The Production of Cucumbers for Pickling Purposes
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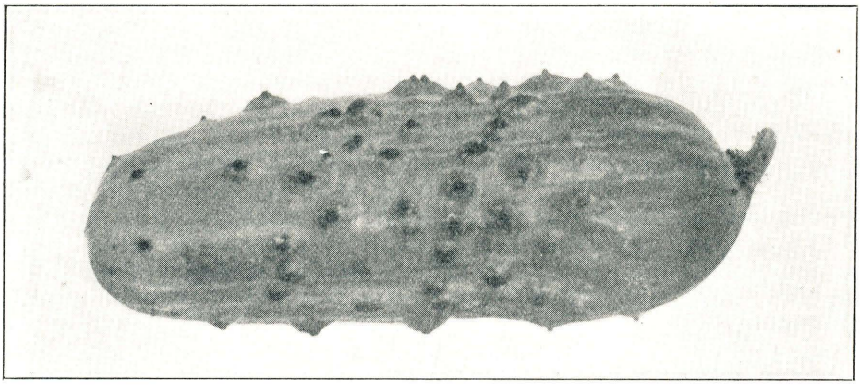

AGRICULTURAL EXPERIMENT STATION
MICHIGAN STATE COLLEGE
Of Agriculture and Applied Science

SECTIONS OF HORTICULTURE
ENTOMOLOGY, AND PLANT PATHOLOGY

East Lansing, Michigan

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THE PRODUCTION OF CUCUMBERS FOR PICKLING PURPOSES

H. L. SEATON

Growing cucumbers for pickling purposes is one of Michigan's important agricultural enterprises. The state ranks first in acreage and total production with 25-30 thousand acres annually devoted to the crop and with a total production of about 1 million bushels. Since approximately one acre is the average farm planting, many thousand farm families are engaged in the industry during the growing season. The pickle companies and independent salters have hundreds of salting and receiving stations scattered throughout the greater portion of the Lower Peninsula. According to the U. S. Census Report for 1930, the value of pickles in the United States in 1929 was $34,480,925, a large portion of which was grown in Michigan.

Pickling cucumbers are usually a good cash crop for the general farmer. Little investment is required and—with the exception of a suitable sprayer—no additional machinery, other than that found on the average farm, is necessary in caring for the crop. The price received is fixed under contract with the pickle company, and the grower has no need to worry about depressed market conditions in seasons of large crops. Usually the grower is paid for each picking when it is delivered to the salting station. The main labor is picking, which usually comes after grain harvest and before bean and corn harvest, or in what is generally a slack season on many farms.

The yields, grades, and returns per acre vary greatly, and frequently severe losses occur from ravages of insects and diseases. It is the purpose of this bulletin to give the grower and packer information concerning those problems. A large part of the material presented is based on experiments conducted at the Michigan and other agricultural experiment stations and on extensive field surveys made in the principal producing areas of the state.

STATISTICS OF PRODUCTION

The statistics of production of pickling cucumbers for the principal states for 1935, taken from Crops and Markets, for December 1935, are given in Table 1.

Approximately 30 per cent of the total acreage in the United States was grown in Michigan, and the state's production was 20 per cent of the total production. The farm value of the crop in Michigan was more than one-half million dollars. The neighboring states, Wiscon-

Table 1. Average, yield, production, price per unit and farm value of cucumbers for pickles by states, for 1935.*

State	Acreage	Yield per acre	Production	Price per unit	Farm value
	acres	bu.	1,000 bu.	dollars	1,000 dollars
Michigan	26,000	40	1,040	.50	520
Wisconsin	9,000	34	306	.52	159
Indiana	8,000	42	336	.45	151
Ohio	6,150	46	228	.52	119
Mississippi	5,550	44	244	.40	98
Virginia	4,100	80	328	.59	194
New York	3,400	90	306	.70	214
North Carolina	3,200	81	259	.75	194
Illinois	2,700	60	162	.60	97
California	2,420	175	424	.46	195
Total all states	89,410	56.3	5,032	.52	2,608

*Crops and Markets, U. S. Dept. of Agr., December, 1935.

sin, Indiana, and Ohio, follow in the order named. These three states and Michigan had more than one-half of the total acreage and produced more than 37 per cent of the total crop in 1935. Acre yields as stated in Table 1 may induce misleading comparisons, since regions vary considerably in the size of pickle predominantly harvested. The yield per acre in Michigan was comparable to that of the neighboring states. Nevertheless, the Michigan yields are lower than they

Table 2. Annual acreage, production and farm value of cucumbers for pickles in Michigan (1920 to 1935, inclusive).*

Year	Acreage harvested	Yield per acre	Total production	Average season farm price	Total value	Average value per acre
	acres	bu.	bu.	dollars	dollars	dollars
1920	26,000	34	884,000	.93	822,000	31.61
1921	29,470	70	2,063,000	1.04	2,146,000	72.81
1922	25,050	40	1,002,000	.87	872,000	34.81
1923	26,840	43	1,154,000	1.11	1,280,000	47.69
1924	35,440	24	851,000	1.13	962,000	27.12
1925	36,810	55	2,025,000	1.11	2,248,000	61.05
1926	25,030	42	1,051,000	.98	1,030,000	41.16
1927	17,350	30	520,000	.90	468,000	27.00
1928	22,840	55	1,256,000	.88	1,105,000	48.40
1929	21,000	29	609,000	.90	548,000	26.10
1930	30,000	51	1,530,000	.90	1,377,000	45.90
1931	22,000	50	1,100,000	.67	737,000	33.50
1932	9,300	40	372,000	.41	153,000	16.40
1933	20,000	56	1,120,000	.43	482,000	24.08
1934	22,500	46	1,035,000	.48	497,000	22.08
1935	26,000	40	1,040,000	.50	520,000	20.00
1920-1935 average	24,727	44.5	1,100,750	.87	956,687	38.69

*Crops Reports for Michigan.

should be, due, partly at least, to the use of inferior soils. High acre yields constitute one of the chief problems in pickle production.

The statistics of Michigan production of pickling cucumbers for the period 1920-35 are given in Table 2. Considerable fluctuation has occurred in the annual acreage during the period, and usually a large production one year resulted in a decreased acreage the following season. The lowest acreage in Michigan for a number of years occurred in 1932, but by 1935 the acreage and total production were back to the pre-depression level. Greater differences than those for acreage are shown in the total production data and are reflected in the value of the crop; in general, high production resulted in high returns per acre to the grower. The data given in Table 2 do not suggest any shift of acreage either to or from Michigan, and the acreage is likely to remain rather constant for the next few years. Although the price per bushel has been low since 1930 and has resulted in low returns per acre, it may reasonably be expected to rise to a higher level with improved economic conditions.

PRODUCING DISTRICTS

The county distribution of 11,157 acres of cucumbers grown in 1929, as shown in the Census report for that year, is shown in Fig. 1. The total acreage is about one-half that given by the Crop Reporting Board, but it shows the important regions. Although some acreage is reported in almost every county of the Lower Peninsula, the most important section is the region along Lake Michigan from Berrien, north to Manistee County. This region includes Allegan, Van Buren, Berrien, Barry, Manistee, Osceola, Ottawa, Kent, Oceana, Newaygo, Mecosta, Muskegon, Mason, Lake, and Wexford Counties. Another section centers around Bay City and includes Bay, Tuscola, Saginaw, Huron, and Arenac counties. Macomb, Wayne, and Monroe counties constitute another area.

CLIMATIC REQUIREMENTS

Cucumber plants are easily killed by frost at any stage and require a frost-free growing season. Warm nights with hot days favor the best development. Good growth is made when the temperature is above 70° F., but heat is less essential than it is for melons. The short season required—40-50 days—for the production of fruit of the pickling size makes possible the successful culture of the crop in nearly all parts of the Lower Peninsula of Michigan.

High temperatures with a maximum amount of sunshine produce a higher sugar content in the fruit than is found in cloudy weather. Packers frequently report losses in the fermenting tanks in seasons of high temperature and bright sunlight. This is doubtlessly the result of the high temperatures at which the fermentation is carried out rather than the sugar content of the cucumbers.

The seed seldom germinates when the temperature is below 50° F. and the optimum is obtained above 70° F. Plantings should be delayed in the spring until conditions are favorable for germination.

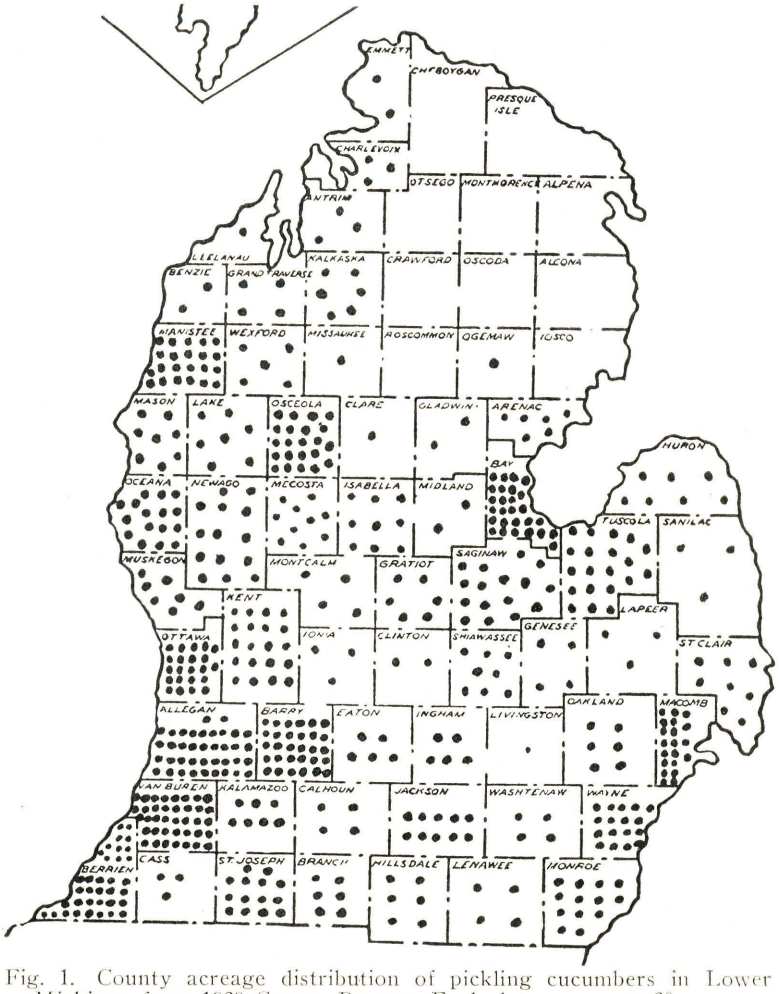

Fig. 1. County acreage distribution of pickling cucumbers in Lower Michigan from 1929 Census Report. Each dot represents 20 acres.

PLANT CHARACTERISTICS

The cucumber is a member of the melon family of plants, often called cucurbits, (*Cucurbitaceae*), which includes muskmelons, gherkins, watermelons, citrons, pumpkins, and squash. The cultivated members resemble one another in general appearance, have similar climatic and cultural requirements and are subject to attacks by several of the same insects and diseases. Some fruit and foliage characteristics are common to certain varieties of different species, and this fact has been erroneously taken as evidence of hybridization or "mixing." However, of the six cultivated species, fertile inter-specific hybrids have never been obtained, despite numerous efforts by investigators in various parts of the world (7). The different species differ in the character of

their pollen and in chromosome number, two factors that make hybridization very unlikely. Within a species, that is, among all the cucumbers, cross-pollination is general and the different varieties, if planted close together, frequently produce worthless offspring.

