Crop Profile for Cotton in Missouri

Prepared: August, 2000

General Production Information

Missouri ranks twelfth in the United States in cotton production with 2.5% percent of total U. S. production concentrated in a seven-county region in Southeast Missouri (often referred to as the 'Bootheel'). The three major cotton producing counties include Dunklin (162,100 acres), New Madrid (101,600 acres) and Pemiscot (77,400 acres). Within the last five years, approximately 2,000 acres of cotton have been grown around the Springfield area in Southwest Missouri. In 1998, 370,000 and 357,000 acres were planted and harvested, respectively. The average yield was 471 lbs. of lint per acre and a total of 135,000 tons of seed and 350,000 bales (480 lbs. per bale) of cotton were produced. The cotton crop in 1998 was the smallest since 1990. Planted acreage in 2000 is estimated at 400,000 acres. From 1994 to 1999, cotton acreage has ranged from 360,000 to 400,000 acres. Cash receipts have ranged from a high of $216 million in 1994 to a low of $159 million in 1998. There also were 600 acres of organic cotton grown in Missouri.

The number of cotton producers in Missouri is estimated at less than 3000. The actual number of producers is difficult to ascertain, since USDA- registered farm numbers include landowners, operators and others. The land-owning entities are often divided among family members in the form of trusts, joint operations and farm corporations. Nonetheless, cotton farm operations continue to decrease in number and increase in size. The increase in number of acres farmed by each farmer means more and bigger equipment, more farm employees, more technical crop management and larger, more sophisticated marketing and finances. More consulting services are being used by farmers for crop, financial and marketing planning and management. These changes have been accelerated by the revisions in the 1995 Farm Bill. This trend of enlargement and consolidation can be expected to continue, driven by the pressures of economics of size, technological advances and competition among the more capable farm managers.

Cultural Practices

All cotton varieties grown in Missouri are known as upland cotton and are indeterminate varieties.

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Farmers plant varieties classified as early to medium in maturity because there are not enough growing degree days (base 60) in southern Missouri for late maturing varieties.

Missouri cotton growers are adopting transgenic varieties. Plantings of bromoxynil-tolerant (BxN) and glyphosate-tolerant (Roundup Ready) varieties have increased to where approximately 30% of the acreage is planted to each type. It is estimated the percentage acreage planted to the herbicide tolerant varieties will continue to increase in the next 3 to 5 years as more varieties and adequate seed supplies become available. Currently there are less than 12 glyphosate-tolerant adapted cotton varieties for Missouri and only one bromoxynil-tolerant variety. It is estimated that its conventional, recurrent parent, Stoneville 474, is planted to 20% of the cotton acreage in Missouri. Cotton varieties with the Bt gene are not widely used (<1% of the acreage) because of the high seed costs and growers generally achieve economic control of the bollworm/budworm complex with insecticides. However, their use of Bt varieties should increase because many of the newer herbicide tolerant varieties are stacked with both the herbicide resistant and Bt gene.

Recommended planting dates for cotton in Missouri range from 20 April to 20 May. Weather conditions (soil moisture and temperature) largely dictate planting date. Cotton planted beyond the optimum planting window has lower yields because of drought stress in the summer and early frost in the fall. For optimum weed and disease control, a planting density of two to four plants per row foot (52,000 seeds/ acre) is recommended. Approximately 90% of the cotton is planted on raised beds with 38-inch row spacing. Another 9.5% is planted in 30-inch rows and 0.5% is broadcasted. Only 5% of the acreage is no-till in the delta region because the alluvial fields are flat and not prone to soil erosion.

Fertilizer applications of potassium and phosphorus to cotton in Missouri are based on soil tests, but most soils are naturally high in phosphorus. Nitrogen is applied based on a yield target of 1.5 to 2 bales per acre (60 lbs N/bale). Generally, 60 to 90 lbs of N are applied with one-third applied preplant and the remaining two-thirds applied at squaring.

Fifty percent of the cotton acreage is now irrigated (furrow or center pivot). All traditionally grown cotton in Missouri is treated with the growth regulator Pix in mid-summer, chemically defoliated in September with Prep, and mechanically harvested.

Pest Management in Cotton

In general, insect problems in Missouri cotton are much less severe than those in other cotton-producing areas of the United States. The primary insect pest of cotton in Missouri is the boll weevil. Approximately one-third of the cotton acres are treated with pyrethroid insecticides. This is generally higher than in the more southern cotton regions due to less pressure from the bollworm/budworm complex in Missouri. Acreage treated for insects will vary from 85 to 100% depending on pest densities. In some years, severe thrips or aphid infestations can lead to significantly increased use of insecticides relative to other years.

