

51  
HORTICULTURE SERIES 618

JANUARY 1991

17072  
Oardc  
2999  
C650  
Horo

# EFFECTS OF SIMULATED HAIL ON PICKLING CUCUMBERS

DALE KRETCHMAN, MARK JAMESON, AND CHARLES WILLER

O. A. R. D. C.  
FEB 15 1991  
LIBRARY

52  
DEPARTMENT OF HORTICULTURE  
THE OHIO STATE UNIVERSITY  
OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER  
WOOSTER, OHIO 44691

639  
OH3

All publications of the Ohio Agricultural Research and Development Center are available to all potential clientele on a nondiscriminatory basis without regard to race, color, creed, religion, sexual orientation, national origin, sex, age, handicap, or Vietnam-era veteran status.

**EFFECTS OF SIMULATED HAIL ON PICKLING CUCUMBERS**  
**Dale Kretchman, Mark Jameson and Charles Willer**  
**Department of Horticulture**  
**The Ohio State University/OARDC**  
**Wooster, OH 44691**

Cucumbers for processing are produced in most states of the U.S. and in Ontario, Canada and northern Mexico. It is not unusual to have damage from hail to this crop in nearly every production area, but it is more common in the eastern part of the continent. Injury ranges from a few cuts or holes in a few leaves to severe defoliation and serious stem damage.

Pickling cucumbers are usually classed as a high value crop. Most of the crop is hand-harvested with multiple pickings of two to three times weekly for 3 to 5 weeks. There is some mechanical harvesting of the once-over destructive type where only one picking is made. The multiple hand-harvest usually results in higher yields and thus greater gross returns than a single machine harvest. The opportunity for multiple pickings also allow for plant recovery from a mechanical damage like hail injury to the plants and still provide a monetary return. Where mechanical harvesting is involved, the likelihood of sufficient plant recovery from a mechanical type of injury to provide an economical return is quite low and even a moderate amount of injury could result in a total loss.

A factor which greatly complicates a calculation of loss or returns from pickling cucumbers is the pricing or value structure. The value of a unit depends upon fruit size with the smaller fruits usually being of higher unit value than the larger sizes. For example, cucumbers less than 1.06 inches, may be contracted at \$300 per ton, while fruits 1.5 to 2.0 inches will be worth only \$90 per ton. This is in contrast to other processing crops like tomatoes or peas where price is based upon tonnage within certain quality parameters. Some contracts for cucumbers are based on a set amount per ton of fruit provided sizes are within ranges for small, medium and large fruit.

Yields of cucumbers may vary considerably between growers and between growing regions because this crop is so responsive to growing and harvesting conditions. The plant is very rapidly growing and thus availability of water is most critical. It is highly sensitive to drought, as well as to excessive water. It is also classed as a "tropical" plant and thus it is temperature sensitive. Cool temperatures will reduce plant and fruit growth rate and high temperatures will accelerate growth.

Harvesting also has a highly significant influence on yield for hand-harvested crops. Training of the vines is critical to minimize the harmful effects of handling the vines during fruit removal. Frequency and thoroughness of picking also affects yields greatly. Usually, more frequent picking results in greater yield, especially with favorable temperature and soil moisture conditions. Thorough picking maximizes yield because fruits left on the vines reduces subsequent fruit set and fruit growth. Continuous training of the vines during the harvest season is important to encourage continuous fruiting. Earliest fruits are produced on the main stem, while later fruits are also produced on lateral shoots. If these lateral shoots are injured during the picking operation or by other mechanical means, yields may be reduced

considerably.

## Objectives

1. To develop a description of cucumber plant growth and development.
2. To determine the influence of several levels of plant injury from simulated hail at different stages of plant development on subsequent yield.
3. To develop tables and charts to predict yield losses from differing severity of hail at various stages of plant development.
4. To determine the influence of stand loss on subsequent yield.

## Materials and Methods

General: The field plots were established at the OARDC, Vegetable Crops Branch near Fremont, OH in 1987, 1988, 1989 and 1990. This is within the primary production area for processing cucumbers in Ohio. The variety used was a standard gynoecious variety, Carolina. Cultural practices were as near to what commercial growers would follow as was possible. Plot size were sufficient to provide reliable data. Irrigation was available and used when necessary to maintain the experiment. A regular pesticide program was followed and no additional treatments were made following hail treatment to control any potential disease threat.

The plots were harvested by hand twice weekly for 3 weeks. The fruits were graded into four commercial sizes of usable fruits and culls. The following sizes and values were used:

Size	\$ Value/Ton
1. Less than 1.06 in.	300
2. 1.07 to 1.50 in.	170
3. 1.51 to 2.00 in.	90
4. 2.00 to 2.25 in.	20

Plant Development (staging): The plant development stages were based upon gynoecious varieties used in the regular variety trials run at the Vegetable Crops Branch. Most of these varieties had similar development characteristics. The period ran from seedling emergence through a 3-week harvest period (6 pickings).

Hail Injury Study: Field plots were established by seeding. Plot rows were 30 ft. long, 5 ft. apart (most commercial plantings have rows 30 inches apart). The 5 ft. row spacing was necessary to allow the tractor with the hail machine to straddle the rows during treatment. Yield data were converted to the 30-inch row spacing. Plants were spaced 6 inches apart within each row.

Hail treatments were made at 3 stages of development, 1) at vine tip, when the plants were 8 to 12 inches tall and started to grow as prostrate plants on the ground; 2) when the earliest fruits were near 1-inch in diameter (early fruiting); 3) between the second and third picking (mid-harvest). Three levels of injury were used--slight, moderate and severe. The amount of injury was

based on defoliation. The percent defoliation of each plot was estimated by 2 or 3 experienced researchers usually 1 or 2 days after treatment. Treatments were replicated 4 times.

The fruits were harvested by hand by the regular labor crew at the Branch. Some of the labor had considerable experience, while others had little to none. Nevertheless, the quality of the picking operation was quite good and with 4 replications of each treatment, it appears that any variation in picking had minimal influence on the results.

Stand Reduction Study: Field plots in this study were 15 ft. long with 6 replications per treatment. Treatments consisted of removal of 0, 10, 25 and 50 percent of the plants from an original stand of single plants every 6 inches (the "0" removal check). The plants were removed 7 or 14 days after emergence. (Emergence usually took 3 to 4 days after seeding.)

### Results and Discussion

Plant Development (staging): Considerable information is already known about cucumber plant development because of its fruiting habit. Previous to the past 2 decades most pickling cucumber varieties were monoecious, i.e., male and female flowers on the same plant, but the earliest flowers for the first 8 to 12 nodes were all male. Since about 1970, most pickling cucumbers are gynoecious; i.e., all flowers on the plant are female. The gynoecious types generally provide higher yields early in the harvest season. (Note: Nearly all fresh market slicing types of cucumbers are monoecious.)

The plant development stages in this study were developed using gynoecious varieties which should have all female flowers on all plants except for the 12% monoecious pollinator plants included in the commercial seed lots. These gynoecious varieties should probably be called predominantly female because most varieties may have some plants with a few male flowers present. This can be due to genetic variability as well as almost any type of stress on the plants early in their growth can result in some male flower expression.

The cucumber is a very rapidly growing plant and the fruits also grow rapidly under ideal conditions. However, growth rate is highly influenced by environmental conditions and thus, it is nearly impossible to set a specific number of days for any particular stage of development. With most fruiting plants, there is a vegetative or plant growth phase, followed by a flowering period, fruit growth period and finally a fruit maturation stage. This occurs for pickling cucumber except the fruits are not permitted to mature. Fruits may be picked when very immature, small sized or very large in size, but still 2 to 3 weeks away from complete maturity.

Depending upon environmental conditions, the first harvest may occur 35 to 45 days after emergence. Fruit may grow from pollination to a 2-inch diameter fruit in 5 to 8 days or it may take 12 to 15 days under less favorable environmental conditions.