The cucumber develops a strong taproot (13) soon after germination. This penetrates downward at the rate of 1 inch per day and extends into the third foot of soil. Numerous horizontal laterals develop rapidly and spread widely in the surface eight inches. When the vines begin to extend, the roots make a vigorous growth. Surface roots become extremely abundant. They fill the soil within a radius of 18-24 inches, the longer ones extending outward 3-4 feet. When the maturing vines are 4-6 feet long, usually about 10 weeks after planting the surface root system is extensive, having a maximum spread of 7 feet. The main laterals not only are exceedingly numerous but profusely

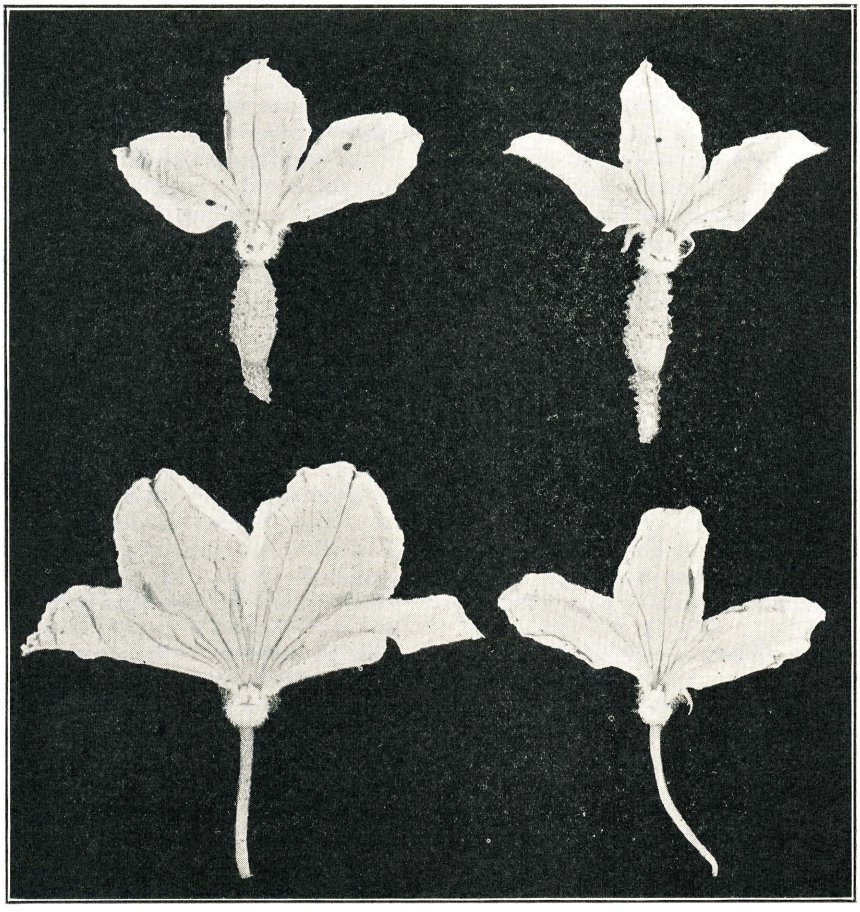

Fig. 2. Types of cucumber flowers. The two upper ones with the immature cucumber beneath the petals are the female or pistillate flowers. The lower flowers are the male or staminate blossoms which produce the pollen.

rebranched in such manner as to occupy the soil thoroughly. The soil, to a depth of 3.5-4 feet is filled with an effective absorbing system that is an efficient protection against drought.

When a cucumber seed germinates, two seed leaves (cotyledons) are unfolded above the ground. These are filled with stored foods that nourish the young seedling. The cotyledons soon develop a green color and begin food manufacture. The stem elongates slightly and four to six true leaves develop. After these have attained nearly full size, elongation of the stem proceeds rapidly and the vines begin to "run." The stem elongates at the end and from each of the lower four or five leaf-axils, a primary branch arises, which may nearly equal the main stem in development. On the main stem and the primary branches numerous short fruiting branches are produced.

Two types of flowers are borne, the male, or staminate, and the female, or pistillate (Fig. 2). The first male blossoms usually appear two weeks before any female blossoms, and consequently no fruit is formed in this period. The staminate flowers occur in clusters of five in the leaf-axils of the main stem and its branches. The female flowers occur singly, or occasionally in clusters of two or more, in the leaf-axils of the secondary branches. The pistillate flowers may be distinguished from the staminate, by the immature ovary, which develops into the cucumber, immediately behind the petals of the flower. Many more male flowers are produced than female, and frequently the ratio of staminate to pistillate flowers exceeds 40:1. Since the female blossoms are borne only in leaf-axils, the number of blossoms is dependent on the number of leaves. In brief, vigorous growth throughout the entire season is absolutely essential to high yields.

SOIL REQUIREMENTS

Pickling cucumbers are grown on many different soil types, but only the better soils can be depended upon to give maximum yields of well-formed cucumbers. Field surveys conducted in various sections of the state show that wide variations occur in the yields and grade on the different soil types. Although considerable data were collected, two illustrations suffice to show the general trend. In Table 3, data on cucumber yields and grade from 40 growers in the Bannister dis-

Table 3. Yields and grade of cucumbers from 40 growers in Bannister section, located on different soil types.

Soil type	No. of growers	Average yield per acre (pounds)	Per cent of various grades	
			small and large	nubs and crooks
Sandy loams	20	4,730	53	47
Clay loams	17	4,513	62	38
Heavy clay	2	2,400	48	52
Very poor sand	1	598	46	54

trict in 1931 are given. These growers were all located within a radius of five miles of the salting station and, in general, their cultural operations were similar. Observations made during visits to these fields suggested that the variations were largely a result of soil type. These data show that the largest yields and the lowest percentages of nubbins and crooks were produced on the sandy loams and clay loams. The heavy clay and poor sand were not suited for cucumber production.

Similar data are submitted in Table 4, representing four growers in the Kinde section, located within a radius of one mile of one another. These growers were selected because of the wide variation in soil conditions. The general condition of soil fertility is reflected in the yields and the percentages of fruits in the various grades. Better soil conditions result in increases in total yields, high percentages of the desirable grades and good financial returns, along with decreases in the percentages of nubbins. Field surveys strongly indicate that high financial returns depend on large yields, and proper soil selection, preparaiton, and fertilization, are necessary to assure good stands of vigorously growing plants.

Table 4. Acre yields, percentages of various grades of four growers with different soil conditions.

	Grower No. 1	Grower No. 2	Grower No. 3	Grower No. 4
Acres grown	2	1	3	1
Soil type	light gray fine sand	light gray fine sandy loam	light gray clay loam	dark gray clay loam
Subsoil	fine sand	clay	clay	clay
General fertility	poor	medium	medium	good
Total yield in pounds per acre	1,023	2,420	4,355	8,248
Per cent small	17	23	24	29
Per cent large	33	35	28	41
Per cent nubbin	50	42	47	30
Gross financial returns per acre	$11.28	$30.53	$55.20	$108.09

In most sections of the state the fertile sandy loams, silt loams, and clay loams are the best suited for cucumbers. An ideal soil type would be a fertile sandy loam underlaid by a clay subsoil. The soil should be well-drained and well-supplied with organic matter. Cucumbers growing in soils lacking humus are likely to be checked in growth unless rainfall is plentiful during July, August, and September. The poorer sandy loams and sands are usually too dry to produce profitable returns, and on heavy clays the plants may suffer in a wet season from the soils becoming hard and packed through the trampling incident to picking. Land with a rolling topography with good air drainage is preferable, because lowlands, including muck, are frequently subjected to frost damage. Numerous experiments in the eastern states have shown that cucumbers do not make satisfactory growth on strongly acid soils, but they will grow well on slightly acid soils.

Cucumbers should not be planted on land that has been recently used for melons, pumpkins, squash, or cucumbers, as serious damage may result from ravages of insects and diseases. Observations indicate that the crop should not follow sugar beets, cabbage, potatoes, or other crops that make heavy fertility demands unless the soil is manured heavily before the crop is planted. A clover, alfalfa, or other type of sod, plowed early, worked down, and harrowed occasionally until planting time usually produces a profitable crop.

Fig. 3. Proper soil selection and a well-prepared seed bed are essential for a good stand of vigorously growing cucumber plants.

MANURES AND FERTILIZERS

Although the cucumber plant is not a gross feeder, to obtain the most profitable returns a vigorous growth must be maintained, and this objective is attained only when the plants are furnished with an abundance of available nutrients. The crop is especially responsive to manure applications as is shown in a 12-year fertilizer experiment conducted in Ohio (3) with "slicing" cucumbers grown on river bottom soil ranging from loam to fine sandy loam. In one series of experiments, 16 tons of manure per acre gave an increase of 82 per cent over the plats receiving no fertilizer and a 21 per cent increase over plats that received 1,220 pounds of 4-10-4 fertilizer. At the rate of 16 tons per acre, manure gave much larger yields and was more profitable on cucumbers than any combination of commercial fertilizers.

Similar results are reported from Rhode Island (6), where 10 cords* of manure per acre were compared with 2,500 pounds 5-6-6 fertilizer and gave yields of 19.12 and 6.98 tons, respectively. Field surveys in Michigan have definitely indicated, on almost all soils, that manure applications are decidedly profitable to the grower of pickling cucumbers.

Fortunately almost all general farmers growing pickling cucumbers have sufficient manure to make annual applications. Probably no other group of plants responds more favorably to manuring than do the cucurbits. Where the manure supply is plentiful, it may be profitable to broadcast 10 to 15 tons per acre with a manure spreader early in the spring before the land is plowed. Coarse, strawy manure should never be applied just before the crop is planted. Small quantities of well-rotted stable manure may be applied to advantage under the hills or in the row furrowed out before planting. This is especially effective on light soils or those low in organic matter. Two or three hundred pounds of complete fertilizer or superphosphate may be applied in the row on the manure. The fertilizer and the manure are covered with soil, and the row leveled for planting the seeds. Poultry manure is sometimes used in the hills or around the plants after they are up. This material gives a good response if properly used, but it should be applied sparingly and thoroughly mixed with the soil. On farms where there is a scarcity of manure, cucumbers should follow alfalfa, red clover, or sweet clover in the rotation.

Commercial fertilizers are often used to supplement light manure applications and occasionally as a substitute for manure. However, if for any reason systematic manuring has been neglected and the soil is in poor physical condition, the organic matter in the soil must be restored before profitable yields can be expected from commercial fertilizers. The kind, the amount to apply, and the method of application depend on the character of the soil, the previous fertilization, and the system of cropping. In general, on sandy loam and clay loam soils, suitable for cucumber culture, where clover or alfalfa has not been grown and where manure has not been applied in the rotation, 300 to 500 pounds per acre of a 4-16-4 fertilizer is recommended. Where clover or alfalfa has been grown or manure applied in the rotation, 300 pounds per acre of 4-16-4, 2-12-6 or 20 per cent superphosphate is recommended. The fertilizer may be applied broadcast and worked into the soil before planting. With the relatively small amounts recommended, greater returns are likely if the fertilizer is applied along the row or around the hills before planting. The standard practice, especially where the fertilizer is applied in the row or hill, has been to mix it thoroughly with the soil to avoid root injury. Recent investigations with other crops, however, indicate that the fertilizer should be applied in bands to the side of the seed at a distance of 2½ to 3 inches and at a depth of 2½ inches for the best response. During a cool, wet season, or if the vines are not making a satisfactory growth, side-dressings of 100 to 200 pounds per acre of nitrate of soda or sulphate of ammonia are beneficial.

*Approximately 40 tons per acre.

