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Management and Production Practices for Control of Insect Pests in Grain Sorghum

Grain sorghum (*Sorghum bicolor* L. Moench), commonly referred to as milo, is an important feed grain in Mississippi. Mississippi imports about 50,000,000 bushels of this and other grains annually. Grain sorghum yields compare favorably with corn in both quantity and quality, and low production costs for sorghum combined with its drought tolerance make it attractive to growers, particularly in a double crop system following early small grains.

Two major problems encountered in the production of grain sorghum have tended to suppress its production in Mississippi. One of these problems is the high moisture content at harvest and the other is loss of the crop to insects. This publication is a report of a study of the management of insects that attack the sorghum grain head and of crop production practices that affect insect populations.

The Sorghum Grain Head

The grain head of sorghum is a panicle or compound racemose inflorescence, with hundreds of individual spikelets that are of two types, sessile and pedicellate. The latter usually contains only anthers or male parts. Each of the sessile spikelets contains an ovary, usually three anthers, and a bifurcated feathery stigma enclosed in a pair of closely-fitting shuck-like covers or glumes. At the time of blooming (flowering), the glumes open and the yellow male pollen-bearing anthers protrude but are held to the structure by fine filaments leaving the pollen-receptive tips of the female pistil exposed.

Blooming of a sorghum head usually takes about a week. The first blooms appear at the top or apex of the head. Each day more blooms appear lower down the head, and so on for about a week when the last blooms occur at the base of the head. Therefore, the first blooms at the top of the head are about 7 days older than those at the base.

After fertilization the small pinhead-sized ovary develops into a seed at the base and within the glumes. About the time that all of the head has completely bloomed, the grains maturing at the top of the head become large enough to force open the glumes and the upper tips of green seeds can be seen. A wave of such seed protrusion then moves down the head day-by-day, proceeding as did the blooming. Soon the seeds at the top of the head begin to turn in color (red, yellow or brown) depending on the color that the mature grain will be. As the seeds turn color, they develop to a "milk" stage, pass through a "dough" stage, and eventually harden. All these stages proceed in the wave-like fashion described for blooming and setting of seed.

Major Insect Pests

In Mississippi, the three major insects that attack sorghum heads differ greatly in classification, appearance and behavior, but they share the trait of being able to destroy sorghum grain efficiently and in a quiet, unnoticed way. Two of these species are so commonly found on sorghum and its grass relatives that their common and scientific names are compounded from the word sorghum, while the third pest is shared with plants of many kinds.

The sorghum midge, *Contarinia sorghicola* (Coquillett), is a small orange-bodied, gnat-like fly or Diptera in the family Cecidomyiidae (Figure 1). Adults of this insect do not damage sorghum, but they deposit eggs that develop into small legless maggots within the glumes. These maggots feed on the fertilized ovary, causing the seed to fail to develop.

The sorghum webworm, *Celama sorghiella* (Riley), is a small moth or Lepidoptera of the family Nolidae. Eggs are laid on sorghum heads and the hairy larvae (Figure 2), frequently in large numbers, feed on the seeds while they are soft and green.

The corn earworm, *Heliothis zea* (Boddie), also known as the cotton bollworm, sorghum headworm, or tomato fruitworm, is a medium-sized moth or Lepidoptera of the family Noctuidae. The eggs laid on the heads of sorghum produce larvae (Figure 3) that feed on the grain in all stages of its development.

