EUROPEAN ACADEMIC RESEARCH
Vol. V, Issue 7/ October 2017

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Effect of soil compaction on shoot and root development and nutrients uptake of sesame plant

ABELKARIM D. ELFADIL
Department of Agricultural Engineering
Faculty of Agricultural Science, University of Gezira
Wad Medani, Sudan
HUSSAIN A. SALIH
Department of Crop Production
Faculty of Agricultural Science, University of Gezira
Wad Medani, Sudan

Abstract:

This study was conducted to assess the effect of different soil compaction levels on the establishment and growth of sesame. Four compaction levels were used, namely, 1.2, 1.4, 1.6 and 1.8 g/cm^3 as well as the control (0.95 g/cm^3). The average plant growth parameters were found to be increased as the compaction level is increased. At the compaction level 0.95g/cm^3 the seed-soil contact is week so the plant did not absorb enough moisture and nutrients from the soil. This effect was reduced when the compaction level is increased to 1.20g/cm^3. The reduction of plant growth parameters under the compaction level 1.60 g/cm^3 and 1.80 g/cm^3 may be attributed to inability of roots to penetrate in the deep layers to absorb moisture and nutrients. The ratio between the shoot and root mass reached its maximum under the compaction level of 1.40g/cm^3. Increasing the compaction level decreased the nutrient uptake. The lowest values in the control and 1.2 g/cm^3 levels indicate that some compaction is needed to give a good seed-soil contact so as to be able to absorb moisture and nutrients. It can be concluded that soil compaction significantly affect plant growth, some soil compaction is needed for good seed-soil contact, but excessive compaction will impede root penetration.

Key words: sesame, compaction, plant height, root length, shoot:root ratio.

1. INTRODUCTION

Compaction reduces the soil's permeability to water, so that runoff and erosion may occur and adequate recharge of ground water is prevented. Compaction reduces aeration of the soil, so that metabolic activities of roots are hampered. Compaction increases the mechanical strength of the soil, so root growth is impeded. All of these effects may reduce the quality and quantity of food and fiber grown on the soil (Gill and Vanden Berg, 1968).

The extensive use of heavy machinery in farming activities brings about numerous benefits. But the use of farm machinery needs proper management otherwise unnecessary and excessive use create soil management problem and can adversely affect plant growth (Raghavan et. al., 1990). Compaction is caused by the use of heavy machinery, pressure from wheels, tillage equipment, trampling by animals, reduced use of organic matter, frequent use of chemical fertilizer and plowing at the same depth for many years (Shafiq et al, 1994). Soil compaction has been recognized as a major physical threat to soil fertility throughout the world (Soane and Ouwerkerk, 1994). Plant height is considered a genetic character which is modified by environmental factors like availability of moisture and nutrients at active growth stages. Significant differences for plant height observed in compacted treatments may be attributed to reduced ability of roots to penetrate in deep layers for extraction of moisture and nutrients, therefore, growth and development was retarded, which ultimately affected overall plant structure. Gaultney et al. (1980) reported that impeded plant height during all crop growth was due to compaction problem.

Plants roots are strongly affected by physical factors in soil. Soil mechanical impedance is caused mainly by natural processes and by the use of heavy machinery for soil cultivation. Soil compaction as well as changes in soil water potential is a major factor that causes high mechanical impedance or excessive soil strength (Lijima, 1991).Typical responses of plant root system structure to soil compaction include reduction of number and length of root, restriction of downward penetration of the main root axes, decrease in leaf thickness, increase in dry matter shoot –to- root ratio and decrease in crop yield (Fageria, et al, 2006). Root length is influenced by soil physical condition and moisture availability. Root growth was significantly affected by compaction level. Beulter and Centurion (2004) reported that root length and distribution of corn, wheat and pearl millet were adversely affected by soil compaction. Root growth in compacted soils is restricted because roots can develop a maximum pressure above which they are not able to expand in soils. In many cases, cracks and fissures will be available for roots to grow through, so a total lack of root growth is not likely. Instead, roots will concentrate in areas above or beside compacted zones in the soil. Aside from the effect of penetration resistance, roots also suffer from increased anaerobic conditions in compacted soils. A reduction of root growth will limit root functions such as crop anchoring and water and nutrient uptake. In addition, soil compaction has been found to reduce nodulation of leguminous crops such as soybean, which may limit nitrogen nutrition of these crops.

