Pickling Cucumbers Production Harvesting
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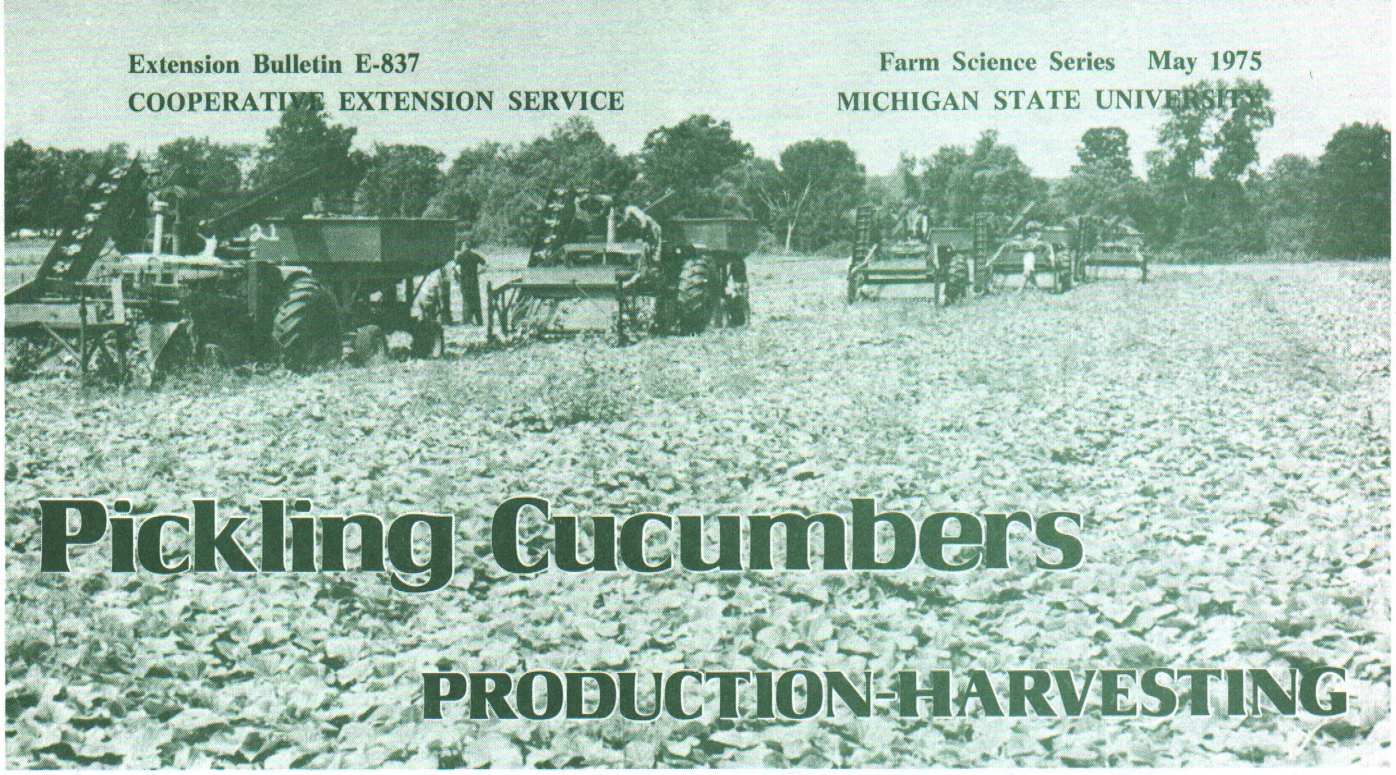

Pickling Cucumbers

PRODUCTION-HARVESTING

By J. E. Motes, Horticulture Dept.

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MICHIGAN is the leading state in pickling cucumber production. Nearly 95% of the state's cucumber acreage is mechanically harvested (see Figure 1, p. 2).

Growing pickling cucumbers for mechanical harvest differs greatly from growing for hand harvest. A maximum number of fruit must be marketable at harvest time for the once-over destructive harvest system used in Michigan. Proper cultural practices are necessary to obtain uniformity in cucumber plant and fruit development.

A number of factors affect the yield, quality and return from pickling cucumbers grown for once-over mechanical harvest. These are: proper field selection, soil preparation, fertilization, varieties, chemical seed treatments, seeding methods, plant population, soil moisture, weed-insect-disease control, bee pollination and timing of harvest.

VARIETIES

Sex Expression

Hybrid varieties should be used for once-over mechanical harvest (Table 1). These hybrids are often termed "gynoecious" but are actually predominantly female (abbreviated PF). The highly female expression of the hybrid plants concentrates the set of fruit for once-over harvest. Generally, several (1 to 5) male flowers are observed before female flowers appear. However, this "PF" expression of hybrids can vary widely depending on the variety, location and year.

The grower is interested in the marketable fruit yield per acre. Yield is not necessarily related to number of female flowers with current hybrids. Vigor and uniformity are some advantages of hybrids over previous open-pollinated varieties.

White Spine Color

Use of white spined hybrids for once-over harvest has increased dramatically in Michigan. There are several advantages for white spine over black spine fruits. Fruits with black spine color commonly turn yellow (loss of green color) and the larger fruits soften with maturity. White spine fruits yellow and soften more slowly; hence, they remain green, firm and usable longer. Use of the larger sizes of fruit for hamburger slices and quartered sections (spears) has increased. The advantages of white spine varieties are obvious for the once-over destructive harvest system.

The skin of white spine varieties is also tougher than black. This seems less pronounced as new white spined hybrids are introduced for once-over mechanical harvest.

Scab Resistance

Traditionally, black spine varieties with resistance to cucumber scab have been

Table 1. Scab resistant varieties suggested for once-over mechanical harvest in Michigan.