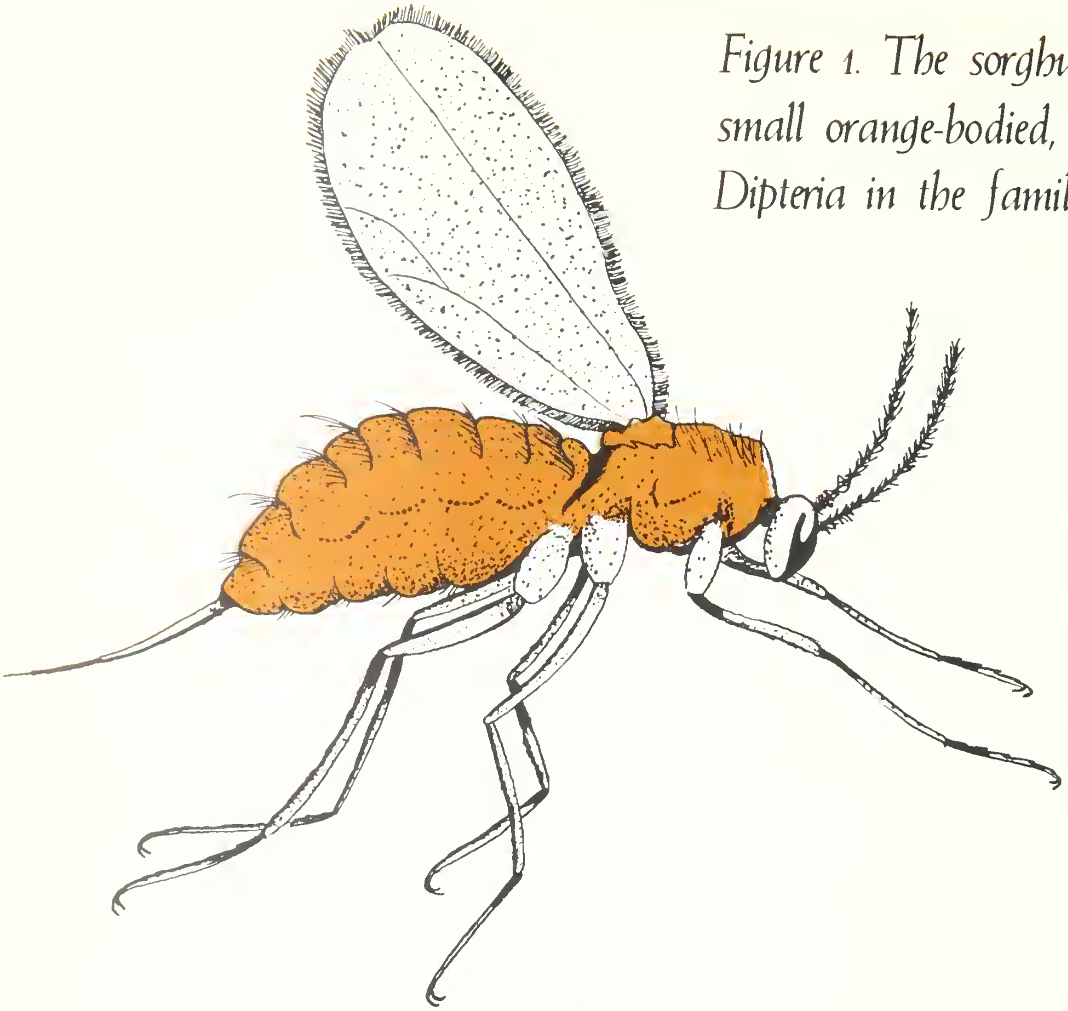

Figure 1. The sorghum midge---a small orange-bodied, gnat-like fly or Dipteria in the family Cecidomyiidae.

These larvae usually are found in small numbers. Open panicle varieties of sorghum are usually less damaged by this insect than are the compact panicle varieties.

Figure 2. The hairy larvae of the sorghum webworm (above), Celama sorghiella.

Figure 3. The larvae of the corn earworm, Heliothis zea, also known as the sorghum headworm.

The Sorghum Field Agro-ecosystem

The current trend in agriculture is to produce large acreages of a single crop species (species homogeneity or monoculture). The result is a highly unstable ecological situation that often allows crop pests to become an economic factor in production.

The problem of species homogeneity is true for most crops and they, too, suffer the common fate of overly-simplified agro-ecosystems. However, some crops may be produced in small acreages (e.g., vegetables) to lend species heterogeneity, or they may develop largely in cooler weather when many insects or other pest species are inactive (e.g., wheat). Others may have high unit value and thus be worthy of insecticide programs (e.g., cotton).

Grain sorghum must be classed with other grains as a low unit-value crop, where a schedule of routine insecticide applications for crop protection generally is considered to be uneconomical. Also the crop is grown in warm weather and is subject to damaging insect attacks that can totally limit production.

