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INSECT PESTS OF SORGHUM AND THEIR MANAGEMENT

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1. INTRODUCTION

Sorghum is the third most important cereal crop in India after rice and wheat. The average grain yield is 675 kg ha-1, although yields up to 7200 kg ha-1 have been obtained at research stations. Sorghum is grown during the rainy (*Kharif*) and the postrainy (*rabi*) seasons. Since high yielding cultivars and improved technology for production are already available, more emphasis needs to be placed on crop protection so as to increase, as well as stabilize the yield on farmers' fields.

Nearly 150 insect species have been reported as pests on sorghum. However, only nine of them are considered as important pests (Table 1). Shoot fly (*Atherigona soccata* Rond.), stem borer (*Chilo partellus* Swin.), oriental armyworm (*Mythimna separata* Wlk.), midge (*Contarnia sorghicola* Coq.), head bug (*Calocoris angustatus* Leth.), and head caterpillars (*Heliothis armigera* Hb., *Eublema* spp, and *Cryptoblabes* spp) are the major pests of sorghum in India. In this paper, the major pest problems are discussed and a strategy for their management has been suggested.

2. EXTENT OF AVOIDABLE LOSSES AND ECONOMIC THRESHOLDS

There is a wide variation in the estimates on the extent of avoidable losses due to insect pests. The National Council of Applied Economic Research (1967) estimated that nearly 12% of the actual sorghum production is lost because of insect damage. Since then, there has been a dramatic change in the cultivars grown, pest spectrum, and the damage levels. Borad and Mittal (1983) have reported that nearly 32.2% of the grain yield is lost due to insect damage. On all India basis, shoot fly has been reported to cause an average loss of 5% (Jotwani, 1983). Yield loss of 55 to 83% has been recorded due to stem borer infestation in northern India (Jotwani et al., 1971). Oriental armyworm has been reported to cause yield loss up to 55.7% (Giraddi and Kulkarni, 1983). Losses due to panicle pests have been estimated to be over Rs. 972 millions annually (Leuschner and Sharma, 1983).

Economic injury level for shoot fly has been reported to be 3.4 to 5.9% deadhearts, and 1% increase in deadheart formation may result in a yield loss of 21 to 143 kg ha-1 (Puri, 1983). However, there is a tremendous scope for compensation in yield because of tillering, and deadhearts up to 20% may not result in a significant reduction in grain yield. Twenty percent deadheart formation due to stem borer results in a significant reduction in grain yield, however, stem tunnelling of the plants up to 60% does not reduce yield (S.L. Taneja 1985, ICRISAT, Personal Communication). Giradi and Kulkarni (1984) reported that the economic threshold for armyworm is one larva/plant for three generations. For sorghum midge, 1 midge fly/panicle constitutes the economic threshold (Taley, 1983). Five pairs of head bugs per panicle at head emergence can result in a 33% reduction in grain yield and renders the grain unfit for humnan consumption (Sharma, 1984b). The economic thresholds for other pests are not available.

3. BIOLOGY AND ECOLOGY

The biology of major insect pests is described below. The number of generations vary according to locations and seasons, and depend upon the rainfall and cropping pattern.

Shoot fiy (*Atherigona soccata*) lays eggs singly on the underside of the leaves, at the 1 to 7 leaf stage. They hatch in 24 to 48 h. The larva first moves to the leaf whorl and finally reaches the growing point which it cuts, producing a deadheart. Larval development is completed in 8 to 10 days and pupation takes place mostly in the soil. The pupal period is about 8 days. The entire life cycle is completed in 17 to 21 days. The shoot fly population begins to increase in July, peaks in August-September, and declines thereafter. Temperatures above 35 C and below 18 C, and continuous rainfall reduce the survival rate of shoot flies (Jotwani *et al*,, 1970). In the off-season, the insect survives on alternate hosts (*Echinochloa colonum* Link., *E. procera* Hubb., *Cymbopogon* sp., *Paspalum scrobiculatum* Linn., and *Pennisetum americanum* Leeke.) and off-season sorghum.

