The CERES Trust Organic Research Initiative Final Report
Project Title: Implementation of novel grafting methods and rootstocks for organic tomato growers in the Midwest
Reported by: Sarah Masterson & Dr. Cary Rivard
Report Year: 2012
Report Type: Final: Graduate Student Project
Start Date: 06/01/2011
End Date: 06/01/2012

Introduction

Although it is a burgeoning area of research in the United States, vegetable grafting has been shown to be an effective organic technique to combat soil-borne diseases, such as verticillium wilt, bacterial wilt, and root-knot nematodes. However, the current dearth of research and technology in the United States prevents small-acreage growers from buying grafted plants domestically, as most are produced in specialized nurseries in Canada and Asia. In addition to the cost of international shipping, research shows that the grafting process can create $0.75 of added cost per plant. This issue illustrates the necessity of further research and extension that develops grafting methods suitable for small and organic growers as well novel methods of grafting that increase the success and reduces the cost of propagating grafted transplants.

Throughout 2011 Dr. Cary Rivard and Sarah Masterson sought to address these issues. Their project – to be concluded in the spring of 2013 – intends to improve organic farming systems by utilizing host resistance/tolerance to soilborne plant pathogens where previously none were available, particularly for growers that utilize heirloom cultivars. This project furthermore seeks to make organic systems more productive and profitable by reducing disease epidemics in organic tomato production systems and testing for yield increases due to added vigor of inter-specific rootstocks.

Field trials performed in 2011 established several research trials at commercial and university farms. Experimental treatments consisting of non-grafted plants and grafted plants ('Maxifort' and 'Trooper' rootstocks) propagated with two tube grafting techniques (the traditional method and the "topping" method). The researchers aimed to determine the effect of this new technique on fruit yield, detrimental or otherwise. Fruit yield was collected and recorded weekly throughout the summer of 2011; biomass samples were harvested and measured at the conclusion of the growing season. The initial replication of this project conducted throughout 2011 yields interesting preliminary results.

Additionally, several trials designed to observe the effect of different rootstock varieties upon fruit yield were set up in Wichita and Manhattan, KS. Unfortunately, excessive heat and high variability in yield compromised any statistical analysis at these sites. Replication trials have been established for the 2012 year of data collection with more hope for success.

Objectives / Materials & Methods

These 2011 field trials utilize three complementary approaches that seek to evaluate the utility of grafting for organic growers in the Midwest and develop grafting methods for small-acreage and organic growers. The general Materials and Methods employed to address each Objective are described as well.

1) ***Evaluation of Rootstocks and Grafting for Tomato Growers in Kansas***: Multiple rootstocks were trialed at several on-farm and research station trials to determine the viability of grafting for organic production in the Midwest. These trials were arranged in a randomized complete block design (RCBD) and included four replications. The trials were conducted utilizing heirloom ('Cherokee Purple') and hybrid ('BHN 589') scion. These cultivars are highly

utilized in Kansas and throughout the United States, particularly for high tunnel production. A trial utilizing 'Cherokee Purple' scion was conducted at the Willow Lake Student Farm in Manhattan, KS. In addition to non-grafted 'Cherokee Purple', the tested rootstocks included 'Maxifort' (De Ruiter Seed Co.), 'Trooper' (Seedway Seed Co.), 'RST-04-106-T' (DP Seeds) and 'DRO 131', an unreleased De Ruiter rootstock. Each plot contained eight plants and four replications arranged in a RCBD. A similar trial was performed at the John C. Pair Horticultural Research and Extension Center near Wichita, KS. This trial utilized 'BHN 589' for non-grafted controls and for scions, as well as the same rootstocks tested in the Student Farm trial. Both trials were monitored for incidence of any major soilborne diseases and fruit yield and plant growth data (plant height and shoot biomass) were to be collected. However, due to extreme heat and a late planting date, neither trial yielded any significant results.