Grain Sorghum Tolerance to Insect Attack

Grain sorghum, like many other plants, produces many more seeds than it can efficiently mature. This results in a diminution of fruit size. Removal of 10% of the blooms or seeds of a sorghum head has no significant effect either on seed size or on grain yield. And at seed head losses as high as 25%, there is no reduction in grain yield because the remaining seed are so much larger. But, despite the large increase in seed size, grain yield is reduced significantly when as much as 50% of the seed head is removed (Table 1). This illustrates an important concept in grain sorghum insect pest management—that limited seed losses, particularly in the earlier stages of development, are not reflected in an equal reduction in grain yields.

This same effect was studied further and it was found that, though seed loss compensation was greatest in the earlier stages of development, it was still quite measurable in the "dough stage". Thus losses caused by earworms as grain approaches maturity are offset, at least partly, by larger seeds.

Indirect Grain Sorghum Losses Attributable to Insect Attacks: In addition to the actual insect feeding losses on the grain, there may be:

1. Head rot,
2. High-moisture grain that results in;
   (a) moisture dockage at the market, or
   (b) higher drying costs, or
   (c) harvest delays that result in;
      (1) weathering losses,
      (2) exposure to bird damage and
      (3) exposure to stored grain pests.

Head rot of grain frequently is associated with earworm or webworm damage. Where there is damage to the heads, the worm excrement in the head and/or the webs causes conditions favorable to head rotting or molding.

High-moisture grain is usually more serious than head rot. It occurs more frequently when there is only a small planting or where there is poor uniformity in fruiting for any of several reasons mentioned elsewhere. It may be caused by any of the three major insect pests—webworm, earworm or midge, and damage is greatest when part of the field is early, or when there are other nearby earlier fields to supply a heavy population of egglaying insects.

When insect damage to a sorghum plant results in less than a rather full grain head, the plant usually responds by putting out several tillers either from the ground or from an upper node, each with a smaller grain head. These heads usually are 3 to 4 weeks or more later than the parent plant. The resulting delay in harvest increases the probability of weathering loss, bird damage and further insect damage.

Table 1.—Compensatory response of seed size in grain sorghum following mechanical removal of 10%, 25%, or 50% of an individual head in the bloom stage or immature seed stage.

Item	Amount of head removed	Seed yield	Seed mass
	Percent	gm/head	gm/1000
Control	0	39 a[1]	26 a[1]
Bloom	10	34 ab	28 a
Seed	10	39 a	28 ab
Bloom	25	33 abc	30 bc
Seed	25	28 abc	31 c
Bloom	50	24 bc	36 d
Seed	50	26 c	37 d

[1]Means followed by the same letter are not significantly different at the .05 level of probability, as determined by Duncan's new multiple range test.