Spotted stem borer (*Chilo partellus*) females can lay upto 500 eggs in batches of 10 to 80 near the midrib on the under surface of the leaves. They hatch in 4 to 5 days. The larvae move to the leaf whorl and feed on tender leaves resulting in leaf-scarification and shot-holes. Third instar larvae move to the base of the plant and bore into the shoot thereby causing a deadheart. In the mature plants, the larvae tunnel inside the stem. The larval period is completed in 19 to 27 days. Pupation takes place inside the stem and the adults emerge in 7 to 10 days. During the off-season, the larvae enter diapause in stalks. With the onset of rainy season, the larvae pupate and the adults emerge in 7 days. In northern India, the moth catch in light traps begins to increase during the last week of July and peaks during August-September, while in southern India, the peak in moth catches has been recorded during January and February (Sharma *et al.*, 1983b).

Oriental armyworm (*Mythimna separata*) females lay 500 to 900 eggs. The eggs hatch in 2 to 7 days. Larval development is completed in 14 to 22 days and the pupal stage lasts for 8 to 9 days. The adults live for 4 to 5 days. Mating occurs on the third and oviposition on the fourth day after eclosion. The larvae mostly feed on leaves during the night, and migrate when the food is exhausted. Maximum larval density occurs during August. Peak moth catches occur in light traps during September. Trap catches are highest during a period of low rainfall, preceded by a 2 to 4 week period of normal to high rainfall, moderate temperatures, and high humidity (Sharma *et al.*, 1982).

Sorghum midge (*Contarinia sorghicola*) females lay 30 to 300 eggs singly into florets during flowering. Eggs hatch in 1 to 4 days. The larvae suck the contents of developing ovaries and complete development in 7 to 12 days. Larvae pupate inside the glumes. The pupal period lasts for 3 to 8 days. The midge damaged florets can be recognized by the presence of pupal cases. Adults live for 2 to 48 h. The population builds up 2 to 3 months after the onset of monsoon rains. A small proportion of the larvae enter diapause in the florets in each generation, which may last up to 3 to 4 years. The larval diapause is terminated by warm and humid weather (25 to 30 C and $> 60\%$ relative humidity).

Head bug (*Calocoris angustatus*) females lay eggs in florets from panicle emergence to shortly after post-anthesis. A female lays 150 to 200 eggs. The eggs hatch in 5 to 7 days. Nymphal development is completed in 15 to 17 days. Nymphs develop on milky and soft dough grains. The population builds up during August-September. During the off-season, the bugs feed on fodder sorghum. There is no evidence of diapause.

Earhead caterpillars feed on the developing sorghum grain. *Hellothis armigera* is a polyphagous pest of a number of crops. The eggs are laid singly all over the panicle. A female lays approximately 700 creamy white eggs, which hatch in 4 to 6 days. The larvae complete development in 3 to 4 weeks. Pupation occurs in the soil and the adults emerge after 2 to 4 weeks. Maximum damage to sorghum occurs during August and-September. *Eublema sillcula* is a serious pest on sorghum varieties having compact panicles. The caterpillars feed on the maturing grain. The caterpillars are hairy and brownish-yellow in color. The egg, larval, and pupal periods last for 4, 12 to 13, and 12 days respectively. *Cryptoblabes* spp. have also been reported as a serious pest of hybrids and high yielding varieties. The eggs are laid on the spikelets and tender grain. Caterpillars are dark brown in color. Egg and larval periods last for 3 to 4 and 9 to 10 days respectively. The entire life cycle lasts for 22 to 24 days.

4. COMPONENTS OF PEST MANAGEMENT

4.1. Cultural practices :

The need for ecologically sound, effective, and economic methods for pest control has prompted renewed interest in cultural methods. The use of cultural practices for insect control is best suited for sorghum growing regions because: they have become an integral component of crop husbandry practices, they involve no additional costs, and they do not harm the natural enemies. The cultural practices that help reduce insect damage are listed in Table 2.

