SCREENING OF SOME ELITE SORGHUM HYBRIDS FOR RESISTANCE TO INSECT PESTS OF SORGHUM

BY

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B.Sc.(Agri.)

DISSERTATION

Submitted to

the Marathwada Agricultural University

in partial fulfilment of the

requirement for the Degree of

MASTER OF SCIENCE
(Agriculture)
IN

AGRICULTURAL ENTOMOLOGY

DEPARTMENT OF ENTOMOLOGY
MARATHWADA AGRICULTURAL UNIVERSITY,
PARBHANI 431 402 (M.S.), INDIA.

2001

Dedicated

To My

Beloved Parents

CANDIDATE'S DECLARATION

I hereby declare that this dissertation

or part thereof, has not been

previously submitted by

me for a degree of

any University

Place : PARBHANI
Date :30 / 06 /2001

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CERTIFICATE-I

This is to certify that **Shri AVISHKUMAR MAHADEVRAO SONONE** has satisfactorily prosecuted his course of research work for a period not less than four semesters and that the dissertation entitled **"SCREENING OF SOME ELITE SORGHUM HYBRIDS FOR RESISTANCE TO INSECT PESTS OF SORGHUM"** submitted by him is the result of original research work and is of sufficient high standard to warrant its presentation for the examination for award of degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **ENTOMOLOGY.** I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

Place : PARBHANI
Date : 30/06/2001

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Research Guide

CERTIFICATE-II

This is to certify that the dissertation entitled **"SCREENING OF SOME ELITE SORGHUM HYBRIDS FOR RESISTANCE TO INSECT PESTS OF SORGHUM"** submitted by **Shri AVISHKUMAR MAHADEVRAO SONONE** to the Marathwada Agricultural University, Parbhani in partial fulfilment of the requirement for the degree of **MASTER OF SCIENCE (Agriculture)** in the subject of **ENTOMOLOGY** has been approved by the Student's Advisory Committee after viva-voce examination in collaboration with the external examiner.

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ACKNOWLEDGEMENT

I express my deep sense of gratitude to ***Prof. B.A. Kadam,*** *M.Sc. (Agri.), Assistant Professor, Department of Entomology, College of Agriculture, Marathwada Agricultural University, Parbhani for his proper guidance, keen interest, timely suggestions, constructive criticism and constant encouragement right from selecting this problem till the final shaping of dissertation.*

I am grateful to Hon. Vice-Chancellor Dr. V.M. Pawar and Hon. Dr. V.D. Patil, Associate Dean (P.G.), College of Agriculture, Marathwada Agricultural University, Parbhani for providing necessary facilities during the course of investigation.

I express my profound thanks to Dr. P.R. Shivpuje, Head, Department of Entomology, MAU, Parbhani for his valuable guidance and provided necessary facilities.

I am grateful to the members of Advisory Committee Dr. D.W. Wadnerkar, Associate Professor; Dept. of Entomology and Prof. K.R. Sable, Sorghum Entomologist, Sorghum Research Station, MAU, Parbhani for their valuable suggestions and guidance during the course of investigation.

I am extremely thankful to Dr. D.S. Suryawanshi, Associate Professor, Dept. of Entomology, MAU, Parbhani for his kind co-operation and guidance in preparation of this manuscript. My sincere thanks are also due to Dr. P.S. Borikar, Paddy Entomologist, Paddy Research Station, MAU, Parbhani for his co-operation during the preparation of this manuscript.

I am very much thankful to , Dr. U.T. Thombre, Dr. B.R. Kawathekar, Dr. D.R. Mundhe, Dr. J.S. Kurtadikar, Dr. P.P. Kausale, Dr. U.S. Bidgire, Dr. R.B. Mokat, Prof. B.S. Kadam and other staff members of Dept. of Entomology, MAU, Parbhani for scholastic

guidance and useful suggestions and co-operation during the period of investigations.

My special thanks to Rahul Bhalerao for his co-operation during the course of this investigation.

I have profound pleasure to record my sincere thanks to my friends Dhiraj, Shekhar, Yogesh, Bharat, Prabhakar, Bhai, Abhay, Hanif, Jayandra, Deva, Avinash, Datta, Zaheeroddin, Manik, Arvind, Santosh, Sachin, Satish, Shivaji, Gajanan, Dinesh, Prashant, Pandurang, Pradeep and other friends Prashant, Avinash, Keshav, Ramesh, Raju, Santosh, Jayesh, Dnyaneshwar, Milind, Amol, Dinesh, Manoj, Ravi, Rahul and Ms. Minakshi.

No words are enough to record my heartiest gratitude and deep sentiments to my parents Shri. Mahadevrao Sonone and Sow. Kashibai Sonone, grandmother Smt. Bhagarthibhai, sister Sow. Jaimala Bhagat and brother-in-law Shri Gajanan Bhagat and brothers Staish, Deepak and sister Rajeshri and Monika for their moral support, encouragement, spiritual inspiration and sharing the difficulties in building my educational career from better to best.

Last but not a worth appreciation goes to Mr. M.A. Khaleque for his friendly behaviour during the neat computerised typing of the manuscript.

(A. M. SONONE)

PARBHANI
Date : 30 / 06 /2001

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Chapter-I

INTRODUCTION

Sorghum bicolor (L.) Moench is one of the major food and fodder crop of Asia and Africa. It is a Principal cereal crop grown on an area of 15.85 million hectares in India (Anonymous, 1992). The area under kharif sorghum in India is 5.3 million hectares with 4.9 million tonnes of production (Rana, 1998).

Sorghum is mainly grown in the states of Maharashtra, Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Gujrat and Rajasthan. Maharashtra is the largest sorghum growing state with an area of 5.69 million hectares with 6.24 million tonnes of production. In Maharashtra, kharif sorghum is cultivated on 21.50 lakh hectares with a production of 39.11 lakh tonnes (Anonymous, 2000).