Roots, stems and leaves are functionally interdependent and these three systems maintain a dynamic balance in biomass which reflects relative abundance of above-ground resources (light and CO_2) compared with root-zone resources (water and nutrients) (Poorter et al. 2012). Whole-plant growth rate and summary measures such as root:shoot ratio are thus an outcome of developmental stage and of environmental influences.

Soil compaction affects nutrient uptake. Nitrogen is affected in a number of ways by compaction:

1. poorer internal drainage of the soil will cause more denitrification losses and less mineralization of organic nitrogen;
2. nitrate losses by leaching will decrease;
3. loss of organic nitrogen (in organic matter) and surface-applied nitrogen fertilizer may increase; and
4. diffusion of nitrate and ammonium to the plant roots will be slower in compacted soils that are wet, but faster in those that are dry.

The objective of this paper is to investigate the effect of soil compaction on some growth parameters and nutrient uptake of sesame plant.

2. MATERIALS AND METHODS

This experiment was conducted in the Plant Protection Nursery of the Agricultural Research Corporation and the Plant Pathology Center Nursery of the University of Gezira in the season 2015/2016.

Materials:

1. 80 cans of 13cm length and 10.8cm diameter.
2. a digital balance,
3. a ruler
4. an electric oven,
5. a scissor
6. a clipper,
7. micrometer for measuring the can dimensions
8. Newman apparatus for root length measurement.

Procedure:

To attain the required compaction levels, a soil compressibility curve was established following the procedures described by (Salih, 2014). Ten samples of soil of 300g weight were taken and mixed with 15, 30, 45, 60, 75, 90, 105, 120, 135 and 150cm^3 of water to obtain 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 percent moisture content. The soil was then compressed into 100 cm^3 steel cylinders by a uniform weight to obtain the maximum weight of soil that can be compressed in the cylinders and then divided by 100 to obtain the bulk density into g/cm^3.

The cans were divided into two groups, each group contains 40 cans. The 40 cans were divided into five levels of compactions with eight cans in each compaction level. The compaction levels were 0.95 (control), 1.2, 1.4, 1.6, and 1.8 g/cm^3. Four holes were made in each can and two seeds were sown in each hole to be thinned into one seed per hole (four plants in each can). The depth of sowing was one cm. The first irrigation was 200ml and the second irrigation after three days from sowing. The emergence occurred in the fourth day and the irrigation then continued every five days (100ml per irrigation). The first reading was made after 15 days from emergence. Ten cans from each group were taken and carefully opened using the scissor and the clipper without destructing the three layers.

The measured parameters were the plant height, shoot mass, root mass, root length and nutrient concentrations. The plants were separated into shoot and root systems. The length of the plant was measured. The shoot system was weighed and then oven dried to obtain the dry weight. The shoot system in each layer was separated, washed and put in the Newman apparatus to obtain the number of intersections and length. Then the wet and dry weighed of the root were obtained. This process was repeated four times. Plant nitrogen was determined using micro-kjelhal digestion method. The samples were dry-ashed at 500^{0}C for six hours for the determination of P and K.

3. RESULTS AND DISCUSSION

Soil compressibility:

The effect of moisture content on soil compaction data were shown in Table (1). And the soil compressibility curve was obtained and shown in Fig.(1). From the figure it can be shown that the maximum soil compaction level can be obtained at the moisture content of 30%. After that soil is difficult to be compressed. From the curve, the soil moisture content to give soil compaction levels of 1.2, 1.4, 1.6 and 1.8 g/cm^3 was determined.

Table (1): Effect of moisture content on soil compressibility.

