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Air Permeability Influence On Sorghum Yield in A Semi-Arid Region of Nigeria

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Abstract
Field experiments were conducted for three years (2005 to 2007) to investigate the effect of air permeability on yield of sorghum (Sorghum bicolor L. Moench) on a sandy loam soil. The experiment was conducted at the University of Maiduguri Agricultural Engineering teaching and research farm (11° 54" N 13°E). The soil of the study area is sandy loam with 6% silt, 17% clay and 77% sand. The treatments consisted of 0, 5, 10, 15 and 20 tractor passes, and four tillage methods of zero tillage (ZT), ploughing (P), harrowing (H) and ploughing plus harrowing (PH). The treatments were laid out in a randomized complete block design with three replicates. The soil and plant parameters measured air permeability, plant height and grain yield. Results over the three years of study showed that the results obtained for the values for soil air permeability decreased with increase in compaction levels for all tillage methods. For all compaction levels PH gave the highest value of plant height and consequently the highest value of grain yield.

Keywords: Air permeability, soil compaction, tillage methods, sorghum grain yield.

1.0 Introduction

Air permeability refers to the ability of a soil to allow air to pass through its horizon (Iverson *et al*., 2001) Soil air is recognized as a source of energy for soil microbial activities and crop root development (Abid and Lal 2009). Air conductivity is influenced primarily by the volume of air filled voids in the soil. At constant moisture content, air conductivity decreases if density is increased; while at a constant density, air conductivity decreases sharply as the moisture content increases. When the total void space is nearly filled with water (saturation of 90 percent or more), the air flow is nearly zero. Michael, 1999). Masayoshi and Kimitoshi (1998) evaluated the effects of three tillage methods on soil air permeability. The tillage methods were rotary tilling (RT), mould board ploughing (MP) and sub-soiling (SS). They reported that MP method produced the best air permeability, followed by RT and then SS. Mamman and Ohu (1997) studied the effect of air permeability on the yield of groundnut in a sandy loam soil and reported that air permeability has influence on the yield.

Sharma *et al*. (1988) compared no till and conventional tillage systems on air permeability and reported that conventional tillage operations increased aeration by 120% in a sandy loam soil. Ayub *et al*. (2006) conducted a field experiment at Faisalabad, Pakistan on the effects of deep tillage, conventional tillage and zero tillage on soil aeration. They reported that deep tillage method increased aeration more than conventional and zero tillage systems. Wairiu and Lal (2006) investigated the effect of tillage methods on soil micro porosity and pore size distribution. The tillage methods were mould board plowing, chisel plowing, and no- till with continuous corn. Tillage treatments had significant effect on the volume of both storage and residual pores. Generally, the literature on the effects of tillage on soil air permeability is scarce. In the north- eastern part of Nigeria, that has semi – arid climate, one of the staple foods produced is sorghum (*Sorghum bicolor*). Sorghum is the fourth most important tropical cereal crop and the second most important food crop after maize in the region (Dogget, 1970). The objective of this study was to evaluate the effects of air permeability on sorghum grain yield in the semi-arid region of Nigeria.

2.0 Materials and Methods

The experiment was conducted at The University of Maiduguri Agricultural Engineering Teaching and Research Farm, Maiduguri (Latitude 11^0 54' N, Longitude 13^0 E, altitude 354 m above mean sea level). The soil of the research farm had earlier been classified as Typic Upstisanment (Rayar, 1984) with aeolian sand formation and weakly aggregated. The soil has a sandy loam texture and made up of 6% silt, 17% clay and 77% sand (Ohu *et al*. 1989).

The experiment was laid as a factorial design involving tractor traffic and tillage methods. The experiment comprised five levels of tractor traffics (0, 5, 10, 15 and 20 passes) and four levels of tillage methods (zero tillage, ploughing, harrowing and ploughing plus harrowing denoted as 0, P, H and PH) giving a total of twenty treatments and the values of air permeability determined. The experiment was laid as a randomized complete block design (RCBD), replicated three times giving a total of sixty plots. The tractor passes were imposed using a Fiat 780D tractor with tyre contact pressure of 31.0 KPa; while the tillage treatments were applied using a 3- bottom disc plough and a 2-gang tandem harrow, mounted on a FIAT 780D tractor. The plot size was 10m x 10m, with 5m spacing between adjacent plots. Air permeability was determined using a modified air permeameter following the principle of the air permeameter of Grover (1955). Six seeds of sorghum (*bicolor* L.*moench*) variety KSV8 were planted per hole at 2.5 cm depth at a spacing of 60 cm by70 cm. The seedlings were thinned to 2 per stand at 2 weeks after emergence. Fertilizer was applied at the rate of 100-30- 30 kg ha^{-1} as NPK urea, SSP and Muriate of potash at planting. All the plots were hand- weeded every week throughout the growth period. Plant heights were measured with a measuring tape on weekly basis throughout the experimental period till the time of harvesting. Measurements were done from the base to the tip of the uppermost whorl using three selected plants on each plot on weekly basis for 12 weeks. Harvesting was done at maturity, 17 WAP. The harvesting was done by cutting the plants at the base, the heads severed from the stalk, sun dried, threshed and the grain yield determined by weighing the threshed and winnowed grains from each plot. The grain yield per plot was converted to kg/ha. All the data collected were subjected to analysis of variance (ANOVA) using the statistical software, Statistix Version 8.0 to compare the significance of the differences between the treatment means. Mean separation was done using Duncan's Multiple Range Test (DMRT). Regression analysis was also carried out.