Data and observations from this study suggest the following as stages of development of pickling cucumbers:

1. Seeding stage-from emergence to vine tip (vertical to horizontal growth) - up to 35 days from seeding with an average in Ohio of about 25 days.
2. Vine development stage - from vine tip to early fruit development - usually 10 to 12 days after vine tip. Vine training at this stage is critical to high yields.
3. Early fruiting stage - usually the first 2 weeks of harvest which usually give the highest portion of total yields.
4. Late fruiting stage - any time after Stage 3. This period may have lower per harvest yields, but it is likely the critical period for providing the grower with a profit from his crop.

Hail Injury Effects on Plant Development and Yield: The hail simulator was very effective in causing injury to cucumber plants (and fruits), which appeared similar to actual hail injury. The younger plants were easily injured with defoliation and stem injury evident. As plants aged, defoliation and stem injury became increasingly difficult and required much more effort and ice to cause high levels of defoliation. The denser foliage on the older plants would protect some of the leaves from injury.

The primary effect of the simulated hail injury was to interrupt and thus, delay plant development. The amount of delay could not be determined because of the wide levels of injury obtained from the treatments and the variation in climatic conditions following each series of treatments during the 3 seasons of the study. There is little doubt, however, that the cucumber plant does recover, even following severe defoliation and a reasonable crop may be produced provided the receiving schedule of the processor will permit late season deliveries. There can also be a problem when injury occurs when fruits are present. The injury may predispose the fruits to disease invasion or fruit scarring which requires costly picking and sorting to remove the damaged fruits, but from which no income is received. We also have data from past experimentation that defoliation itself can reduce fruit quality of a crop for a period time after defoliation by increasing the amount of short and crooked fruits which are unmarketable.

Results from the study on the influence of hail injury are summarized in Figures 1 through 8. There is no doubt that the injury caused yield reductions in both weight and value for the fixed harvest period. As the amount of defoliation (injury) increased, the loss of yield also increased. The data also clearly demonstrated the variation in responses which can occur. The relatively low  $r^2$  indicate the lack of the uniformity in the data. This wide variation is somewhat characteristic of data from a highly vegetative fruiting crop which is so sensitive to many external variables. Further, a crop which is hand-picked several times introduces a human error which likely additionally confounds the data.

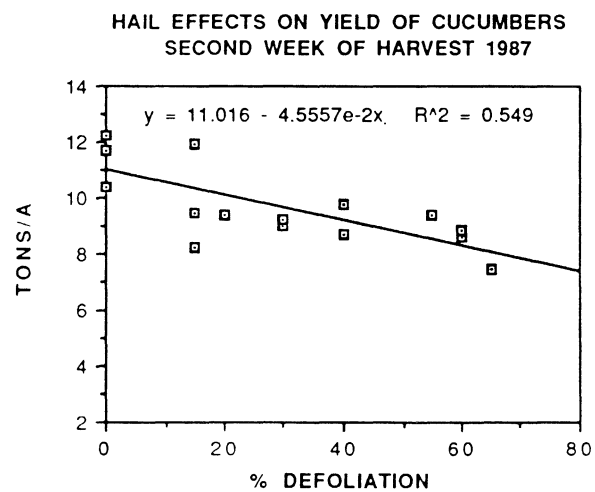
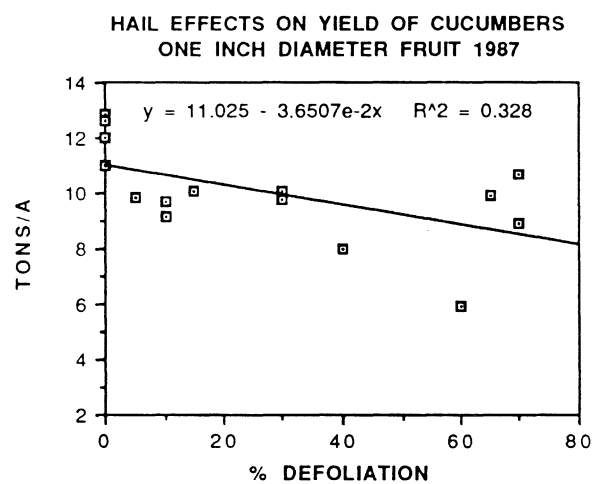
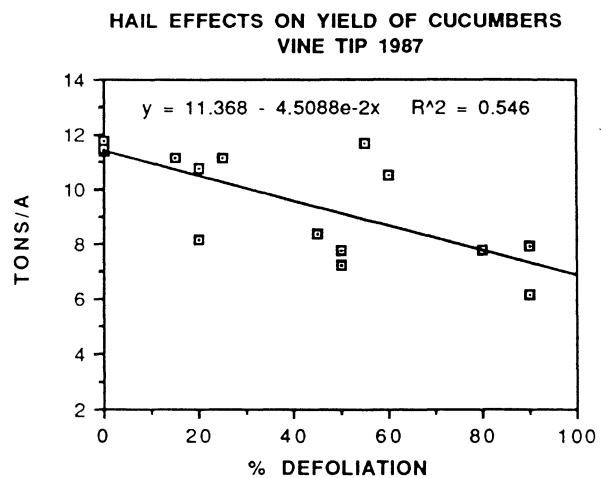


Fig. 1. Influence of hail injury at 3 stages of development of pickling cucumbers on total yield, 1987.

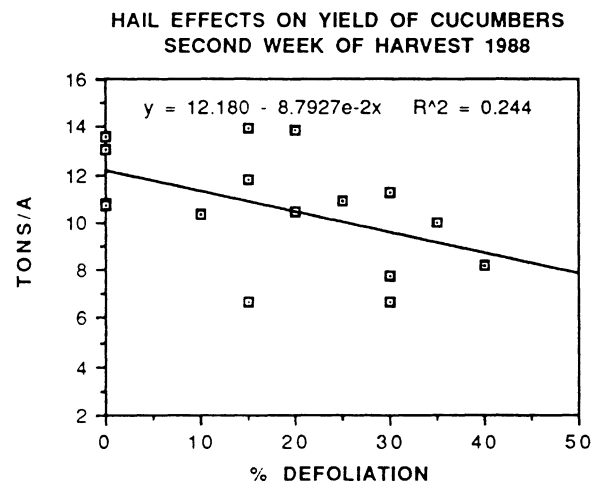
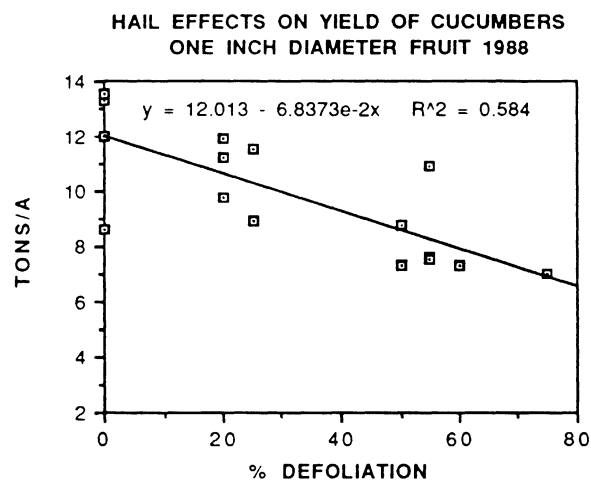
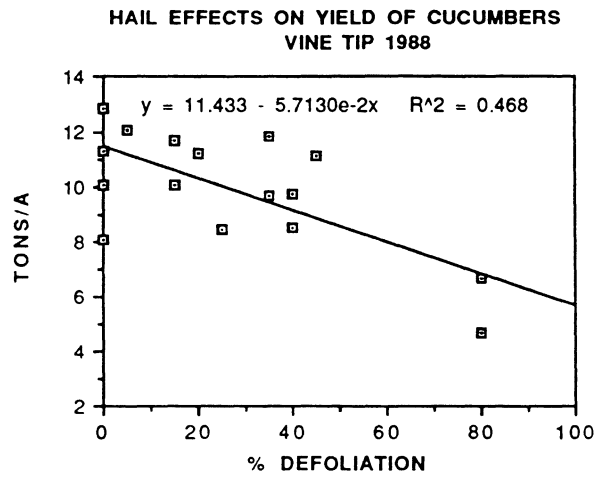
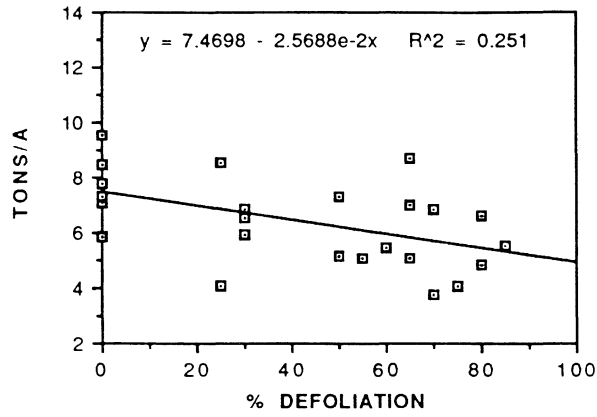


