Pickle Research at Michigan State University - 1972

Michigan State University Agricultural Experiment Station and Cooperative Extension Service

Research Report

L. R. Baker, Horticulture; C.L. Bedford, Food Science; R. N. Costilow, Microbiology and Public Health; D. R. Heldman, A.W. Hooper, Agricultural Engineering; J. H. Levin, D. E. Marshall, USDA, ARS Agricultural Engineering

Issued July 1972

12 pages

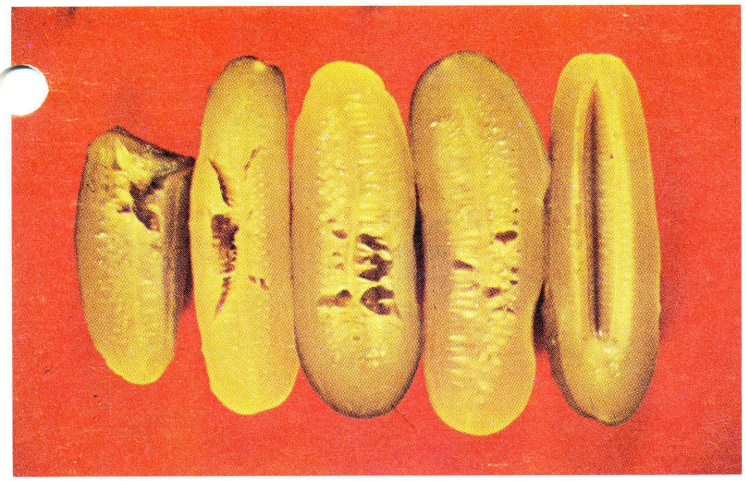
JULY 1973

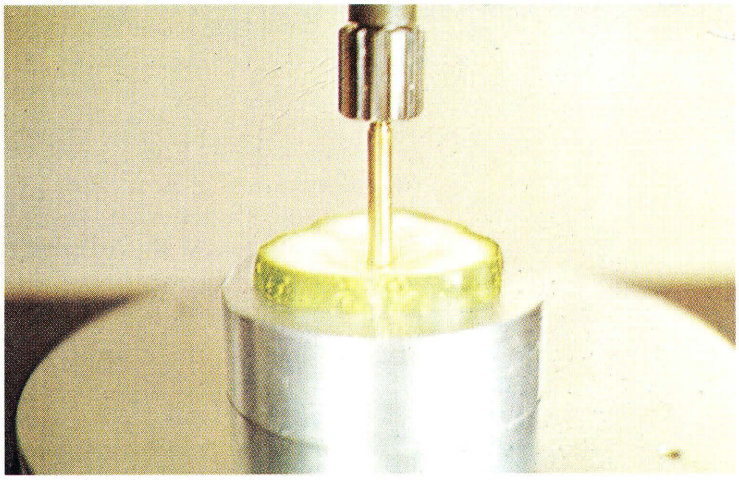
RESEARCH REPORT 213

Farm Science

FROM THE MICHIGAN STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION EAST LANSING

PICKLE RESEARCH AT MICHIGAN STATE UNIVERSITY-1972





CONTRIBUTORS

L. R. Baker, Department of Horticulture; C. L. Bedford, Department of Food Science; B. F. Cargill, Department of Agricultural Engineering; W. H. Clifford, Department of Packaging; C. Collison, Graduate Assistant, Department of Entomology; R. N. Costilow, Department of Microbiology and Public Health; R. C. Crum, Technician, Department of Botany and Plant Pathology; D. J. deZeeuw, Department of Botany and Plant Pathology; D. R. Heldman, Department of Agricultural Engineering; J. B. Holtman, Department of Agricultural Engineering; A. W. Hooper, Graduate Assistant, Department of Agricultural Engineering; J. H. Levin, USDA, ARS, Department of Agricultural Engineering; E. C. Martin, Department of Entomology; D. E. Marshall, USDA, ARS, Department of Agricultural Engineering, A. K. Patel, Graduate Assistant, Department of Agricultural Engineering; H. S. Potter, Department of Botany and Plant Pathology; A. R. Putnam, Department of Horticulture; J. W. Scott, Graduate Technician, Department of Horticulture; and H. M. Sell, Department of Biochemistry.

COVER: Different kinds of defects and bloaters found in brine stock of pickling cucumbers (top left). Research using the Instron Universal Testing Machine (top right) associated strong carpel suture strength with resistance to balloon bloating. Seedless, parthenocarpic pickles have been tested developed experimentally (bottom left) which are higher yielding with much improved quality. Mechanical harvesting (bottom right) in Michigan for 1972 approximated 90% of the total acreage (26,000 A).

PICKLE RESEARCH AT MICHIGAN STATE UNIVERSITY—1972

INTRODUCTION

This report compiles information on several diverse research projects being conducted by Michigan State University and USDA staff. In 1972, a number of projects were coordinated into a "systems approach," combining the efforts of researchers from different departments.

This is desirable because of changes occurring within the pickling cucumber industry and because Michigan is at the forefront of these changes. The purpose of this report is to inform other researchers and the pickle industry of research aimed at producing better pickles more efficiently.

SPECIAL BRINE STOCK AND CARPEL SEPARATION PROJECT[1]

The objectives of this project were:

1) To determine if variations of green stock carpel suture strength in different lines of cucumber are related to bloating of brine stock.
2) To determine the effect of postharvest handling on green stock carpel strength and subsequent bloater formation.
3) To develop techniques for brining small lots of cucumbers under laboratory conditions.

