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RECENT ADVANCES IN ENTOMOLOGY

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PREFACE

During the recent past, a large volume of Indian literature on different aspects of entomological research has appeared which indicates the rapid strides of the subject. It was, therefore, decided by the organising committee of National Conference on Key Pests of Agricultural Crops & their Management, to compile up-todate literature in a book form for students, teachers, research and extension workers engaged in the field of Entomology. In order to incorporate the best possible coverage on different relevant aspects, a number of eminent & experienced authors have been requested to make contribution in their field of specialization.

This volume deals with polyphagous pests, management of Agricultural and Horticultural crops. The articles provide detailed accounts on the bionomics and management of various noxious pests. All possible efforts have been made to include latest information on these aspects in the present document. We hope that this publication would certainly be useful for the students of entomology, research and the extension workers.

Kanpur
November 15th, 1987. Editors

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Host-Plant Resistance In The Management Of Sorghum Stem Borers

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Sorghum is an important cereal crop in the semi-arid tropics (SAT). In India, it is grown during the rainy (*kharif*) and the postrainy (*rabi*) seasons. In central and southern India, sorghum is cultivated for grain and fodder purpose while in northern India it is primarily grown as a fodder crop. Nearly 150 insect species have been reported as pests or potential pests of sorghum (Young and Teetes, 1977; Seshu Reddy and Davies, 1979a; FAO, 1980). However, the most widespread and devastating insect pests of sorghum in the SAT as a whole are shoot fly, several species of stem borers, armyworm, midge, head bugs and head caterpillars.

Stem borers constitute the most widely distributed and serious group of insect pests of sorghum in the world. (Table 1). Plant damage is caused by larvae feeding in the leaf whorls or in the stem. Due to their internal feeding habits, larvae are protected to a large extent from natural enemies (predators and parasites), unfavourable environmental conditions, and insecticides. Host-plant resistance offers an economic, efficient, and a long term solution to manage these insects either alone or in combination with other methods of control. Host-plant resistance has several advantages : it avoids environmental pollution, it is compatible with natural control processes, it integrates effectively with other pest control tactics, and involves no additional costs to the farmer. Therefore, an attempt has been made to present an overview of host-plant resistance, and its potential in the management of stem borers in sorghum.

Distribution and Biology

Twenty three species of stem borers are known to infest sorghum (Table 1) which belong to several genera within two families (Tams and Bowden, 1953; Ingram, 1958; Nye, 1960; Harris, 1962; Bleszynski, 1970; Sandhu and Ramesh

Chander, 1975). The most important borer species attacking sorghum are *Chilo partellus* Swinhoe and *Sesamia inferens* Walker in Asia; *Busseola fusca* Fulle *C. partellus*, *Sesamia calamistis* Hampson and *Eldana saccharina* Walker in Afric *Sesamia cretica* Laderer in Mediterranean Europe and Middle East; and *Diatra* spp. in southern United States, Mexico and New World Tropics (Young, 197 FAO, 1980).

Distribution of different stem borer species is influenced by altitu rainfall and temperature. In warm and low altitude areas, *C. partellus* is t most important stem borer, however, it has been recorded at altitudes rangi from 21 to 1678 m (Seshu Reddy, 19[illegible]). Ingram (1958) reported that *C. partel* could not live above 1220 m in western Uganda or 1525 m in eastern or northe Uganda. Nye (1960) also found it in the coastal and plateau regions of E Africa up to 1525 m. *B. fusca* was found to be the dominant stem borer spec in cooler and high altitude areas above [illegible] m. Nye (1960) reported that t species was distributed in areas over [illegible] m and is unable to tolerate the h temperatures occurring below 610 m in East Africa. In West Nile, *B. fusc* common above 1220 m (Ingram, 19[illegible]). *S. calamistis* has been recorded in [illegible] areas in Kenya from sea level up to [illegible] m (Seshu Reddy, 1983), but in same region Nye (1960) recorded this borer at all altitudes from

