Compacted Soils Reduce Corn Growth

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Abstract

Crop yields can be reduced by different types of cultivation before planting. This greenhouse study examined the effect of bulk density (compaction) on growth. Corn with three replications at each of three bulk densities (1.15, 1.30, 1.45 g/cm^3) was grown in soil columns for 49 days in a sandy loam. Shoot and root dry weight and root length were measured. Root mass and length decreased as the bulk density increased. Compaction of the soil had a minimal effect on shoot growth. Shoot mass was not significantly different among the treatments. Root mean length was different among the different treatments 45.2 m 36.3 m 32.5 m respectively. Root weight was also different at 1.93 kg, 1.47kg, and 0.9kg respectively. Lower bulk density increased root growth and may increase yield in water or nutrient stressed environments.

Introduction

With increasing demands for profits and smaller profit margins growers are looking to become more efficient. No-till cultivation methods can increase efficiency. No-till methods can increase soil compaction, which can reduce nutrients for plant growth. Compaction can stunt plant growth and reduce plant production.

Compaction occurs in different ways. Historically, compaction is thought to take place when implements or machinery travel across a piece of land. However compaction can occur from cattle grazing (Matches, 1992) or just simply over time (Pando-Moreno et al., 2004). Compaction is the movement of aggregates in a soil closer together removing pore space within the soil. With this the larger pores decrease and the smaller pores increase (Richard et. Al., 2001).

The less cultivation the more these soils become compacted (Matches, 1992). Abu-hamdeh (2003) found compacted soils hinder plant growth and where soils were aerated the wheat crop increased. Compacted soils limit the amount of respiration that is allowed to take part in the soil and will decrease the plants availability of nutrients. Raich and Mora (2005) found that the respiration of the roots was correlated with the physical properties of the soil. This was done by limiting the decomposition of existing organic matter and limiting the oxygen diffusion rates (Asady and Smucker, 1989). Pando-Moreno et al., (2004) found as the bulk density of soils increase the water holding capacity of the soils decrease. Plant growth will be reduced due to the lack of pore space and nutrient availability in compacted soils. To determine if different levels of compaction hinder plant growth particularly in the roots soil columns will be created at 3 different bulk densities 1.15, 1.30 and 1.45 g/cm3. In each of these columns corn, a widely used crop, will be planted in these columns and will be allowed to grow for 2 months. Following, these plants will be extracted and plant biomass and root growth will be examined to determine if plant growth was affected by the bulk densities. The study will determine if the root and shoot growth was limited, the ratio of the roots to shoots, and the total root length of the plants in the different bulk densities.

Materials and Methods

This was a 50 day greenhouse study using a Kidman sandy loam. Nine soil columns were used measuring 5.2 cm diameter and 30.5 cm in length. These columns had double layered window screen at the bottom to hold the soil in while allowing any extra water to leach out. A large amount of soil was brought into the green house and allowed to air dry. A small sample of the soil was then weighed and then oven dried to determine the initial water content at 3%. Following three soil columns with one of three bulk densities 1.15, 1.30, and 1.45 was filled to 27 cm. This was done by figuring the volume of the cylinder area used and then weigh the amount of soil needed based on the water content to bring the soil column to the corresponding bulk density.

We initially saturated the soil columns by placing them in a large barrel with 20 cm of a complete plant nutrient solution. In the top of each of the soil columns 2 corn kernels were planted approximately 2 cm deep into the saturated soil. Each soil column was then placed on a growth table and attached to an automated watering system that waters each column (approximately 15mls) for about 15 minutes twice a day. The plants were then allowed to grow. On the 13 of November 30 days later the watering schedule was changed to three times a day of 15 mls.

On the 49^{th} day the plants were extracted from the columns and all remaining soil was removed. The Roots were removed from the plants and the root length was determined using a Hewitt packer flat scanner and Delta-T Scanner Software. The roots and the shoots were dried and weighed to determine dry weight biomass. Root length density and root and shoot biomass were analyzed.

Results

The total length of the roots determined that the treatments that had the lowest level of compaction had more roots (45.18) throughout the soil column then the column that received the higher level of compaction (19.32 m). While the roots in the medium level of compaction (36.28 mm) was closer to the roots in the higher level of compaction (Fig.1).

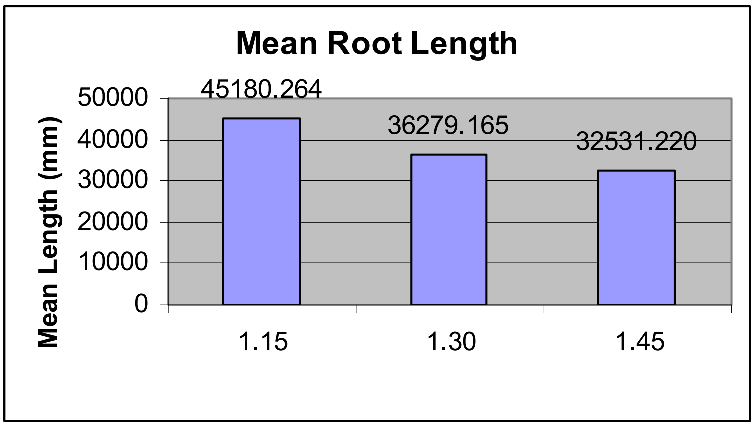

Fig. 1 shows the different mean lengths of the roots compared to the different levels of compaction.

