Department of Agriculture, Trade and Consumer Protection
Division of Agricultural Development
Agricultural Development & Diversification Program (ADD)
Grant Project Final Report

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Grant Project Title: **Development of Opportunities for Wisconsin Cucumber Growers Through Optimal harvesting**

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WDATCP Ag Diversification and Development Program
Optimizing machine harvest of pickling cucumber
Final Report: 10/5/07
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Wisconsin ranks in the top five in the country in pickling cucumber production. Average annual production of pickling cucumber in Wisconsin totals 4,000 to 5,000 acres. Pickling cucumber is commonly grown in Central part of Wisconsin in rotation with other processed vegetables such as carrot, red beets, potato or field corn and soybean. Total yields typically average 5 to 6 ton per acre. Pickling cucumber are packaged and marketed by several different companies with most of processing occurring in Green Bay.

Pickling cucumber were traditionally harvested by migrant labor. Migrant labor is still used to harvest 30 to 40% of the Wisconsin crop. Hand labor was necessary due to the staggered maturation of the cucumber crop and lack of mechanical harvesting technology. Typical harvest generally lasts 4 to 6 weeks when picked by hand depending on the growing season and the productivity of the crop. Hand harvest costs approximately $500 to 700 per acre and is 50% of the cost of cucumber production in Wisconsin. Harvest is one of the largest expenses in production of pickling cucumber. Tighter profit margins and limited availability of migrant labor required the development of alternative harvest approaches in pickling cucumber.

Several new developments now enable pickling cucumber producers to machine harvest their crop. First, mechanical harvesters have been designed that successfully pick up the crop and separate ripened fruit from the vines and allow for safe transport to grading tables and brine yards. Second, new cucumber varieties have been bred for with different flowering patterns that allow for more uniform maturation of fruit.

Cucumber produces male and female flowers with a majority of the flowers on older varieties being male. Female flower growth was staggered over time resulting in fruit maturation

over several weeks. To maximize productivity, pickling cucumber had to be harvested over a 4 to 6 week period of time and the vines had to remain in tact. Plants of new pickling cucumber varieties have mostly female or perfect flowers. In addition, most of the fruit matured at similar times. However, average number of fruit produced per plant is typically less when cucumber is machine harvested compared to hand harvest. Therefore, more plants are required when machine harvesting compared to hand harvesting to optimize yield.

Pickling cucumber are planted in rows spaced 30 to 36" apart when hand harvest with a planting population of 50 to 60 thousand plants per acre. Mechanically harvested pickling cucumber requires a higher planting population to maintain yields relative to hand harvest. Higher plant populations can be accomplished with narrower spacing between crop rows and a higher plant population. Increasing plant populations should increase competitiveness of the cucumber crop resulting in improved weed management with potential decrease in reliance on herbicides. However, larger plant populations will also result in decreased cucumber size and decreased internal quality.

Project Objectives

Approaches for optimizing yield and quality of mechanically harvested pickling cucumber are necessary to maximize profits. The goal of this project is to improve the productivity of machine harvested pickling cucumber. Specific objectives include:

1) Evaluate and compare the efficiency of mechanical harvest versus hand harvest of pickling cucumber
2) Optimize row spacing of pickling cucumber to maximize yield, size grade, and internal quality of harvested fruit.
3) Optimize density of pickling cucumber to maximize yield and size grade of harvested fruit.
4) Disseminate research results to pickling cucumber growers and pickle packers.

This is the first year of a two year project. Research projects will be completed that quantify the yield, cucumber size, and internal quality response to different planting populations. Planting populations will be manipulated by changing the spacing between cucumber rows and the seeding rate. In addition, mechanical harvest (single harvest) efficiency will be compared to hand harvest (sequential harvest) efficiency by quantifying fruit recovery, size range, and internal defects. Time, equipment costs, and other harvest associated expenses will be tabulated and compared to calculate the relative harvest efficiency. We anticipate the cost savings in mechanical harvest will offset potential yield and cucumber fruit size differences due to single versus sequential harvest.

Objective 1: Evaluate and compare the efficiency of mechanical harvest versus hand harvest of pickling cucumber

This objective is still being completed as part of the second year of the project and will include quantification of harvest times and expenses incurred by growers relative to yield and price

received. Less than 1/3 of the Wisconsin cucumber crop grown for pickles is hand harvested and this number continues to diminish.