SOIL PREPARATION

The soil intended for cucumbers should be plowed moderately early in the spring and kept well-worked until planting time. Alfalfa or clover sod should be plowed and disked the preceding fall to kill the roots and to allow sufficient time for decay of the tops. On light, sandy loams, particularly those with rolling topography, plowing should be deferred until spring, but then it should be done as soon as the soil is dry enough. Where broadcast applications of manure are made, it is best to make them just before plowing. Harrowing the soil immediately after plowing and at frequent intervals, especially after rains, until planting time, is desirable. Where the soil is plowed early and worked down, many of the weed seeds germinate in a few days, and these are easily destroyed by harrowing on a bright day. A second harrowing a week later will destroy a second lot of weed seedlings, while the third and fourth harrowings will nearly rid the top soil of weed seeds. The cheapest, quickest, and best way to cultivate a crop is frequent harrowing before the seed is planted.

Early plowing and keeping the soil well-worked to kill weeds conserves moisture and enables the seed to germinate no matter how dry the weather may be at planting time. Soil that has not been plowed or worked until it is needed is likely to be dry and full of clods. By the time the clods have been worked down sufficiently fine to make a good seed bed, the top soil will have lost most of its moisture. Such seed bed preparation may be satisfactory for corn, or for other crops with large seeds which are planted rather deep, but it is not satisfactory for cucumber seeds which should be planted not to exceed one inch in depth. Soil that has been plowed early and harrowed occasionally will be moist an inch below the surface even during a dry season. Cucumber seed planted in such soil will germinate readily and produce an even stand of vines. Early preparation of the soil generally results in an improved physical condition and a loose, mellow, friable seed bed, which is not likely to form a hard crust that is often injurious to young cucumber seedlings.

DATE OF PLANTING

Since the cucumber plant is tender and easily injured by frost and low temperatures, plantings should be delayed until danger from low temperatures is over and the soil has become reasonably warm. Field surveys in 1929 and 1930 indicated that a large majority of growers planted too early to insure good stands of vigorously growing plants. In 1931 and 1932, date of planting tests were conducted at East Lansing on Hillsdale sandy loam soil of medium fertility. The 1931 plots followed a crop of tomatoes that received a liberal manure application and the 1932 crop followed a green manure crop of soybeans supplemented with light manuring. A broadcast application of 500 pounds of a 4-16-4 fertilizer was made each season several days before planting. Seeds of the National Pickling variety were drilled at the rate of 1½ pounds per acre in rows 6 feet apart. When the plants were sufficiently

large they were thinned to 18 inches apart. Three replications for each planting date were used each year. As nearly as was possible, the plots all received the same cultural treatments and each plot was harvested twice weekly. The data given in Table 5 and shown graphically in Fig. 4 are averages for the two seasons.

In this experiment early plantings resulted in poor stands, but when yields are considered, increase in stand after June 10 was not great enough to warrant plantings after that date. Plantings made May 21 did not produce fruit any earlier than those made 10 days later,

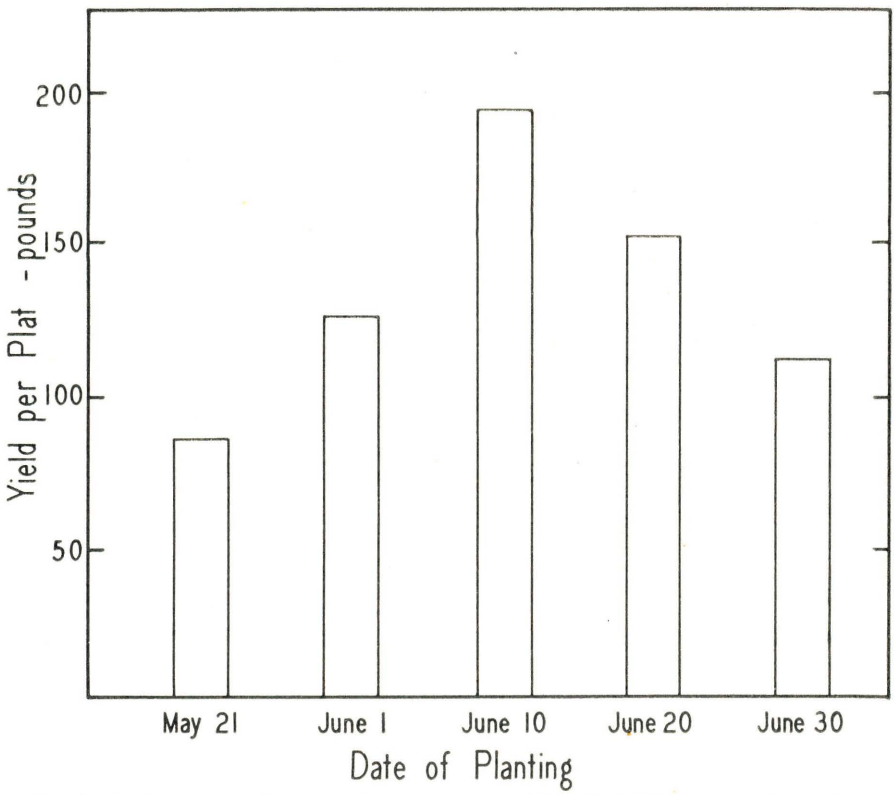

Fig. 4. Influence of the date of planting on yield of pickling cucumbers at East Lansing, 1931-32. The best stands and largest yields are secured when the seed is planted about 4 weeks after average date of last killing frost in the spring.

and where the plantings were later than June 10 the length of the picking season was curtailed, which resulted in lower yields. The largest weekly harvest for the May 21, June 1, and June 10 plantings occurred the third week in August, while for the June 20 planting it was the first week in September, and for those planted June 30 it was the second week of September. The yield data given on the plat basis more nearly represent what might be expected under field conditions than those given on the 100-plant basis. The lowest yields were ob-

Table 5. Influence of date of planting on stand of plants, length of picking season, yields and grades of pickling cucumbers at East Lansing, 1931-1932.

Date planted	May 21	June 1	June 10	June 20	June 30
Stand of plants (per cent)	25	37	85	79	96
Date of 1st picking	July 15	July 15	July 21	August 3	August 10
Length of picking season (weeks)	11	11	10	8	7
YIELDS PER PLOT					
Total number of fruits	1,569	2,310	3,518	2,532	1,946
Total weight (pounds)	89.07	127.60	194.69	155.89	114.90
YIELDS PER 100 PLANTS					
Total number of fruits	4,297	4,330	2,762	2,138	1,230
Total weight (pounds)	218.63	238.62	152.43	130.91	72.23
Per cent small	23	28	26	25	21
Per cent large	29	27	27	30	21
Per cent nubs and crooks	48	45	47	45	48

tained from plantings made May 21, and increases of 143 and 218 per cent were obtained where the plantings were delayed until June 1 and June 10. A reduction in yields is shown for the plantings made June 20 and 30. Even where the yields are reduced to a per plant basis the general trends are the same. There is, however, an indication that if satisfactory stands had been obtained, the June 1 plantings would have been more profitable. When the percentages of the various grades are considered for the entire season, no significant differences are apparent. The harvest records showed that differences did occur—that is, the earlier plantings showed a higher percentage of nubbins and crooks during the major portion of the harvesting season but, because of the small numbers of fruits produced on these plants in late September, their percentage of nubbins was not materially affected. On the other hand, the late plantings produced a far superior grade during the first pickings, but because of the adverse weather for pollination and the heavier set of fruits after the first week in September these differences are not shown in the data given. The climatic conditions in 1931 and 1932 were comparable to what may be normally expected in this section. The data indicate that at East Lansing plantings should be made between June 1 and 10, or approximately 4 weeks after the average date of the last killing frost in the spring, which is May 4.

Since the climate varies greatly in different parts of the state, no definite date of planting can be given that would be suitable for all sections. In Table 6 a summary of the average dates of the last killing frosts in the spring, average dates of first killing frosts in the fall are given for most of the stations in the Lower Peninsula within the areas where pickling cucumbers are raised commercially. From this table, the average date of last killing frost in the spring may be determined and using this as a working basis, the planting date for a section may be determined.

In certain well-protected locations with good air drainage and southern exposures the plantings may be made safely a week to 10 days

Table 6. U. S. Weather Bureau record of frost data.*

Western Lower Michigan				Eastern Lower Michigan			
Station	No. years data	Average date last killing frost in spring	Average date first killing frost in autumn	Station	No. years data	Average date last killing frost in spring	Average date first killing frost in autumn
Allegan	36	May 10	Oct. 6	Adrian	40	May 4	Oct. 9
Battle Creek	39	May 6	Oct. 11	Alma	38	May 12	Oct. 1
Benzonia	28	May 14	Oct. 6	Ann Arbor	39	May 3	Oct. 13
Big Rapids	35	May 15	Sept. 23	Arbela	28	May 12	Sept. 26
Bloomingdale	26	May 13	Oct. 9	Armada	33	May 14	Oct. 5
Cadillac	22	May 15	Oct. 6	Bay City	33	May 7	Oct. 7
Cassopolis	28	May 7	Oct. 13	Detroit	57	Apr. 28	Oct. 14
Centerville	33	May 2	Oct. 12	Durand	18	May 12	Oct. 7
Charlevoix	31	May 11	Oct. 18	Eloise	32	May 8	Oct. 8
Charlotte	27	May 15	Oct. 3	Flint	38	May 10	Oct. 5
Coldwater	36	May 6	Oct. 5	Grape	24	May 6	Oct. 11
Croton	23	May 15	Oct. 4	Harbor Beach	34	May 8	Oct. 8
Fife Lake	12	June 3	Sept. 9	Harrison	27	May 15	Oct. 1
Frankfort	26	May 18	Oct. 13	Hayes	20	May 14	Oct. 5
Ganges	21	May 7	Oct. 17	Hillsdale	34	May 9	Oct. 6
Grand Haven	89	Apr. 30	Oct. 18	Howell	28	May 11	Oct. 6
Grand Rapids	37	May 1	Oct. 18	Jackson	34	May 6	Oct. 9
Greenville	14	May 12	Oct. 7	Lansing (East)	41	May 4	Oct. 9
Hart	30	May 17	Oct. 7	Lapeer	30	May 12	Oct. 9
Hastings	28	May 11	Sept. 26	Midland	25	May 13	Oct. 1
Holland	25	May 8	Oct. 8	Morenci	24	May 12	Oct. 6
Howard City	25	May 28	Sept. 19	Mount Clemens	29	May 9	Oct. 7
Ivan	28	May 25	Sept. 23	Mount Pleasant	28	May 21	Oct. 3
Kalamazoo	48	May 2	Oct. 17	Omer	25	May 22	Sept. 14
Ludington	34	May 4	Oct. 12	Owosso	33	May 13	Oct. 3
Luther	20	May 30	Sept. 18	Plymouth	20	May 12	Oct. 8
Manistee	29	May 14	Oct. 16	Pontiac	27	May 10	Oct. 8
Muskegon	34	May 1	Oct. 16	Port Austin	26	May 14	Oct. 5
Old Mission	36	May 12	Oct. 18	Port Huron	56	May 7	Oct. 11
Olivet	27	May 4	Oct. 7	Saginaw	34	May 1	Oct. 7
Petoskey	34	May 16	Oct. 6	St. Johns	11	May 7	Oct. 6
Reed City	20	May 22	Sept. 24	Sandusky	20	May 22	Sept. 30
St. James	22	May 14	Oct. 13	Thornville	35	Apr. 27	Oct. 12
St. Joseph	29	Apr. 25	Oct. 27	West Branch	25	June 3	Sept. 23
Saranac	25	May 16	Sept. 30	Ypsilanti	45	May 6	Oct. 7
South Haven	32	May 4	Oct. 15				
Traverse City	33	May 11	Oct. 16				

*These data furnished by U. S. Weather Bureau Station at East Lansing. Includes a summary up through 1930.

earlier. Earliness is not a factor in the production of pickling cucumbers, however, and planting should be delayed until the soil is warm enough to insure proper germination, which is essential for good stands of vigorously growing plants.