Table 1

Species of stem borers infesting sorghum

Species	Family	Common name	Distribution
Acigona ignefusalis Hampson	Pyralidae		West Africa
Busseola fusca Fuller	Noctuidae	Maize stalk borer	Africa
Busseola segeta Bowden	Noctuidae	–	East Africa
Chilo agamemnon Bleszynski	Pyralidae	-	
Chilo diffusilineus J.de Joannis	Pyralidae	–	
Chilo infuscatellus Snellen	Pyralidae	Yellow top borer	Indian subcontinent, Taiwan Java, Korea
Chilo orichalcociliellus Strand	Pyralidae	–	East Africa
Chilo partellus Swinhoe	Pyralidae	Spotted stem borer	East Africa, Indian subcontinent, Sri Lanka,

Species	Family	Common name	Distribution
			Thailand, West Africa
Diatraea grandiosella **Dyar**	Pyralidae	South Western corn borer	South Western U.S. Mexico, New world
Diatraea lineolata **Walker**	Pyralidae	—	New world
Diatraea saccharalis **F.**	Pyralidae	Sugarcane borer	Southern U. S. New world Tropics
Elasmopalpus lignosellus **Zell.**	Pyralidae	Lesser corn stalk borer	North, Central and South America
Eldana saccharina **Walker**	Pyralidae	Sugarcane borer	West & East Africa
Ematheudes **spp.**	Pyralidae	—	
Maliarpha sepratella **Rag**	Pyralidae	Green striped borer	
Ostrinia nubilalis **Hbn**	Pyralidae	European corn borer	North east & Central U. S., Europe, W. Asia, Asia minor, the Caucasus, China
Procerus venosatus **Walker**	Pyralidae		
Sesamia botanephaga **Tams & Bowden**	Noctuidae	—	West & East Africa
Sesamia critica **Lederer**	Noctuidae	Sorghum borer	South & Eastern Europe, Morocco, Middle East
Sesamia calamistis **Hampson**	Noctuidae	Pink borer	Africa
Sesamia inferens **Walker**	Noctuidae	Pink stem borer	Indian sub continent, S. E. Asia, China, Japan, Philippines
Sesamia penniseti **Tams & Bowden**	Noctuidae	—	Africa
Sesamia poephaga **Tams & Bowden**	Noctuidae	—	Africa

level to 2440 m. *E. saccharina* was found on sorghum and maize in Western and Nyanza Provinces of Kenya upto 1525 m (Seshu Reddy, 1983). Ingram (1958) indicated that *E. saccharina* was not a pest in East Africa while Girling (1978) found it in maize, sorghum and sugarcane and commented that it was becoming a serious pest in East Africa.

Most of the borer species (*Chilo, Busseola, Sesamia, Diatraea, Eldana*) lay eggs in batches, which hatch in about 4 to 6 days. The larval period is mostly spent inside the stems, and lasts for 2 to 3 weeks. Pupation takes place mostly in the stem, and the adult emerges within a week. Thus, the whole life cycle is completed in about a month and 3-4 generations in single crop growing season. In areas where there is one crop per year, the larvae enter into diapause during the off-season in stalks and stubbles. In southern India, where environmental conditions are equitable, *C. partellus* remains active throughout the year. There may be up to ten generations per year in this area. In case of *D. saccharalis*, the larvae girdle the stalk near the ground and hibernate below girdling. Besides sorghum, a number of cultivated and wild host plants have been reported (Ingram, 1958; Nye, 1960; Harris, 1962, Young and Teetes, 1977, FAO, 1980). Maize pearl millet, rice, and sugarcane are the major cultivated crop hosts, while *Sorghum halepense, S. verticilliflorum, Pennisetum purpureum, Panicum maximum* are some of the wild host plants.

Crop Losses

Early attack of borers may kill young plants by causing 'dead hearts', thereby reducing the crop stand, while attack during later growth stages reduces yield by larval feeding in the leaves and stems. Stem tunneling weakens stems, which may cause lodging and also interferes with the supply of nutrients to the developing grains and results in chaffy panicles. Trehan and Butani (1949) reported borer infestation up to 70 per cent, but estimated that the average infestations in Maharashtra did not exceed 5 per cent. In a field survey, where 73.6 per cent of the plants were affected by *C. partellus*, the grain loss was estimated to be about 112 kg/hectare. Pradhan and Prasad (1955) reported a 0.9 g average decrease in yield per plant with each unit increase in percentage of stem length tunneled. Overall losses due to stem borers may be 5 to 10 per cent in many sorghum-growing areas, especially where early infestation takes place (Jotwani, 1972). The avoidable grain losses due to the spotted stem borer on the susceptible sorghum cultivars CSH 1 and Swarna have been estimated between 55 and 83 per cent in northern India (Jotwani *et al.*, 1971 b).