Research conducted in 1971 and 1972 focused on three major factors that affect the incidence of carpel separation in green stock. These are, genetic differences or variety, postharvest handling and brining methods.

Genetics

Differences for carpel separation between varieties are positively associated with balloon bloating (longitudinal separation) in Table 1. The correlation coefficient approximates 0.9 depending on the brining treatment. However, the association of carpel separation with other types of bloating is questionable.

[1]Investigators: L. R. Baker, C. L. Bedford, R. N. Costilow, D. R. Heldman, A. W. Hooper, J. H. Levin, and D. E. Marshall

Table 1. Varietal differences for green stock carpel separation and subsequent balloon bloating of brine stock; based on 2 replicates, 30-gal. tanks, yeast inoculated

		1971				1972			
Variety	Carpel Phenotype	Carpel Strength	Balloon Bloat	Lens Bloat	Honeycomb Bloat	Carpel Strength	Balloon Bloat	Lens Bloat	Honeycomb Bloat
		(gm)	(%)	(%)	(%)	(gm)	(%)	(%)	(%)
MSU 381M	Weak	223	53	3	1	277	28	8	3
Pioneer	Intermediate	317	3	14	8.5	382	4	3	0
SC601H	Strong	319	3	6	6	427	1	3	0

Carpel separation is a heritable character and hybrids are being developed to be resistant to balloon bloating. In other research data, J. E. Wilson indicated that this character was controlled by many genes. Still other data in 1971 indicated that F_1 hybrids are intermediate between their two parents for carpel strength.

Postharvest Handling

The influence of controlled, single blows on bloating frequency of pickles was monitored. Tests indicated that both the frequency and severity of bloating defects increased as impact force increased (14). Usually, a single impact caused a lens bloat (a separation perpendicular to longitudinal axis) near the area of impact. The effect of controlled multiple impacts has not yet been tested.

In an attempt to improve the technique for evaluating carpel suture strength, the carpel strength test (Fig. 1) described by Hooper *et al.* (13) was compared to two different relaxation tests. Evaluation of the influence upon carpel strength of an impact at the cucumber center indicated that as force increased, the carpel strength decreased.

The relaxation test tended to be the best for detection of an impact, but detection decreased with the amount of time after impact. However, relaxation tests were not suitable for differentiating the carpel strength between varieties. The carpel strength test was best for determining carpel suture strengths between varieties.

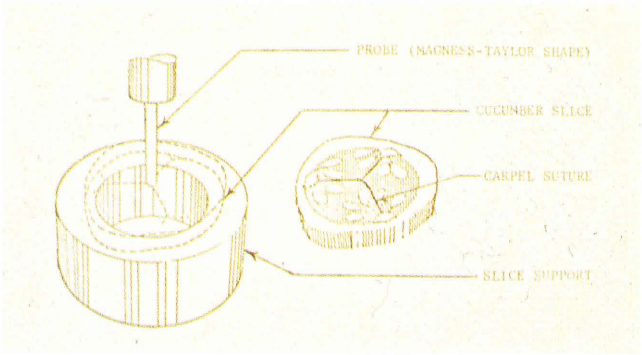


Fig. 1. Orientation of fresh cucumber slice on Instron for determination of carpel strength.

Brining Technique

Three varieties of pickling cucumbers (Pioneer, SC 601H and MSU 381M) were brined in 1, 5, 10, 15, and 30 gal polyethylene tanks fitted with perforated false heads. Groups of 4, 20, 50, 70, and 140 lb of grade size 3 (1.5-2.0 in. diameter) cucumbers were put in the tanks and covered with 20°S brine at 72°F. Four series of tanks were prepared with three under ultraviolet lights and treated as follows: a) control, b) yeast inoculated, c) yeast inoculated with 2% dextrose added. A fourth series was placed under normal light with .05% potassium sorbate added.

Dry salt was added to the false head to maintain 20°S brine during active fermentation and later enough was added to increase the salometer readings 5°S per week until 60°S was obtained. The tanks were pumped over weekly before the addition of the salt.

Brining in 1, 5, 10, 15 and 30 gal polyethylene tanks showed that lactic acid fermentation proceeded at a similar rate for all varieties in the 5, 10, 15 and 30 gal tanks, but a slightly slower rate in 1 gal tanks. Maximum acidity was reached between 12 and 18 days.

Maximum utilization of sugar for lactic acid production occurred when there was minimum yeast activity. Reducing sugar content of the cucumbers ranged from 1.3-2.3%. Within grade size 3 no correlation was found between different sizes of cucumber and the sugar content.

There was an indication that sugar content was lower in cucumbers harvested in late-season. Brine stock data indicated that 5 or 10 gal tanks provided a satisfactory means to determine relative differences for varietal susceptibility to carpel separation and subsequent balloon bloating.

Summary

Relative varietal differences in carpel strength were consistent over the 2 year test. Carpel suture strength was inversely correlated with the frequency of balloon bloating. Carpel strength decreased with increased postharvest handling simulated by controlled impacting.

This reduced carpel strength was related to more frequent bloating. Laboratory brining tests were judged adequate with 5 or 10 gal tanks. Endogenous sugar content was not related to bloating frequency in these 3 varieties. The combined efforts of breeding for strong carpel strength and improving brining techniques should greatly reduce balloon bloating.