Approximately 85% of the cotton acres in Missouri will receive a seed or soil-applied, pre- or at-plant (ing) insecticide application for control of thrips and nematodes. All cotton seeds are treated with fungicides for control of seedling diseases.

Most of Missouri's cotton acreage contains significant weed infestations. Cotton's slow growth during cool soil conditions during spring allows weeds to germinate and compete with the crop. Also, cotton is planted relatively thinly and provides poor shading for later-season weed suppression.

Insect Pests

Boll weevil (*Anthonomus grandis grandis*)

Adult boll weevils are easy to identify as they are either gray (overwintering adults) or reddish-brown (in-season adults) with spiny projections on their front legs. Adult weevils damage young squares and small bolls by feeding on and /or laying eggs within these structures. Damaged squares will have yellowish-green coloration and the square bracts will flare before being aborted by the plant. Squares damaged by egg-laying females also have a small raised area or bump, whereas squares damaged by feeding adults have small holes with orange fecal material present. Damaged bolls may abort or develop abnormally.

During the 1990's, the boll weevil has been Missouri's most destructive cotton pest. In 1998 and 1999, an estimated 10,344 and 11,140 bales, respectively, were lost because of boll weevil damage. In years following mild, dry winters the boll weevil is an serious economic pest particularly in fields located near Crowley's Ridge, floodway drainage ditches, and the St. Francis and Mississippi rivers. Two to three consectutive cold winters are required to suppress boll weevil densities below economic thresholds. The last time this occurred was the late 1970s.

Control of boll weevil in Missouri cotton relies on pheromone trapping and timely insecticide applications once economic threshold levels are reached in the field. Currently, the University of Missouri deploys pheromone traps at approximately 60 sites throughout southeast Missouri to monitor migrating weevils. If 3 weevils per trap are caught for two consecutive weeks, then one to two early season insecticide applications are recommended at the pinhead square stage (5 to 7 nodes). Frequently, early-season insecticide applications for boll weevils may eliminate beneficial arthropods and flare secondary pests such as aphids. After these applications, fields are scouted 1 to 2 times per week to assess in-field migration of weevils. If square feeding damage reaches 10%, fields are treated every 5 days until the weevil's reproductive cycle is broken. The choice of insecticide is based on the need for control of other insect pests in addition to the boll weevil.

Missouri cotton growers will vote a second time on a boll weevil eradication referendum in August, 2000. For the program to be successful, malathion ULV will be required. This insecticide formulation is cheap, effective, safer to humans and suited for application by air. The current program is expected to run for seven years at a cost of $15 per acre per year. If the program is successfully implemented, overall insecticide use in Missouri should decrease.

Bollworms/Budworms (*Helicoverpa zea/ Heliothis virescens*)

Both species attack cotton in Missouri, but the cotton bollworm is the predominant species. In 1998 and 1999, an estimated 42,392 and 5,741 bales, respectively, were lost in Missouri because of bollworm/budworm infestations. Both of these insects feed on fruiting structures, but bollworms are more frequently seen than tobacco budworms in Missouri. Bollworm moths vary in

color from reddish-brown to a whitish green-brown. Adult females singly deposit >1000 eggs onto the plant's terminal, foliage, blooms, and/or squares. The newly hatched bollworm larvae [whitish color with a black head initially feed on terminals and very small squares; however, larger

larvae tend to move downward into the plant canopy to feed on blooms and large squares and bolls. Typical damage symptoms are terminals destroyed and squares, blooms, and bolls have holes.

When scouting for bollworm eggs and larvae it is important to examine the whole plant and its fruiting structures (particularly underneath the bloom tags). Generally, the biggest threat from bollworm infestations begins when corn stops silking. Bollworm moths are attracted to cotton that is blooming, and fields must be scouted one to two times each week until the last effective boll population matures. Low-level bollworm infestations may be controlled by

beneficial arthropods unless beneficial parasitoids and predators were eliminated by earlier insecticide applications. If armyworms or budworms also are present, growers generally tank-mix pyrethroids with other types of insecticides. Tobacco budworm resistance to pyrethroids continues to increase, and pyrethroid control of armyworms is not recommended due to inadequate control.