Insect Pests are one of the major factors limiting sorghum production. About 32 per cent of the actual crop produce is lost due to insect pests in India. Nearly 150 insect spcies have been recorded to infest sorghum from sowing to harvest. Out of them, 31 species are economically important. In India, about 20 species have been recorded to infest sorghum notably shoot fly, *Atherigona soccata* Rondani; stem borer, *Chilo partellus* ear head bug, *Calocoris angustatus* Leth., midge fly, *Contarinia*

sorghicola Coq., armyworm, *Mythimna separata*, Walkar and webworms, *Eublemma* spp and *Cryptoblabes* spp. in different stages of the crop (Reddy and Devies, 1977).

Sorghum shoot fly assumed a major pest status in the state in general and Marathwada in particular. Sorghum hybrids were reported to be susceptible to the attack of shoot fly. First commercial hybrid, CSH-1 and the variety CSV-1 (Swarna) was heavily damaged due to this pest on the farmers fields (Jotwani *et al.*, 1970 and Raodeo *et al.*, 1972).

The crop sown after second week of July suffers badly due to this pest resulting in poor yield. The incidence of shoot fly is mainly confined to late sown kharif and early sown rabi crop. The fly lays cigar shaped white eggs singly on the lower surface of the leaves. The maggots of shoot fly on hatching crawl to the plant whorl and then cut the growing point and feed on decaying leaf tissues. As a result central shoot dies, turn yellow and subsequently forms dead heart. The damage also spreads to tillers subsequently and the losses to the tune of 22.11 to 83.94 per cent are inflicted. (Jotwani and Sukhani, 1971, Mote et al, 1981 and 1982).

With timely sown crop, it is possible to reduce shoot fly menance. However, due to the weather aberrations this is not feasible. The utilization of insect resistance in crops is one of the most important and practical methods

of controlling shoot fly. A large sources of resistance to the shoot fly have been identified and some of these have been utilised in the breeding programme. (Singh *et al.*, 1968, Pradhan, 1971 and Jotwani, 1978).

In a crop like sorghum, which is attacked by most of insect pests; identifying and using sources having multiple resistance is utmost important.

The pest in succession is a spotted stem borer (Chilo Partellus Swinhoe) which attack a month old crop. The larva initially feed on tender leaf whorls and later bore in to the stem causing `dead heart'. Recently released hybrids and varieties of sorghum are found to be susceptible to stem borer and their yield potential can not be fully realised without insecticidal umbrella. The average sorghum grower can not afford costly insecticides as sorghum being low unit value crop grown mostly under rainfed conditions. Therefore development of resistant varieties and hybrids appears to be right approach for pest management.

The third important insect pest attacking sorghum is earhead bug, *Calocoris angustatus* (Heteroptera, Miridae). The bug builds up in large number, when the crop is sown late or caught in cloudy weather at the time of flowering. Both nymphs and adults suck the sap from developing grains and make them shrivelled or chaffy. Ballard (1916) and Ayyar (1963) reported that maximum

damage of sorghum grain occurred at milky stage. The pest caused losses to the extent of 27.57 to 43.70 per cent (Kulkarni and Bhuti, 1983 and Jadhav, 1993).

In sorghum chemical control is expensive and frequent applications may be required for pest suppression. Under such circumstances, the use of resistant or less susceptible cultivars is one of the realistic alternatives to chemical control. Present studies may help the breeders to develop and select suitable plant hybrids with desirable characters for cultivation.

Keeping in view the importance of the aspects of shoot fly, stem borer and earhead bug resistance, studies on reaction of different hybrids to major insect pests were undertaken with the following objectives.

1. To evaluate the sorghum hybrids against sorghum shoot fly, stem borer and ear head bug.
2. To determine the correlations between plant characters and attack of insect pests.
3. To identify sorghum hybrids for multiple resistance to the above pest species.

REVIEW OF LITERATURE

Chapter-II

REVIEW OF LITERATURE

The literature pertaining to the present investigations is reviewed under the following headings.

2.1 Reaction of different sorghum hybrids to shoot fly.

2.2 Reaction of different sorghum hybrids to stem borer.

2.3 Reaction of different sorghum hybrids to earhead bug.

2.1 Reaction of different sorghum hybrids to shoot fly

2.1.1 Incidence and damage caused by shoot fly

Krishnanda *et al.* (1970) Screened 19 selected genotypes against shoot fly and found that the entries like CSH 1, IS 24, CSH 2 and Co-18 were highly susceptible and preferred for oviposition as compared to resistant varieties like IS 5666 and IS 5285. Maximum infestation was noticed during third and fourth week after emergence.

Jotwani *et al.* (1971) studied ovipositional preference of shoot fly on 24 resistant and 3 susceptible lines of sorghum and found the minimum number of eggs (0.75 to 1.03 per cent) were laid on resistant lines viz. IS 5801, IS 5665, IS 5490 while maximum number of eggs (5.73 per plant) were laid on Swarna which is susceptible one.

Under All India Co-ordinated sorghum improvement Project 41 lines were screened in the trials carried out at Hyderabad and Parbhani in the year 1971-72. All the promising lines showed significantly less dead hearts than the susceptible check and number of eggs laid on promising lines were significantly less than on the susceptible check CSH 1 (Anonymous, 1972).

Narayana (1975) reported that the average number of eggs laid by shoot fly were less (1.00 per plant) on tolerant varieties than on susceptible ones. The percentage of infested plants of the entries tested ranged from 29.6 (IS 5566) to 79.4 (CK-60-B). The sorghum variety IS 5566 was found more tolerant.

Bapat *et al.* (1977) tested forty eight entries and found the entries viz. M-35-1, CS-3341, CS-168, R-69, 2-39-1 were relatively less susceptible to the attack of shoot fly, in which the damage ranged between 18.33 to 29.83 per cent as compared to 58.55 per cent in susceptible check CSH 1.

Sangappa *et al.* (1978) studied performance of hybrids and varieties, and indicated that the average number of eggs laid per plant on the 21st day after germination ranged from 1.8 to 4.06. Minimum egg laying was observed in muguthi variety (1.80/plant) followed by RSH 1, FR 169, CSH 8, and CSH 6. The local muguthi was more resistant to shoot fly than other hybrids and varieties.