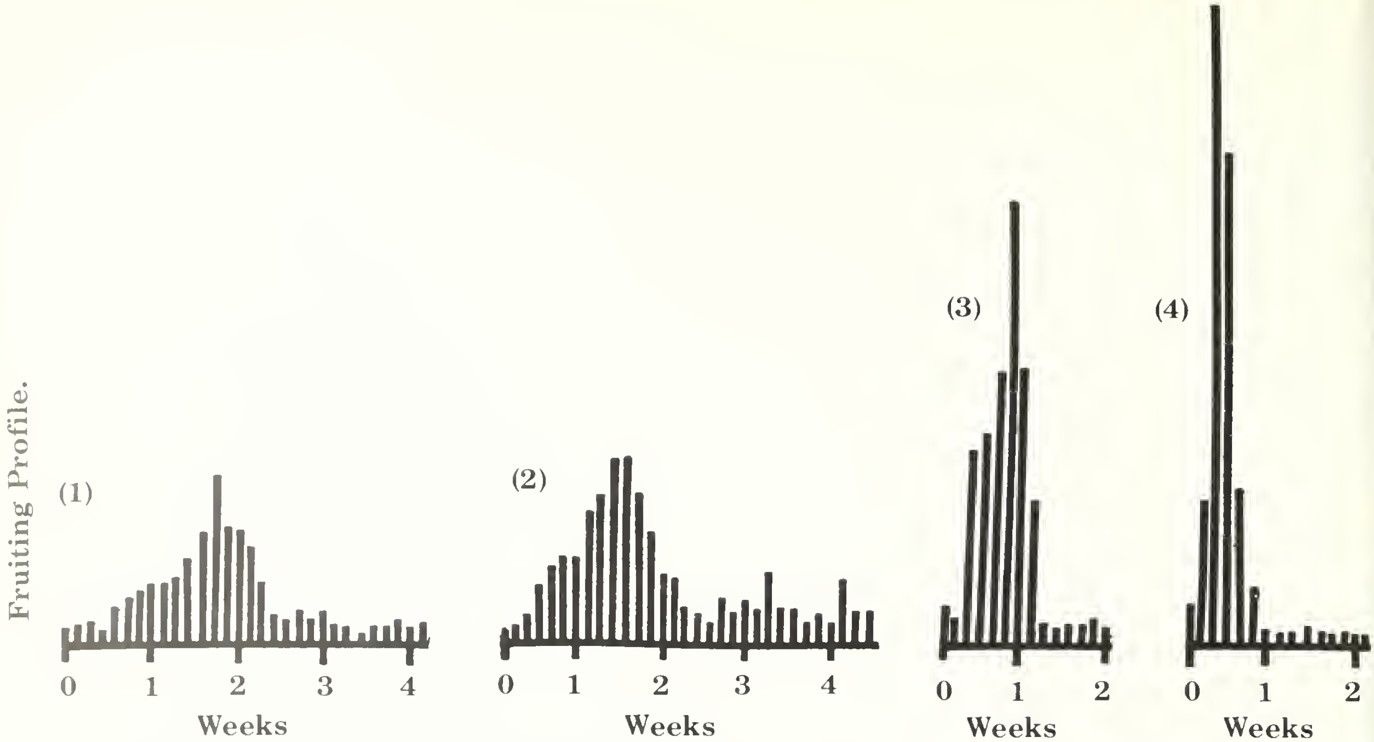

Figure 4. Fruiting profiles of some large grain sorghum fields in the Mississippi Delta in 1958 and 1961. (1) and (2)---Poor uniformity, with fruiting occurring over more than 4 weeks, resulting in almost total loss of the crop to insects, particularly field reared midge. (3) and (4)---Excellent uniformity, with little or none of the crops exposed to field reared midge in the short 2-week fruiting period, resulting in good to excellent yields of high quality grain that was harvested early for optimum seed quality.

Grain Sorghum Fruiting

The importance of uniformity of grain sorghum fruiting cannot be overemphasized. A cycle of insect buildup resulting in seed losses can begin with poor fruiting uniformity. The insect most likely to cause these losses is the sorghum midge, since it requires only about 12-18 days to complete a generation.

Large acreages of grain sorghum planted over a period of several weeks usually result in almost complete crop failure of the later planted acreage. This is illustrated by fruiting profiles of typical fields of grain sorghum in the Mississippi Delta (Figure 4). Fields with uniform fruiting had excellent yields of high-quality grain. A virtual total loss of crop to insects was observed for fields with poor fruiting uniformity and even the use of insecticides would not have prevented serious crop losses.

Practices For Control of Insects

Most of the factors that affect uniformity of fruiting can be handled by proper planning and good crop management. Some of the more important of these are:

Time of planting---early planted sorghum crops usually escape large populations of grain-damaging insects. Also, insects do not have to be a limiting factor in production from later plantings, given proper planning for insect pest management. A small-plot field study in Oktibbeha County in 1972 revealed the importance of planting early to escape large populations of the sorghum midge at crop bloom. Sorghum planted April 28 received less than 1% seed damage (Table 2). Small acreages planted on different dates suffered severe damage---15%, 55% and 98% seed damage, respectively, occurred in sorghum planted on May 19, June 23 and July 13. This same effect occurs when poor crop uniformity in a field results in high field-reared midge populations.

Varietal characteristics---some varieties have variable seedling

Table 2.—Sorghum midge damage on grain sorghum planted on different dates in small field plots, Oktibbeha County, 1972.