Plant Bugs (*Lygus* spp.)

Two species (clouded and tarnished) plus cotton fleahoppers are found in Missouri cotton fields, but the tarnished plant bug, *L. lineolaris*, is the predominant species. In 1998 and 1999, an estimated 2,337 and 6,245 bales, respectively, were lost in Missouri due to plant bug feeding damage. Clouded plant bug adults have mottled coloration (gray, brown, and yellow) and the first antennal segment is enlarged; whereas, tarnished plant bug adults are yellowish-brown with black

and yellow lines and a distinct "v" shaped area at the base of the wings. Cotton fleahoppers are pale green with tiny black spots and are smaller (1/8-inch vs. 1/4-inch in length) than plant bugs.

Plant bugs cause injury by extracting plant juices, and these plants will abort damaged squares and small bolls. Cotton fleahopper damage also can cause plants to develop spindly branches. The most severe injury from these insects occurs during the first four weeks of the fruiting season. Environmental conditions that lead to carbohydrate stress also can cause square shedding; therefore, growers must be sure that these insects are causing this fruit shed before applying insecticides.

Scouting efforts should be intensified for plant bugs and other pests if square retention drops below 80% at first position sites prior to bloom. Fields treated for plant bugs also are closely monitored until harvest for subsequent aphid and/or bollworm infestations. Typical damage symptoms include square shed, deformed and brownish colored blooms, and young bolls stunted with reddish-brown specks that later turn yellow and drop off the plant.

Thrips (several species)

This group of insects is Missouri cotton growers most important early-season cotton pest. These small, slender insects extract plant juices and cause foliar damage. Cotton plants at the four-leaf stage or younger can be stunted, and this damage can delay crop maturity. An in-furrow systemic insecticide or treated seeds are recommended for preventive control. In-furrow systemic insecticides also may suppress aphids, nematodes and early-season spider mite infestations. Typical damage symptoms include brown, crinkled, and upward-curled foliage. A majority (>85%) of the acreage was protected with an in-furrow insecticide treatment. Additional acreage is protected with insecticide-treated seed or foliar applications. Overall, estimated yield losses from thrips was low in 1998 (<100 bales) to moderate (~2,000 bales) in 1999.

Secondary insect pests

Spider Mites (several species)

The estimated yield loss was low (<100 bales) in 1998 to moderate (~1,600 bales) in 1999.

Aphids (several species)

In parts of southeast Missouri where boll weevil pressure is highest, aphid infestations are more common when beneficial arthropods are reduced by insecticide applications for weevils. In 1998 and 1999, the estimated yield losses were 15,432 and 13,353 bales, respectively.

Fall Armyworm (*Spodoptera frugiperda*)

The estimated yield loss was 3,290 bales in 1998.

European Corn Borer (*Ostrinia nubilalis*)

The estimated yield loss was low (<150) bales in both 1998 and 1999. Treatment for this pest is rarely needed and only then in fields adjacent to corn.

Cutworms (several species)

Annual treatments for these pests are rarely needed in Missouri.

Cabbage loopers (*Trichoplusia ni*)

No acreage was treated for this infrequent economic pest, but 69,120 acres were reported infested with cabbage loopers in 1998.

Insect Pest Management

Approximately 85% of the cotton acreage in Missouri was treated with an insecticide in 1997. The use of pheromones or attractants to monitor for boll weevils is used extensively in cotton.

Prevention Strategy

Framers are encouraged to destroy existing vegetation three weeks before planting cotton to lessen damage from cutworms.

Avoidance Strategy

Stalk destruction within one week after harvest is practiced on 99% of the cotton acres in Missouri. This practice is not required by law but adoption by Missouri cotton farmers is among the best across the cotton belt.

Monitoring Strategy

The University of Missouri in cooperation with private consultants operates a region-wide pheromone trapping program for boll weevils. This program has operated in conjunction with, but independent of, trapping programs for boll weevils and pink bollworms that were administered through the Missouri Department of Agriculture and the Animal Plant Health Inspection Service, respectively, during the mid-1990s.

Suppression Strategy

Insecticides are applied throughout the season when economic thresholds are exceeded. In 1997, 85% of the treated acres received at least one application. A total of 297,474 pounds active ingredient of insecticides were applied to 380,000 acres of cotton in 1997. An average of 2.18 insecticide applications and 0.93 insecticide active ingredient pounds were applied to cotton.

