Crop Profile for Field Corn in New Jersey

COMMODITY PRODUCTION FACTS

CORN GRAIN

National and state production, contribution and rank: US corn grain production in 2001 was 9.5 billion bushels grown on 68.8 million acres (57). New Jersey corn grain production in 2001 was 7.39 million bushels, or 0.077% of the total US production. This ranks NJ 33rd among the 41 states reporting (57, 58).

Yearly corn grain production:

- 1995 = 78,000 acres, 93 bushel per acre, 7.25 million bushel (55)
- 1996 = 94,000 acres, 126 bushel per acre, 11.84 million bushel (55)
- 1997 = 94,000 acres, 108 bushel per acre, 10.15 million bushel (55)
- 1998 = 98,000 acres, 92 bushel per acre, 9.02 million bushel (57, 55)
- 1999 = 60,000 acres, 37 bushel per acre, 2.22 million bushel (57, 55)
- 2000 = 75,000 acres, 134 bushel per acre, 10.05 million bushel (57)
- 2001 = 66,000 acres, 112 bushel per acre, 7.39 million bushel (45)

Yearly corn grain prices and values: NJ yearly average season price and total cash value ($US) of the corn grain crop (55):

- 1995 = $3.75/bushel, $27.20 million total value
- 1996 = $3.00/bushel, $35.53 million total value
- 1997 = $2.80/bushel, $28.43 million total value
- 1998 = $2.20/bushel, $19.84 million total value
- 1999 = $2.20/bushel, $4.88 million total value
- 2000 = $1.90/bushel, $19.09 million total value

CORN SILAGE

National and state production, contribution and rank: US corn silage production in 2001 was 102.352 million tons. New Jersey corn silage production in 2001 was 208,000 tons, or 0.203% of the total US production. This ranks NJ 38th among the 43 states reporting (44).

Yearly corn silage production:

- 1995 = 19,000 acres, 15 ton per acre, 285,000 ton (55)
- 1996 = 14,000 acres, 16 ton per acre, 224,000 ton (55)
- 1997 = 22,000 acres, 15 ton per acre, 330,000 ton (55)
- 1998 = 21,000 acres, 12 ton per acre, 252,000 ton (55)
- 1999 = 25,000 acres, 6 ton per acre, 150,000 ton (55)
- 2000 = 14,000 acres, 17 ton per acre, 238,000 ton (55)
- 2001 = 208,000 ton (44)

Production costs on a yearly basis: Conventional corn grain production costs (1996) for New Jersey are $378.74 per acre at a crop value of $3.05 per bushel (2); organic production costs are $619.19 per acre (3). Conventional corn silage production costs for New Jersey are $484.83 per acre (1996) at a crop value of $23.75 per ton (4), while organic silage production costs are $757.92 per acre (5).

Identification of crop uses: In 2000, 84.3% of the corn crop was raised harvested for grain and 15.7% for silage (55).

PRODUCTION AND CULTURAL PRACTICES

Production regions: New Jersey is divided into two growing regions, the northern and southern halves of the state. These growing regions are defined primarily by differences in soil types, elevation and latitude. Highway US 1, between Trenton and New Brunswick, runs approximately between these two geographical regions.

- ***Southern New Jersey:*** This area is part of the Coastal Plain and the soils are generally light soils ranging from sand to sandy loams, but areas of heavier, clay and silt loam soil do exist. Elevations in most of the area are less than 200 feet. The warmest, seasonal temperatures occur in the extreme southern part of the state with the Salem County area being the warmest (28). Approximately 44% of corn production occurred in this region of the state between 1998-2001 (55).

- ***Northern New Jersey:*** The northern soils are Piedmont and Appalachian types, heavy silt loams and shaley soils, respectively. Elevations are generally above 200 feet and reach 1800 feet at High Point in extreme northern New Jersey. The topography is more rugged than southern New Jersey with alternating ridges and valleys running approximately from the southwest to the northeast, ending rather abruptly at the New Jersey-New York state line. The ridges extend southwesterly

into eastern Pennsylvania. These ridges are important in influencing both weather conditions and pest infestations for the north (28). Approximately 56% of corn production occurs in this region of the state between 1998 and 2001 (55).

Tillage Systems

Conventional tillage (plow plus disk and/or harrow), minimum tillage (chisel plow plus disk, disk plus disk), and no-till are the three basic tillage systems used for corn.

- ***Conventional tillage:*** The majority of corn in New Jersey is grown using conventional tillage. A moldboard plow, chisel plow or disk is used for primary tillage and secondary tillage (disking or harrowing) for seedbed preparation. Plowing may be done well in advance of planting, with the final disking done just before seed is planted. This timing will allow some weed seeds to germinate and be eliminated with the secondary tillage operation. Conventional tillage also aids in the control of some perennial weeds. Volunteer corn may also be reduced. Each tillage operation results in some soil compaction and adversely affects soil structure. This does not result in a better seedbed but only increases the potential for soil crusting problems, which can lead to seedling emergence problems. The corn seedbed should be adequate for uniform planting depth, good seed coverage, and firm contact between seed and soil (31).

- ***Minimum and no-tillage:*** Minimum- and no-tillage corn production systems are being used on a growing percentage of the total corn acreage. These systems can save time and reduce costs for seedbed preparation over the conventional system by reducing tillage trips. In addition, soil erosion, soil compaction, and water runoff are reduced. In general, any yield advantages for minimum and no-till systems over conventional systems involve better water conservation and reduced soil erosion. Minimum and no-till systems require that all existing vegetation be controllable with herbicides. In addition, monitoring for potential disease, insect, and weed problems, since pests may be more damaging and/or more difficult to control under minimum-tillage systems. Infected corn residue on the soil surface may increase the incidence of certain diseases and insects, but in general, increased pest problems have not been observed (31).

Planting Date and Seeding Rate

Planting date: On average, corn is planted in northern New Jersey between April 25 and June 1 and in southern New Jersey between April 15 and June 15. Corn can be planted 10 to 14 days before the average date of the last killing frost. More times than not, this will insure the earliest possible planting with minimum risk of loss. Due to annual variations in spring weather conditions, it is recommended that planting not occur until soil temperatures are warm enough for fast germination and seedling emergence. Quick germination can help to reduce losses to soil born seed and seedling diseases (31, 53).

Seeding rate: Under average conditions, 26,000 to 30,000 seeds per acre are planted on loam and silt-loam soils for a final plant population of 24,000 to 28,000. These fine-textured soils retain moisture better and support heavier populations than coarse-textured soils. On loamy sand and sandy loam soils this rate is often reduced by several thousand plants to achieve 21,000 to 24,000 plants per acre. For better than average conditions, higher rates may be justified. Plant populations for silage may be 10 to 15 percent greater than for grain (31, 53).

Soil Requirements

The best way to determine the kind and amount of lime and fertilizer needed for most efficient corn production is to have the soil tested and follow the recommendations based on the yield goal potential of the soil type or types being farmed. Frequent soil tests including the presidedress nitrogen test (PSNT) are recommended especially where high rates of manure and fertilizer are being used. In the absence of soil tests, the following recommendations assume that the soil tests medium in phosphorus and potassium. It is also assumed that the crop is to be grown on fields where no legume crop has been grown and/or where no animal manures have been applied preceding the corn crop.

Soil pH and liming: Where corn is grown in rotation with alfalfa, soil pH should be maintained between 6.5 and 7.0. For other cropping programs involving corn, soil pH should be maintained between 6.0 and 6.5. Plant nutrient uptake efficiency and the performance of some herbicides are best within these pH ranges (31).

Fertilization: Crop fertilization needs vary depending on the soil fertility level and the crop yield goal established for the field. On average one pound of N should be applied per bushel of expected grain yield. Corn typically removes 0.75 lb N per bu of grain or 9 lb N per ton of silage (30); 0.45 lb of P_2O_5 per bushel of grain or 5 lb P_2O_5 per ton of silage; and 0.3 lb of K_2O per bu of grain or 11 lb K_2O per ton or silage. (23, 31).

To determine commercial fertilizer need, credit must be given to nutrients being supplied when a legume crop precedes the corn crop or where animal manure are being used. Fertilizer recommendations should be reduced according to standard credit values or testing (31). Specifically:

- On non-manured fields, fertilizer may be applied for corn as a plow-down, disked in after plowing, banded along the row, or as a side-dressing during the growth of the crops. The best method or combination of methods of application depends on the texture, organic matter content, and fertility level of the soil and the type of tillage system being used.

- On fine-textured loam and silt-loam soils, the major proportions of the fertilizer should be broadcast and plowed down in the spring prior to planting. The remainder of the fertilizer, 100 to 300 pounds having a high P_2O_5 ratio, such as a

1-2-1 or 1-3-1 should be applied in a band 2 inches to the side and 2 inches below the seed at planting.

- On coarse-textured sandy loam and loamy sand soils, the major proportions of the P_2O_5 and K_2O and approximately 25 to 50 percent of the N should be broadcast and plowed down. Generally 100 to 300 pounds of a high P_2O_5 ratio fertilizer such as a 1-2-1 or 1-3-1 is banded 2 inches to the side and 2 inches below the seed at planting time. The remainder of the N needed should be side-dressed when the corn is 1 to 2 feet tall.

- The application of a "starter fertilizer" is more important on low-fertility soils and during seasons when the soil is abnormally cold and wet following planting. Row fertilization may or may not be profitable on high-fertility soils that warm up quickly in the spring. Improper row placement or excessive rates of starter fertilizer will cause seedling injury. Plant nutrient needs and fertilizer recommendations are the same as for conventional-tillage corn, except that broadcast fertilizer will be surface applied and not plowed down (31).

Presidedress soil nitrogen test (PSNT): The PSNT assesses a soil's ability to supply nitrogen from the mineralization of soil organic matter, crop residues, and manure in the late spring when the soil has warmed. The sidedress nitrogen recommendations therefore give credit to the nitrogen contributions from manure and legumes. On corn fields where the PSNT will be used, nitrogen fertilizer should not be broadcast but rather only as a starter at 20 lb N/A in the row at time of planting. Soil samples are taken to the 0 to 12 inch depth when corn is 6 to 12 inches tall (22, 31).

Irrigation

Although corn responds well to irrigation, particularly on light-textured soils and in dry years, few acres in New Jersey are irrigated. In 1997, only 5.6% of the corn grain crop was irrigated, while the number of silage acres irrigated were too low to report (59). Most of the irrigated crop is done using irrigation equipment once used for potato production, or on vegetable farms that rotate crops. On sandy soils or during drought periods, irrigation can make the difference between getting a good crop or no crop at all. The most critical time for water in corn is the period covering tasseling, silking, and pollination. Water stress during this period will significantly reduce final yield.

Harvesting

Silage corn is harvested when grain is dented and stalks are still green; this growth stage begins in early September or later depending on variety and growing conditions. Fully dented corn has accumulated all the dry matter possible and further maturity is simply a loss of moisture. Moisture is needed in the silo for the ensiling process. Silage is most often utilized on the farm to feed livestock. Grain can be harvested either as ear corn or shelled corn but only a small portion of corn is harvested as ear corn and primarily for livestock feed. Grain harvest occurs begins on average in mid-late October.

Grain is stored on the farm for on farm use, for future sale, or sold directly. Post harvest handling and on farm storage is discussed later in this profile.

Worker Activities - Exposure to Pesticides

Worker exposure to pesticides can occur throughout the growing season. However, the utilization of personal protective equipment can be used to protect the user and worker from exposure. During planting, fungicide treated seed may be handled or seed-box treatments applied. Since the farmer most often does the planter loading and planting, his/her exposure to these materials may be of concern especially during product handling. Fungicides are not often used at any other time during the growing season. These materials are of lower toxicity than the insecticides used at-planting.
At planting insecticides used most frequently in field corn production in New Jersey includes the organophosphate insecticides chlorpyrifos, terbufos and tefluthrin (46). Their use at this stage in crop production is much greater for corn rootworm than most likely any other pest. Chlorpyrifos is also used for European corn borer after the corn has emerged; however, materials with different chemistries and toxicity are available and can be used for these two major insect pests of corn. During the growing season, insecticides may be used to control a wide range of pests. These applications, similar to herbicides, may be done by the farmer or custom applicators. Recommended nematicides used at-planting are all organophosphates with few options available.

Pre plant, pre-emergence or postemergence herbicide applications are made by the farmer or by custom applicators. Custom applicators have sophisticated equipment bearing air filtration systems and apply a significant amount of applications. Farmers with a wide range of equipment types apply the remaining applications. Larger pieces of equipment, such as those used to apply and incorporate preemergence herbicides, typically have a cab and air filtration system. However, for postemergence and spot applications, smaller vehicles, which have exposed operators, may be used. The frequency with which small vehicles are used is unknown. Applications of granular or dry formulations of herbicides are used more in recent years, with most new dry formulations being water-dispersible granules that have reduced dust inhalation risk. Dry formulation packaging has also reduced container disposal problems.

Other factors affecting operator exposure include: distance between the spray boom and the operator, prevailing weather conditions, protective clothing worn by applicators, and the prevalence of vapors and dispersed spray droplets. Exposure of either farmers or custom applicators during mixing and loading has not been well researched. We can speculate that the increase in use of pesticides that are available in highly concentrated dry formulations has great potential for reducing such exposure however make personal protective equipment use essential when handling and loading.

After grain harvest, workers may be exposed to various insecticides used to treat empty grain bins, the grain stream as it enters the storage bin, or to top dress the grain mass. These products include biologicals and chemicals that require the standard use of personal protective equipment. Fumigants can be used but it is strongly suggested that

only trained and experienced workers work in tandem with another person when applying these materials and utilize respirators and other required personal protective equipment.

INSECT PESTS

PEST IDENTIFICATION

The following insect pests of corn and listed by their occurrence during the growing season (7). While all of these pests may affect field corn produced in New Jersey, the insect pests of highest significance in terms of infestation and losses are corn rootworm and European corn borer.

April to May

Seedcorn maggot, *Delia plature* (Meigen): The adult flies of the seedcorn maggot emerge during late April and early May. Eggs are deposited on or near the soil surface and hatch in a few days. The maggots work their way into the soil in search of food and complete their development in 7 to 10 days. Three to five generations emerge each year. Any cultural practice that speeds up germination and plant emergence helps to reduce crop losses from maggots (18).

The pest occurrence is sporadic with 1% of fields in New Jersey infested annually. Usually no more than 2% of seedlings in a given field are infested, but occasionally fields may suffer 30 to 60% plant loss due to this pest. The pest is most prevalent in fields with an abundance of decaying organic matter such as plant residue or manure and during years when the early growing season is cool and damp (18).

> ***Threshold:*** Treat seed pre-plant if cool or wet spring conditions may delay seed germination, or if planting information fields with poor drainage, old sod fields, heavily or manured or high crop residue fields (56). Replant decisions would be made based on the percent affected corn stand, loss, growth stage and time of year.

May

White grubs, *Phyllophaga* spp.: This complex of insect species is a problem in home lawns and in corn planted into an old grass sod; particularly in bluegrass sod fields. In heavily infested sod fields, grubs can be found feeding on the roots of grasses about 1 to 4 inches deep in the soil. If the soil is dry, the insects migrate deeper into the soil profile. When corn is planted into a grass sod, the food source (grass roots) is eliminated, leaving only the corn roots as food.

Injury symptoms include small stunted plants, dead plants, and plants with a purple coloration (caused by the roots' inability to acquire phosphorus in the soil). Grubs are

dirty white, soft bodied, and robust, with a brown head and six well developed legs (25). The pest occurrence is sporadic with 1% of fields in New Jersey infested annually, however, there is increasing field observations over the past few years in southern New Jersey.

> ***Threshold:*** Sample 2 to 3 weeks before planting by randomly selecting 10 samples (1 ft^2 per sample) for every 10 acres. Dig the soil to a depth of 6 inches and count the number of grubs and identify the grub type. Application of a soil insecticide at planting may be required if the counts of May/June bug grubs exceed 2 per ft^2 (56).

May to June

Wireworm, *Agroites mancus* (Say) and *Limonius agonus* (Say): Wireworms overwinter mainly in the soil as partly grown larvae and as adult beetles. The larvae feed on underground plant parts for 1 to 3 years before reaching maturity. This insect is a pest for only 2 to 3 years after a field has been in a grass sod. Damage is often confined to areas of the field and stand losses could range from 0 to 75 or 80%. Damage occurs when wireworms eat the seed or cut off the seedlings below the ground level. A few weeks later they will tunnel into the underground portion of the stem and cause the plant to wilt and die. After the plants are 18 inches tall, wireworms feed on the roots or tunnel or scar the larger roots (10). The pest occurrence is sporadic with 5% of fields in New Jersey infested annually. More often the pest is found in fields on sandier textured soil types where potatoes were once grown and small grains are in the current crop rotation.