DENSITY STUDIES AND SORTING OF GREEN STOCK PICKLING CUCUMBERS FOR BLOATER POTENTIAL[2]

The objectives of this project were:

1) To determine if density of green stock is related to bloater formation in brine stock.
2) To test the density sorting principle under commercial conditions.
3) To measure cucumber density as a function of fruit size, variety, time of harvest and growing location.

Two different 300 bu lots of green stock cucumbers were sorted and put into a solution of approximately 20% ethanol in water. The cucumbers were then designated as "sinkers" or "floaters." All were salted in two different commercial salt yards where the salt stock was evaluated by a joint processor-researcher team.

The occurrence of balloon bloating was inversely related to green stock density but there was no consistent relationship between lens bloating and green stock density.

Green stock density was inversely related to cucumber diameter with a decrease of 0.02 g per cc in density for each 1.0 in. increase in diameter. Grade size 3 cucumbers were divided into 3 A's (1.50-1.75 in.) and 3 B's (1.75-2.0 in.) and sorted separately to maintain a desired sinker-floater ratio. Cucumbers of several varieties and growing locations were in the general density range of 0.960-0.985 g per cc for 1.75 in. diameter cucumbers which suggested adjustment of the sorting solution density for different varieties and locations may be necessary. Cucumber

[2]Investigators: Dale Marshall and Jordan Levin
Cooperators: D. R. Heldman and L. R. Baker

density decreased about 0.01 g per cc with each of three successive hand-harvests of eight varieties during August.

Summary

Sorting by density may be a useful technique to sort green stock pickling cucumbers into two marketing groups. First, those fruits most likely to bloat (floaters) would be processed immediately as fresh-pack. Second, those fruits least likely to bloat (sinkers) would be salted. The frequency of balloon bloating among sinkers (most dense cucumbers) was half or less than that of floaters (Fig. 2). Total bloater formation (balloon + lens + honeycomb bloaters) was also less among sinkers, though the correlation was not so great. It appears that different varieties grown in different locations or different size grades cannot be sorted meaningfully in solutions of identical density and will require appropriate adjustment for a given sinker-floater ratio.

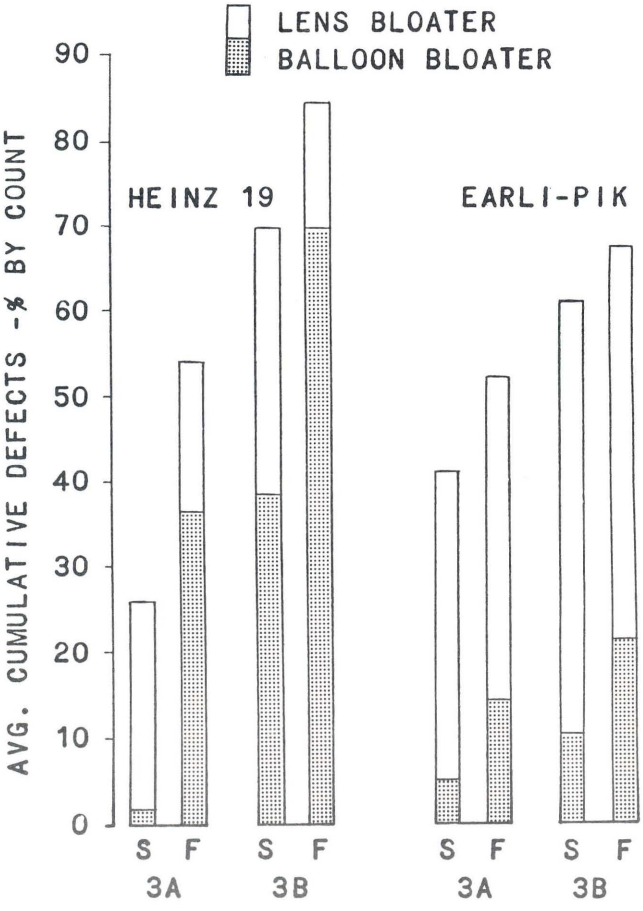


Fig. 2. Reduction of balloon bloating by dividing into most dense (sinkers) and least dense (floaters) fruits; latter to be fresh packed and former brined.

PICKLING CUCUMBER BREEDING RESEARCH[3]

This project's objective is to increase yield, quality, and disease resistance of pickling cucumber varieties for once-over mechanical harvest.

The Conventional Program

Continuation of the "Michigan Final Phase Testing Program" was carried out with great difficulty due to an adverse growing season. Data from 1971 indicated that yields based on 5-acre plots of an experimental hybrid, MSU 9805, and the commercial hybrid Pioneer were variable for both hybrids (Table 2). Yield ranged from 100-150 bu. per acre with neither variety showing a decided advantage. Brine stock exhibited a high percentage of bloating (60-80%) for both hybrids, with neither variety showing an advantage. Yield and brine stock data from 1972 were similar.

Table 2. Yields from once-over harvest and percent bloating of varieties in Michigan Final Phase Testing Program

Location	Pioneer				MSU 9805				Premier	
	% bloat		Bu/A		Bu/A		% bloat		Bu/A	% bloat
	1971	1972	1971	1972	1971	1972	1971	1972	1972	1972
1	—	*	—	*	76	*	77	*	*	53
2	102	111	93	53	67	92	96	58	130	60
3	131	130**	61	—	101	105**	87	—	125**	—
4	167		94		181		67			
Average	133		83		116		82			

Yield (usable to 2") and bloat (1½-2")

*Yield data incomplete or missing due to wet field conditions.
**Yield data based on 2nd harvest; field was hand picked for 1st harvest due to extremely wet field conditions; pickles were fresh-packed and not brined.