4.2. Host plant resistance :

Host plant resistance as a method of pest control offers many advantages in the semi-arid tropics. The most attractive feature is that virtually no skill or cash investment is involved by the farmers. Host-plant resistance can be used as a principal component of pest control supplemented by cultural, biological, and chemical control in an integrated pest-management program. Sources of resistance to important sorghum pests have been identified (Table 3). Reasonable levels of resistance have been reported against shoot fly, stem borer, and midge. DJ 6514 and PM 11344 (SPV 692) are resistant to sorghum midge and are being introduced for cultivation in midge-endemic areas of Karnataka. M 35-1, which is less susceptible to shoot fly and stem borer, is widely cultivated in the postrainy season. SPV 504 and SPV 491 are less damaged by shoot fly and are being distributed to farmers in Maharashtra (D.R. Bapat, 1985; Mahatama Phule Krishi Vidyapeeth, Rahuri, Personal Communication). Cultivars with multiple resistance need to be developed for specific pests, and regions.

Host plant resistance may also enhance the effectiveness of Insecticides eg.,. loose panicles allow better penetration of the insecticides meant to kill panicle feeding insects, and provide easy access to parasites and predators. Resistance based on imbalanced nutrition or toxic substances increases the susceptibility of insects to insecticides (Sharma, 1985). Resistant cultivars also help preserve natural enemies through reducing the need to use pesticides.

4.3. Natural enemies :

Natural enemies of insects feeding on sorghum have been listed by Pradhan (1971), Reddy and Davies (1979), Gahukar and Jotwani (1980), Thontadarya *et al.* (1981), and Sharma (1985). The Natural enemies of important pests of sorghum are listed in Table 4. In sorghum, the scope for total biological control appears to be limited because there is no crop continuity to sustain the natural enemies and their hosts. Future research on natural enemies should focus on: activity periods, efficiency, usefulness, and studying farming systems, crop combinations, and crop cultivars that encourage the activity of natural enemies.

4.4. Chemical control :

Chemical control should only be adopted as a last resort. Varlous aspects of chemical control of insect pests of sorghum have been discussed by Gahukar and Jotwani (1980) and Sharma (1985). The insecticides reported to be effective against various insect pests of sorghum between 1960 to 1984 (Sharma, 1985) are depicted in Fig. 1.BHC, lindane, carbaryl, carbofuran, malathion, and endosulfan can be used effectively to control seedling pests. Depending on the insect to be controlled, time, and mode of application, dusts, granules, or sprays may be applied. Seed treatment with carbofuran, (0.5 g ai/kg) and mixing the treated seed with untreated seed (1 to $1\frac{1}{2}$ times) has given encouraging results for shoot fly control. For earhead pests, dusts or sprays of BHC, carbaryl, endosulfan, quinalphos, or malathion may be applied at the panicle emergence, half-anthesis, post-anthesis or milky stages depending on the pest to be controlled. Care should be taken to use insecticides that do not leave harmful residues on the grain. Considering the difficulties involved in conventional high volume spraying, dusts, granules, and ULV applications may be considered for applying insecticides.

4.5 Others :

Insect control involving pheromones, bacteria, viruses, chemosterilants, genetic sterility, irradiation, antifeedants, and repellents have been tried on some crops/insects with varying degrees of success. Sex pheromones can be used as male attractants for monitoring populations of *C. partellus* and *H. armigera.* Antifeedants from neem (*Azadirachta Indica* A. Juss) seed kernels reduce the damage by spotted stem borer, oriental armyworm, shoot bug, and head bug, and can result in a yield increase of 25-30% (Sharma *et al.*, 1983). More research is needed on the efficacy and usefulness of these control measures against the insect pests of sorghum.

5. CURRENT PEST CONTROL RECOMMENDATIONS AND SCOPE FOR ADOPTION ON FARMERS FIELDS

Most farmers consider pest control unnecessary until the damage becomes visible and threatens to reduce crop yields substantially. A number of pest control recommendations involving cultural practices, insecticides, and in some cases resistant varieties have been made. The main factors that seem to restrict the adoption of effective pest control measures are low benefit/cost ratios, non-availability of agronomically superior pest resistant cultivars, pesticides, and ignorance of the potential benefits of pest control.