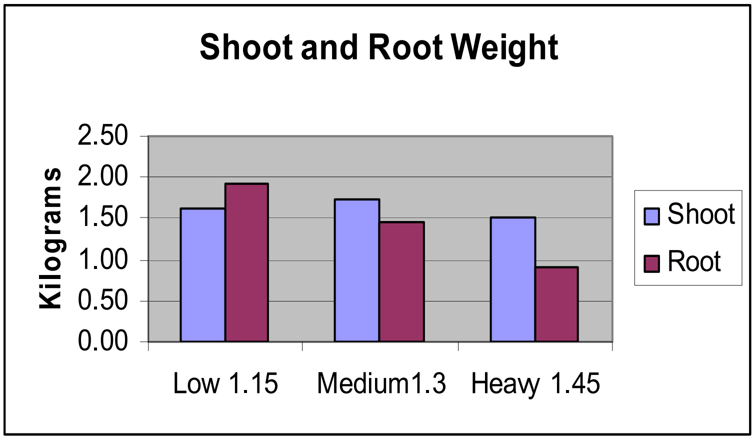

Fig 2 Root and Shoots weights of the different plants at time of harvest.

Shoot mass doesn't change significantly as compaction increases. The roots of the different plants decrease in weight as the bulk density of the soil increases. The root dry weights were different among the different treatments. The light treatment of 1.15 had a mean weight of 1.93 g the medium treatment of 1.30 had 1.47g and the heavy treatment 1of .45 had 0.90 g of root weight (fig 2).

The shoot mass however doesn't have a significant change in the amount or show a trend based upon the data present (fig. 2).

The ratio however of the root to shoot shows that as the level of compaction increases the ratio for the amount to roots to the shoot decreases (Fig. 3).

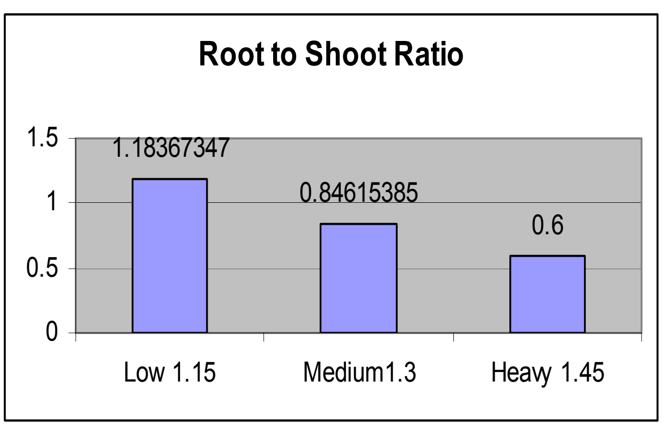

Fig. 3 The root to shoot ratio shows a decline in value as the level of compaction increases.

Discussion

The amount of total roots in the area shows that the treatments that are not heavily compacted have a greater tendency for the roots to disperse throughout the entire root column. With the ability for the roots to cover the larger area of the soil it then allows the roots to uptake nutrients in areas that would be limited to the growth patterns of compacted soils. This may not be a problem when the plant is fed a nutrient solution like in a greenhouse study. A field situation when the corn plant doesn't have a constant source of nutrients a corn plant with a more disperse rooting system will have the advantage. Plants in a lighter bulk density are then capable of using nutrients the corn grown in compacted soils could not. This is also observed when comparing the root to shoot ratio. The corn plants that have the higher root to shoot ratio are capable of withstanding drought and other problems.

It was expected that the shoot mass would have been higher in the lower bulk densities soils. This result may have been due to the inconsistent growth of plants within the columns. In all of the lower bulk density soils both corn plants germinated, whereas, in the heavily compacted soils only one replication had both corn plants germinate. This may have given single plant in the higher compacted soil an advantage because it did not have to compete against another plant.

Given the information present different studies should be conducted. This study should be repeated to gain more definite answers to the questions it was trying to solve. This new study should try to examine more in depth the changes the soil bulk density on the plants. In this study more treatments should be applied to try and model the rate at which growth decreases to the different changes. To correct the possibility of competition among plants, causing different shoot mass and more replications would allow for more error. More replications would then make it possible to determine if the number of germinating corn plants is correlated to the bulk density. If to limit competition in the columns, remove the second corn plant after germination form the columns, this would allow a more precise comparison of the different treatments. It would also be recommended to see if this competition does exist in these columns and if the compaction level increases the level of competition among plants.

Literature Cited

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