The organophosphate and carbamate insecticides accounted for 69% and 28.8%, respectively, of the pounds active ingredients applied to cotton and 55% and 20%, respectively, of the treated acres. However, the pyrethroids and other insecticide classes, while accounting for less than 3% of the pounds active ingredients applied to cotton, were applied to 25% of the treated acres. The top three insecticide active ingredients (oxamyl, aldicarb and zeta-cypermethrin) applied to cotton accounted for 48.8% of the treated acres. In terms of pounds insecticide active ingredients applied to cotton, aldicarb, malathion and disulfoton accounted for 58.5% of the total pounds active ingredients applied to cotton.

Chemical:

Azinphosmethyl (Guthion 2L). Azinphosmethyl is applied to an estimated 5% of the cotton acreage at an average of 2 applications per acre for boll weevils. Average use rates rate range from 0.19 to 0.25 lbs. active ingredient (AI) per acre and it has a 2 day pre-harvest interval (PHI).

Cyfluthrin (Baythroid 2E). An estimated 10% of the Missouri cotton acreage is treated with this product. Rate ranges are 0.025 to 0.05 lbs. AI per acre and it has a 0 day PHI.

Malathion (Cythion 5). Use rates range from 0.6 to 1.3 lbs. AI per acre and has a 0 day PHI. Infrequently (<5%) used now for boll weevil control. However, its use (ULV formulation) will increase if Missouri's boll weevil eradication program is initiated.

Oxamyl (Vydate C-LV 3.77). Use rates range from 0.25 to 0.5 lbs. AI per acre and it has a 14 day PHI. Because this product also controls plant bugs, growers commonly ($20% of base acreage) use this product when making pin-head square and in-season applications for boll weevils.

Zeta-cypermethrin (Fury 1.5E). Use rates range from 0.033 to 0.05 lbs. AI per acre and it has a 14 day PHI. An estimated 10% of the Missouri cotton acreage is treated with this product for boll weevils and bollworms.

Acephate (Orthene 90S, Payload 15G). Use rates range from 0.32 to 1.0 lbs. AI per acre and it has a 21 day PHI. This product is primarily used for plant bugs at the lower rate and for thrips at the higher rate. An estimated 5% of the Missouri cotton acreage is treated with this product for plant bugs and 10% of the Missouri cotton acreage is treated with this product for thrips.

Dicrotophos (Bidrin 8E). Use rates range from 0.25 to 0.5 lbs. AI per acre and it has a 30 day PHI. An

estimated 10% of the Missouri cotton acreage is treated with this product for aphids and plant bugs. At rates of 0.2 lbs. AI per acre, an estimated 10% of the Missouri cotton acreage is treated with this product for thrips.

Imidacloprid (Provado 1.6F) The use rate is 0.047 lbs. AI per acre and it has a 14 day PHI. Provado is the most frequently used insecticide to combat aphid infestations with one to two applications per season. An estimated 20% of the Missouri cotton acreage is treated with this product for aphids.

Aldicarb (Temik 15G). An estimated 35% of the Missouri cotton acreage is treated with this product. Use rates range from 0.5 to 0.75 lbs. a.i. per acre. Aldicarb is applied in-furrow at planting for control of thrips and nematodes, and suppression of aphids.

Disulfoton (DiSyston 15G). This product is primarily used to safen cotton from damage by the herbicide clomazone (Command). Less than 10% of the Missouri cotton acreage is treated with this product for thrips. Use rates range from 0.6 to 1.0 lbs. AI per acre. Use of disulfoton has decreased with the increased planting of herbicide-resistant cotton varieties and the corresponding decreases use of the herbicide clomazone.

The following registered insecticides were used on less than 3% of the cotton acres in Missouri in 1997: **bifenthrin**, **profenofos**, **cypermethrin**, **esfenvalerate**, **methomyl**, **methyl parathion**, **permethrin**, **propargite**, **thiodicarb, methamidophos, dicofol, dimethoate, chlorpyrifos, spinosad, sulprofos, amitraz, tralomethrin, carbofuran** and ***Bacillus thuringiensis*** **formulations**.

Integrated Pest Management Strategies

An estimated 82% of Missouri's cotton acreage is currently under an integrated pest management program. Practically all of this acreage is managed by private consultants for an average fee of $5.50 per acre. This service primarily includes insect and weed scouting. The cotton expert system Gossym/ Comax is no longer used in Missouri due to its cost of operation, and the newly developed production and pest management expert system "Cotton Man" is implemented on only 1-2% of the acreage. Its adoption is restricted due to the high labor and skill requirements to map plants in the field and monitor boll retention.

