

Using Grafting Technology to Enhance Greenhouse Cucumber Production in High Tunnels

Final report for ONC17-027

Project Type: Partnership

Funds awarded in 2017: \$29,791.00

Projected End Date: 02/28/2019

Grant Recipient: Purdue University

Region: North Central

State: Indiana

Project Coordinator:

[Wenjing Guan](#)

Purdue University

Project Information

Summary:

Short growing seasons in the North Central Region limit farmers' participation in local food markets. High tunnels are valuable tools for season extension. Farmers who consistently grow tomatoes in high tunnels need additional high-value crops to increase the sustainability of the production systems. As a potentially promising alternative, greenhouse cucumbers are high-value and high-demand crops, but low soil temperatures in early spring limit its extended season production in high tunnel systems. This project introduces grafting technology with cold tolerant rootstocks to address this challenge. Nine farmers in Indiana and one farmer in OH have collaborated in the project. Fifteen on-farm trials were conducted in 2017 and 2018 spring production season. Grafted cucumbers enhanced transplant survival rate, and in most cases, increased early-season cucumber yield. The most pronounced effects were observed when cucumbers were grown in heated high tunnels that the crop was planted as early as in February. The estimated cost of the grafted transplants was about 2.3 times more expensive than normal cucumber transplant, but partial return analysis indicated that farmers growing the grafted plants is economically feasible. Results of the project were distributed to farmers through presentations, demonstrations at grower meetings, field days and newsletter articles. An extension bulletin and a video were developed to teach the grafting technology. Immediate outcomes of the project are improved yield and extended harvest duration of cucumbers grown in high tunnel systems. In the long term, the changes in farmers' activities increase the sustainability of high tunnel production system and increase farmer income.

Project Objectives:

Objective 1. Evaluate the effectiveness of using grafting technology to enhance early season production, control pests and increase the yield of seedless cucumbers grown in

high tunnel systems.

Objective 2. Determine the economic feasibility of integrating grafting technology into high tunnel greenhouse cucumber production systems.

Objective 3. Train farmers on cucumber grafting technique, and develop and deliver extension programs on the integrated use of grafting technology in growing greenhouse cucumbers in high tunnel systems in the North Central Region.

Cooperators

- [Bud Vogt](#)

bud@budsfarm.com

Buds Farm Market (Commercial (farm/ranch/business))

3301 S Weinbach Ave
Evansville, IN 47714

- [Jim Baughman](#)

jim@freedomvalleyfarm.com

Freedom Valley Farm (Commercial (farm/ranch/business))

2977 Steubenville Rd
Freedom, IN 47431

- [Candace Minster](#)

cminster@spsmw.org

White Violet Center for Eco-Justice (Nonprofit / non-governmental organization)

3850 U.S. 150 Saint Mary-of-the-Woods
Terre Haute, IN 47876

- [Becky Brubaker](#)

weatheredplow@privategarden.org

3106 East 300 north,
Camden, IN 46917
(574) 686-4194 (office)

- [John Raber](#)

guan40@purdue.edu

10847 east 1250 north
odon , IN 47562

- [Steve Willis](#)

williscrg@aol.com

Just Farmin
6887 Devon Dr
Middletown, OH 45044

- [Daniel Garcia](#)

farmerdan@garciasgardens.com

Garcia's Garden (Commercial (farm/ranch/business))
11717 E 42nd St,
Indianapolis, IN 46235

- [Dan Perkins](#)

perkinsgoodearthfarm@gmail.com

Perkins' Good Earth Farm (Commercial (farm/ranch/business))
(219) 869-5831 (office)

- [Elaine Dougherty](#)

guan40@purdue.edu

S & E Produce & Flowers (Commercial (farm/ranch/business))
320 Griffith Rd,
Greenwood, IN 46143
(317) 727-7432 (office)

- [Nathan parks](#)

neta@silverthorn-farm.com

Silverthorn Farm (Commercial (farm/ranch/business))
9870 North 430 West Roseville
Roseville, IN 46065

- [Dan Egel](#) (Researcher)

egel@purdue.edu

Purdue University

- [Ariana Torres](#) (Researcher)

torres2@purdue.edu

Purdue University

Research

Materials and methods:

Background information collection

We collected information from farmers regarding their preferred cucumber varieties and targeted transplanting date before the start of the production season. Most information was collected through personal visit, phone calls or email conversation. We talked to about 18 farmers who have grown cucumbers or plan to grow cucumbers in high tunnels. We also provided our recommendation regarding variety choice, cultural practices, and pest control approaches to farmers.