However, based on other commercial trials of MSU 9805, seed of this new variety—Spartan Jack—is available for 1973. It is recommended for high plant populations and more intensive cultural practices. It has shown a definite yield advantage in such conditions on research plots.

Angular Leaf Spot

There is a new technique to screen seedlings for resistance to angular leaf spot under greenhouse conditions (Fig. 3). This technique may have application to resistance under field conditions. A highly resistant line of pickling cucumber, MSU 9402, has been distributed to other cucumber breeders as germplasm for resistance to this disease.

Present reports from other breeders indicate that this method is practical once sufficient experience

[3]Investigators: L. R. Baker and J. W. Scott
Cooperators: D. J. deZeeuw, R. C. Crum, and H. M. Sell

has been gained in it. Most difficulty revolves around the condition of the seedling for inoculation, i.e., neither too hard nor too soft.

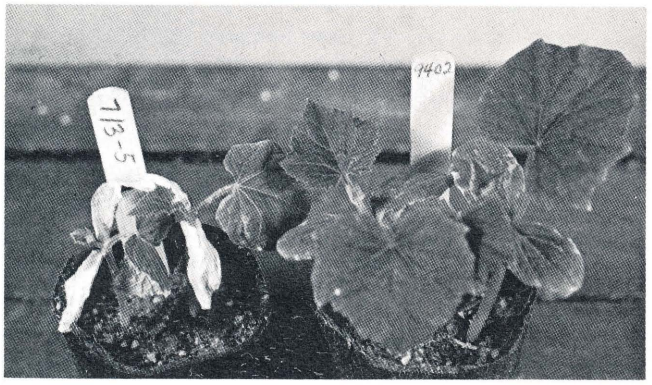


Fig 3. Response of susceptible MSU 713-5 (left) and resistant MSU 9402 (right) seedlings to angular leaf spot inoculation.

Sex Expression

The significance of developing techniques for producing gynoecious hybrid varieties lies in the possibility of concentrating and increasing fruit set for once-over mechanical harvest, as well as for use in parthenocarpic hybrid seed production.

The majority of this effort has been with hermaphroditic and androecious combinations for production of gynoecious hybrid seed (Fig. 4). Experimental gynoecious varieties have been produced using the hermaphrodite as a pollen parent. However, in certain combinations with gynoecious lines, a low frequency (1% or less) or predominantly female plants can be observed, which have only one to three nodes of male flowers expressed.

Preliminary results in 1972 from the cross of gynoecious with androecious phenotypes indicate a situation similar to that with the hermaphrodite pollen parent. Predominantly female plants are observed with occasional 100% gynoecious plants.

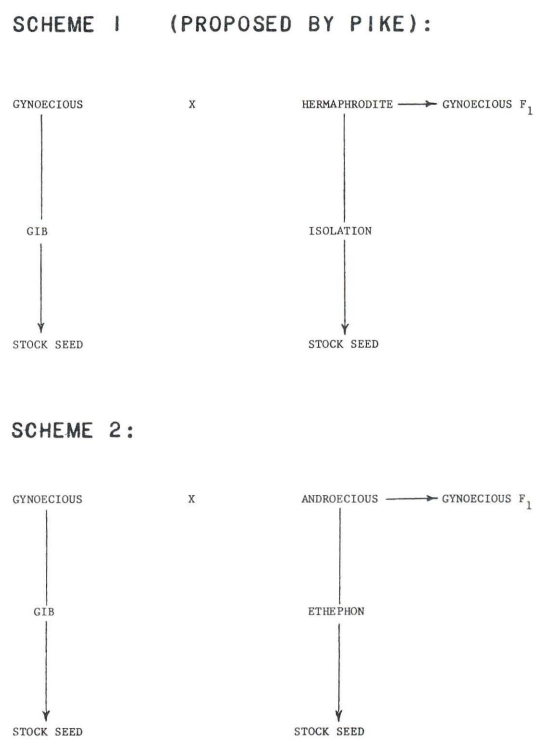


Fig 4. Diagram of two different proposals for seed production of 100% gynoecious hybrids.

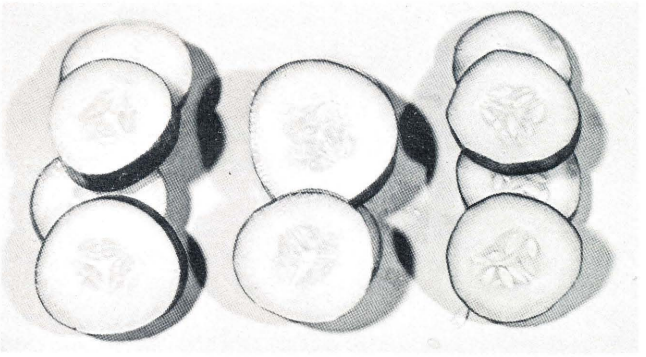


Fig 5. Comparison of slices (from left to right): seedless, seed coats and conventional seeded cucumber fruits. Note wall thickness of seedless slices resulting in firmer, fleshier fruits with increased quality and attractiveness of seedless slices.