Insecticide Resistance Guidelines:

The potential risk of insecticide resistance is an important aspect to managing insect pests and harvesting a profitable cotton crop. The tobacco budworm is the key pest because of resistance to carbamate, organophosphate, and pyrethroid insecticides. Historically, tobacco budworms are not an annual pest in Missouri; however, control failures were reported in 1998 when this pest invaded Missouri cotton fields. Additionally, insecticide resistance has been reported for aphids, beet armyworms, and plant bugs. The following guidelines are directed primarily at tobacco budworms, but they also are useful to slow resistance by other pest species. The intent of these

guidelines is to discourage use of a single class of insecticide for managing cotton pests.

These guidelines are not intended to limit the professional judgement of qualified individuals dealing with unique pest situations. Because certain pest species (i.e. tobacco budworm) are highly mobile, a resistance management program is maximized when adopted by all producers in a large geographic area. The goals of this program are to maintain economic, season-long control of resistant pest species and minimize flaring of secondary pest outbreaks.

1) Optimize for crop earliness by planting early-maturing varieties during a 30-day period from April 20 to May 20. Soil temperatures >60°F will lessen the chance of delayed seedling emergence and growth, and help reduce mortality caused by insects and the weather.

2) At-planting fungicides and insecticides will minimize plant stand loss and help promote seedling growth and early crop maturity.

3) Avoid excessive nitrogen rates and late-season, foliar, nitrogen sprays that delay maturity.

Phase I (Planting to pre-bloom)

1. Avoid using pyrethroid insecticides and limit the use of organophosphates (ex. Curacron and Bolstar).

2. Avoid automatic insecticide applications.

3. Maintain beneficial insect populations that help suppress aphid and bollworm/tobacco budworm populations.

4. Properly-timed, early-season treatments (pin-head sized squares) are recommended for control of overwintering boll weevils.

5. Strive for >80% first position square retention.

Phase II (Post-bloom to end-of-season)

1. Scout fields at least once and preferably twice a week when pest populations are peaking.

2. Bollworm/tobacco budworm treatments should be targeted at eggs and small larvae (<1/4-inch in length). Selection of insecticides should be based on the species composition of the bollworm/ tobacco budworm complex. Agricultural consultants and producers can utilize pheromone trap data, moth flushing counts, etc. to determine this species complex.

3. Alone, pyrethroid insecticides are not recommended for effective tobacco budworm control. A minimum of two applications four to five days apart may be needed to provide satisfactory control of moderate to heavy tobacco budworm infestations.

4. Evaluate the potential reasons (ex. population level and age structure, application timing, environmental conditions, and levels of insecticide resistance) in the event of a control failure with tobacco budworms. Avoid consecutive applications of insecticides from the same chemical class.

5. Except for boll weevil diapause sprays before harvest, discontinue insecticide applications once a majority of harvestable bolls are past the economic loss stage to insect damage.

***Bacillus thuringiensis* (Bt) cotton guidelines:**

1) Bt-transgenic varieties are recommended for areas with a high risk for tobacco budworm and cotton bollworm infestations.

2) Do not base insecticide treatment of tobacco budworm and cotton bollworm infestations on egg counts because larvae must first ingest a toxic dose of the Bt toxin.

3) Monitor fields at least once a week and closely examine blooms and under bloom tags where caterpillar larvae may feed on developing bolls. Flower pollen has a low expression of the Bt toxin; therefore, larvae feeding on flowers are less likely to die and may damage developing bolls.

4) When using the 20% acreage refuge option for maintaining susceptible moth populations, do not control tobacco budworms or cotton bollworms in these areas with foliar Bt sprays. With the 4% refuge option, do not control tobacco budworms or cotton bollworms in these areas with any product specially targeted at these pests. Whether you chose the 4% or 20% refuge option, you should still control all non-caterpillar pests.

5) Insecticide Use: Once-a-week scouting is usually sufficient to determine insecticide use; however, in areas with high insect pressure or rapidly increasing populations (ex. tobacco budworms), twice-a- week scouting may be required. Economic thresholds (ET), the pest density when treatment is needed to prevent pest populations from reaching economically damaging levels, have been established for most cotton pests. Total fruit loss, nodes incurring loss, and the status of fruit positions on those node should be considered when utilizing an ET. Insecticides should only be applied when needed so to preserve beneficial insects and prevent secondary pest outbreaks.

