A Meta-Analysis of Grafted Tomato Trials to Determine Rootstock Performance

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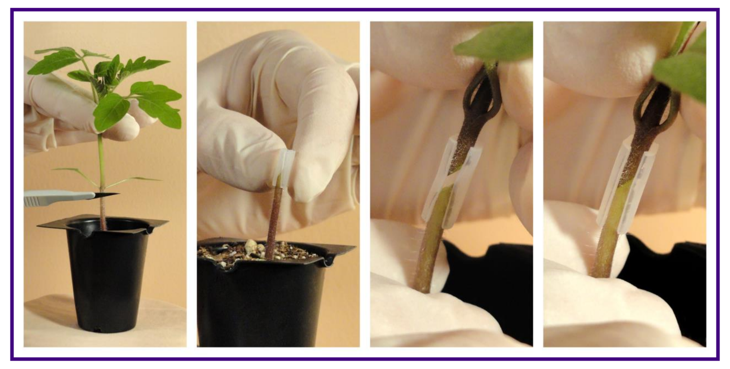
INTRODUCTION

The practice of grafting tomatoes in the United States is expanding in order to utilize rootstocks that confer resistance to soilborne plant pathogens (Louws et. al, 2010), tolerance to abiotic stressors (Rivero et al., 2003), and potentially increased vigor (Masterson, 2016). Such grafted plants with vigorous rootstocks can produce higher



per square foot yields, making them especially valuable for small urban farms, high tunnels, and other areas where space is at a premium. Second, grafting may be able to improve plant tolerance to detrimental soil conditions that may be present in areas with less-than-ideal soil types, a mixed land-use history, or in intensive cropping systems like high tunnels.

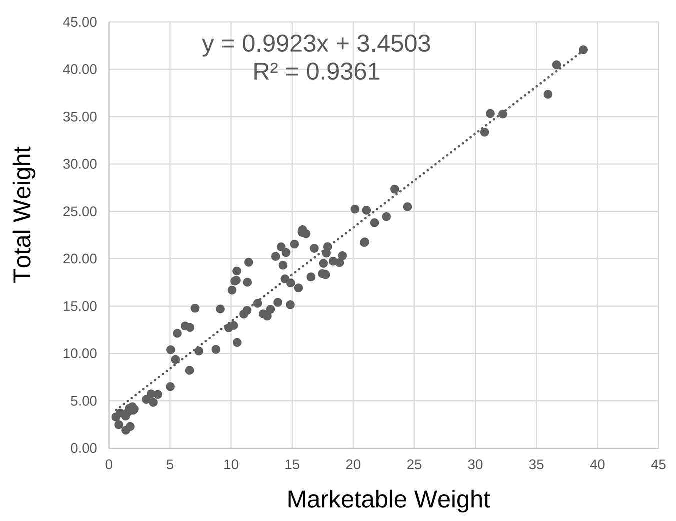
RESEARCH OBJECTIVES

It is currently not clear which rootstocks show increased vigor and under what specific growing conditions. Therefore, the objectives of this study were to: 1) utilize a meta-analysis approach to determine the characteristics of a vigorous rootstock; 2) identify rootstocks that consistently showed increased vigor across diverse production systems and under specific growing conditions; and 3) explore the relationship between increased vigor and genetic yield potential.

META-ANALYSIS METHODS

Meta-analysis is the process of compiling multiple data sets from different trials of a similar nature, normalizing the data, and then using the new, larger data set to draw conclusions that were not previously possible. This meta-analysis was used to measure the yield potential for each rootstock as it related to the non-grafted control group, the genetic yield potential differences between rootstock varieties, and the production advantages of different rootstocks under the improved growing conditions of a high tunnel. The presence of nongrafted control plants in each trial allowed for a consistent production baseline across trials.