Producing grafted transplants

Cucumber transplants were produced at the Southwest Purdue Ag Center in Feb.-Mar. 2017 and 2018. Plants were grafted with one-cotyledon method. Briefly, the scion plant was cut at the hypocotyl and attached to the rootstock plant that has had one of the cotyledons and the apical meristem tissue removed. Grafted plants were healed in a healing chamber that was built on the greenhouse bench with polyvinyl chloride pipe frame and plastic film cover. During the first three days, temperatures inside the chamber were 28 ± 3 °C with relative humidity close to 100%. Relative humidity was gradually reduced after day 3 to around 60% after 6 d. Grafting survival rate was above 90%.



Grafted cucumber plants

Crop production and data collection

Cucumbers were grown following production practice used by each of the collaborating farmers. We prepared a pest management recommendation sheet and handed to farmers. We also provided farmers data entering sheet that can be easily used to record data and make notes on observation. Data loggers were installed on each site to automatically measure soil and air temperatures.

Table 1. Collaborate farms, and their production systems in 2017

Collaborate farms	Production system	Transplant date	Plant number per treatment	In-row spacing	Trellis system	Organic
Freedom Valley Farm	High tunnel	Mar. 27, 2017	17	30	Single leader	Yes, not certified

White Violet Center	High tunnel	Mar. 31, 2017	15	18	Trellis netting	Yes, certified
Bud's Farm Market	High tunnel	Mar. 31, 2017	5-23 depending on varieties	18	Single leader	Yes, not certified
Bud's Farm Market	Open field	Apr. 23, 2017	23	24	No trellis	Yes, not certified
Silverthorn Farm	High tunnel	Apr. 1, 2017		18	Single leader	Yes, not certified

Table 2. Cucumber varieties evaluated at each of the collaborate farms in 2017. The same number of grafted and non-grafted plants were grown at each site.

Collaborate farms	Corinto	Sweet Success	Excelsior	Socrates	Taurus	Diva
Freedom Valley Farm	Yes	Yes				
White Violet Center		Yes	Yes	Yes	Yes	
Bud's Farm Market		Yes		Yes	Yes	Yes
Silverthorn Farm	Yes					

Table 3. Collaborate farms, and their production systems in 2018

Collaborate farms or farmers name	Production system	Transplant date	Plant number per treatment	In-row spacing	Trellis system	Organic
Bud's Farm Market	Heated hightunnel	Feb. 27	Varied by variety	1'	One-leader	Organic not certified
The Weathered Plow farm and greenhouse	Heated hightunnel	Feb. 27	30	1'	One-leader	Conventional
The Weathered Plow farm and greenhouse	High tunnel	Apr. 11	Varied by variety	1'	One-leader	Conventional
S&E produce & flowers	High tunnel	Apr. 26	14	2'	One-leader	Conventional

Freedom Valley Farm	High tunnel	Mar. 30	Varied by variety	1'	Netting	Organic not certified
Perkins' good earth farm	High tunnel	Apr. 18	12	1'	One-leader	Organic not certified
White Violet Center	High tunnel	Apr. 23	15	1'	One-leader	Certified organic
John Raber	Heated high tunnel	Feb. 22	50	1.5'	One-leader	Conventional
Garcia's Garden	High tunnel	Apr. 10	20	1'	One-leader	Organic not certified
Steve Willi	High tunnel		20		One-leader	Conventional

Table 4. Cucumber varieties evaluated at each of the collaborate farms in 2018.