> ***Thresholds:*** 2 or more wireworms per 10 shovels of soil taken to a depth of about 10 inches (10); **or** 1 wireworm per 2 shovels of soil per site (minimum of 7 sites) prior to working the soil (temperature >55^{o}F) (27); **or** bait stations should be used (mixture of untreated corn and wheat) buried 6 inches deep in the soil, in a least 5 locations in a field. Each bait stations should be covered with black plastic to rapidly heat the soil and enhance germination. After 2 weeks, examine the stations and record the number of wireworms attracted to the grain. If 1+ wireworm is found per station, a soil insecticide should be applied in the seed furrow (56).

Flea beetle, *Chaetocnema pulicaria*: Flea beetles causing problems occur from early May to late June. Damage is caused by adults feeding on the leaves and transmitting bacterial wilt disease (Stewart's wilt). Flea beetles complete many generations during the growing season, but only those generations attacking seedling corn are considered of economic importance. Survival of overwintering flea beetle adults is closely tied to temperatures during the winter months. For this reason, they seldom are a problem with less than 1% of fields, mostly no-till, infested annually.

> ***Threshold:*** The possibility of economic damage increases if the average monthly temperature for January, February and March total 85 (^{o}F) or more.

Under these conditions a higher number of adults survive. Most fields do not reach an economic threshold caused by the disease (6).

Billbugs, *Sphenophorus* spp.: One generation of this pest occurs each year. Billbugs overwinter as adults in the soil, emerging during May and feeding on various kinds of grasses including corn during May. Upon emerging from the soil, adults chew small cavities in the stems, feed and lay eggs. Numerous stem punctures can severely retard or even kill small plants especially those up to the 6-leaf stage. Slits in the lower stems and rows of oblong holes in expanded leaves are noticeable. The emerging larvae can also feed on roots and tunnel into the stalk (12). The pest occurrence is sporadic with less than 1% of fields in New Jersey infested annually.

Threshold: 5% of seedlings show excessive damage or loss (61). Soil insecticides are not recommended unless this is a chronic problem.

Cutworm, *Agrotic ipsilon* (Hufnagel): Black cutworms are among the most difficult insect pests of corn to control. The insects overwinter as pupae in the soil and also as adults. Some adults may fly in from southern areas of the United States. Cutworms deposit their eggs in April and May, usually before the crop has been planted. The cutworm develops from egg to adult in approximately 2 months. Adults tend to be attracted to trashy fields or those where green weeds are present, particularly winter annuals such as common chickweed. A majority of the adults migrate into the state from southern regions.

Newly hatched larvae feed on the weeds until new corn seedlings emerge. When larvae are small, their feeding may go unnoticed. Damage to plants becomes noticeable when the larvae are about one-half to two-thirds grown. If the soil is moist, cutworms cut the plants off just above ground level. Under dry conditions, however, larvae stay below ground level and cut the plants off; damage is noticeable when the seedling are wilted. If the majority of larvae are 1.5 to 2 inches long, control does not help because most of their feeding is complete (13).

Problems with cutworm are sporadic from year to year, and damage can range from slight to severe possibly leading to corn replanting in areas of a field. Annually approximately less than 10% of fields is infested but most often damage occurs in low, wet areas in the field. Rescue treatments of insecticide or poison baits may be used if activity and plant losses are observed. Control is best when soils are moist as the pest remains underground during dry weather (13). Due to the erratic nature of the pest, preventative treatments are not warranted (56).

Thresholds: 3% of the stand showing dead stem or cut off seedlings (27); **or** before 3-5 leaf stage, if 10%+ of the plants show fresh feeding and cutworms present; at 3-5 leaf stage if 5% of the plants show fresh feeding and 4 or more cutworms present per 100 plants (56).

Sod webworms, *Crambus* spp.: Several species of sod webworms occasionally may be serious pests of field corn in New Jersey. The corn root webworm and bluegrass webworm are the two most common species. Damage usually occurs in corn fields previously in sod and is seldom uniform throughout the field. The pest occurrence is sporadic with 1% of fields in New Jersey infested annually.

Sod webworms overwinter as partly grown larvae. They start feeding in April and complete their development in early June. Young corn plants are damaged near ground level. Some plants may be cut off and partly dragged into the silk-lined tunnels made by the larvae. Up to 75% of plants in an infested area may be damaged. The damage is similar to that caused by the black cutworm (20).

> ***Threshold:*** None established. Use black cutworm thresholds (8).

Garden centipede (symphylan), *Scutigerella immaculata* (Newport): The garden symphylan is an occasional but very destructive pest of field crops. Symphylans overwinter in the soil as adults. In the spring, they move up into the top 6 inches of soil when the soil temperature rises to about 45°F. Symphylans deposit eggs in late April, May, and June. The eggs hatch 2 to 3 weeks later into tiny, white nymphs that resemble the adults except that they have only six pairs of legs. The pest feeds on sprouting seeds, underground stems of seedlings and root hairs, weakening, stunting or killing the plant (17).

Infestations seldom encompass an entire field, but rather comprise one or more small areas of 0.25 acre to several acres (17). The pest occurrence is less than 1% of fields in New Jersey infested annually.

> ***Threshold:*** None. Treat if a significant area in the field is affected. No rescue treatment is effective while the crop is growing. If damage is seen, turn over at least 10 shovels of soils looking for active symphylans. An average of one per shovel of soil is a signal that the area in the field should be treated before the next crop is planted. Control of garden symphylans involves preventive treatment before or at the time of planting. Broadcast treatment and incorporation before planting, or banded applications (17).

Slugs, gastropods: Slugs overwinter in either the egg or the adult stage, depending on species. Juvenile slugs hatch from eggs in the spring, soon after the soil warms, and remain in the field all summer. Several slug species produce one, and possibly a partial second generation per year. Slugs prefer environments with high humidity, relatively cool temperatures, and debris such as crop litter or manure for shelter from the sun. Feeding on and shredding of leaves occurs during the night. Damage to corn can be severe but often the young corn plant does not die because the growing point usually escapes damage (19). In New Jersey, 3-5% of fields is infested annually.

> ***Threshold:*** No-till or weedy fields should be surveyed especially during cool, wet weather. Nighttime observations should be done as slugs are night feeders.

Five or more slugs around each plant between spike and 3-leaf stage may require treatment if wet, cool conditions prevail. If weather turns hot or dry, 10+ slugs per plant may be tolerated by the 3-leaf stage (56). Early season control action usually is not profitable unless 7% or more of plants are infested or showing damage symptoms (19).

Armyworm, *Pseudaleta unipuncta* (Haworth): Armyworms overwinter as partially grown larvae under plant trash and in clumps of grass, and as pupae in the soil. Moths emerge from early May to early June, eggs are deposited and larvae hatch and develop over approximately a 3-week period. Migration may also be a source of armyworm during this period. The first symptom of damage is ragged feeding on the top leaves, with wet, brown pellets in the area (11).

Armyworm infestations occur irregularly in New Jersey, with 1-2% of fields infested annually. Heavy infestations are most frequently observed in no-till fields that were sod the previous year or in fields where rye or wheat was used as a mulch. Corn fields likely to be attacked should be checked every few days during the first 2 weeks of June.

Thresholds: Control action usually is not profitable unless 7 to 10% or more of plants are infested or showing damage symptoms (11); **or** examine 20 plants at 5 locations with the field, record the percentage of damaged plants, the average size of the armyworm, and the severity of the injury. Control is recommended if 35%+ of the plants are infested and 50%+ defoliation is seen on damaged plants, provided the larvae average less than 0.75 inches long. Larvae greater than 1.25 inches long have completed their feeding (56).

June

European corn borer, *Ostrinia nubilalis* (Hubner): There are two generations per year in New Jersey with 20-25% of fields infested annually. They pass the winter as fully-grown larvae inside the stalk and residue of their host plants, and transform into the pupal stage from late April to early June. Adult moths emerge from late May to late June, mate and lay eggs. The larvae hatch in about one week. This first brood of the year feed on leaves then move to the main stalk, feeding for about 3 weeks before pupating during July and early August (15). Hybrids that have been genetically engineered to produce their own *Bacillus thuringiensis* (Bt) delta endotoxin are effectively protected from this pest.

Thresholds: For silage corn, there is little economic loss therefore pesticide treatments are not recommended. For grain corn, check weekly for fresh whorl feeding when plants reach 18-24 inches high; examine 20 consecutive plants at each of five locations in the field and determine % infestation. Also count number of active larvae in whorls and determine the average number per plant. Control is suggested in fields where 75 to 80%+ of the plants show whorl feeding in mid-June with an average of one larva per plant (56).

For second brood, the threshold to determine pesticide application is when 50% of the plants have an egg mass by peak flight in the second brood. Corn planted before May 20 seldom is hurt by the second generation. If corn is planted late and is to be harvested for silage, borer damage is of little significance. The big loss occurs with corn varieties that have a tendency to drop ears (15). On an average there is less than 3% yield loss; one out of every 4 to 5 years can experience 5 to 10%+ yield loss in non-Bt hybrids.

June to July

Corn rootworm (larvae), Northern *Diabrotica barberi* (Say) and Western *Diabrotica virgifera virgifera*: Two species of corn rootworm (northern and western) are present in New Jersey. These species have similar life cycles, except that the western corn rootworm tends to hatch about 3 to 5 days earlier in the spring. Larvae begin hatching about mid-June in most areas of the state but may begin hatching earlier in southern areas. The larval stage inflicts the most severe damage to corn plants, so most chemical control is aimed at this stage (53) There is only one generation per year in New Jersey (31). This is the number one corn pest in northern New Jersey, while in southern New Jersey the problem is less severe due to the sandy textured soils that occur in the region. Based on field observations, up to 50% of corn in continuous corn rotations may be infested. Average yield losses of 10% have been observed and in some occasions up to 50% yield loss with heavy pressure.

There is no need to treat for rootworm if the problem is not in the field. Rootworms will not be a problem in the field if any crop other than corn was grown the previous year. Fields in continuous corn may develop problems, but these can be predicted by what happens to the plants in July and August of the previous year. Plants that fell over in July should be checked for damage to the root system. Badly damaged roots at this time indicate a problem in the field. In mid-August, examine the ear tips for beetles (53).

Thresholds: Examine and count beetles on 60 plants in three locations in the field and determine the average per plant; treatment is warranted if average is 1 beetle per plant (Western) or 2 beetles per plant (Northern) (27). **Or** depending on the threshold of a field average of 5 or more beetle per plant if less than 50% of the ears have silked and been pollinated, and silks are clipped to within 0.5 inch of husks (31).

If the field is to be replanted to corn the following year, scouting should be also be done during this period. If an average of one or more rootworm adults per plant if found, a soil insecticide is warranted next year (31).

Stalk borer, *Papaipema nebris* (Guenee): The importance of the stalk borer has grown with the increase in no-till corn production in New Jersey, however, less than 5% of fields are infested annually. One generation occurs per year. Moths are present from late August to mid-October, and most of the eggs are deposited from mid-September to early October. Eggs are laid singly or in groups in folded, dead grass and weed leaves;

they also may be deposited on corn plants. Moths are very attracted to orchardgrass and rye for egg deposition. The stalk borer overwinters in the egg stage, then hatches over a relatively long period of 4 to 5 weeks, from mid-May to mid-June. The larval stage lasts approximately 9 to 12 weeks, and most corn damage occurs from early to late June. Stalk borers attack near ground level, eating their way upward through the center of the plant or crawl to near the top of the plant, eating through the rolled leaves and into the stalk. Both lead to wilted plants (21).

> ***Threshold:*** 3% of the plants infested (27), or treatment is suggested if more than 4, 6 and 10% of the plants are damaged at the 2-, 3-, and 4-leaf stages and the worms have not bored into the stalks (56).

July to August

Corn rootworm (adult), Northern *Diabrotica barberi* (Say) and Western *Diabrotica virgifera virgifera*: Corn rootworm beetles emerge during late summer (mid-July to mid-August) in most areas of the state and can remain until the first killing frost in the fall. In some southern areas of the state, beetles emerge as early as early July. Adults are capable of interfering with pollination by damaging silks. The result is early only partially filled out with kernels (31). It is at this time that corn fields should be scouted and the need for control determined for the next season if corn is to be planted again. Rootworm beetles begin depositing eggs in corn fields approximately 2 weeks after they emerge. They deposit the eggs in soil around the base of corn plants, and the eggs remain there until the following spring (53).

> ***Thresholds:*** Scouting for adults should be done weekly from mid-July to late August. Use the threshold of a field average of 5 or more beetle per plant if less than 50% of the ears have silked and been pollinated, and silks are clipped to within 0.5 inch of husks (31)
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> If the field is to be replanted to corn the following year, scouting should be also be done during this period. If an average of one or more rootworm adults per plant if found, a soil insecticide is warranted next year (31). **Or**, weekly counts at five locations in every 40 acres; count the number of adults on 10 plants in each location and determine an average per plant. Yellow sticky traps: Place one, 4x6 inch Olsen sticky panel per 5 acres of corn attached to a corn plant at the ear zone with a wooden dowel and secured with a clothespin. Traps should be changed weekly and beetles counted. In second or third year cornfields, the use of a soil insecticide is recommended if visual counts exceed 0.25 adult rootworms per plant of if yellow sticky traps exceed 10 adults per week. In fields with continuous corn for 4 or more years, a soil insecticide is recommended if the visual counts exceed 2 adult rootworms per plant or if yellow sticky traps exceed 35 adults per week (56).

European corn borer, *Ostrinia nubilalis* (Hubner): The second brood occurs during this time. Larvae feed on the corn tassel and shank area, weakening the stalk in the upper

portion of the plant and causing them to bend over. Weakening of the shank often results in the ears dropping to the ground where they cannot be gathered with harvesting equipment (15).

Threshold: See above entry for European corn borer

Fall armyworm, *Spodoptera frugiperde* (Smith): Fall armyworms migrate to New Jersey from the southern US, usually in late July to mid-August. Upon arrival eggs are deposited on plants, hatch and feed near the ground or in the whorl of corn plants. Infested plants appear ragged, and wet, brown, sawdust like pellets are scattered throughout the whorl. The larvae will feed for 15 to 18 days, then pupate in the soil, emerging in about 2 weeks (16). Infestation rates vary annually based on adult migration, but on average yield losses are less than 10% in infested fields.

Threshold: Scout at least weekly all late plantings of both silage and grain corn before tassel emergence. Examine 20 consecutive plants at each of five locations for the presence of whorl feeding. 75% of plants taller than waist high infested with 1 larvae per plant or 50% infested with 2 larvae per plant (27, 56). Later in the season fall armyworm larvae are difficult to control as corn plants are often too tall to spray with conventional ground rigs at this growth stage. If 100 percent of the plants are infested and they are less than 30 inches tall, treatment with an insecticide using a large volume of water (about 100 gallons per acre) can be used (16).

Corn leaf aphid, *Rhopalosiphum maidis* (Fitch): The corn leaf aphid is a minor pest of field corn in New Jersey occurring rarely (1 in 15 years). Infestations either build up too late or are controlled by natural enemies such as lady beetles and wasp parasites (56). From early July until fall, colonies of the pest can be found on or near tassels or whorl leaves in most corn fields. Unless the insect is widespread across the field, there is no need to instigate control measures. If left uncontrolled, the honeydew produced from their feeding falls onto the silks and prevents pollination, resulting in some barren plants (14).

Thresholds: Unless the insect is widespread across the field, there is no need to instigate control measures. Unfold leaf whorls of 20 plants at each of five locations in the field and note the severity of aphid colonies and any natural enemy activity. Treatment may be needed when 25% of the plants are heavily infested and natural enemy activity is low (56).

Grasshopper, *Malanoplus* spp.: Damage occurs during the middle and late summer especially during drought seasons, but losses due to grasshoppers are less than 1% annually. Grasshopper nymphs and adults feed on leaves and adults may also feed on ears. Damage is most evident at field margins or in corn planted after pasture (24).

Threshold: Examine field edges along pastures and grassy areas in mid to late summer. Treatment of adjacent areas to prevent grasshopper movement into

corn should be considered when young grasshoppers reach 20 per square yard. Field sprays of corn may be justified when 5 to 8 grasshoppers per square yard are present during corn silking (56).