6. STRATEGY FOR PEST CONTROL

Economic thresholds based on reliable means of monitoring pest populations or damage caused by them should form the basis of pest management. This information should be generated by the Agricultural Universities and Research Institutes, and then passed to extension agencies in a particular region for dissemination to the farmers.

Cultural pest control operations such as synchronous planting of the same cultivar, (particularly hybrids) or different cultivars with similar maturity with the first good monsoon showers can substantially reduce the damage by shoot fly, midge, and possibly head bugs by reducing the chances of population build up. Balanced fertilizer application, field sanitation, weeding, and cropping systems that help reduce insect damage should form an essential component of crop husbandry. Pest resistant cultivars with moderate yield and acceptable grain quality (e.g. SPV 504, SPV 491, M 35-1 against shoot fly and SPV 692 against midge) should be recommended for cultivation. Loose panicled cultivars should be grown in head bug and head caterpillar endemic areas. Granules, dusts, and ULV application of insecticides can be substituted for conventional high volume spraying. A pest control schedule for the management of insect pests of sorghum is given in Table 5.

7. NEED FOR FUTURE RESEARCH

The pest problems and their relative importance are fairly understood. However, pest surveys in farmers' fields need to be undertaken to determine the actual extent of pest caused losses. More emphasis should be placed on determining economic thresholds. Information is available on population fluctuations and biology of the important pest species. Simple techniques to monitor populations of aphids, shoot bug, midge, and head bugs need to be developed. The role of diapause/carryover in insect abundance and damage needs to be clarified.

A number of cultural practices are known to decrease insect damage, and studies should be undertaken to evaluate their effectiveness. The role of natural enemies in pest suppression needs to be determined in conjunction with other pest management practices. Sources of resistance have been identified against different insect pests. However, sources of stable resistance against aphids, shoot bug, armyworm, head bugs, and head caterpillars still need to be identified. Resistance to shoot fly, stem borer, and midge should be transferred to cultivars (preferably hybrid parents) with good agronomic backgrounds. Major emphasis should be placed on developing cultivars with multiple insect and disease resistance. A number of insecticides have been identified for the control of different insect pests. However, effective and economical pest control schedules for different agro-climatic zones need to be developed. Finally, an integrated pest management system involving cultural, biological, host-plant resistance, and chemical control should be developed for various agro-ecosystems.

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Table 1. Important insect pests of sorghum

Common name	Scientific name	Plant part damaged	Seasonal abundance	Off season carryover	Remarks
White grub	*Holotrichia consanguinea* Blanch.	Roots	Most damaging during June-July	Grubs	Endemic in light Sandy soils in Rajasthan and Maharashtra
Sorghum shoot fly	*Atherigona soccata* Rond.	Cuts the growing point in 5-15 day old seedlings resulting in deadheart formation	Most active during August-September	Alternate hosts and off-season sorghum	Severe infestation occurs on late rainy and early postrainy season crop
Spotted stem borer	*Chilo partellus* Swin.	Smaller larvae feed on leaves producing leaf scarification and shot holes. Third instar larvae bore at the base and produce a dead heart and tunnels the stem	Maximum damage occurs during August-September in North India and February-March in southern India	Diapausing larvae in stalks and stubbles	
Corn-leaf aphid	*Rhopalosiphum maidis* Fitch.	Sucks sap in the leaf whorls and panicle	Damage is greater during postrainy season	Winged adults migrate between crops and regions	Population builds up during dry periods
Shoot bug	*Peregrinus maidis* Ashm.	Sucks sap in the leaf whorls	Maximum damage occurs during postrainy season	—	Damage is greater during periods of drought
Oriental armyworm	*Mythimna separata* Walk.	Larvae defoliate the plants and sometimes feed on the panicle	Maximum damage occurs during August-September	Populations migrate across migrate regions and between cereal crops	Outbreaks occur during periods of prolonged drought preceded by high rainfall
Sorghum midge	*Contarinia sorghicola* Coq.	Larvae feed on the developing ovary	Maximum damage occurs during September-November	Diapausing larvae in dry sorghum heads	Most damaging in areas having staggared planting or different maturity cultivars
Head bug	*Calocoris angustatus* Leth.	Sucks sap from the developing grain	September-October in most areas	—	Damage is severe during rainy season
Head cater-pillars	*Heliothis armigera* Hb. *Eublema silicula* Swin. *Cryptoblabes gnidiella* Mill.	Larvae feed on the developing grain	August-September	*H. armigera* migrates between crops and possibly regions	Compact panicled genotypes suffer higher damage