Objective 2 and 3.
Optimize row spacing of pickling cucumber to maximize yield, size grade, and internal quality of harvested fruit.
Optimize density of pickling cucumber to maximize yield and size grade of harvested fruit.

Research trials specific to objective 2 and 3 were completed during the summer of 2006 and included field scale research as well as small plot research. Small plot research was completed on Trzebiatowski Farms south of Wautoma. Factors evaluated included spacing between the rows, plant density, and cucumber variety (Figure 1). Initial results show the importance of planting date on cucumber yield and fruit size distribution. Delays in harvest of 36 to 48 hrs increases size by one grade. In addition, as fruit number per acre increased the days to optimal harvest date is delayed. The interaction with time of harvest and crop density across varieties will be more fully evaluated during 2007. In addition to small plot experiments, field scale research trials were completed at Guth Farms, Paradise farms (2005 and 2006), and Trzebiatowski Farms. Growers covered all production costs related to both small plot and field scale experiments providing matching funding in support of this project. The results can be more fully seen in the appended powerpoint file.
Field scale experiment results: Yield response was variable to plant density, but yield response to fruit density was much tighter and larger. The relationship between lateral (branching) and fruit density with plant density was variable contributing to the poor predictability of yield from plant density. Factors such as heat and drought stress, excess moisture, pollinator activity, disease, and other potential crop stresses can have large influences on fruit set diminishing the influence of intra-specific competition (plant density) on fruit density. Low fruit set at Paradise farms occurred relative to Guth farms in part due to wider row spacing at Paradise farms. Fruit size was not influenced by crop density at Guth farms (bedded planting), but increasing crop density decreased fruit size at Paradise farms (in rows) despite differences in fruit set per plant. Planting cucumbers in narrower rows with wider spacing between plants may decrease effects of higher densities on fruit size relative to planting in rows.
Small plot experiment results: Yield maximum appeared similar across row spacings but occurred at lower density in 30" rows. Yield was still increasing at maximum density established within the beds making interpretation of maximum yield difficult. Increasing density had larger effect on fruit diameter and subsequent grade in 30" rows compared to beds. Larger or wider ranged in fruit size distribution occurred in beds with the exception of 4A size grade. Lower number of fruit in 30" rows led to more large fruit.

Objective 4. Disseminate research results to pickling cucumber growers and pickle packers.

Preliminary results of field experiments were discussed with the Wisconsin pickling cucumber growers and allied industries on several occasions. Results were presented at the Midwest Pickle Association meeting in Green Bay in November of 2005 and 2006. There were 40 to 45 attendees at the Midwest Pickle Association meeting in Green Bay. Results were also presented at the Pickle Packers International meeting during April 2007. There were approximately 65 participants in the Pickle Packers meeting. A field day was held in conjunction with the

Midwest Pickle Association at Hancock, WI during August 2007.

Work to be completed.
Small plot field experiments will be completed during the summer of 2007. Increased emphasis will be placed on multiple harvest dates to document changes in yield and fruit size distribution across plant densities. Future research may target fewer varieties and densities to more fully evaluate the influence of harvest time on changes in yield and fruit size. In addition, brine tests were completed to evaluate the effect of row spacing and density on pickle quality. Brine evaluations were completed in November 2006 and samples were placed into brine fields for evaluation during November 2007.

Data still needs to be completely analyzed. Density, row spacing and variety effects on yield and fruit quality will be published in crop science. In addition, new analytical methods for predicting fruit size distribution are being compared across several crops including potato, onion, and cucumber for future publication in Agronomy Journal (example of analysis in potato is provided). Upon completion of manuscripts data will be subjected to economic analyses and results published in extension bulletins. Growers will continue to be updated as results are generated.