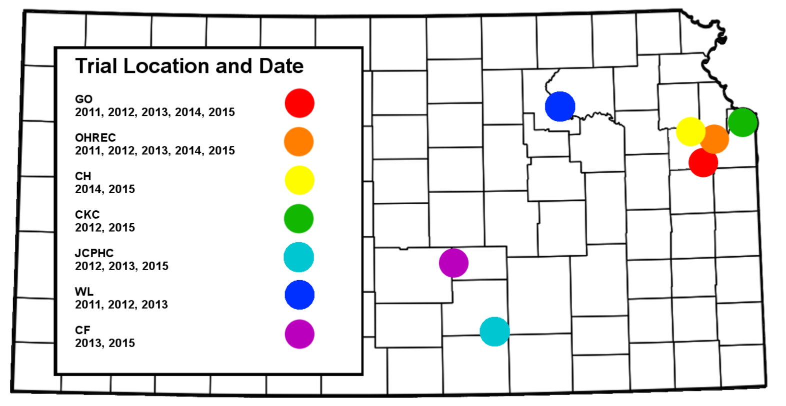
- A Liner Regression Analysis comparing the total weight of tomatoes produced per plant to the weight of marketable tomatoes produced per plant for non-grafted treatments resulted in a strong positive linear correlation (p value < 0.0001, $R^2 = 0.93$). This indicates that either metric may be used in determining yield potential as long as it is used consistently. In this case we will be using marketable fruit weight.



- Per plant yield for each rootstock was plotted against the per plant yield of the nongrafted control from within the same replication. A linear line of best fit was added to each graph, and the R^2 value for each line was calculated.
- The resulting scatter plots (Figure 1) show the productivity of each rootstock as compared to the corresponding non-grafted production under the given conditions at each site.
- The slope of each line of best fit indicates the response of the rootstock yield as the yield of comparable nongrafted plants (a measure of growing condition favorability) increases.

GRAFTING TRIALS

Data was collected from twenty-five grafting trials (sixteen high-tunnel, and nine open field), conducted from 2011-15. Two scions, Cherokee Purple and BHN 589 were utilized. Cherokee Purple was used in one high tunnel trial and six open field trials, while BHN 589 was used in fifteen high-tunnel and three open field trials. The compiled data was used to determine rootstock performance under a variety of growing conditions. The seven trial locations were spread throughout North Eastern, Central, and South-Central Kansas: The performance of five rootstocks, 'Maxifort', 'Arnold', 'BHN RT1028' , 'RST-04-106', and 'Trooper Lite' were assessed. Each site used a randomized complete block design with 4-6 replications. All sites used typical farm management practices and yield data was collected weekly.



RESULTS

Figure 1) Linear regression analysis of the relationship between rootstock yield and nongrafted yield for five rootstocks. A dashed line representing slope=1 was added for comparison of rootstock vs. nongraft performance. Data points beneath the line indicate replications where nongrafted plants performed better than the grafted ones. Similarly, the slope of the best fit line indicates rootstock performance benefit relative to the nongrafted plants. All yield data represented here is equal to the number of marketable pounds of fruit produced per plant. Data was compiled from twenty-five trials conducted from 2011-15.