Japanese beetle (adults), *Popillia japonica* (Neman): The Japanese beetle is the adult of one species of white grub. Its larvae are soil-feeding insects. The adults begin emerging around July 4 and move to many species of plants to feed on the foliage. Corn fields that are silking can be extremely attractive to the beetles. When populations of the pest are extremely high, the number of beetles feeding on corn silks can reduce pollination, resulting in poor kernel set. In many cases, however, damage is restricted to the field margin. Consider control only if the feeding is spread throughout the field (25). In New Jersey, Japanese beetle populations are found in most corn fields, however, attributable yield loses are only 1-2% annually.

Threshold: Begin scouting in mid-July before pollination. Examine 20 plants in five locations in the field to determine the stage of pollination, the number of beetles present per plant, and percentage of plants with silks cut back to 0.5 inch or less. If silks are wilted and turned brown, pollination is complete and further silk feeding will not affect yields. An insecticide treatment may be necessary if 50% of plants have silks cut back to 0.5 inch or less (56).

CHEMICAL CONTROLS

The anticipated or existing pest complex, intensity of pest pressure, the time of year and weather conditions, specific management objectives, and the properties of the pesticides dictate corn production pesticide use. In New Jersey, 99.616% of applications used ground equipment while only 0.384% are aerially applied (46).

The top 5 insecticides applied to New Jersey corn grain and corn silage in 2000 were determined according to grower records of total pounds active ingredient applied (46). Of these materials, chlorpyrifos (Lorsban), terbufos (Counter) and tefluthrin (Force) are organophosates, and carbofuran (Furadan) is a carbamate. The possibly unavailability of these products and other organophosphates and carbamates would have a significant impact on corn grain and silage production in the state. Although some alternative materials exist, yield losses could dramatically rise if they were unavailable.

- **Chlorpyrifos** (Lorsban): Chlorpyrifos ranked first (45%) of insecticides used on corn grain and silage in New Jersey for 2000; 3746.57 lbs. active ingredient were applied and at least 2422 acres were treated, or about 6.8% of the corn acreage reported (46). Chlorpyrifos (Lorsban 4E, Lorsban 15G) is registered to control cutworms, European corn borer (first generation), grasshopper, corn rootworm, seedcorn maggot, stalk borer, armyworm, white grub and wireworm. Used preplant, at planting, preemergence and postemergence depending on the pest. Restricted use for 4E formulation. Toxic to birds, fish and aquatics (56). Chlorpyrifos is an organophosphate insecticide.

- **Terbufos** (Counter): Terbufos ranked second (19%) of insecticides used on corn grain and silage in New Jersey for 2000; 1546.32 lbs. active ingredient were applied and at least 1419 acres were treated, or about 4.0% of the corn acreage reported (46). Terbufos (Counter 15G, Counter 20CR) is registered to control corn rootworm, white grub, and wireworm. Used preplant and at planting. Restricted use; acute dermal or oral toxicity, toxic to birds (56). Terbufos is an organophosphate insecticide.

- **Tefluthrin** (Force): Tefluthrin ranked third (17%) of insecticides used on corn grain and silage in New Jersey for 2000; 1444.23 lbs. active ingredient were applied and at least 9702 acres were treated, or about 2.7% of the corn acreage reported (46). Tefluthrin (Force 3G) is registered to control cutworm, corn rootworm, white grub and wireworm. Used at planting as in furrow treatment or banded. Restricted use; worker exposure concerns (56). Tefluthrin is an organophosphate insecticide.

- **Carbofuran** (Furadan): Carbofuran ranked fourth (11%) of insecticides used on corn grain and silage in New Jersey for 2000; 891.86 lbs. active ingredient were applied and at least 1080 acres were treated, or about 3.0% of the corn acreage reported (46). Carbofuran (Furadan 4F) is registered to control European corn borer (first generation), grasshopper and corn rootworm. Used at planting as in furrow treatment, post-plant banded or postemergence depending on pest. Restricted use; acute oral, dermal and inhalation toxicity, and toxic to birds. Cannot be applied before 30 days of harvest, REI is 14 days unless protective equipment is used, and no more than two foliar applications per season (56). Carbofuran is an carbamate insecticide.

- **Permethrin** (Pounce): Permethrin ranked fifth (4%) of insecticides used on corn grain and silage in New Jersey for 2000; 303.48 lbs. active ingredient were applied and at least 2731 acres were treated, or about 7.7% of the corn acreage reported (46). Permethrin (Pounce 3.2EC, Pounce 1.5G, Ambush 2E) is registered to control cutworm, European corn borer (first generation), stalk borer and armyworm. Used preplant, pre-emergence, banded or broadcast depending on pest. Restricted use. Toxic to fish and aquatics (56). Permethrin is a pyrethroid insecticide.

Current Recommendations

The insect pests of highest significance in terms of infestation and losses are corn rootworm and European corn borer. The following insecticides are recommended for control of these pests (53, 56). There have been no Section 18 Emergency Exemptions or Section 24C Special Local Needs for field corn insect control in New Jersey in recent history (9, 26, 29).

Corn rootworm

Carbofuran

- Active ingredient: carbofuran
- Trade name and formulation: Furadan 4F
- Use rates: 0.5 lb ai/A
- Type of application: band or broadcast, rainfall or irrigation needed or cultivation into the soil to move the insecticide into the root zone. Banding more effective as concentration of toxicant in root zone is higher.
- Application rates of formulation: 2 pt/A
- Application timing: at plating or post-planting; coincide with hatch of pest
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 48 hours
- Class: organophosphate

Chlorethoxyfos

- Active ingredient: chlorethoxyfos
- Trade name and formulation: Fortress 5G, Fortress 2G
- Use rates: See application rate
- Type of application: T-band or in furrow
- Application rates of formulation: 3.5 oz/1000 ft of row, 6.0 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 48 hours; restricted use
- Class: organophosphate

Chlorpyrifos

- Active ingredient: chlorpyrifos
- Trade name and formulation: Lorsban 15G
- Use rates: 1.2 oz ai/1000 ft row
- Type of application: band over row or T-band
- Application rates of formulation: 8.0 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 0 days
- Restricted entry interval: 12, 24 hours
- Class: organophosphate

Ethoprop

- Active ingredient: ethoprop
- Trade name and formulation: Mocap 10G
- Use rates: 0.6 oz ai/1000 ft row
- Type of application: band over closed seed furrow

- Application rates of formulation: 6.0 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 0 days
- Restricted entry interval: 48 hours; restricted use
- Class: organophosphate

Fipronil

- Active ingredient: fipronil
- Trade name and formulation: Regent 80WG, Regent 4SC
- Use rates: 0.12 oz ai/1000 ft row
- Type of application: injected into seed row; mixed with pop-up liquid fertilizer
- Application rates of formulation: 0.15 oz/1000 ft of row, 0.24 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 90 days
- Restricted entry interval: 24 hours, restricted use
- Class: Fiproles

Imidacloprid

- Active ingredient: imidacloprid
- Trade name and formulation: Gaucho 600, Prescribe or Gaucho seed treatment
- Use rates: 0.18-0.23 lb ai/80000 unit of seed
- Type of application: only applied by commercial seed treaters
- Application rates of formulation: 4.5-6.0 fl oz/80000 unit of seed
- Application timing: seed treatment
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 12 hours
- Class: chloronicotinyl

Phorate

- Active ingredient: phorate
- Trade name and formulation: Thimet 15G
- Use rates: 1.2 oz ai/1000 ft row
- Type of application: band before or after closing or covering devices
- Application rates of formulation: 8.0 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 0 days
- Restricted entry interval: 48 hours; restricted use
- Class: organophosphate

Terbufos

- Active ingredient: terbufos
- Trade name and formulation: Counter 15G, Counter 20 CR
- Use rates: 1.2 oz/1000 ft row
- Type of application: band before or after closing or covering devices or in-furrow
- Application rates of formulation: 8.0 oz/1000 ft of row, 6.0 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 0 days
- Restricted entry interval: 48 hours; restricted use
- Class: organophosphate

Tefluthrin

- Active ingredient: tefluthrin
- Trade name and formulation: Force 3G
- Use rates: 1.2-1.5 oz ai/1000 ft row
- Type of application: banded or in-furrow
- Application rates of formulation: 4.0-5.0 oz/1000 ft of row
- Application timing: at planting
- Typical number of applications per year: 1
- Pre-harvest interval: 0 days
- Restricted entry interval: none; restricted use
- Class: organophosphate

European corn borer

Bacillus thuringiensis

- Active ingredient: Bacillus thuringiensis (Bt)
- Trade name and formulation: Several including Dipel 10G
- Use rates: 0.5 lb ai/A
- Type of application: ground sprayer
- Application rates of formulation: 5 lb/A
- Application timing: over whorl when larvae are young
- Typical number of applications per year: 1-2
- Pre-harvest interval: 0 days
- Restricted entry interval: 4 hours
- Class: biological

Bt corn hybrids

- Active ingredient: Bacillus thuringiensis (Bt)
- Trade name and formulation: Bt corn hybrids. See text for more information

Carbaryl

- Active ingredient: carbaryl
- Trade name and formulation: Sevin 80S
- Use rates: 2.0 lb ai/A
- Type of application: ground sprayer
- Application rates of formulation: 2.5 lb/A
- Application timing: direct spray into whorl when larvae are young
- Typical number of applications per year: 1-2
- Pre-harvest interval: 0 days
- Restricted entry interval: 12 hours
- Class: carbamate

Carbofuran

- Active ingredient: carbofuran
- Trade name and formulation: Furadan 4F
- Use rates: 1.0 lb ai/A
- Type of application: ground sprayer, use a minimum of 3 gal of diluted spray per acre
- Application rates of formulation: 2.0 pt/A
- Application timing: at plating or post-planting; coincide with hatch of pest
- Typical number of applications per year: no more than 2 according to label
- Pre-harvest interval: 30 days
- Restricted entry interval: 48 hours; restricted use
- Class: carbamate

Chlorpyrifos

- Active ingredient: chlorpyrifos
- Trade name and formulation: Lorsban 4E, Lorsban 15G
- Use rates: 1.0 lb ai/1000 ft row
- Type of application: ground sprayer over whorl
- Application rates of formulation: 2.0 pt/A, 8.7 lb/A
- Application timing: at planting
- Typical number of applications per year: not to exceed 2 per label
- Pre-harvest interval: 35 days (grain), 14 days (silage)
- Restricted entry interval: 12, 24 hours; restricted use
- Class: organophosate

Esfenvalerate

- Active ingredient: esfenvalerate
- Trade name and formulation: Asana XL 0.66 EC
- Use rates: 0.04-0.05 lb ai/A
- Type of application: ground sprayer over whorl
- Application rates of formulation: 5.8-9.6 oz/A
- Application timing: at planting
- Typical number of applications per year: not to exceed 2 per label
- Pre-harvest interval: 21 days

- Restricted entry interval: 12 hours; restricted use, extremely toxic to fish.
- Class: pyrethroid

Fipronil

- See entry under Corn rootworm

Permethrin

- Active ingredient: Permethrin
- Trade name and formulation: Pounce 3.2EC, Pounce 1.5G, Ambush 2E
- Use rates: 0.1-0.2 lb/A
- Type of application: ground, direct spray (minimum of 3 gallon of finished spray per acre) or granules into whorl
- Application rates of formulation: 4.0-8.0 oz/A, 6.7-13.4 lb/A, 6.4-12.8 oz/A
- Application timing: whorl to prior to brown silk stage
- Typical number of applications per year: 1
- Pre-harvest interval: none listed
- Restricted entry interval: 24 hours, restricted use, extremely toxic to fish
- Class: pyrethroid

Phorate

- Active ingredient: phorate
- Trade name and formulation: Thimet 20G
- Use rates: 1.0 lb ai/A
- Type of application: ground, broadcast into whorl
- Application rates of formulation: 5 lb/A
- Application timing: at whorl
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 48 hours; restricted use
- Class: organophosphate

Zeta-cypermethrin

- Active ingredient: zeta-cypermethrin
- Trade name and formulation: Mustang 1.5EW
- Use rates: 0.034-0.05 lb ai/A
- Type of application: ground, minimum 10 gallons of spray per acre
- Application rates of formulation: 2.9-4.3 oz/A
- Application timing: whorl
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days (grain, fodder), 60 days (forage)
- Restricted entry interval: 12 hours; restricted use
- Class: pytheriod

Chemical Use in IPM Programs

Chemical management of seed and seedling insect pests has been critical for New Jersey corn production. Aside from manipulating planting dates and using other cultural practices described below, there are no other reliable means of controlling these insect pests. The use of seed treatments or in-furrow treatment are only recommended based on IPM scouting or anticipated problems due to historical problems or cropping history. Insecticides are infrequently applied to field corn as ground applications are limited by crop height after knee-high; but when recommended, farmers are urged to use insecticides that are effective, inexpensive and more selective. The use of broad-spectrum insecticides are discouraged as they may kill most insects found in the fields.

Chemical Use in Resistance Management

There is no attempt of resistance management in insect control in corn production, except for Bt-corn. The use of postemergence insecticides is limited and therefore the chances for chemical resistance development are less than for other agronomic and vegetable crops.

Bt-corn: European corn borer and other pests have the potential to develop resistance to the Bt toxin. This is of particular concern when planting Bt-enhanced corn varieties (see "Alternatives" section below). Resistance management is based on "high dose" or "refuge". Bt corn hybrids have been designed to produce very high levels of toxin, much higher and consistent than levels resulting form a Bt insecticide application. The dose is high enough to eliminate all corn borers with no genes for resistance, as well as those with one copy of a resistance gene. Refuges provide a source of unselected corn borer moths to mate with any surviving resistant moths emerging from nearby Bt corn. No more than 80 percent of corn acreage should be planted to Bt-corn (1, 56).

ALTERNATIVES

Bt Corn: Hybrids that have been genetically engineered to produce their own *Bacillus thuringiensis* (Bt) delta endotoxin are effectively protected from this pest. However, variations and differences in the inserted genes also provide varying degrees and at different times of the year in different parts of the plant. Therefore knowledge of the strengths and weaknesses of a given hybrid should be compared with the needs in each production system. The endotoxin produced is the same protein found in nature and commercial Bt formulations for control of European corn borer and other caterpillars. Bt hybrids can be a highly effective and environmentally compatible alternative to managing European corn borer (1, 56).

CULTURAL CONTROL PRACTICES

Seedcorn maggot, *Delia plature* (Meigen): Any cultural practice that speeds up germination and plant emergence helps to reduce crop losses from maggots. Plant the field after 450 degree days (based 40°F) have elapsed since organic materials have been plowed under, allowing the larvae to complete development and move onto to find another host (18).

White grubs, *Phyllophaga* spp.: Avoid planting into a recently converted sod, grass hay or pasture (25).

Wireworm, *Agroites mancus* (Say) and *Limonius agonus* (Say): There are no practical or effective ways to control the pest after the crop is planted. Prevention of damage requires chemical treatment before or at planting (10).

Flea beetle, *Chaetocnema pulicaria***:** Monitor the average monthly temperature for January, February and March. If the total is 85 (°F) or more, the likelihood of flea beetle feeding and transmission of Stewart's wilt increases. Resistant varieties can be planted (6).

Billbugs (several species, including *Sphenophorus aequalis aequalis* Gylential**:** Eliminating weedy plants from the field and surrounding areas a year prior to planting corn is the best pest management option (12). Use crop rotation, early planting if possible, and natural parasitic wasp populations (61).

Cutworm, *Agrotic ipsilon* (Hufnagel): Due to the erratic nature of the pest, preventative treatments are not warranted (56). The migratory nature of the pest into the crop field limits cultural control measures.

Sod webworms, *Crambus* spp.: Birds, beneficial insects and other biological and natural controls play an important role in reducing webworm population (20).

Garden centipede (symphylan), *Scutigerella immaculata* (Newport): None.

Slugs, gastropods: None.

Armyworm, *Pseudaleta unipuncta* (Haworth): Plow down crop and plant residues that harbor overwintering larvae. Observe no-till fields for infestations, particularly where grass cover crops in the field or surrounding fields were recently burned down with herbicides (11).

European corn borer, *Ostrinia nubilalis* (Hubner): Cultural controls include the use of Bt-enhanced corn hybrids. For non-Bt-enhanced hybrids, select a hybrid that performs well in area. Most hybrids carry some tolerance to corn borer damage. Avoid late

planting as second general corn borer is apt to attack late maturing plants. Keep fields as weed free as possible as the adult moths hide in grass and weeds during the day. Keep field edges and border mowed to reduce moth habitat. Shred or bury old stalks to kill overwintering larvae (15).

Corn rootworm, Northern *Diabrotica barberi* (Say) and Western *Diabrotica virgifera virgifera*: Rotate out of continuous corn (53).