Figure 1. Treatment list for small plot experiment

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Variety, row configuration, and density effects on cucumber yield and quality

Trial ID: cuke001 Study Dir.: Pfaff, Bussan, Drilias
Location: Treb Farms, Investigator: Dr. Larry Binning
Reps: 4 Plots: 11 by 20 feet

Trt No.	Treatment Name	Amt Product to Measure	Plot No. By Rep 1	2	3	4
1	30" row	NA for Unit	101	217	303	401
1	Journey	NA for Unit				
1	seed per foot 2	NA for Unit				
3	30" row	NA for Unit	102	219	301	405
3	Journey	NA for Unit				
3	seed per foot 4	NA for Unit				
2	30" row	NA for Unit	103	216	305	402
2	Journey	NA for Unit				
2	seed per foot 3	NA for Unit				
5	30" row	NA for Unit	104	218	302	404
5	Journey	NA for Unit				
5	seed per foot 6	NA for Unit				
4	30" row	NA for Unit	105	220	304	403
4	Journey	NA for Unit				
4	seed per foot 5	NA for Unit				
10	30" row	NA for Unit	106	229	307	414
10	Lafayette	NA for Unit				
10	seed per foot 6	NA for Unit				
7	30" row	NA for Unit	107	226	306	415
7	Lafayette	NA for Unit				
7	seed per foot 3	NA for Unit				
6	30" row	NA for Unit	108	227	308	412
6	Lafayette	NA for Unit				
6	seed per foot 2	NA for Unit				
9	30" row	NA for Unit	109	230	309	411
9	Lafayette	NA for Unit				
9	seed per foot 5	NA for Unit				
8	30" row	NA for Unit	110	228	310	413
8	Lafayette	NA for Unit				
8	seed per foot 4	NA for Unit				
13	30" row	NA for Unit	111	224	311	408
13	Vlaspick	NA for Unit				
13	seed per foot 4	NA for Unit				
12	30" row	NA for Unit	112	223	313	409
12	Vlaspick	NA for Unit				
12	seed per foot 3	NA for Unit				
14	30" row	NA for Unit	113	225	315	406
14	Vlaspick	NA for Unit				
14	seed per foot 5	NA for Unit				
11	30" row	NA for Unit	114	221	312	410
11	Vlaspick	NA for Unit				
11	seed per foot 2	NA for Unit				

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Reps: 4 Plots: 11 by 20 feet

Trt No.	Treatment Name	Amt Product to Measure	Plot No. By Rep 1	2	3	4
15	30" row	NA for Unit	115	222	314	407
15	Vlaspick	NA for Unit				
15	seed per foot 6	NA for Unit				
19	15" in bed	NA for Unit	116	214	319	428
19	Journey	NA for Unit				
19	seed per foot 5	NA for Unit				
16	15" in bed	NA for Unit	117	211	318	427
16	Journey	NA for Unit				
16	seed per foot 2	NA for Unit				
18	15" in bed	NA for Unit	118	213	320	426
18	Journey	NA for Unit				
18	seed per foot 4	NA for Unit				
17	15" in bed	NA for Unit	119	212	317	430
17	Journey	NA for Unit				
17	seed per foot 3	NA for Unit				
20	15" in bed	NA for Unit	120	215	316	429
20	Journey	NA for Unit				
20	seed per foot 6	NA for Unit				
25	15" in bed	NA for Unit	121	209	325	424
25	Lafayette	NA for Unit				
25	seed per foot 6	NA for Unit				
22	15" in bed	NA for Unit	122	210	322	423
22	Lafayette	NA for Unit				
22	seed per foot 3	NA for Unit				
24	15" in bed	NA for Unit	123	207	324	421
24	Lafayette	NA for Unit				
24	seed per foot 5	NA for Unit				
21	15" in bed	NA for Unit	124	208	321	425
21	Lafayette	NA for Unit				
21	seed per foot 2	NA for Unit				
23	15" in bed	NA for Unit	125	206	323	422
23	Lafayette	NA for Unit				
23	seed per foot 4	NA for Unit				
29	15" in bed	NA for Unit	126	203	328	417
29	Vlaspick	NA for Unit				
29	seed per foot 5	NA for Unit				
30	15" in bed	NA for Unit	127	201	327	420
30	Vlaspick	NA for Unit				
30	seed per foot 6	NA for Unit				
28	15" in bed	NA for Unit	128	205	326	416
28	Vlaspick	NA for Unit				
28	seed per foot 4	NA for Unit				
26	15" in bed	NA for Unit	129	202	329	418
26	Vlaspick	NA for Unit				
26	seed per foot 2	NA for Unit				
27	15" in bed	NA for Unit	130	204	330	419
27	Vlaspick	NA for Unit				
27	seed per foot 3	NA for Unit				