Hybrid	Spine color	Maturity	Originator[1]
Premier	white	mid	Asgrow
Score	white	mid	Asgrow
Bounty	black	mid	Asgrow
Carolina	white	mid	Clemson University
Pioneer	black	early	Clemson University
Ranger	black	early	Clemson University
LaSalle	black	early	Ferry-Morse
Greenpak	white	mid	Harris
Spartan Jack	black	mid-late	Michigan State University
Green Spear	white	mid	Northrup, King

[1] *University releases are available from most seed companies.*

grown in the northern U.S. White spine varieties without cucumber scab resistance were grown in the southern U.S. because scab is not a major disease there. The advent of once-over mechanical harvest has caused the rapid conversion from black to white spine hybrids in Michigan.

Some white spined hybrids are resistant to scab. However, certain white spine varieties susceptible to scab have also been grown in Michigan. This is a high risk situation and resulted in significant losses in 1973 and 1974. Scab-susceptible varieties are not recommended for planting in Michigan. See Extension Bulletin E-675T, for current varieties suggested for once-over mechanical harvest in Michigan.

Cucumber Mosaic Virus

Resistance or tolerance to this disease is common to all currently popular hybrids in use for once-over mechanical harvesting in Michigan. Because of this varietal resistance, its importance as a disease in Michigan is nonsignificant.

Angular Leaf Spot

Tolerance to this bacterial disease has been incorporated into several commercial hybrids now in use. The relatively short time from planting to harvest (50 to 60 days) of pickles for once-over harvest minimizes the crop damage and loss from this disease, as compared to the prolonged handpick season. Hybrid varieties highly resistant to angular leaf spot are in various stages of research and testing and will become available over the next few years.

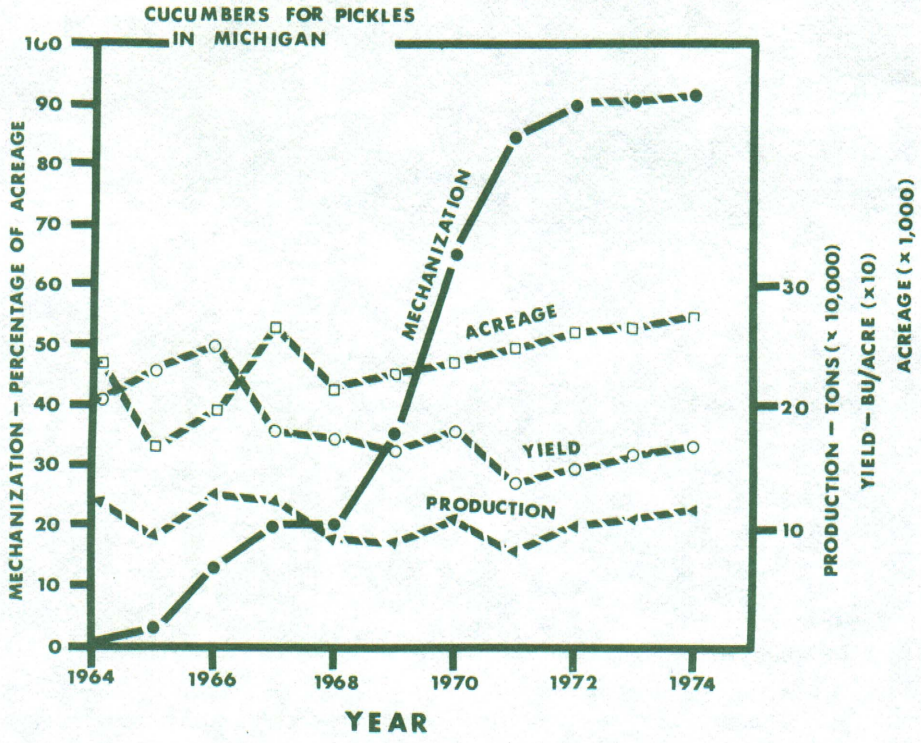
SCHEDULING PLANTING

The harvest capacity of a machine is approximately one acre per hour. A series of planting dates is necessary to efficiently use the harvester and maintain a uniform pickling cucumber supply at the processing plants. To avoid oversized cucumbers, plantings should not exceed the harvester capacity. Varieties differ in the number of days from planting to harvest (Table 1). Early varieties require up to 7 days less growing time to harvest than late varieties. Variety maturity differences can be beneficial in scheduling plantings. Plant population also influences days to harvest as lower populations usually develop more slowly than high populations. In Michigan, 50-60 days are normally required from planting to harvest with most varieties.

In early planting when soils are cool, or in dry, nonirrigated fields, plant emergence is the best indicator of subsequent planting dates. Under these conditions, the use of calendar days between planting dates is unsatisfactory. Processors usually dictate planting dates and acreages for their contract growers.

In Michigan, planting begins when soils become warm (60^{o}F) in late May and continues until mid-July. Plantings prior to May 25 and after mid-July are endangered by late spring or early fall frosts. Double cropping is possible in southern Michigan. Yields from late crops are frequently low due to disease, cooler temperatures and shorter days in late summer and fall.

FIGURE 1.



FIELD SELECTION

Select a field with the best characteristics for the production of pickling cucumbers to eliminate many problems and enhance success. Some important considerations:

1. Select a well-drained, sandy loam or loamy sand soil that will allow planting, cultivation and harvesting operations the day after a 2-inch rain.
2. Avoid stony fields.
3. Select a field with uniform soil texture to promote uniform crop development over the entire field.
4. Avoid fields with toxic herbicide residues from previous crops, e.g. atrazine.
5. Avoid holes and low areas with poor air drainage to reduce disease infestation.
6. Avoid fields known to be heavily infested with annual weeds and fields with perennial weeds such as quackgrass and nutsedge.
7. Fields should be long for efficient harvester operation. Irregular shapes and short rows waste harvester time.

SOIL PREPARATION

Proper seedbed preparation promotes uniform seed germination and rapid emergence. Cover crops or existing plant residues should be plowed-under early. Decaying plant materials attract seed corn maggot flies and sometimes clog planting equipment. Allowing the cover crop to continue growing until near planting time uses soil moisture and nutrients needed by the cucumber crop.