Table 2. Cultural practices for reducing numbers/damage of important insect pests of sorghum

Cultural practice	Insect pests affected	Remarks
Crop rotation	Shoot, fly, midge, head bugs, and other mono or oligophagous insects	Unavailability of the main host plant checks the population build up. Sorghum is generally rotated with cotton, groundnut, sugarcane and pulses.
Cropping system	Shoot fly and midge	Sorghum-legume intercropping reduces the damage possibly by making the mircro-environment less hospitable to these insects.
Fallowing	Shootfly, head bug etc.	Non-availability of host-plants checks the population build up
Tillage	Spctted stem borer and white grubs	The carryover population is exposed to natural enemies and adverse weather conditions.
Fertilizer application	Shoot fly and spotted stem borer	Vigorously growing plants tend to escape dead heart formation.
Soil moisture	Shoot fly, spotted stem borer, and possibly shoot bug	Vigorously growing plants suffer less damage.
Timely, planting, high planting density and late thinning	Shoot fly, midge, and possibly head bugs	Timely and synchronously planted crop with similar maturity restricts the population build up these insects. High planting density and late thinning (after nearly 20-25 days) helps to reduce shoot fly damage.
Interculture	White grubs, and possibly shoot fly, and oriental armyworm	Larvae and pupae are exposed to natural enemies.
Weeding	Oriental armyworm	Weeds provide hiding space to the larvae.
Field sanitation	Spotted stem borer and midge	Collecting and burning of stubbles, stalks and chaffy sorghum heads reduces the carryover. Stalks should be fed to cattle before March.

Table 3. Sources of resistance identified against important insect pests of sorghum

Insect	Cultivar	Level of resistance	States recommended	Remarks	Reference
Atherigona soccata	M 35-1 (IS 1054)	Less susceptible	Central and Southern India	Popular in the postrainy season	Roshan singh and Narayana, 1978
	IS 5469 and IS 5440	Highly stable	—	Local cultivars	Singh et al. 1987
	PJ 3K, PJ 20K, PJ 4K, PJ 6K, PJ 34J, and PJ 14K	Most promising	—	—	Mote et al, 1981)
	PJ 4R × Shenoli 4-2-5, ND 15×, Improved Soaner 10, M 35-1X, PJ 4R 22, M 35-1XPJ 4-25, M 35-1X, Improved Soaner 12	Less susceptible	—	—	Bapat and Mote, 1982
	Improved Soaner, GM 2-3-1 and IS 3922	Less susceptible	—	—	Salunkhe et al., 1982
	IS 1082, IS 2122, IS 2195, IS 4663, IS 4664, IS 5490, IS 5484, IS 5565, and IS 18551	Less susceptible	—	Sources of shoot fly resistance	Sharma et al,. 1983b
Chilo partellus	E 302 (BP 53X KaferB) and E 303 (BP 53 × IS 3954)	Less susceptible	—	Sources of resistance	Jotwani et al., 1974
	DU 19, DU 98, DU 245, DU 291, U 218, U 373, U 358, and U 376	Less susceptible	—	Derivatives of M35-1XBP 53	Jotwani et al., 1979
	D 168, D 172, D 259, D 358, D 367, D 369	Shows stable resistance	—	Useful as sources of resistance	Singh et al., 1980
	E 501, E 502, E 503, E 504, E 601, E 602, E 603, and E 604	Highly promising with good agronomic characters	—	,,	Jotwani, 1982
	IS 1044, IS 2123, IS 2137, IS 2168, IS 2205, IS 2309, IS 5538, IS 5560, IS 5571, IS 5585, IS 5604, IS 5622, IS 7229, IS 18551, IS 18573, IS 18577, IS 18578, IS 18584, and IS 18662	Less susceptible	—	Sources of resistance	Sharma et al., 1983b