The new hybrids RSH 1, CSH 8 and varieties Muguthi, RFD 169 were highly resistant.

Singh and Narayana (1978) reported that CSH 1 and Swarna were highly susceptible whereas IS 2312 and IS 5604 were moderately resistant on the basis of egg laid.

Jadhav and Jadhav (1979) found that IS 4515 was least preferred whereas CSH 1 was highly preferred for oviposition of shoot fly in kharif. In *rabi* IS 4705 and M-35-1 were least preferred and 2077 B was highly preferred. The minimum percentage of dead hearts was observed in M-35-1, IS 4315 and IS 4705 while maximum percentage was noticed in CSH 9 in both seasons.

Raina *et al.* (1984) observed more ovipositional non-preference of sorghum shoot fly for seven selected cultivars of sorghum as compared with that of susceptible hybrids CSH 1 in green house. In a single choice test, female exhibited a significant non preference for oviposition on IS 2146, IS 3962 and IS 5613. Females that had no choice for oviposition substrate but could escape in to an outer cage, showed significant non preference for five test cultivars. Strong preference was observed for CSH 1 hybrid as 80 to 82 per cent eggs were laid on them. Fewer eggs per plant on resistant plants were observed as females lay eggs on non preferred cultivars only after laying several eggs on alternate sown CSH 1 plants.

Naik and Bhuti (1985) Screened 28 entries for resistance to *Atherigona soccata* and recorded least (17 per cent) dead hearts percentage in IS 2312 but selected varieties SPV 351,SPV 475 were having below 30 per cent dead hearts and in hybrids it ranged from 27.8 to 34.3 per cent dead hearts.

Taneja and Leuscher (1985) studied the behaviour of shoot fly on different cultivars. According to them female adults prefer to lay less number of eggs on IS lines as compared to hybrids and varieties.

Patel *et al.* (1989) reported that the genotypes viz. IS 1054, IS 2205, IS 3969, IS 5459, IS 5619, IS 18577, IS 18584 and SPV 102 showed multiple resistance to shoot fly and stem borer.

Dalvi *et al.* (1990) reported that out of 45 varieties of sorghum screened for resistance to shoot fly, five varieties R 24, 370 x 3660 A, E 0303, M-35-1 and M-47-3 were most tolerant on the basis of oviposition intensity.

Patel and Sukhani (1990) observed minimum eggs (0.78 eggs/plant) of shoot fly on IS 2205 and maximum oviposition (3.94 eggs/plant) on CSV 1. It was concluded that ovipositional non preference was responsible for the resistance to shoot fly. Positive and highly significant correlation was observed between shoot fly eggs per plant and per cent dead hearts.

Nineteen entries were evaluated for relative susceptibility of sorghum hybrids to shoot fly. The shoot fly infestation was significantly less in IS 2312 and next to this, in SPH 798. The highest percentage of dead hearts was observed in SPH 802 and it was at par with SPH 794, SPH 799, SPH 800, H 3, SPH 829 and SPH 795 (Anonymous, 1995).

Singh and Grewal (1997) Screened 26 advanced sorghum genotypes from ICRISAT against shoot fly. Pooled data revealed that dead hearts formed by shoot fly varied from 8.5 to 76.5 per cent. IS 18551 and ICSV 93091 had less than 10 per cent dead hearts due to shoot fly. Dead hearts formation due to shoot fly was 15 to 20 per cent in ICSV 700, ICSV 99093, PB 15438 and IS 2312.

Out of 36 advanced hybrids evaluated for resistance to shoot fly, the entries SPH 660, SPH 792, PVK 400, SPH 1002, SPH 960, SPH 975 and SPH 305 recorded significantly less number of dead hearts due to shoot fly than CSH 14 (Anonymous, 1999).

Out of 22 entries evaluated, shoot fly damage was significantly less in SPH 1127, SPH 1134, SPH 1137, SPH 1145, SPH 967 and IS 2312 than 9806 on the basis of dead hearts. (Anonymous, 1999).

Out of 20 entries screened, IS 2312 was free from shoot fly incidence. However, dead hearts were significantly less in SPH 1135 and at par with most of the entries except, SPH 1142, SPH 1146 and SPH 1150. (Anonymous, 1999).

Balikai and Kullaiswamy (1999) tested 14 F2 populations of sorghum for resistance to sorghum shoot fly during *rabi* 1990-91 and found crosses of M-35-1 x SPV 488, M-35-1 x IS 8, M-35-1 x Afzalpur local, M-35-1 x Selection 3 and M-35-1 x IS 2312 to be promising, on the basis of percentage dead hearts.

All the entries recorded significantly less shootfly dead hearts over DJ 6514. However, the entries SPH 981, CSH 9, SPH 960, SPH 1065, CSH 13, CSH 14 were at par with IS 2312 (Anonymous, 2000a).

2.1.2 Morphological characters of sorghum hybrids associated with resistance to shoot fly

2.1.2.1 Leaf length and leaf breadth

Singh (1977) Observed that leaves of resistant sorghum lines were invariably longer (19.1 to 26.6 cm), errect and narrow (15 to 16 mm) than those of susceptible hybrid CSH 1 whose average leaf length and width were found 19.8 cm and 17.6 mm respectively. The broadness of leaf lamina in susceptible hybrid CSH 1 may provide sufficient space for shoot fly to move about and select suitable site for egg laying.

Bothe (1979) observed that the tolerant varieties viz. IS 5490, M-35-1 had narrower leaves than susceptible ones.

Maiti and Bidinger (1979) reported that varieties with errect and yellowish narrow leaves were resistant to shoot fly.

Rasker (1979) reported that differences in leaf width of different entries of sorghum were significant, the widest leaf was found in CSV 6 followed by CSH 1 and lowest leaf width was recorded in IS 5469. Positive correlation was found in leaf width and susceptibility to shoot fly.

Moholkar (1981) observed positive correlation within leaf width, oviposition and dead hearts. He concluded that broader leaves of susceptible varieties provided more area to move about and select suitable place for oviposition.