Work the soil as little as possible to obtain a firm, level seedbed. Unnecessary trips over the field compact the soil and reduce crop yields.

FERTILIZATION

Production of pickling cucumbers at high plant populations (above 50,000 plants/A) requires good levels of soil fertility. Cucumbers grow best on well-drained soils which provide an adequate oxygen and moisture supply to the plant roots. Many sandy soils offer desirable moisture characteristics but do not have a large nutrient holding capacity. Providing adequate nutrition for the crop requires good fertilizer management practices.

Nitrogen applied to soils may be taken up by plants, lost by leaching or lost by

denitrification under excessively wet conditions. Hence, application of nitrogen close to the time of plant uptake is essential for efficient use of nitrogen fertilizer. Hybrid cucumber varieties which mature in 50-60 days, require less nitrogen than monoecious varieties which were hand harvested. About 25 lbs. of actual nitrogen are removed from the field with yields of 300 to 350 bu. of pickles/A. An additional 25 to 35 lbs. N/A is contained in the vines, but this will be returned to the soil and gradually become available to subsequent crops.

For soils containing less than 2% organic matter, 40 to 50 lbs. N/A is recommended. On soils with greater than 2% organic matter, 25-40 lbs. N/A is adequate. On sandy soils where leaching occurs, application of nitrogen fertilizer close to the time of uptake by the plants is important to prevent leaching. On these soils, one-half of the nitrogen should be applied close to planting and the remainder applied as the vines begin to fill the rows. Where irrigation is used, nitrogen can be applied easily through the irrigation systems. For best results, do not apply more than 10 lbs. N/A during any one irrigation. On loamy soils, where leaching is not a problem, 25-40 lbs. N/A may be broadcast and disked in prior to planting or sidedressed at the second or third true leaf stage.

Lime, phosphorus, potassium and micronutrient needs should be based on a good soil test which truly represents a given field. Sample 20 spots in a field no larger than 15 acres, mix these together and take a sub-sample from this mixed soil to send to a soil testing laboratory (see Extension Bulletin E-498 for more detail on soil sampling).

Soil pH (a measure of soil acidity or alkalinity) is one of the most important properties of soil. The availability of all nutrients in soil is directly dependent on soil pH (Table 2). The most desirable pH range is between 6.0 and 7.0. Below 6.0, the availability of nitrogen, phosphorus, potassium, sulfur, calcium and magnesium decreases. Above pH 7.0, the availability of iron, manganese, zinc, boron and copper decreases markedly. When lime is required, apply dolomitic limestone. This contains magnesium which may be low on some sandy soils (see Extension Bulletin E-471 for information about soil liming).

Table 2. Optimum pH range for nutrient availability.

Nutrient	Symbol	pH range for optimum avail.
nitrogen	N	6.0-7.5
phosphorus	P	6.3-7.3
potassium	K	above 6.0
calcium	Ca	above 7.0
magnesium	Mg	above 5.5
sulfur	S	above 6.0
iron	Fe	below 6.0
manganese	Mn	below 6.8
zinc	Zn	below 7.0
boron	B	5.0-6.5
copper	Cu	below 7.0

Table 3. Phosphate recommendations.

Soil test	Phosphate recommended
lbs. P/A	*lbs. P_2O_5/A*
0-19	250
20-39	200
40-69	150
70-99	100
100-199	50
200+	0

A 300 to 350 bu./A pickle yield requires from 25-40 lbs. of phosphate (P_2O_5) per acre. Only 10 to 15 lbs. of phosphate/A are removed from the field in the cucumbers. Once a good phosphate soil test level is established, only maintenance amounts of phosphate fertilizer are necessary. Increasing soil test phosphate levels above 200 lbs. P/A is unwise as high levels may induce zinc deficiency where soil zinc levels are marginal. Phosphate rates should be based on soil test information (Table 3). With close row spacings (9-10 in.), phosphate can be broadcast and disked in prior to planting and band placement offers no particular advantage.

High phosphate fertilizer on or near the seed insures good seedling growth. For the early crop, which is seeded when the soil is still cool, liquid fertilizer (10-34-0) applied over the seed will stimulate early seedling growth and may increase the rate of maturity. Once the soil warms, seed or band application of liquid fertilizer offers no particular benefit, especially on soils which already have good soil test levels (over 100 lbs. P/A and 250 lbs. K/A). Early seedling growth may be somewhat improved by row applications, but usually there is no difference in maturity or yield compared to complete broadcast application of phosphorus.

Potassium recommendations depend upon concentrations already present in the soil (Table 4). From 100 to 140 lbs. of potash (K_2O), is taken up by a 300 to 350 bu./A pickle crop with 40 to 50 lbs. K_2O being removed from the field in the pickles. Broadcast and disk in potassium fertilizer prior to planting. Building the soil test potassium level to above 350 lbs. K/A is unwise use of fertilizer, especially on sandy soils where potassium may be lost from the soil profile by leaching.

Zinc (Zn) and manganese (Mn) are the most important micronutrients in the production of pickling cucumbers. As the soil pH increases (becomes more alkaline), the availability of Zn and Mn decreases. Therefore, more Zn and Mn need to be present in the soil at high soil pH's to meet the needs of cucumber plants. Under high phosphate conditions, phosphorus ties up zinc in the plant root preventing translocation to the vine, resulting in a zinc deficiency. Hence, excessive phosphate levels may actually decrease yields.

Zinc and Mn needs can be met by soil or foliar application. Rates for soil applications are best based on soil test information (see Extension Bulletins E-486 and E-550). Where additional Zn and Mn are required, rates for band application range from 2 to 5 lbs. Zn/A and from 4 to 8 lbs. Mn/A. Broadcast application of 25 lbs. Zn/A usually supplies sufficient zinc for 5 years. Manganese is readily tied up in soil so broadcast applications are not recommended.