Planting date	Average midge/head	Seed loss
	Number	Percent
April 28	—[a]	1
May 19	167	15
June 23	192	55
July 13	311	98

[a]Not numerically recorded, but observed to be very low.

vigor and this results in uneven crop maturity. Planting varieties that do not have this trait helps to alleviate the problem of poor fruiting uniformity.

Soil uniformity---delaying planting on heavy, non-uniform soils allows time for earlier insect populations to subside. Heavier soils frequently can be planted successfully under the normally drier summer conditions.

Seedbed preparation---this management aspect often is related to soil uniformity, and lack of stand uniformity on heavier soils frequently results in part from poor seedbeds. On any type of soil, however, good seedbed preparation results in more uniform plant populations.

Uniform fertilization---proper application of recommended fertilizers aids in growing a uniform crop. Lack of nitrogen delays fruiting.

Proper seeding rate---higher plant populations in a row generally lead to more uniform fruiting. Isolated plants in a "skippy" row tend to be large, "wolfy" and late fruiting, often with side shoots bearing later fruiting heads.

Soil moisture at seeding---a uniform stand requires adequate soil moisture at seeding time. If planting is done in dry soil, it should be dry enough to preclude any germination until there is a rain to wet the soil. However, this is a dangerous practice since a light shower can start germination and still leave the soil dry beneath the plants.

Biology and Control of Insect Pests on Grain Heads

The Corn Earworm: The corn earworm is a native insect that attacks sorghum in the leaf whorl and grain head stages. This insect survives the winter in a pupal or resting stage in the soil and emerges in the spring as a variably colored moth about 3/4 inch long. It has many host plants, including vetch, alfalfa, tomato, corn, sorghum, soybean, and cotton. There are several generations a year and the insect may move from one host to another to lay eggs. The larvae are of different colors, mostly green or brown, and have several stripes along their sides and backs. In warmer weather the larval stages last about 2 weeks, and a new generation of moths appears about every 30 days.

Under most conditions small larvae appear in the heads in the early green seed stage and complete their development at about the time most of the seeds in a sorghum head reach a hard dough stage. Very small worms do not eat much, and it is mostly in the last several days of their development that most seeds are destroyed. Under most circumstances, infested heads of sorghum have only a single earworm in them since their numbers are regulated by cannibalism as the larvae develop and move about encountering others of their kind.

Sorghum varieties with open-branched heads favor the effectiveness of natural regulating factors, particularly predatory natural enemies of the eggs and immature larvae, as well as allowing the worm excrement and frass to fall from the head, thus avoiding some rot conditions in the heads.

Selected insecticides approved for use on sorghum and applied as a directed spray provide good to fair control of corn earworms on grain sorghum heads (Table 3). In general, the normally-occurring infestations of this pest in fields of uniform bloom do not usually decrease yields. This is in part due to the limited number of larvae per head and the seed size compensation noted earlier.

Large fields of a uniformly-fruiting, open-headed type of grain sorghum generally do not suffer yield losses due to this pest.

The Sorghum Webworm: The sorghum webworm has a limited host range relative to that of the earworm and seems to be limited to johnsongrass and various sorghum and sorgo crops. The adults are whitish moths only about 1/2 inch long and have distinctive tufts of scales on the forewings.

Unlike the corn earworm, the sorghum webworm larvae feed into the seeds and hull them out and frequently may be seen in large numbers (in excess of 200 larvae per head) on individual sorghum heads. The larvae are about 1/2 inch long, are spindle shaped, are brown and white striped and bear a thin coat of long hairs. They spin a thin webbing of silk in the head. This catches excrement and frass and may cause even open-headed varieties to have rot problems in the head.

The sorghum webworm does not seem to be able to increase as rapidly on johnsongrass as it does on sorghum heads, but in some years when large hay meadows of johnsongrass are allowed to mature heads, usually as a result of poor haying weather, large populations can result. When this occurs, or when a series of sorghum plantings in an area have headed over a long period, a serious outbreak may result. Webworm outbreaks are usually in late summer or in the early fall. The sorghum webworm also produces a new generation about every 30 days and large populations develop when there are available sorghum heads to build up on. Large populations are capable of causing extensive damage.