Parthenocarpic Cucumbers

In 1971, the first experimental hybrid trial was conducted with parthenocarpic pickling cucumbers (seedless pickles) and a limited commercial trial was attempted in 1972 (Fig. 5). The one-harvest yields varied from below 100 bu per acre to over 600 bu per acre. Likewise the frequency of bloaters (all types) varied from 10-100% of the harvest. Most bloaters were balloon with lens and honeycomb bloaters extremely rare. This may be related to the absence of seeds.

Two major problems evolved from the 1972 seedless pickle research. First, it was found that sex expression must be over 99% gynoecious. Less than that is not sufficient as bees scatter the limited pollen widely. A second problem was that all experimental plots set parthenocarpic fruit in September regardless of the planting dates (from early June to late July). This suggests that parthenocarpic fruiting in the heterozygous parthenocarpic hybrids may be related to daylength.

Research is underway to further stabilize the gynoecious sex expression and the parthenocarpic fruiting character in the F_1 hybrid for commercial use.

Summary

Yields of once-over harvested pickling cucumbers in Michigan have increased each year due to the use of better varieties and cultural practices. Average yield for the 1972 season was 125 to 150 bu per acre as compared to approximately 100 bu in 1971.

Some of this increase is related to use of white spine varieties which hold in the field longer than black spined. Caution is required in using white spine hybrids since many are susceptible to cucumber scab (spot rot). Commercial seedsmen are expected to provide quantities of scab resistant white spine hybrids for machine harvest within the next two to three years.

Angular leaf spot is prevalent in Michigan but has little effect on yield of once-over mechanical-harvested pickles due to the relatively short time between planting and harvest of the crop. Hybrids highly resistant to angular leaf spot are not available commercially, but should be within two or three years. Consequently, this disease is not expected to reach epidemic proportions in Michigan where pickles are mechanically harvested.

Lastly, eventual production of seedless pickles is very appealing. Practical problems relating to sex expression and the parthenocarpic fruiting habit need further research before commercial use is possible.

Research on genetic control of sex expression indicates gynoecious counts of hybrids can be significantly increased to a figure near 100%. Findings based on two years experience indicate the heterozygous parthenocarpic condition of the hybrid seedless pickle may not be strong enough for commercial use. Ultimately, breeding research will strengthen the parthenocarpic fruiting, but chemical treatment may serve as an interim measure.

TIMING OF HARVEST OF ONCE-OVER HARVESTED PICKLING CUCUMBERS[4]

The objectives of this project were:

1) to develop a mathematical model to forecast the size distribution of fruit one to three days in advance; and

2) to devise a commercially feasible system for use of the model.

[4]Investigators: J. B. Holtman, A. K. Patel and B. F. Cargill

Once-over mechanical harvest of cucumbers is a timely operation. The value of a field of cucumbers typically changes 5-10% and sometimes 20% or more in a 24 hr period. Each field actually exhibits a unique cash value-time trajectory. A major contributor to this uniqueness is the characteristic of highly variable fruit set over time.

In the 1970, 1971 and 1972 seasons, fields were sampled on three or four successive days just prior to harvest. Moving diagonally across a field (typically 10-20 acres), 10-row lengths were selected at random, but were equally spaced on the diagonal. A total of 100 sq. ft. was sampled (row length of 51½ in. in 28 in. rows).

The plants in the selected row lengths were pulled, and all fruit were removed, graded, counted and weighed. Continuous recordings of temperature, radiation and relative humidity were also obtained.

Based upon the data collected over the three seasons, several alternative mathematical forecasting models have been developed (Holtman *et al.*). Forecasts can be made in two or three minutes in the field after a sample has been taken. Forms and instructions on their usage are available from the authors.

The estimated models from each year's data were essentially the same, i.e., the fruit development rates did not vary over the three years.

The models do not produce precise forecasts of fruit size distribution for a given situation, but provide a forecast based on *average* fruit development rate. Therefore, an adjustment upward or downward based upon the forecasters' impressions of growing conditions is useful. Nevertheless, the forecasts are a reliable and useful starting point for the necessary extrapolation of fruit distribution into the future.

All data collected have been summarized to give the average size distribution of fruit over the time the field matures (Table 3).

Table 3. Fruit size distribution patterns for use in predicting harvest dates for once-over harvest. Each value is the average of 30 samples and are ranked in order by highest % grade size no. 2 presumed indicative of maturity

Grade size (by wt.)*					
%2	%1	%3	%4	Total wt.	Ratio Total no./Total wt.
55.69	18.54	24.46	.31	13.91	10.51
44.89	17.58	36.32	1.21	15.32	9.44
38.83	14.47	43.59	3.11	16.88	8.60
34.92	12.13	47.70	5.25	16.65	7.85
31.32	12.79	50.03	5.86	17.82	8.21
28.00	9.50	53.18	9.32	20.60	6.75
24.20	7.93	59.18	8.68	21.00	6.25
20.59	8.78	58.07	12.56	20.92	6.18
17.48	5.33	60.27	16.91	23.07	5.07
12.39	5.95	61.24	20.42	22.93	5.22

*Grade size no. 1 = 3/8" to 1-1/16", no. 2 = 1-1/16" to 1-1/2", no. 3A = 1-1/2 to 1-3/4", no. 3B = 1-3/4 to 2", no. 4 = 2". Other summaries have been prepared and may be requested.