Foliar application of Zn and Mn should be made 2 to 3 weeks after emergence. Since Mn and Zn are not readily translocated, a second spray application will be needed 2 weeks later to cover new vine growth. Recommended rates are 1 to 2 lbs. of Mn/A and 0.3 to 0.7 lbs. of Zn/A. When using chelated materials, use the rates recommended on the label. Additional information on foliar application of nutrients is contained in Extension Bulletin E-486.

Table 4. Potassium recommendations.

Soil test	Potash recommended
lbs. K/A	*lbs. K_2O/A*
0-59	300
60-99	250
100-149	200
150-199	150
200-249	100
250-349	50
350+	0

PLANT POPULATION

Optimum plant population depends upon the soil texture and availability of irrigation water. With lighter textured soils and no irrigation, 40-50,000 plants/A are adequate. Slightly higher populations are suggested on less droughty soils. With irrigation, populations from 70-100,000 plants/A are suggested. With average germinating conditions, 12-15,000 plants can be expected per pound of cucumber seed planted.

High plant populations require greater grower skill and management to meet the demands of the crop. Plant stresses from a shortage of water or nutrients develop more quickly. Insect and disease problems can spread more rapidly in a high

population planting. Close attention must be given to the immediate and future needs of the crop. Without intense management, the potential returns from high population planting (Figure 2) can be lost and crop failure can result.

PLANTING

Common row spacings are 20 and 28 inches. These row spacings accommodate planting and cultivation equipment commonly used in other row crops. However, closer row spacings are beneficial, particularly with high populations under irrigation. With close row spacings, plants are spaced more uniformly over the field. Cultivation, however, is difficult or impossible in closely spaced rows and chemical weed control must be relied upon entirely.

For rapid germination and emergence, delay planting until the soil temperature at seed depth reaches 60°F. In most Michigan growing areas, soil temperatures reach 60°F. in late May. Planting in colder soils slows germination and allows more time for disease and insect organisms to reduce stands. The optimum soil temperature for cucumber seed germination is about 85°F.

Planting depth should be from 1/2 to 1 in. Plant at the shallower depths on heavier, wet soils. Uniform planting depth is very important to obtain uniform seedling emergence and crop development.

Precision seeding equipment will provide the best results. A seeder that provides uniform depth of planting and seed placement reduces variability between plants. Satisfactory results have been obtained with the standard unit planters. Some recently developed precision seeders are effective for planting pickling cucumbers. For best results, planters should space single seeds uniformly in the row and not cause mechanical damage to the seed.

WEED CONTROL

For maximum yields of pickling cucumbers that can be successfully mechanically harvested, weeds must be effectively controlled from planting until harvest time. Land known to be infested with perennial weeds such as quackgrass or nutsedge or with heavy infestations of annual weeds should not be planted to cucumbers as crop failure can likely occur.

The cucumber is more susceptible to injury by several classes of selective herbicides than most other crops. All herbicides that have been evaluated for weed control in cucumbers have a limited safety margin, and even at safe rates of application, the number of weeds they control varies with environmental conditions.

Figure 2. Intense cultural management is required to successfully grow pickling cucumbers like this. Note rye strips for wind protection.

The proper herbicide program depends on the soil type and the weed species present in the field. Usually, better results are obtained by using combinations of herbicides. The most common reason for herbicide failure is a lack of soil moisture at the time of application. Application of 1/4 to 1/2 acre-in. of water as soon as possible after herbicide application is the key to effective weed control and also helps to provide uniform emergence of cucumber plants. Current suggestions for chemical weed control are in Extension Bulletin E-433.

Where row spacing allows cultivation, cucumbers may be cultivated until the 3 to 4 leaf stage with a minimal amount of damage. Rolling cultivators or finger weeders which stir only the top inch of soil are preferred. Deeper cultivation can cause serious root injury, as well as expose many new weed seeds.

CUCUMBER INSECTS

The following insects are the major pests of pickling cucumbers in Michigan. All of these insects may not be in every field every year. Thrips and cutworms are irregular pests, that is, they may be found only in certain areas of the field and only in certain years. On the other hand, maggots and beetles cause varying dollar losses every year throughout major pickle growing areas.

Thoroughly learn the life cycle of these pests to known when, where and how to apply the control measures (including cultural practices and chemicals) for maximum control. Early control measures are essential in all cases. This is especially true with high plant populations. Current suggestions for chemical insect control are in Extension Bulletin E-312.

It is extremely important to notify nearby beekeepers before applying any insecticide when the plants are in blossom.

Seed-Corn Maggot

Hosts — Cucumbers (and other cucurbits), corn beans and several other crops. *Damage*—the maggots attack seeds and tender underground stems. Attacked seeds (Figure 3) fail to sprout or if they do, the

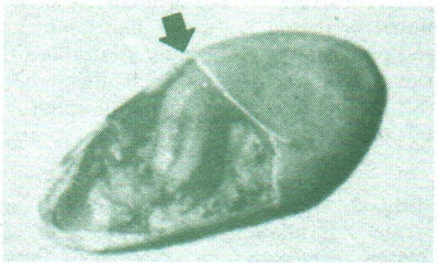


Figure 3. Cucumber seed infested with seed corn maggot (arrow).

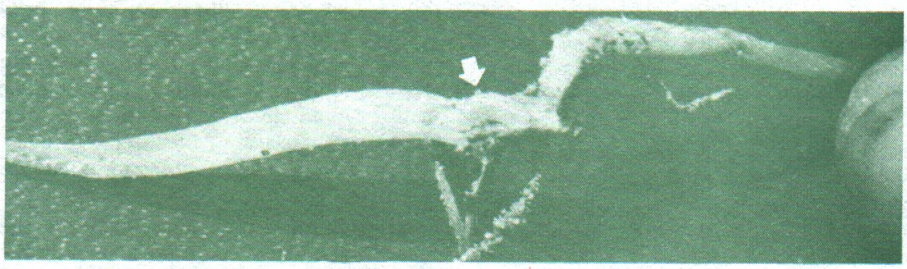


Figure 4. Cucumber seedling infested with seed corn maggot (arrow).

seedlings are weak and sickly. Tender stems and roots (Figure 4) are eaten and the plants wilt and die. *General life cycle*—winter is passed as maggots in a brown puparium in the soil of infested fields. In the early spring, the maggots pupate and adults emerge. The adults are grayish brown flies about 1/5 in. long.