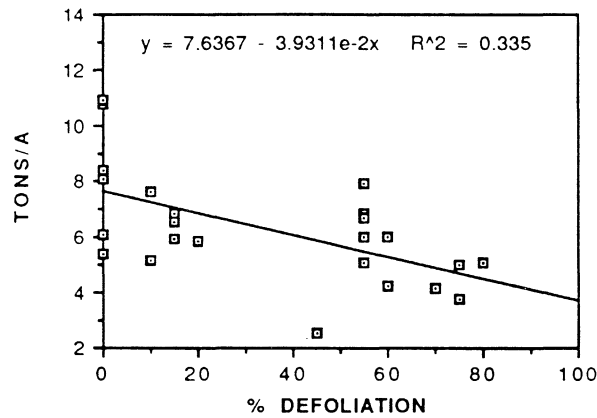
Fig. 2 Influence of hail injury at 3 stages of development of pickling cucumbers on total yield, 1988.



HAIL EFFECTS ON YIELD OF CUCUMBERS  
VINE TIP 1989



HAIL EFFECTS ON YIELD OF CUCUMBERS  
ONE INCH DIAMETER FRUIT 1989



HAIL EFFECTS ON YIELD OF CUCUMBERS  
SECOND WEEK OF HARVEST 1989

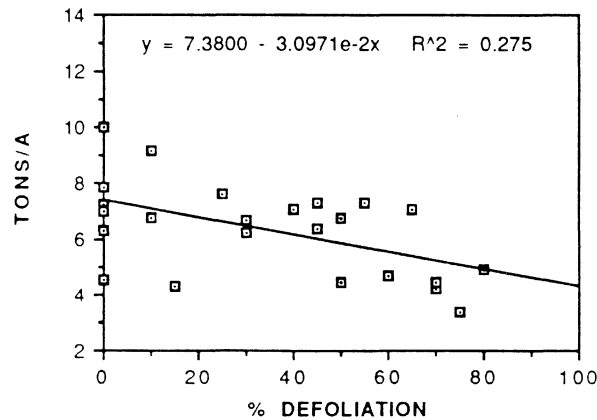


Fig. 3. Influence of hail injury at 3 stages of development of pickling cucumbers on total yield, 1989.

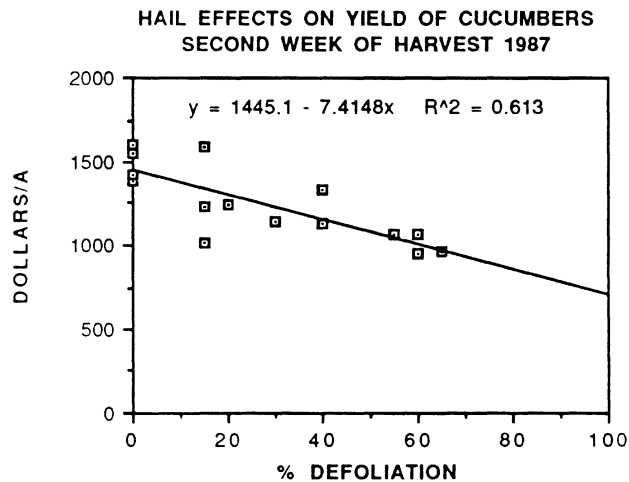
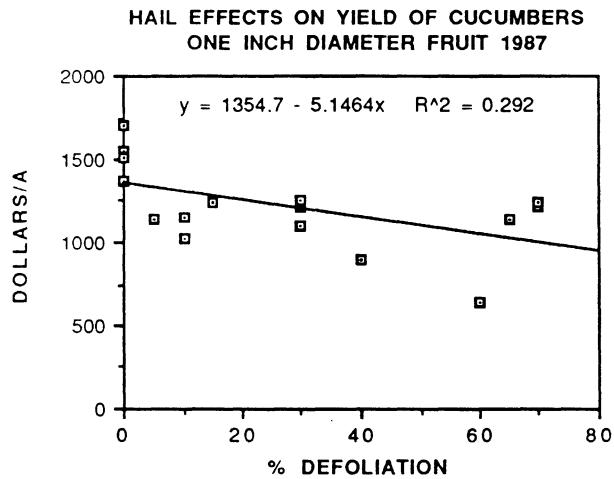
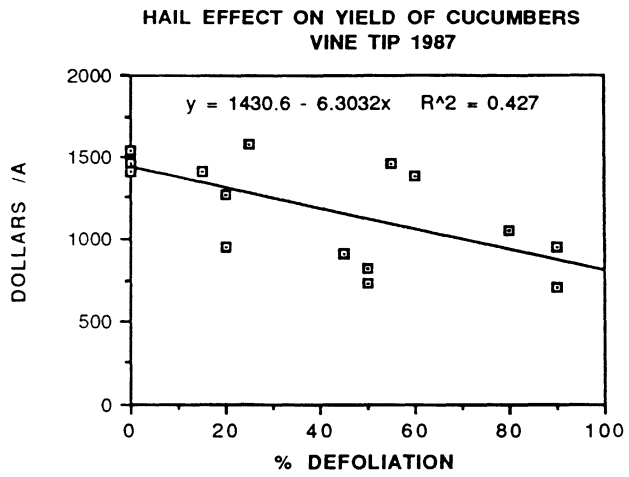


Fig. 4. Influence of hail injury at 3 stages of development of pickling cucumbers on total value of the crop, 1987.