SEEDING

Two methods of planting—either seeding in hills or drilling the seed in solid rows—are popular among the growers of pickling cucumbers. If the plants are grown in hills, the field may be marked with rows 4 feet apart one way and 6 feet apart the other. Sufficient seed (8 to 10) should be planted in each hill to insure a full stand; after the plants are well-established and the ravages of the cucumber beetle are over, they should be thinned to two plants per hill. In planting with a hand hoe, care should be exercised to place the seed in moist

soil, which should be tamped lightly with the hoe, after which a little loose soil should be drawn over the hill. The seed should not be covered deeper than one inch. In planting a large acreage, a modified hand corn planter is often used. Wooden blocks are bolted near the bottom to prevent the point from entering the soil to a greater depth than one inch. The hole left by the planter should be filled by scuffing in some soil with the foot.

Most growers of pickling cucumbers plant the seed in drills. Where this method is practiced, it is necessary to mark the field in one direction only. The seed are drilled in continuous rows, spaced 5 to 6 feet apart, and later the plants are thinned to 12 to 18 inches apart in the row. The drill should be so regulated that a single seed is dropped every 5 to 6 inches. This method tends to give a more uniform distribution of the seed; insures a better spacing of the plants, involves less labor in applying fertilizers and manure, and facilitates picking. On the other hand, with the crop grown in hills it is possible to cultivate in both directions, thus saving somewhat in hand hoeing. However, if the soil is plowed early and given frequent harrowings until planting time, weed control should not be a serious problem.

INTERPLANTING

The opinion is prevalent among some growers that cucumbers need a certain amount of shade for their proper development and to provide this they plant corn or some other crop between the rows. Still other growers, after the crop is planted, believe that too much space has been allowed between the rows and attempt to utilize it by planting a single row of some other crop between the rows of cucumbers. This practice can not be recommended for several reasons. In the first place, cucumbers make their best development in full sunlight; shade is not necessary and often decidedly detrimental. Second, the intercrop competes with the cucumber plants for nutrients and moisture, and third, it interferes with cultivation and harvesting. These facts have been observed repeatedly in the field surveys and are substantiated by an experiment conducted at East Lansing in 1932. The planting arrangement in this case comprised cucumbers planted in 6-foot rows and between four of these rows, three rows of sweet corn were planted the same day as the cucumbers. The two center rows were taken as the plot with the intercrop, while other rows where no corn was grown were used as the check plots. Three replications of each treatment

Table 7. Influence of intercrop of sweet corn on the yields and returns of pickling cucumbers, 1932.

	Clean cultivation	Interplanted with sweet corn	Differences
Total number of fruits per 100 plants	2,507	1,992	615
Total yield per acre (pounds)	5,459	4,369	1,090
Gross returns per acre	$45.00	$36.20	$8.80

were included, and the averages for the three are given in Table 7. Although these data are for only a single season they show what may generally be expected, that is, a material reduction in yield and returns. Had the season been abnormally dry even greater differences may have been expected to occur.

CULTIVATION

The function of cultivation is to conserve moisture by eliminating weeds, to close up cracks in the soil and to provide a loose, rough surface which will more efficiently absorb rainfall and help to prevent erosion. Cultivation should begin as soon as the rows can be followed. Frequent, shallow cultivations will enable the grower to subdue the weeds very largely before the vine growth prohibits the practice. Any implement suitable for corn will serve, but the teeth should be adjusted so that they will not cut deeply since many of the feeding roots are near the surface. When the vines have attained a length of 12 to 18 inches cultivation should cease. Moving the vines to permit cultivation usually does more harm than good. It destroys the blossoms, drives away the bees, and results in kinking and matting of stems. During average seasons from four to six cultivations are necessary and, after cultivation ceases, one or two hoeings may be required to keep down weeds. Large weeds should always be cut rather than pulled.

POLLINATION

Reference was made earlier, under the heading of Plant Characteristics, to the fact that two kinds of flowers are borne on the cucumber plant—that is, the male or pollen-producing flowers and the female blossoms. At the base of the latter can be seen the undeveloped cucumbers. The male flowers are the first to appear, often in great abundance. When these are observed to wither and fall off, the erroneous conclusion is often formed that the cucumbers are failing to set. With the appearance of the pistillate blossoms, however, normal fruit production should occur. The production of normal fruits, however, must be preceded by the transfer of pollen from the male blossoms to the stigmas of the female blossoms; if this does not occur, the blossoms wither, and the fruit fails to develop.

Both types of flowers usually open about two hours after sunrise, but the opening is markedly influenced by temperature and humidity. They close the afternoon of the same day, and by the following morning the petals are withered. The pollen is released soon after the petals are fully expanded. It is covered with an oily film and remains in masses in the pollen sacs. The stigma of the female flower is receptive the day the flower opens and remains receptive until the afternoon of the same day. However, receptivity is greatly influenced by climatic conditions and usually, in the field, the stigma is most receptive early in the morning.

Pollination is not likely to occur unless the flowers are visited by insects or pollinated by hand. Honeybees are the most frequent visit-

ors. In reaching for the nectar at the base of the male flower the bee brushes against the pollen, and some of it sticks to the bee's hair. Then, when the bee visits the female flower, some of the pollen is brushed on the sticky stigmatic surface. Here the individual pollen grains begin to send out tubes which penetrate into the ovary and enter the ovules. After this the ovules develop into the seeds. A single fruit contains several hundred ovules, most of which must be fertilized before the fruit can develop properly; therefore, it is essential that several hundred pollen grains come in contact with the stigma of a single female flower, since a single grain is capable of fertilizing only one ovule (seed). After fertilization the immature fruit (ovary) increases in size, with the greatest increase occurring 4 to 6 days after pollination, and reaches the pickling size in from 7 to 10 days. Hence, it follows that with pickling cucumbers it is necessary that some pollination occur daily if the maximum number of well-formed fruits are produced.

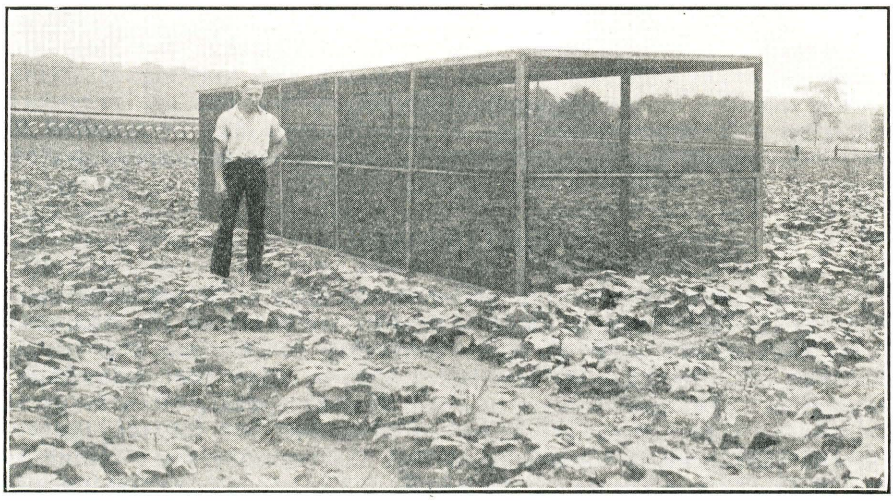

Fig. 5. One of the screen cages used to prevent insect visitation to the flowers in the 1935 pollination experiments.

Occasionally cucumbers set fruit without the stimulus of fertilization. Such fruits are always seedless and usually misshapen. If slices are cut across the fruit, small holes, which should be filled with immature seeds, may be observed frequently. In the manufacture of sliced pickles it is necessary to remove such sections by hand picking after the slicing process, which is a costly factory operation.

Since flowers are chiefly insect-pollinated, the presence of bees in the field is necessary. This was clearly shown by an experiment conducted at East Lansing during 1934 and 1935. Cages made of window screening (Fig. 5) were placed over cucumber plants to exclude insects. The plants were sprayed several times with a strong nicotine solution to kill any insects in the cages. All honeybees were kept out

but a few insects, cucumber beetles mostly, were found in the 1934 cages. Plants in adjoining rows were used as open-pollinated controls. In 1934 the plats were within a few hundred yards of the College Apiary, and in 1935 a hive was placed in the center of the plots; hence, each year ample opportunities for pollination were afforded for the uncaged plants. In 1934 two cages, each containing 20 plants, were used, and the open pollinated plots consisted of 40 plants each. In 1935 larger cages enclosing two 6-foot rows 35 feet long were used. One cage was so constructed that a bee hive with two entrances, one into the cage and one to the open, was placed in one of the side walls. The data for the two seasons are given in Table 8.

Table 8. Yields and percentages of fruit shapes from open-pollinated and from caged cucumber plants.

	1934		1935		
	Open-pollinated	Caged. no insects	Open-pollinated	Caged with bees	Caged. no insects
Number of plants	20	20	45	45	45
Total number of fruits harvested	500	198	557	230	65
Per cent increase over caged	253	.....	857	354	.....
Total weight of fruits (pounds)	41.20	14.20	83.01	30.80	12.60
Per cent increase over plants caged without insects	290	.....	660	245	.....
Per cent straight fruits	56	25	36	34	8
" " misshaped fruits	44	75	64	66	92
" " constricted at blossom end	14	29	19	22	37
" " constricted at stem end	8	4	33	36	45
" " constricted in center	not recorded		7	4	6
" " crooked	22	42	5	4	4

The necessity of honey bees in cucumber fields is clearly shown in the large increases in number and weight of fruits produced by the open-pollinated plants. The larger number of fruits produced in the 1934 cages is undoubtedly the result of cucumber beetles feeding on the flowers, while in 1935 few beetles were found in the cages. The differences in the plants caged with bees in 1935, and the open-pollinated plants is also explicable on the basis of the reaction of the bees to confinement. In the high cages (6 feet) the bees invariably exert most of their efforts in flying against the screening at the top of the cage and spend little time in flower visitation; consequently, although many more bees are present, fewer are found working on the flowers than on the uncaged plants. Observation showed that the screening had little influence on the temperature and humidity within the cages; however, it undoubtedly produced some shade which may account partly for the limited results within the cages containing bees. Nevertheless, the superiority of the cages containing bees over those containing none is striking and significant. The large increases in the percentages of straight fruits in the cages containing bees indicate that adequate pollination is essential for good shape. This is particularly true for the constrictions at the blossom and stem ends.

Pickle producers should realize that better pollination conditions are needed for a good pickle crop than for a good crop of mature slicers or even for seed production. Pickle production requires the

partial development of large numbers of fruits, while slicers and seed crops require fuller development of comparatively small numbers of fruits. Heavy pickle production involves almost continuous development of new fruits, and failure to obtain set for a few days is an irreparable loss, while with the other cucumber crops it is soon compensated by a few days of favorable set.

Conditions affecting the activity of bees in cucumber fields are likely to increase or decrease correspondingly the percentage of flowers setting fruit. Inactivity due to cold weather when pollination should take place is likely to result in a poor set. When weather conditions are favorable, large areas of honey-producing crops such as white clover, alsike clover, and sweet clover may compete with the cucumbers and attract the bees away from them. The proximity of hives to the cucumber fields may decidedly influence the yields and deserves the attention of the grower. Many growers report increased production with a lower percentage of nubbins where hives are located in or near the fields. In general, the fields should not be farther than one-quarter of a mile from one or more swarms of bees.