Singh (1998) found a positive correlation seedling mass with leaves per plant and leaf width with oviposition and dead heart formation. It is concluded that rapid seedling growth and long thin leaves during the seedling stages makes plant less susceptible to shoot fly.

2.1.2.2 Height and growth rate of plant

Blum (1966) reported that forage sorghum hybrid grow at a more faster rate at seedling stage than RS 610 (dwarf variety) and escaped the shoot fly damage.

Raghunath *et al.* (1972) reported that the low incidence of shoot fly in case of CBE-X, might be due to its initial vigorous growth.

Narayana (1975) observed that IS 5565 a tall variety, was more tolerant to shoot fly than dwarf varieties.

Rasker (1979) recorded lowest plant height in CSV 1(Swarna) which is susceptible to shoot fly while it was highest in IS 5469 which is more resistant to shoot fly.

Khurana (1980) studied the plant height of nine lines (six resistant and three susceptible) and observed that the resistant varieties were taller than susceptible varieties. He concluded that height of the plant was positively correlated to resistance of shoot fly.

Singh and Jotwani (1980) reported that on the 17th day after germination, the average height of shoot fly susceptible CSH 1 seedling was 29.13 cm whereas it varied from 38.40 to 39.33 cm in seedlings of IS 5469 and IS 5490. indicating there by that resistant varieties had highly significant height.

Kishore (1994) reported that dual purpose sorghums, DS 1, DS 2, DS 3 ,DS 4, DS 5 and DS 6 showed resistance to both *Atherigona soccata* and *Chilo partellus* and possessed desirable quality traits as plant height, stem girth, total number of leaves.

2.2 Reaction of different sorghum hybrids to stem borer

Kishore and Jotwani (1982) reported that the

sorghum lines viz. E 501, E 502, E 503, E 0601, SPV 17, SPV 19, SPV 58 were resistant to *Chilo partellus* on the basis of leaf injury and stem tunneling.

Dalvi *et al.* (1983) recorded the minimum percentage stem length tunneled and percentage internodes attacked in the variety E 303 in kharif and E 302 in *rabi* season.The maximum infestation was observed in CSH 1. In single row experiment the minimum stem borer incidence based on internal damage was noticed on the varieties Savner and Ramkel while minimum in SGIRL ML-1. The maximum and minimum leaf injury index was recorded in varieties SGIRL ML-1 and Bilchigan, respectively.

Dobrowaski and Kidvai (1983) reported that IS Nos. 2162, 2262, 18228, 18349, expressed less dead hearts and IS Nos. 4660, 18327 ad 18479 showed reduced tunneling due to stem borer.

Singh *et al.* (1983) found CSV-8R, SPV 35, SPV 103, SPV 140, SPV 192 to be resistant to *Chilo partellus* on the basis of leaf feeding, leaf injury, per cent dead hearts, number of holes on leaves and percentage tunneling.

Singh *et al.* (1991) reported that IS 2123 and IS 5469 had the fewest dead hearts, least leaf injury and stem tunneling damage . IS 2205, IS 18578 and IS 18584, were also relatively resistant to the pest, while CSH 1 and Swarna were susceptible.

Kishore (1992) screened 11 sorghum germplasms for resistance to *Athergona soccata* and *Chilo partellus*. The entries E 103, E 108, E 109, E 112 and E 358 showed multiple resistance to both pests.

Nour (1995) identified four hybrids viz. HYD 1, HYD 5, HYD 8 and HYD 10 for resistance to stem borer and for commercial production of the crop.

Twenty two entries were screened at Sorghum Research Station, M.A.U. Parbhani during 1994-95 for stem borer. The infestation ranged from 5.08 (SPV 1134) to 15.03 (CSH 14) per cent. The percentage of stem borer infested stalks ranged between 29 (CSH 1) to 65 (CSH 938) per cent whereas the percentage of infested peduncles was between 20 (CSH 1) to 59 (SPV 881) per cent. Similarly the tunneling in the stem and peducncle ranged between 9 (CSH 13) to 28 (SPV 1192). Per cent , respectively. (Anonymous, 1995).

Patel *et al.* (1996) rated IS 18584, IS 18577 and IS 2205 to be most resistant on the basis of dead hearts, leaf injury, stem tunneling, peduncle tunneling and exit holes.

Singh and Grewal (1997) Screened twenty six advanced sorghum genotypes from ICRISAT against shoot fly and stem borer. Dead hearts formed by stem borer varied from 12.0 to 78.5 per cent. IS 2205, PB 15925, ICSV 700 and IS 2312 exhibited less than 20.0 per cent dead hearts due to stem borer.. More than 70.00 per cent dead hearts due to

both pests were recorded in susceptible controls SPH 1, CSH 9 and ICSV 1. It is conlcuded that ICSV 700 and IS 2312 are highly promising sources of multiple resistance to both shoot fly and stem borer.

Out of fourteen entries evaluated for resistance to stem borer, hearts, stalk and peduncle damage were significantly less in CSV 13, SPV 1231, SPV 1022, CSV 15, SPV 1328, IS 2312 and PVK 400 over rest of the entries (Anonymous, 1998).

The stem borer dead hearts, stalk and peduncle damage infestation ranged in between 0.00 (IS 2312) to 19.69 (SPH 1200) 30.44 (SPH 1185) to 52.40 (SPH 1188) and 8.03 (SPH 1200)to 35.60 (SPH 1182), respectively. (Anonymous, 2000).

Out of 24 entries screened, SPH 1191 escaped from stem borer infestation. However, the entries SPH 1198, SPH 1207, CSH 16, PVK 400 and ICSV 705 recorded significantly less dead hearts as compared to rest of the lines. (Anonymous, 2000).

2.3 Reaction of different sorghum hybrids to earhead bug

Paul (1976) observed that earhead bug *Calocoris angustatus* generally appears during the milky stage of the sorghum crop in the kharif season and severe infestation results in chaffy earhead. Out of 20 sorghum lines SGRIL-

MRL, E 302 and CSH 1 exhibited less incidence of bug than the other entries.

