# THE IMPACT OF SOIL COMPACTION ON THE VEGETATIVE GROWTH OF CARROTS *(Daucus carota, var. Sativas)* PLANTED IN LOOSENED AND UNLOOSENED SOIL IN THE EASTERN FREE STATE.

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**Abstract**

*This study focuses on trials conducted on plots in the Leratong and Mpho vegetable gardens in the Eastern Free State. The aim was to investigate the possible impact of soil compaction on the growth of carrots planted on loosened (treated) and unloosened (untreated) soil. Aspects such as sprouting, vegetative length after 14 days of sprouting and diameter, as well as the length and mass of carrots after harvesting, were observed and compared between the treated and untreated carrot plots. Although there was no significant ($P>0.05$) difference between the two soil management practices applied in all locations, as well as the vegetative growth in the locations, a significant ($P<0.05$) difference between the length of carrots from the treated and the untreated plots was observed.*

**Keywords:**

Soil compactions, vegetable garden, vegetative growth

## 1. INTRODUCTION

The restricted root distribution in compacted soils can lead to a reduction in shoot growth and yield by limiting water and nutrient uptake (Wolfe et al., 1995:956-963). Bennie and Nhantumbo (2000:44-46) state that soil bulk density is an indicator of the compactness of a specific soil. Steyn (1994) states that tillage may also lead to the breakdown of organic matter, loss of soil moisture and an increase in wind and water erosion. Compaction may restrict soil aeration and crop root development, limiting water uptake, nutrient availability and overall crop growth. As far as the physical and chemical soil environment is concerned, the formation of organic soil matter provides feedback on the activity of decomposers and the plant community since it affects the retention of water and nutrients, the germination of seeds and the distribution and activity of plant roots, while the regulation of turnover is the main feature of the decomposition subsystem (Christensen, 2001:345). Cultivation refers to all gardening and farming operations that disturb the soil, including digging and ploughing. The term is usually reserved for tillage of the soil after the seeds have been sown (Hadfield, 1967:40). Soil tillage is a basic management tool has a great impact on crop establishment and growth (Govers et al. 1994:469; Thompson, 1978:416). Non-inversion deep tillage successfully loosens the compact and root-resisting pan. A conservation tillage system retains more residues and creates a rougher soil surface than conventional systems. It also results in a slower runoff and a slower rate of loss of particulate phosphorus (Ball et al., 1997:48,599; Tolmay, 1995:1). Maclay (1984:1) states that the effect of traffic on soil is to close up some of the larger air-filled spaces. The purpose of soil cultivation is to create physical conditions for the sustainable growth of plants. Wolfe et al. (1995:956-963) state that soil compaction on farms is most commonly caused by vehicle traffic, particularly the use of heavy equipment with poor weight distribution on wet soils. Consequently, soil compaction is common in vegetable production systems since farming activities must often be performed within narrow time frames that do not allow for adequate soil drying before working on the field. Fields left relatively undisturbed (by not tilling) develop a very porous structure, which promotes the unrestricted exchange of oxygen and carbon dioxide, improves moisture and nutrient movement and reduces the effect of compacted soil layers (Russell, 2001:14-15).

## 2. MATERIALS AND METHODS

The Leratong vegetable garden is 0.16 ha in size, and the Mpho garden 0.19 ha. Carrots were planted as trial vegetables in both vegetable gardens. Three identical plots, each covering an area of 14 m2, were used in each location. A randomised block design was used to assign either loosened (experiment) or compacted (control) areas before trial crops were planted. Soil samples from the Mpho and Leratong projects were analysed at the Glen soil laboratory. Although there were slight variations, the soil texture was classified as sandy clay (i.e. 50% sand and 50% clay plus silt) in most cases. With regard to alkalinity, the conductivity was 49 and the Standard Acid Ratio was 1.1. Soil reaction or pH (potassium chloride) was determined as 3.9. In the Mpho garden the level of the slope varied between 0 and 2%, while it was up to 12% in the Leratong garden.

### 2.1 Treatments on the plots

In these trials no disease or pest control were applied in their gardens, since it was feared that children might eat some of the sprayed vegetables. Garlic was mixed with water and sprayed on both the treated and the untreated plots, as practised by the farmers in that region. On the planting date (14 September) the Ideal red variety was planted on both the experiment and control plots, while 400g of 2:3:2(22) fertilizer per 14 $m^2$ was applied.

### 2.2 Parameters used in the trials

For the purpose of determining carrot length and mass, a plot of 14 square metres was subdivided into nine quadrants and four carrots were harvested from each quadrant. Every sixth sprout in each row was measured. Twenty-four sprouts per block from both the treated and the control plots in two different locations were measured. The length (in centimetres) and mass (in grams) of carrots from both the treated and control plots were determined. The length and mass of carrots were compared, taking into account soil management practices and location effects.

## 3. RESULTS

### 3.1 Plant growth

After 14 days, the plant population in the treated plots was denser than that of the control plots. In order to balance the plant population in both plots, the seedlings were thinned out. Plant population/density in the plots were assessed visually, and all plots were given equal amounts of fertilizer. After one month, the vegetative growth in the treated plots was higher than in the control plots (see Table 1).