Stalk borer, *Papaipema nebris* (Guenee): Cultural Control: Plow under the egg-harboring grass, weeds, and trash appears to provide satisfactory control (21).

Fall armyworm, *Spodoptera frugiperde* (Smith): There are no late cultural control practices.

Corn leaf aphid, *Rhopalosiphum maidis* (Fitch): None.

Grasshopper, *Phyllophaga* spp.: None.

Japanese beetle (adults), *Popillia japonica* (Neman): None.

BIOLOGICAL CONTROLS

Applications of *Bacillus thuringiensis* (Bt) are the most common form of biological control measure utilized, if any, in New Jersey field corn production.

PRODUCTION DISEASE PESTS

PEST IDENTIFICATION

As in the insect pest section, the corn diseases are listed by their time of occurrence during the growing season (7). Unlike insect pests, thresholds for disease pests have not be widely developed nor utilized; therefore only where threshold information is available is it included. While the following disease pests may affect field corn produced in New Jersey, the diseases of highest significance in terms of infestation and losses are seed rots and seedling blights, anthracnose and gibberella.

April to May

Seed rots and Seedling blights (*Fusarium*, *Rhizoctonia*, and *Pythium*) are caused by a variety of fungal organisms that persist in the soil. The diseases are prevalent in poorly drained soil during periods of cold wet weather, with soil temperatures below 50 to 55^{o}F favoring seedling blight. Symptoms include poor emergence, killing of embryo before germination, rotting of seedling roots and yellowing, wilting and death of seedling leaves (34).

May to June

Maize Dwarf Mosaic Virus (MDMV) and Maize Chlorotic Dwarf Virus (MCDV): Both viruses are potentially destructive diseases where johnsongrass (*Sorghum halepense*) is established. The two viruses that cause these diseases are able to survive in this perennial weed grass. Aphids and leafhoppers feeding on johnsongrass in the spring pick up the virus and inoculate nearby corn (48).

June to July

Anthracnose leaf blight, *Colletotrichum graminicola*, is caused by a fungal organism that can attack the corn plant any time during the year. In the spring to early summer, leaf lesions (oval to elongate, tan and 0.25 to 0.75 inch long, with brown to orangish borders) can be found on young plants when the disease has overwintered in the field. Eventually spore bodies with black spines can be seen with hand lens. Anthracnose may cause seedling death early in the season. Symptoms are usually observed on older (lower) leaves under conditions of high humidity and may resemble those of nitrogen deficiency, yellowish-orange leaves. These leaf lesions can spread from bottom leaves to top leaves (35). The fungus survives on corn residues and spores are spread by splashing rain, and favored by normal to above rainfall and moderate to warm temperatures (80 to 85^{o}F).

July to August

Leaf blights: A number of leaf-blight diseases occur on corn. The most common are gray leaf spot, Stewart's bacterial leaf blight, and northern corn leaf blight. These diseases can be found in almost any field, depending on the year and susceptibility of the hybrid planted. Some leaf-blight diseases are most often found associated with continuous corn, especially in reduced-tillage, continuous corn fields. These are anthracnose, gray leaf spot, eyespot, and northern leaf spot (48).

All leaf blight diseases cause loss of green leaf tissue, resulting in fewer kernels and lightweight grain. Plants may be predisposed to stalk-rot diseases when leaf damage is severe. The amount of yield loss is usually related to the time when the plant's upper leaves become infected. The most severe yield loss occurs when the upper leaves, the ear leaf, and those above the ear, become infected at or soon after tasseling. Yield losses will be minimal if disease does not occur on these leaves until six to eight weeks after tasseling (48).

Bacterial wilt and leaf blight, *Pantoea stewartti*, is a bacterial disease. The organism causing the disease overwinters in the corn flea beetle and is transmitted by this insect. The sum total of the mean temperatures (°F) for the months of December, January, and February indicates how well the flea beetle will survive the winter. If this sum is greater than 85, severe levels of bacterial leaf blight may be expected on highly susceptible hybrids. Young plants that become diseased will usually wilt and die. They develop white strips on the lower leaves and often produce several tillers. Plants that do not die

are stunted and usually produce no ears. The streaks enlarge, turning pale yellow to brown and are often most detected after tasseling (33, 53).

Gray leaf spot, *Cercospora zeae-maydis*, is a fungal disease. Most severe cases of gray leaf spot occur in fields of continuous, no-till corn where air drainage is poor. Fields along creeks and rivers are particularly vulnerable to gray leaf spot because of the extended periods of dew. Disease symptoms are gray, rectangular lesions that are restricted by the leaf veins. An individual lesion resembles a paper match. Loses in yield are due to loss of photosynthetic production and may average 5 to 50 bu/A, but higher losses are been reported (37). Areas along the Delaware River in northern New Jersey appear to most often infected.

Northern corn leaf blight, *Exserohilum turcicum*, is caused by a fungus that overwinters on corn residue. The resting spores produce conidia during warm, moist weather in early summer that are carried by wind or rain to lower leaves of the corn plant. Infection occurs and spreads during periods of high humidity and wet weather (40). This disease is characterized by long (1- to 6-inch), boat-shaped, grayish-green to tan lesions. Lesions first appear on the lower leaves, progressing to the upper leaves over time. Genetic resistance in hybrids have limited losses in the last several years. Potentially, however, this disease can result in yield losses of up to 30 to 50% if infection occurs before tasseling.

Anthracnose leaf blight, *Colletotrichum graminicola:* See information above.

Northern leaf spot, *Helminthosporium carbonum*, is a fungal disease that overwinters on infected leaves, husks and stalks of corn. Chlamydospores, the overwintering stage, spread the disease to corn seedlings as they emerge through the soil and crop residues. Infection and spread of the disease if favored by temperatures of 65 to 80^{o}F and heavy dews, and hindered during dry weather. The lesions begin as long, linear, chainlike gray-tan lesions then develop and spread along the leaf veins (41). The disease is observed throughout the state and probably only rarely causes a significant yield loss.

August to September

Eyespot, *Kabatiella zeae*, is a leaf blight caused by this fungus. It is most severe in fields where residues from a previous corn crop after left on the surface and those in continuous corn for two or more years. Eyespot is favored by long periods of cool, wet growing conditions during the growing season. Spores are dispersed by the wind and infect the corn leaf. Under favorable conditions, new spores are produced and spread quickly. Affected leaves are covered with numerous small round spots, 1/8 inch in diameter, oval to circular, and initially appear water soaked. The center of the spot dies, leaving a tan to cream-colored spot in the center surrounded by a brown to purple border (38).

Anthracnose stalk rot, *Colletotrichum graminicola*: Stalk rot is the most frequently observed corn diseases in New Jersey. The disease infects more than 50% of the field, but reduces yields by less than 10%. One of the causal organisms is anthracnose. Spores that cause anthracnose leaf blight earlier in the season continue infection if warm, moist and overcast conditions occur. The shiny black linear streaks and blotches appear on the surface of the lower stalk above the brace roots, and internal stalk tissue and pith becomes discolored. These stalks are weakened and are likely to lodge before harvest. This phase usually causes the greatest production losses (35). Anthracnose stalk rot is usually associated with continuous corn.

September to harvest

Gibberella stalk rot, *Gibberella zeae*, and anthracnose stalk rot currently are the most prevalent stalk rot diseases. The disease infects more than 50% of the field, but reduces yields by less than 10%. Both are fungal diseases that result in premature ripening, chaffy ears, and lodging of plants before harvest. The interior of the stalk becomes rotted, tissues break down, and the stalk is easily broken. Stalks with Gibberella stalk rot can be found in nearly any field. Affected stalks often have pink to reddish discolored internal tissues (32).

Ear rot (*Gibberella, Fusarium, and Diplodia*) ear rot diseases occur in New Jersey, but Gibberella ear rot is the most important. The Gibberella ear rot fungus is the same fungus that causes Gibberella stalk-rot disease. Gibberella enters from the silk end of the ear when cool, wet weather persists for several weeks through late silking of the crop. The occurrence of a whitish to pinkish mold on the ear tip is diagnostic, but extensive mold growth may not occur. On shelled grain, the symptoms may be seen as a pinkish coloration in some of the kernels. Even though extensive rotting does not always occur, the disease is serious because the fungus frequently produces toxins that makes the corn unfit for feeding (see 'Grain Storage Pest' section) (36). Under favorable conditions, 50-75% of fields may be infested to varying degrees, with quality losses occurring.

Nematode Diseases

Nematodes are microscopic roundworms that can be parasitic on plants; specifically root-knot, lesion, lance, sting, stunt and stubby root nematodes can attack corn. These organisms can introduce disease causing organisms such as wilts or root rots. In other instances the nematodes themselves cause the disease, disrupting the flow and water and nutrients in the xylem system, resulting in rootknot or deprivation of the above-ground parts, and ultimately causing stunting (62).

CHEMICAL CONTROLS

The top 3 fungicides applied to New Jersey corn grain and corn silage in 2000 were determined according to grower records of total pounds active ingredient applied (46).

- **Copper** (Tenncop): Copper ranked first (58%) of fungicides used on corn grain and silage in New Jersey for 2000; 48.43 lbs. active ingredient were applied and at least 30 acres were treated, or about 0.46% of the corn acreage reported. Growers following National Organic Program certifications standards to control foliar diseases most commonly use copper.

- **Captan** (several): Captan ranked second (26%) of fungicides used on corn grain and silage in New Jersey for 2000; 21.97 lbs. active ingredient were applied and at least 4541 acres were treated, or about 70% of the corn acreage reported; for seed decay, damping off, seedling blights.

- **Carboxin** (several): Carboxin ranked third (16%) of fungicides used on corn grain and silage in New Jersey for 2000; 13.72 lbs. active ingredient were applied and at least 1914 acres were treated, or about 29.5% of the corn acreage reported; for seed decay and seedling diseases, including *Rhizoctonia solani.*

Current Recommendations

The following labeled materials are recommended. There have been no Section 18 Emergency Exemptions or Section 24C Special Local Needs for field corn disease control in New Jersey in recent history (9, 26, 29).

Seed and seedling diseases: Seed treatment for corn continues to be a highly effective and inexpensive disease management tool for seed and seedling diseases. As a result all major brands of hybrid seed corn are sold already treated. If purchasing seed for a small or local producer, a farmer may be able to choose the seed treatment material. These products are listed below:

For seed decay, damping off, seedling blights (56)**:**

Captan (Captan 400)

Captan + metalaxyl (Captan 400 + Allegiance FL, Maxim XL)

Fludioxonil + mefenoxam (Maxim + Apron XL LS)

For seed decay and seedling diseases, including *Rhizoctonia solani* (56)**:**

Carboxin (Vitavax-34)

Carboxin + thiram (Vitavax T)

PCNB + etridiazole (Terra-Coat L-205)

Foliar diseases of corn: A few chemical control measures are registered for foliar diseases of corn, however their use is limited to the production of seed corn and is not recommended for general production. Rather use cultural methods listed below under "Cultural Control Practices" to reduce disease occurrence and severity.

Nematode diseases: Base the need for a nematicide on the results of a soil test for the presence and level of plant pathogenic nematodes and on the site history. The best time to sample for nematode testing is fall, immediately after harvest. Recommended pesticides include (56):

Terbufos (Counter 15G), 8 oz/1000 linear feet of row, in-furrow or band over row. Restricted use; terbufos is an organophosphate nematicide.

Terbufos (Counter 20CR), 6 oz/1000 linear feet of row, in-furrow or band over row. Restricted use; terbufos is an organophosphate nematicide.

Ethoprop (Mocap 10G),18-21.5 oz/1000 linear feet of row, 12-15 inch band over row/incorporated 2-4 inches into soil. Restricted use; ethoprop is an organophosphate nematicide.

Chemical Use in IPM Programs

Other than seed treatments to control seed and seedling diseases, disease prevention or control with fungicides usually is not economical and should be considered only on an individual basis. Scouting programs can be used to keep abreast of disease occurrence, however, action thresholds are not established. The use of fungicides would depend on the economics and ability to apply the chemical in an efficient manner especially if after the corn crop is knee-high or taller. The cultural methods described below are used by the majority of producers.

The use of nematicides would be based on soil testing to determine population types and numbers. In most New Jersey production, nematicides are not used unless the grower is growing corn in rotation with higher value vegetable crops.

Chemical Use in Resistance Management

There is no attempt of resistance management in disease control in corn production in New Jersey as no development of chemical resistance to fungicides or nematicides is known.

ALTERNATIVES

None.

CULTURAL CONTROL PRACTICES

The major corn diseases can be grouped into four categories: leaf blights, stalk rots, ear rots, and viral diseases. Corn diseases are strongly influenced by weather conditions and are very difficult to predict. Using resistant hybrids and a balanced fertility program controls them best. Since major corn pathogens can overwinter in New Jersey, tillage and rotation are common cultural practices for reducing sources of disease-causing organisms, particularly if disease was a problem the previous year. In no-till plantings of continuous corn, extra care must be taken to select disease-resistant hybrids. A high incidence of leaf blight causes early death of plants and moves harvest dates ahead of the norm; stalk rot increases in blighted fields. Therefore it is important to harvest earlier to prevent greater field losses (53). Disease specific recommendations are listed below:

Seed rots and Seedling blights (*Fusarium*, *Rhizoctonia*, and *Pythium*): Management includes the use high quality uncracked seed, chemical seed treatment, and proper seed bed preparation to allow from quick germination (34).

Maize Dwarf Mosaic Virus (MDMV) and Maize Chlorotic Dwarf Virus (MCDV): Control is achieved by planting resistant or tolerant hybrids. Efforts also should be made to eradicate johnsongrass (39).

Anthracnose leaf blight, *Colletotrichum graminicola*: Control includes resistant hybrids, crop rotation, clean plowdown of corn residues, and balanced soil fertility (35).

Bacterial wilt and leaf blight, *Pantoea stewartti*: The most practical control for this disease is to plant resistant hybrids and controlling the corn flea beetle early in the season (48, 53).

Gray leaf spot, *Cercospora zeae-maydis*: Control measures include rotation, tillage, controlling weeds to improve air circulation in the canopy, and planting resistant hybrids (38, 48, 53).

Northern corn leaf blight, *Exserohilum turcicum*: Avoiding inoculum by rotation and/or tillage, along with planting resistant hybrids, are the best methods of controlling this disease (48, 53).

Northern leaf spot, *Helminthosporium carbonum*: Control measures include resistant hybrids, crop rotation, and clean plowing of crop residues (41, 48, 53).

Eyespot, *Kabatiella zeae*: Control includes resistant hybrids, crop rotation and clean plowing to bury infected crop residues (38, 48, 53).

Anthracnose stalk rot, *Colletotrichum graminicola* and **Gibberella stalk rot**, *Gibberella zeae*: Control of stalk rot diseases is based on reducing plant stress from factors such as lack of moisture, leaf diseases, insect injury, and nutritional stress. To reduce the affects of stalk rot diseases: select hybrids with good standability and

resistance; adjust soil fertility to avoid excessive rates of nitrogen in relation to potassium; practice crop rotation; avoid overly high plant populations to maintain good stress-free growing conditions; harvest fields with the greatest level of rotted stalks first to avoid lost ears on lodged plants; and control insects, particularly root worms and stalk borer. Insects cause injuries to plant roots and stalks permitting stalk rot fungi to enter the plant (32).

Ear rot (*Gibberella, Fusarium, and Diplodia*): Some corn hybrids are less susceptible than others to ear rot. Ears with tight husks that mature in an upright position often have more ear rot than those maturing in a declined position. Diplodia ear rot appears to be more common in continuous corn under reduced tillage (36).

BIOLOGICAL CONTROLS

There are no effective biological controls for these diseases.

POST HARVEST INSECT PESTS

PEST IDENTIFICATION

Stored Grain Insect Pests

Direct feeding damage by insects reduces grain weight, nutritional value, and germination of stored grain. Infestations also cause contamination, odor, mold, and heat-damage problems that reduce the quality of the grain and may make it unfit for processing into food for humans or animals. Commercial grain buyers may refuse to accept delivery of insect contaminated grain, or may pay a reduced price (47).

