1) Project name and contact information

The comparison of trellis-grown cucumbers and tomatoes versus free-standing plants, on three types of mulch, for disease severity and yield.

FNE03-496
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2) Goals

This project compared trellis-grown cucumbers and tomatoes with free-standing plants, on three types of mulch, for yield and disease severity. One goal was to determine if using a trellis system was beneficial, in terms of fruit quality, yield, disease and insect prevention. Another goal was to determine if one mulch type was better than another, in terms of weed control and holding moisture in the soil. The overall goal of this project was to find the advantages and disadvantages of growing organic cucumbers and tomatoes on a trellis system with various mulches and share this information through a valuable outreach program with other farmers, extension agents and other interested individuals.

3) Farm profile

This research project was conducted on a 110-acre farm that sits between Wills Mountain and Evitts Mountain, which are both part of the Appalachian Mountains. It is located in south-central Pennsylvania, in the tri-state area of West Virginia, Pennsylvania and Maryland. Approximately 65% of the farm is forested. It is owned by part-time farmers, Kristie and Jim Schwartz, who currently farm approximately 20 acres of hay and 1 acre of organically grown vegetables.

4) Participants

Kristie Schwartz served as the project leader for this research. Her role was to oversee and conduct all steps of the project. Duties included preparation of research site, planting, monitoring, harvesting, collecting, recording and analyzing data, and conducting the 'outreach' activities.

Dr. James B. Kotcon, Associate Professor of Plant Pathology of West Virginia University's Division of Plant and Soil Sciences, served as technical advisor for this project. His roles in this project were to provide consultation on pre-planting, disease and insect monitoring and identification throughout the season, and statistical analysis of the data collected at the end of the season.

5) Project activities

This research project evaluated ways of growing organic cucumbers and tomatoes on trellis systems. In May, Dr. Kotcon visited the site to help select the best area to maximize light efficiency to all plots. This layout was revised from the original layout submitted due to the excessive amount of rain this spring. Two (2) 300' long beds, approximately 3' wide, were prepared for the planting of 180 'Marketmore 76' cucumbers and 180 'Jetstar' tomatoes. The beds were comprised of ¾ topsoil and ¼ compost.

Next, organic transplants were purchased locally from a grower near Penn State University, PA. On June 10, they were planted in random plots of five (5) plants per plot. Each 'plot' (for example: trellised tomatoes with hay as the mulch) was replicated six (6) times. This gave us a total of thirty (30) plants per treatment, which strengthened the statistics and validity of the design. The treatments were as follows: 2 crops (cucumber and tomato) x 2 trellis (with vs. without) x 3 mulch types (hay, shredded newspaper, and crushed leaves). These mulches were chosen because they are both accessible and inexpensive for farmers to use. The mulches were applied immediately after planting at a 3" thickness. It took four (4) people approximately three (3) hours to apply the mulch. It should be noted that the shredding of the newspaper took about eight (8) hours, which was more time consuming than expected. It is recommended that an industrial size shredder should be used instead of a standard paper shredder. The paper shredding was done in the early springtime.

Following the planting of cucumbers and tomatoes, the trellis system was built into place. First, sixty-four (64) 8' posts were pounded into the ground 2' deep with a hand post-pounder. One post was placed between each plot. Two types of posts were used: angle iron and T-posts. It was determined that the angle irons are better suited for the trellis system because they held the wire better and they have holes which made them easier to string the wire (clips had to be added to the T-posts to attach the wire). There were also six 8' locust posts secured into each row (2 being used as endposts) for support and stability. Then, three 12.5 gauge wires were strung down each row. The first wire was strung 2' off the ground, the second wire strung at 3.5' off the ground, and the third wire was strung at 5' off the ground. Each strand of wire had one wire tightener placed midway down the row. This entire trellis building process took sixteen (16) hours, broken up into two (2) days, with two (2) people working on it.

