Influence of Soil Aggregate Size on Corn (*Zea mays* L.) Seedling Growth

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Introduction

- Corn (*Zea mays* L.) is a major grain crop grown in various crop rotations and land management systems in Ontario, Canada.
- Tillage and rotation affects soil aggregate size and distribution[2].
- Soil aggregate size and their distribution are connected directly or indirectly with root growth of crops[1,4,5].
- Early season root growth is vital in procuring even plant population and high yields[3].
- The effect of mechanical resistance caused by soil aggregate size on root growth can be misleading due to the indirect effects associated with size and distribution of aggregates such as differences in aeration, availability of water due to different hydraulic conductivities, and strength of growing medium due to packing rather than mechanical resistance.

Objective

To determine the effect of mechanical resistance caused by aggregates on early corn root and shoot growth using a novel hydroponics system that eliminates indirect effects of aggregates on aeration, water availability and fertility.

Materials and Method

- Growth room conditions – 25ºC/20ºC day/night temperature and 16hr photoperiod.
- Plastic pots 30cm diameter/30cm high.
- Hydroponics system to eliminate confounding effects of moisture, nutrients, oxygen and temperature differences (Figure 1).
- Three treatments (Figure 1), Randomized Complete Block Design.

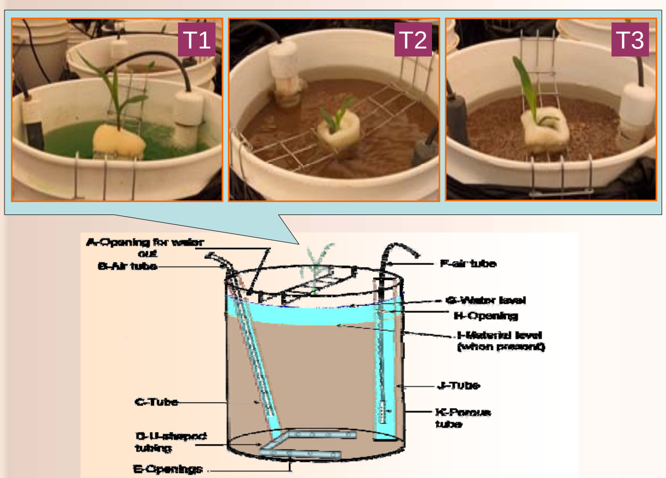

Figure 1. Treatments (T1-Nutrient mixture alone, T2- Nutrient mixture + fine aggregates (<0.2mm), T3- Nutrient mixture + coarse aggregates (2-7mm)) and schematic view of a pot (B,C,D,E – circulate water, F,H,J,K – provide aeration with no disturbance to roots

- Seedlings for T1 raised in paper cups till emergence.
- After emergence submerged with nutrient solution and in T1, seedlings were transferred to hydroponics pots.

Sampling and Measurements

- 3 plants sampled at 5, 7 and 10-leaf tip stages.
- Leaf area measured by LI-6400 (LI-COR Inc,) area meter.
- Root images taken at 800dpi gray scale analyzed for root characteristics using WinRhizo Pro computer software. (Regent, Canada)
- Root and shoot dry weights after oven drying at 80 ºC for 48hrs.

Results

Table 1. Corn root characteristics measured at 5-leaf tip stage and total leaf area measured at 5 and 7-leaf tip stages

	Root characteristics (at 5-leaf tip stage)			Leaf area (cm^2 $plant^{-1}$)	
Treatment	Length (m $plant^{-1}$)	Surface area (cm^2 $plant^{-1}$)	Volume (cm^3 $plant^{-1}$)	At 5-leaf tip	At 7-leaf tip
T1. Pure nutrient mixture	13.4	130	1.3	89	425
T2. Nutrient mixture + <0.2mm aggregates	8.9	75	0.8	77	353
T3. Nutrient mixture + 2-7mm aggregates	6.2	36	0.6	58	287
se (p=0.05)	1.46	17	0.103	6.4	32
	Orthogonal contrasts -------------------------- *P>F*----------------------				
T1 vs T3	0.02	0.004	0.01	0.02	0.03
T1 +T3 vs T2	0.64	0.61	0.43	0.67	0.93

Root characteristics

- Decreasing mechanical stress increased total root length, surface area and volume at 5-leaf tip stage (Table 1). 118% and 44% higher root lengths by T1 and T2 compared to T3 at 5 leaf tip stage. Effect disappeared over time (not shown).
- Primary root length: T1 produced longest primary roots at 5-leaf tip stage. Latter stages both T1 and T2 produced greater lengths compared to T3 (Table 2)
- Seminal root length: Similar to primary roots but only at 5 and 7-leaf tip stages (Table 2).
- Nodal root length: T1 and T2 produced greatest nodal root length at 5-leaf tip stage (Table 2). At the 10-leaf tip stage T3 resulted in greatest nodal root length.

Plant biomass

- 78% and 32% reduced root weights for T3 at 5 leaf tip compared to T1 and T2, respectively (Figure 2).
- Shoot dry weight also followed the similar pattern.

Leaf area

- Total leaf area of T3 at 5 and 7-leaf tip stages was significantly lower than T1 (Table 1) but was not at 10-leaf tip stage (not shown).

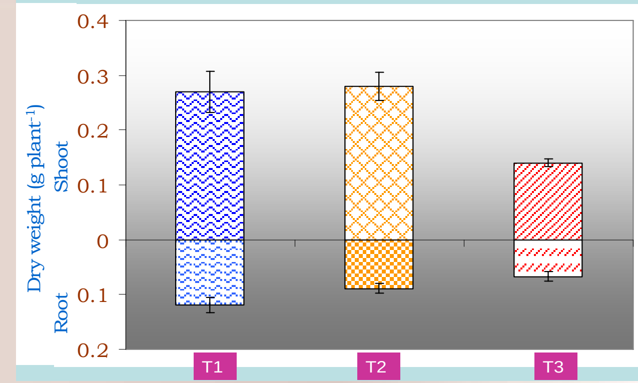

Figure2. Corn shoot and root dry weights at 5-leaf tip stage. Error bars are standard error of the mean.

Table 2. Corn root characteristics measured at 5-leaf tip stage and total leaf area measured at 5 and 7-leaf tip stages

Root type and Leaf tip stage	Root length (m $plant^{-1}$) Treatments T1	T2	T3	Se	Orthogonal Contrast (*P>F*) T1 vs T3	T1+T3 vs T2
Primary						
5-tip	4.9	3.0	2.4	0.70	0.01	0.45
7-tip	27.0	23.8	10.4	2.97	0.001	0.17
10-tip	42.9	35.3	14.2	4.51	0.0003	0.26
Seminal						
5-tip	6.2	4.1	2.4	0.66	0.0003	0.59
7-tip	28.6	23.3	11.8	2.84	0.001	0.38
10-tip	33.1	33.5	29.5	ns	0.55	0.68
Nodal						
5-tip	2.1	1.8	1.3	ns	0.07	0.80
7-tip	28.6	36.7	20.7	2.79	0.06	0.002
10-tip	70.3	87.2	113.9	12.55	0.01	0.74

Conclusions

- Effect of aggregate size on corn shoot growth and root extension starts at very early stages.
- The primary roots affected the most at early stages.
- Nodal root growth in coarse aggregates may recover root lengths lost at early stages in absence of any other stresses.
- Finer soil aggregates, which are associated with low mechanical stress during early growth, contributes to improve corn growth and yield.

References

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Acknowledgement

Natural Sciences and Engineering Research Council, Canada