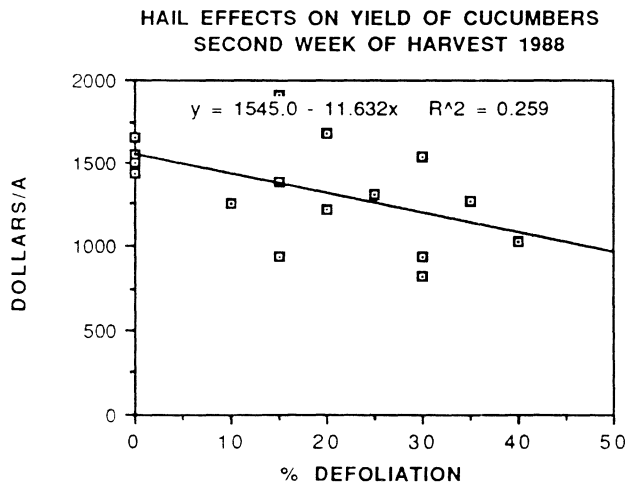
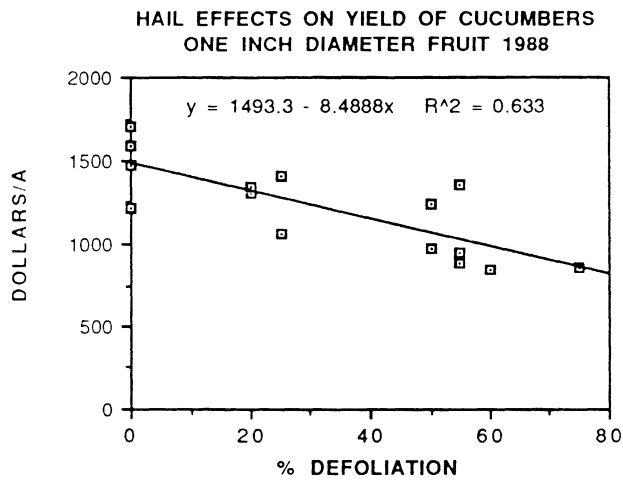
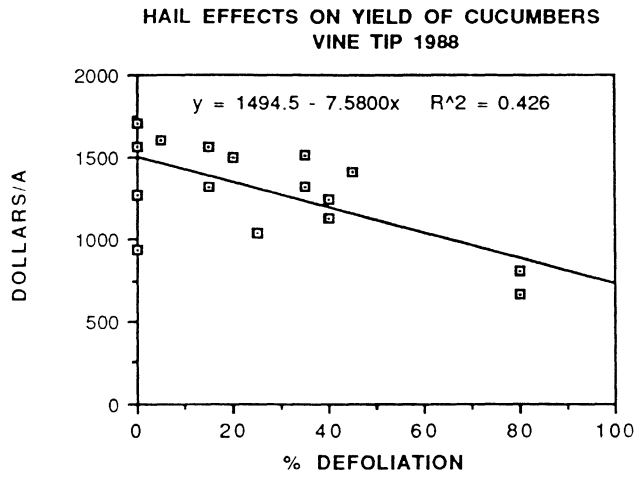


Fig. 5. Influence of hail injury at 3 stages of development of pickling cucumbers on total value of the crop, 1988.

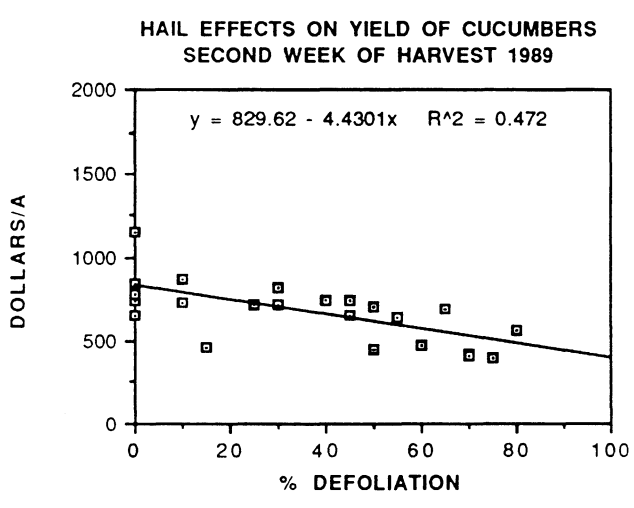
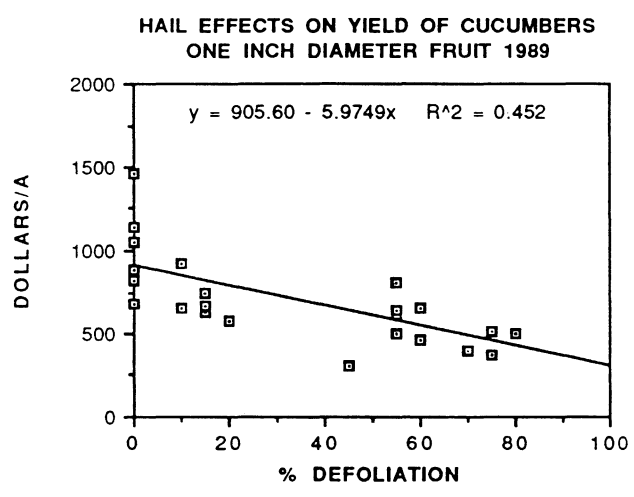
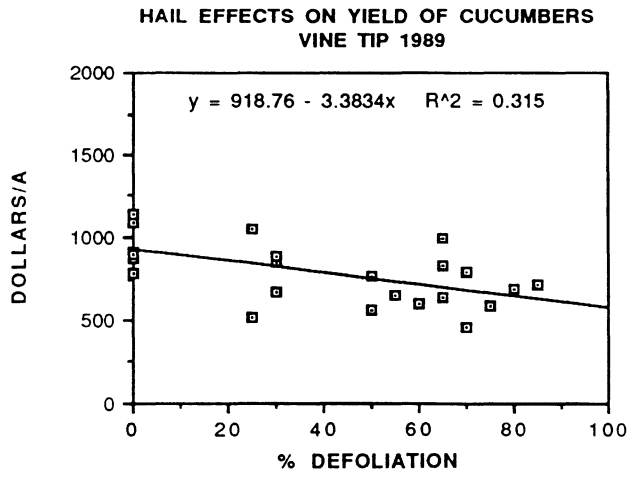
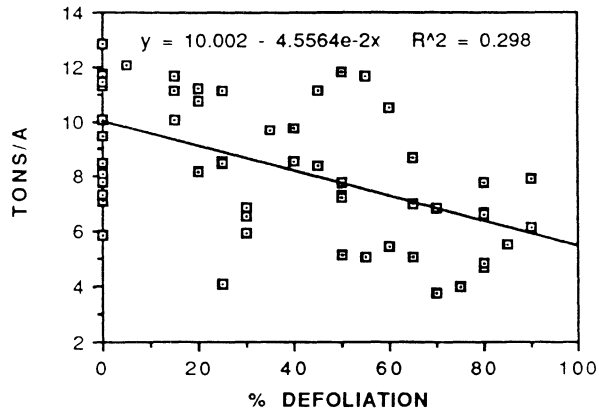
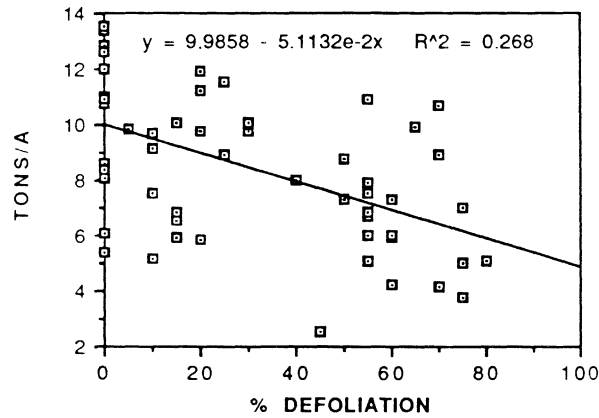


Fig. 6. Influence of hail injury at 3 stages of development of pickling cucumbers on total value of the crop, 1989.

HAIL EFFECTS ON YIELD OF CUCUMBERS  
VINE TIP 87,88,89



HAIL EFFECTS ON YIELD OF CUCUMBERS  
ONE INCH DIAMETER FRUIT 87,88,89



HAIL EFFECTS ON YIELD OF CUCUMBERS  
SECOND WEEK OF HARVEST 87,88,89

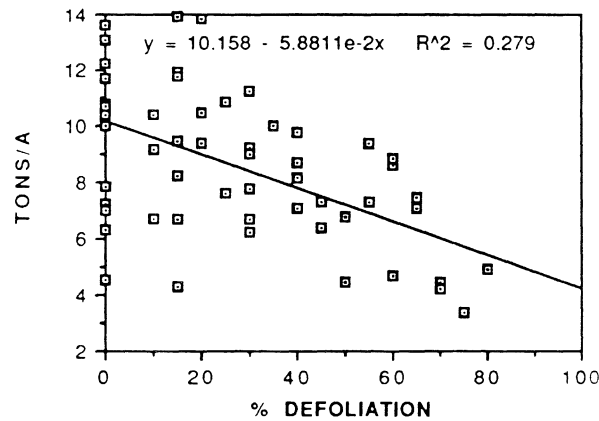


Fig. 7. Influence of hail injury at 3 stages of development of pickling cucumbers on total yield, 1987, 1988 and 1989.