Sample No	Volume of water (cm^3)	Moisture content (%)	Bulk density (g/cm^3)
1	15	5	1.17
2	30	10	1.26
3	45	15	1.40
4	60	20	1.59
5	75	25	1.78
6	90	30	1.86
7	105	35	1.76
8	120	40	1.70
9	135	45	1.65
10	150	50	1.62

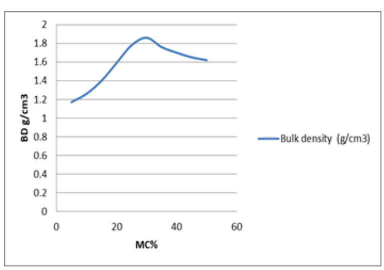

Fig. (1): Effect of moisture content on soil compressibility

Plant height:

The average plant height was found to be increasing as the compaction level is increased and reached its maximum (20.81cm) in the compaction level of 1.40g/cm^3. At the compaction level 0.95g/cm^3 the seed-soil contact is week so the plant did not absorb enough moisture and nutrients from the soil. This effect was reduced when the compaction level is increased to 1.20g/cm^3. The reduction of plant height under the compaction level 1.60 g/cm^3 and 1.80 g/cm^3 may be attributed to inability of roots to penetrate in the deep layers to absorb moisture and nutrients, Table. 2 and Fig.2.

Table (2): Effect of soil compaction on plant growth parameters:

Compaction level (g/cm^3)	Plant height (cm)	Shoot mass (g)	Root length (cm)	Root mass (g)	Root:shoot ratio
0.95	18.10	0.41	2.40	0.08	0.20
1.20	19.60	0.76	3.00	0.12	0.16
1.40	20.81	0.86	4.00	0.23	0.27
1.60	19.90	0.61	3.36	0.09	0.15
1.80	17.58	0.48	3.07	0.08	0.17

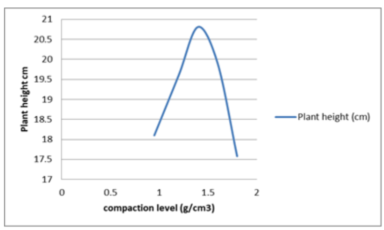

Fig.2: effect of compaction on plant height

Shoot development:

According to Table 2 and Fig 3, the maximum shoot mass appeared under the compaction level of 1.4 g/cm^3. Again this may be attributed to the inability of the root system to penetrate deep to absorb moisture and nutrients under higher bulk density and the lack of good seed-soil contact under lower bulk density.

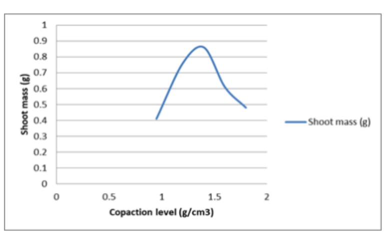

Fig.3: Effect of soil compaction on shoot mass

Root length:

The results of soil compaction on root length were shown in Table 2 and Fig.4. It may be seen from the results that the maximum root length (4.00cm) was found under the compaction level 1.4g/cm^3 the length began to decrease with the increase in compaction level.

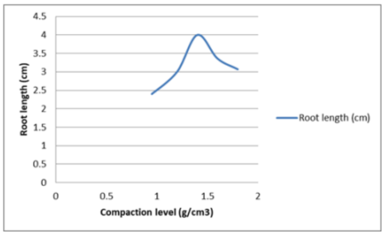

Fig.4: Effect of soil compaction on root length

Root development:

The root mass is shown in Table (2) and Fig.5. The minimum root mass (0.08g) was found under the two extremes of the compaction levels, while the maximum (0.23g) was appeared under the compaction level of 1.40g/cm^3.

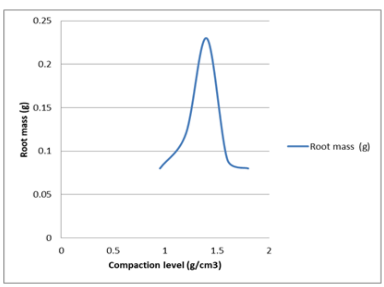

Fig.5: Effect of soil compaction on root mass

Root-to-shoot ratio:

the ratio between the shoot and root mass reached its maximum under the compaction level of 1.40g/cm^3, Table 2 and Fig.6.