The principal pests that cause damage to stored grains are adult and larval stages of beetles, and the larval stage of moths. Stored grain insects are known as “internal feeders” if they feed with the kernels, otherwise they are referred to as “external feeder”. Internal feeders include the granary weevil, rice weevil, lesser grain borer, and larvae of the Angoumois grain moth. External feeders that feed on grain dusts, cracked kernels and grain debris without entering the kernel include Indianmeal moth, sawtoothed grain beetle, red and confused flour beetles, flat grain beetle, and cadelle. Other species, such as the foreign grain beetle and hairy fungus beetle, feed on molds or fungi growing on grain stored at excessive moisture levels (47). A short description of some of these stored grain insect pests are listed below:

Angoumois grain moth, *Sitotroga cerealella* (Olivier) larvae attack and feed within whole kernels of a variety of grains. Full-grown larvae are 0.2 inch long, white caterpillars with yellow heads. This stage occurs within the kernel and normally is not seen. This damage may result in weight losses per kernel of as much as 24 percent for corn. Badly infested grain has an unpleasant smell and is unpalatable. Angoumois grain moths are primarily pests of crib-stored corn. Infestations in bins are confined to the

surface layer of grain. The presence of small holes in kernels and adult moths are the most likely evidence of infestation. The female oviposits in damp grain in preference to old, dry grain. Development from egg to adult may be completed in four weeks. Two to three larvae may develop within a single corn kernel (51).

Threshold: Five insects per quart sample of grain (56).

Indianmeal moth, *Plodia interpunctella* (Hubner) larvae prefer to feed on fines or damaged kernels. Infestations are most common in the upper four to six inches of grain in a bin. They become active in early spring because surface grain is usually the first to warm. The larvae produce silken threads that result in "caking" or "crusting" of the surface grain. Their frass, cast exoskeletons and silk contaminate the grain. Female moths deposit from 60 to 300 eggs, singly or in groups on or within the upper surface of the grain mass. Full grown caterpillars may leave their food source and climb up walls to pupate. The life cycle from egg to adult takes about six to eight weeks during warm weather. There are usually four to six generations per year depending on food supply and temperature conditions (51).

Threshold: Five insects per quart sample of grain (56).

Grain beetles, *Sitophilus granarius* (Linne); **Granary weevil**, *Sitophilus oryzae* (Linne); and **Maize weevils**, *Sitophilus zeamais* (Motschulsky) are very destructive grain pests. The larvae feed in grain kernels and develop within them. They can completely destroy grain in elevators or bins where conditions are favorable and the grain is left undisturbed. Infested grain will usually heat at the surface and may be so damp that sprouting occurs. Eaten out kernels containing small, white, legless grubs and small yellow brown to black snout beetles are signs of infestation. Other storage insect pests then may attack damaged kernels.

The life cycles of these weevils are very similar. The female chews a small hole in the grain kernel and deposits a single egg in the hole and seals it with a gelatinous material. Females of both species can lay 200-400 eggs during their lifetime. The period of egg laying depends upon temperature and is usually very sporadic during the winter months. The weevil grubs feed entirely within the kernel. Rice and maize weevils may complete their development from egg to adult in about four weeks. Granary weevils generally require an additional five to ten days. The rice weevil has four larval instars. It requires warmer temperatures than the granary weevil. Development occurs only at temperatures above 55°F. The life cycle may be completed in as few as 32 days in the warmest portions of the year. The rice and maize weevils can fly and infestations may develop in the field prior to harvest. Granary weevils cannot fly and so are most likely to be found where grain is stored and moved about in infested grain (51).

Threshold: One weevil or five other insects per quart sample of grain (56).

Cadelle beetle, *Tenebroides mauritanicus* (Linne), produce irregular borings in kernels. Cadelles, the largest of the major stored grain beetles, are shiny dark to red brown and

about 0.6 long. Cadelle larvae are the worm-like immature stage. They have creamy white elongate bodies with distinct black heads. Full grown larvae are about 0.6 to one inch long. Females may live more than a year and lay an average of 1,000 eggs each. Both larvae and adults attack grain and typically go from kernel to kernel, feeding on the germ. There are usually four larval instars and one or two generations of the insect per year in temperate regions. Larval development may be as short as eight weeks under optimum conditions. The larvae often migrate from the source of the infestation to pupate in a hole within wood or other materials. Eggs and pupae are easily killed at 0°F, however larvae and adults can survive at 15 to 20°F for several weeks (51).

Threshold: Five insects per quart sample of grain (56).

Lesser grain borer, *Rhyzopertha dominica* (Fabricius) Both the larvae and adults are primary pests, which mean they bore irregularly shaped holes into kernels and the larvae may develop inside the grain. Grain kernels may be reduced to dust and thin brown shells as a result of larval and adult feeding. A sweet, musty odor is often associated with infestations of this insect.

The adults are 0.1 inch long, brown to black beetles. They have cylindrical bodies with numerous small pits on the wing covers. The female deposits her eggs in clusters of two to about 30 outside the kernels. Most of the newly-hatched larvae chew their way into kernels and complete their entire development there. However, the larvae are capable of feeding on fines and can develop as free-living insects in the grain. There are four larval instars. Development from egg to adult requires about 25 days under ideal conditions of 93°F and 12 percent moisture. Both the larvae and adults produce a large amount of frass. Larval fecal pellets are pushed out of the kernel and large amounts may accumulate in the grain. The adults are winged and may fly to spread infestations (51).

Threshold: Five insects per quart sample of grain (56).

Flat grain beetle, *Cryptolestes pusillus* (Schonherr) are scavengers and often infest grain in poor condition. Flat grain beetles cannot feed on whole, undamaged kernels; however, even the minutest damage will allow invasion. Both the adult and larval stages feed on grain. Another species of *Cryptolestes*, the flour-mill beetle, *C. turcicus* (Grouv) is usually present with the flat grain beetle. Often both species are referred to as flat grain beetles and their appearance and biology is very similar. Another related species *Cryptolestes ferrugineus* (Stephens) is more resistant to cold weather than the other two and is more commonly found in the Northern states. Flat grain beetles are small, less than 0.1 inch in length, and red brown, and are among the first insects to attack newly binned grain. They prefer high moisture grain. Females may lay up to 200 eggs that are placed in cracks in kernels or dropped loosely in the grain. Egg to adult development time is about five to nine weeks (51).

Threshold: Five insects per quart sample of grain (56).

Confused flour beetle, *Tribolium confusum* (duVal) and **Red flour beetle**, *Tribolium castaneum* (Herbst) are secondary pests of whole, undamaged grain; they are, however, often found among dust, fines and dockage. Both species cause damage by feeding but probably cause more problems because of contamination. Large numbers of dead bodies, cast skins and fecal pellets, as well as liquids (quinones), can produce extremely pungent odors in the grain.

Both beetles are red-brown and about 0.1 inch long. They are very similar in appearance but can be distinguished by the shape of their antennae. Full grown larvae are less than 0.3 inch long, yellow-white worms. Under favorable conditions, a female may lay 400 or more eggs at a rate of six to twelve eggs per day. Eggs are covered with a sticky fluid allowing particles of debris to adhere to them resulting in almost perfect camouflage. There are generally four larval instars; the egg to adult life cycle takes about 30 days (51).

Threshold: Five insects per quart sample of grain (56).

Yellow mealworm, *Tenebrio molitor* (Linne) and **Dark mealworm**, *Tenebrio obscurus* (Fabricius) damage is largely limited to contamination by the worms and their waste products. Mealworms are beetles very similar in size, shape and color, and both species are about 0.5 inch long. Larvae are 1.25 inch long when fully developed. They are cylindrical, hard bodied and very similar in appearance to wireworms. The yellow mealworm is bright yellow while the dark mealworm is dark brown.

Adults emerge in spring and early summer. Females lay eggs for 22 to 137 days. On the average, a dark mealworm female will lay 463 eggs while a yellow mealworm female will lay about 276 eggs. The eggs are white, bean-shaped and covered with a sticky secretion. This secretion allows particles of debris to adhere to the eggs. The larval period for both insects can last more than 600 days. Pupation occurs near the surface of the grain. The complete life cycle of both mealworms is ten months to two years (51).

Threshold: Five insects per quart sample of grain (56).

Foreign grain beetle, *Ahasversus advena* (Waltl), do not feed on the kernels or damaged grain; rather, they feed and develop on molds and fungi. Therefore, the presence of foreign grain beetles indicates grain that is too wet for prolonged storage.

The foreign grain beetle is a small camel-brown beetle about 0.1 inch long. It belongs to the same family as the sawtoothed grain beetle. Foreign grain beetles are frequently found in stored grain. These beetles are one of a group of beetles called fungivores that feed on the molds and fungi that grow on high moisture grain. If they are found on stored grain, the grain is invariably moldy. Eggs are laid in the moldy material and the larvae feed on the molds and fungi (51).

Threshold: Five insects per quart sample of grain (56).

Sawtoothed grain beetle, *Oryzaephilus surinamensis* (Linne) feed on damaged kernels but will sometimes penetrate and feed on and/or develop in the endosperm of sound kernels. They are found in grain bins or grain handling facilities. They are usually associated with grain dust, fines and kernels that have been damaged during harvest or by other types of grain feeding insects.

Adult sawtoothed grain beetles are small, slender, dark brown, flat insects about 0.1 inch long. Female sawtoothed grain beetles may lay from 50 to 300 eggs in their six to ten-month lifetimes. Eggs are laid singly or in small batches in cracks or crevices in the food material. Eggs may also be laid directly into finely ground materials such as flour or grain dust. At temperatures of 80 to 85°F, sawtoothed grain beetle eggs hatch in four to five days whereas at 68 to 73° F it takes eight to 17 days. Larvae molt two to four times depending on temperatures. The larval stage lasts about 40 days. When mature, the larvae construct crude pupal cells utilizing bits of food material held together with oral secretions. When pupating the larva attaches its anal end to a solid object. The pupal stage lasts about seven days. The entire life cycle from egg to egg takes from 27 to 375 days. The adult life span can last up to three years (51).

Threshold: Five insects per quart sample of grain (56).

CHEMICAL CONTROLS

There have been no Section 18 Emergency Exemptions or Section 24C Special Local Needs for corn stored insect pest control in New Jersey in recent history (9, 26, 29). The following labeled materials are recommended.

Empty Bin: Cleaned bins should be sprayed inside and out with the following residual insecticides. Insides of the bin should be sprayed thoroughly 2 to 5 weeks before filling to kill existing pests. Sprays should be applied to "run off" on all walls, ceiling, ledges, braces, rafters and floor. Outsides of the bin should be sprayed at the base, the walls up to 15 feet from the base and the soil around the base.

Empty Bin Treatments

Diatomaceous earth

- Active ingredient: diatomaceous earth
- Trade name and formulation: Insecto
- Type of application: hand spray
- Application rates of formulation: 0.4-1 lb/1000 ft^2

Bacillus thuringiensis

- Active ingredient: *Bacillus thuringiensis*
- Trade name and formulation: Dipel, Biobot, Thuricide, Bactospeine, Top-Side
- Type of application: hand spray

- Application rates of formulation: 0.5 lb/5-10 gal water

Cyfluthrin

- Active ingredient: cyfluthrin
- Trade name and formulation: Tempo 2, Tempo 20W
- Type of application: hand spray
- Application rates of formulation: 8 ml/gal/1000 ft^2, 9.5 g/1000 ft^2 (56)

Treatment of Grain Going Into Storage: Insecticides (protectants) are used to treat the grain as it is being augured into the bin:

Liquids:

Pinmiphos-methyl

- Active ingredient: pinmiphos-methyl
- Trade name and formulation: Actellic SE
- Type of application: grain stream
- Application rates of formulation: 9.2-12.3 oz in 5 gal of water/4070 bu grain
- Effective against Indianmeal moth at higher rates; suppresses grain borer.

Pyrethrins

- Active ingredient: pyrethrins
- Trade name and formulation: several
- Type of application: grain stream
- Application rates of formulation: dilute one part spray with 29 gal of water, and apply 4-5 gal per 1000 bu of grain.

Dusts:

Diatomaceous earth

- Active ingredient: diatomaceous earth
- Trade name and formulation: Insecto
- Type of application: grain stream
- Application rates of formulation: 1-2 lb/1000 bu, treat first loads and last loads into bin (56)

Topdressing Binned Grain: When a protectant is not used on all incoming grain, an insecticide should be applied to the top 6 to 12 inches of grain. This provides a barrier against migrating insects.

For larvae of Indianmeal moth and other caterpillars:

Bacillus thuringiensis

- Active ingredient: *Bacillus thuringiensis*
- Trade name and formulation: Dipel, Biobot, Thuricide, Bactospeine, Top-Side

- Type of application: hand spray, topdressing
- Application rates of formulation: 1 lb/10 gal water of suspension to 500 ft2 of grain surface then raked into top 4- inches of grain or 0.6 pt/bu of last truckload of grain augured into bin

Bacillus thuringiensis

- Active ingredient: *Bacillus thuringiensis*
- Trade name and formulation: Dipel
- Type of application: dust, topdressing
- Application rates of formulation: 4 lb/500 ft^2 raked into top 2-4 inches of grain

Pirimiphos-methyl

- Active ingredient: Pirimiphos-methyl
- Trade name and formulation: Actellic 5E
- Type of application: hand spray, topdressing
- Application rates of formulation: 3 oz/2 gal water per 1000 ft^2, apply one-half of mixture to surface and rake in 4 inches deep and one-half of mixture as surface application

DDVP or dichlovos

- Active ingredient: DDVP or dichlovos
- Trade name and formulation: Vapona
- Type of application: vapor treatment, headspace
- Application rates of formulation: one strip per 1000 cu ft of headspace, replace every 3-4 months.
- Protect against Indianmeal moth infestations (56)

Fumigation

Fumigants come in several forms and formulations and include **methyl bromide** and phosphide producing materials such as **magnesium phosphide** and **aluminum phosphide**. Fumigants can be used in a empty bin prior to grain introduction to control any existing pests in subfloors, crack and crevices; they can also be used one the bins are filled to control insect pest infestations. These restricted use materials should be only be applied by trained, experienced and registered applicators (56)

Chemical Use in IPM Programs

Insecticides are used as a preventative or rescue treatment when the cultural practices listed below (see “Cultural Control Practices”) cannot be successfully used to manage stored grain pests. Since the tolerance for insect pests at grain markets is low, the need to treat grain bins with insecticides is crucial when pest populations warrant.

Chemical Use in Resistance Management

There is no attempt of resistance management in stored grain insect control as no development of chemical resistance to the insecticides used is reported.

ALTERNATIVES

The use of diatomaceous earth as described above under “Chemical Controls” is not widely used expect perhaps by farmers following National Organic Program certification standards.

CULTURAL CONTROL PRACTICES

See section below after “Post-Harvest Disease Pests” section.

BIOLOGICAL CONTROLS

None other than the use of Bt described above.

POST-HARVEST DISEASE PESTS

PEST IDENTIFICATION

Corn Grain: Storage rots or moldy grain may develop grain storage bins if the moisture content of the kernels is excessive and the air temperature is high enough to permit fungus growth. The major storage fungi are species of the common molds, *Aspergillus* and *Penicillium*. Some species of fungi such as *Alternaria* sp. and *Fusarium* sp. can cause infection in the field and can cause advanced decay in high moisture grains. Some of the fungi that grow in grains and other seeds before harvest or in storage produce toxins. One of the common storage fungi, *Aspergillus flavus*, produces several toxins called aflatoxins, which cause problems when fed to animals. Storage fungi cause loss of germination, dark germs, bin burning, mustiness and heating. These are the final results of invasion of grain by storage fungi. Storage fungi are the cause, not the result, of spoilage. Depending on the commodity, toxin contamination is either a field problem, a storage problem or a combination of the two. Since fungi produce toxins, they should be viewed as a potential danger anywhere fungi grow on materials that are used as food or feed. Fungal contamination is necessary for production of toxins, but toxicity is certainly not the inevitable result of all fungal invasion. Fungi are almost universally present on and in cereal grains, but toxicity seems to be the exception rather than the rule.

It is sometimes difficult to identify the specific species of fungi that are causing a particular problem in a given lot of grain. A laboratory equipped with a compound microscope and culture facilities is necessary to confirm the identity of a fungus species. Many times, however, the significance of a fungus in a given bulk of grain can be judged

by observing the color and shape of the mold growth, and by having a knowledge of the immediate history of the grain and future plans for the grain. A fungus that is common on grain in the field, for example, would be commonly found in freshly harvested grain. If corn or wheat seeds are covered with a black mold (likely *Alternaria* or *Cladisporium*), they may be of low germination and would not be desirable for seed. Corn with extensive white mold growth is likely to be infected with *Diplodia*. If the grain is obviously infected with a white, pink; orange or red fungus, a *Fusarium* sp. is most likely present. Some species of *Fusarium* are toxic and can cause problems when infected grain is fed to livestock. If a large amount of this mold is present and/or if feeding or reproductive problems in animals are associated with the feeding of a given bulk of grain, it should be tested for the presence of *Fusarium* toxins. If grain is in storage and has been for some time, the appearance of a greenish fungi on the germ of the grain could mean that the grain is on the verge of severe deterioration. These fungi would most likely be species of *Aspergillus* or *Penicillium*. The following are brief descriptions of a few common and important fungi that are found in seeds and the relative significance of each (56).