Adults mate soon after emerging and deposit their eggs in soil where there is an abundance of decaying vegetable matter or on the seeds or seedlings. The eggs hatch at temperatures as low as 50°F. The resulting maggots can develop and pupate at temperatures between 52° and 92°F.

The maggots, when mature, are yellowish-white, about 1/4 in. long, tough skinned, pointed on the head and rounded on the rear end. They cause damage as they feed and grow. At maturity, they crawl into the soil and form a brown puparium. Pupation is completed and the adult flies of the next generation emerge. The life cycle, from egg to egg, takes about 3 weeks. Hence, there are 3 to 5 generations per year.

Cucumber Beetles

Hosts—adults of both the spotted and striped cucumber beetles feed on a large number of plants including all cucurbits (cucumbers, melons, squash, pumpkins). *Damage*—both of these beetles defoliate the plants. In addition, they transmit bacterial wilt disease and the striped cucumber beetle also transmits cucumber mosaic virus. The larvae of the spotted cucumber beetle (Figure 5) feed on the roots of the same variety of plants as the adults. However, larvae of the striped cucumber beetle (Figure 6) feed only on roots of the cucurbits. Larval feeding damages the roots and facilitates entry of soil borne diseases. *General life cycle*—both species overwinter as adults and in the case of the striped cucumber beetles, as unmated adults in woodlots, fence rows, ditch banks or similar areas along field borders. These adults become active in the early spring. As soon as the cucumbers are planted, the beetles migrate to the cucumber field and begin feeding on the seed leaves and subsequent foliage. Mating takes place soon after they begin feeding on the young plants. The yellowish-orange eggs are deposited at the base of the plants or in the soil. The eggs hatch and the young larvae crawl down to the roots and begin to feed. This feeding by the larvae damages the roots and allows soil borne diseases to enter the plants.

When mature, the larvae pupate and the adults of the next generation emerge around mid-summer. These adults feed extensively on the leaves, stems and flowers of the plants until fall. It is these adults that overwinter. There is only one generation of striped cucumber beetles per year. However, the spotted cucumber beetle has one and possibly a partial second generation in Michigan.

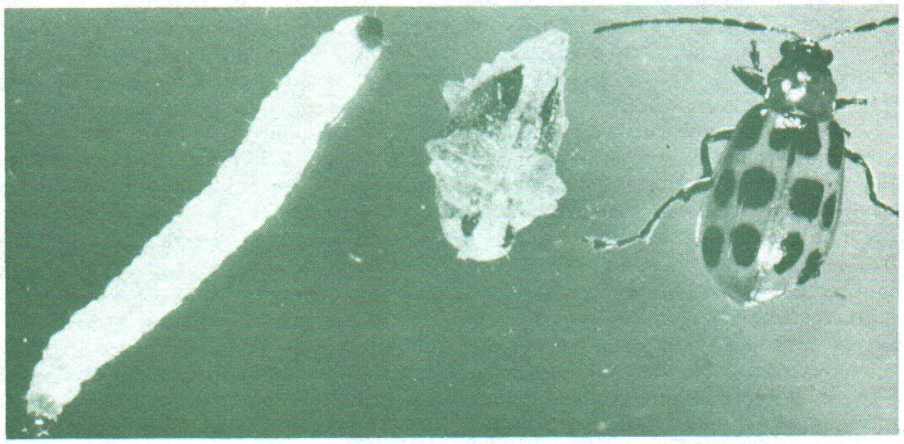


Figure 5. Spotted cucumber beetle larvae, pupae and adult (left to right).

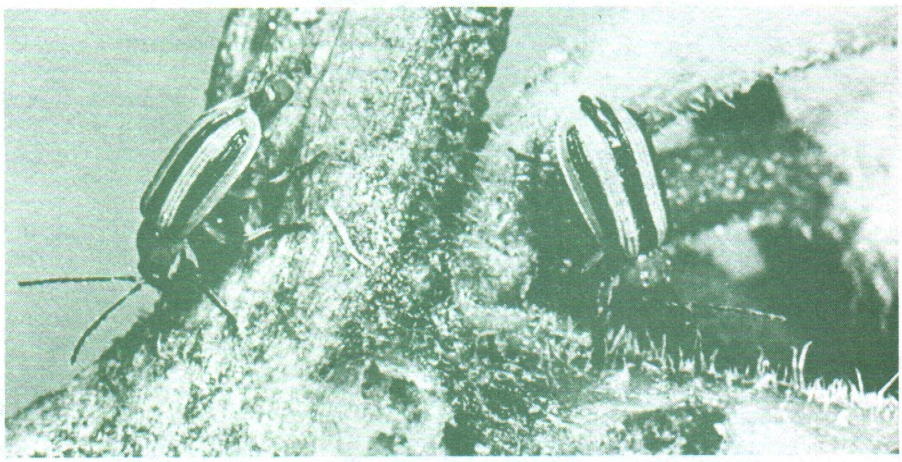


Figure 6. Striped cucumber beetle feeding on cucumber vines.

Aphids

Hosts—the melon aphid feeds mainly on cucurbits, but also on other crops and weeds. *Damage*—aphids suck plant juice, generally from the underside of the leaves and may cause the leaves to curl downward. In addition, they transmit cucumber mosaic virus disease. *General life cycle*—aphids, sometimes called plant lice, are around 1/16 in. long at maturity. They are usually greenish or bluish green to black in color and may or may not have wings. The winter is passed as tiny eggs on a host plant.