2) ***Healing Chamber Management and Grafting Methods for Success***: Various greenhouse experiments were conducted to determine the effects of healing chamber temperature and humidity on graft survival. Additionally, novel methods of grafted propagation were developed that cater towards production for small-acreage organic growers. These experiments were performed at Kansas State University in Manhattan, KS. Preliminary data has shown that removing the leaves of the scion reduces the water stress dramatically among the scion tissue, thereby increasing the success rate of the grafting procedure. Furthermore, using this method, growers may be able to carry out

Image 1 Standard vs. "topped" tube grafting

the grafting procedure without building specialized healing chambers. *Image 1* shows a plant 24 hours after grafting utilizing the standard tube grafting technique (left) as well as the modified tube technique (right) when the plants are not placed into a healing chamber. Interestingly, this evidence indicates that organic growers may be able to carryout on-farm grafting without the additional complication of healing chamber management.

In order to determine how healing chamber density and the "topping" method affect graft survival in the healing chamber, multiple identical batches of grafted plants were produced over time and analyzed in a RCBD, whereby each of the individual batches represented blocked replicates. Each batch (rep) of plants contained 1050 plants, and experimental design was in a split-plot RCBD design. Upon grafting, plants were placed into three healing chambers, which represented each of the three treatments (density). Chamber 1 contained 600 plants, Chamber 2 contained 300 plants, and Chamber 3 contained 150 plants. Each chamber was considered a main plot. Sub-plot treatments within each main plot consisted of both plants grafted with the standard tube-grafting method and plants grafted using the "topping" method. Temperature and humidity were monitored and recorded via electronic sensors, and measures were taken to reduce experimental bias of grafting success among multiple research assistants. After a period of roughly 10-14 days in the healing chamber, seedlings were removed from the chambers and counted for survival rates. This greenhouse experiment ran from February 2012 – May 2012 and results are currently being analyzed.

3) *Grafting Methods "follow-through" Studies*: We also tested the effect of utilizing a novel method of grafting on fruit yield by conducting studies at Gieringer's Orchard (Edgerton, KS), the Clark Family Farm (Buhler, KS), and the K-State Horticulture Research and Extension Center (Olathe, KS). In each of these trials, a RCBD were utilized with four replications and all

data was analyzed using the MIXED procedure (SAS 9.1; Cary, NC). All of these trials were managed organically and similarly to typical production practices in the region. In all cases, the treatments consisted of non-grafted plants, as well as those grafted with 'Maxifort' and 'Trooper' rootstocks. Furthermore, each of the rootstocks was tested with modified tube grafting technique discussed in objective two. The aim of this study is to determine the effect of this new technique on fruit yield and determine if this advanced technique has any detrimental effect on fruit production. The trials at the Gieringer's Orchard and the Olathe sites will be conducted in a high tunnel and will utilize 'BHN 589' for non-grafted controls and scions. The trial at the Clark family farm utilized 'Cherokee Purple' for scions and was conducted in the open-field; unfortunately, extreme heat limited fruit set and only plant height/biomass data were recorded.

Results & Discussion

Figure 1 displays the fruit yield data from the 2011 high tunnel trials at the Olathe Horticultural Research and Extension Center (OHREC) and Gieringer's Orchard. Harvested yields were separated and weighed based on marketability, as indicated by color on the bar graph. At both trials, there were significant increases in production of all grafted plants compared to nongrafted plants ($P<0.05$). At the commercial farm (*Fig. 1A*), data indicated a 125% yield increase with 'Maxifort' grafted tomatoes and 117% with plants grafted with 'Trooper' rootstocks. However, the 'topping' method appears to penalize the yield of those plants when grafted with 'Trooper'. This suggests that the required re-growth of the scion tissue after "topping" the plants resulted in less yield than standard grafting methods. The OHREC high tunnel shows a similar trend although differences in yield are less dramatic. Plants grafted with 'Maxifort' and 'Trooper' had significantly high yield than nongrafted plants ($P<0.05$), and the

minimum yield increase was 44%. In this case, the use of the "topping" method eliminated the