Collaborate farms	Corinto	Sweet Success	Excelsior	Iznik	Socrates	Taurus	County Fair	Diva
Bud's Farm Market	Yes	Yes			Yes			
Becky Brubaker	Yes				Yes	Yes		
Freedom Valley Farm	Yes						Yes	
Perkins' good early farm				Yes	Yes			
White Violet Center	Yes		Yes			Yes		
John Raber	Yes				Yes			
Garcia's Garden			Yes					Yes
Steve Willi	Yes				Yes			Yes

Research results and discussion:

What we found during background information collection

- Not all the farmers understand technical words commonly used to describe cucumber varieties.
- In terms of seedless cucumber varieties, Corinto is a popular slicing cucumber,

but growers are also interested in other types of cucumbers, particularly long-type cucumbers.

- In USDA hardiness zone 5 and 6, cucumbers were planted in end March to early May in unheated high tunnels. If heating is available, growers would target transplant as early as end Feb.

2017 results

The difference in the transplant survival rate of grafted vs. non-grafted cucumber plants was observed in the open-field trial at the Bud's farmers market. 52% of non-grafted Diva cucumber seedlings died 7 d after transplanting, while all the grafted Diva plants survived. Following transplanting, the lowest recorded air temperature on the site was 46 °F. Average air temperatures in the week following transplanting ranged from 52-73 °F. The observation indicated that grafted cucumbers are more likely to survive during suboptimal temperature conditions that often occur in the early spring.

Pronounced yield increase of grafted cucumbers was observed at White Violet Center. The highest yield increase was observed on Excelsior (159%). One of the reasons that lead to the dramatic yield difference was because of plant loss due to bacterial wilt. Almost all the non-grafted Excelsior plants were died because of bacterial wilt while more than half of grafted Excelsior plants were still producing in July (Fig. 1). Although the different response toward bacterial wilt of grafted vs. non-grafted cucumber plants was observed at the White Violet Center, no difference on plant survival under bacterial wilt pressure was observed at Freedom Valley Farm, at where, regardless of grafted or non-grafted plants, a tremendous amount of plants were lost due to bacterial wilt in June. Yield increase of other cucumber varieties ranged from 27% to 97% at the White Violet Center. Grafted plants had stronger stems compared to non-grafted cucumbers (Fig. 2) The farmer is very happy with the performance of grafted cucumbers.

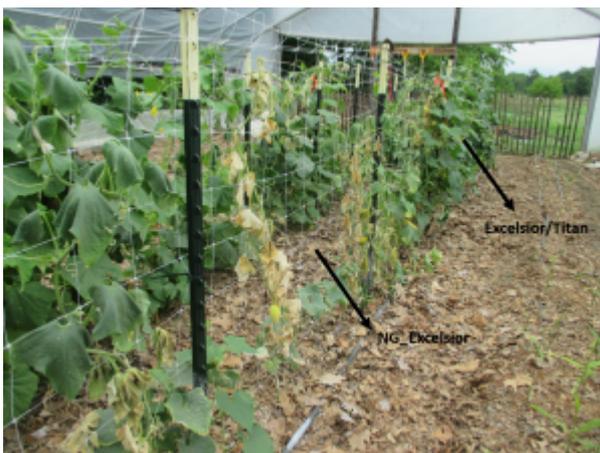


Figure 1. Non-grafted Excelsior and Excelsior grafted onto Titan rootstock in July 2017 in the trial at the White Violet Center.



Figure 2. Stems of a non-grafted cucumber plant on the left and a grafted cucumber plant on the right

Grafted Corinto increased yield by 6% at Freedom Valley Farm. As Corinto and Sweet Success seem to be more cold tolerant compared to other greenhouse cucumbers. Response of the two varieties to grafting in terms of the improved cold tolerance may be decreased. However, according to growers' observation, grafted plants were taller and more vigorous compared with the non-grafted plants.

Two trials were conducted at Bud's Farmers Market, one in a high tunnel and another one in the open-field. More than half of transplant failure of non-grafted Diva lead to a significantly lower yield of non-grafted plants compared to grafted Diva. The farmer also indicated that he normally planted cucumbers every 4-6 weeks. But growing grafted plants allow him harvesting cucumbers from June to Sep. with one planting, which dramatically saved his labor to grow transplants and field planting.

Insects netting was installed in the high tunnel at Bud's Farmers Market that effectively controlled cucumber beetles. No bacterial wilt was observed.