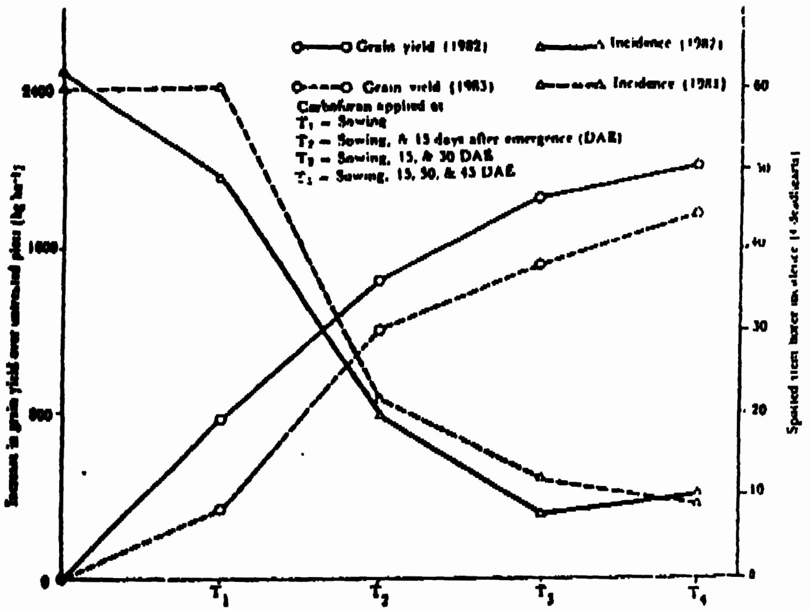

Figure 1. Effect of stem borer infestation on grain yield of sorghum hybrid CSH 1

Experiments at ICRISAT Center have indicated that crop protection against stem borer in the early growth stages contributed to the maximum yield increase on sorghum hybrid CSH 1 (Fig. 1). Deadhearts caused by stem borer resulted in a significant reduction in yield. The correlation coefficient between the number of deadhearts and yield was –0.9**. Stem tunneling up to 60 per cent in any portion of the stem did not cause any reduction of grain yield in CSH 1 (Taneja and Leuschner, 1985).

Host-Plant Resistance

Most of the work on host-plant resistance to stem borers has been confined to *C. partellus*. The earliest report on sorghum cultivars resistant to stem borer is by Trehan and Butani (1949). Pant *et al.* (1961) and Swarup and Chaugale (1962) reported some sorghum varieties to be less damaged by spotted stem borer. A systematic screening of the world sorghum germplasm collection against stem borer was initiated in 1962 in India (Singh *et al.*, 1968; Anonymous, 1971 and 1978). Since then, screening has been continued by the All India Coordinated Sorghum Improvement Project (AICSIP) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

The development of host-plant resistance requires detailed information of knowledge of the ecology of the insect and its relationship with host plant, development of an effective and reliable screening techniques, reliable criteria for measuring resistance, identification of stable sources of resistance, a knowledge of the genetics of resistance, and the incorporation of genes for pest resistance into elite agronomic backgrounds.

Resistance Screening Techniques

An efficient and reliable screening technique should ensure uniform and sufficient 'insect pressure' at the most susceptible stage of the crop. These requirements can be achieved either by selecting a location where the pest occurrence is adequate and regular, 'a hot-spot' or by testing the material under artificial infestations with laboratory-reared insects. Screening under natural conditions requires information on the population dynamics of the insect. With this information the time of sowing can be adjusted so that the susceptible stage of the crop coincides with the peak activity period of the insect. Hisar, in northern India is such a 'hot-spot' for the spotted stem borer (*C. partellus*), where severe borer infestation occurs on sorghum planted during the first fortnight of July (Taneja and Leuschner, 1985).