Fusarium moniliforme commonly invades the stems of corn plants during the growing season, grows up into the interior of the cobs, then outward into the point of attachment of the kernels. It may be present in 50 to 100 percent of the kernels of even the highest quality corn, but usually as only a minute amount of mycelium in the kernel's tissues near the point of attachment. In years of high moisture during harvest. *F. moniliforme* may decay many of the kernels, especially some of the high lysine hybrids. A moisture content of 22 percent is required to grow *Fusarium* and so it does not normally increase in shelled corn. It may continue to increase in corn of high moisture content stored on the cobs in cribs. It frequently is the predominant fungus in badly decayed earcorn. *F. moniliforme* is not commonly considered a toxic mold (54, 56).

Fusarium roseum causes cob rot or ear rot of corn. Shriveled and reddish discolored kernels, sometimes with a chalky interior characterize scab. Ear rot caused by *F. roseum* may involve the tip or the outer one-third to one- half of the ear; in this portion, the kernels may be partly covered and the spaces between them filled up by white mycelium with a reddish cast. The fungus requires a high moisture content and normally does not continue to grow in shelled corn. It may continue to grow in high moisture ear corn stored in cribs or left on the plants after normal harvest time. *F. roseum*, when growing in ear corn in the field before harvest, may produce "refusal factor." The compounds that make the corn unattractive to swine are trichothecenes, the major one being vomitoxin or deoxy-navenal. If more than five percent of kernels containing this refusal factor are present in the corn, the pigs may refuse to eat it. If *F. roseum* continues to grow in ear corn stored in cribs or on standing plants in the field during the fall and winter, it may produce an estrogenic compound, known as F-2 or zearalenone, which can cause vulvovaginitis, prolapse of the vagina or rectum, infertility and abortion in swine. Rations containing one to five parts per million can cause swollen vulvas (54, 56).

Fusarium tricinctum has been isolated commonly from field corn. Like many other mainly saprophytic fungi, it probably colonizes and decays a great variety of plant remains, but heavy invasions are only in corn stored on the cob in cribs. Isolates *of F. tricinctum*, when growing under suitable conditions, can produce extremely toxic compounds known as trichothecenes, commonly referred to as T-2 toxins (56).

Aspergillus glaucus is the most common grain storage mold and causes significant spoilage under low moisture conditions. The fungus grows in materials whose moisture content is in equilibrium with relative humidities of 73 to 75 percent in stored seeds, and the lower limit of moisture content that permits invasion by *A. glaucus* is about 14 to 15 percent in corn. This fungus kills and discolors germs of cereal grains and causes blue eye in corn stored at 14.5 to 15.5 percent moisture. It can cause mustiness and caking. When growing near its lower limits of moisture, it does not cause detectable heating but if growing vigorously, it can increase temperatures up to 95°F. The beginning stages of spoilage can be detected by culturing seeds in a given lot of grain. If *A. glaucus* is present and increases upon subsequent culturing, spoilage is underway and corrective measures are recommended before damage is evident to the naked eye. *A. glaucus* is one of the fungi responsible for initiating deterioration of stored grains and seeds, but has never been implicated in a case of mycotoxicoses (56).

Aspergillus flavus requires minimum moisture content in equilibrium with a relative humidity of 85 percent. In the starchy cereal seeds such as corn this is a moisture content of 18.3 to 18.5 percent. It will grow at temperatures up to 131°F. *A. flavus* and *A. candidus* both cause heating of stored grains and other organic materials up to these high temperatures. Some strains of *A. flavus*, when grown under suitable conditions, can produce a very potent toxin, aflatoxin, which is said to be the most potent naturally-occurring carcinogenic or cancer-causing agent known. **I**f aflatoxin is to be produced, a strain of the fungus capable of producing this toxin must be present, the moisture content must be higher than that in equilibrium with a relative humidity of 85 percent, the temperature must be between about 54°F and 104°F, and the fungus must be present in almost pure culture. Presence of this fungus in a particular sample of grain, food or feed does not mean that the toxin is present. To confirm the presence of aflatoxin in a given sample, the toxin must be isolated, purified and chemically identified. A black light, with a wave-length of 365 nm, can be used as a field tool in a preliminary test for aflatoxin. The corn will show a bright greenish-yellow (BGY) fluorescence that is a presumptive indication of aflatoxin contamination (56).

Penicillium sp. *Penicillium* grows on just about everything that can support the growth of fungi. Some species are adapted to a low temperature and a few will grow well at moisture contents in equilibrium with relative humidities of 85 to 90 percent; moderately low temperatures (from just below to just above freezing) may result in the invasion by almost pure cultures of some of these species of *Penicillium*. Several species, when grown in pure culture in the laboratory, produce highly toxic compounds, and one, *P. viridicatum*, can produce ochratoxin. Numerous field cases of poisoning have been associated with consumption of foods or feeds heavily invaded by known toxin-producing species of *Penicillium* (56).

Thresholds For Storage Diseases: Grain bins should be inspected at least once per month for any signs of off odors, crusting, temperature differences greater than 10^{o}F, visible water vapor, sprouting grain and discoloration. Cultural control practices, including aeration to reduce temperature and moisture in the grain mass (56).

Corn Silage: Mycotoxins in corn silage has been identified with dairy herd health problems in some states, primarily due to *Fusarium*. These molds, as described under the "Disease Pest" section occur in the field have harvest corn stalk and ears can be infected prior to the ensiling process. These toxins, in DON, T-2, zearalenone and fumonsin may be present. However feeding studies and surveys with dairy cattle have not been able to conclusively show a negative cause-effect relationship based on elevated pure DON levels. Cattle do not appear to be extremely sensitive to zearalenone or fumosin (52).

CHEMICAL CONTROLS

There are no chemical controls that can be used to control these pests. Cultural methods and management practices discussed below under "Cultural Control Practices" help to reduce or prevent the occurrence and associated losses. As such, there have been no Section 18 Emergency Exemptions or Section 24C Special Local Needs for stored grain disease control in New Jersey in recent history (9, 26, 29).

Chemical Use in IPM Programs

Monitoring for fungi, using aeration and other management practices described below under "Cultural Control Practices" are used since there are no chemical controls for these stored grain molds and diseases.

Chemical Use in Resistance Management

None; there are no chemical controls.

ALTERNATIVES

See "Cultural Control Practices" below.

CULTURAL CONTROL PRACTICES

Corn Grain: It is important to monitor stored grain for insects and mold to prevent any storage losses or reduction in grain quality. These practices include:

- Bin inspection 4 to 6 weeks after storage and then every 30 days thereafter.
- Look for any signs of crusting or webbing on the upper surface. This indicates that insects are active in the grain. Consider using monitoring devices. There are commercially available plastic pit fall traps that can be used to monitor insects.

These traps at about 2 feet long and cylinder shaped. Small pieces of cracked grain are placed in each trap. The grain gives off odors that attract insects. Once the insects enter the trap, they cannot get out. This is not used to control the insects, but rather to indicate that insects are present and control measures may be needed. If necessary, check with your agricultural Extension agent for specific pesticide recommendations.

- Be alert for any foreign, musty or sour odors. This indicates the grain may be too wet or mold growth is occurring.
- Be cautious for wet or warm grain. Measure moisture and temperature with a probe. In general, if the moisture level of the grain is greater than 14 to 16 percent, a problem may be occurring, especially with storage molds. Aeration helps to reduce mold development and prevents moisture from migrating within the grain mass. Bins should be aerated regularly to prevent sweating when outside temperatures drop.
- Watch for melting snow on the grain bin roof. This would indicate that excessive heat is being generated, probably caused by spoiling grain. Temperature record keeping is important. A steady rise in temperature over time indicates trouble and should receive immediate attention.

During the fall, winter and spring, the temperature of the grain:

- should be within 10^{o}F of the average monthly temperature to prevent natural air currents from transferring moisture in the bin,
- need not be less than 35^{o}F to 40^{o}F because mold growth is minimal at or below this temperature, and;
- should not exceed 60^{o}F because mold activity increases at a much faster rate past this point. The optimum temperature for insect development is 70^{o}F. If the grain temperature is below 50^{o}F to 60^{o}F, insect feeding and egg laying stop.

The use of fans to aerate the grain mass will help to reduce temperature and alleviate some moisture problems. The lower the moisture and temperature of the grain mass, the longer the grain can be safely stored and less profits are lost (51, 54, 56).

Corn Silage: Mycotoxins may be present in silage if the causal organisms are present in the harvested corn plants. Therefore, good production management is essential to reduce possible infection in the field, including hybrid selection, tillage and crop rotation and optimizing harvest timing. Corn silage should be tested to determine levels of mycotoxins (54).

BIOLOGICAL CONTROLS

None.

WEED PESTS

PEST IDENTIFICATION

Weeds reduce corn yield primarily by competing for water, sunlight and nutrients, thus diminishing total corn yield potential. Heavy weed infestations can also affect harvest efficiency by increasing grain moisture content at harvest and increasing foreign material levels in harvested grain, both resulting in added cost to the producer.

Annual weed species comprise a majority of the weed control problems in New Jersey corn production. The most troublesome weeds are those adapted to the continuous corn or two-crop rotation system of corn and soybean widely used. Weeds that are able to germinate in the spring following primary tillage, compete with the crop, and produce seed before frost or harvest are the most common. However, as the amount of tillage in corn production decreases, there has been an increase in the frequency of perennial and biennial weed problems.

Annual Grasses

Annual grasses infest nearly all corn acres in New Jersey. Many of these are controlled with pre-emergence herbicide applications and tillage. While not as competitive as broadleaf weed species, annual grasses can reduce crop yields when significant populations are present. In most weed management programs, control of grasses is of secondary concern to control of broadleaf weed species. Of the many species present, two of the most prevalent are discussed below:

Foxtails: There are three important foxtail species in New Jersey: giant foxtail (*Setaria faberi*), yellow foxtail (*Setaria glauca*), and green foxtail (*Setaria viridis*). At least one of these species infest nearly 100 percent of the corn acres in New Jersey. While low populations cause little crop competition, because of seed production an unchecked population can quickly become a severe problem. A primary control method for foxtails is the application of preemergence grass herbicides. These provide early season control, reducing early season competition with the corn (50).

Shattercane (*Sorghum bicolor*) is an annual grass that is found only in cultivated fields where it reseeds itself. Shattercane is commonly found in areas where forage sorghum has been grown. All sorghums are members of the same species and can hybridize. It may develop if seeds from hybrid grain or forage sorghums are allowed to grow and flower through several generations. Therefore, it is highly variable (50). While found in areas throughout New Jersey, it is more prevalent in the southern and spreading in northwestern regions (Somerset, Hunterdon, and Mercer Counties).

Other annual grasses of economic importance or of concern:

- fall panicum (*Panicum dichotomiflorum*)
- barnyardgrass (*Echinochloa crus-galli*)
- herdsgrass (*Poa trivialis*)

Perennial Grasses

Perennial grasses were once a severe problem in New Jersey corn production prior to selective herbicides, but since their availability, many perennial grasses have declined in importance. The following two perennial grasses are the most prevalent:

Quackgrass (*Agropyron repens*) is a perennial grass that spreads by rhizomes. These rhizomes are effectively spread by tillage, increasing the scope of the population in a field. Quackgrass is more common in small grains, fields in rotation with pasture, or field where application of manures containing weed seeds. Tillage is an effective control by depleting food reserves and bringing rhizomes to the surface and atrazine is also provides excellent control (50).

Johnsongrass (*Sorghum halepense*) is nearly identical to shattercane and commonly found in southern New Jersey and in isolated locations in northern New Jersey. As a sorghum species, it is a result of hybridization of grain and forage sorghums. Johnsongrass produces large rhizomes that can be spread throughout the field making it difficult to contain and control (50).

Annual Broadleaves

Annual broadleaf weed species are the main weed management target in New Jersey corn production. The following three weeds can provide significant crop yield reduction as they are often escape weeds in many herbicide program and due to their aggressive growth habit and canopy.

Common cocklebur (*Xanthium strumarium*) is spread by attaching to animal fur or by tillage or harvesting equipment. Cocklebur is a serious competitor for moisture. Cultivation, tillage, and mowing will all help control cocklebur establishment, however, the seeds can germinate from spring to early summer, with later germinating seeds unaffected by early applied herbicides or tillage 49).

Morningglories (*Ipomoea* spp.): Tall morningglory (*Ipomoea pupurea*) and ivyleaf morningglory (*Ipomoea hederacea*) are the two major annual morningglory species found on New Jersey farms. The seeds of these summer annuals may survive for several years in soil. Annual morningglories twine about the crop, so shading by the canopy is not particularly successful in reducing growth. Newly emerged seedlings can be controlled by tillage and cultivation, but this may result in conditions that favor emergence of weed seeds deeper in the soil profile. After vines begin to twine about the stems of the crop, cultivation may not be as effective. These vines that can make harvest nearly impossible (49). This group of weeds is found throughout the state but are more prevalent in southern New Jersey.

Lambsquarter (*Chenopodium album*) is an summer annual reaching 3 feet in height and produces numerous seeds if left to reach maturity. Rains that dilute or leach herbicides from the soil surface (49) favor survival.

Other broadleaf weeds of economic importance or of concern:

- redroot pigweed (*Amaranthus retroflexus*)
- common ragweed (*Ambrosia artemisiifolia*) and giant ragweed (*Ambrosia trifida*)
- Jimsonweed (*Datura strimonium*)
- spurred anoda (*Anoda cristata*)
- prickly sida (*Sida spinosa*)
- burcucumber (*Sicyos angulatus*)

Perennial Broadleaves

The occurrence of perennial broadleaf weeds is highly dependent on the tillage regime used in corn production. Since most perennial broadleaf weeds do not tolerate tillage, these weeds are more of a problem in reduced tillage and no-till operations.

Canada thistle (*Cirsium arvensis*) is a perennial weed with a vigorous, rhizomatous root system. Propagation is by rootstock and seeds. Canada thistle problems have found across the entire state. Preplant tillage and row cultivation can contrd small seedlings but are less effective in controlling plants arising from rootstocks (49).

Other broadleaf weeds of economic significance or of concern:

- yellow nutsedge (*Cyprus esculentus*)
- field bindweed (*Convolvulus arvensis*) and hedge bindweed (*Convolvulus sepium*)
- horsenettle (*Solanium carolinense*)
- common pokeweed (*Phytolacca americana*)

CHEMICAL CONTROLS

Herbicides continue to be the primary strategy used for corn weed management in New Jersey. There are nearly 30 chemical families and 13 herbicide classes that can be used to control weeds in corn. The top six herbicides applied to New Jersey corn grain and corn silage in 2000 were determined according to grower records of total pounds active ingredient applied (46). They include triazines, chloroacetamides, dintroanalines, and amino acid derivatives.

- **Atrazine** (several): Atrazine ranked first (27%) of herbicides used on corn grain and silage in New Jersey for 2000; 32962.59 lbs. active ingredient were applied and at least 30923 acres were treated, or about 25% of the corn acreage reported. Atrazine is a triazine herbicide, the mode of action is photosynthesis inhibition, controls a wide spectrum of annual broadleaves, Restricted use due to ground water and surface water concerns, and weed resistance is a concern. Atrazine is a triazine.

- **Acetochlor** (several): Acetochlor ranked second (24%) of herbicides used on corn grain and silage in New Jersey for 2000; 28770.04 lbs. active ingredient were applied and at least 10786 acres were treated, or about 8.7% of the corn acreage reported. Acetochlor is a chloroacetamide, mode of action is seedling growth inhibition, controls annual grasses and certain broadleaves, restricted use. Acetochlor is a chloroacetamide.

- **Metolachlor** (several): Metolachlor ranked third (22%) of herbicides used on corn grain and silage in New Jersey for 2000; 26492.96 lbs. active ingredient were applied and at least 21460 acres were treated, or about 17.4% of the corn acreage reported. Metholachlor is a chloroacetamide, mode of action is cell growth inhibition, controls annual grasses and yellow nutsedge. Metolachlor is a chloroacetamide.

- **Pendimethalin** (Prowl): Pendimethalin ranked fourth (6.3%) of herbicides used on corn grain and silage in New Jersey for 2000; 7695.11 lbs. active ingredient were applied and at least 5495 acres were treated, or about 4.4% of the corn acreage reported. Pendimethalin is a dinitroaniline; used pre-emergence and post-emergence; used preplant, pre-plant incorporated, preemergence or post-emergence; mode of action is seedling root growth inhibition; controls annual grasses and certain broadleaves. Pendimenthalin is a dinitroanaline.