The next step was to tie up half of the research plants up on the trellis. A total of 90 cucumbers and 90 tomato plants were tied to the wires. We had to wait until the plants were tall enough, which was in mid- July, to tie up the plants. It took four (4) hours for two (2) people to tie up the plants onto the three (3) strands of wire. Baler twine was used to tie the plants to the wire. The plants were fairly easy to tie up – there was little breakage while attaching them to the wire.

6) Results

Data was collected on the twelve (12) different treatments throughout the harvest season. It was randomly collected from each of the six (6) plots that comprised each treatment. The data collected each time was 1) weight of vegetables per treatment, 2) total number of vegetables harvested per treatment, 3) quality rating of vegetables per treatment, 4) soil temperatures, 5) soil moisture content, 6) hours spent weeding each treatment.

After all the data was collected, a statistical analysis system (called JMP) was used to analyze results. In summary, the trellis increased cucumber and tomato quality ratings significantly, but did not affect fruit weights, number or total yield, or soil moisture or soil temperature. The hay mulch produced higher quality ratings in both cucumber and tomato than did the newspaper mulch. Quality of tomato fruits on leaf litter was less than that on newspaper in trellised tomato, but was greater than newspaper on free-standing tomato (un-trellised).

Trellised cucumbers were a darker green, more uniform in color, longer and more slender, with little or no blemishes and far less insect damage. Non-trellised cucumbers were shorter, fatter, yellow on the bottom, more blemished and had more insect damage. Trellised tomatoes were perfectly round, uniform in color, had fewer cracks, blemishes and less insect damage. Non-trellised tomatoes were not uniform in shape, had many more cracks and blemishes and far more insect damage. Among both trellis and non-trellis, the hay mulch produced better quality fruits than the leaf litter and shredded newspaper.

Yield was the highest among the hay mulch, in both the trellised and non-trellised plots. Fruit numbers and fruit weights tended to be lower on newspaper mulch than the other mulches, resulting in lower total yield per treatment, but differences were not usually statistically significant. The interpretation of lower weights in cucumber is difficult, because large, over-size fruits are rated as lower quality. Thus, the lower weights of trellised cucumber than free-standing may be especially misleading. The weights of fruits had no correlation with the quality of fruits.

Because newspaper mulch produced the lowest average quality of cucumber fruits, as well as lower weights and numbers, it appears that newspaper is a poor choice under this year's conditions. Because 2003 was an exceptionally wet year, and newspaper produced the highest soil moisture readings, the yield and quality responses may have been due to over-saturated soils. Newspaper mulch had the highest soil moisture readings on both tomato and cucumber, and the differences were not affected by trellising. It also created an excellent habitat for slugs. Newspaper may perform better during a drought year when the higher soil moisture produces a yield or quality response.

An unexpected observation noted throughout the harvest season was that the trellised plants showed signs of stress in late August, appearing more wilted than the non-trellised plants, possibly due to wind abrasion. Also, there was no significant effect on disease control between the trellised and non-trellised plants. None of the cucumbers were affected by disease and a small portion of tomatoes were affected by early blight and Septoria leaf spot in October. Finally, soil samples were collected on each of the treatments at the end of the season. It was

expected that the treatments with the leaf mulch would have a higher nutrient content since, by early September, approximately 75% of the leaf litter mulch had decomposed. However, there were no significant differences in any of the treatments' soil sample results.

Weeds were pulled on the plots five (5) times throughout the growing season to determine which mulch type is best for weed control. Minutes spent weeding each treatment was timed by a stop watch. The data results showed that the hay mulch had the least time spent weeding (195 minutes throughout season), however, shredded newspaper mulch was close behind (200 minutes). The mulch with most time spent weeding was shredded leaves (304 minutes). There was no significant difference in weed control between cucumbers and tomatoes. Also, there was no significant difference between weeding trellis and non-trellised plots, meaning that the shading effect of plants had no significance on weed populations.

The advantage of using a trellis system for tomatoes and cucumbers is it produces a higher quality, more uniform fruit, allows for less insect damage and makes it easier to harvest fruits on the vines. The disadvantage of a trellis system is it takes time and money to build and it becomes a permanent structure in the field. Overall, since weeding time tended to be lowest with hay mulches, and yield and quality were highest, the results suggest that the combination of trellis and hay is the preferred management approach for both tomato and cucumber.