The screening of sorghum cultivars for *C. partellus* resistance under artificial infestation has been carried out by rearing insects on natural (Singh *et al.*, 1983) and synthetic diets (Chatterji *et al.*, 1968; Dang *et al.*, 1970; Lakshminarayana and Soto, 1971; Siddiqui and Chatterji, 1972; Siddiqui *et al.*, 1977; Sharma and Sarup, 1978; Seshu Reddy and Davies, 1979b). Taneja and Leuschner (1985) have described rearing, field infestation and evaluation methods for *C. partellus* resistance in sorghum. Screening for *Diatraea* spp. resistance under artificial infestation is carried out at CIMMYT, Mexico (Mihm, 1985). *S. inferens* (Chatterji *et al.*, 1969), *B. fusca* (van Rensburg and Walters (in press), and *D. saccharalis* (Dinther and Van Goozens, 1970, Miskimen, 1965) have also been reared on artificial diet for field infestation.

Selection Criteria for Resistance

Stem borer attack in sorghum causes leaf damage, dead hearts and stem tunneling. All these symptoms of attack are not necessarily related to loss in grain yield. Brar (1972) reported that leaf injury caused by the spotted stem borer varies over time because the plant recovers by producing new leaves. However, Singh and Sajjan (1982) observed a positive relationship between leaf injury score and grain yield loss in maize. Stem tunneling is not related to grain yield reduction in sorghum (Singh *et al.*, 1983; Pathak and Olela, 1983; Taneja and Leuschner, 1985). Singh *et al.* (1968) indicated that deadheart formation is the most stable criterion to select for stem borer resistance. Taneja and Leuschner (1985) observed a highly significant and negative relationship between deadhearts and grain yield of sorghum. Thus the rank order for damage criteria is deadheart, leaf injury and stem tunneling.

Identification of Resistant Sources

A number of sorghum germplasm lines and their derivatives have been reported to be the resistant to spotted stem borer (*C. partellus*) by various workers in India and elsewhere (Singh *et al.*, 1968; Anonymous; 1971; Jotwani *et al.*, 1974; Kundu and Jotwani, 1977; Anonymous, 1978; Jotwani *et al.*, 1979; Singh *et al.* 1980; Dalvi *et al.*, 1983; Singh *et al.*, 1983; Sharma *et al.*, 1983; Taneja and Leuschner, 1985). Fig. 2 shows the flow chart for the identification of sources of resistance followed at ICRISAT Centre. Nearly 12000 germplasm lines have been tested for *C. partellus* resistance for more than three seasons, and 61 lines have been found to be resistant (Table 2). Of these, IS 5470, IS 5604, IS 8320 and IS 18573 have been found to be stable for resistance over locations. Twenty eight lines showed <40 per cent borer incidence with moderate levels of stability for resistance as compared to 70 per cent incidence on sorghum hybrid CSH 1. Thirty six of these lines originated in India, eight in Nigeria, seven in USA, four in Sudan, two in Uganda and one each in Ethiopia and Zimbabwe. Taxonomically, 84 per cent of the resistant lines belong to *durra*, 10 per cent *durra membraceum*, 4 per cent *bicolor* and 2 per cent *guinea bicolor*. In addition, selections from 9000 germplasm lines are under various stages of testing.

Mechanisms of Resistance

Although, ovipositional nonpreference, is not a strong resistance mechanism against stem borers, some cultivars have been reported to be less preferred by the *C. partellus* moths for egg laying (Rana and Murty, 1971; Lal and Pant, 1980a; Singh and Rana, 1984). The main mechanisms of resistance to *C. partellus* in sorghum have been reported to be antibiosis and tolerance (Pant *et al.*, 1961; Kalode and Pant, 1967a; Jotwani *et al.*, 1971a; Jotwani, 1976; Pathak

and Olela, 1983; Singh and Rana, 1984). High mortality in larval stages (Jotwani *et al.*, 1978; Lal and Pant, 1980b) have been reported in resistant