- **Alachlor** (several): Alachlor ranked fifth (5.9%) of herbicides used on corn grain and silage in New Jersey for 2000; 7234.14 lbs. active ingredient were applied and at least 4450 acres were treated, or about 3.6% of the corn acreage reported. Alachlor is a chloroacetamide; used pre-plant incorporated, preemergence or post-emergence; mode of action is seedling growth inhibition; controls annual grasses and certain broadleaves; restricted use; weed resistance is a concern. Alachlor is a chloroacetamide.

- **Glyphosate** (several): Glyphosate ranked sixth (5.4%) of herbicides used on corn grain and silage in New Jersey for 2000; 6169.97 lbs. active ingredient were applied and at least 6949 acres were treated, or about 5.6% of the corn acreage reported. Glyphosate is an amino acid derivative; mode of action is amino acid biosynthesis inhibition; used pre-plant or pre-emergence, or postemergence with Roundup Ready corn; controls annual and perennial grasses and broadleaves; restricted use; weed resistance is a concern. Glyphosate is an amino acid derivative (42, 43, 46).

Current Recommendations

There have been no Section 18 Emergency Exemptions or Section 24C Special Local Needs for weed control in field corn in New Jersey in recent history (9, 26, 29). The following herbicides are recommended for control of the weeds indicated above as

being of significance economically and or of concern to growers and industry personnel (42, 43, 53, 56, 60):

Foxtails (*Setaria* spp.)

Soil Applied

EPTC + safener

- Active ingredient: EPTC + safener
- Trade name and formulation: Eradicane 6.7 E
- Use rates: 6.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 7.33 pt/A
- Application timing: preplant incorporated
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 12 hours
- Family: thiocarbamate

Acetochlor

- Active ingredient: acetochlor
- Trade name and formulation: Harness 7E, Degree 3.8L, Surpass 6.4EC, Topnotch 3.2CS
- Use rates: 0.88-3.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.0-2.5 pt/A, 1.13-2.75 qt/A, 1.5-3.0 pt/A, 2.0-3.75 qt/A
- Application timing: preplant incorporated or preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 21 days
- Restricted entry interval: 12 hours, restricted use
- Family: chloroacetamide

Alachlor

- Active ingredient: alachlor
- Trade name and formulation: Micro-Tech 4L, Partner 65WDG
- Use rates: 1.5-3.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.5-3.0 qt/A, 2.3-4.6 lb/A
- Application timing: preplant incorporated or preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 21 days
- Restricted entry interval: 12 hours, restricted use
- Family: chloroacetamide

Dimethenamid-p

- Active ingredient: Dimethenamid-p
- Trade name and formulation: Outlook 6EC
- Use rates: 0.66-0.98 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 14.0-21.0 oz/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 40 days
- Restricted entry interval: 12 hours
- Family: chloroacetamide

Simazine

- Active ingredient: simazine
- Trade name and formulation: Pricep 4L; Princep 90W
- Use rates: 1.0-1.8 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.0-1.8 qt/A; 1.1-2.0 lb/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 12 hours
- Restricted entry interval: none
- Family: triazine

Pendimethalin

- Active ingredient: pendimethalin
- Trade name and formulation: Prowl 3.33EC
- Use rates: 0.75-2.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.8-4.8 pt/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 75 days
- Restricted entry interval: 24 hours
- Family: dinitroanaline

Butylate

- Active ingredient: butylate
- Trade name and formulation: Sutan Plus 6.7E
- Use rates: 4.0-6.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 4.75-7.3 pt/A
- Application timing: preplant incorporated
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 12 hours

- Family: thiocarbamate

Postemergence

Nicosulfuron
- Active ingredient: nicosulfuron
- Trade name and formulation: Accent 75SP
- Use rates: 0.031 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.66 oz/A
- Application timing: postemergence; prior to corn 11 leaf stage
- Typical number of applications per year: 1-2
- Pre-harvest interval: 30 days
- Restricted entry interval: 4 hours
- Family: sulfonylurea

Sethoxydim
- Active ingredient: sethoxydim
- Trade name and formulation: Poast Plus 1EC, Poast 1.5EC
- Use rates: 0.19-0.28 lb ai/A
- Type of application: directed; to SR or Poast Protected corn only
- Application rates of formulation: 1.5-2.25 pt/A, 1-1.5 pt/A
- Application timing: postemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 60 days grain, 40 days silage
- Restricted entry interval: 12/24 hours
- Family: cyclohexanediones

Glyphosate
- Active ingredient: glyphosate
- Trade name and formulation: Roundup Ultra Max 4L
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground; Roundup Ready corn only
- Application rates of formulation: 19-26 oz/A
- Application timing: postemergence, corn V8 up to 30 inches in height
- Typical number of applications per year: not to exceed 6.5 qt/A
- Pre-harvest interval: 7 days
- Restricted entry interval: 4 hours
- Family: amino acid derivative

Glyphosate
- Active ingredient: glyphosate
- Trade name and formulation: Touchdown IQ 4SL
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground, broadcast; Roundup Ready corn only
- Application rates of formulation: 0.75-1.0 qt/A

- Application timing: postemergence, up to V8 or 30-inch corn
- Typical number of applications per year: not to exceed 2 qt/A up to V8, 5 qt total per season
- Pre-harvest interval: 7 days grain, 50 days silage
- Restricted entry interval: 12 hours
- Family: amino acid derivative

Rimsulfuron + Thifensulfuron-methyl

- Active ingredient: Rimsulfuron + thifensulfuron-methyl
- Trade name and formulation: Basis 75WDG
- Use rates: 0.01 lb ai/A + 0.005 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.33 oz/A
- Application timing: postemergence; weeds 1 to 3 inches tall
- Typical number of applications per year:
- Pre-harvest interval: 30 days
- Restricted entry interval: 4 hours
- Family: sulfonylurea

Nicosulfuron + Rimsulfuron + Atrazine

- Active ingredient: Nicosulfuron + Rimsulfuron + Atrazine
- Trade name and formulation: Basis Gold 89.5DF
- Use rates: 0.01 lb ai/A + 0.01 lb ai/A + 0.75 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 14.0 oz/A
- Application timing: postemergence; 1 to 3 inch tall grasses
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 12 hours, restricted use
- Family: sulfonylurea

Nicosulfuron

- Active ingredient: nicosulfuron
- Trade name and formulation: Celebrity Plus 70 DF
- Use rates: 0.031 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 4.8 oz/A
- Application timing: postemergence; apply to corn from 4 to 24 inches tall
- Typical number of applications per year: 1-2
- Pre-harvest interval: after milk stage
- Restricted entry interval: 12 hours
- Family: sulfonylurea

Glufosinate-ammonium

- Active ingredient: glufosinate-ammomium
- Trade name and formulation: Liberty 1.67L

- Use rates: 0.31-0.37 lb ai/A
- Type of application: broadcast; Liberty Link corn only
- Application rates of formulation: 1.5-1.75 pt/A
- Application timing: postemergence; until corn is 24 inches tall
- Typical number of applications per year: 1-2
- Pre-harvest interval: 70 days
- Restricted entry interval: 12 hours
- Family: amino acid derivative

Imazethapyr + Imazapyr

- Active ingredient: imazethapyr + imazapyr
- Trade name and formulation: Lightning 70DG
- Use rates: 0.042 lb ai/A + 0.014 lb ai/A
- Type of application: ground; only to IMI corn, IR or IT hybrids
- Application rates of formulation: 1.28 oz/A
- Application timing: postemergence when weeds are no larger than 3 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 45 days
- Restricted entry interval: 12 hours
- Family: imidazolinone

Glyphosate + Atrazine

- Active ingredient: glyphosate + atrazine
- Trade name and formulation: Ready Master ATZ 4L
- Use rates: glyphosate 0.75-1.0 lb/A + atrazine 0.75-1.0 lb/A
- Type of application: ground; Roundup Ready corn only
- Application rates of formulation: 1.5–2.0 qt/A
- Application timing: postemergence, corn up to 12 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 50 days
- Restricted entry interval: 12 hours, restricted use
- Family: amino acid derivative + triazine

Nicosulfuron + Rimsulfuron

- Active ingredient: Nicosulfuron + Rimsulfuron
- Trade name and formulation: Steadfast 75DF
- Use rates: 0.023 lb ai/A + 0.012 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.75 oz/A
- Application timing: postemergence; corn up to 12 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 4 hours
- Family: sulfonlyurea

Shattercane (*Sorghum bicolor*)

Soil Applied

EPTC + safener: See entry under Foxtail

Butylate: See entry under Foxtail

Postemergence

Nicosulfuron: See entry under Foxtail

Primsulfuron

- Active ingredient: primisulfuron-methyl
- Trade name and formulation: Beacon 75WDG
- Use rates: 0.018-0.036 lb ai/A
- Type of application: ground, broadcast; Beacon resistant varieties
- Application rates of formulation: 0.38-0.76 oz/A
- Application timing: postemergence; corn height 4 to 20 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 60 days grain, 45 days silage
- Restricted entry interval: 12 hours
- Family: sulfonylurea

Sethoxydim: See entry under Foxtail

Glyphosate

Nicosulfuron + Rimsulfuron + Atrazine: See entry under Foxtail

Nicosulfuron: See entry under Foxtail

Imazethapyr + Imazapyr: See entry under Foxtail

Primisulfuron + Sodium salt of dicamba

- Active ingredient: primisulfuron + sodium salt of dicamba
- Trade name and formulation: NorthStar 51.4 WDG
- Use rates: 0.075 lb ai/A + 0.4 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 5 oz/A
- Application timing: postemergence; 4 to 20 inch tall corn, directed spray if corn is 20 to 36 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 60 days grain, 45 days silage
- Restricted entry interval: 12 hours
- Family: sulfonylurea + benzoic acid

Glyphosate + Atrazine: See entry under Foxtail

Nicosulfuron + Rimsulfuron: See entry under Foxtail

Quackgrass (*Agropyron repens*)

Soil Applied: None recommended

Postemergence

Nicosulfuron: See entry under Foxtail

Primsulfuron: See entry under Shattercane

Sethoxydim: See entry under Foxtail

Glyphosate: See entry under Foxtail

Nicosulfuron + Rimsulfuron + Atrazine: See entry under Foxtail

Nicosulfuron: See entry under Foxtail

Primisulfuron + Sodium salt of dicamba: See entry under Shattercane

Glyphosate + Atrazine: See entry under Foxtail

Nicosulfuron + Rimsulfuron: See entry under Foxtail

Johnsongrass (*Sorghum halepense*)

Soil Applied (controls seedlings only)

EPTC + safener: See entry under Foxtail

Butylate: See entry under Foxtail

Postemergence

Nicosulfuron: See entry under Foxtail

Primsulfuron: See entry under Shattercane

Sethoxydim: See entry under Foxtail

Glyphosate: See entry under Foxtail

Glyphosate: See entry under Foxtail

Nicosulfuron + Rimsulfuron + Atrazine: See entry under Foxtail

Nicosulfuron: See entry under Foxtail

Imazethapyr + Imazapyr: See entry under Foxtail

Primisulfuron + Sodium salt of dicamba: See entry under Shattercane

Glyphosate + Atrazine: See entry under Foxtail

Nicosulfuron + Rimsulfuron: See entry under Foxtail

Common cocklebur (*Xanthium strumarium*)

Soil-Applied

Atrazine (p. 2-36)

- Active ingredient: atrazine
- Trade name and formulation: Atrazine 4L, Atrazine 90W
- Use rates: 1.5-2.0 lb ai/A
- Type of application: ground
- Application rates of formulation: 1.5-2.0 qt/A, 1.39-2.2 lb/A
- Application timing: preemergence
- Typical number of applications per year: 1, not to exceed 20 lb ai/A/year
- Pre-harvest interval: 21 days
- Restricted entry interval: 12 hours, restricted use
- Family: triazine

Simazine

- Active ingredient: simazine
- Trade name and formulation: Pricep 4L; Princep 90W
- Use rates: 1.0-1.8 lb ai/A
- Type of application: ground
- Application rates of formulation: 1.0-1.8 qt/A; 1.1-2.0 lb/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 12 hours
- Family: triazine

Metolachlor + Atrazine

- Active ingredient: metolachlor + atrazine
- Trade name and formulation: Bicep II Magnum 5.5 FL

- Use rates: metoacholr 0.76 lb ai/A + atrazine 1.0-2.0 lb ai/A
- Type of application: ground
- Application rates of formulation: 1.3-2.6 qt/A
- Application timing: preemergence, weeds at 2 leaf stage, corn less than 5 inch
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 24 hours, restricted use
- Family: chloroacetamide + triazine

Alachlor + Atrazine

- Active ingredient: alachlor + atrazine
- Trade name and formulation: Bullet 4ME
- Use rates: alachlor 1.5-3.0 lb ai/A + atrazine 1.0-1.6 lb ai/A
- Type of application: ground
- Application rates of formulation: 2.5-5.3 qt/A
- Application timing: preemergence or preplant incorporated
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 12 hours, restricted use
- Family: chloroacetamide + triazine

Alachlor + Atrazine

- Active ingredient: acetochlor + atrazine
- Trade name and formulation: Fultime 4 CS
- Use rates: alachlor 0.8-2.4 lb ai/A + atrazine 1.0-2.0 lb ai/A
- Type of application: ground
- Application rates of formulation: 2.5-5.0 qt/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 21 days
- Restricted entry interval: 12 hours, restricted use
- Family: chloroacetamide + triazine

Dimethenamid + Atrazine

- Active ingredient: dimethenamid + atrazine
- Trade name and formulation: Guardsman Max 6L; Leadoff 5L
- Use rates: dimethenamid 0.66-0.98 lb ai/A + atrazine 1.0-2.0 lb ai/A
- Type of application: ground
- Application rates of formulation: 3.0-4.6 pt/A; 1.5-2.5 qt/A
- Application timing: preplant incorporated
- Typical number of applications per year: 1
- Pre-harvest interval: none
- Restricted entry interval: 12 hours, restricted use
- Family: chloroacetamide + triazine

Acetochlor + Atrazine

- Active ingredient: acetochlor + atrazine
- Trade name and formulation: Harness Xtra 6L/Degree Xtra 4EC/Field Master 4.25SE
- Use rates: acetochlor 1.54-2.4 lb ai/A + atrazine1.25-2.0 lb ai/A
- Type of application: ground
- Application rates of formulation: 1.8-2.7 qt/A; 2.9-3.7 qt/A ; 3.5-5.0 qt/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 21 days
- Restricted entry interval: 12 hours, restricted use
- Family: chloroacetamide + triazine

Postemergence

Atrazine

- Active ingredient: atrazine
- Trade name and formulation: Atrazine 4L; Atrazine 90DF
- Use rates: 1.0-2.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.0-2.0 qt/A; 1.1-2.2 lb/A
- Application timing: postemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 21 days
- Restricted entry interval: 12 hours, restricted use
- Family: triazine

Dicamba

- Active ingredient: dicamba
- Trade name and formulation: Banvel 4S; Clarity 4S
- Use rates: 0.25-0.5 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.5-1.0 pt/A
- Application timing: postemergence; when weeds are small; corn less than 36 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: after milk stage
- Restricted entry interval: 24 hours
- Family: benzoic acid

Bentazon

- Active ingredient: bentazon
- Trade name and formulation: Basagran 4L
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.75-1.0 qt/A

- Application timing: postemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 12 days
- Restricted entry interval: 12 hours
- Family: benzothiadiazole

Mesotrione

- Active ingredient: mesotrione (ZA-1296)
- Trade name and formulation: Callisto 4FL
- Use rates: 0.094 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 3.0 oz/A
- Application timing: postemergence up to 12 corn height
- Typical number of applications per year: not to exceed 10.7 oz/A
- Pre-harvest interval: not specified
- Restricted entry interval: 12 hours
- Family: triketone

2,4-D

- Active ingredient: 2,4-D
- Trade name and formulation: 2,4-D Amine 4S, 2,4-D LVE 4E
- Use rates: 0.24-0.48 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.5-1.0 pt/A
- Application timing: postemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 7 days
- Restricted entry interval: 48 hours (amine), 12 hours (LVE)
- Family: phenoxy

Ametryn

- Active ingredient: ametryn
- Trade name and formulation: Evik 80W
- Use rates: 1.6-2.0 lb ai/A
- Type of application: directed spray
- Application rates of formulation: 2.0-2.5 lb/A
- Application timing: postemergence, directed spray after corn is 15 inches high
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 12 hours
- Family: triazine