Table 3 is meaningful assuming that percentage of grade size 2 cucumbers (1.0-1.5 in. diameter) by weight is an indicator of field maturity. Field samples collected were sorted into descending order by percentage of grade size 2 by weight. The samples then presumably are ranked in increasing order of maturity (the field sample with the highest percentage of grade 2 by weight being the most immature field).

This information should be useful in establishing a grade price system which will lead to growers delivering the desired grade size distribution to the plant. The achievement of a harvest with a size distribution consistent with demand for processed product sales is an important ingredient for an efficient industry—from growers to processors to consumers.

Summary

A mathematical model has been developed which is an effective tool in forecasting fruit size distribution one to two days in advance. A series of graphs are available which permit a forecast to be made in the field immediately after a sample is taken.

THE EFFECT OF OVERHEAD IRRIGATION ON THE BEE POLLINATION OF PICKLING CUCUMBERS[5]

Pollination is a key factor in pickle production but so may be irrigation. Most irrigated pickles in Michigan are irrigated by an overhead sprinkling system and our research indicates overhead irrigation drives bees from flowers.

From 65-93% or a mean of 79% of pollinating bees were driven from the field during overhead irrigation in experiments in 1972. Bees gradually returned to the field after irrigation ceased, but on none of the 12 days that counts were taken did bee populations reach the numbers present prior to irrigation (Table 4). Thirty minutes after irrigation ceased, bee numbers reached 35% of the number present before irrigation, 40% 1 hr after irrigation and 54% 2 hr after irrigation.

There was one occasion when flying conditions became more favorable than before irrigation and bees returned to 98% of the original numbers within 90-105 min. Greater return of bees occurred after morning irrigation than after afternoon irrigation.

The bees that do return do not work flowers as long as they are wet. Cucumber flowers are shaped and situated so water can accumulate inside. In a total of almost 3,000 flowers, counted on nine occasions, 89% of them contained some water. In a group of 64 female flowers, 73% had wet petals and 45% had sufficient water in the flowers to wet the stigmas.

Table 4. The rate at which honey bees returned to cucumber fields after overhead irrigation

Date	No. Bees/10,000 Flowers Before Irrigation	Percentage Bees Returned at Different Periods After Irrigation		
		15-30 Min.	61-75 Min.	91-105 Min.
Aug. 1	280 A	64	45	10
Aug 4	339 A	22	45	44
Aug. 14	640 A	28	23	19
Aug. 15	770 M	39	67	93
Aug. 17	670 A	7	10	0
Aug. 18	1030 M	17	14	23
Aug. 21	680 M	49	55	61
Aug. 22	790 M	31	50	98
Aug. 29	247 A	17	89	61
Aug. 30	375 A	20	9	—

*A—Afternoon irrigation M—Morning irrigation

To substantiate suspicions, two wet flowers and two dry flowers were wet from an eyedropper and observed while bees worked. During 34 replications of the test 88 bees worked the dry flowers, while none worked the wet flowers (though many visited them).

Tests also indicated that the application of water to the stigma of a pollinated flower reduced both fruit production and the number of seeds per fruit. Pollination accomplished within 3 hr prior to irrigation was rendered less effective by application of water to the stigma.

Summary

There is a definite conflict between overhead irrigation and pollination and overhead irrigation might cause yield reduction. Most bees were driven from the field during irrigation experiments. Some bees possibly turned their attention to other species of plants, which could result in reduced numbers of bees visiting the crop. Bees returned to the field but did so slowly and did not work flowers which were noticeably wet.

Application of water to a pollinated flower reduced chances of fruit production. Flowers pollinated within three hr prior to irrigation might fail to produce fruit because water washed pollen from the stigma or interfered with pollen tube growth. Since bee visits to cucumbers taper off after about 4 p.m., the problem might best be solved by using late afternoon and evening irrigation.

[5]Investigators: E. C. Martin and Clarence Collison

CHEMICAL CONTROL OF FOLIAGE & FRUIT DISEASES ON PICKLING CUCUMBERS[6]

A number of new bactericides were evaluated as aerial sprays for protection against angular leaf spot. A very finely milled copper oxide wettable powder and a flowable copper hydroxide were particularly effective with the copper concentrations well below the recommended amounts.

A heavily diseased commercial planting of pickling cucumbers (var. Pioneer) sprayed with these two compounds reduced infection on the average of 78% on foliage and 80% on fruit, when compared to unsprayed checks. Control of the disease resulted in an average increase of 13% in marketable yield, accounting for an additional $88 per acre in estimated gross profit.

The addition of adjuvants Nu-film 17 or Biofilm in the spray tanks increased the effectiveness of both compounds. Weathering was lessened, extending protection on foliage by more than a week. This indicates that the amount of bactericide used could be reduced substantially if Nu-film 17 or Biofilm were added.

DEVELOPMENT OF NEW WEED CONTROL METHODS FOR PICKLING CUCUMBERS[7]

Effective weed control must be obtained in high plant population plantings or the field may be completely lost. All herbicides registered for use on seeded cucumbers have a narrow safety margin and control only a limited number of weeds effectively. Field experiments conducted from 1966-72 showed that selected combinations of herbicides can be used with great success. Naptalam + bensulide and chloramben ME + bensulide gave consistent results without crop injury on all soil types. Naptalam + dinoseb, naptalam + nitralin and chloramben + nitralin were promising on some soil types, but the safety margin was minimal on loamy sands and sandy loams with low organic matter content.

