nutrients content either with the use of inorganic fertilizers such as NPK or through the use of organic materials such as cow dung. Maize generally requires heavy fertilizer dosage, a considerable amount of nutrient especially in relation to nitrogen and potassium. In temperate zones, maize cultivation without organic or inorganic fertilizer would hardly be thinkable (Walter, 1973). The choice of the suitable form of fertilizer for the proper growth of the plant is governed by local natural conditions and variations in soil and climate with regard to their suitability for maize cultivation (Thompson, 1975).

Soil compaction occurs when soil particles are pressed together, reducing pore space between them. Heavily compacted soils contain few larger pores and have a reduced rate of both water infiltration and drainage from the compacted layer. This occurs because large pores are the most effective in moving water through the soil when it is saturated. However, the exchange of gases slows down in compacted soils, causing an increase in the likely hood of aeration-related problems (Shutter and Wood, 1992). In addition, Krmenec (2000), stated that soil compaction reduces the soil structure and pore spaces resulting in less air and moisture in the soil which negatively influences all

phases of crop production including seed germination, root growth, nutrients and water uptake.

However, Sidhu (2006) stated that even though the effects of soil compaction are detrimental to crop growth, in some cases it was observed that slight compaction can aid germination and plant growth when soil moisture is low, such as during periods of low rainfall or in soils with low water-holding capacity. Thus, the objective of this study is to investigate the performance of maize crop in terms of stem diameter, crop height and yield when planted in sandy loam soil incorporated with organic manure (cow dung) and inorganic fertilizer N.P.K. after different load applications of soil compaction.

MATERIALS AND METHODS

Experimental Site

Gundiri Farm is located 5 km South of Yola Town, Yola South Local Government Area, Adamawa State, Nigeria. It is situated between 12º21' to 22º18' E and 9º16' to 19º19' N. The area is between 150 and 180 m above sea level within the savannah ecological zone of Nigeria. The farm area has two major seasons; the rainy and the dry season. The rainy season lasts from the beginning of May to the end of October, while the dry season lasts mainly from November to the end of April. The driest months are January and February when the average minimum relative humidity is 13%. This is mainly due to the prevalent dry and desiccating north-east trade winds. This season is favourable for the cultivation of many crops under irrigation as there is no rainfall during the period. The wettest months are August and September when the depth of rainfall reaches up to 25% of total annual rainfall. The relative humidity of air rises in these months to about 81% from July to September. Temperatures in the area vary; the hottest month is April with a monthly average maximum temperature of 39.7ºC, while the coldest months are December and January with minimum average temperatures of 16ºC (Team Planning International, 1992).

Plot Layout and Preparation

A plot area of size 48 m x 72 m (3456 m^2) was harrowed and levelled. The plots were then divided into four 3m x 3m plots. Fertilizers (Cow dung and NPK) were applied to the plots in a complete randomized block design experiment. The plots were then subjected to 0,5,10 and 15 passes of MF 180 tractor with tyre inflation pressure of 31 kpa before sowing in a complete randomized block design experiment. This was replicated four times making a total of sixteen plots used for the experiment. The zero tractor pass served as a control since there was no soil compaction. Each tractor pass was a to and fro movement of the tractor along the same path. The crop (maize) was sown to depths of 5cm at 30 cm between raw and 40 cm within row. The organic and in-organic materials were applied to the plots at the rate of 120 kg/ha which is the basal application of fertilizer for maize cropsin line with Schrmpt (1965). The growth parameters were monitored starting from two weeks after sowing. This continued at interval of two weeks till the end of the experiment. The yield of the maize was also taken by measuring the mass of the maize produce on each plot using weighing scale.

RESULTS AND DISCUSSION

Stem Diameter of the Crop

The results on stem diameter of the maize crop throughout the entire growing period for the respective number of tractor pass and the organic and inorganic materials incorporated is presented on Table 1.

It was observed that stem diameter decreases with an increase in the number of tractor pass. It was also observed that stem diameter varied even for the same treatment and the respective organic and inorganic fertilizer incorporated. This may be attributed that the fact that the soil under this condition is most compacted and therefore was difficult for the maize seedlings to get enough nutrients for their growth. This caused the seedlings to have stunted growth which leads to decrease in stem diameter. This is in contradiction to the findings of Ohu and Folorunso (1989) who reported that some amount of compaction is necessary for good crop growth in sandy loam soil.