Glufosinate-ammonium

- Active ingredient: glufosinate-ammomium
- Trade name and formulation: Liberty 1.67L
- Use rates: 0.31-0.37 lb ai/A

- Type of application: broadcast; Liberty Link corn only
- Application rates of formulation: 1.5-1.75 pt/A
- Application timing: postemergence; until corn is 24 inches tall
- Typical number of applications per year: 1-2
- Pre-harvest interval: 70 days grain, 60 days silage
- Restricted entry interval: 12 hours
- Family: amino acid derivatives

Halosulfuron-methyl

- Active ingredient: halosulfuron-methyl
- Trade name and formulation: Permit 75 WG
- Use rates: 0.032-0.063 lb ai/A
- Type of application: broadcast or with drop nozzles
- Application rates of formulation: 0.6-1.3 oz/A
- Application timing: postemergence; spike to layby stage of corn
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 12 hours
- Family: sulfonylurea

Glyphosate

- Active ingredient: glyphosate
- Trade name and formulation: Roundup Ultra Max 4L
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground; Roundup Ready corn only
- Application rates of formulation: 19-26 oz/A
- Application timing: postemergence, corn V8 up to 30 inches in height
- Typical number of applications per year: not to exceed 6.5 qt/A
- Pre-harvest interval: 7 days grain, 50 days silage
- Restricted entry interval: 4 hours
- Family: amino acid derivative

Glyphosate

- Active ingredient: glyphosate
- Trade name and formulation: Touchdown IQ 4SL
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground, broadcast; Roundup Ready corn only
- Application rates of formulation: 0.75-1.0 qt/A
- Application timing: postemergence, up to V8 or 30-inch corn
- Typical number of applications per year: not to exceed 2 qt/A up to V*, 5 qt total per season
- Pre-harvest interval: 7 days grain, 50 days silage
- Restricted entry interval: 12 hours
- Family: amino acid derivative

Clopyralid

- Active ingredient: Clopyralid
- Trade name and formulation: Stinger 3S
- Use rates: 0.09-0.25 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.25-0.67 pt/A
- Application timing: postemergence up to 24-inch corn; thistle 6-8 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 40 days
- Restricted entry interval: 12 hours
- Family: carboxylic acid

Nicosulfuron

- Active ingredient: nicsulfuron
- Trade name and formulation: Celebrity Plus 70 DF
- Use rates: 0.031 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 4.8 oz/A
- Application timing: postemergence; apply to corn from 4 to 24 inches tall
- Typical number of applications per year: 1-2
- Pre-harvest interval: after milk stage
- Restricted entry interval: 12 hours
- Family: sulfonylurea

Diflufenzopyr + Dicamba

- Active ingredient: diflufenzopyr + sodium salt of dicamba
- Trade name and formulation: Distinct 70DF
- Use rates: 0.05 lb ai/A + 0.175-0.263 lb/A
- Type of application: ground, broadcast
- Application rates of formulation: 4.0-6.0 oz/A
- Application timing: 4-10-inch tall corn at 4 oz/A; 10-24 inch tall corn at 6 oz/A
- Typical number of applications per year: 1-2, not to exceed 10 oz/season
- Pre-harvest interval: 72 days
- Restricted entry interval: 12 hours
- Family: semicarbazone + phenoxy

Prosulfuron/Primisulfuron methyl

- Active ingredient: prosulfuron/primisulfuron methyl
- Trade name and formulation: Exceed 57WC
- Use rates: 0.036 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.0 oz/A
- Application timing: postemergence; when corn is 4 to 30 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 60 days grain, 40 days silage
- Restricted entry interval: 12 hours

- Family: sulfonylurea

Flumetsulan + Clopyralid

- Active ingredient: flumetsulam + clopyralid
- Trade name and formulation: Hornet 68.5 DF
- Use rates: flumetsulam 0.023 lb ai/A + clopyralid 0.063 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 2.0 oz/A
- Application timing: weeds 3-8 inches tall, corn up to 24 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 85 days
- Restricted entry interval: 48 hours
- Family: traizolopyrimidine + carboxylic acid

Bentazon + Basagran

- Active ingredient: bentazon + atrazine
- Trade name and formulation: Laddok S12 5L
- Use rates: 1.0-1.5 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.33-2.33 pt/A
- Application timing: postemergence; weeds 1-5 leaf stage
- Typical number of applications per year: 1
- Pre-harvest interval: 21 days
- Restricted entry interval: 48 hours, restricted use
- Family: benzoic acid + triazine

Glufosinate-ammonium

- Active ingredient: glufosinate-ammonium
- Trade name and formulation: Liberty 1.67L
- Use rates: 0.31-0.37 lb ai/A
- Type of application: ground; apply to Liberty Link or GR hybrids only
- Application rates of formulation: 1.5-1.75 pt/A
- Application timing: postemergence until corn is 24 inches tall or has 8 developed collars
- Typical number of applications per year: 1-2
- Pre-harvest interval: 70 days
- Restricted entry interval: 12 hours
- Family: amino acid derivative

Imazethapyr + Imazapyr

- Active ingredient: imazethapyr + imazapyr
- Trade name and formulation: Lightning 70DG
- Use rates: 0.042 lb ai/A + 0.014 lb ai/A
- Type of application: ground; only to IMI corn, IR or IT hybrids
- Application rates of formulation: 1.28 oz/A

- Application timing: postemergence when weeds are no larger than 3 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 45 days
- Restricted entry interval: 12 hours
- Family: imidazolinone

Dicamba + Atrazine

- Active ingredient: dicamba + atrazine
- Trade name and formulation: Marksman 3.2L
- Use rates: 0.25-0.5 lb ai/A + 1.0-2.0 lb ai/A
- Type of application: ground
- Application rates of formulation: 2.0-3.5 pt/A
- Application timing: postemergence up to 5-leaf stage corn
- Typical number of applications per year: 1
- Pre-harvest interval: after milk stage
- Restricted entry interval: 48 hours, restricted use
- Family: benzoic acid + triazine

Primisulfuron + Sodium salt of dicamba

- Active ingredient: primisulfuron + sodium salt of dicamba
- Trade name and formulation: NorthStar 51.4 WDG
- Use rates: 0.075 lb ai/A + 0.4 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 5 oz/A
- Application timing: postemergence; 4 to 20 inch tall corn, directed spray if corn is 20 to 36 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 60 days grain, 40 days silage
- Restricted entry interval: 12 hours
- Family: sulfonylurea + benzoic acid

Glyphosate + Atrazine:

- Active ingredient: glyphosate + atrazine
- Trade name and formulation: Ready Master ATZ 4L
- Use rates: glyphosate 0.75-1.0 lb/A + atrazine 0.75-1.0 lb/A
- Type of application: ground; Roundup Ready corn only
- Application rates of formulation: 1.5–2.0 qt/A
- Application timing: postemergence, corn up to 12 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 50 days
- Restricted entry interval: 12 hours, restricted use
- Family: amino acid derivative + triazines

Atrazine + 2,4-D

- Active ingredient: atrazine + 2,4-D
- Trade name and formulation: Shotgun 3.25L
- Use rates: 1.0-2.0 lb ai/A + 0.24-0.48 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 2.0-3.0 pt/A
- Application timing: postemergence
- Typical number of applications per year: 1
- Pre-harvest interval: do not feed
- Restricted entry interval: 12 hours, restricted use
- Family: triazine + phenoxy

Morningglories (*Ipomoea* spp.):

Soil Applied: See entries under Cocklebur for all of the following recommended herbicides:

Simazine

Metholachlor + Atrazine

Alachlor + Atrazine

Acetochlor + Atrazine

Dimethenamid + Atrazine

Postemergence: See entries under Cocklebur for all of the following recommended herbicides:

Atrazine

Dicamba

2,4-D

Glufosinate-ammonium

Gyphosate

Nicsulfuron

Dicamba + Atrazine

Primisulfuron + Sodium salt of dicamba

Glyphosate + Atrazine

Lambsquarter (*Chenopodium album*)

Soil-Applied

Atrazine: See entry under Cocklebur

Mesotrione

- Active ingredient: mesotrione
- Trade name and formulation: Callisto 4SC
- Use rates: 0.188-0.24 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 5.0-7.7 oz/A
- Application timing: preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: not specified
- Restricted entry interval: 12 hours
- Family: triketone

Simazine: See entry under Cocklebur

Flumetsulam

- Active ingredient: flumetsulam
- Trade name and formulation: Python 80WDG
- Use rates: 0.04-0.067 lb ai/A
- Type of application: ground; to Clearfield IR corn
- Application rates of formulation: 0.8-1.33 oz/A
- Application timing: pre-plant incorporated or preemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 85 days
- Restricted entry interval: 12 hours
- Family: triazolpyrimidines

Metholachlor + Atrazine: See entry under Cocklebur

Alachlor + Atrazine: See entry under Cocklebur

Acetochlor + Atrazine: See entries under Cocklebur

Dimethenamid + Atrazine: See entry under Cocklebur

Postemergence

Atrazine: See entry under Cocklebur

Dicamba: See entry under Cocklebur

Bromoxynil

- Active ingredient: bromoxynil
- Trade name and formulation: Buctril 2EC
- Use rates: 0.25-0.375 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 1.0-1.5 pt/A
- Application timing: postemergence
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 12 hours
- Family: nitriles

Mesotrione: See entry under Cocklebur

2,4-D: See entry under Cocklebur

Ametryn: See entry under Cocklebur

Thifensulfuron

- Active ingredient: thifensulfuron
- Trade name and formulation: Harmony GT
- Use rates: 0.0004 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.083 oz/A
- Application timing: postemergence, corn up to 12 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 30 days
- Restricted entry interval: 4/12 hours
- Family: sulfonylurea

Pyridate

- Active ingredient: pyridate
- Trade name and formulation: Tough 5EC
- Use rates: 0.5-1.0 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.8-1.6 pt/A
- Application timing: postemergence; weeds 1 to 4 leaf stage
- Typical number of applications per year: 1
- Pre-harvest interval: 68 days
- Restricted entry interval: 12 hours
- Family: phenyl-pyridazine

Rimsulfuron + Thifensulfuron-methyl

- Active ingredient: Rimsulfuron + thifensulfuron-methyl
- Trade name and formulation: Basis 75WDG
- Use rates: 0.01 lb ai/A + 0.005 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.33 oz/A
- Application timing: postemergence; weeds 1 to 3 inches tall
- Typical number of applications per year:
- Pre-harvest interval: 30 days
- Restricted entry interval: 4 hours
- Family: sulfonylurea

Nicsulfuron: See entry under Cocklebur

Diflufenzopyr + Dicamba: See entry under Cocklebur

Glufosinate-ammonium: See entry under Cocklebur

Imazethapyr + Imazapyr: See entry under Cocklebur

Dicamba + Atrazine: See entry under Cocklebur

Primisulfuron + Sodium salt of dicamba: See entry under Cocklebur

Glyphosate + Atrazine: See entry under Cocklebur

Canada thistle (*Cirsium arvensis*)

Preemergence: none recommended

Postemergence

Mesotrione: See entry under Cocklebur

Glyphosate (p. 2-58)

- Active ingredient: glyphosate
- Trade name and formulation: Roundup Ultra Max 4L
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground; Roundup Ready corn only
- Application rates of formulation: 19-26 oz/A
- Application timing: postemergence, corn V8 up to 30 inches in height
- Typical number of applications per year: not to exceed 6.5 qt/A
- Pre-harvest interval: 7 days grain, 50 days silage
- Restricted entry interval: 4 hours
- Family: amino acid derivative

Glyphosate

- Active ingredient: glyphosate
- Trade name and formulation: Touchdown IQ 4SL
- Use rates: 0.75-1.0 lb ai/A
- Type of application: ground, broadcast; Roundup Ready corn only
- Application rates of formulation: 0.75-1.0 qt/A
- Application timing: postemergence, up to V8 or 30-inch corn
- Typical number of applications per year: not to exceed 2 qt/A up to V*, 5 qt total per season
- Pre-harvest interval: 7 days grain, 50 days silage
- Restricted entry interval: 12 hours
- Family: amino acid derivative

Clopyralid

- Active ingredient: Clopyralid
- Trade name and formulation: Stinger 3S
- Use rates: 0.09-0.25 lb ai/A
- Type of application: ground, broadcast
- Application rates of formulation: 0.25-0.67 pt/A
- Application timing: postemergence up to 24-inch corn; thistle 6-8 inches tall
- Typical number of applications per year: 1
- Pre-harvest interval: 40 days
- Restricted entry interval: 12 hours
- Family: carboxylic acid

Dicamba: See entry under Cocklebur

Flumetsulan and clopyralid: See entry under Cocklebur

Glyphosate and atrazine: See entry under Cocklebur

Chemical Use in IPM Programs

Weed scouting is an integral part of an Integrated Pest Management program. If weed populations are present, then cultivation or the application of herbicides will be used. Unlike insect pests, individual thresholds are rarely developed and utilized for decision making. In addition to the potential yield losses that weeds cause, farmers are often motivated to strive for weed-free fields because their fields are on public display. As a result, the expectations for weed-free fields tend to be high, and farmers are inclined to spend more for weed control and use products rather than use IPM methods to determine use (49)

Chemical Use in Resistance Management

Weed resistance to herbicides is now recognized as a major threat to corn production across the United States. Weed species resistant to herbicides in New Jersey now

include pigweeds (*Amaranthus* spp.) and horseweed (marestail) (*Conyza canadensis*), with possible resistance development in lambsquarter (*Chenopodium album*) The herbicides that have resulted in the development of resistant weeds include the triazines and glyphosate. The potential for resistance development is greatest for herbicides with systemic modes of action and long half-life, such as triazine, imidazolinone and sulfonylurea chemistries. The likelihood of resistance also increases if the herbicide is used at high rates or repeatedly in the same field.

The use of imidazolinone and sulfonylurea herbicides, which have the ALS inhibition mode of action, has raised concerns about the development of new resistant weeds. These herbicides have been well received by farmers and their use continues to expand on both corn and soybean crops. Because of a broad-spectrum of weed control and their use on both corn and soybeans in rotation, the potential for development of resistance to this class of compounds is high. If herbicides with alternative modes of action are not available the risk rises significantly. After populations of resistant weeds develop, only expensive or environmentally unsound remedies may remain. The use of glyphosate for burndown weed control, as well as in Roundup Ready corn and Roundup Ready soybean rotations may lead to increased spread of resistant horseweed into other areas of the state.

A number of new products have been registered for weed control for corn. These products expand the spectrum of weeds controlled and the window for applications. Unfortunately, many of these new products have the ALS inhibition mode of action and, as mentioned above, significantly increase the potential for development of resistant weeds (43, 49, 60).

ALTERNATIVES

Weed control alternatives (parasites, biologicials, etc.) are not readily available or used by corn producers in New Jersey. Rather, cultural practices may be used as an alternative to or in concert with chemical controls.

CULTURAL CONTROL PRACTICES (48, 49)

Common cocklebur, *Xanthium stramonium*, is a summer annual weed. Cultivation, tillage, and mowing will all help control cocklebur establishment.

Morningglories, Ipomoea spp., are summer annuals. Tillage and cultivation can control newly emerged seedlings, but this may result in conditions that favor emergence by weeds deeper in the soil profile.

Common lambsquarters, *Chenopodium album*, is a summer annual that can be controlled with cultivation.

Canada thistle, *Cirsium arvense*, is a perennial weed with a vigorous, rhizomatous root system. Preplant tillage and row cultivation can control small seedlings but are less

effective in controlling plants arising from rootstocks. Control measures include keeping the plants from going to seed in neighboring fields to avoid wind carried seed from landing in the field. Rotation with other crops and the use of frequent tillage can be used to control this weed.

Foxtails, *Setaria* spp., are annual grasses that best controlled with cultivation while they are seedlings; once established, their clumping growth habit make tillage or plowing difficult. All foxtails are more serious in reduced and no-till fields.

Shattercane. *Sorghum bicolor*, is an annual grasses that can be controlled with cultivation while they are seedlings.

Quackgrass, *Elytrigia repens*, is a cool season perennial that reproduces by rhizomes, and to a lesser amount by seeds. Tillage can help control this weed.

Johnsongrass, *Sorghum halepense*, is a perennial weed and produces prolifically via rootstock and seeds. Rhizomes overwinter; both rhizomes and seeds sprout in the spring. Seeds may survive for several years before germination. Surface tillage is not an effective control although continued fallow tillage can help to reduce rhizome regrowth.

BIOLOGICAL CONTROLS

There are no effective biological controls for these weed species.

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