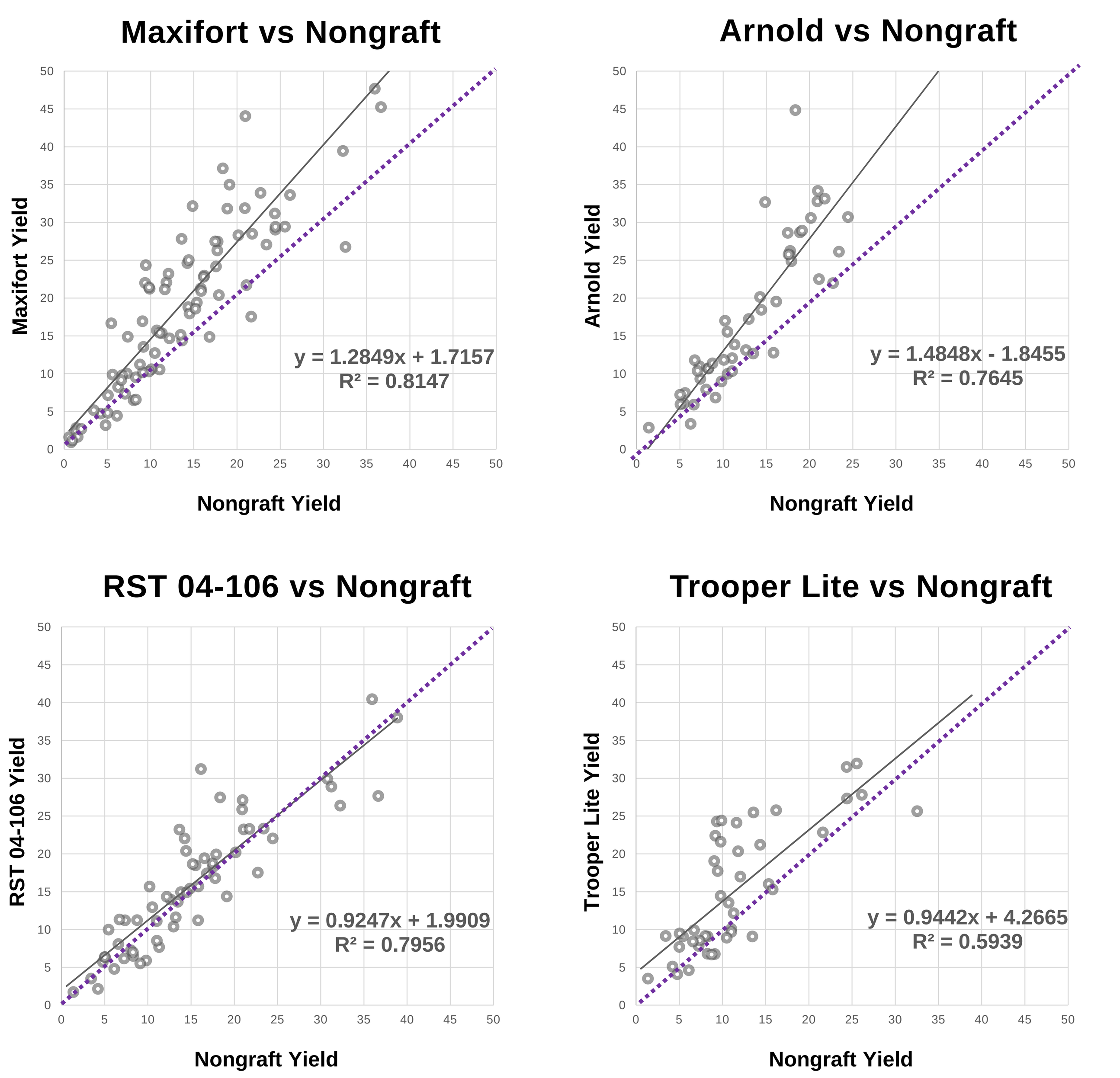


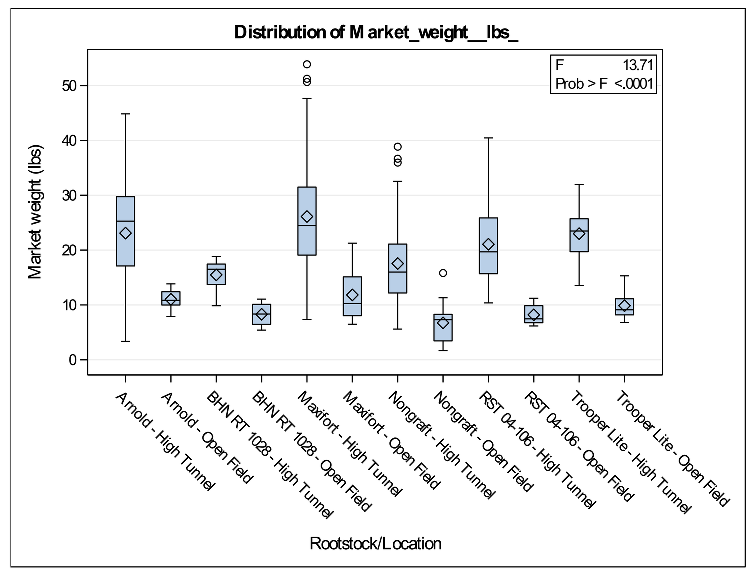
Figure 2) An ANOVA was run on BHN 589 only, comparing marketable yield for five rootstocks both in high tunnels and in the open-field. Most rootstocks (and non-grafted plants) performed significantly better in high tunnel trials than in open-field trials.