In the early spring, the eggs hatch and all are females. One or two generations may be spent on these host plants but ultimately the wing forms fly and are blown by the wind to other hosts during the summer. Throughout the summer, all members of each generation are females that reproduce live young from their bodies in 5 to 7 days. Each female reproduces about 80 young. In the fall, when their hosts reach maturity, day length shortens and temperatures cool, there is a generation which consists of both males and females. These mate and the females lay the eggs which overwinter.

During the summer, a generation can be completed in 5 to 7 days. Hence, there may be 15 to 20 generations per season. It is this short generation time, coupled with the live birth of female young that makes possible the extremely rapid buildup of aphid populations.

Cutworms

Hosts—various species of cutworms attack cucumbers and nearly all plants not having hard woody stems. *Damage*—principal ways: 1) solitary, surface cutworms cut off the plants just above, at, or slightly below, the soil surface. Most of the plant is not consumed, but rather chewed just enough to make it fall over.

Members of this group include the black, the bronzed, the clay backed and the dingy cutworms. 2) the climbing cutworms climb the stems of herbaceous plants, vines, shrubs and trees and feed on the leaves, buds and fruits of crops.

Members of this group include the variegated and spotted cutworms. *General life cycle*—in general, cutworms pass the winter as partly grown larvae. They resume feeding and growth in the following spring and early summer.

In mid-summer, they change to brown pupae in the soil. Adult moths emerge from the pupae in mid to late summer. The moths have about a 1½ in. wing span. They are generally gray or tan with various light and dark markings on the wings. The adults mate and the females deposit their eggs on the soil surface, trash, plant stems or similar places. Egg hatch requires from 2 days to 2 weeks. The larvae feed mainly at night until cold temperatures force them to hibernate in the soil for the winter. Most species of cutworms have just one generation per year.

Thrips

Hosts—these insects attack nearly all vegetable crops, many weeds and some field crops. Serious injury occurs on all cucurbits. *Damage*—thrips rasp tiny holes in the surface of the leaves and suck up the resulting sap. Under continued attack, the leaves acquire whitish blotches and dashes. Young plants may be killed and old plants severely deformed. *General life cycle*—both adults and nymphs pass the winter on plants or rubbish in and near the fields. The adults are very small, about 1/25 in. long, yellowish in color and very active. The males are wingless and scarce. The females regularly reproduce without mating. The females have 4 extremely narrow wings which are fringed with long hairs on the rear margins.

These insects remain on the underside of leaves, mostly out of reach of insecticides. The white, bean-shaped eggs are thrust into the plant tissue. On onions, the eggs hatch in 5 to 10 days and the resulting nymphs resemble the adults except for size. They reach maturity within 15 to 30 days, passing through 4 instars, two of which are passed in the soil without taking food. After the fourth molt, the adult females return to the plants to lay eggs for the next generation. There are usually 5 to 8 generations per year.

DISEASE CONTROL

Recommended Practices:

1. Plant disease resistant (disease tolerant) varieties when available.
2. Plant disease-free seed. Seed grown in the West under dry, disease-free conditions is preferable. Treat seed with chemicals if purchased untreated (see Extension Bulletin E-312).
3. Rotate (3-4 years) with non-cucurbit crop to reduce population of disease-causing organisms in the soil.
4. Plow down or burn infected crop debris. Deep plowing is effective following severe infection.
5. Maintain balanced soil fertility so that plants are better able to withstand disease infection.
6. Provide good air drainage so that microclimatic conditions in plantings will not favor spread of disease.
7. Avoid planting in low areas where soil drainage is poor. Plants are unthrifty under these conditions and diseases are favored.
8. Control insects and nematodes which may transmit pickle diseases or injure tissue, thereby decreasing the opportunity for infection.
9. Control weeds, particularly wild cucurbits which may be alternate hosts for diseases affecting pickles.
10. Irrigate only when necessary and not before 4:00 a.m. or after 4:00 p.m. Prolonged retention of water on the foliage is a major factor in the spread of scab.
11. Apply chemicals to protect plants against invasion by disease-causing organisms (see Extension Bulletin E-312).

For information on common diseases, see chart on p. 7.

IRRIGATION

Returns from pickling cucumbers may increase with proper irrigation. With irrigation, it is possible to insure more uniform seedling emergence and plant development under dry soil conditions. Weed control chemicals are also more effective when followed by a light irrigation. In Michigan, maintaining precise planting and harvesting schedules is difficult without irrigation. With irrigation high plant populations can also be safely grown without losses due to lack of soil moisture.

The irrigation system should be capable of supplying 1 to 2 acre-inches of water per week. At no time during the growth of the plant should the leaves be allowed to wilt. Water needs of the cucumber plant are particularly sensitive during the fruit set and development period. One acre-inch of water per application is adequate on light soils. Heavier soils need 1½ to 2 acre-inches per application. Frequency of irrigation will be higher on light textured soils.

Irrigation systems with large gun type nozzles are most economical. However, improper operation of large gun type nozzle systems can cause damage. Large water droplets falling greater distances increase soil compaction and crusting problems and may wash seeds to the soil surface. Cucumber foliage can also be injured by the impact of large water droplets. Irrigation systems with small nozzles will cause fewer such problems.

When scheduling irrigation, consider foliage disease development and interference with honeybee pollination activity. Minimize the time foliage is wet to help avoid disease infestation. Schedule irrigation when bees are inactive to improve pollination.

POLLINATION

Cucumber pollination is accomplished by bees, particularly honeybees, so it is essential to move colonies into or alongside the field. Gynoecious hybrid varieties for mechanical harvest need about one colony of honeybees per 50,000 plants. Fields with low plant populations for hand harvest should have about one colony to every three acres. Seed of commercial hybrid varieties usually contains 10 to 15% monoecious seed, but for most available varieties, this percentage could be lower and there would still be plenty of male flowers to supply pollen.