3.0 Results and Discussion

3.1 Effects of Tractor Traffic Passes and Tillage Methods on Air Permeability

The relationship of air permeability and tractor passes at different tillage methods for the three years are shown in Table 1. Results showed that the effect of tillage methods differed significantly for treatments (P<0.01). In general, tillage significantly improved air permeability above the no till (zero tillage) treatment; however, harrowing resulted in significantly lower effects than the other tillage methods in general, soil air permeability significantly increased with tillage intensity. The order was multiple tillage (ploughing plus harrowing) > ploughing > harrowing > zero tillage. It was also observed that ploughing plus harrowing increased the values of air permeability more than all the other tillage methods and tractor passes. Ploughing only as tillage method increased the values of air permeability than harrowing.

These results generally showed that soil compaction from tractor passes decreased soil air permeability, while tillage resulted in increased air permeability. This finding is in line with that of Mamman and Ohu (1997) and Ohu *et al*, (2006).Similar reports have also been reported by researchers (Masoyoshi and Kimitoshi ,1998; Iverson *et al* 2001;Wairiu and Lal,2006;).

Table 1: Mean values of Air permeability at the Tillage methods and Tractor Traffic Passes (μm^2) of sandy loam soil (2005 – 2007)

	Tractor Traffic Passes					
Tillage method	**0**	**5**	**10**	**15**	**20**	**Tillage mean**
Zero tillage	38.221^{b}	28.304^{gh}	25.604^{i}	21.629^{j}	19.741^{j}	26.700^{y}
Harrowing	41.941^{a}	33.495^{cd}	30.333^{efg}	28.902^{gh}	27.446^{hi}	32.423^{x}
Ploughing	42.881^{a}	35.091^{c}	32.159^{def}	29.992^{fg}	28.62^{gh}	33.750^{w}
Ploughing + Harrowing	43.660^{a}	35.103^{c}	32.300^{de}	30.393^{efg}	29.204^{gh}	34.132^{w}
Traffic mean	41.676^{v}	32.998^{w}	30.099^{x}	27.729^{y}	26.255^{z}	

Means followed by similar superscript letter(s) a-p for treatment combinations, v-z for traffic and w-z for tillage are not significantly different at 1% probability level of the Duncan's Multiple Range Test

3.2 Effects of Air permeability on Growth and Yield of Sorghum.

The effect of air permeability on growth and yield of sorghum are shown in Tables 3 and 4. The air permeability value at multiple tillage treatment (Ploughing plus Harrowing) in combination with 10 traffics gave the best plant growth. In general, though, plant height increased with increase in air permeability on the value at zero pass up to ten passes and decreased with any further increase in number of tractor passes regardless of the tillage method. This finding agrees with that of Ohu and Folorunso (1989), Mamman and Ohu (1997). Sharma *et al.* (1988), Rashidi *et al.* (2008) and Yau *et al.* (2010) reported tillage methods had significant effects on plant heights.

It was observed air permeability at ploughing plus harrowing treatment produced the highest yield of 1275.3kg/ha followed by ploughing with 1248.2kg/ha followed by harrowing with 1227.8kg/ha and the least yield produced was produced at zero tillage with 1159.2kg/ha. Mamman and Ohu (1997) and Ohu *et al*. (2006) which agreed with this study.