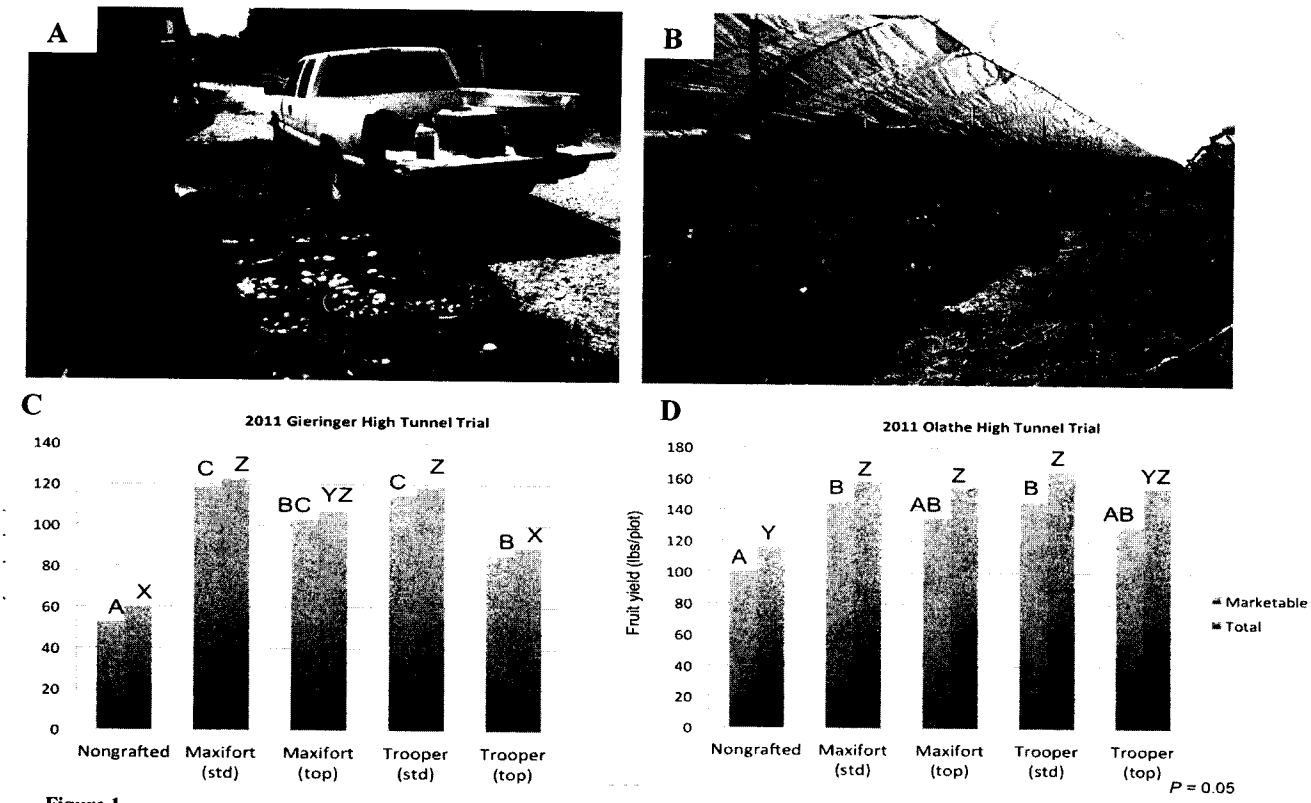

Figure 1. Fruit harvest at (**A**) Gieringer's Orchard and (**B**) the Olathe Horticultural Research Center. Marketable and total fruit yield of grafted and nongrafted plants at a commercial farm (**C**) and at the Olathe Horticultural Research and Extension Center (**D**). Plants were grafted with 'Maxifort' and 'Trooper' rootstocks (std = standard method, top = topping method).

statistical significance of the benefit of grafting in regards to marketable yield. Overall, both trials indicated that grafting with 'Maxifort' and 'Trooper' rootstocks significantly increased fruit yield ($P<0.05$). However, results regarding the impact of grafting methods upon yield suggest that top grafting has either an inconsistent or a negative impact upon yield. More research is required to determine how the role of leaf removal during the grafting procedure affects fruit production.