A stale seedbed approach with an interval of 10-21 days from seedbed preparation to application of a contact herbicide was also evaluated. The use of low concentrations of pre-emergence herbicides with paraquat or glyphosate provided excellent weed control. On a conventional seedbed, the results when using half the recommended concentrations were equal or superior to those obtained with double concentrations.

Destroying emerged weeds without soil disturbance decreased germination of weed seeds. Contact herbicides killed a higher percentage of rapidly germinating weeds than most pre-emergence treatments that are more dependent on adequate moisture. Excellent weed control was maintained from planting to harvest and the growth and yield of cucumbers appeared improved using this system.

Summary

New methods of chemical weed control using herbicide combinations are acceptable for wide row spacings, but may be inadequate for high plant populations unless irrigation is utilized. A stale seedbed technique using a contact herbicide combined with a pre-emergence herbicide at lower concentrations appears promising for high population plantings.

COST REDUCTION IN PICKLE PACKAGING THROUGH PACKAGING IMPROVEMENTS[8]

A hard look at jar handling and packaging practices with the possibility of using shrink-wrapped trays and modified inserts is underway. The shrink-over-wrapped tray has the combined benefits of eliminating about 75% of the corrugation in the regular slotted boxes that it replaces while saving about 5/8 in. in stacking height per layer in warehousing. Also, since jars have so much less corrugation between them, warehousing stability should be increased, not to mention ease of inspection of stocks for quality of appearance.

Alternative methods of bringing jars into the plant are needed. Some industries receive jars stacked on pallets with newsboard separators between them and the whole pallet is shrink-wrapped. This makes inspection of incoming supplies easier and increases the capacity of empty jar storage space.

Current developments in plastics technology place the plastic soft drink bottle just a few years off. At the very least, pickling cucumber processors should be kept current. When plastic soft drink bottles become popular, many other products will also switch.

In addition, research is underway in one company to develop a blow-molded laminate bottle, which would offer the cheapness of polyethylene and the barrier properties of saran. The changeover to plastics in the pickle industry will change sterilization

---

[6]Investigator: H. S. Potter
Cooperators: W. Iott, grower, Monroe, Michigan, and Michigan Agricultural Aviation Association

[7]Investigator: A. R. Putnam

[8]Investigator: Wayne H. Clifford

techniques, bringing possible aseptic filling methods, and a likely change to rack storage in the warehouse.

The individual package represents a potential new market for pickles in vending machines and drive-in restaurants. The ability to capture and hold this market, however, will depend on reliable, inexpensive packages which offer a maximum of convenience to the purchaser and vendor. Sample packages have been made for this with more and better types being designed.

Summary

Packaging is a major cost item in the pickle industry, but it receives little attention. This project outlines three areas which show promise for increasing profits through better packaging. They are shrink-wrapped trays, plastic jars and individual wrapping. The first two innovations cut costs, and the last expands markets.

REFERENCES

1. Augustine, J. J., and L. R. Baker (1972). Female flower induction on an all-male (androecious) cucumber, *Cucumis sativus* L. HortSci. 7: 326 (Abstr.).

2. Augustine, J. J., L. R. Baker and H. M. Sell (1973). Female flower induction on androecious cucumber, *Cucumis sativus* L. J. Am. Soc. Hort. Sci. 98: 197-199.

3. Augustine, J. J., L. R. Baker and H. M. Sell (1973). Chemical reversion of sex expression on dioecious cucumber with ethephon and a benzothiadiazole. HortSci. 8: 218-219.

4. Byers, R. E., L. R. Baker, H. M. Sell, R. H. Herner, and D. R. Dilley (1972). Ethylene: A definitive role in the sex expression of *Cucumis melo* L. Proc. Nat. Acad. Sci. 69: 717-720.

5. Collison, C. H. and E. C. Martin (1970). Competitive plants that may affect the pollination of pickling cucumbers by bees. Am. Bee J. No.: 262.

6. Connor, L. J. and E. C. Martin (1970). The effect of delayed pollination on yield of cucumbers grown for machine harvest. J. Am. Soc. Hort. Sci. 95: 456-568.

7. Conner, L. J. and E. C. Martin (1971). Staminate: pistillate flower ratio best suited to the production of gynoecious hybrid cucumbers for machine harvest. HortSci. 6: 337-339.

8. deZeeuw, D. J., R. Crum, J. E. Wilson, and L. R. Baker (1971). Screening cucumber seedlings for angular leaf spot resistance. HortSci. 6: 276. (Abstr.).

9. Hemphill, D. D., Jr., L. R. Baker, and H. M. Sell (1972). Different sex phenotypes of *Cucumis sativus* L. and *C. melo* L. and their endogenous gibberellin activity. Euphytica 21: 285-291.

10. Hemphill, D. D., Jr., L. R. Baker, and H. M. Sell (1972). Isolation and identification of the gibberellins of *Cucumis sativus* and *C. melo*. Planta 103: 241-248.

11. Holtman, J. B., A. Patel, F. Panol and B. F. Cargill (1972). A mathematical model to schedule cucumber harvest. ASAE Paper 72-149.

12. Hooper, A. W., D. E. Marshall, L. R. Baker, and D. R. Heldman (1972). A method for measurement of carpel strength in pickling cucumber. ASAE Paper 72-379.

13. Hooper, A. W., L. R. Baker, D. E. Marshall, and D. R. Heldman (1972). Determination of force required to separate carpels of cucumber fruit slices (*Cucumis sativus* L.). HortSci. 7: 337 (Abstr.).