Table 2: Effects of Air Permeability on plant height (cm) of sorghum grown on sandy loam soil (2005 – 2007)

Zero tillage	118.86^{gh}	177.17^{b-f}	147.42^{efg}	139.79^{fg}	86.54^{h}	133.96^{z}
Ploughing	201.13^{bcd}	203.70^{bcd}	221.21^{ab}	190.99^{b-e}	188.58^{b-e}	201.12^{x}
Harrowing	173.81^{c-f}	178.24^{b-f}	180.75^{b-f}	158.58^{d-g}	158.52^{d-g}	169.98^{y}
Ploughing + Harrowing	185.43^{b-e}	213.45^{bc}	262.43^{a}	195.77^{bcd}	172.63^{c-f}	205.94^{x}
Traffic mean	169.81^{z}	193.14^{xy}	202.95^{x}	171.28^{yz}	151.57^{z}	

Means followed by similar superscript letter(s) a-e for treatment combinations, x-z for traffic and tillage are not significantly different at 1% probability level of the Duncan's Multiple Range Test.

Table3: Effects of Air Permeability on grain yield (kg/ha) of sorghum grown on Sandy loam soil (2005 – 2007)

Tillage method	0	10	15	20	Tillage mean
Zero tillage	1074.9^{de}	1173.0^{a-d}	1112.8^{cd}	987.9^{e}	1097.2^{y}
Ploughing	1180.1^{a-d}	1230.6^{ab}	1173.0^{a-d}	1159.5^{a-d}	1189.4^{x}
Harrowing	1144.7^{bcd}	1191.4^{abc}	1165.9^{a-d}	1151.5^{bcd}	1163.9^{x}
Ploughing + Harrowing	1201.8^{abc}	1260.5^{a}	1174.9^{a-d}	1161.2^{a-d}	1203.5^{x}
Traffic mean	1150.4^{yz}	1213.9^{x}	1156.6^{yz}	1115.1^{z}	

Means followed by similar superscript letter(s) a-e for treatment combinations, x-z for traffic and tillage are not significantly different at 1% probability level of the Duncan's Multiple Range Test.

4.0 Conclusion.

The results show that air permeability decreased with increase in tractor passes but this was ameliorated with tillage intensity. Higher soil compaction was found to reduce moisture infiltration to lower depth, thus all the imposed compaction treatments resulted in higher moisture content than in the un-compacted soil, except the 20 tractor traffics. Generally, the optimum sorghum growth and yield was obtained at values of air permeability whereby PH combined with 10T tractor passes.

References

Abid, M. and Lal, R. (2009). Tillage and drainage impact on soil quality. Soil and Tillage Research 101(2): 364-372.

Ayub, M., Tanveer. A, Nadeen, M.A and Tayyub, M (2006). Fodder yield quality of sorghum as Influenced by different Tillage Methods and seed rates. *Pakistan Journal of Agronomy*. 2(3):179-184.

Dogget,H. (1970). Sorghum. Longman. London. FAO production Year Book.

Grover, B.L. 1955.Simplified air permeameter for soils in place. Soil Science Society of America. Proceedings. 19(4):414-418.

Iverson, B.V., Schjonning, P. Poulson, T.G. and Moldrup, P. (2001). Insitu and laboratory measurements of soil air permeability: Boundary conditions and measurement scale. *J. Soil. Sci*. 166(2):97-106.

Mamman, E. and Ohu, J.O. (1997). Millet yield as affected by tractor traffic in a sandy loam soil in Borno State, Nigeria. Soil Tillage Research. 42:133-140

Masayoshi, K. and Kimitoshi, S. (1998). Evaluating the characteristics of tilled soil by using air Permeability measurements. Japanese Farm Work Research. 33 (4): 187-195.

Ohu,J .O. and Folorunso ,O.A., (1989). The effects of machinery traffic on the physical properties of a sandy loam Soil and on the yield of sorghum in north–eastern Nigeria. Soil and Tillage Research 13: 399- 405.

Ohu, J.O.; Mamman, E. and U.B. Muni. (2006). Influence of vehicular traffic on air permeability and groundnut production in a semi-arid sandy loam soil . *International Journal of Agro physics*, 20:309-315.

Rayar, A.J. (1984). University of Maiduguri farm development planning report for Faculty of Agriculture. Annex A, Soil Survey Details.

Rashidi, M. Keshavarzpour, F. and Gholami, M. (2008). Effect of different tillage methods on yield and yield components of forage corn. American–Eurasian Journal of Agriculture and Environmental Sciences. 3(3);347-351.

Sharma, P.K; De Datta, S.K and Redulla, C.A. (1988). Response of maize (Zea Mays E) and mungbean (Virgnaradiata E) to tillage in relation to water table depth in tropical low land rice soils. Soil Tillage Res. 12:65-79.

Wairiu M. and Lal, R. (2006). Tillage and land use effects on soil micro porosity in Ohio,USA and Kolombangara Solomon Islands. Soil and Tillage Research. 88(1-2)80-84.

Yau, S.K., Sidahmed, L. and Haider, M. (2010). Conservation versus conventional tillage on performance of three different crops. *Agronomy Journal*. 102:269-276.