Table 1: Mean and standard errors (SE) for vegetative length of carrots after one month

| Soil management applied | Location | Mean (SE) in cm* |
|---|---|---|
| Control (compacted) | Leratong | 2.11(0.29)a |
| Control (compacted) | Mpho | 2.59(0.29)a |
| Treated (loosened) | Leratong | 3.94(0.29)a |
| Treated (loosened) | Mpho | 4.16(0.29)a |

* Values in brackets are standard errors; means with the same letters in the same column are not significantly different ($P>0.05$).

As measured one month after planting, the mean vegetative length of the carrots in the control plots was 0.48 cm shorter compared to the treated ones in the Mpho vegetable garden. There was a 0.22 cm difference in the mean length of carrots planted in loosened plots in the Mpho and Leratong vegetable garden locations respectively. However, there was no significant ($P>0.05$) difference in carrot length between the two soil management practices applied in all locations. It must be taken into account that factors such as climate (especially rainfall) and fertigation may also have influenced the experiment. In stress situations (low levels of rainfall/irrigation and fertilizer), it is expected that the loosened soil will have a significant advantage over the compacted soil. In general, the loosened subsoil had a positive effect on the vegetative growth of carrots in both locations; the assumption is therefore made that carrot seeds were restricted by soil compaction during sprouting.

### 3.2 Yield

When harvested, the carrots in the experiment plots were longer than the ones in the control plots, which were short and thick in diameter. The mean length, diameter and mass of carrots harvested from the treated and control plots are indicated in Table 2.

Table 2: Mean and standard errors (SE) for carrot length, diameter and mass with regard to the control and treated plots.

| Soil management treatments | Length in cm. | Diameter in cm. | Mean mass in g. |
|---|---|---|---|
| Control | 13.61 (0.18) a* | 3.95 (0.05) b | 39.62 (0.33) c |
| Treated | 14.71(0.18) b | 3.36 (0.05) b | 38.75 (0.33) c |

* Values in brackets are standard errors; means with different letters in the same column are significantly different ($P<0.05$).

The mean length of the carrots from the control plot was significantly shorter (1.1 cm) than that of the treated ones ($P < 0.05$). The better growth of the carrots on the treated plots could be the result of the loosened topsoil. The mean carrot diameter for control plots was 0.59 cm more than that of the ones planted in the loosened soil. In view of the unloosened subsoil, it was assumed that the carrot roots developed in a sideways direction due to the root restriction associated with soil compaction. The mean mass of carrots harvested from control plots was 0.90g more than that of carrots harvested from loosened soil; however, this difference was not significant. The findings confirmed that the carrots from the control plots were shorter in length, thicker in diameter and heavier in mass than the ones planted in the loosened plots.

The carrots in the treated plots were longer than those in the control plots due to the removal of compaction, improved drainage and the greater availability of nutrients resulting from more favourable growing conditions (Tomay, personal communication). In the control plots, the soil was compacted and the nutrients were only available within the upper 10 cm of the topsoil. Bennie et al. (2000:44) report that soil bulk density is an indicator of the compactness of the specific soil. Compaction is a common problem in vegetable production systems, since farming activities are often conducted within a narrow time frame that does not allow for adequate soil drying before entering the field or garden. The restricted root distribution in compacted soils can cause a reduction in shoot growth and yield by limiting water and nutrient uptake (Wolfe et al., 1995:956). The fertilizers applied did not penetrate into the deeper subsoil, but remained in the upper 10 cm of the soil due to soil compaction.

Table 3 illustrates mean and standard deviation (SD) for carrot length, diameter and mass according to location and soil management treatments.

Table 3: Carrot length, diameter and mass according to location and soil management treatments

| **Soil management treatments** | **Location** | **Length in cm.** | **Diameter in mm** | **Mass in g.** |
|---|---|---|---|---|
| Control | Leratong | 14.12 (2.05)b* | 3.98 (0.40)b | 39.27 (3.95)ab |
| Control | Mpho | 13.03 (1.88)a | 3.93 (0.48)b | 40.23 (3.33)b |
| Treated | Leratong | 14.52 (1.59)b | 3.30 (0.63)a | 38.72 (3.46)a |
| Treated | Mpho | 14.87 (2.35)c | 3.41 (0.64)a | 38.86 (4.08)a |

* Values in brackets are standard errors; means with the same letters in the same column are not significantly different ($P>0.05$).

In the Leratong vegetable garden there was no significant difference in carrot length between the control group and the loosened soil group, whereas there was a significant difference (1.83 cm) between control and treated groups with regard to the carrots planted in the Mpho vegetable garden. In both locations there was a significant difference in carrot diameter between the control and treated groups. Carrots harvested from the loosened soil at the Mpho location were significantly ($P<0.05$) heavier (1.29 g) (Table 3). It is postulated that the difference in carrot yield can be ascribed to the difference in soil type between the Leratong and Mpho vegetable gardens, as shown earlier.

# 4. CONCLUSION

The significant ($P<0.05$) difference between the mean length of the carrots in the control group and the treated group respectively is postulated to be the result of the loosened topsoil. Carrot mean diameter and mass were significantly influenced by soil compaction. This trial's findings showed that soil compaction has an effect on the production of carrots. Farmers must therefore be advised to loosen their vegetable garden soil to enable them to compete with the commercial markets.

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