Figure 2 illustrates the effect of rootstock and grafting method on plant growth. One plant per plot was sampled, dried, and weighed to determine and compare biomass production among the various treatments. The data from the trials suggest that plants grafted with

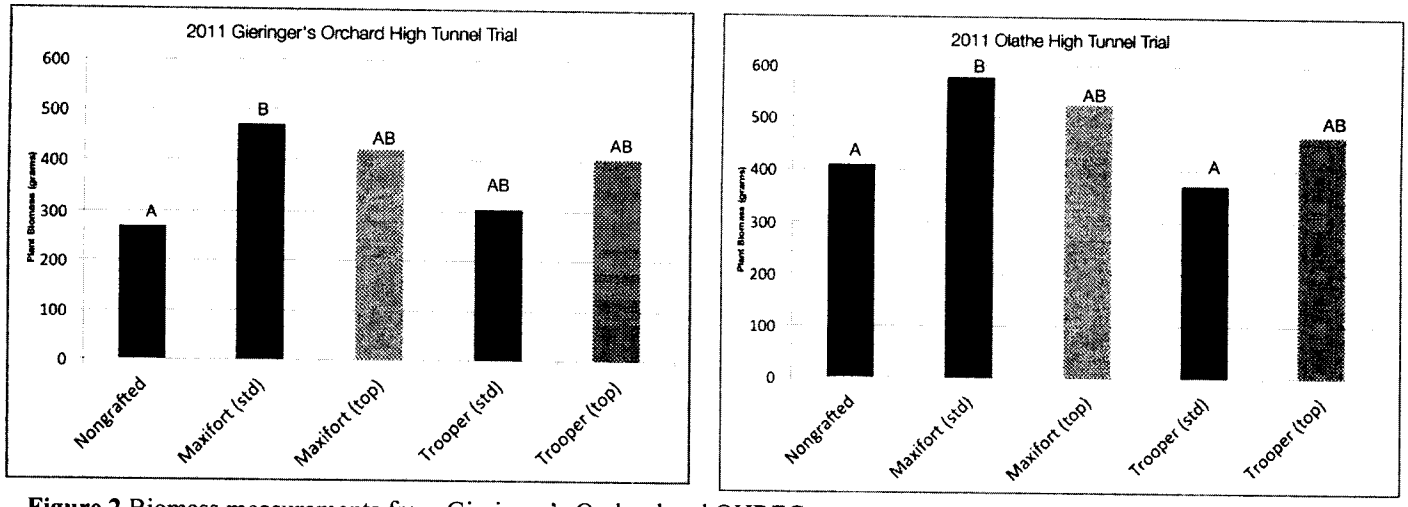

Figure 2 Biomass measurements from Gieringer's Orchard and OHREC.

'Maxifort' rootstocks grew larger and more vigorously, and this effect was significant at both locations ($P<0.05$). However, plants grafted with 'Trooper' had similar biomass than nongrafted plants. Interestingly, the effect of the "topping" method was not consistent across the two rootstocks. Biomass production of the 'Maxifort' grafts was penalized by the "topping" method, although this effect was not statistically significant. In contrast, biomass production of the plants grafted with the 'Trooper' rootstock was higher among the plants where the "topping" method was utilized, but it was not statistically significant. Similarly to the fruit yield data, more research is required in 2012 to determine if these trends are consistent across multiple locations and growing seasons.

This preliminary data suggests that grafting will be a highly advantageous technology for high tunnel growers in the Midwest. Because 2011 was the first year of trials for this project, another year of data will be collected before any firm conclusions can be drawn pertaining to the effect of grafting methods upon plant growth and yield. In particular, the "topped" plants showed somewhat inconsistent results across the board and will certainly benefit from a repetition of this experiment in 2012. Overall, the yield penalty that resulted from the "topping" method was less pronounced among the plants grafted with 'Maxifort' than those grafted with 'Trooper'.