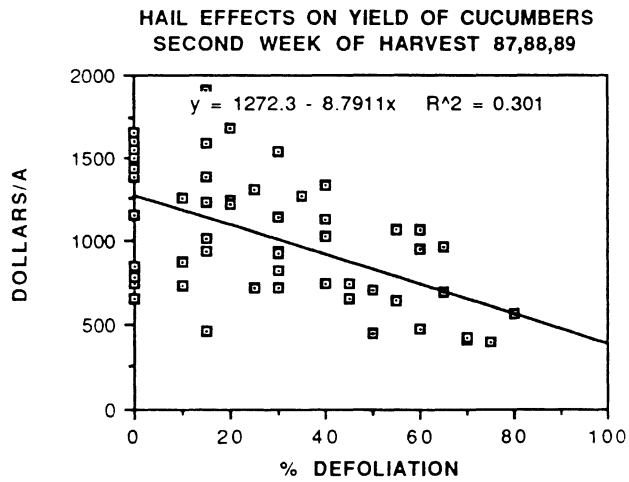
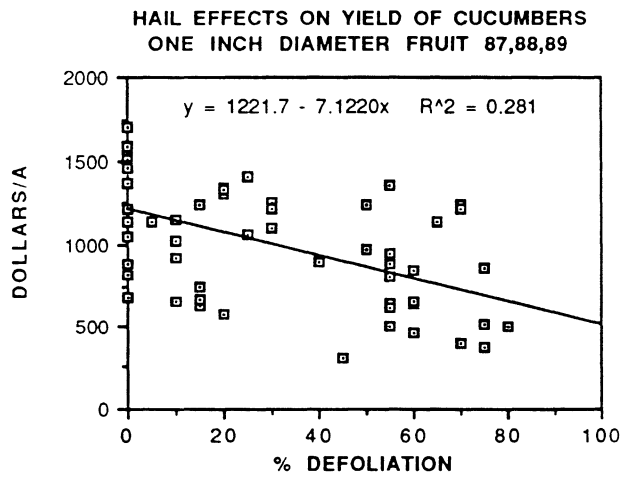
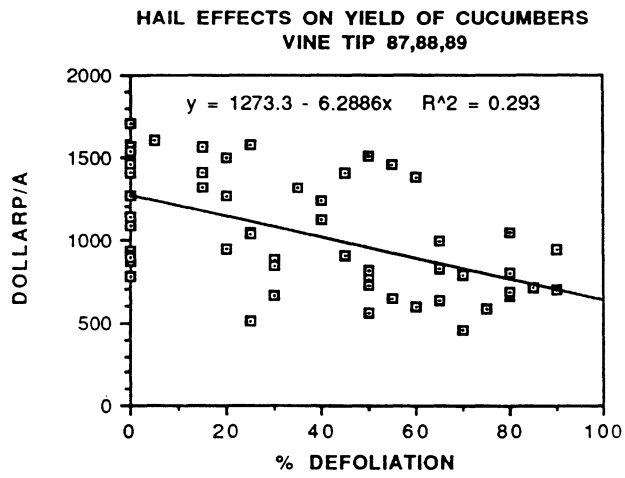


Fig. 8 Influence of hail injury at 3 stages of development of pickling cucumbers on total yield, 1987, 1988 and 1989.

In spite of these variations, the slopes of the lines are similar for the 3 seasons and it thus, appears reasonable to establish yield losses based upon the calculated formula given for each set of data. These will be discussed in the next section.

The influence of hail injury on amount of cull fruits is illustrated in Fig. 9. Injury at vine tip which is prior to fruiting resulted in no influence on the amount of cull fruits harvested. However, hail injury after fruits were present did cause an increase in cull fruits harvested and as the amount of injury increased, so did the amount of culls.

Prediction of Yield Losses Based Upon Defoliation: Calculated yield losses based upon weight and value are illustrated in Fig. 10 with more detailed graphs in Fig. 11, and 12. The following regression formulae were used for the initial calculations (From Figs. 7 and 8):

<b>Tons/Acre</b>	
Vine tip	$y^* = 10.002 - (.045564.x^*)$
1 in. diam.	$y = 9.9858 - (.051132.x)$
2nd week	$y = 10.158 - (.058811.x)$

<b>Dollars/Acre</b>	
Vine tip	$y = 1273.3 - (6.2886.x)$
1 in. diam.	$y = 1221.7 - (7.1220.x)$
2nd week	$y = 1272.3 - (8.7911.x)$

\*y = actual tons or dollars predicted from regression formulae  
 x = percent plant defoliation observed

To then calculate the percentage of loss based upon estimated defoliation, use the following formulae:

<b>Tons/Acre</b>	
Vine tip	$y^* = (4.5564.x) + 10.002$
1 in. diam.	$y = (5.1132.x) + 9.9858$
2nd week	$y = (5.8811.x) + 10.158$

<b>Dollars/Acre</b>	
Vine tip	$y = (62.886.x) + 1273.3$
1 in. diam.	$y = (71.220.x) + 1221.7$
2nd week	$y = (87.911.x) + 1272.3$

\*y = % decrease in tons or dollars/acre  
 x = percent observed plant defoliation

Calculations using dollar values give a slightly larger percentage of loss than those using the tons/acre yields (Table 1). The decision to use either calculation should likely be determined by the type of contract the producer has with a processor, either bushels (weight) or price based upon fruit sizes. It is likely that the contract prices will be different than those used in our calculations. However, the loss relationship will still be quite similar unless the price relationships for the several sizes differ greatly.

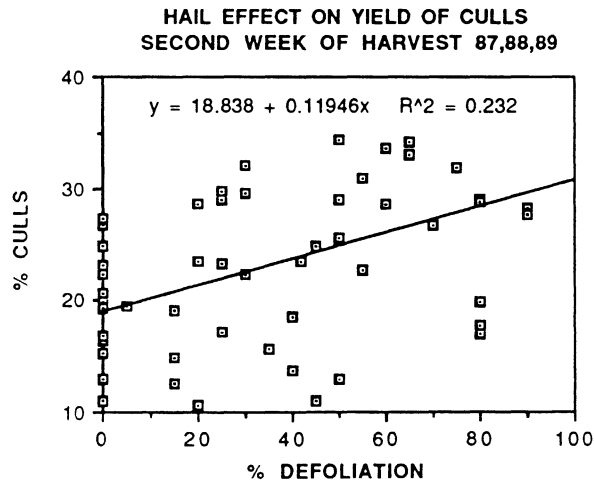
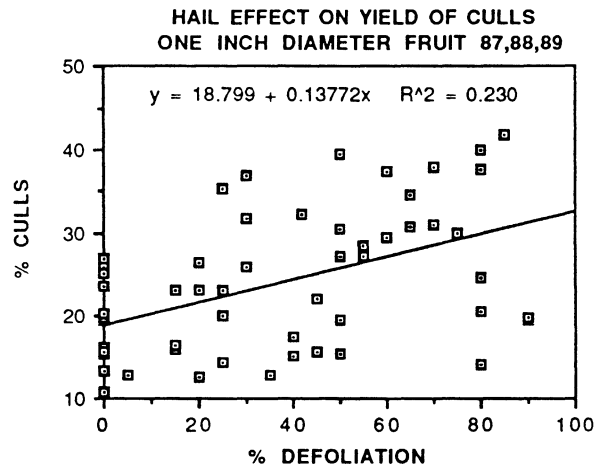
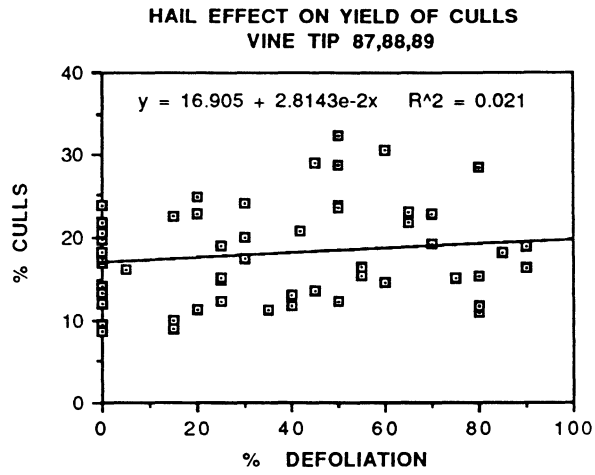
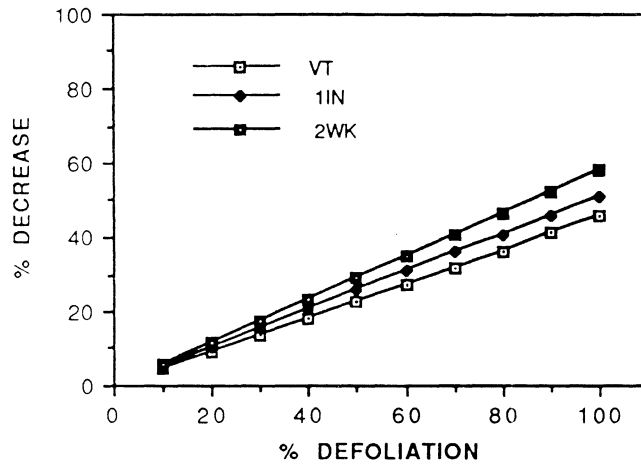