7) Conditions

2003 was one of the wettest seasons our region has had. Bedford County received over 40 inches of rainfall. In these growing conditions, the shredded newspaper held a lot of moisture. It provided an excellent habitat for slugs and proved to be a poor mulch in a very wet growing season. However, it may be an excellent mulch in a dry season. Overall results may differ in a drought season.

8) Economics

The data collected from this project was mostly from a scientific standpoint, focusing on quality and yield of fruits, as well as interaction with mulches. Data was not collected to determine the market value of fruits. However, the grower was able to get a better economic return from the trellised fruits versus the non-trellised fruits.

As previously noted, both tomatoes and cucumbers grown on the trellis system were of higher quality. The higher quality cucumbers sold for $0.50 each, while the non-trellised, lower quality cucumbers sold for $0.33 each. Higher quality (trellised) tomatoes sold for $1.25/lb, while the lower quality tomatoes sold for $1.00/lb.

The entire trellis system cost $735.00 to put into place. To grow 360 plants, that costs approximately $2.00 per plant. The economic input is heavy in the first year; however, the trellis system should last several years. If a grower is looking to grow high quality tomatoes and cucumbers, a trellis system will help them achieve that goal.

9) Assessment

The results from project generated some new ideas. One idea is what other plants would benefit from growing on the trellis system with the cucumbers and tomatoes. Some possible candidates could be beans, peas, squash, gourds, peppers, eggplant, zucchini. Another possibility that the grower would like to try on the trellis system is small fruits, such as blueberries, raspberries or blackberries. They would be more permanent, just like the trellis system.

The next step to solve the problems that this project addresses is to focus on the economic findings in the data results. The grower will revise her data collection techniques to get significant data to determine the market values of each treatment.

Results from this experiment suggest that another trial should involve yield data collection that evaluates quality differences. Observations from these preliminary results indicate that differences in produce quality are more important than yield differences, and future trials are needed to focus on this aspect

10) Adoption

The grower will be using this practice for several years. As previously mentioned, the grower will experiment with growing other vegetables, and possibly small fruits, on the trellis system. Cucumbers and tomatoes will definitely continue to be grown on the trellis system as well.

One revision will be to try a green manure as a mulch. The newspaper mulch did not seem like an efficient mulch. It was time consuming to shred and also time consuming to remove at the end of the season.

Otherwise, this practice will be used to continue to grow high quality vegetables and the grower will look for any new problems that may arise. Economic findings will be an important aspect of this practice in the future growing seasons.

11) Outreach

In July, the project leader displayed a poster board describing the cucumber and tomato research project at West Virginia University's Organic Research Farm Field Day, which is an annual event. Besides the poster board display, brochures for the upcoming 'field days' were distributed to the many visitors. There was a high interest level among the visitors in the SARE funded research project.

Throughout August and September, four (4) free 'field days' were held at the research site. Visitors received a tour of the research site, a handout of Frequently Asked Questions (EXHIBIT A), and a handout with space to take notes on each of the treatments observed (EXHIBIT B). Each of the treatments was labeled with a laminated sign that informed visitors which treatment it was and the advantages/disadvantages observed with that treatment. These signs made it easier for visitors to compare the different treatments. All steps involved with the research project were shared with the visitors. Visitors also had the opportunity to harvest from the various treatments to allow them to make their own judgment if one harvest method had an advantage over the other. The 'field days' were fun and successful, and visitors left with a new perspective on trellis systems and mulch types for cucumbers and tomatoes.

The 'field days' were advertised by delivering brochures to various places throughout the tri-state area of Pennsylvania, Maryland, and West Virginia. They were delivered to county extension agencies, farm bureaus, and farm supply stores. They were also posted locally at grocery stores and gas stations. The brochures were also mailed to the agricultural departments of Penn State University and West Virginia University. These brochures described the research project and the goals of the project. There were pictures of the project included in the brochure, as well as directions to the farm for the 'field days' that were offered throughout the season.