Atkine (1983) evaluated hybrids from crosses of 37 R lines with three susceptible male sterile parents. Results indicated that resistance source SA 7536-1 had potential for producing high yielding hybrids with less grain damage due to earhead bug.

Mote and Kadam (1984)evaluated 30 genotypes using 5 point scale for rating damage caused by *Calocoris angustatus*. None of the genotype was free from damage. SPV 472, Swarna, SPH 196, CSH 1, CSH 6 and CSH 9 were moderately resistant with score rating from 1.1 to 2.

Hiremath (1987) Screened 36 kharif and 16 *rabi* sorghum genotypes and found that SGRIL-MRL and CSV 5 were promising. The correlation between mirid population and damage grade index was significant in both the screening trials.

Natarajan and Shridhar (1988) noted that out of 86 sorghum varieties CSV 745, CSV 88032 and IS 19937, IS 5604 were the most resistant with 0.1 bugs per panicle.

Sharma and Lopez (1990) while studying mechanism of resistance to *Calocoris angustatus* observed that IS 19973, IS 2761, IS 9692, IS 17610, IS 17618 and IS 17645 were not preferred by adults under multichoice conditions. The susceptible controls CSH 1 , CSH 5, CSH 9 suffered more due to earhead bug attack.

Sharma and Lopez (1992a) screened 15000 accessions between 1980 to 1990 for resistance to earhead bug under natural and head cage conditions and observed 34 genotypes with moderate levels having grain damage with rating, 1.7 to 2.9 as compared to 4.0 to 4.6 in the susceptible controls i.e. CSH 1, CSH 5 and CSH 9.

Sharma and Lopez (1992b) evaluated 8 sorghum genotypes for resistance to *Calocoris angustatus* at 3 infestation levels viz. 5, 10 and 15 pairs of bug per panicle over 6 seasons. Results, showed that IS 17610 was most resistant and stable genotype over seasons at different infestation levels.

Ramesh (1992) noted IS 2761, IS 17645, IS 9692, IS 6989 and IS 23001 sorghum to be less susceptible among the 10000 lines screened.

Sharma *et al.* (1993) reported that IS 2761, IS 4334, IS 2318 and IS 21444 suffered less grain damage due to earhead bug compared with CSH 1, CSH 5 and CSH 9.

The entries viz. CSH 14 an SPH 1182 recorded significantly less bug population per panicle than all other entries screened. (Anonymous, 2000b).

MATERIALS AND METHODS

Chapter-III

MATERIALS AND METHODS

A field experiment was conducted during kharif 2000 to screen some sorghum hybrids against major insect pests. The materials used and methods followed during the course of investigation are described in this chapter.

3.1 Experimental location

Experiment was conducted at Sorghum Research Station, MAU, Parbhani. The site selected was uniform, medium black cotton soil having medium fertility and good drainage.

3.2 Sowing and other agronomic practices

3.2.1 Cultural operations

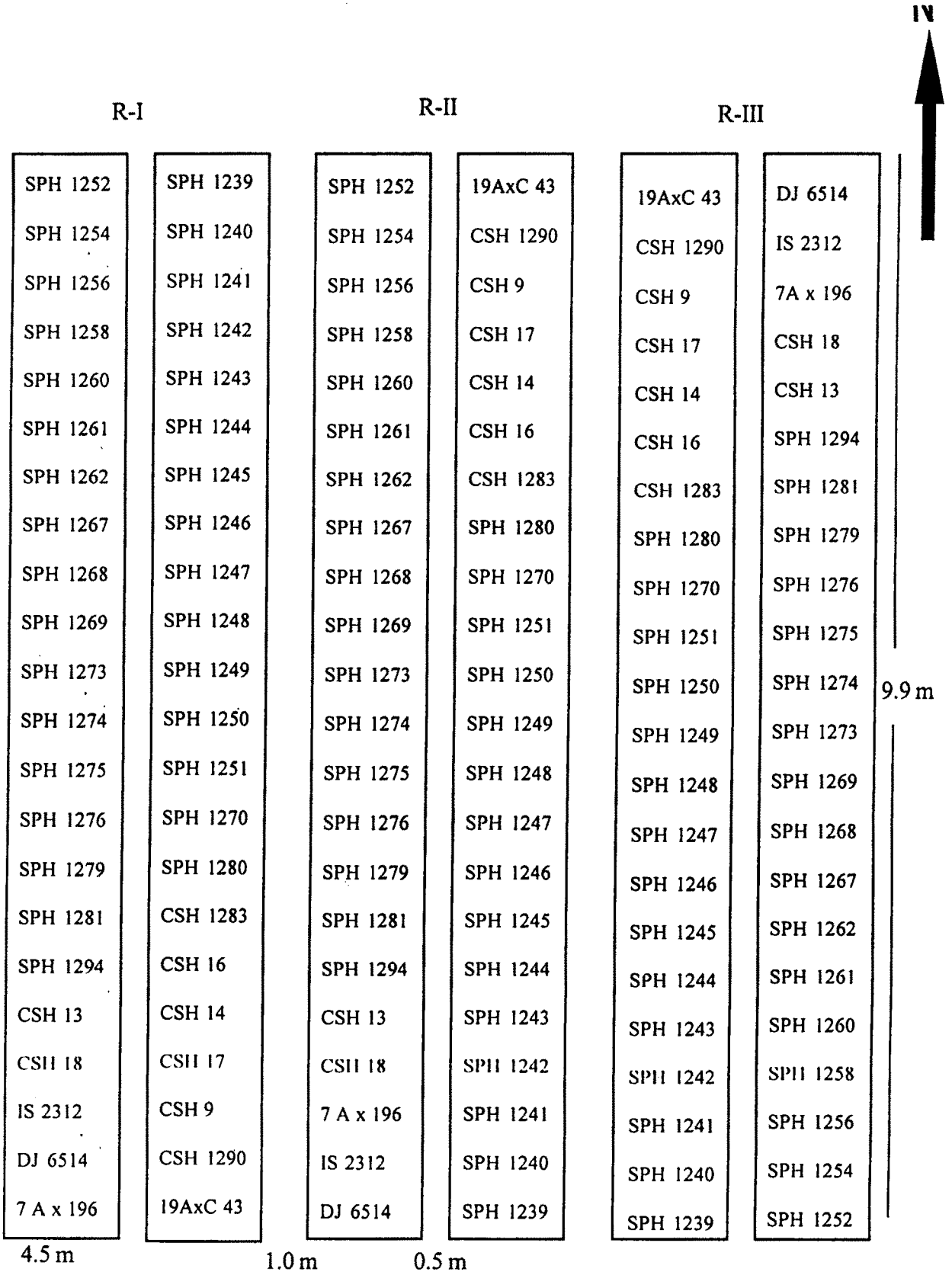
The field was ploughed once and harrowed twice before sowing. The flat beds of 4.5 x 9.9 m gross size were prepared. The fertilizer dose was applied at the rate of 80 kg nitrogen, 40 kg phosphorus and 40 kg potash/ha. The half dose of nitrogen and full dose of phosphorus and potash were applied as a basal dose and remaining half dose of N was applied as top dressing at 30 days after sowing. Weeding and hoeing operations were done as and when required.