Fig. 9. Influence of hail injury at 3 stages of development of pickling cucumber on the amount of cull fruits producer, 1987, 1988, 1989.



INFLUENCE OF DEFOLIATION ON TOTAL YIELD  
ON CUCUMBERS (TONS/A), 87,88,89



INFLUENCE OF DEFOLIATION ON TOTAL YIELD  
OF CUCUMBERS (\$/A), 87,88,89

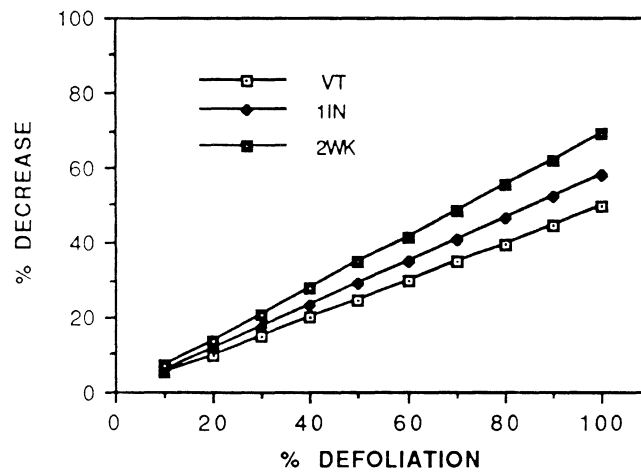
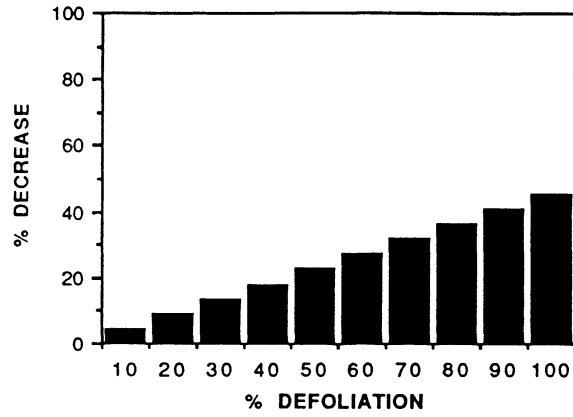
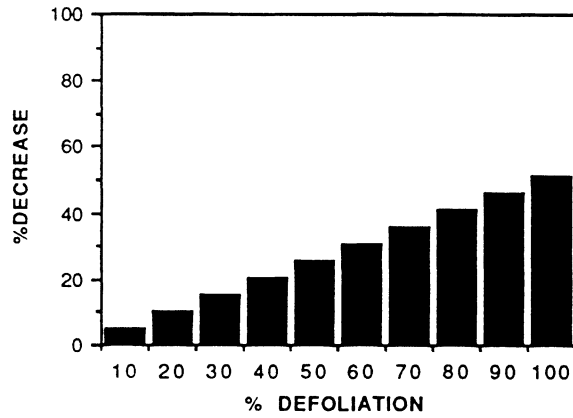


Fig. 10. Relationship of plant defoliation from hail injury to the decrease in total yield or dollar values of pickling cucumbers, 1987, 1988, 1989.

INFLUENCE OF HAIL INJURY AT VINE TIP ON  
TOTAL YIELD OF CUCUMBER, 87,88,89



INFLUENCE OF HAIL INJURY AT ONE INCH DIAMETER FRUIT ON  
TOTAL YIELD OF CUCUMBER, 87,88,89



INFLUENCE OF HAIL INJURY AT SECOND WEEK OF HARVEST ON  
TOTAL YIELD OF CUCUMBER, 87,88,89

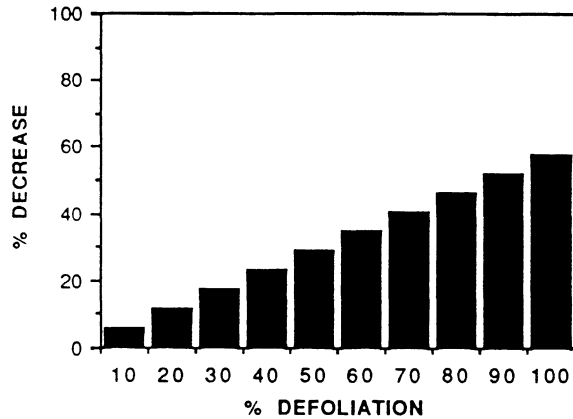
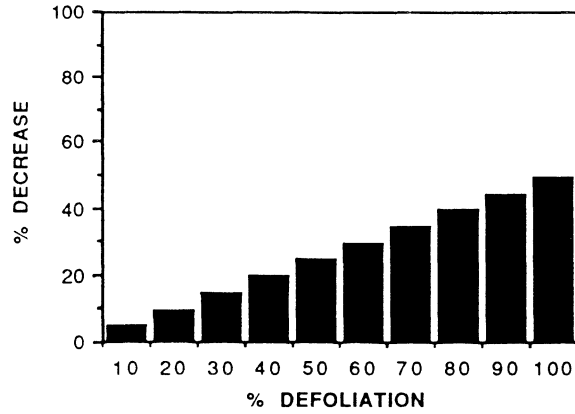
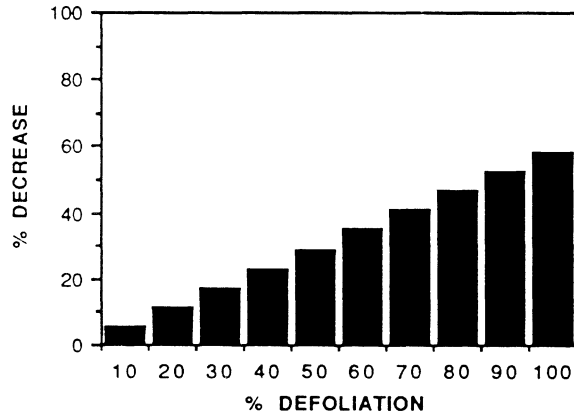


Fig. 11. Relationship of defoliation caused by hail injury to pickling cucumbers on the decrease in total yield, 1987, 1988, 1989.