An ANOVA comparing the yields of BHN 589 and Cherokee Purple in both high tunnel and open-field found a significant yield difference between scions, therefore this ANOVA was run on trials utilizing BHN 589 scion only,

Least Squares Means for effect Rootstock_Location
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: Market_weight__lbs_

Rootstock_Location	Market_weight__lbs_ LSMEAN	i/j	1	2	3	4	5	6	7	8	9	10	11	12
Arnold - High Tunnel	23.0931622	1		0.0073	0.5652	0.0214	0.8739	0.0179	0.0728	<.0001	0.9962	0.0002	1.0000	0.0018
Arnold - Open Field	11.0271875	2	0.0073		0.9959	1.0000	<.0001	1.0000	0.5182	0.9841	0.0463	0.9999	0.0143	1.0000
BHN RT 1028 - High Tunnel	15.4835053	3	0.5652	0.9959		0.9552	0.0684	0.9993	1.0000	0.4699	0.8939	0.8480	0.6365	0.9730
BHN RT 1028 - Open Field	8.2915625	4	0.0214	1.0000	0.9552		0.0008	0.9999	0.4669	1.0000	0.0808	1.0000	0.0303	1.0000
Maxifort - High Tunnel	26.1169416	5	0.8739	<.0001	0.0684	0.0008		0.0001	<.0001	<.0001	0.0877	<.0001	0.9269	<.0001
Maxifort - Open Field	11.8264063	6	0.0179	1.0000	0.9993	0.9999	0.0001		0.7129	0.9440	0.0980	0.9987	0.0322	1.0000
Nongraft - High Tunnel	17.5487864	7	0.0728	0.5182	1.0000	0.4669	<.0001	0.7129		0.0002	0.5345	0.0628	0.2073	0.2614
Nongraft - Open Field	6.7274554	8	<.0001	0.9841	0.4699	1.0000	<.0001	0.9440	0.0002		<.0001	1.0000	<.0001	0.9989
RST 04-106 - High Tunnel	21.0604107	9	0.9962	0.0463	0.8939	0.0808	0.0877	0.0980	0.5345	<.0001		0.0017	0.9990	0.0134
RST 04-106 - Open Field	8.1953906	10	0.0002	0.9999	0.8480	1.0000	<.0001	0.9987	0.0628	1.0000	0.0017		0.0005	1.0000
Trooper Lite - High Tunnel	22.9988464	11	1.0000	0.0143	0.6365	0.0303	0.9269	0.0322	0.2073	<.0001	0.9990	0.0005		0.0039
Trooper Lite - Open Field	9.8714375	12	0.0018	1.0000	0.9730	1.0000	<.0001	1.0000	0.2614	0.9989	0.0134	1.0000	0.0039	



* Number close to zero indicate statistically significant differences between trial yields, numbers closer to one indicate a lack of significant difference.

DISCUSSION

- Trend lines in figure 1 indicate that both 'Arnold' and 'Maxifort' may be vigorous rootstocks since they have slopes greater than one.
- The slope of Arnold (1.48) was greater than that of Maxifort (1.28) indicating Arnold may be the more vigorous of the two (Figure 1).
- Plants with 'Trooper Lite', and 'RST 04-106' rootstocks had a slope of approximately 1 and performed similarly to the nongrafted plants, (Figure 1) indicating that they were neither more or less vigorous than the non-grafts.
- While the performance of all rootstocks was very similar in the open field, Maxifort outperformed all other rootstocks under high tunnel growing conditions (Figure 2 in blue).
- 'BHN RT1028' was the only rootstock whose productivity did not significantly increase under high tunnel growing conditions. (Figure 2 in red) This suggests a lack of vigor, as it does not take advantage of the improved growing conditions of the high tunnel.
- Performance changes corresponding to changes in environment demonstrate different levels of vigor (a plants relative ability as compared to other, similar plants to increase it's own productivity by utilizing beneficial aspects of the environment.)

FUTURE WORK

This work represents a meta-analysis of rootstocks using data from twenty-five trials across five years. We hope to utilize a larger data set (>100 trials) for further work. Among these data are the results of a wide variety of rootstocks, additional scion cultivars, varying degrees and types of pest and disease pressure, and a variety of management practices. This will allow us to identify rootstocks that consistently increase yield across diverse production systems. Furthermore, we expect to test a number of questions related to crop management, including the

effects of season length, soil fertility, planting density, and other practices to determine the best way to identify and maximize the benefit of grafting with vigorous rootstock. A larger data set will result in stronger evidence and the ability to draw more specific conclusions. Additionally, a more in-depth statistical procedure involving data transformation may be needed to clearly identify trends in the data.

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