Highest mean stem diameter of 15.45 and 18.74 mm for soil incorporated with organic manure and N.P.K fertilizer was recorded for no tractor pass when there was no soil compaction (control). This was followed by the mean stem diameters of 5 and 10 number tractor passes, while the lowest mean stem diameter of 9.85 and 14.34 mm were obtained for 15 number tractor pass and the soil incorporated with organic manure (cowdung) and NPK fertilizer, respectively. The result indicates that the more the number of tractor pass, the more the soil compaction which leads to decrease in nutrient up-take by the crop and resulted in the decrease in crop stem diameter which is in line with Jodi (2007) and Solomon *et al*. (2012). It was observed that Maize stem was thicker when the soil was incorporated with inorganic fertilizer (NPK) compared to those soils incorporated with cow dung for the same soil compaction throughout the season. Statistically using analysis of variance (Table 2) for crop stem diameter, it was observed that the difference between the mean stem diameters of the crop for the various soil compaction and the fertilizers incorporated to the soil for the study area was highly significant at 5% probability level.

Maize Crop Height

Results of the maize crop heights for the season after various tractor pass and fertilizer incorporation in the soil is presented on Table 3. It was observed that crop heights vary throughout the growing period of the crops. At two (2) weeks after planting (WAP), crop heights were higher for no tractor pass (control) with values of 26.00 and 39.25 cm, when the soil was incorporated with organic manure and NPK fertilizer, respectively. These values decreases with increase in the number of tractor pass where lowest crop heights values of 20.50 and 30.50 cm , respectively was recorded for organic manure and fertilizer NPK incorporated in the soil and had 15 number tractor pass. This trend was observed throughout the growing period of the crop for the number of tractor passes and fertilizers incorporated in the soil. Highest mean crop heights of 103.50 and 134.86 cm was recorded for soil incorporated with organic and inorganic fertilizer and had no tractor pass (control), this was followed by the mean crop heights of 5 and 10 number tractor passes incorporated with fertilizers, while the lowest

mean crop heights of 79.44 and 120.54 cm for soil incorporated with organic and inorganic fertilizer and had 15 number tractor pass. The result revealed that crop height was affected by soil compaction throughout the growing period of the crop and the incorporation of the fertilizers to the soil showed that NPK fertilizer performed better than the organic manure (cow dung) for the various soil compaction which is in line with Solomon, *et al*. (2012) and Tanimu, *et al*. (2013). Statistically, using analysis of variance as presented on Table4, the results indicates that there is an existence of highly significant difference among the crop height with respect to fertilizers incorporated in the soil and the various levels of the soil compaction at 5% level of significance.

Crop Yield

Results for the maize crop yields obtained for 0, 5, 10 1nd 15 number of tractor pass and the soil being treated with organic and inorganic fertilizer is presented on Table 5. The result indicates that crop yield varies among the various levels of soil compaction and the fertilizer applied. Highest crop yield of 4.02 and 2.90 t/ha was recorded for soil treated with NPK fertilizer and organic manure, respectively and had no tractor pass (control) while the lowest crop yield of 3.10 and 1.90 t/ha, respectively was obtained for soil treated with NPK fertilizer and organic manure with 15 number of tractor pass. The overall mean crop yield of 3.43 and 2.28 t/ha, was obtained when the soil was treated with NPK fertilizer and organic manure for all the levels of soil compaction in the study area which is in line with Tanimu, *et al*. (2013). This implies that soil compaction reduces crop yield as a result of restriction in nutrient up take by the crop due to a reduction in soil structure and pore spaces which eventually leads to less air and moisture in the soil.

The result revealed that there was a significant difference between the crop yield obtained for no soil compaction (control) and the various levels of soil compaction. Also, there was a significant difference between the crop yields for soils treated with NPK fertilizer compared with the organic manure for the same soil compaction. These differences may be due to the fact that N.P.K fertilizer as a source of plant nutrient can be added to the soil to supplement easily while the nutrients present in cow dung can be released only when it decomposes, these takes a longer period of time.