Additionally, plant growth (biomass) was significantly higher among the standard 'Maxifort' grafts than the nongrafted plants. It may be that the added growth rate of the plants grafted with 'Maxifort' was able to compensate for the required re-growth needed for the "topped" plants. Further research is needed to determine what the effects of grafting methods are in regards to crop productivity.

Extension and Outreach

A comprehensive outreach program was utilized to communicate research results to stakeholders locally and nationally. A field tour was provided at the Wichita and Olathe sites during annual vegetable field days, as well as during a Kansas High Tunnels Bus Tour in Olathe, KS. Grafting workshops are also a part of the Growing Growers Farmer Workshop Series and will be open to the public, as there is a lot of interest in grafting in the region. Furthermore, Sarah and Dr. Rivard have also composed and distributed a summary of their 2011 field trial yield results to growers via both electronic and hardcopy versions at the Great Plains Vegetable Growers' Conference, and the aforementioned High Tunnel Bus Tour.

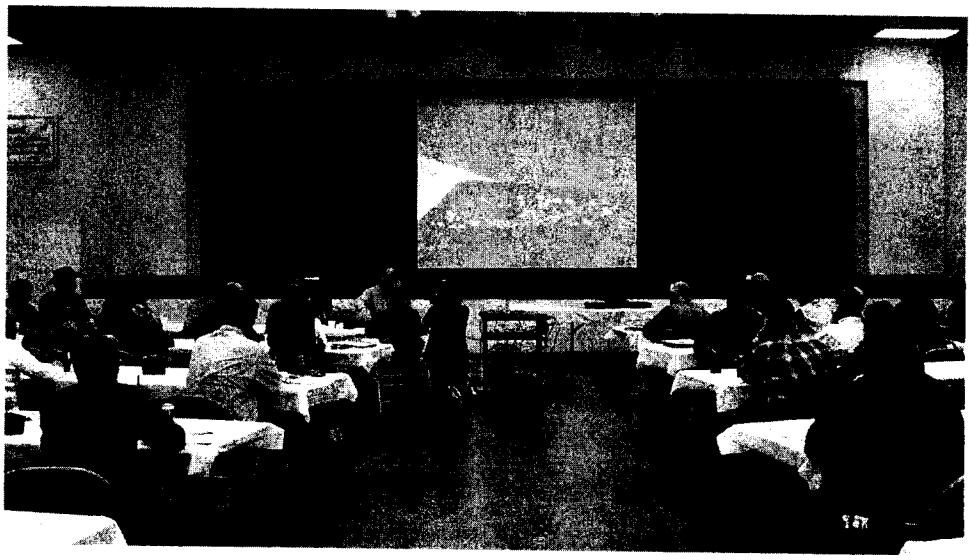

Image 2 Dr. Rivard demonstrating grafting procedure at the Central Kansas Market Vegetable Growers & Tomato Grafting Workshop earlier this year. Sarah Masterson also updated the attendees on her research and disseminated an extension flier describing her results.

Sarah Masterson's List of Presentations and Guest Lectures To Date

- Great Plains Grower's Conference – St. Joseph, MO; January 6, 2012
- HORT 560 Grafting Lab – KSU; February 14 & 16, 2012
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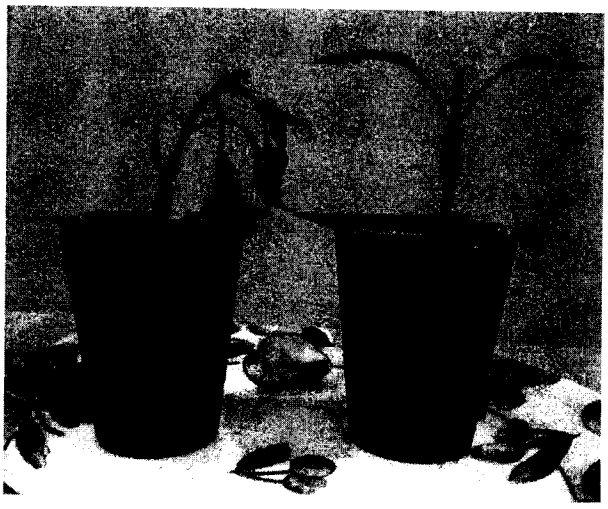