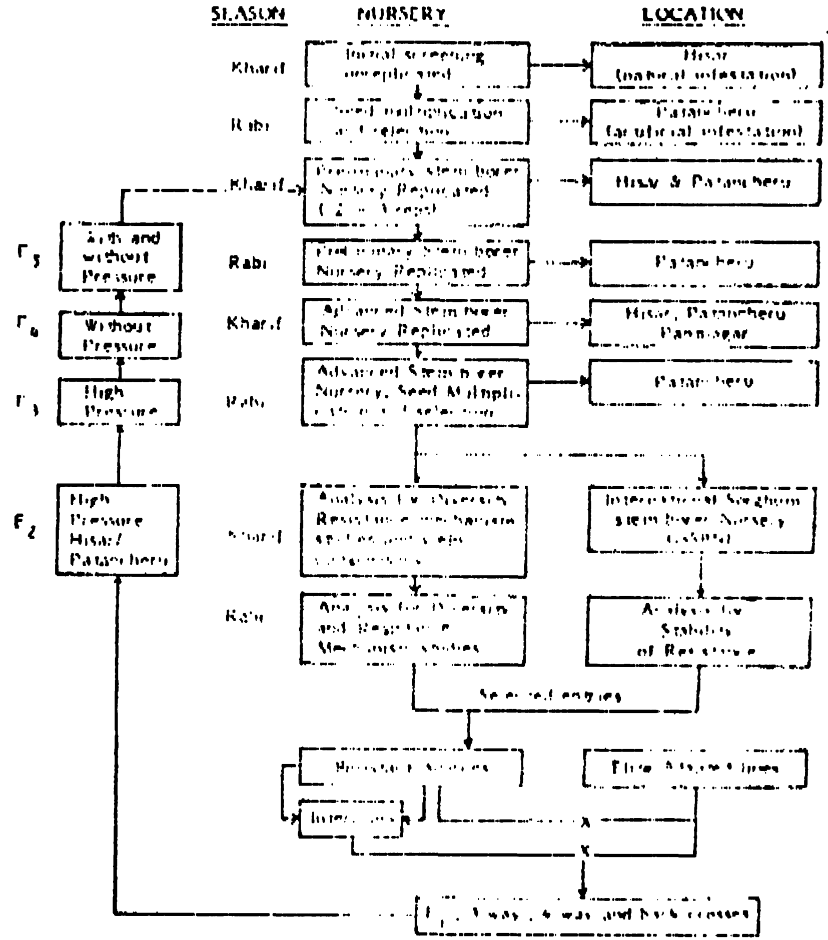

Figure 2 SCREENING FOR STEMBORER RESISTANCE IN SORGHUM AT ICRISAT CENTER

TABLE 2

Sorghum germplasm lines identified as resistant to stem borer at ICRISAT Center (Taneja and Leuschner, 1985)

Pedigree	Origin	Stem borer Damage (deadhearts)
IS 1044	India	32.9
1082	India	45.3
1119	India	42.4
2122	USA	35.8
2123	USA	30.6
2146	USA	46.1
2168	USA	50.4
2195	India	43.8
2205	India	40.6
2263	Sudan	38.1
2269	USA	48.6
2291	Sudan	31.7
2309	Sudan	33.8
2312	Sudan	33.3
4273	India	63.9
4546	India	43.9
4637	India	41.4
4756	India	38.1
4776	India	38.0
4881	India	41.0
4981	India	48.3
5075	India	49.5
5253	India	53.4
5429	India	41.1
5469	India	28.3
5470	India	35.5
5480	India	37.9
5538	India	33.1
5566	India	32.9
5571	India	35.3
5585	India	35.2
5604	India	23.3
5622	India	41.0
7224	Nigeria	44.4
8320	India	33.6
8811	Uganda	56.4
10711	USA	38.7
12308	Zimbabwe	38.0
13100	India	36.8
[illegible]	Uganda	33.9
17742	India	44.6
17745	India	44.4
17747	India	51.4
17750	India	47.5
17948	India	43.6
17966	India	45.4
18333	India	48.1
18366	India	53.7
18551	Ethiopia	36.0
18573	Nigeria	24.0
18577	Nigeria	34.9
18578	Nigeria	40.6
18579	Nigeria	34.6
18580	Nigeria	49.8
18584	Nigeria	40.5
18585	Nigeria	43.8
18662	Nigeria	39.0
19677	India	45.8
20643	India	47.6
SB 8530	USA	39.0
PB 825..		59.4
CSH 1		70.4

1/ Mean of six replicated trials.

cultivars. Dabrowski and Kidiavai (1983) have found that ovipositional non-preference, reduced leaf feeding, low deadhearts and stem tunneling and tole rance to leaf and stem feeding contribute to resistance. Marked differences in the establishment of first instar larvae among resistant and susceptible cultivars have been reported by Chapman *et al.* (1983) and Bernays *et al.* (1983). Surface waxes on the leaf and stem probably affect the movement of first instar larvae, and some wax components act as feeding deterrents (Woodhead, 1983). Low sugar content (Swarup and Chaugale, 1962), amino acids, total sugars, tannins, total phenols, neutral detergent fibre (NDF), acid detergent fibre (ADF), lignins (Khurana and Verma, 1982; 1983); and high silica content (Narwal, 1973) have also been reported to be associated with *C partellus* resistance in sorghum.