Table 1: Stem diameter of maize crop (mm)

	Weeks after planting (WAP)															
	2		4		6		8		10		12		14		MEAN	
Tractor pass	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK
0	0.53	1.22	11.80	16.95	11.90	18.17	16.47	21.12	17.95	22.12	23.26	25.92	26.25	25.68	15.45	18.74
5	0.52	0.88	9.81	15.25	11.18	18.17	14.20	19.96	15.85	20.83	16.21	22.46	21.93	23.45	12.00	17.17
10	0.51	0.72	11.70	15.25	9.72	16.88	13.30	15.60	15.45	19.50	16.12	19.46	17.23	20.63	12.00	15.43
15	0.47	0.55	8.00	14.68	8.80	16.73	10.60	12.96	12.70	18.85	12.95	17.87	15.41	18.72	9.85	14.34

Note: OM – Organic manure, NPK – Nitrogen Phosphorus and Potassium (Inorganic fertilizer)

Table 2: ANOVA for mean stem diameter of crop for 0,5,10 and 15 levels of soil compaction incorporated with fertilizers

Source of variance	Degree of freedom	SS	MS	$F_{calculated}$	F_{Table}
Replication	3	2.41	0.81	1.29^{ns}	3.86
Treatments (Levels of Soil compaction)	3	103.81	34.60	54.92**	3.86
Error	9	5.68	0.63		
Total	15				

Note: ns – no significant difference ** - Highly significant difference

Table 3: Maize crop height (cm)

	WEEKS after planting (WAP)															
	2		4		6		8		10		12		14		MEAN	
Tractor pass	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK	OM	NPK
0	26.00	39.25	47.25	70.25	68.50	112.50	96.25	129.75	141.00	183.50	167.50	210.50	178.00	198.25	103.50	134.86
5	25.50	38.75	42.00	67.25	59.00	104.25	84.00	128.50	122.50	161.75	163.30	206.00	168.50	202.50	94.97	129.86
10	23.25	36.50	36.75	67.25	49.50	100.75	72.00	123.30	113.00	155.75	162.25	190.00	156.50	195.85	87.61	124.13
15	20.50	30.50	35.60	60.25	47.30	100.00	66.50	120.25	95.75	161.00	140.15	178.75	150.30	193.00	79.44	120.54

Note: OM – Organic manure, NPK – Nitrogen Phosphorus and Potassium (Inorganic fertilizer)

Table 4: ANOVA for mean height of crop for 0,5,10 and 15 levels of soil compaction incorporated with fertilizers

Source of Variance	Degree of Freedom	SS	MS	$F_{calculated}$	F_{Table}
Replication	3	36.80	12.27	3.06^{*}	3.86
Treatments (Levels of Soil compaction)	3	1359.07	453.02	112.97**	3.86
Error	9	36.10	4.01		
Total	15				

Note: * Significant difference ** highly significant difference

Table 5: Mean maize crop yield (tons/ha)

No. of tractor pass	ORGANIC fertilizer	NPK fertilizer
0	2.90	4.02
5	2.40	3.51
10	1.93	3.10
15	1.90	3.10
Mean	2.28	3.43

CONCLUSIONS

The effect of different levels of soil compaction (0, 5, 10 and 15 number of tractor pass), incorporated with organic and inorganic fertilizer on some features (stem diameter, height and yield) of maize crop was observed. There was a significant difference in the rate of crop growth and development as a result of using different soil compaction incorporated with dissimilar forms of fertilizer. Stem diameter, crop height and yield was observed to be higher in the no tractor pass incorporated with different fertilizer compared with the various level of soil compaction incorporated with organic and inorganic fertilizer treatments. Maize crop performance decreased with increase in a number of tractor pass. In addition, soils incorporated with N.P.K fertilizer resulted in higher crop yield compared with soils incorporated with organic manure (cow dung) even for the same treatment. Mean crop yield value of 3.34 and 2.28 t/ha was obtained for the study area using different soil compaction levels incorporated with N.P.K fertilizer and Cow dung manure, respectively. Thus, minimum level of soil compaction incorporated with fertilizer (N.P.K.) can be recommended to obtain optimum crop (Maize) performance in sandy loam soil in the study area.

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