14. Hooper, A. W. (1973). The effect of impact on green stock carpel strength and brine stock quality for cucumbers, *Cucumis sativus* L., Thesis for M.S. degree, Department of Agricultural Engineering, Michigan State University.

15. Marshall, D. E., J. H. Levin and D. R. Heldman (1973). Density sorting of green stock cucumbers for brine stock quality. ASAE Paper 73-304.

16. Marshall, D. E., L. R. Baker, J. H. Levin and B. F. Cargill (1972). The effect of mechanical harvesting and handling on pickling cucumber quality. ASAE Paper 72-885.

17. Marshall, D. E., B. F. Cargill and J. H. Levin (1972). Factors influencing recovery of pickling cucumbers harvested mechanically. ASAE Paper 72-150.

18. Marshall, D. E., B. F. Cargill and J. H. Levin (1972). Physical and quality factors of pickling cucumbers as affected by mechanical harvesting. Trans. of ASAE 14: 604-608, 612.

19. Marshall, D. E., B. F. Cargill and J. H. Levin (1971). Mechanical harvesting and handling of pickling cucumbers—recovery and evaluation of quality. ASAE Paper 71-347.

20. Marshall, D. E., B. F. Cargill and J. H. Levin (1971). Mechanical harvesting and handling of pickling cucumbers—an evaluation of green stock and brine stock quality. ASAE Paper 71-348.

21. Martin E. C. and C. H. Collison (1970). Honey bee pollination of pickling cucumbers. Theory and Practice. The Pickle Pak 30: 3-5.

22. Martin, E. C. (1970). The use of honey bees in the production of hybrid cucumbers for mechanical harvest. Rep. Pollination Conf. Univ. Ark., 9th MP127: 106-9.

23. Martin E. C. and S. E. McGregor (1973). Changing trends in insect pollination of commercial crops. Ann. Rev. Entomol. 18: 207 and 226.

24. Miller, J. C., Jr., D. Penner, and L. R. Baker (1973). Basis for variability in the cucumber for tolerance to chloramben methyl ester. Weed Sci. 21: 207-211.

25. Miller, J. C., Jr., and L. R. Baker (1971). Differential phytotoxicity of amiben methyl ester to *Cucumis sativus* lines. HortSci. 6: 276. (Abstr.).

26. Miller, J. C., Jr., D. Penner, and L. R. Baker (1972). The basis for differential tolerance of cucumber lines to chloramben methyl ester. Weed Sci. Soc. Am. (Abstr. No. 3).
27. Miller, J. C., Jr., L. R. Baker, and D. Penner (1972). Inheritance of tolerance to chloramben methyl ester in cucumber, *Cucumis sativus* L. HortSci. 7:350. (Abstr.).
28. Putnam, A. R. and F. D. Hess (1971). Techniques for improved weed control efficiency in cucumbers. Mich. Agr. Exp. Sta. Res. Rept. 140. 8 pp.
29. Putnam, A. R., A. P. Love, G. Pagano, E. L. Silvia, and M. Van Buskirk (1971). Weed control research in vegetable crops. Mich. State Univ. Hort. Rept. 18. pp. 15-17.
30. Putnam, A. R., A. P. Love, E. L. Silvia, G. Pagano and M. Van Buskirk (1972). Weed control research—1972. Mich. State Univ. Hort. Rept. 21. pp. 13-16.

Research Units of the Michigan Agricultural Experiment Station

(1) Upper Peninsula Experiment Station, Chatham. Established 1907. Beef, dairy, soils and crops. In addition to the station proper, there is the Jim Wells Forest.

(2) Dunbar Forest Experiment Station, Sault Ste, Marie. Established 1925, forest management.

(3) Lake City Experiment Station, Lake City. Established 1928. Breeding, feeding and management of beef cattle; and fish pond production studies.

(4) Graham Horticultural Experiment Station, Grand Rapids. Established 1919. Varieties, orchard soil management, spray methods.

★ Michigan Agricultural Experiment Station, Headquarters, 101 Agriculture Hall, MSU, East Lansing. Established 1888. Research work in all phases of Michigan agriculture and related fields.

(6) Muck Experimental Farm, Laingsburg. Plots established 1941, crop production practices on organic soils.

(7) South Haven Experiment Station, South Haven. Established 1890. Breeding peaches, blueberries, apricots. Small fruit management.

(8) W. K. Kellogg Farm and Bird Sanctuary, Hickory Corners, and W. K. Kellogg Forest, Augusta. Established 1928. Forest management, wildlife studies, mink and dairy nutrition.

(9) Fred Russ Forest, Cassopolis. Established 1942. Hardwood forest management.

(10) Ferden Farm, Chesaning. Plots established 1928. Soil management, with special emphasis on sugar beets. (Land Leased)

(11) Montcalm Experimental Farm, Entrican. Established 1966. Research on crops for processing, with special emphasis on potatoes. (Land Leased)

(12) Sodus Horticultural Experiment Station, Sodus. Established 1954. Production of small fruit and vegetable crops. (Land Leased)

(13) Trevor Nichols Experimental Farm, Fennville. Established 1967. Studies related to fruit crop production with emphasis on pesticides research.

(14) Saginaw Valley Beet and Bean Research Farm, Saginaw. Established 1971. Studies related to production of sugar beets and dry edible beans in rotation programs.

7-73—5M