HARVESTING

Cucumbers planted from June 1 to 10 will begin to produce fruits in late July or early August. The first two or three pickings will hardly pay for the labor in harvesting, but for the benefit of the subsequent pickings it is very important that these early fruits be removed. Few growers realize the extent to which maturing fruits reduce the production of new blossoms (8). If a vigorously growing cucumber plant is allowed to develop normally, the first three to five female flowers near the base of the plant will set fruit. These are often referred to as the "crown set" and will continue to increase in size until maturity. During the development of these fruits the plant continues to develop, and many more female blossoms are produced. However, even if pollinated, these latter blossoms are deprived of manufactured foods and nutrients by the more favorably located fruits near the base of the branches, and consequently they do not set. Later, when the crown set is nearly mature, if growing conditions are favorable, a second setting may occur several feet from the base of the plants, and a situation similar in all respects to that produced by the crown set occurs. Thus, the plant will mature from 5 to 12 fruits during the season. However, if the young fruits are removed before they attain any considerable size (2 inches) the plant will produce from 35 to 50 fruits (9). It is practically impossible to find and remove every cucumber at any one time, but that should be the aim. If a fruit is missed and becomes too large it should be removed as soon as noticed. Serious injury may be done by careless picking which results in tearing and breaking the vines. If grown in rows the plants may be rolled over and, after the fruits are removed, rolled back in their original position. One man can pick the cucumbers from one acre of vines by picking one-half acre each day; school children usually pick about half as large an acreage as an adult.

Harvesting the crop is regarded commonly as the largest item of expense, and this outlay is governed largely by the frequency of the pickings. Field men, in general, urge farmers to pick frequently so that a large portion of the crop will be of the desirable grade. Growers contend, however, that less frequent pickings result in total yield increases great enough to overbalance the lower prices paid for the

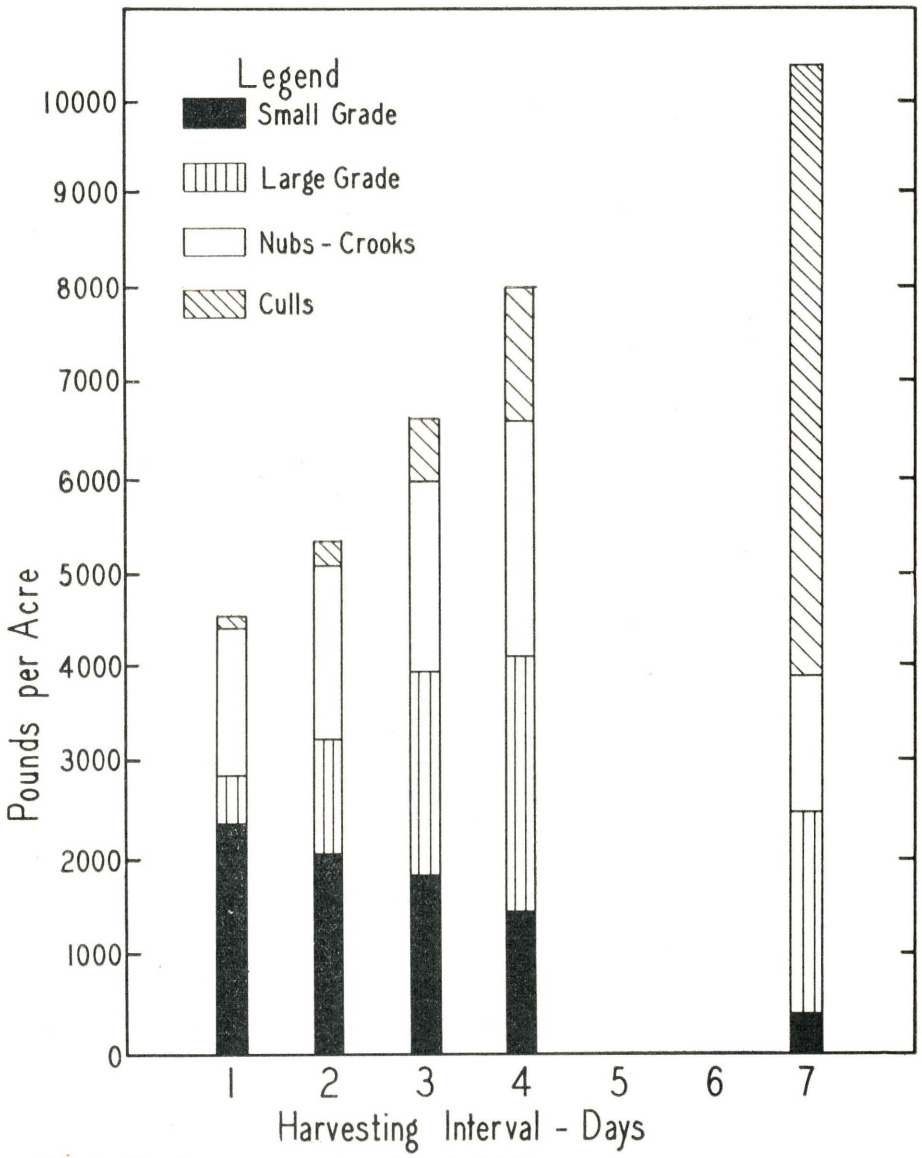

Fig. 6. Graphic representation of total yield in pounds per acre and the amounts of each grade produced when pickling cucumbers were harvested at one-, two-, three-, four- and seven-day intervals.

larger fruits. In other words, they contend that the prices paid for small cucumbers are not high enough to make their production more profitable than the production of larger sizes. Obviously, with frequent pickings smaller sizes will prevail; with more time elapsing between pickings larger specimens will be harvested. Since oversized cucumbers are rejected, picking intervals must have some maximum limit. The question is often asked: "What picking interval will, under ordinary weather and soil conditions, produce the most profitable combination of large and small sizes, with a minimum of oversize and off-shape (nubs) fruits?"

A recent publication (9) from the Michigan Agricultural Experiment Station reports the results of an extensive experiment over a period of three years on this question. The experimental plats were grown at East Lansing on a Hillsdale sandy loam of medium fertility, in a different location each season. The usual methods of fertilization, planting and culture were followed. Each experimental plat consisted of two rows, 100 feet long, containing approximately 133 plants and arranged in such manner that every third plat constituted a check plat. In 1931 each treatment was replicated three times, in 1932 four replications were included for each picking interval, and six in 1933. The treatments of all plats were identical except for the interval between harvests. These intervals between pickings were: one day, two days, three days, four days, and in 1932 several plats were picked every seventh day. The vines were examined carefully at each picking, and as nearly as possible, all fruits more than 1¾ inches in

Table 9. Influence of length of interval between harvests on yield, grade, and financial returns of pickling cucumbers (3-year averages).

Picking Interval (days)	1	2	3	4	7
Total number of fruits (per 100 plants)	3,764	3,020	2,657	2,179	1,162
Total weight (pounds per acre)	4,570	5,357	6,720	8,139	10,388
Small grade (pounds per acre)	2,366	2,056	1,866	1,476	373
Large grade (pounds per acre)	476	1,232	2,059	2,613	2,166
Nubs and crooks (pounds per acre)	1,710	1,881	2,142	2,340	1,459
Culls (pounds per acre)	18	187	653	1,653	6,390
Small (per cent of total salable by weight)	52	39	30	22	9
Large (per cent of total salable by weight)	11	23	32	40	54
Nubs and crooks (per cent of total salable by weight)	38	38	37	37	36
Gross returns per acre					
Small at $1.25 per cwt	$29.65	$25.70	$23.32	$18.45	$4.66
Large at $0.75 per cwt	3.57	9.49	15.45	19.60	16.24
Nubs and crooks at $0.50 per cwt	8.55	9.41	10.71	11.70	7.30
Total returns	$41.68	$44.60	$49.48	$49.75	$28.20
Gross returns less harvesting costs	−38.32	4.60	22.82	29.75	16.77
Influence on size within grades					
Small (calculated number per barrel)	12,876	10,686	8,850	7,901	6,531
Large (calculated number per barrel)	2,118	2,127	2,004	1,767	1,716
Nubs and crooks (calculated number per barrel)	12,411	9,459	7,533	5,655	4,089

length were harvested. All plats were picked separately, and the fruits from each were separated into four grades, and records were kept of the number and weight of the cucumbers of each grade. A summary of the data obtained is given in Table 9 and shown graphically in Fig. 6.

Total numbers of fruits produced are shown to increase with frequent pickings, while the total weights of fruits were greatest from the longer intervals. On a graded basis, the percentage of small-grade fruits increased with frequent pickings, while, on the other hand, the increase in the percentage of the large size from the longer intervals more than offset this effect. The percentage of nubbins and crooks remained constant for the various intervals. Where the intervals between pickings was lengthened beyond four days, a large percentage of culls resulted. It is suggested that under ordinary soil and weather conditions cucumber fields be picked twice weekly.

Financial returns per acre minus estimated harvesting costs were largest for the four-day interval and showed a loss for the one-day interval. Even with a wider spread in the prices for the various grades, one- and two-day pickings were not profitable. The data indicate that high financial returns depend on large acre-yields, which are generally accompanied by a better grade of pickling cucumbers.

GRADING

Practically all pickling cucumbers are grown under contract between a pickle company and the farmer. The contract specifies the grades into which all the cucumbers are to be separated and the price to be paid for each grade. The grades vary with the different companies and are largely governed by the kind of pickles manufactured. Some contracts specify the maximum percentage of the large grade that will be accepted. The following grade specifications represent those commonly used in Michigan and were used throughout the experiments reported in this publication:

1. **Small**—All straight, perfectly shaped cucumbers less than 3¼ inches long and less than 1⅛ inches in diameter.
2. **Large**—All straight, perfectly shaped cucumbers more than 3¼ and less than 5½ inches long and more than 1⅛ and less than 2 inches in diameter. Fruits of this grade are packed as "dill" pickles.
3. **"Nubbins" and "Crooks"**—All misshaped fruits of small and large sizes not meeting the requirements of the other grades.
4. **"Culls"**—Over-matured fruits and large, seedy nubbins that would be rejected at salting stations.

The usual practice is for the farmer to grade each picking. The pickers bring all of the fruit to a sorting table where the culls are thrown out, and the other grades are placed in separate containers for delivery to the salting station. Here they are quickly run over sorting tables or machines and the cucumbers not meeting the grades are picked out. Each grade is then weighed and usually the scales receipt is payable at the local bank.

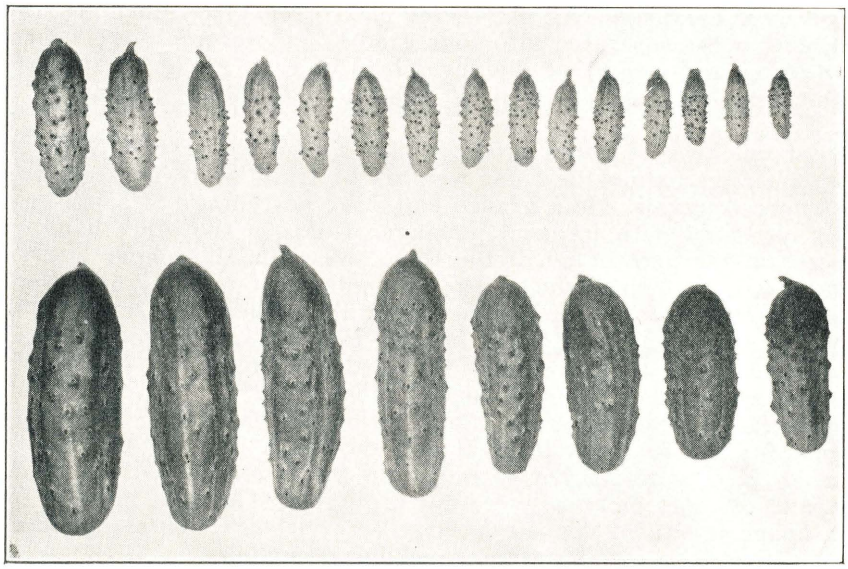

Fig. 7. Small-grade pickling cucumbers in upper row, the large-grade fruit in lower row.