INFLUENCE OF HAIL INJURY AT VINE TIP ON  
DOLLAR YIELD OF CUCUMBER, 87,88,89



INFLUENCE OF HAIL INJURY AT ONE INCH DIAMETER FRUIT ON  
DOLLAR YIELD OF CUCUMBER, 87,88,89



INFLUENCE OF HAIL INJURY AT SECOND WEEK OF HARVEST ON  
DOLLAR YIELD OF CUCUMBER, 87,88,89

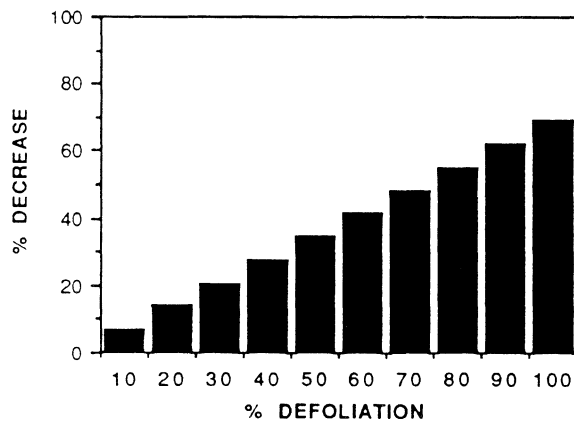


Fig. 12. Relationship of defoliation caused by hail injury to pickling cucumbers on the decrease in dollar value, 1987, 1988, 1989.

Stand Loss Effects on Yield: This study has been run for 2 seasons and the results are somewhat different between seasons (Figs. 13,14,15). Weather conditions in 1990 were more favorable for high production and dollar value than in 1989. It also clearly showed that population loss effects are quite minimal when plant loss occurs during the first two weeks after emergence, especially during seasons of favorable weather for cucumber production.

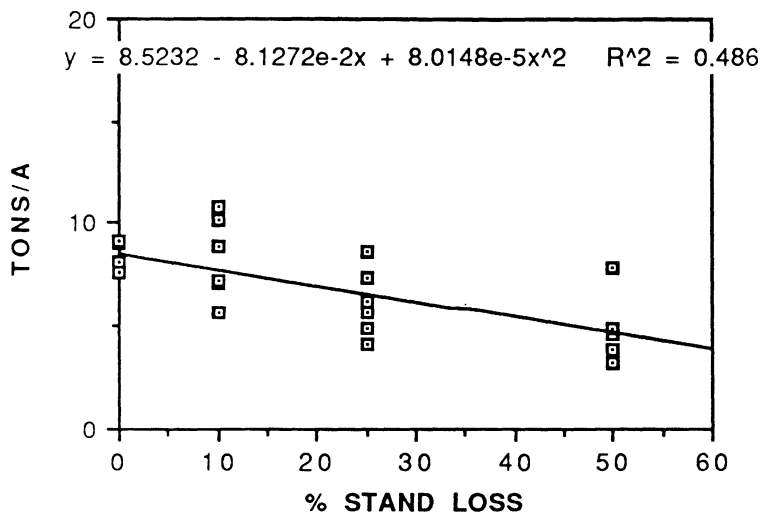
The base spacing in this study is 6 inches between plants. Growers may have spacings as much as 18 inches between plants and they still have economically acceptable yields.

A third season's data may help improve the reliability of the data. One aspect that is important is the uniformity of plant loss. A loss of a large area of a field equivalent to 10% would be much more serious than a loss of one of every 10 plants uniformly throughout the field. In the latter case, adjacent plants would compensate for the missing plants.

Table 1. Influence of hail injury on predicted loss in yield of pickling cucumbers. 1987, 1988 and 1989 data.

Defoliation	\$/Acre			Tons/Acre		
	Vine tip	1-inch fruit	2nd week of harv.	Vine tip	1-inch fruit	2nd week of harv.
10	4.94	5.83	6.91	4.56	5.12	5.79
20	9.88	11.66	13.82	9.11	10.24	11.58
30	14.82	17.49	20.73	13.67	15.36	17.37
40	19.76	28.32	27.64	18.22	20.48	23.16
50	24.69	29.15	34.55	22.78	25.60	28.95
60	29.63	34.98	41.46	27.33	30.72	34.74
70	34.57	40.81	48.37	31.89	35.84	40.53
80	39.51	46.64	55.28	36.44	40.96	46.32
90	44.45	52.47	62.19	41.00	46.08	52.11
100	49.39	58.30	69.10	45.56	51.21	57.90

EFFECT OF STAND REDUCTION ON CUCUMBERS  
1989



EFFECT OF STAND REDUCTION ON CUCUMBERS  
1989

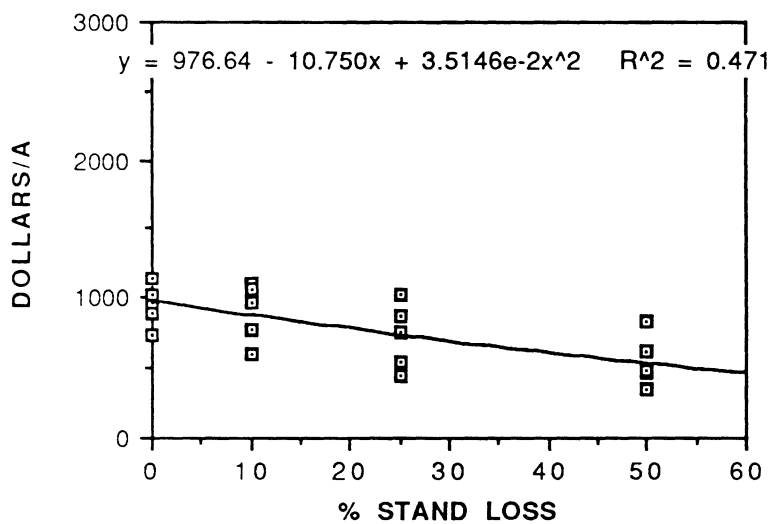
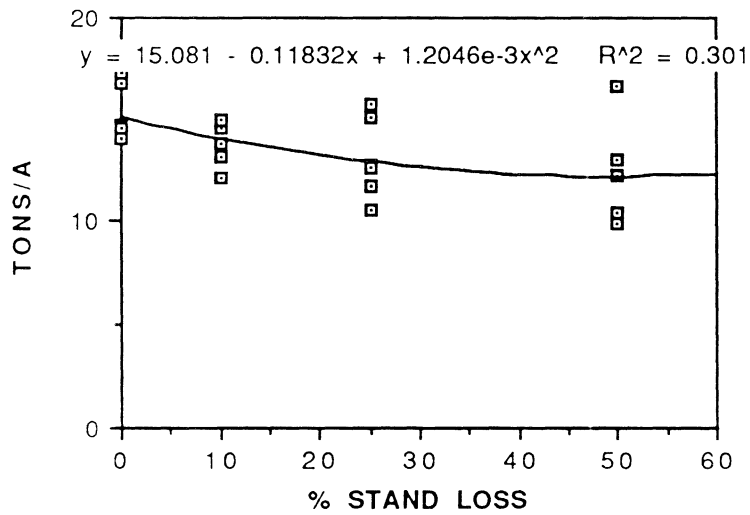


Fig. 13. Relationship of stand loss to total yield and dollar value of pickling cucumbers, 1987.