Missouri’s proposed boll weevil eradication program:

The boll weevil has been a key pest for cotton growers in Missouri in recent years. The mild winters have allowed the weevil populations to increase dramatically beginning in the 1990s. In 1996, record-setting low temperatures were experienced throughout the state. It was estimated that these lower temperatures would considerably decrease the overwintering weevil population. The potential of lower weevil populations provided an opportunity to begin an area-wide management program for boll weevil. This started the beginning of boll weevil eradication planning in Missouri.

Enabling legislation was first proposed and adopted by the Missouri legislature in 1995, giving the Missouri Department of Agriculture the authority to regulate an eradication program in the state. Nine individuals were appointed to the board of directors for the Missouri Cotton Growers Organization: two members were Missouri cotton growers recommended by the Governor; three members were Missouri cotton growers recommended by the largest general farm organization in the state; three members were Missouri cotton growers recommended by the largest cotton producer organization in the state and one member represented state government.

Boll weevil populations were monitored during the 1996 and 1997 growing seasons by the Missouri Department of Agriculture, with assistance from University of Missouri Delta Center personnel. The Missouri legislature provided over four hundred thousand dollars over two years, to provide baseline information on boll weevil populations. Early season boll weevil trapping was conducted in two counties, Stoddard and Dunklin. The second stage of the program monitored weevil populations in six counties of Southeast Missouri. Maps were developed to display the fall trapping data and distributed to local gins and FSA offices. Even though the boll weevil populations decreased in 1996 to more traditional economic levels, the maps illustrated a thriving weevil population which continued to persist in specific areas. Based upon the data, it was decided that a boll weevil eradication program could be justified.

The Missouri Cotton Growers Organization became incorporated in October of 1998 and was certified by the Missouri Department of Agriculture to operate the eradication efforts in Missouri. These two organizations have worked together to develop regulations to govern the future program and conduct the first boll weevil eradication referendum held in Missouri.

Missouri’s first referendum was held in March of 2000. While the proposed referendum received fifty-six percent of the votes, it failed to reach the required two thirds majority needed for implementation. Because of the positive votes in the first round, Missouri Cotton Growers Organization elected to hold a second referendum in August of 2000.

Diseases

Seedling diseases (*Pythium* spp.; *Rhizoctonia solani*)

Seedling diseases reduced cotton production in Missouri 1.5% in 1996 or 4.4 million pounds of lint. Depending on the year, 15-30% of the cotton acreage receives an in-furrow fungicide at planting to reduce seedling disease damage to cotton. In 1997, an estimated 15% of the acreage was treated with pentachloronitrobenzene at 0.70 lbs. a.i. per acre per year; 10% with etridiazole at 0.18 lbs. a.i. per acre per year; and 5% with metaloxyl at 0.07 lbs. a.i. per acre per year. In 2000, an estimated 15% of the cotton acres were treated in-furrow with metalaxyl for control of pythuim.

All farmers plant fungicide-treated seed to provide protection against seedling diseases. 100% of the cotton seed is treated with thiram (0.03 lbs a.i. per acre) and with metalaxyl (0.005 lbs a.i. per acre). An additional 80% of the cotton seed is treated with baytan (0.001 lbs a.i. per acre).

Root-knot nematode (*Meloidogyne incognita*)

Meloidogyne incognita root infections result in stunted plants that yield poorly at harvest. Root systems on nematode-infected plants are galled and reduced in root mass. This nematode is present in approximately one-third of cotton fields in Missouri. Root-knot nematode reduced cotton production in Missouri .0.5% (1.5 million pounds of lint) in 1996. Control measures include crop rotation and in-furrow applications of aldicarb.

Reniform nematode (*Rotylenchulus reniformis*)

This nematode is present in only 3% of cotton fields in Missouri. It's present impact is minimal and nematicides used for control of root-know nematode will control reniform nematode. There are no resistant cotton varieties to this nematode.

Bronze wilt (unknown etiology)

This disease occurs infrequently in Missouri and can reduce yields by 80%.