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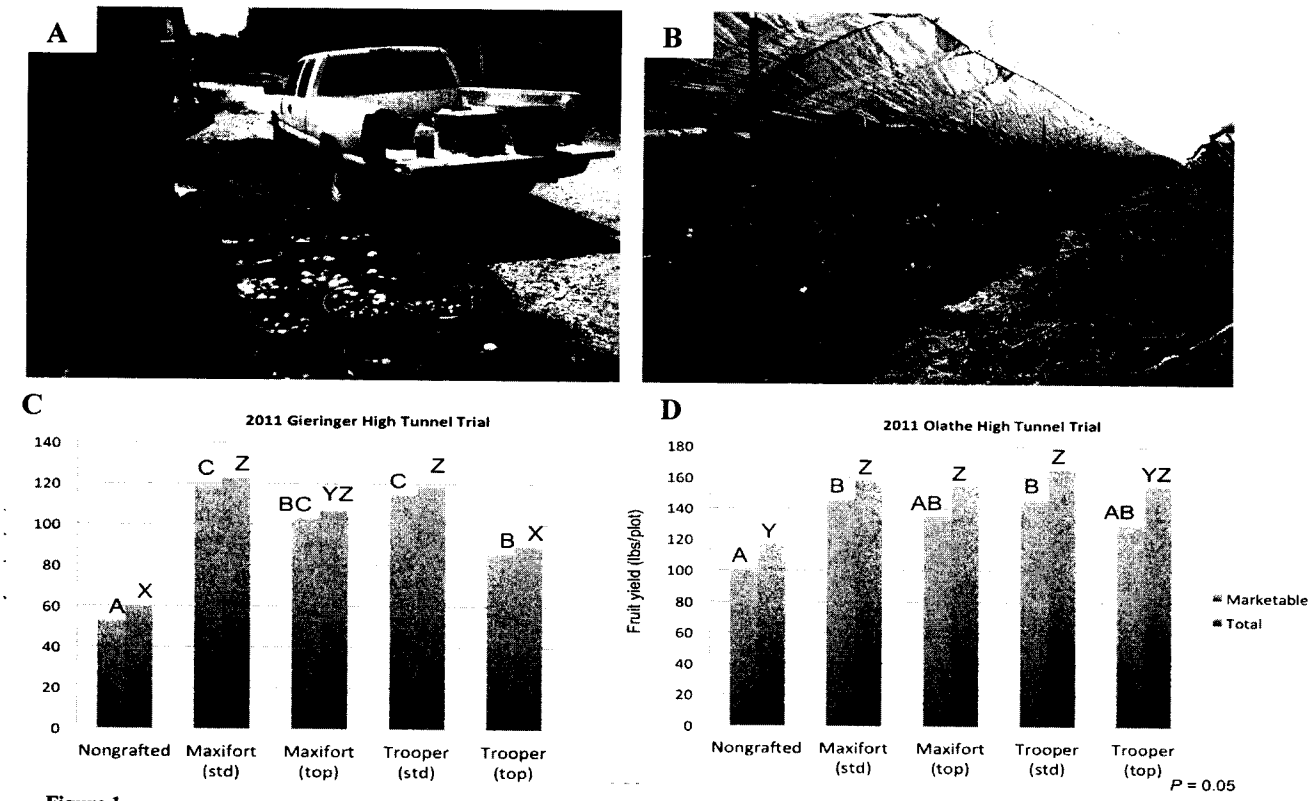