Fig. 8. Different fruit shapes and sizes classified as nubbins and crooks.

VARIETIES

Since nearly all pickling cucumbers are grown under contract, the pickle packer reserves the right to specify the variety to be planted and furnishes the grower with the seed, either free or at a nominal price. Where this system is followed certain difficulties are avoided: If each grower were allowed his own preference, many sorts would be planted, with a resultant lack of uniformity in the product turned out by the salting station. Most small pickles are marketed in glass containers. Only three or four varieties produce fruits suitable for this purpose.

Two distinct types of cucumbers are commonly grown—those with black and those with white spines. As a black-spined cucumber matures it gradually develops a deep reddish-brown color with a trace of netting; in the white-spined sorts the green color fades until at maturity the fruits are nearly white. Black-spined varieties are used almost exclusively for pickling, while the market gardener finds many of the white-spined varieties better adapted to the market for slicers.

Although the slicing varieties of cucumbers are occasionally used for pickling purposes by home gardeners, they are never used by the commercial pickle packer. These varieties are much less prolific than the pickling varieties and when the small fruits reach the pickling size they are very slender, often pointed at the blossom end, and commence to shrivel badly soon after harvest (5). Such varieties as National Pickle, Snow's Perfected Pickling, and Boston Pickling are generally used for the small sizes, while Chicago Pickling, a somewhat longer cucumber, is used primarily as a dill pickle. The type represented by the above-mentioned varieties, has been selected because of its ability to produce large numbers of well-shaped fruits when systematically harvested and to retain its shape after the fermentation and the other pickling processes.

The differences between varieties of pickling cucumbers are not great and, since the plant is normally cross-pollinated, it is difficult to keep the seed stocks true to type. Selections and other improvement work in the hands of different men are likely to be based on different ideals of type. These conditions account largely for the variations found in different seedmen's stocks of the important varieties and in a majority of cases the particular strain used is far more important than the variety. Brief characterizations for the major varieties follow:

National Pickle—This is a variety of pickling cucumber that resulted from a cooperative breeding project between the Michigan Agricultural Experiment Station and the National Pickle Packers Association. This work was started in 1925 and continued through 1930. A large number of strains of pickling cucumbers were grown, and representatives of the pickle packers agreed that the Snow's Perfected Pickle more nearly met their requirement than any of the other varieties. A large number of plant selections were made in this variety, and their progenies were grown for observation at the Experiment Station. One selection, No. 60, was outstanding in type, shape, habit of growth, vigor, and productivity. It was so superior in every way

that all the others were discarded. The remnant sample of seed of this selection was planted in the greenhouse and all flowers carefully self-pollinated. These lines were then grown in the field where the better plants were self-pollinated. By growing two generations each season in this manner, it was possible by the inbreeding followed to standardize the type. In 1928 a large increase plot yielded 1,000 pounds of seed, which was distributed through the National Pickle Packers Association for trial purposes. Numerous test plantings were made in all the important pickle producing states and with one or two exceptions the reports from these tests were especially favorable. At that time (1929) the strain was named "The National Perfected Pickle" or "The National Pickle" (11).

Fig. 9. A fruiting branch of the National pickling cucumber. A well shaped pickling cucumber is produced in most of the leaf axils.

In 1931 an extensive variety test was conducted at East Lansing where the National Pickle was compared with 25 samples of pickling cucumbers from seedsmen supplying the industry with a large proportion of its seed. In every case the National Pickle out-yielded all the other strains. The range in total production, based on 100 per cent for the National Pickle, was from 60 for the lowest to 94 for the highest strain. In the small sizes the range was from 42 per cent for the lowest to 107 per cent for the highest, which was a seedman's stock of National Pickle. A number of pickle packers have expressed the opinion that the breeding work not only produced an improved acquisition to the varieties available but it also resulted in considerable improvement by seedsmen in their stocks of the other varieties.

Since the first seed was distributed for trial purposes and as stock seed, the breeding work at the Michigan State College has been continued in order further to improve the strain and to maintain a source of supply for stock seed.

The National Pickle resembles the Snow's Perfected Pickling in most respects. It is, in general, more vigorous and more productive than the parent variety. The fruits are symmetrical in all sizes, so the variety may be used for small fancy packs or for dill pickles. The fruits are solid, with thick, strong walls. While most varieties are angular or three-lobed in cross section, the National is nearly round. The fruits are "square-ended," a highly desirable character in a pickling sort, and the color is a uniform green. The earlier releases of this variety were inclined to be proportionately short for their diameter, especially in dry seasons; however, this defect has been largely eliminated in the improvements made in the last few years. Since its introduction, the demand for seed has been considerable; at present the strains of this variety vary considerably, and the packer should be careful in his source of supply.

Snow's Perfected Pickle—This is a popular variety for the production of small-sized pickles. The fruits are well-filled at both ends, symmetrical in shape and have a good green color. It produces a small percentage of "nubs and crooks." In the dill sizes, the fruits may be somewhat short and blocky in a dry season.

Boston Pickling (Green Prolific)—This is used by some packers for the production of dill pickles. In the smaller sizes the pickles are symmetrical, but somewhat slender. The color is a darker green than that of most pickling varieties.

Chicago Pickling—This is one of the best varieties for the production of dill pickles. When it reaches the dill size the proportionate length and thickness are about right. In the smaller sizes it is satisfactory but may be a trifle slender as compared with the National Pickle.

Davis Blend—This is a strain used by many packers. Ordinarily it produces fruits of a good pickling type, but stocks of this variety tested at East Lansing and observed in trial grounds in several locations seem not to be as uniform as the other varieties mentioned.

To the grower who plans to sell pickling cucumbers on the market, rather than under contract, it may be pointed out that he should grow pickling cucumbers, rather than use small fruits of the slicing strains. Doing this, he not only delivers material better suited for the purpose, resulting perhaps in further future sales, but he obtains the advantage of the greater productivity of the pickling strains, when they are picked frequently. Slicing varieties are selected primarily for maturing a comparatively small number of fruits, while pickling varieties are selected for starting the development of large numbers of fruits, none of which is to be matured. The National Pickling variety is the most popular for this purpose.

SEED PRODUCTION

Successful cucumber production depends largely on the quality of the seed, and there are several different aspects to the question of quality. Of paramount importance is the purity of the seed from the standpoint of variety. The requirements for pickling demand a cucum-

ber having certain characteristics, and such fruit cannot be produced unless the seed planted comes from vines producing cucumbers possessing the desired qualities. As has been mentioned previously, cucumber varieties cross freely, and taking seed from vines standing near cucumber vines of other varieties will almost invariably lead to contamination sufficient to affect the value of the crop. Removal of all off-type plants before some crossing can occur is almost impossible. This introduces foreign seed which makes the next crop still more off-type, and so on. Consequently, frequent renewal of seed stocks from

Fig. 10. Threshing cucumber seed. The hopper is equipped with corrugated rollers, which crush the fruits and the revolving wire mesh cylinder separates the seed and juice from the rinds. The storage tank in the rear supplies water for washing the seeds from the fermented pulp.

lines kept pure by rigorous selection is highly important. Most large seed companies are acquainted with the methods that must be employed in the production of good cucumber seed. These methods are expensive, however, and the packer should stand ready to pay for the quality demanded.

To be of good quality, seed must be viable; that is, when planted under conditions suitable for germination, from 90 to 95 per cent of the seed should produce plants. However, lack of viability is seldom a problem with cucumber seeds, which retain germinating power for at least five years, if stored in a cool, dry place. Some growers claim seed three or more years old gives better results than new seed. There is no evidence to support the theory that old seed has any physiological

superiority over new. An experiment conducted at the Cornell Experiment Station in 1889 (1) gave no evidence whatever that older seeds give shorter and more productive vines. There is one practical advantage from using old seed; that is, if tests on a small scale one year are satisfactory, the same lot may be used to plant the main crop in succeeding years.

There has been considerable discussion of the relative merits of seed grown in different sections of the country. Little well-substantiated information is available concerning the effect of climate on the crop-producing power of cucumber seed. That climatic factors may be the direct cause of the "running out" of the variety is improbable. Proper selection to maintain varietal type is probably a more common factor in cucumber seed production than the section of the country in which it was grown.

The opinion is common among pickle packers and growers that seed from nubbins and crooks produce a higher percentage of misshaped fruits than seed saved from straight, well-formed cucumbers. There is little experimental evidence bearing on this contention, but probability of its soundness is slight (12). This view assumes the inheritance of acquired characters, which has never been proved by research. It is not intended to imply that a stock that produces a large percentage of misshaped fruits is a good stock. On the other hand, it has been brought out under the discussion on pollination that fruit shape depends largely on the weather conditions prevailing at the time the fruit sets rather than on the source of the seed. In other words, seed from a misshapen fruit on a vine producing predominantly good fruits is more likely to produce good offspring than seed from a good fruit on a vine producing a high percentage of poor fruits.

More than one million pounds of pickling and slicing cucumber seed are produced annually in the United States. The most important seed-producing states are Colorado, Michigan, California, Nebraska, and New York. Each year seedsmen contract with Michigan farmers for between one and two thousand acres of cucumbers for seed purposes. Most of the acreage devoted to seed production is scattered in the areas where most pickling cucumbers are produced, and it is not uncommon to find a farmer growing cucumbers for both purposes.

In general, the soils used and the methods of production followed in producing a seed crop are practically the same as those recommended for the pickling cucumbers. As has been stressed with pickling cucumbers, the acre returns from a seed crop depend on good stands of vigorous plants and all cultural operations which will assure this objective are important.

It is extremely important that the seed fields be isolated from all other cucumbers in order to prevent crossing and disease contamination. Most seed contracts specify that only one variety be grown on a farm and that space of at least 40 rods intervene between the seed field and other cucumbers. A greater distance is preferable. Since there are a number of serious cucumber diseases that are carried by insects, isolation will aid greatly in their control.

Before the crop is harvested, the usual practice is for trained field men from the seed companies to rogue the fields to remove off-type plants. Variations in color and shape of fruits indicate mixtures, and

such plants and their fruits are removed before the crop is harvested. Ordinarily one picking only is made when the fruits are fully mature, as indicated by the color. It is often advantageous to delay this operation until after a slight frost has destroyed the leaves. The ripe fruits are usually picked and thrown in piles or they may be threshed with a movable outfit in the field.

The usual practice is for the seed company to provide the threshing equipment. The threshers used vary somewhat in design but in each case the basic principles of construction are similar. There is a set of corrugated rollers to crush the fruit and the crushed material falls into a revolving wire mesh cylinder which separates the seed and juice from the coarse rinds. It is extremely important that the thresher be cleaned thoroughly, immediately after each variety is threshed, or mixtures will occur. Cleaning while seeds are wet is an easy matter, but if they are allowed to dry, cleaning is difficult.