Disease Management

During 1997, approximately 11% of Missouri's cotton acreage was treated with a fungicide, primarily for control of seedling diseases. Four fungicides were applied to cotton above that which is applied to seed before purchase by the farmer. PCNB, iprodione, metalaxyl and etridiazole were applied to 14,469 acres, 11,166 acres, 10,468 acres and 4,001 acres, respectively. PCNB alone accounted for 71.6% of the 11,983 pounds active ingredient applied to cotton.

Prevention Strategy

A. Crop rotation: Rotating crops will help manage several diseases of cotton. For example, the number of root knot nematodes in the soil declines when a root knot nematode-resistant soybean variety is planted. The population of this nematode will fall below the cotton damage threshold after planting a resistant variety for a few years. The grower can then resume planting cotton but should continue rotation to keep the nematode problem minimized.

B. Planting in warm soil (62-65 F @ 2" depth): Seedling diseases of cotton are worse when the soil around the seed and seedling is cool and wet. Seed and seedling diseases can result in severely reduced stands and reduced yields. Surviving plants have a stunted root system and yield poorly. Growers should avoid planting in cool wet soil and when the weather forecast indicates that cool wet conditions may develop within 5-7 days of planting.

C. Plant high quality, delinted seed. Delinting seed controls bacterial blight.

D. Planting seeds in raised beds enhances drainage and prevents conditions suitable for seedling diseases.

Avoidance Strategy

Resistant varieties: Varieties immune to all or most cotton diseases do not exist. However, newer varieties often have improved levels of resistance. Growers should choose varieties based on MU yield trials in their area and resistance to locally important diseases.

Monitoring Strategy

No monitoring tactics are practiced for disease management in cotton.

Suppression Strategy

Fungicide seed treatments are very helpful in managing seedling diseases. All commercially sold cotton seed in the United States is treated with fungicides. Fungicides applied in-furrow may be useful when planting cotton, especially when planting in late April and in soil that is poorly drained.

Chemical:

PCNB (PCNB, Terrachlor). PCNB was applied to 4% of Missouri's cotton acreage at 0.2 lb a.i per acre.

Iprodione (Rovral).

Etridiazole (Terrachlor).

Metalaxyl (Apron, Ridomil Gold)

Other fungicides registered for cotton seedling diseases include: **Bacillus subtilis** (Kodiak HB) and **Mancozeb** (Penncozeb).

Weeds

Palmer Amaranth (*Amaranthus palmeri*) has emerged as the most troublesome weed species because a majority of the cotton herbicides are somewhat weak at controlling this weed. Why it has became a more widespread problem is not completely clear; however, it has shown some tolerance to traditional cotton herbicides. Also, it may germinate for longer time periods and/or later in the season, and it has demonstrated a higher growth rate than that of other pigweed species and cotton.

Cocklebur (*Xanthium strumarium*) is a highly competitive, annual broadleaf weed in cotton. If not controlled, the large spiny seeds become entangled in the cotton lint during harvest and can lead to dockage during the ginning process.

Morningglory species (*Ipomea spp.)* are summer annual broadleaf vines that clog harvesting equipment if not controlled in cotton.

Weed Management

Weeds infest 100% of Missouri's cotton acreage and 100% of the cotton acreage is treated with herbicides. Cotton herbicides are more expensive than corn and soybean herbicides and weed control costs in cotton can be as high as $50.00 per acre. Consequently herbicides are often banded, with the row middle kept weed free with cultivation. Cotton herbiicdes are applied by ground sprayers because the risks associated with aerial applications due to drift are too high. In reduced tillage situations, glyphosate is often used (because of its relatively low price) on row middles of normal cotton varieties via a hooded sprayer.

Typically, cotton is treated with four to eight different herbicides spread over 3 to 5 applications. Two or sometimes three herbicides are tank-mixed and applied at the same time. In the last five years, three new herbicides and technologies have become available. While all of these herbicides have brought certain advantages, they also have certain weaknesses and are generally used with traditional chemistry in an overall weed control program. These new herbicides also have increased the diversity of weed control

programs and thus it is difficult to profile a "common" weed management program. Dinitoranaline herbicides are still commonly used because they provide good early-season Palmer amaranth suppression. In fact, triflurallin remains the most commonly applied herbicide in Missouri cotton. The broadleaf herbicide fluometuron is also used extensively as a preemergence treatment. However, use rates have been reduced (or eliminated altogether as a preemerge) because of the availability of new postemergence broadleaf herbicides. Another disadvantage with preemerge fluometuron is it often causes a small amount of crop injury. Thus many growers are making an early postemergence application of pyrithiobac, bromoxynil (in BxN cotton), or glyphosate (in Roundup Ready cotton). In many, but not all cases, postemergence, directed applications of MSMA or DSMA plus one of several directed broadleaf herbicides may be made.