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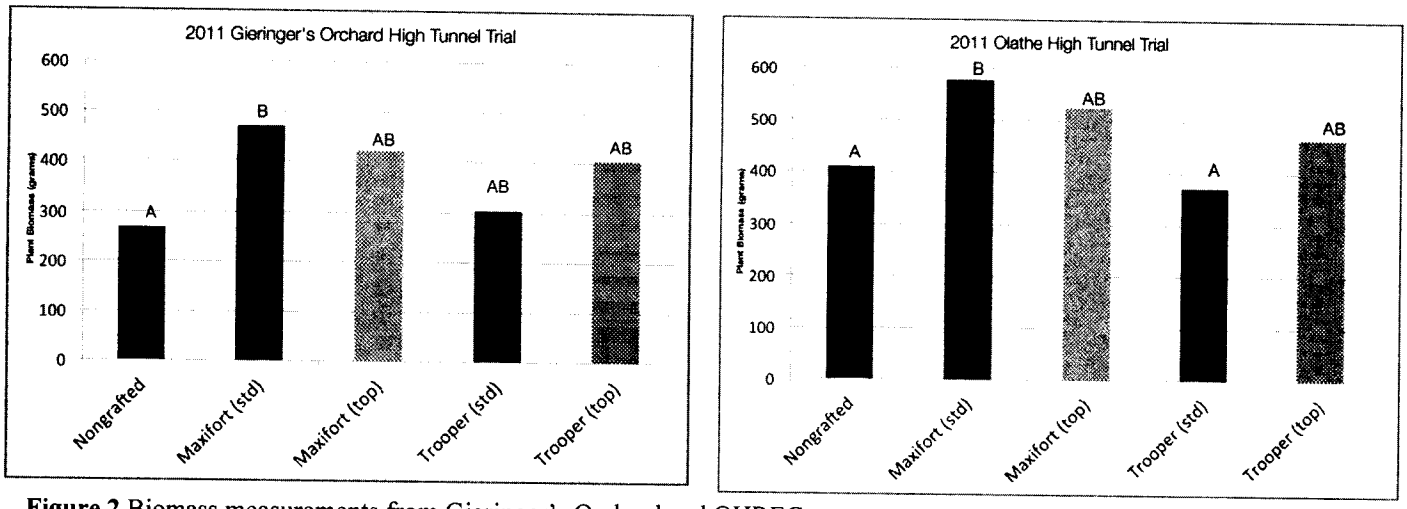

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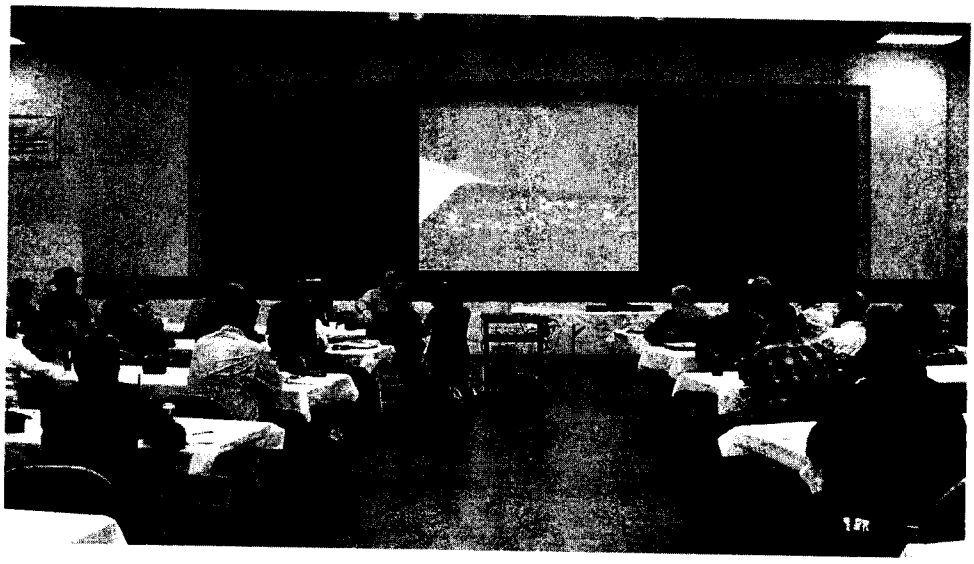

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