The outreach program was an invaluable tool for those who are interested in trying different ways of growing organic vegetables. Each visitor left with some new insight to share with future generations.

Kristie M. Schwartz February 18, 2004

EXHIBIT A

Frequently Asked Questions

The comparison of trellis-grown cucumbers and tomatoes versus free-standing plants, on three types of mulch for disease severity and yield.

1) **What are the advantages of using a trellis system?**
   It produces a higher quality cucumber and tomato. The cukes grown on the trellis are a deeper green, more uniform in shape, longer & cylindrical. The tomatoes have less insect damage and are more uniform in shape & color. The trellis also makes it easier to harvest & easier to find the fruits on the vine.

2) **What are the disadvantages of using a trellis system?**
   It takes money & time to build. It's a permanent structure. Also, preliminary readings show that when on a trellis, the plants tend to not hold as much moisture. Plants hold more moisture when less sunlight hits the ground.

3) **How much did the trellis system cost to install?**
   Approximately $700 (materials can be purchased at a fencing supply store or your local Tractor Farm Supply)

4) **How long did the trellis take to install?**
   2 days

5) **What happens if the plants grow taller than the highest wire?**
   That's okay – they can be strung back down & then back up again.

6) **What is the wire gauge used? What is the spacing of the wires?**
   12 ½ gauge wire spaced at 2', 3 ½', & 5' intervals.

7) **Why are there 2 different posts used to hold the trellis?**
   We experimented with using 8' angle irons & 8' T-posts. The angle irons were preferred because they hold the wire better & were easier to string.

EXHIBIT B

FIELD DAY WORKSHEET

Trellis / Hay

Trellis / Leaves

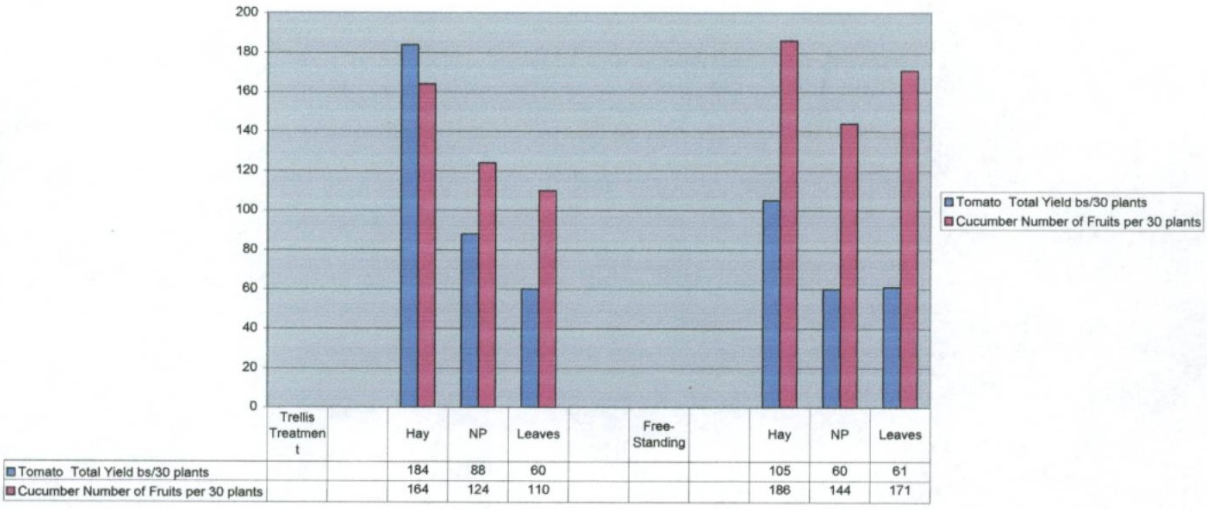
Trellis / Shredded Newspaper

NO Trellis / Hay

NO Trellis / Leaves

NO Trellis / Shredded Newspaper

Trellis Treatment			Hay	NP	Leaves		Free-Standing		Hay	NP	Leaves
Tomato			4.7	4	3.7				3.3	2.3	3
Cucumber			4.75	3.75	4				3.25	1.75	2.5