After rinds are removed the juice and the seed-bearing pulp is fermented to break down the gelatinous coating of the seed. Small amounts may be fermented in barrels or vats, but when a large bulk is to be handled, the pit system (4) is the more economical. A pit of the required dimensions is prepared and lined with a burlap sheet. This prevents discoloration of the seeds from contact with the soil and checks the escape of the juice. If the seed mass becomes too dry during fermentation, heating will result and the vitality of the seed may be impaired. The number of days required to complete fermentation depends largely on prevailing temperatures. If the weather is warm, two or three days will suffice, while during cool weather in the fall a week or more may be required. The pulp should be stirred thoroughly several times daily to keep the seed on top from drying out and becoming discolored. If the seeds separate freely from the pulp when a handful is squeezed, they have undergone sufficient fermentation and should be washed. Long fermentations give dark seed that germinate poorly. The pulp is removed from the seed by washing with water. The good seeds are slightly heavier than water and settle to the bottom, while the pulp and light, worthless seeds are floated off. Long boxes and other containers are used for washing. Several washings are required and after most of the pulp has been removed the seed is spread in a thin layer on screens exposed in the sun or placed in a mechanical drier. The dry seed is cleaned with a fanning mill and stored in grain bags in a dry, well-ventilated, mouse-proof storehouse. Cucumber seed maintains its germination for a period of five years or longer.

The average production of cucumber seed is about 150 pounds per acre. Yields as high as 300 to 400 pounds are not uncommon.

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CUCUMBER INSECTS

By Ray Hutson
SECTION OF ENTOMOLOGY

The three important insects infesting cucumbers are the striped cucumber beetle, the spotted cucumber beetle, and the melon or cucumber aphid.

CUCUMBER BEETLES

Cucumber beetles are well-known, since yellowish beetles with black stripes or spots upon their wing covers abound wherever cucumbers are grown. They are approximately ¼ inch long and damage cucumber and related plants by devouring the leaves and gnawing at the stems of the plant. Attacks commonly occur while the plants are young, and the entire plant may be consumed.

Direct injury to the plant by striped cucumber beetle may be very serious but probably the damage this insect causes by carrying cucumber wilt is of even greater importance. The spotted cucumber beetle also transmits wilt. Larvae of these beetles are small and thread-like. They feed upon the roots of the plant and pupate in the soil nearby.

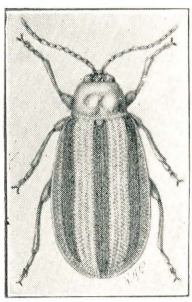

Fig. 11. The striped cucumber-beetle, greatly enlarged.

Control of cucumber beetles is difficult. One of the main reasons for this is the necessity of keeping all parts of the plant covered with insecticide, a hard task.

The best dust treatment consists in the application of a mixture of calcium arsenate (1 part) and finely ground gypsum (19 parts). The proportion of calcium arsenate is sometimes increased, although it is doubtful whether this is good practice since the same purpose can usually be accomplished by careful and thorough application. Gypsum is too heavy to work well in a duster and is applied best with a shaker. A good shaker can be made by attaching a rigid handle to any container with a tight-fitting lid, such as a honey pail, and then punching holes in the bottom. Good results have been obtained with shakers made from burlap or other coarse meshed fabric.

It is sometimes hard to distinguish between injury from cucumber beetles and disease and under such circumstances blame is placed upon the beetles. Whenever it is desirable to use bordeaux on cucumbers, calcium arsenate added to the spray at the rate of 2 pounds in 100 gallons of spray may be used against the beetles, but a thorough job of spraying is necessary for the vines must be covered.

APHIDS

Cucumbers are often infested with small black plant lice, which suck so much juice from the tissues that the tissues die. This insect, the cucumber or melon aphid, attacks cotton in the South. In the North it goes through the winter on live-forever, or orpine (Sedum).

Infestation of cucumbers by this insect occurs when the females move to cucumber fields. This commonly occurs in spots, and many incipient infestations have been stopped by watching fields closely and then pulling and burying the infested plants.

Insecticidal control of cucumber aphids can be accomplished if adequate machinery is available but it is difficult if hand sprayers or dusters must be used.

Nicotine sulphate with 1 pint in 100 gallons of spray with a good spreader, such as thoroughly dissolved soap or one of the commercial spreaders such as the sulphated higher alcohols,* may be used but will probably have to be repeated unless a good power sprayer is used. One hundred to two hundred gallons of spray per acre will be necessary, depending upon size of vines as the insects must be contacted.

A nicotine dust made by thoroughly mixing in a barrel or drum with some loose stones 50 pounds of hydrated lime with 3 pints of nicotine sulphate is probably the best treatment if a hand duster is used. Large "spot" infestations of cucumber aphids have been cleaned out by using a dust such as this, a hand duster, and a large sheet of cheese cloth. This method works best when the following procedure is followed: Dust an area about the size of the sheet and cover it; dust another similar area; and then move the sheet. This plan exposes the aphids to the confined nicotine fumes during the time it takes to dust a new area and increases the kill. About 25 pounds of prepared dust will cover an acre.

*Consult insecticide dealers: There are several good brands.

CUCUMBER DISEASES

By J. H. Muncie
SECTION OF PLANT PATHOLOGY

The cucumber is subject to several diseases, any one of which may be the limiting factor in profitable production. Usually, not all of these diseases attack the crop during any one season. Weather conditions have an important bearing upon the severity of these diseases. However, as a matter of crop insurance certain practices, such as crop rotation, sanitation, seed treatment, and application of a fungicide, should be followed out each season. Certain insects cause severe damage to the crop and, in addition, are carriers of the parasites causing bacterial wilt and mosaic. Therefore, a comprehensive disease control program must also include the control of cucumber insects.

BACTERIAL WILT

Bacterial wilt is present each year to some extent in cucumber fields and in many instances causes serious losses through killing of the vines before any fruit is picked. This disease also attacks muskmelons, squash, and pumpkin. The disease is first seen on a few leaves, causing them to wilt and die. This typical wilting spreads to other leaves of the same vine, and later other vines may show the wilted condition. In contrast to other cucumber diseases, the causative organism of bacterial wilt may be found within affected stems and fruits. If the diseased stem is cut across and the finger tip applied to the cut surface and removed slowly, the sap will pull out into long threads. The stickiness is caused by the growth of the wilt bacteria within the stem tissues.

Bacterial wilt lives over winter within the bodies of the striped and 12-spotted cucumber beetles. Infection occurs through the feeding of the beetles upon the young plants. To control the disease, pull out and burn or bury the wilted plants as soon as discovered and protect the plants from beetle attack as given on page 32.

ANGULAR LEAF SPOT

Angular leaf spot is another bacterial disease which, in certain years, causes considerable damage to the crop. The bacteria causing this disease are carried over winter on the seed through the pulping process.

The disease first appears on the leaves in the form of small, angular, water-soaked spots between the leaf veins. As infection progresses, the affected leaf tissue dries, turns gray in color, and may drop out.

The bacteria ooze out of the affected spots in small droplets, which later dry, forming a whitish scab-like residue. On the fruits the spots are circular in outline, water-soaked and often show the bacterial droplets.

The causal bacteria spread from plant to plant on the pickers' hands, if picking is done when the vines are wet. The fruit may become inoculated during picking, but show no signs of the disease until placed on the market or delivered to the pickle station. Frequent rains with warm temperature favor development of angular leaf spot. The disease bacteria live over winter in infected vines and fruit left in the field. Cucumbers, following a diseased crop, become infected by the splashing of the bacteria in the soil and crop refuse to the young plant parts.

Control of angular leaf spot lies in crop rotation, plowing under diseased refuse immediately after harvest, seed treatment, and protection of the plants by spraying or dusting. For seed treatment, place the seed in small cheese cloth bags and soak for five minutes in a 1-1,000 solution of corrosive sublimate. This solution is made up by dissolving 1 ounce of the corrosive sublimate in 7½ gallons of water.

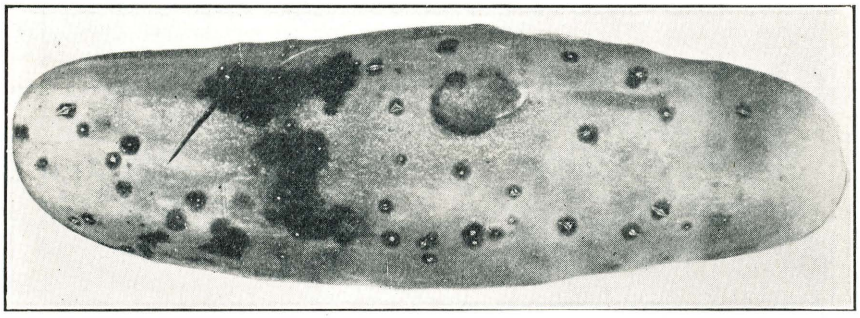

Fig. 12. Cucumber fruit affected with angular leaf spot. Note the small water-soaked areas. These are invaded by the leaf spot bacteria.

Always use earthenware, glass, or wooden containers for the solution. It corrodes metal containers. This solution is a deadly poison and must be kept out of reach of children and animals. After soaking the seed, rinse in fresh water for 15 minutes, remove and dry. Better results in growing plants will be obtained if the dried seed is further treated with red copper oxide dust or Semesan before planting to prevent damping-off of the seedlings.

At least one application of Bordeaux mixture 4-6-100 or monohydrated copper-lime dust 15-85 should be made before the plants begin to run. This application can be made so as not to interfere with dusting for control of cucumber beetles. After this time, spray or dust with these materials at intervals of 5-7 days until picking starts or danger of infection is past. Use 150-200 gallons of spray or 35 pounds of dust per acre on large vines.

If it is necessary to continue applications of a fungicide after the fruit is formed, spray or dust immediately after picking to prevent spotting of the fruit.

When the plants are small, spraying may be done with a hand sprayer. But when the plants begin to vine and later, a machine of greater capacity, giving pressures of 200-300 pounds per square inch, is necessary. At least three nozzles to the row should be used, and these should have small-holed discs to produce a fine mist of the spray, which must

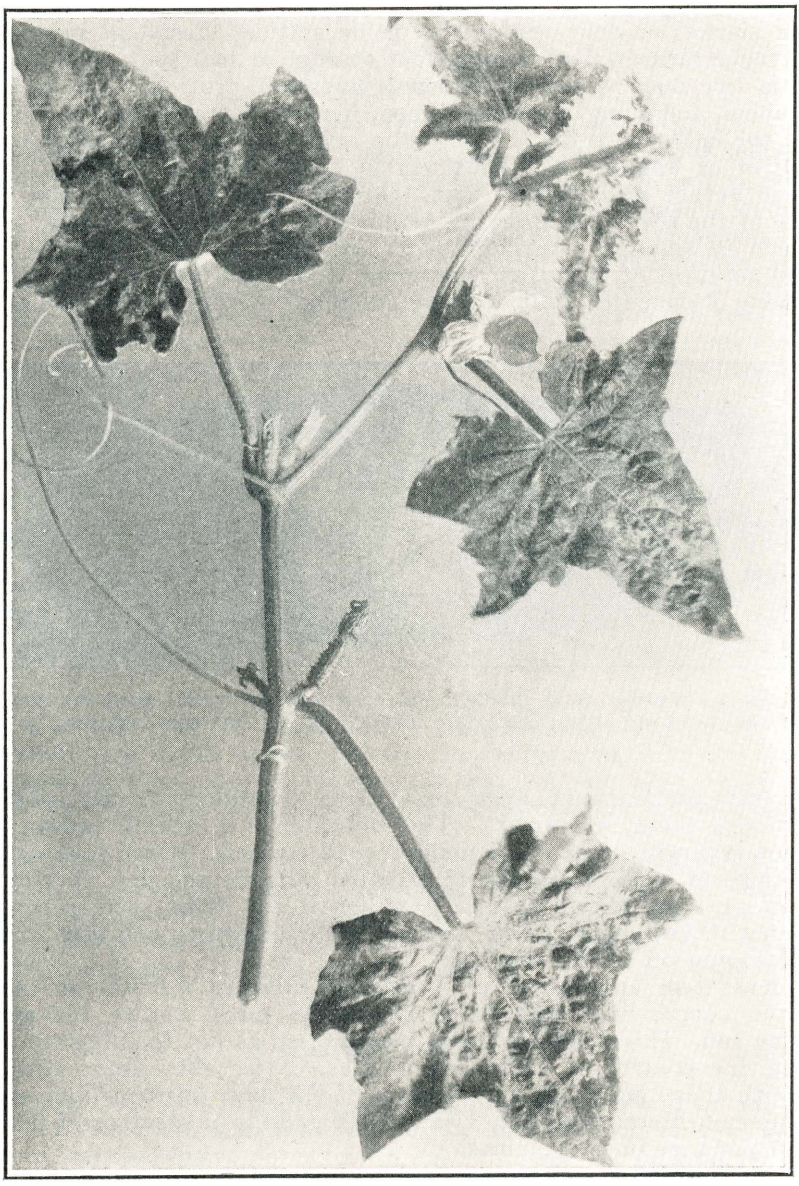

Fig. 13. Cucumber leaves affected with mosaic. Note wrinkling and mottling.

be driven into the centers of the plants and to the under sides of the leaves to be effective.