3.2.2 Sowing

The seeds of the test entries were obtained from the Sorghum Research Station, MAU, Parbhani. The sowing of different entries was done on 15-7-2000 by dibbling method at the spacing of 45 x 15 cm and 3 seeds per hill were sown and only one healthy plant was maintained after thinning (25-7-2000).

3.3 Details of the experiment

The experiment was laid out in randomised block design with three replications and 44 entries as treatments. Single row of 4.5 m length for each entry was sown at 45 x 15 cm. The details of layout of the experiment are presented in Fig.1.



Design : Randomised block design
No. of replications : 3
No. of treatments : 44

Fig. 1. PLAN OF LAYOUT

3.4 The experiment consisted of following treatments (Test entires)

Sr.No.	Entry	Sr. No.	Entry
1	SPH 1239	23	SPH 1252
2	SPH 1240	24	SPH 1254
3	SPH 1241	25	SPH 1256
4	SPH 1242	26	SPH 1258
5	SPH 1243	27	SPH 1260
6	SPH 1244	28	SPH 1261
7	SPH 1245	29	SPH 1262
8	SPH 1246	30	SPH 1267
9	SPH 1247	31	SPH 1268
10	SPH 1248	32	SPH 1269
11	SPH 1249	33	SPH 1273
12	SPH 1250	34	SPH 1274
13	SPH 1251	35	SPH 1275
14	SPH 1270	36	SPH 1276
15	SPH 1280	37	SPH 1279
16	CSH 1283	38	SPH 1281
17	CSH 16	39	SPH 1294
18	CSH 14	40	CSH 13
19	CSH 17	41	CSH 18
20	CSH 9	44	7A X 196
21	CSH 1290	42	IS 2312 - RC
22	19 AXC-43	43	DJ 6514 - SC

RC - Resistant check

SC - Susceptible check

3.5 Methods of recording observations

Five plants were selected randomly for recording the observations.

3.5.1 Reaction of different sorghum entires to shoot fly

3.5.1.1 Oviposition

The observations on egg laying were recorded at 7 days interval starting from the 7th day of emergence and continued upto 28th day.

3.5.1.2 Dead hearts

The total number of plants showing dead hearts were recorded at 7 days interval starting from the 7th day of emergence till 28th day.

3.5.1.3 Plant characters of different sorghum entries associated with shoot fly resistance

3.5.1.3.1 Plant height

The plant height was recorded by measuring the height of shoot from the soil surface to the base of last fully opened leaf.

3.5.1.3.2 Leaf length and leaf breadth

The observations on the leaf length and leaf breadth were recorded beginning from the 7th day after emergence and continued up to 28th day. Fourth leaf from

top was randomly selected for measurement. The leaf length was measured along the mid rib and leaf breadth from broadest point of same leaf by using centimeter scale.

3.5.2 Reaction of different sorghum entries to stem borer

Observations on leaf and shoot damage on total number of plants, peduncle and stalk damage were recorded on five randomly selected plants.

3.5.2.1 Leaf and shoot damage

Total number of plants showing leaf injury and dead hearts were counted at 35 and 60 days after emergence respectively.

3.5.2.2 Length of tunneling

At the time of harvest, total length of stalk and peduncle was measured. The plants were split open giving vertical cut and length of tunneling was measured and per cent tunneling was worked out.

3.5.2.3 Peduncle and stalk damage

The selected plants were examined for stalk and peduncle damage at harvest and per cent damage to stalk and peduncle was worked out.

3.5.3 Reaction different sorghum entires to earhead bug

3.5.3.1 Incidence of earhead bug

The observations on number of nymphs and adults of earhead bug per cob were recorded on five randomly selected cobs at 50 per cent flowering and milky grain stage.

3.5.3.2 Number of shrivelled grains per panicle

Observations on number of shrivelled grains per panicle were recorded on 100 grains each on 5 randomly selected cobs.

3.5.3.3 Observations on chaffy cobs

Total number of chaffy cobs per entry were counted and per cent chaffy cobs were worked out.

3.6 Statistical analysis

The data on percentage infestation were transformed to angular values, and data on number of ear head bugs were transformed to Poisson values ($\sqrt{x+0.5}$). The data collected were subjected to standard statistical procedure and the results were interpreted accordingly.

RESULTS

Chapter-IV

RESULTS

The present investigations were carried out to identify resistant entries to shoot fly, *Atherigona soccata* Rondani, stem borer, *Chilo partellus* Swinhoe and earhead bug, *Calocoris angustatus* Leth. and the results obtained are presented in this chapter.

4.1 Reaction of different sorghum entries to shoot fly

4.1.1 Number of eggs laid by shoot fly

The data in respect of the average number of eggs laid per plant on each entry are presented in Table 1.

The differences in number of eggs laid per plant on different entries on the 7th day after emergence were statistically significant.