Genetics of Resistance

Rana and Murty (1971) reported that resistance to stem borer is polygenically inherited. They found that resistance to primary damage (leaf feeding) was governed by additive, and additive x additive type of gene action while additive and non-additive type gene action were important for secondary damage (stem tunneling). Pathak and Olela (1983) reported that resistance to *C. partellus* for primary damage i.e. deadhearts' was governed by both additive and non-additive type of gene actions while resistance for secondary damage i.e. stem tunneling was governed predominatly by additive gene action. It was also noted that the inheritance pattern of primary and secondary damage was different. Haji (1984) found that resistance to *C. partellus* was polygenically governed. The epistatic gene affects were more pronounced under artificial infestation. He also noticed that under natural infestation, resistance was controlled by additive and dominant major gene affects. Cytoplasmic influences were present, which may play an important role in the inheritance of stem borer resistance.

Breeding for Resistance

The quantitative nature of the inheritance of resistance to stem borers makes the breeding task difficult because both resistance and yields are quantitatively controlled trails. Both pedigree and population breeding methods have been used to incorporate resistance into good agronomic backgrounds. Pedigree breeding has been used at ICRISAT Center as a short term approach. The use of broad based, random mating pest resistant populations is a long term approach for breeding sorghums resiatant to stem borers (Agarwal and House 1982).

Starks and Dogget (1970) described the breeding methodology to incorporate resistance to stem borer in sorghum. They concluded that an effective

method of developing cultivars possessing resistance to *C. partellus* should involve population breeding. All plants in a composite population or the S1 lines from a composite population should be infested with egg masses 20 days after plant emergence. The crop should then be evaluated for yield using recurrent selection. At ICRISAT Center a shoot pest (shoot fly and stem borer) population is being developed using ms 3 and ms 7 male sterility genes (Agarwal and House, 1982; Agarwal and Abraham, 1985). Once this population is improved for characters like height, maturity, grain quality and resistence, S2 testing will be used. Major selection pressure is placed on resistance to shoot pests (deadhearts) so that only undamaged plants are advanced to the next generation.

There are three basic units in pest resistance breeding approach (Agarwal and House, 1982). Unit 1 involves the strengthening of source material, unit 2 the development of agronomically elite lines, and unit 3 the crossing of material identified in units 1 and 2. Unit 1 segregating material is advanced with continuous testing (selecting undamaged plants) using different levels of insect pressure. Jotwani *et al.* (1974) bred two *C. partellus* resistant varieties E 302 and E 303 by incorporating resistance from a local cultivar BP 53. Several varieties have been identified with high levels of resistance to *C. partellus* (Anonymous, 1978, Singh *et al.*, 1980; Kishore, 1984 b). Singh *et al.* (1983) concluded that inspite of the low heritable nature of stem borer resitance (leaf feeding and stem tunneling), it is possible to develop cultivars with stable resistance by continuous selection under high infestation in advanced generations of agronomically improved progenies of susceptible (high yielding) resistant crosses

Host-Plant Resistance in Integrated Pest Management

Integrated pest management involves a variety of pest suppression measures that suppress pest density and damage and favours crop production. There are several ways by which host-plant resistance can be used in an integrated pest management programme. Ideally, resistant cultivars should provide complete and permanent control. However, high levels of resistance have not been transferred in high yielding cultivars. Also high resistance may result in the development of insect biotype which will be able to infest the previously resistant cultivars. Thus host plant resistance can be used as a component of integrated pest management in combination with other control measures such as cultural, biological and chemical methods.

Resistant Cultivars and Economic Thresholds

Economic threshold level (ETL) is the pest density at which control measures should be used to prevent the increasing pest density from reaching the level that causes economic damage. An insect resistant cultivar may lower pest density or raise the ETL depending on the type of resistance. Antibiosis and non-preference result in lowering the pest density, whereas tolerance type of resistance raises the ETL (Teetes, 1982). In the case of stem borers infesting sorghum, antibiosis and tolerance, the main resistance mechanisms, lower the pest density as well as raise the ETL (Fig. 3).