Copper-lime dust may be applied in place of Bordeaux mixture if a spray machine is not available. Best results are obtained if the dust is applied in a cloud around the plant so that the under surfaces of the leaves are covered. Dusting is most effective if done when the air is still and the leaves are moist.

Angular leaf spot, like other leaf diseases, is spread during periods of rainfall. To give the plants adequate protection, the leaves must be kept covered with the fungicide. If the material is washed off during a rain, spray or dust immediately afterward to insure protection.

MOSAIC

Cucumber mosaic is probably the most widespread and certainly one of the most serious diseases of the crop in Michigan. It is especially dangerous because few growers recognize its presence until it has become well established in the field. Muskmelon and squash are also affected.

When first apparent in the field, only a few plants show the disease;

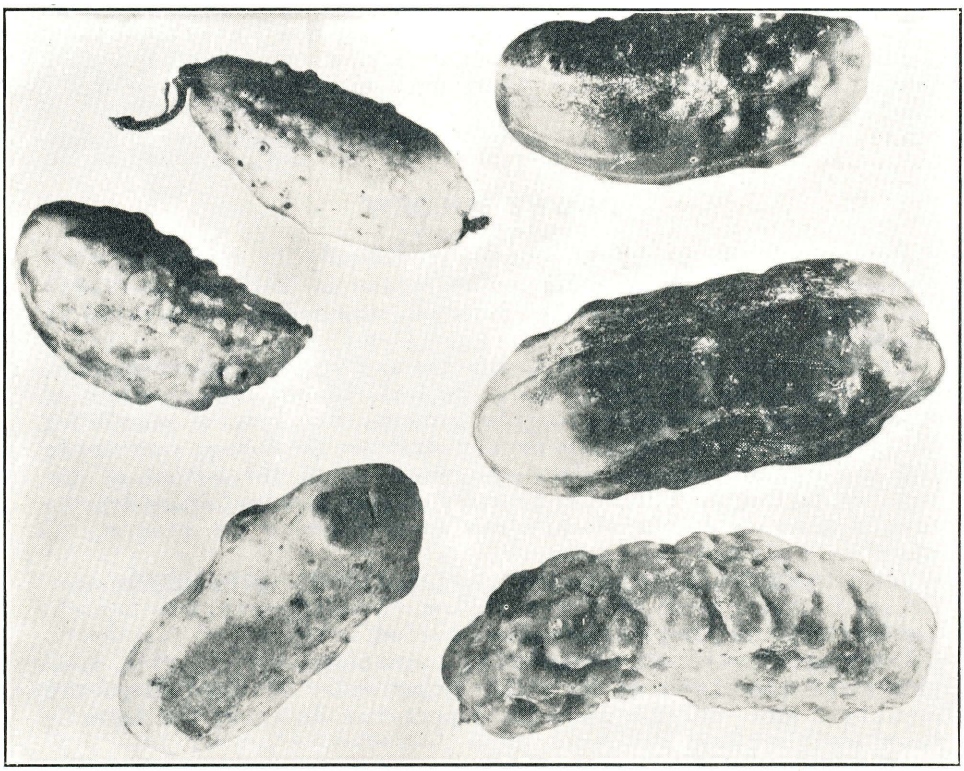

Fig. 14. Cucumbers affected with mosaic "white pickle." Affected fruits are warty.

and in many cases, the symptoms are not conspicuous. These consist of a yellow mottling of the green leaf, or the entire leaf may elongate into a "shoe string" and become yellow-green in color. Infected fruits often show knobby or warty islands of green surrounded by white bleached skin, producing the characteristic "white pickle." Sometimes, the fruits are only faintly mottled or may be entirely yellowed and much dwarfed.

The causal agent of mosaic is a virus, carried in the sap of the plant and too small to be seen even with the aid of a high-power microscope. From a few diseased plants infection is spread by the cucumber aphid and possibly other insects, and the hands of the pickers. Perennial weeds, such as ground cherry, catnip, milkweed and pokeweed carry the virus over from year to year in their roots, each season sending out diseased foliage. The wild cucumber also carries the virus in its seed. From such plants the disease is carried by aphids to healthy cucumber plants in nearby fields.

Control of cucumber mosaic necessarily must take into consideration the following points:

(1) Pull out or keep mowed all pokeweed, milkweed, ground cherry, catnip or wild cucumber plants near the cucumber field. This should be done before any of the cucumber plants have come above ground.

(2) Rogue out and bury any cucumber plants showing mottling or stringing of the leaves typical of mosaic. Frequent and thorough roguing of the field should begin when the first true leaves appear and continue at least until the plants begin to vine. After pulling mosaic plants, do not handle healthy plants until the hands are thoroughly washed in strong soap suds.

(3) Control aphids and other insects that feed upon the cucumber.

DOWNY MILDEW

Downy mildew, or blight, occurs sporadically in Michigan when weather conditions are suitable. The season of 1935 was favorable for its development, and severe infection resulted in some areas of the state.

On the leaves, the disease first appears as irregular yellowish spots, which enlarge in size, often killing the leaf. On the under surface of infected areas, the purplish fungous growth often may be seen when the leaves are moist. Infection usually starts on the foliage nearest the hill and spreads outward along the vines. With the advent of dry weather, further infection may be arrested, and normal foliage develop toward the ends of the vines. Fruit formed during the progress of the disease is small and misshapen.

Abundant moisture with warm days and cool nights is necessary for rapid development of downy mildew. Besides cucumbers, squash, muskmelons and pumpkins are also attacked.

Downy mildew is best controlled by a combination of rotation, sanitation and application of fungicide, either spray or dust. Bordeaux mixture is more effective than the copper-lime dust, but the latter is more easily applied.

Apply spray or dust as given for the control of angular leaf spot, page 35.

SCAB

During seasons of high humidity with medium or high temperature, scab often becomes serious in some cucumber fields.

First indications of the disease are small water-soaked spots on the leaves, which later wilt. Similar areas appear upon the stems but are most noticeable upon the fruit. First signs of infection on the fruit are indicated by slight oozing of the sap in small droplets, as from an insect puncture. Later, slightly sunken spots are formed. These disease cavities are lined with the olive-green growth of the scab fungus. The fungus lives over winter in the old infected vines and fruit, and also on the seed.

Crop rotation, and plowing under old vines are essential in a control program. Seed treatment and application of a fungicide, as for the control of angular leaf spot, page 35, are necessary.

ANTHRACNOSE

This disease, like scab, often occurs during moist weather. Small circular to irregular spots appear on the leaves. These enlarge and may involve large areas of the leaf surface. Sunken circular spots also are formed on the fruit. Within these spots are formed a salmon-colored spore masses of the fungus. The disease is spread by rains splashing the spores from infected spots on leaves or fruit. Muskmelon and watermelon are also attacked. Cucumber anthracnose is controlled by crop rotation, sanitation, seed treatment and applications of a fungicide as given for angular leaf spot, page 35.

LEAF SPOT

Macrosporium leaf spot is most serious during seasons of abundant rainfall with high temperature. Small circular spots first appear on the leaves. As the spots enlarge and the diseased tissue dies, concentric markings appear. This gives the characteristic target board effect to the infected area. Severe infection often results in killing the leaves. The disease is spread by means of spores splashed from the soil. The fungus lives over winter in infected fruits and vines left in the field. Leaf spot is controlled by those measures recommended for the control of angular leaf spot, page 35.

SUMMARY OF CULTURAL RECOMMENDATIONS

Profitable returns from pickling cucumbers depend on large yields, which are obtained only from good stands of healthy, vigorously growing plants. The following practices are recommended to assure this aim:

1. Select fertile, well-drained, sandy loam, silt loam or clay loam soils well-supplied with organic matter. Avoid poor sandy soils that are subject to drouth and avoid low, frosty locations (page 8).

2. Insects and diseases are much less of a problem when rotations and sanitation are followed rigorously. Growing cucumbers and related plants year after year on the same land allows both insects and diseases to build up to serious proportions (pages 32-39).

3. Cucumber plants are especially reponsive to manure, and annual applications are recommended. If the supply is plentiful, broadcast 10 to 15 tons per acre before plowing. Small quantities of well-rotted manure may be applied in the hills or row before seeding. Supplement with a row application of 300 to 400 pounds per acre of 4-16-4 fertilizer (page 10).

4. Plow the land early in the spring and harrow at frequent intervals until planting time. Prepare a good seed bed (page 12).

5. To control mosaic, pull or keep mowed down all pokeweed, milkweed, ground cherry, catnip and wild cucumber plants in and near the fields (page 37).

6. Use the best seed obtainable of suitable pickling variety (pages 25 and 27).

7. Treat seed before planting with corrosive sublimate, wash thoroughly, and dry. A further treatment of the dry seed with red copper oxide dust or Semesan will aid in preventing "damping off" (page 35).

8. Delay planting until danger of low temperatures is over and the soil has become warm. Plant about 4 weeks after average date of last killing frost in the spring (page 12).

9. Plant 8 to 10 seed in hills 6 x 4 feet or drill thinly in rows 6 feet apart. *Do not cover seed deeper than one inch* (page 15), and do not interplant with other crops (page 16).

10. When the plants appear above ground, dust with gypsum-calcium arsenate mixture for cucumber beetle control (page 32). *Keep the leaves covered with this material.* If leaf diseases appear, spray with Bordeaux 4-6-100 adding 2 pounds calcium arsenate to each 100 gallons (page 35).

11. Thin to two plants per hill before the plants begin to vine, or if drilled, allow 12 to 18 inches between plants (page 15).

12. Cultivate shallow and frequently until vine growth prohibits. Do not move vines to cultivate. Large weeds should be cut with hoe—not pulled (page 17).

13. Make weekly inspections of cucumber fields as soon as true leaves appear and pull out and bury at once all mosaic-affected plants (plants with yellow and green mottled leaves). If aphis-infested plants are found, pull and bury if only a few occur. If a large area is infested with aphis treat according to directions (page 33).

14. When plants start to vine, make first applications of 4-6-100 Bordeaux mixture. If aphids are present add 1 pint of nicotine sulphate to each 100 gallons of spray. If rains wash off the spray, make another application. *Keep the vines covered.*

15. See that there is at least one hive of bees within ¼ mile of cucumber field to insure proper pollination (page 17).

16. Harvest at regular intervals from the time the first fruits appear. Pick twice weekly and handle the vines carefully. Remove all cucumbers before they attain a large size (page 20).

17. Grade according to standard set forth in contract with packer and deliver promptly to the salting station (page 23).