It is best to place the colonies in the field about 5 days after bloom starts. This insures that flowering will be sufficiently well along to attract bees into the field; if introduced into the field too early, the bees may become excessively "locked in" to other plants in the area. Figure 7 illustrates misshapen fruit due to poor pollination. Overhead irrigation during the middle of the day drives bees from the cucumbers, but this problem can be avoided by irrigating in the late afternoon and evening during the pollination period.

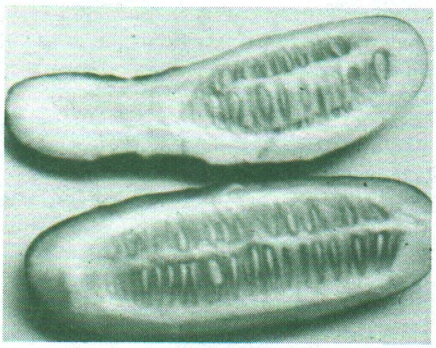


Figure 7. Normal cucumber fruit and misshapen fruit due to inadequate pollination. Note misshapen cucumber failed to enlarge on end attached to the vine.

Figure 8. Honey bee visiting cucumber flower for nectar.

Bees visit cucumber blossoms for nectar but not for pollen (Figure 8). As a result, colonies kept in large acreages of cucumbers suffer from a scarcity of pollen and may have trouble surviving the winter. This problem will not likely arise on smaller acreages where other pollen sources are available in the surrounding areas. Because the cucumber pollination period coincides with the period when beekeepers produce their major honey crop, beekeepers hesitate to move to pickles for fear of losing a honey crop. As a result, growers may have difficulty renting needed numbers of colonies. It is advantageous to get to know a beekeeper and make arrangements for strong colonies well ahead of the flowering season.

Diseases of Picking Cucumber

Pickling cucumbers are subject to many diseases, some of which seriously affect production. Plants are attacked at all stages of growth. Seedling diseases, root rots and wilts frequently reduce stands. Vigor of plants and production are often limited by early infection of the foliage. Secondary infection may destroy the fruit or reduce its quality. Current suggestions for chemical disease control are in Extension Bulletin E-312.

Disease and Causal Organism	Symptoms	Conditions favoring disease	Life cycle
Angular leaf spot; Bacterium, *Pseudomonas lachrymans*	*Leaves*—light brown, angular spots, diseased tissue drops out leaving irregular, tattered holes. *Fruit*—water soaked, gray spots, often with amber-colored ooze. Spots crack and produce a crusty tan to white lesion. Seed invaded.	Humid, wet, temperatures 70-80°F., mechanical and insect damage.	Bacterium overwinters in plant refuse, soil or seed. Infection through wounds and natural openings. Transmitted by wind, splashing water, insects.
Scab; Fungus, *Cladosporium cucumerinum*	*Leaves, stems*—irregular spots with yellow margins, brown centers. Disease tissue drops out, leaving ragged holes. Because of angular appearance of spot disease may be confused with angular leaf spot. *Fruit*—water soaked spots, often with amber-colored ooze, become dark gray to black sunken spots.	Humid, wet, temperatures 60-80°F.	Fungus overwinters in plant refuse and soil. Transmitted by tools, wind, splashing water, insects.
Anthracnose; Fungus, *Colletotrichum lagenarium*	*Leaves*—round, water-soaked yellow spots turn brown with red-brown margins. Centers drop out giving the leaves a shot-holed appearance. Defoliation often occurs. *Fruit*—circular dark brown to black sunken lesions with pinkish-orange centers (spore mass).	Humid, wet, temperatures 70-80°F.	Fungus overwinters in plant refuse, soil and in or on seed. Transmitted by tools, wind, splashing water, insects.
Alternaria leaf spot; Fungus *Alternaria cucumerina*	*Leaves*—circular tan spots often with a concentric ring pattern. Defoliation may occur.	Bright sunshine with frequent dews and showers. Temperatures 60-90°F. Weakened plants most susceptible.	Fungus overwinters on perennial weeds, in refuse, soil, in or on seed. Transmitted by tools, splashing water, air, insects.
Bacterial Wilt; Bacterium *Erwinia tracheiphila*	*Leaves*—dull green; leaves, branches and finally whole plant wilts and dies. Sticky, stringy ooze can be squeezed from cross section of diseased stem.	Dry weather encourages cucumber beetle migration and feeding. Temperatures 50-70°F. Frequent dews aid infection.	Fungus overwinters in intestinal tract of striped and/or spotted cucumber beetles, passed in feces. Enters plant through wounds made by beetles.
Powdery mildew; Fungus, *Erysiphe cichoracearum*	*Leaves, stems*—powdery white coating; infected tissue turns yellow and shrivels. Premature defoliation. *Fruit*—yields reduced and quality inferior.	Humid, frequent dews, high temperatures 70-90°F.	Fungus overwinters on perennial weeds or spores windborne from South.
Cucumber mosaic virus	*Leaves*—dark and light green mottle, crinkling, most noticeable on younger leaves. Older leaves with V-shaped dead areas extending from margin toward midrib. *Fruit*—mottled, warty, misshaped.	Poor weed control within and surrounding a planting (weeds) may be alternate hosts for virus. Failure to control aphids and cucumber beetles.	Virus overwinters in seed and perennial weeds. Transmitted by insects (aphids, cucumber beetles) and mechanically.

MECHANICAL HARVESTING

Once-over mechanical harvesting should be done when cucumbers have attained a size that produces the greatest dollar return. Planting schedules, growing conditions, acres to be harvested, weather and fruit size should all be considered when determining the optimum time for harvest. Pickling cucumber fruit can have a 40% weight increase in 24 hours. Hot, humid weather with adequate soil moisture promotes rapid increase in fruit size. Thus, once-over mechanical harvesting is a timely operation. The value of a field of cucumbers changes as the fruit size changes; typically, depreciation in value of 5 to 10%, and sometimes 20%, occurs in a 24-hour period.