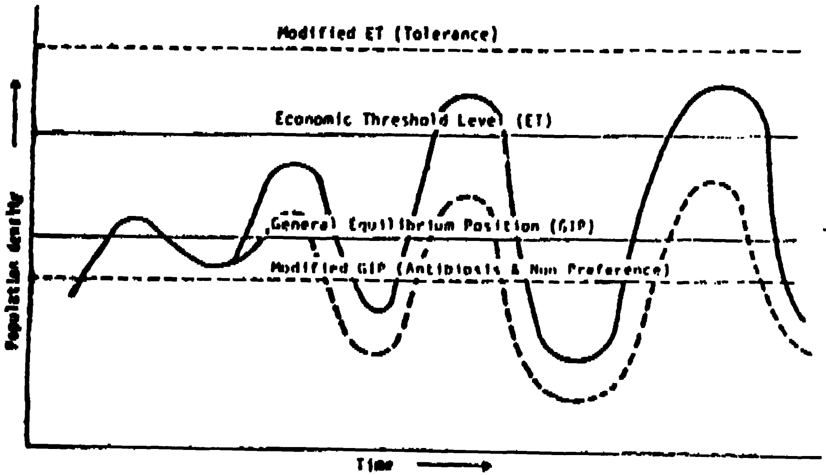

Figure 3. Schematic illustration of the fluctuation of theoretical insect population in relation to general equilibrium position, economic threshold and resistant cultivars

Antibiosis to *C. partellus*, as expressed by the high mortality in larval stages (Jotwani *et al.*, 1978; Lal and Pant, 1980b), may reduce the borer density by inducing a constant level of suppression on each pest generation (Table 3). It will reduce the rate of population increase and retard population growth. Therefore, ETL is not reached or is reached at a later point in time depending on the level of resistance (Fig. 4). If a large area is occupied by a resistant cultivar, the reduction in pest density will be cumulative over time

TABLE 3

Theoretical rate of increase of *C. partellus* population on a susceptible and two resistant cultivars that reduce population size by 25%, and 50% respectively, in each generation. Assume fivefold rate of increase per generation (Adapted from Knipling, 1964)

Generation	Number of insects		hectare
	Susceptible cultivar	Resistant cultivar-1	Resistant cultivar-
First year			
parent	100	100	100
F1	500	375	250
F2	2 500	1 406	625
F3	12 500	5 273	1 562
F4	62 500	19 775	3 906
Assume all insects enter diapause at the end of first year of which only 5% survive			
Second year			
parent	3 125	983	195
F1	15 625	3 705	488
F2	78 125	13 893	1 219
F3	390 625	52 101	4 047
F4	1 953 125	195 380	[illegible] 917

(Table 3). Lengthening of the larval period on resistant cultivars has also been reported (Anonymous, 1978), which implies that the number of genera-