Trellis Treatment			Hay	NP	Leaves		Free-Standing		Hay	NP	Leaves
Tomato Total Yield bs/30 plants			184	88	60				105	60	61
Cucumber Number of Fruits per 30 plants			164	124	110				186	144	171

Table 1. Quality and yield of tomato and cucumber in trellis and mulch trials, 2003

	Tomato		Cucumber [a]	
Treatment	Quality Rating [b]	Total Yield lbs/30 plants	Quality Rating [b]	Number of Fruits per 30 plants
Trellis				
Hay	4.7	184	4.75	164
Newspaper	4	88	3.75	124
Leaves	3.7	60	4	110
Free-Standing				
Hay	3.3	105	3.25	186
Newspaper	2.3	60	1.75	144
Leaves	3	61	2.5	171
LSD (0.05) [c]	0.53	64	0.76	37

[a] Cucumber quality and ratings based on four harvests in August. A few early fruits were harvested in July form some treatments, but data were too sparse to be

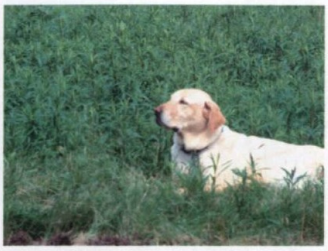
[b] Fruit quality was rated on a 0-5 scale with 5 = highest quality.

[c] LSD = Least Significant Difference, based on pair-wise tests at P= 0.05. The two-way action between trellis and mulch treatments was statistically significant for tomato quality and cucumber number.

3 different mulches used when first planted

Partial funding for the work reported here was provided by the USDA Sustainable Agriculture Research and Education Program.

Cucumbers (Marketmore variety) strung on a 3 - wire trellis system



A very special thanks to Dr. James Kotcon, Associate Professor of Plant Pathology at West Virginia University, for serving as technical advisor of this project AND to all those who helped make this project possible.

Also, a very big thank you SARE for supporting sustainable agriculture.

Your Invited

to learn another way of growing organic cucumbers & tomatoes using a trellis system

This research project compares trellis grown cucumbers & tomatoes with freestanding plants, using 3 types of mulch (hay, shredded newspaper & leaves)

at Pick'n Grin Farms in Bedford County, PA

Jim & Kristie Schwartz
-Proprietors

Goals of Project

Is using the trellis system.....

1) less labor intensive ?
2) more cost effective ?
3) make it easier to harvest ?
4) increasing vegetable quality ?
5) decreasing disease severity ?
6) decreasing insect damage ?

Planting the research plots in mid-June using a no-till method

Come See the Research

at one of our 'field days' in 2003

Drop by anytime from 10 a.m.–2 p.m.
NO COST

- Friday, August 22
- Friday, August 29
- Friday, September 5 *

* *NOTE:* This field day is being held especially for extension agents, researchers & other agricultural professionals.

From 68 - Take 220 North (Bedford Exit). Go 12 miles to Centerville. At the intersection (there is NO stop light), you'll see a Citgo gas station on Left and the Fire Hall on Right. Make this Right onto White Church Road. Go 1.4 miles to stop sign. Make Left onto Evitts Creek Road. Go 0.6 miles and make left onto gravel road.

From PA Turnpike - Get off at Exit 145 (old Exit 11) – Bedford.
Make Left at light.
Go to next light and make a Left on 220 South. (Road is also marked as 99 & 30). Follow 220 S.
Go 12 miles to Centerville. At the intersection (there is NO stop light), you'll see a Citgo gas station on Right and the Fire Hall on Left. Make this Left onto White Church Road. Go 1.4 miles to stop sign. Make Left onto Evitts Creek Road. Go 0.6 miles and make left onto gravel road.

The farm is located at 3773 Evitts Creek Road.

Please email pickn grin@gardener.com or call (814) 285-7107 if you have any questions.