Contarinia sorghicola	DJ 6514	27.8 damage	Midge endemic areas of Karnataka	Highly resistant	Shyamsunder et al., 1975
	AF 28, DJ 6514, TAM 2566, IS 271, IS 2761, IS 3461, IS 7005, IS 8571, IS 8721, IS 9807, IS 10712, IS 12666C, IS 14889, IS 15107, IS 18733, IS 18836, IS 19474, IS 19512, IS 20506, and IS 21873	Received a damage rating of 3 compared to 5 in CSH 1	—	Sources of midge resistance	Sharma, 1984a
	PM 11344 (SPV 692)	Highly resistant	Under demonstration in Karnataka	It is highly resistant cultivar with acceptable grain quality	Agrawal et al., 1986
Calocoris angustatus	IS 2761, IS 17645, IS 17618	Less damaged under headcage	—	—	Sharma, 1984b
Heliothis armigera	Chencholam	Less damaged	Local cultivar in Tamil Nadu	—	Balasubramanian et al., 1979

Table 4 Natural enemies of some important insect pests of sorghum

Scientific name	Stage parатized/predated upon	Period of activity	Extent of mortality caused	Scientific name	Stage parasitized/ predated upon	Period of activity	Extent of mortality caused
Shoot fly				Oriental armyworm			
Abrolophus sp	Predates on larvae	—	16-60.	*Apanteles ruficrus* Hal.	Larval	Aug.Sept.	upto 60%
Aprostocetus sp	Larval	—	—	*Carcelia* spp	Larval	Aug.-Sept.	—
Calitula bipartiıus Frq.	Larval	—	—	*Disophrys alhopilosellus Cam*	Larval	Sept.-Dec.	—
Cartaepiella sp	Larval	—	—	*Exorista xanthaspis* Wied.	Larval, Ex-Lar.	July-Sept.	—
Diaulinopsis sp	Larval	—	—	*Metopius rufus* Cam.	Larval	,,	—
Ganaspis sp	Larval	Oct.	2%	*Metopius* sp	Larval		—
Hemiptarsenus sp	Larval	—	—	*Palexorista solemmis* Walk.	Larval	Aug.-Sept.	—
Monelta sp	Larval	—	—	Sorghum midge			
Psilus sp	Larval	—	—	*Apanteles* sp	Larval	—	—
Spalangia indicus Walk.	Larval	—	—	*Aprostocetus* sp	Larval	—	—
Tetrastichus neymitawus Roh.	Larval	—	—	*Daryhelea* sp	Predates on larvae		—
Trichogramma chilonis Ishu	Egg	—	—	*Eupelmus popa Gir.*	Larval		
Trichogramma japonicum Ashm.	Egg	Oct.	8%	*Orius maxidentex* Ghauri	Predates on adults		—
Trichogrammatoidea sp	Egg	Oct.	8%	*Scymnus nubilus* Muls.	Predates on adults		—
Trichopria sp	Larval	—	—	*Tapinoma indicum* Forel.	Predates on adults		—
Spotted stem borer				*Tetrastichus coimbatorenis* Roh.	Larval	—	—
Adoxomyia heminopla Wied.	Larval	—	—	*Tetrastichus diplosidis* Crawt.			