Unexpected, we saw a negative effect of grafting in this trial. Yields of grafted plants were lower than non-grafted plants with all the evaluated varieties. We suspect it is the poor quality of grafted plants that lead to the lower yields. It is possible that the grafted plants were not fully recovered before planted in the high tunnel at Bud's Farmers Market. The trial will be repeated at the same site in 2018, which could provide us more opportunities to better understand why grafting did not work in this case.

Table 1: Cucumber yield at the Freedom Valley Farm (Harvest duration: May 5 --- June 17)

Treatment	Lb	Num	Lb per plant	Num per plant
NG_Corinto	89.52	152	5.26	8.94
Corinto/Titan	94.84	164	5.57	9.65
NG_SS	129.35	135	7.61	7.94
SS/Titan	137.24	153	8.07	9.00

Table 2. Cucumber yield at the White Violet Center (Harvest duration: May 12-July 19)

Treatment	Lb	um	Lb per plant	Num per plant
NG_Excelsior	37.33	133	2.49	8.87
Excelsior/Titan	96.79	298	6.45	19.87
NG_Socrates	87.63	125	5.84	8.33
Socrates/Titan	172.37	238	11.49	15.87
NG_SS	71.38	83	4.76	5.53
SS/Titan	88.17	101	5.88	6.73
NG_Taurus	39.2	64	2.61	4.27
Taurus/Titan	49.89	68	3.33	4.53

Table 3. Cucumber yield of high tunnel trial at the Bud's farmers market (Harvest duration: May 1-June 13)

Treatment	Lb	Num	Lb per plant	Num per plant
NG_Diva	26.1	30	3.7	4.3
Diva/Titan	26.3	35	3.7	5
NG_Socrates	38.9	66	7.78	13.2
Socrates/Titan	18.9	40	3.78	8
NG_SS	136	169	5.90	7.34
SS/Marvel	127.8	166	5.55	7.21
NG_Taurus	33.6	42	6.72	8.4
Taurus/Titan	24	36	4.8	7.2

Table 4. Cucumber yield of open-field trial at the Bud's farmers market (Harvest duration: June 5-Sep 15)

Treatment	Transplant survival	Lb
NG_Diva	48%	325.2
Diva/Titan	100%	493.55

2018 results

Ten on-farm trials were conducted in 2018. We will discuss the results of two major production systems.

Heated greenhouses

A pronounced advantage of using grafted cucumbers was observed in the situations that cucumbers were grown in soils in heated greenhouses. Trials were conducted in three greenhouses across Indiana. Cucumbers were planted in soils at the same time as early tomatoes were planted at the end of February. Soil temperatures

across the three sites were in the lower 60°F in March, and 2 to 3 degrees higher in April. All the cucumber plants survived transplanting. At John Raber's farm, the non-grafted cucumbers struggled badly and never seemed to put out new growth (Figure 3). The grower eventually decided to take out all the non-grafted plants and replanted cucumbers later in the season.

At the Weathered Plow farm, a pest damaged cucumber stem right above soil-line that caused about 30% plant loss at the end of March (Figure 4). The grower also noticed that non-grafted cucumber plants had premature blooms, considerably earlier than the grafted plants. The observation indicated that the non-grafted plants were suffering from environmental stresses. Harvesting started in early April, mainly from grafted plants. Yields (per plant basis) from the remaining non-grafted plants were 65% and 39% lower compared to the yields of grafted ones in April and May (Table 5).

Table 5. Yield per plant of non-grafted Corinto and Corinto grafted onto Titan rootstock at the Weathered Plow farm.

Treatment	Apr.	May	June	Total
Corinto non-grafted	0.58	2.14	3.14	5.86
Corinto grafted onto Titan	1.56	3.52	3.06	8.14

The growers commented that they have never harvested cucumbers that early, and they were very happy about the yield of the grafted plants. Although this is a favorable situation, some growers may face the challenge of finding buyers in April as most farmers' markets in Indiana do not open until May. Another problem expressed by the grower is that they are uncertain about how to price the cucumbers in the early months.



Figure 3. Non-grafted cucumbers are in front of the row, grafted cucumbers are in the back.



Figure 4. The damaged stem of a non-grafted cucumber plant.