Sorghum webworms are apparently easily killed with insecticides approved for use on sorghum, when applied as a directed spray (Table 3).

Table 3.—Insecticide control of insects on grain sorghum planted on June 23, 1971, Oktibbeha County, Mississippi.

Treatment[1]		Insects/16 heads			
Insecticide and formulation	Rate	Sorghum webworn	Corn earworm	Sorghum midge damage	Head Yield
	(lb/A)	Number		% seed loss	g dry matter/ 20 heads
ethion 4EC*	0.50	1.50 abc[2]	7.50 abcde	43.5 a	899 a
ethion 4EC*	0.25	1.25 abc	12.75 de	44.4 ab	884 a
leptophos 3EC	0.50	0.50 ab	3.50 abc	54.7 bc	817 abc
azinphosmethyl 2EC	0.50	0.75 abc	5.50 abcd	55.5 c	894 ab
diazinon 4EC	0.50	2.00 abc	11.50 cde	57.3 cd	811 abc
leptophos 3EC	0.25	1.25 abc	5.00 abcd	58.0 cd	749 abc
methomyl 90% WP	0.50	0.009 a	0.00 a	61.5 cd	786 cd
disulfoton	0.50	6.25 cd	7.50 abcde	66.5 de	653 cd
disulfoton	0.25	15.40 f	9.25 bcde	72.5 ef	662 cd
azinphosmethyl 2EC	0.25	1.25 abc	6.75 abcde	72.9 ef	801 abc
diazinon 4EC*	0.25	7.50 de	13.25 de	74.5 efg	852 ab
carbaryl 80% WP*	0.50	3.75 abcd	3.00 ab	77.4 fgh	676 c
carbaryl 80% WP*	0.25	5.8 bcd	6.7 abcde	80.3 fghi	503 e
malathion 57% EC*	0.25	0.8 abc	5.3 abcd	81.0 fghi	698 bc
dimethoate 2EC	0.25	1.3 abc	12.8 de	83.6 ghi	481 e
dimethoate 2EC	0.50	4.5 abcd	10.0 bcde	84.5 ghij	509 e
methomyl 90% WP	0.25	4.8 abcd	7.8 abcde	86.1 hij	657 cd
malathion 57% EC*	0.25	11.8 ef	14.5 e	90.9 ij	667 cd
Untreated		49.5 g	47.5 f	95.1 j	225 f

***Material labeled for use on grain sorghum for sorghum midge control (WP = wettable powder; EC = emulsifiable concentrate).**

[1]Insecticide spray applied when 75% of the plants were in early bloom (August 19); second application 5 days later (August 24).

[2]Means followed by the same letter are not significantly different at the .05 level of probability as determined by Duncan's new multiple range test.

The Sorghum Midge: The sorghum midge is thought to be from Asia, but is now a widespread pest of grain sorghum in the United States. This insect overwinters in an immature stage in sorghum head and johnsongrass head residues and usually emerges as an adult before grain sorghum heads are in a bloom stage. During the early-season generations they usually infest johnsongrass heads near the site of their overwintering. The midge adults are feeble fliers and have a short life span. Males usually live only a few hours and females live only 1 or 2 days. The small, gnat-like orange-bodied adult midge is about 1/16 inch long and can be seen on or hovering near blooming sorghum heads, since the females lay their eggs between the glumes at the time of blooming.

For practical purposes, there is a new generation of adult sorghum midge each two weeks. The larvae develop next to the developing seed near the base of the glumes and pupate between the glumes. The pupae move up to the tip of the glumes as they near the time for adult emergence. At the time of emergence they move up until the pupal case is left hanging from the tip of the glumes. These pupal cases can often be seen bristling from heavily infested heads.

The seed in an infested glume fails to develop and where there is a complete loss of seeds, the sorghum heads have a typical, slim compact look (Figure 5). Where there is less than complete seed loss, there may be a scattering of oversized seeds. When there is an abrupt reduction of midge adults in the field due to insecticide use or some other factor temporarily reducing the midge population to a low level, it has been noted that heads may have their tops slim and compact and their bases full of seeds.