Approximately 20% of Missouri's cotton acreage is grown in a reduced tillage or cover crop system where burndown herbicides are applied. Cutleaf evening primrose *(Oenothera lacunosa*), is a difficult species to control because it is moderately tolerant of no-till, burndown herbicides; however, this weed species is not excessively competitive with cotton. In March, 2,4-D applications are often made for control of this weed. Glyphosate products are frequently applied to kill wheat cover crops, and paraquat is sometimes used to control newly germinated weeds at planting.

Prevention Strategy

Pre-plant tillage provides control of winter annual and other emerged weeds. Most weed germination occurs during the first four weeks after cotton planting. Approximately 50% of the cotton acreage is inter-planted to winter wheat primarily to suppress wind erosion and sand injury to young seedlings. However, this practice also prevents weed seed germination and helps with early season weed control.

Avoidance Strategy

Crop rotation is the important avoidance tactic used in weed management.

Monitoring Strategy

It is estimated that 40-60% of the cotton acres are scouted for weeds by independent crop consultants.

Suppression Strategy

In Missouri, 100% of cotton fields are treated with herbicides to suppress weed competition. Each acre receives an average 2.36 herbicide applications. Growers are encouraged to rotate herbicides with different modes of action to delay the emergence of weed resistance.

Chemical:

Fluometuron (Cotoran 4l, DF and Meturon DF). Fluometuron was applied to 72% of the cotton acres in 1997. Fluometuron is applied pre-emergence or early post-emergence at 0.7 to 1.0 lb active ingredient per acre for control of broadleaf weeds.

Pyrithiobac (Staple). Pyrithiobac was applied to 63% of the cotton acres on 1997.

Trifluralin (Treflan, Tri-4EC). Trifluralin was applied to 63% of the cotton acres in 1997. Trifluralin is applied pre-plant with incorporation at 1 to 2 lbs active ingredient per acre for control of grasses and small-seeded broadleaves.

Pendimethalin (Prowl). Pendimethalin was applied to 22% of the cotton acres in 1997. Pendimethalin is applied pre-plant or pre-emergence at 1 to 2 lbs active ingredient per acre for control of grasses and small-seeded broadleaves.

Glyphosate (Roundup). Glyphosate was applied to 21% of the cotton acres in 1997. With the introduction of RR cotton varieties use in 2000 is estimated at 30% of the cotton acres. Glyphosate is applied post-emergence for control of both grass and broadleaf weeds. It has become increasingly popular with growers due to its broadspectrum weed control. One disadvantage of glyphosate on RR cotton is that it cannot be applied after the fifth true leaf. Thus other herbicides must be used for later season weed control.

MSMA/DSMA (MSMA/DSMA). MSMA/DSMA were applied to 21% of the cotton acres in 1997.

Clomazone (Command). Clomazone was applied to 19% of the cotton acres in 1997.

Cyanazine (Bladex). Cyanazine was applied to 17% of the cotton acres in 1997.

Diuron (Karmex). Diuron was applied to 7% of the cotton acres in 1997.

Bromoxynil (Buctril). Bromoxynil was applied to 6% of the cotton acres in 1997. With the introduction of a BxN cotton variety in 1999 this herbicide is now estimated to be applied on 30% of the cotton acres. Bromoxynil is applied post-emergence for control of most broadleaf weeds in cotton. A major advantage on BxN cotton is that there is no restriction on the time of application, however, control of pigweeds, waterhemp and Palmer amaranth is weak.

Metolachlor (Dual 4E, 8E). Metolachlor was applied to 5% of the cotton acres in 1997.

Fluazifop (Fusilade 2000). Fluazifop was applied to 5% of the cotton acres in 1997.

Quizalofop (Assure II). Quizalofop was applied to 5% of the cotton acres in 1997.

Norflurazon (Zorial Rapid 80 DF). Norflurazon was applied to 5% of the cotton acres in 1997.

Lactofen (Cobra). Lactofen was applied to 5% of the cotton acres in 1997.

The following registered herbicides were used on less than 3% of the cotton acres in Missouri in 1997: **alachlor** (Lasso), **clethodim** (Select), **sethoxydim** (Poast), and **prometryn** (Caparol).

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