Unheated high tunnels

Another significant benefit we observed on grafted cucumbers is a higher transplant survival rate under lethal soil temperatures in the spring in unheated high tunnels. Newly planted cucumber seedlings may wilt and die when average soil temperatures were around 55°F for two or more nights depending on the variety, the status of the seedlings, and temperatures during the day. A significant amount of plants will be lost if average soil temperatures are in the lower 50°F range. An advantage of using grafted cucumbers is that they are likely to survive in these lethal soil temperatures. Jim Baughman at Freedom Valley Farm commented that he is really amazed by the hardiness of the grafted plants. He lost more than 70% of non-grafted cucumber plants but none of the grafted ones after transplanted on March 31, 2018, in an unheated high tunnel. He reported a low air temperature inside the high tunnel at 21°F one morning in early April 2018. Data loggers recorded minimal air (under row covers) and soil (4''-depth) temperatures were 33°F and 48°F in his high tunnel after transplanting.

Undoubtedly, Jim is very experienced at managing temperatures in an unheated high tunnel in the spring. But still, there is an extremely high risk of losing all the plants when temperatures dropped to that level. Actually, this is exactly what happened at the Perkins' good earth farm. The temperature around the plants dropped to 28°F, that temperature killed all the cucumber plants regardless of whether grafted or not.

Using grafted plants provides a higher chance for seedling survival if frost occurs after transplanting. This is surely an advantage of using grafted plants. However, we realize that in reality, growers may not take the risk of planting cucumbers in an unheated high tunnel if frost is expected shortly after transplanting. Most growers may wait until the frost has passed. So that they may not benefit from a higher transplant survival rate of grafted plants under lethal soil temperatures.

The next question is whether grafted plants bring higher yield if they were planted after the spring frost passed. Not surprisingly, we found this is very weather-dependent. In 2018, we experienced an unusually cold April. Most growers delayed planting cucumbers in unheated high tunnels till about end April. May is quite warm in 2018. Average soil temperatures were in the upper 60°F in May and stayed above

70°F in June and July in our trials across Indiana. We saw little difference in plant growth and yield between grafted and non-grafted cucumbers. While in 2017, cucumbers were planted on March 31 and successfully established in two growers' unheated high tunnels. Growers reported more vigorous and healthier looking grafted plants compared to non-grafted. Yield improvement ranged from 6% to 159% depending on varieties. In the situations that yield on grafted plants was almost doubled compared to non-grafted cucumbers, this was due to plant loss caused by bacterial wilt. However, we did not see differences in susceptibility to bacterial wilt between grafted and non-grafted cucumbers on other farms.

Table 6. Yield per plant of non-grafted and grafted Iznik and Socrates at the Perkins Good Earth Farm.

Variety	Treatment	June	July	Total
Iznik	Non-grafted	2.19	6.78	8.97
Iznik	Grafted with Marval rootstock	2.43	8.11	10.54
Socrates	Non-grafted	2.52	9.49	12.02
Socrates	Grafted with Marval rootstock	2.91	9.62	12.53

Table 7. Yield per plant of grafted and non-grafted Corinto at S&E Produce & Flower farm.

Treatment	May to June
Non-grafted Corinto	7.78
Corinto grafted onto Marval	8.14

More questions need to be answered

A big surprise to us is that we noticed grafted plants were less healthy, and yield was reduced on grafted plants at Bud's Farmers Market. The same trend was observed in both 2017 and 2018 at the same high tunnel. A unique situation for this greenhouse was very high, above 8 soil pH and relatively higher soil salinity. We suspect the grafted plants may be more susceptible to high soil pH and salinity. Further research in this area is needed.

The observation that unexpected pest damaged stems of non-grafted cucumber plants but not the grafted plants in one greenhouse was a surprise. Unfortunately, we were not able to catch the pest and confirm it, but according to our entomologist, the damage looked like it was caused by seedcorn maggot (Figure 4), which is a common pest that occurs in early spring when the soil is cool. We would like to confirm this observation and understand why this happens.

Economic analyses

We estimated the cost of grafted cucumber plants is about \$1.36 per plant, which is 2.3 times more expensive than the normal cucumber plants.

