Report to the Pennsylvania Vegetable Research and Marketing Board
Cover Crops as a Solution to High Soluble Salt Levels in High Tunnels

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Farmers across Pennsylvania need solutions for high soluble salts levels in their high tunnel soils. In 2017, with funding from the PVRMB, we worked with 27 farmers across Pennsylvania and found soluble salts levels averaged 1.48 mmhos/cm, which is well above levels where yields of salt-sensitive vegetables are reduced. Salts accumulate from the use of fertilizers and organic nutrient sources. Interpretation of soluble salt levels is dependent on which testing method is used. Penn State University's Agricultural Analytical Services Laboratory uses the 1:2 (soil:water) method (Gartley, 2011). Soils with soluble salts levels of 1.48 are considered strongly saline and only salt-tolerant crops, like beets, will grow well (AASL.psu.edu). Most of the 27 farmers told us they were unsatisfied with yields, mostly of tomatoes, from their tunnels, and in some cases, tunnels were taken out of production. While some of them knew about this issue, most did not.

Cover crops with tolerance to high soluble salts levels and that have large above-ground canopies, extensive root systems, and high transpiration rates have the potential to be used to extract salts from the soil. We have suggested this general option to farmers with high soluble salts levels but we do not know which specific cover crop types are best for drawing down salt levels.

Study objective: We evaluated using cover crops, cut flowers, and tomato cultivars for their ability to extract soluble salts as a solution for high tunnel soils.

How the study was conducted: The experiment was set up in a greenhouse at the Russel E. Larson Agricultural Research Center. Cover crops, cut flowers, and tomato cultivars (Table 1) seeds were planted on May 26 into 3-gallon grow bags filled with soilless potting medium. Plants were watered every Monday, Wednesday, and Friday with 250 mL of 1) normal strength Hoagland's solution (normal strength salt solution) or 2) Hoagland's solution + 150 mM NaCl (high salt solution). For the first week plants receiving the high salt solution were watered with a ¼-strength solution. Treatments were arranged in a completely randomized design with three replications. Plant height was recorded weekly for 4 weeks once seedlings had germinated. Height data were converted to percent change in growth between each salt solution treatment in each block and analyzed using the mixed procedure in SAS. Means were separated using pdiff.

Results: Significant differences were not observed among plants receiving either salt solution treatment for the first date that height was recorded. On June 15th all plants receiving the normal strength salt solution were taller than those receiving the high salt solution. Winter rye and 'Red Russian' kale were significantly taller with high salt solution treatment than 'Oregon Spring' tomato, birdsfoot trefoil, 'New Girl' tomato, 'Wisconsin' tomato, and sugar beets (Table 1). Winter rye was significantly taller when watered with the high salt solution compared to 'Cauralina' tomato. Sorghum, 'Bolder' beet, and 'Royal' sunflower grew taller with the high salt solution compared to 'Oregon Spring' tomato and birdsfoot trefoil. All other plants were not different from each other.

By June 22 most crops did not significantly differ from each other in the percent change in height. However, birdsfoot trefoil, sorghum, buckwheat, and winter rye grew taller with the high salt solution compared to the normal strength salt solution. Winter rye grew taller than all other crops receiving the high salt solution and sorghum and buckwheat grew taller than most other crops.

On the last date height was recorded, June 29th, most crops receiving the normal strength salt solution were taller than those receiving the high salt solution. Rye remained the top performer compared to all other crops except sorghum. Sorghum outperformed most other crops.

What the results mean: Some crops grew taller than others with the high salt nutrient solution compared to the normal strength salt solution and have the potential to be used to accumulate excess soluble salts in high tunnel soils. Winter rye and sorghum may be possible options to be used as cover crops when soluble salts levels in high tunnels are high. The key to using cover crops to remove excess soluble salts is to remove them from the high tunnel when they are terminated. Incorporating them back into the soil will add the excess salts back into the soil. Other cover crops to evaluate further include berseem clover, birdsfoot trefoil, and sugar beets. Tomatoes did not respond well to the high salt nutrient solution (Photo 1). By the second date height was recorded, plants were stunted compared to plants receiving a normal strength nutrient solution. At the last date of data was recorded, tomatoes receiving the high salt solution were between about 60 and 70% shorter than plants that had received normal strength nutrient solution. The difficulty in visually identifying the issue with high soluble salts levels in high tunnel soils is that the salts are uniformly found throughout tunnels. What this means is that all the plants in the tunnel will be stunted because of high soluble salts levels which masks the problem. If even one plant was not affected, it would be taller and the stunting of plants throughout the tunnel would be evident. The solution to this issue is to determine the soluble salts levels in high tunnel soil with regular testing. This study provides evidence that certain cover crops can be used to remove excess soluble salts in soils from high tunnels.

Table 1. Percent change in high between plants receiving a normal strength salt solution and plants receiving a high salt solution at three dates.

	Mean change in plant height (%)		
Crop	**June 15, 2021**	**June 22, 2021**	**June 29, 2021**
'Oregon Spring' tomato	0.63 a	0.62 a	0.59 a
Birdsfoot trefoil	0.60 a	-111E-18 a-b	0 ab
'New Girl' tomato	0.51 ab	0.51 a	0.32 a
'Cauralina' tomato	0.50 abc	0.53 ab	0.60 a
'Wisconsin' tomato	0.47 ab	0.50 a	0.68 a
Sugar beets	0.46 ab	<1 a-b	-222E-18 ab
Ornamental kale	0.40 a-d	0.58 a	0.55 a
'Balady 1' Berseem clover	0.26 a-d	0.36 a-c	0.08 ab
'CDC Copeland' barley	0.26 a-d	0.10 a-b	.28 a
'Boro' beet	0.25 a-d	0.38 a	.46 a
Buckwheat	0.22 a-d	-2.02 c	-

'Purple Majesty' millet	0.22 a-d	0.35 a	.22 a
WGF sorghum	0.19 b-d	-1.67 bc	-2.3 bc
'Bolder' beet	0.17 b-d	0.25 ab	.43 a
'Royal' sunflower	0.12 b-d	0.73 a	.78 a
'Red Russian' kale	0.04 cd	0.48 a	.54 a
Winter rye	0.03 d	-4.83 d	-4.7 c

How to read this table: Each value is the mean of how each crop grew with the high salt solution compared to the normal strength salt solution. Values near zero indicate that plants grown with the normal strength and high salt solution were close in height. Positive values mean that the plants grew taller with the normal strength salt solution compared to the high salt solution. Negative values mean that the plants growing with the high salt solution grew taller than those watered with the normal strength salt solution. For example, on June 15th 'Oregon Spring' tomato growing with the high salt solution was 63% shorter than plants growing with the normal strength salts solution.

Photo 1. The tomato plant on the left received the normal strength salt solution. The one on the right received the high salt solution.

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