EFFECT OF STAND REDUCTION ON CUCUMBERS  
1990



EFFECT OF STAND REDUCTION ON CUCUMBERS  
1990

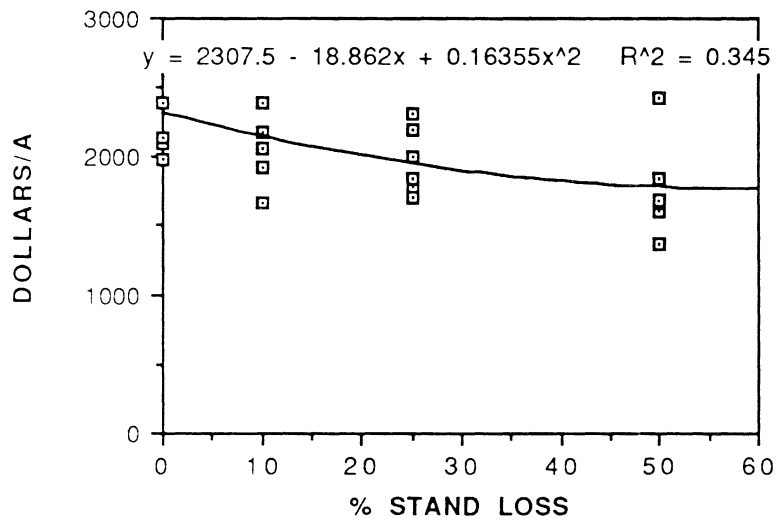
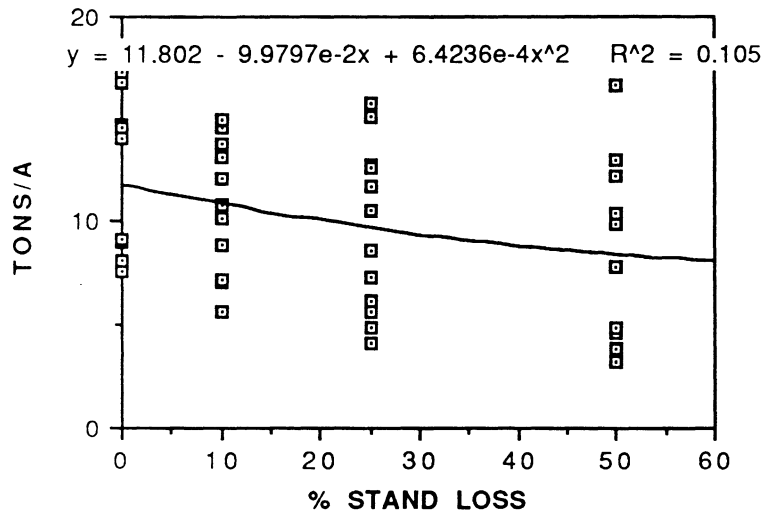


Fig. 14. Relationship of stand loss to total yield and dollar value of pickling cucumbers, 1990.

EFFECT OF STAND REDUCTION ON CUCUMBERS  
1989-90



EFFECT OF STAND REDUCTION ON CUCUMBERS  
1989-90

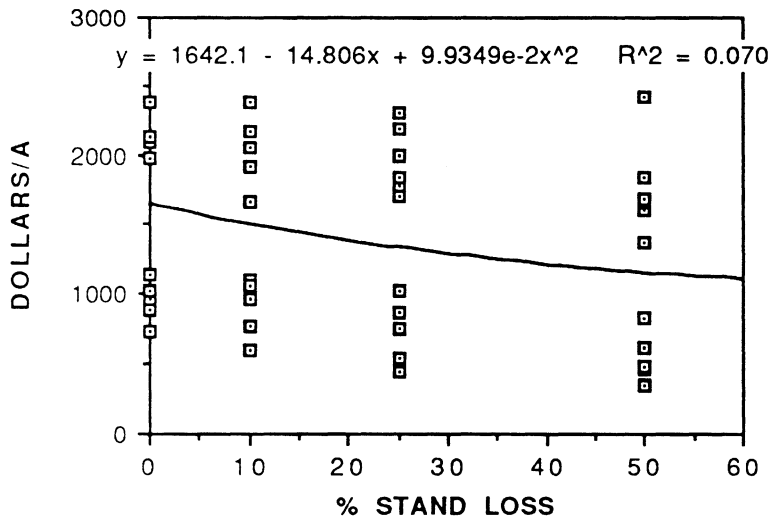


Fig. 15. Relationship of stand loss to yield, data from 1989 and 1990 combined.



APPENDIX A

- 7 -

OSU FARM MANAGEMENT EXTENSION

1989 PICKLING CUCUMBER PRODUCTION BUDGET  
HAND HARVEST

ITEM	EXPLANATION	PRICE PER UNIT	Bu./A. T/A.	YIELD/ACRE			YOUR BUDGET
				360 9	530 13.25	700 17.5	
<b>RECEIPTS</b>							
	20% #1 @ \$15 /cwt 1/						
	40% #2 @ \$8.50 /cwt	\$8.20 /cwt.		\$1,476	\$2,173	\$2,870	\$ _____
	40% #3 @ \$4.50 /cwt						
<b>VARIABLE COSTS</b>							
Seed	2.5 lbs.	\$11.00 /lb.		\$28	\$28	\$28	\$ _____
Fertilizer 2/							
Starter(8-25-3)	225 lb/A.	\$0.12 /lb.		\$26	\$26	\$26	_____
N	100 lb/A.	\$0.21 /lb.		\$21	\$21	\$21	_____
P205	125 lb/A.	\$0.23 /lb.		\$29	\$29	\$29	_____
K20	225 lb/A.	\$0.11 /lb.		\$25	\$25	\$25	_____
Lime	1000 lb.	\$12.80 /T.		\$6	\$6	\$6	_____
Chemicals							
Lindane	0.125 gal.	\$23.40 /gal.		\$3	\$3	\$3	_____
Sevin	6 lbs.	\$2.70 /lb.		\$16	\$16	\$16	_____
Fixed Copper	3 gal.	\$10.00 /gal.		\$30	\$30	\$30	_____
Prefar	1 gal.	\$31.00 /gal.		\$31	\$31	\$31	_____
Alanap	1 gal.	\$13.40 /gal.		\$13	\$13	\$13	_____
Custom Spraying	5 sprays	\$5.50 /A.		\$28	\$28	\$28	_____
Bee Rental	0.5 hive/A	\$40.00 /hive		\$20	\$20	\$20	_____
Pickers Share 3/	60% of Gross			\$886	\$1,304	\$1,722	_____
Crop Insurance		\$16.00 /A.		\$16	\$16	\$16	_____
Hampers 4/	75 /A.	\$0.33 /hamper		\$25	\$25	\$25	_____
Fuel, Oil, Grease				\$15	\$15	\$15	_____
Repairs				\$21	\$21	\$21	_____
Transportation for labor 5/				\$2	\$2	\$2	_____
Miscellaneous 6/				\$6	\$6	\$6	_____
Int. on Oper. Cap. 7/	6 mo.	10%		\$17	\$17	\$17	_____
<b>TOTAL VARIABLE COSTS - Per Acre</b>				\$1,264	\$1,682	\$2,100	\$ _____
- Per Ton				\$140	\$127	\$120	\$ _____
- Per Bushel				\$3.51	\$3.17	\$3.00	\$ _____
<b>FIXED COSTS</b>							
Housing Charge 8/				\$29	\$29	\$29	\$ _____
Labor Charge	7 hrs.	\$6.00 /hr.		\$42	\$42	\$42	_____
Mach. & Equip. Charge				\$43	\$43	\$43	_____
Land Charge				\$100	\$150	\$200	_____
Management Charge	5% of Gross			\$74	\$109	\$144	_____
<b>TOTAL FIXED COSTS</b>				\$288	\$373	\$458	\$ _____
<b>TOTAL COSTS - Per Acre</b>				\$1,552	\$2,055	\$2,558	\$ _____
- Per Ton				\$172	\$155	\$146	\$ _____
<b>RETURN ABOVE VARIABLE COSTS</b>				\$212	\$491	\$770	\$ _____
<b>RETURN ABOVE TOTAL COSTS</b>				(\$76)	\$118	\$312	\$ _____

This page intentionally blank.

This page intentionally blank.

This page intentionally blank.