Table 8. The estimated cost of grafted vs. normal cucumber plants

Item		Grafted		Non-grafted	
		Materials ^x	Labor ^y	Materials	Labor
		(\$/1000 plants)		(\$/1000 plants)	
Seeds	Scion (Socrates)	\$416.25	-	\$333.00	-
	Rootstock	\$168.75	-	\$0.00	-
Seedling production	Potting soil	\$55.00	-	\$22.00	-
	Flats	\$52.50	-	\$21.00	-
	Seed sowing and care	-	\$105.67	-	\$42.27
Grafted transplant production	Grafting labor	-	\$131.87	-	\$0.00
	Grafting clips	\$119.40	-	\$0.00	-
	Grafting supplies (razor blade, sanitizer, paper towels etc.)	\$16.25		\$0.00	
Post-graft healing	Grafting chamber	\$68.70		\$0.00	
	Humidifier	\$50.00		\$0.00	
	Post-graft care		\$38.07		\$0.00
	Greenhouse heating	\$140.00		\$0.00	
Subtotal		\$1,086.85	\$275.61	\$376.00	\$42.27
Total Costs		\$1,362.46		\$418.27	
Cost/plant		\$1.36		\$0.42	

Then we conducted partial return analyses based on yield results from research trials conducted from 2016-2018. The analyses indicated that assuming all the production costs, except transplant cost, are the same for growing grafted and non-grafted cucumbers. Growers can make more money in growing grafted plants (Figure 5). This analyses used a flat cucumber price \$1.5/lb and did not consider potential premium price in the early season. We are conducting more in-depth studies to evaluate the economic feasibility of using grafting technology in high tunnel cucumber study.

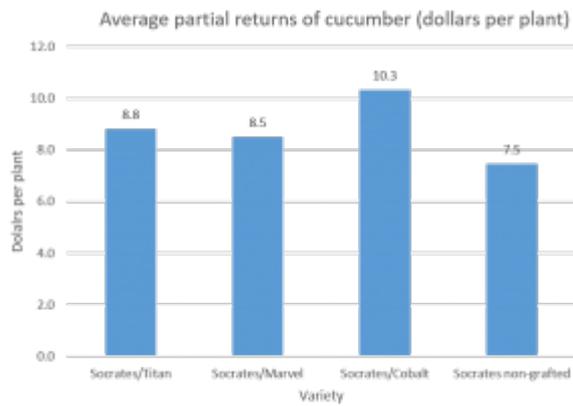


Figure 5. Average partial returns of cucumbers.

Participation Summary

10 Farmers participating in research

Educational & Outreach Activities

18 Consultations

2 Curricula, factsheets or educational tools

14 On-farm demonstrations

6 Published press articles, newsletters

5 Webinars / talks / presentations

3 Workshop field days

2 Other educational activities: Invited collaborate farmers visit Southwest Purdue Ag Center facility to participate in the grafting; Trained university students and international visitors about cucumber grafting

PARTICIPATION SUMMARY:

275 Farmers

35 Ag professionals participated

Education/outreach description:

Extension bulletin and video demonstrating cucumber grafting technology

A factsheet *How to Splice Graft Cucumber Plants* was published through Purdue Extension. The publication can be downloaded free at <https://mdc.itap.purdue.edu/item.asp?itemID=23252>

A video *How to Splice Graft Cucumber Plants* was published through Purdue Extension. The video is available at

<https://www.youtube.com/watch?v=z-tXoobiMnY&t=10s>

Published press articles, newsletters

Cucumber grafting on-farm trials conducted at the White Violet Center was showcased at the Eco-Justice Natural day event. Indiana public media participated in this event, and reported the cucumber grafting project. The radio show and the report can be accessed at

<https://indianapublicmedia.org/eartheats/grafting-cucumbers-pickling-radishes/>

Vegetable Crops Hotline Newsletter. Issue 653. *Learn How to Graft Cucumber and Tomato Plants*

<https://vegcropshotline.org/article/learn-how-to-graft-cucumber-and-tomato-plants/>

Vegetable Crops Hotline Newsletter. Issue 652. *Are You Interested in Participating in a Grafted Cucumber Study?*

<https://vegcropshotline.org/article/are-you-interested-in-participating-the-grafted-cucumber-study/>