Nutrients uptake:

Increasing the compaction level decreased the nutrient uptake. The lowest values in the control and 1.2 levels indicate that some compaction is needed to give a good seed-soil contact so as to be able to absorb moisture and nutrients.

Table (3): Effect of soil compaction on nutrient concentration.

Compaction level (g/cm3)	N	P	K
0.93	2.10	0.141	0.29
1.20	2.52	0.135	0.27
1.40	2.80	0.139	0.24
1.60	2.38	0.140	0.23
1.80	2.66	0.138	0.24

CONCLUSION:

From the above it can be concluded that soil compaction significantly affect plant growth, some soil compaction is needed for good seed-soil contact, but excessive compaction will impede root penetration. This is in line with Memon et. al. (2007).

REFERENCES

1. Beulter, A.N. and J.F. Centurion, 2004. Effect of soil compaction on root development and distribution on soybean yield. Pesquisa Agropecuaria Brasileira, 39: 531-588.
2. Chauddhary, A.D., M. Javed, M.A. Rana, A. Sarwar and Q. Zaman. 1992. Comparative performance of direct drilling and conventional tillage practices under rice-wheat rotation system. Pakistan J. of Agric. Sci., 29:5-8.
3. Fageria, N.K., Badigar V.C and Clark R.B.2006. Physiology of crop production. The Haworth Press Inc. New York, London, Oxford.Pp23-60.

4. Gaultney, L., G.W. Krutz, G.C. Steinhardt and country. J.B. Liljedahl, 1980. Field **and** laboratory tests to determine the effects of subsoil compaction on corn yield. ASAE, Paper No. 80-1011, ASAE, St. Joseph,ML, USA.
5. Gill, W.R. and G.E. Vanden Berg, 1968. Soil dynamics in tillage and traction. Agricultural handbook. Washington DC: USDA-Agric. Res. Service.
6. Hemmat, A. and D. Taki.2001. Grain yield of irrigated wheat as affected by stubble tillage management and seeding rates in central Iran. Soil and Tillage Res. 63:57-64.
7. Kesharvarzpour, F. and M. Rashidi.2008. Effect of different tillage methods on soil physical properties and crop yield of watermelon (citrullus vulgaris). World Appl. Sci. J.3:359-364.
8. Lijima M.K., Yanauchi A and Pradles J.R.1991. Effects of soil compaction on the development of rice and maize root system. Environ. Exp. Bot. 30.333-342.
9. Mahmoud M.M.1993. Sesame in the world and Sudan. Paper presented in the mechanical harvesting of sesame seminar, Gedarif state, Sudan, 1993.
10. Memon, S.Q., Mirza, B. B and Mari, G.R.2007.Tillage practices and effect of sowing methods on growth and yield of maize crop. Agricultura Tropica et Subtropica vol. 40 (3) 2007. Pp89-199
11. Poorter H, Niklas KJ, Reich PB, Oleksyn J, Poot P. (2012) Biomass allocation to leaves, stems and roots: meta-analyses of interspecific variation and environmental control. New Phytol 193: 30–50.
12. Raghavan G.S.V., E. Mokyes and M. Chasse, 1990. Effect of wheel slip on soil compaction. J. Agri. engg. Res., 22(2): 79-83.
13. Salih, A. A. 2004. Personal contact. Soil Physics specialist, Agricultural Research Corporation, Ministry of Agriculture, Sudan.

14. Shafiq, M., M.A. Hassan and S. Ahamad.1994. Soil physical properties as influenced by induced compaction under laboratory and field conditions. Soil Tillage Research, 29(1-2): 13-22.
15. Soane B.D. and Van Ouwerkerk (1994). Implications of soil compaction in crop production for the quality of the environment. Soil tillage. Research., 35, 5-22.