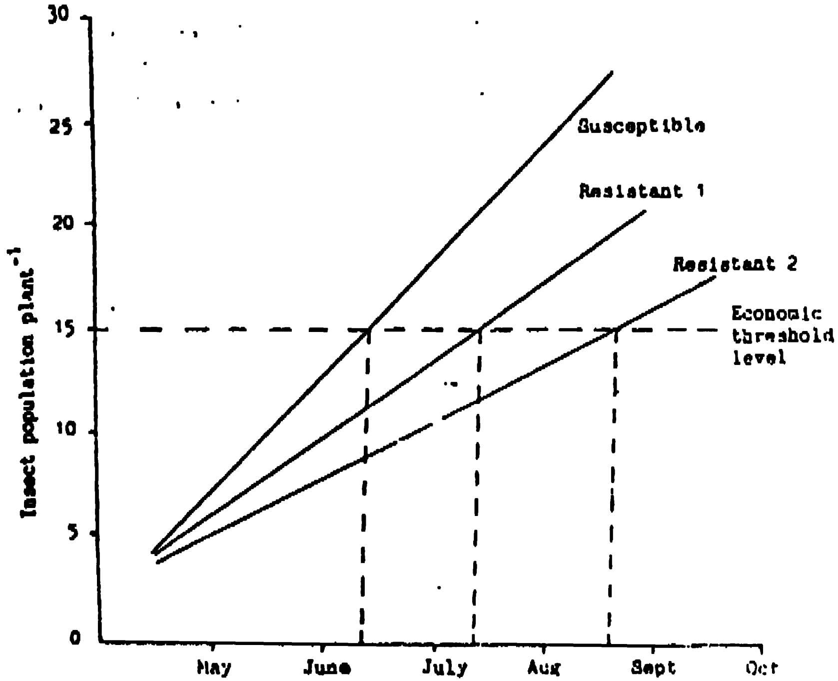

Figure 4. Theoretical population trends of a hypothetical insect population on susceptible variety, resistant variety 1, and 2, and its influence in relation to time.

tions per season or year is reduced (Table 4). Incorporation of resistance not only increases the ETL but also delays the time when that level is reached (Teetes 1982).

TABLE 4

Theoretical rate of increase of *C. Partellus* population on a susceptible and two resistant cultivars that reduce one generation with same and 50% reduction in population size per generation, respectively. Assume fivefold rate of increase per generation. (Adapted from Knipling, 1964)

Generation	Number of insects		hectare
	Susceptible cultivar	Resistant cultivar-1	Resistant cultivar
First year			
Parent	100	100	100
F1	500	500	250
F2	2 500	2 500	625
F3	12 500	12 500	1 562
F4	62 500	–	—
Assume all insects enter diapause at the end of first year of which only 5% survive			
Second year			
Parent	3 125	625	78
F1	15 625	3 125	195
F2	78 125	15 625	975
F3	390 625	78 125	4 875
F4	1 953 125	—	—
End of Second year	1 953 125	78 125	4 875

Resistant Cultivars and Cultural Control

The following agronomic practices have some potential in reducing th stem borers population in sorghum : destruction of crop residues and alternat hosts (Duerden, 1953; Atkins, 1957; Ingram, 1958; Bowden, 1976; Girling, 1978); tillage and mulching (Du Plessis and Lea, 1943; Kaufmann, 1983); time of planting (Swaine, 1957; National Academy of Sciences, 1969; Bowden, 1976); multiple and intensive cropping (Bytinski-Salz, 1965); intercropping (Kaufmann, 1983; Ogwaro, 1983); fertilizer use (Singh and Shekhawat, 1964; Kalode and Pant, 1967b; Singh and Singh, 1969; Singh, *et al.*, 1968; Starks *et al.*, 1971), and irrigation (Chowdry and Sharma, 1960). These practices can be used along with growing resistant cultivars, which will further reduce the population buildup of the pest.

Resistant Cultivars and Biological Control

Scope for biological control in sorghum appears to be limited because of the non-continuity of the crop. Growing of resistant cultivars may increase the effectiveness of natural enemies. Resistant cultivars help in the efficiency of bio-control agents by lengthening the larval period of stem borers (Anonymous, 1978) and by exposing the young larvae outside the feeding sites for a longer period (Chapman *et al.*, 1983). This will provide more time for the natural enemies to find their prey.

A number of predators and parasites attacking sorghum stem borers have been reported. *Trichogramma chilonis* Ishii is the only egg parasite (Anonymous, 1981), while a large number of larval and pupal parasites and predators have been recorded on *C. partellus* (Jotwani and Verma, 1969; Anonymous, 1971; Jotwani *et al.*, 1972; Sandhu, 1977; Seshu Reddy and Davies, 1979a; Anonymous, 1981).

Resistant Cultivars and Chemical Control

Effectiveness of chemical control increases when used in combination with resistant cultivars provided need based application is practiced. Effectiveness of chemical control in conjuction with growing resistant cultivars increases because of the following reasons : slower growth and lengthening of the larval period on resistant cultivars (Anonymous, 1978) increases the chances of borer larvae to come in contact with the chemical; more dispersal of early instar larvae on resistant cultivars (Chapman *et al.*, 1983) make them more vulnerable to chemical contact; by raising the economic threshold level and by reducing the frequency of application. Kishore (1984a) reported no net monetory benefit with even two insecticide applications in 12 stem borer resistant lines while insecticide applied to a susceptible hybrid CSH 1 increased the grain

yield substantially. Similarly, Kishore and Govil (1982) recommended two resistant cultivars P 37 and P 151 for general cultivation without insecticide control against stem borer.

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