The suggested practice for determining optimum harvest time is to walk the field diagonally and collect fruit samples from 10 areas at random. Sampling should be started about 3 days before the field appears to be ready for harvest and repeated daily. If fruit from 10 square feet is collected in each of the 10 samples, 100 square ft. (1/435 acre) has been harvested. Size grade these cucumber fruits by hand and consult your pickle processor's fieldman for a recommendation on optimum harvest time.

Follow the manufacturers' instructions for recommended harvester operation. The relationship of ground speed, pickup reel speed, pinch-roll speeds and pinch-roll pressure is very critical.

Walk beside the harvester while it is in operation and observe the vine flow onto the pickup reel (Figure 9). Ground speed and pickup reel speed should be coordinated so that the vines feed freely onto the apron and do not lag. Strive for condition 2 and avoid conditions 1, 3 and 4. Condition 1 causes the pickup reel fingers to strip the cucumbers from the vines. Conditions 3 and 4 cause the stems to bend and the cucumbers to detach from the vines. The pickup reel cannot pick up fruit that is not attached to a vine.

Pinch-rolls that detach the cucumbers from the vines operate slightly differently on various manufacturers' harvesters. Pinch-roll pressure adjustment is very important, and the adjustment necessary is determined by each field situation. Recovery of small cucumbers is influenced by roll pressure. Use as high a roll pressure as practical while still permitting a desirable throughput of vines. Be aware that there are "rough" pinch rolls and "smooth" pinch rolls. All rolls may be smooth or used in rough/smooth combination. Rough rolls are more aggressive than smooth rolls and have a tendency to damage the small pickles. Rough rolls may be necessary in fields that contain weeds or heavy vine foliage.

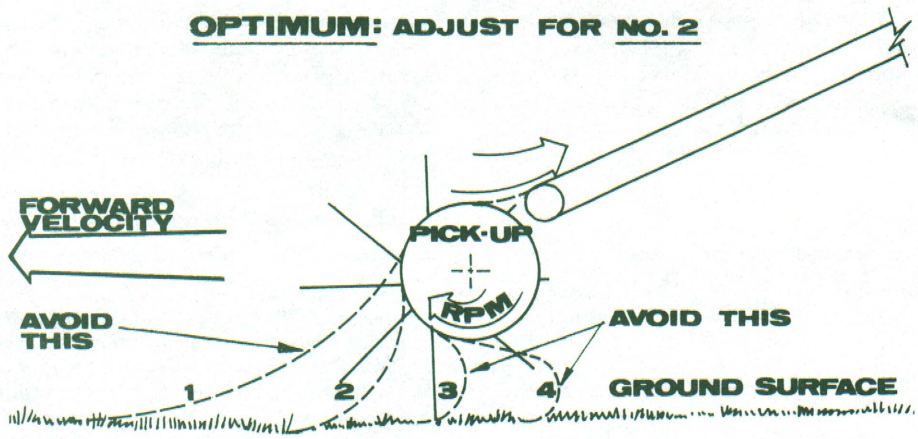


Figure 9. Cross sectional view of cucumber harvester pickup reel showing four possible conditions of vine flow. Condition 2 is best. Avoid conditions 1, 3 and 4.

Proper harvester adjustments will result in increased field recovery and fewer damaged cucumbers. Adjust components of the harvester as often as necessary. The collection of dirt and mud is influenced by the depth of the cut-off blade below the soil surface. For conservation of power requirements and reduction of dirt, operate the cut-off blade as near the surface as possible without cutting cucumbers.

Minimize or eliminate the dropping of cucumbers whenever possible. The breaking, damaging and bruising of cucumbers is influenced by the height of the harvester discharge conveyor above the collection source (e.g., bin, wagon, high-lift, truck). Preliminary findings from recent research indicate that as little as a 2½ ft. drop causes visible internal fractures. Every effort should be made to reduce the number and height of drops throughout the harvesting and handling system. Use of foam rubber (3 in. minimum) on the floor of transport vehicles drastically reduces damage to the first few layers of fruit.

HANDLING CUCUMBERS

Impacts and pressure during handling can cause serious damage to pickles—damage which cannot be seen because it is internal. This internal damage increases bloating during brining and drastically lowers the value of the pickles. All key operations such as loading, hauling, unloadling and grading influence the quality of pickles that go into the processing plant. Reduce drop heights to a minimum on the harvester conveyors and transfer points. If cucumbers are piled over 3 ft. deep in transport vehicles, the likelihood of damage increases.

Keep harvester aprons, baffles and conveyors free of mud accumulations. Keep the truck floors free of mud buildup. Keep conveyor side rails smooth and free of any protrusions such as bolt heads or welds that can severely damage and abrade cucumbers. Reduce abrasion by unloading with or into water, or both, and by reducing the accumulation of dirt with the harvested product. It may be feasible to set up field washing stations during seasons of excess dirt and mud accumulation. Additional information on harvesting cucumbers mechanically can be found in Agricultural Engineering Department Information Series No. 291, Michigan State University.

STORING AND HOLDING

Pickling cucumbers are normally stored for long periods of time in brine solution. If, however, fresh pickles need to be stored or held for a short period of time before being processed or placed in brine tanks, the cucumbers should be cooled as rapidly as possible to 45 to 50°F. Hydrocooling has been used successfully to remove field heat. The cucumbers should be held at 45 to 50°F. under 90 to 95% relative humidity for no longer than 7-10 days and should be processed immediately after removal from storage. Holding cucumbers at higher temperatures will cause a rapid loss of green color. Loss of color will also occur more rapidly if held in the same room with apples, tomatoes or other ethylene producing crops. Humidity should be as high as possible to prevent shriveling. Temperatures lower than 45-50°F. will result in severe chilling injury, especially if removed from storage and held at a high temperature before use. Symptoms of chilling injury include pitting, water soaked spots and tissue collapse followed by infection with decay organisms.

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