Vegetable Crops Hotline Newsletter. Issue 652. *Growing Grafted Cucumbers for Early Season Production in Protected Cultural Systems - Lessons Learned from on-farm Trials.*

<https://vegcropshotline.org/article/growing-grafted-cucumbers-for-early-season-production-in-protected-cultural-systems-lessons-learned-from-on-farm-trials/>

Vegetable Crops Hotline Newsletter. Issue 640. *Check Soil Temperatures before Planting Cucumbers in a High Tunnel.*

<https://vegcropshotline.org/article/check-soil-temperatures-before-planting-cucumbers-in-a-high-tunnel/>

Vegetable Crops Hotline Newsletter. Issue 637. *Are You Interested in Growing Greenhouse Type Cucumbers in High Tunnels, and Targeting for Early Season Production?*

<https://vegcropshotline.org/article/are-you-interested-in-growing-greenhouse-type-cucumbers-in-high-tunnels-and-targeting-for-early-season-production/>

Tours

2018 Southwest Purdue Agricultural Center High Tunnel Tour (attendance 25)

2017 Southwest Purdue Agricultural Center High Tunnel Tour (attendance 35)

2017 Southwest Purdue Agricultural Center Field Day (attendance 70)



Takes and Presentations

2019 Indiana Small Farm conference. *Cucumber grafting*. Danville, IN. Mar. 2019. (Attendance: 25)

2019 Indiana Small Farm conference. *Cucumber grafting demonstration*. Danville,

IN. Mar. 2019. (Attendance: 50)

Indiana Hort Congress. *Seedless cucumber: another high-value crop for high tunnels and what grafting could do*. Indianapolis, IN, Feb. 2019. (Attendance: 34)

Illiana Vegetable Growers Symposium. Cucumber production in high tunnels. Schererville, IN. Jan. 2019. (Attendance: 33)

Parke County Vegetable Growers Meeting. *Cucumber production in high tunnels*. Marshall, IN. Dec. 2018. (Attendance: 33)

Other Activities

We invited collaborate farmers visit Southwest Purdue Ag Center facility during the period when we were producing grafted transplants. Mr. Bud and Jim, and Ms. Candace visited us. They learned the cucumber grafting technique. They all indicated that they are very interested in using this technique at their farms.

In addition to farmers, we trained university students and international visitors about cucumber grafting at the Southwest Purdue Ag Center in Nov. 2017. The audience included 14 undergraduate student from Vincennes University and 3 visitors from Herat University, Afghanistan. They showed a strong interest in learning this technique (Fig. 4).



Figure 4. Dr. Wenjing Guan taught cucumber grafting to undergraduate students from Vincennes University at Southwest Purdue Ag Center in Nov. 2017

On-going Activities:

We are working with individual farmer to set up grafting facility at their own farm. At least three collaborate farmers expressed interest. We will develop specific protocols depending on the unique situation of each farm. The goal of the effort is to help farmers successfully grow their own grafted plants.

Learning Outcomes

50 Farmers reported changes in knowledge, attitudes, skills and/or awareness as a result of their participation

Key changes:

- Importance of soil temperatures in cucumber production
- The benefit of using grafting technology in cucumber production

- Cucumber grafting technique

Project Outcomes

- 23** Farmers changed or adopted a practice
- 2** Grants received that built upon this project
- 6** New working collaborations

Project outcomes:

Immediate outcomes of the project are improved yield and extended harvest duration of cucumbers grown in high tunnel systems in the North Central Region. Introduction of the new technology made high tunnel cucumber production more profitable and encouraged farmers to grow cucumbers as a rotational crop to tomatoes. In the long term, the changes in farmers' activities increase the sustainability of high tunnel production system and increase farmer income.

Information Products

- [Are You Interested in Growing Greenhouse Type Cucumbers in High Tunnels, and Targeting for Early Season Production? \(Article/Newsletter/Blog\)](#)

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture or SARE.



Sustainable Agriculture
Research & Education [US Department of Agriculture](#)



This site is maintained by SARE Outreach for the SARE program and is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award No. 2019-38640-29881. SARE Outreach operates under cooperative agreements with the University of Maryland to develop and disseminate information about sustainable agriculture. [USDA is an equal opportunity provider and employer.](#)