The sorghum midge, when present in large numbers may completely destroy small plantings or late portions of highly nonuniform fields. Large fields of grain sorghum planted early and fruiting in a highly uniform manner usually receive only limited seed loss which is compensated for by larger seed.

Light infestations of sorghum midge on early-planted, uniform stands of grain sorghum do not require insecticide controls. Late planted sorghum may be vulnerable to damaging midge populations that build up in the surrounding area. In fields with a midge problem or where the pest is detected in large numbers during early fruiting, a preventive insecticide spray program may be required to protect the crop during the bloom period. Several insecticides (Tables 3 and 4) currently available for use against the sorghum midge are effective in preventing seed head losses[1]. Insecticides should be applied on a 3- to 4-day schedule, beginning when 10% of the plants begin to bloom. The cost of insecticide treatments can be reduced by using the lower rates indicated in Table 4. These are as effective as the higher rates in a preventive spray program where the blooming grain head receives 3 spray applications at 4-day intervals. When insecticides are used, crop uniformity may shorten the time that insecticide protection is needed.

Table 4.—Evaluation of insecticides for control of the sorghum midge on sorghum planted June 28, 1972, Oktibbeha County, Mississippi.

Insecticide and formulation[1]	Rate	Visual estimate of midge damage
	(lb/A)	% seed loss/head[2]
diazinon 4EC*	0.10	17.7 a
leptophos 3EC	0.25	19.7 a
phosalone 3EC	0.50	19.9
ethion 4EC*	0.25	20.4 a
leptophos 3EC	0.50	20.7 a
diazinon 4EC*	0.25	21.6 a
oxydemetonmethyl 3EC	0.50	22.6 a
Sevimol® 4EC*	1.00	24.3 ab
ethion 4EC*	0.10	25.0 ab
phosalone 3EC	0.25	26.2 abc
disulfoton 6EC	0.50	29.4 bc
carbaryl 80% WP*	1.00	32.2 bc
disulfoton 6EC	0.25	35.9 cde
oxydemetonmethyl 3EC	0.25	45.4 def
dimethoate 2EC	0.10	45.9 ef
dimethoate 2EC	0.25	48.0 f
Untreated		70.1 g

*Material labeled for use on sorghum for midge control.

[1]Insecticide applied on September 5 when 10% of the crop was initiating bloom, and on September 9 and 13.

[2]Means followed by the same letter are not significantly different at the .05 level of probability as determined by Duncan's new multiple range test.

Conclusions

Good management and crop production practices can minimize insect damage as a limiting factor in grain sorghum production. Insect pests are more destructive on small, late-planted and large non-uniform plantings. A good crop under such conditions requires the use of insecticides. Cultural practices, including selection of land, land tillage, crop rotation, and timeliness of planting for uniformity of bloom are probably the most important crop production practices for reducing insect damage.

The possible need for insecticides on grain sorghum must be determined and may be based on acreage planted, crop uniformity, and insect pest populations. Knowledge that sorghum in an area is annually attacked by specific insect pests may be justification for a preventive insecticide spray program. On the other hand, close observations of the crop during the growing season, to determine damaging insect pest populations, may be used in deciding the need for insect control. Nevertheless, the choice of insecticide is important for greatest efficiency in control of specified pests. Also, rates and method of application are critical. Identification of the insect pest is of primary importance. Insecticides are not all equally effective against all pests. It should be borne in mind that the use of insecticides for midge control while the plant is in the bloom stage kills natural enemies of the earworm and may result in the need for a control program directed at this pest.

[1]*Diazinon, ethion, malathion, carbophenothion, and carbaryl currently have labels for use on grain sorghum for control of the sorghum midge in Mississippi.*

Spray applications of insecticides for midge control, beginning at 10% bloom stage and at 3- to 4-day intervals during blooming, is critical, if spraying is needed. Low dosages of insecticides can be utilized effectively in a spray program to control the sorghum midge. Insecticide dosages higher than those recommended should be avoided. Excessive use of insecticides results in resistance in insect populations. If insecticides are used judiciously, insect pest management includes the conservation of natural populations of beneficial arthropods in the field.

Figure 5. A midge-damaged head (left) and a healthy sorghum head.