The egg laying on the 7th day after emergence ranged from 0.0 to 1.6 eggs per plant. The entries viz. IS 2312 (Resistant check), 19 A x C-43, SPH 1248, 7 A x 196, SPH 1268 and SPH 1274 were found significantly superior over rest of the entries. These entries were observed free from egg laying. They were at par with the entries SPH 1280 and SPH 1269. The maximum number of eggs laid per plant were recorded on the entry SPH 1294 (1.6 eggs per plant). The entry SPH 1254 was at par with the entry SPH

Table 1. Number of eggs laid by shoot fly in different sorghum entries.

Sr. No.	Entries	Average number of eggs laid per plant			
		Days after emergence			
		7	14	21	28
1	SPH 1239	1.20	3.53	4.20	1.80
2	SPH 1240	1.33	3.80	4.10	1.10
3	SPH 1241	0.80	3.73	5.10	1.33
4	SPH 1242	1.46	4.46	6.09	1.20
5	SPH 1243	0.93	4.40	5.73	1.00
6	SPH 1244	0.80	4.26	6.13	1.00
7	SPH 1245	1.13	3.80	4.06	1.10
8	SPH 1246	1.20	3.86	4.73	1.20
9	SPH 1247	1.46	4.40	5.93	1.40
10	SPH 1248	0.00	0.50	1.65	0.80
11	SPH 1249	0.80	2.66	6.33	1.50
12	SPH 1250	0.93	3.73	4.80	1.00
13	SPH 1251	0.86	4.00	5.86	1.50
14	SPH 1270	1.30	4.66	7.00	3.00
15	SPH 1280	0.10	0.50	1.55	0.70
16	CSH 1283	0.80	2.30	4.86	1.60
17	CSH 16	0.80	3.10	3.60	1.13
18	CSH 14	0.60	2.93	3.80	1.46
19	CSH 17	1.13	4.06	5.33	1.50
20	CSH 9	1.13	3.60	6.33	1.26
21	CSH 1290	0.70	3.66	4.66	1.00
22	19AxC 43	0.00	0.40	1.50	0.80
23	SPH 1252	1.00	3.53	4.13	1.20
24	SPH 1254	1.50	4.20	6.00	1.26
25	SPH 1256	0.80	3.80	4.26	1.80

Table 1. Contd....

Sr. No.	Entries	Average number of eggs laid per plant			
		Days after emergence			
		7	14	21	28
26	SPH 1258	1.26	4.60	4.80	2.10
27	SPH 1260	1.40	4.70	6.20	2.90
28	SPH 1261	1.00	4.33	5.26	1.70
29	SP 1262	1.20	3.40	4.00	1.10
30	SPH 1267	0.80	3.66	4.53	1.33
31	SPH 1268	0.00	0.90	1.60	0.70
32	SPH 1269	0.10	1.00	1.65	1.33
33	SPH 1273	1.00	2.90	4.46	1.10
34	SPH 1274	0.00	0.85	1.60	0.80
35	SPH 1275	1.13	3.26	5.06	3.00
36	SPH 1276	0.80	4.00	5.93	1.46
37	SPH 1279	0.60	4.80	5.60	2.90
38	SPH 1281	1.10	3.73	5.33	1.13
39	SPH 1294	1.60	4.80	6.35	3.00
40	CSH 13	0.70	3.00	4.26	1.10
41	CSH 18	1.10	3.93	4.73	1.00
42	7Ax196	0.00	0.80	1.50	0.80
43	IS 2312 (RC)	0.00	0.40	1.60	0.70
44	DJ 6514 (SC)	1.46	5.60	7.10	3.30
	SE ±	0.039	0.52	0.057	0.07
	CD at 5%	0.109	0.144	0.158	0.22

RC - Resistant check

SC - Susceptible check

1294. The remaining entries occupied intermediate positions.

The egg laying on the 14th day after emergence ranged from 0.4 to 5.6 eggs per plant. The minimum number of eggs per plant were recorded on entries IS 2312 and 19A x C-43, which were significantly less than the rest of the entries. However, they were at par with the entries SPH 1248 and SPH 1280. The maximum number of eggs per plant were recorded on the entry DJ 6514 (5.6 eggs per plant) which recorded significantly higher number of eggs than the rest of the entries. The remaining entries occupied intermediate positions.

The egg laying on the 21st day after emergence ranged from 1.5 to 7.10 eggs per plant. The minimum number of eggs per plant were recorded on the entries 19 A x C-43 and 7A x 196, which were significantly less than the rest of the entries. However, they were at par with the entries SPH 1280, IS 2312, SPH 1268, SPH 1274, SPH 1269 and SPH 1248. Significantly higher number of eggs per plant were recorded on the susceptible check DJ 6514 (7.10 eggs per plant) than rest of the entries except 1270. The remaining entries occupied intermediate positions.

On the 28th day after emergence egg laying ranged from 0.7 to 3.3 eggs per plant. Minimum number of eggs were recorded on the entries SPH 1280, SPH 1268, and resistant check IS 2312 (0.7 eggs per plant) and were

significantly less than the rest of the entries exept the entries SPH 1248, 19 A x C 43, SPH 1274 and 7A x 196. The remaining entries occupied intermediate positions.

4.1.2 Shoot fly damage as indicated by dead hearts

The data regarding the percentage of dead hearts caused due to shoot fly are presented in Table 2 and graphically depicted in Fig. 2.

On the 7th day after emergence dead hearts ranged from 0.0 to 6.63 per cent. Significantly less dead hearts were recorded in the entries IS 2312, 19 A x C-43, SPH 1248, SPH 1280, 7 A x 196, SPH 1274 and SPH 1268. These entries were free from dead hearts (0.0 per cent). Significantly high percentage of dead hearts were recorded on the susceptible check entry DJ 6514 (6.63 per cent) than the rest of the entries. The remaining entries occupied intermediate positions.

The deadhearts on the 14th day after emergence ranged from 3.3 to 28.46 per cent. Minimum percentage of dead hearts were recorded on the resistant check IS 2312 (3.3 per cent), which was significantly less than the rest of the entries. It was at par with the entries 19 A x C-43 and SPH 1280. Maximum percentage of dead hearts were recorded on the susceptible check DJ 6514 (28.46 per cent) which recorded significantly higher percentage of dead hearts than the rest of the entries except the entries SPH

Table 2. Shoot fly damage in different sorghum entries.