Apanteles flavipes Cam.	Larval	July-Nov.	17%
Bracon chinensis Szepl.	Larval	—	—
Brumoides suturalis Fab.	Pradates on larvae	—	—
Carcelia sp	Larval/Ex-larval	July-Nov.	5%
Ceraphron jijiensis Ferr.	Larval	—	—
Chelonus sp	Larval	July	—
Chlaenius hamifer Chaud.	Predates on larvae	—	—
Coccinella septempunctata Linn.	,,	—	—
Coccinella undecimpunctata Linn.	,,	—	—
Enicospilus sp	Larval	August	10%
Eurytoma sp	Attacks larvae	—	—
Glyptomorpha deesae Cam.	Paupal	—	—
Halidaya luteicornis Walk.	Larval	—	—
Hyperchalcidia soudanensis Steff.	Papul	—	—
Invreia sp	Pupal	—	—
Menochilus sexmaculata Fab.	Predates on larvae	—	—
Microplitis sp	Larval	—	—
Palexorista sp	Larval	July	10%
Pseudalsomyia sp	Larval/Pupal	—	—
Stenobracon deesae Cam.	Attacks larvae	—	—
Sturmiopsis inferens Tns.	Larval	July	3%
Tetrastichus ayyari Roh.	Pupal	August	—
Trathala flavoorbitalis Cam.	Larval	—	—
Trichogramma chilonis Ishii	Egg	—	—
Xanthopimpla stemmator Thnb.	Pnpaul	—	—

Head bug			
Componotus compressus Linn.	Predates on nymphs/adults		—
Componotus paria Emer.	..		—
Cephalosporium sp (Fungus)	Parasitic on nymphs/adults		—
Rhinocoris fuscipes Fab.	Predates on nymphs/adults		—
Head caterpillars			
Apanteles sp	Larval	Sept.	1%
Campoletis chloridleae Uch.	Larval	Sept.	90%
Disophrys sp	Larval	Sept.	1%
Carcelia illota Curran	Larval	Aug-Dec.	18%
Eriborus argenteopilosus Cam.	Larval	Aug-Dec.	32%
Eriborus trichanteratus Morl.	Larval	Sept.	6%
Exorista xanthaspis Wied.	Larval	Sept.	17%
Delta companiforme F.	Predates on larvae	—	—
Delta conoideus C.	Predates on larvae	—	—
Goniophthalmus halli Mes.	Larval	Sept	6%
Menochilus sexmaculatus F.	Predates on larvae		
Microchelonus curvimaculatus Cam.	Larval	Aug.-Sept.	10%
Overmis albicans Sieb.	Larval		
Palexorista laxa Curr.	Larval	Aug.-Sept.	4%
Palexorista solennis Walk.	Larval	Aug.-Sept.	6%
Paromius gracilis Ramb.	Predates on larvae	—	—
Sturmiopsis interens Tns.	Larval	Sept.-Oct.	4%
Temelucha sp	Larval	Aug.-Sept.	16%
Trichogramma chilonis Ishii.	Egg	—	—
Trichogrammatoidea bacctrae sp. *fumata* Nag.	Egg.	—	—
Tropiconabis capsiformis Ger.	Predates on larvae	—	—

1. Based on reports published between 1969 to 1985 (Sharma, 1985)

Fig.1 . Chemical control of important insect pests of sorghum.[1]

Insects \ Insecticides	Aldicarb	BHC	Carbaryl	Carbofuran	Carbophenathion	Chlorfenvinphos	Cypermethrin	Deltamethrin	Diazinon	Dichlorvos	Dimethoate	Disulfoton	Endosulfan	Ethion	Fensulfothion
Shoot-fly	■		■	■					■		■	■	■		■
Stem-borer			■	■									■		
Army-worm		■	■								■		■		
Sorghum-midge		■	■		■	■			■	■	■	■	■	■	
Head bug		■	■		■	■			■				■		
Head caterpillars		■	■				■	■		■	■		■		

Insects \ Insecticides	Fenvalerate	Isophenphos	Lindane	Malathion	Mephospholan	Methamidophos	Methyl-demeton	Methyl-parathion	Monocrotophos	Permethrin	Phenthoate	Phorate	Phosalone	Quinalphos	Tetrachlorfenvinphos
Shoot-fly	■	■			■		■		■			■	■		
Stem-borer	■		■	■					■		■			■	
Army-worm				■											
Sorghum-midge	■		■	■		■	■	■	■	■	■		■	■	■
Head bug	■		■	■										■	
Head caterpillars	■								■	■	■			■	

[1] Based on reports published between 1965 to 1982 (Sharma, 1985)