Sr. No.	Entries	Average percentage of dead hearts			
		Days after emergence			
		7	14	21	28
1	SPH 1239	4.10 (11.68)	12.16 (20.41)	27.38 (31.54)	75.96 (60.63)
2	SPH 1240	6.30 (14.53)	19.56 (26.24)	26.33 (30.87)	51.15 (45.65)
3	SPH 1241	2.47 (9.03)	14.93 (22.46)	28.88 (32.50)	80.68 (63.91)
4	SPH 1242	4.56 (12.33)	27.76 (31.79)	45.58 (42.45)	88.14 (69.84)
5	SPH 1243	4.30 (11.96)	18.30 (25.32)	24.44 (29.62)	65.92 (53.79)
6	SPH 1244	3.90 (11.38)	16.50 (23.96)	29.15 (32.75)	87.00 (68.86)
7	SPH 1245	5.13 (13.09)	20.50 (26.91)	33.00 (35.05)	67.90 (55.48)
8	SPH 1246	3.66 (11.03)	22.23 (28.12)	26.85 (31.20)	75.25 (60.15)
9	SPH 1247	4.96 (12.87)	15.80 (23.41)	30.12 (33.28)	82.50 (65.26)
10	SPH 1248	0.00 (0.00)	3.90 (11.38)	8.33 (16.77)	18.10 (25.17)
11	SPH 1249	2.90 (9.80)	14.83 (22.64)	28.50 (32.26)	73.33 (58.90)
12	SPH 1250	4.46 (12.19)	14.66 (22.51)	18.78 (25.72)	79.84 (63.31)
13	SPH 1251	4.40 (12.10)	14.63 (22.48)	22.18 (28.09)	86.85 (68.73)
14	SPH 1270	3.10 (11.96)	27.13 (31.38)	44.13 (41.62)	89.78 (71.35)
15	SPH 1280	0.00 (0.00)	15.33 (10.93)	8.40 (16.84)	19.10 (25.91)
16	CSH 1283	2.60 (9.27)	11.50 (19.82)	22.90 (28.58)	58.10 (49.65)
17	CSH 16	1.75 (7.60)	8.30 (16.74)	22.24 (28.13)	83.78 (66.24)
18	CSH 14	1.20 (6.28)	11.76 (20.05)	24.33 (29.55)	56.22 (48.56)
19	CSH 17	3.33 (10.51)	20.80 (27.12)	36.78 (37.33)	52.19 (46.24)
20	CSH 9	3.53 (10.78)	13.50 (21.55)	37.85 (37.76)	78.36 (62.27)
21	CSH 1290	1.26 (6.46)	18.43 (25.42)	28.14 (32.03)	71.10 (57.47)
22	19AxC 43	0.00 (0.00)	3.50 (10.78)	8.50 (16.94)	19.00 (25.83)
23	SPH 1252	4.00 (11.53)	16.88 (24.25)	24.07 (29.37)	83.07 (65.69)
24	SPH 1254	4.00 (11.53)	20.12 (26.64)	40.25 (39.37)	80.42 (63.73)
25	SPH 1256	3.33 (10.51)	18.09 (25.16)	28.06 (31.98)	86.94 (68.80)

Table 2. Contd...

Sr. No.	Entries	Average percentage of dead hearts							
		Days after emergence							
		7		14		21		28	
26	SPH 1258	4.43	(12.15)	19.98	(26.54)	28.37	(32.17)	90.08	(71.63)
27	SPH 1260	5.56	(13.63)	23.41	(30.02)	41.23	(39.94)	95.83	(78.21)
28	SPH 1261	3.50	(10.78)	22.12	(28.05)	33.49	(35.35)	77.22	(61.48)
29	SP 1262	4.40	(12.10)	14.06	(22.21)	18.75	(25.65)	84.30	(66.65)
30	SPH 1267	2.56	(9.21)	19.91	(26.49)	30.64	(33.79)	81.89	(64.80)
31	SPH 1268	0.00	(0.00)	6.40	(14.65)	12.80	(20.96)	23.89	(29.25)
32	SPH 1269	1.36	(6.71)	7.00	(15.34)	15.42	(23.11)	84.07	(66.47)
33	SPH 1273	3.30	(10.46)	12.95	(21.08)	23.55	(29.02)	82.16	(65.01)
34	SPH 1274	0.00	(0.00)	6.50	(14.76)	12.64	(20.82)	23.92	(29.27)
35	SPH 1275	3.40	(10.62)	20.69	(26.81)	26.60	(30.82)	89.33	(70.92)
36	SPH 1276	1.60	(7.25)	21.77	(27.80)	31.38	(34.06)	82.89	(65.56)
37	SPH 1279	2.36	(8.84)	22.86	(28.55)	30.19	(33.32)	70.91	(57.35)
38	SPH 1281	5.40	(13.43)	16.61	(24.04)	24.35	(29.56)	87.24	(69.06)
39	SPH 1294	6.33	(14.67)	22.83	(28.54)	42.33	(40.58)	94.44	(76.36)
40	CSH 13	4.36	(12.05)	12.44	(20.65)	30.83	(33.72)	84.84	(67.08)
41	CSH 18	3.10	(10.13)	16.99	(24.33)	21.73	(28.01)	67.86	(55.46)
42	7Ax196	0.00	(0.00)	6.33	(14.57)	12.50	(20.70)	23.83	(29.21)
43	IS 2312 (RC)	0.00	(0.00)	3.3	(10.46)	8.16	(16.60)	18.57	(25.52)
44	DJ 6514 (SC)	6.63	(10.92)	28.46	(32.24)	48.14	(43.92)	100	(89.98)
	SE ±	0.099		0.242		0.164		0.200	
	CD at 5%	0.274		0.671		0.455		0.553	

Figures in the parentheses are angular transformed values.

RC - Resistant check

SC - Susceptible check

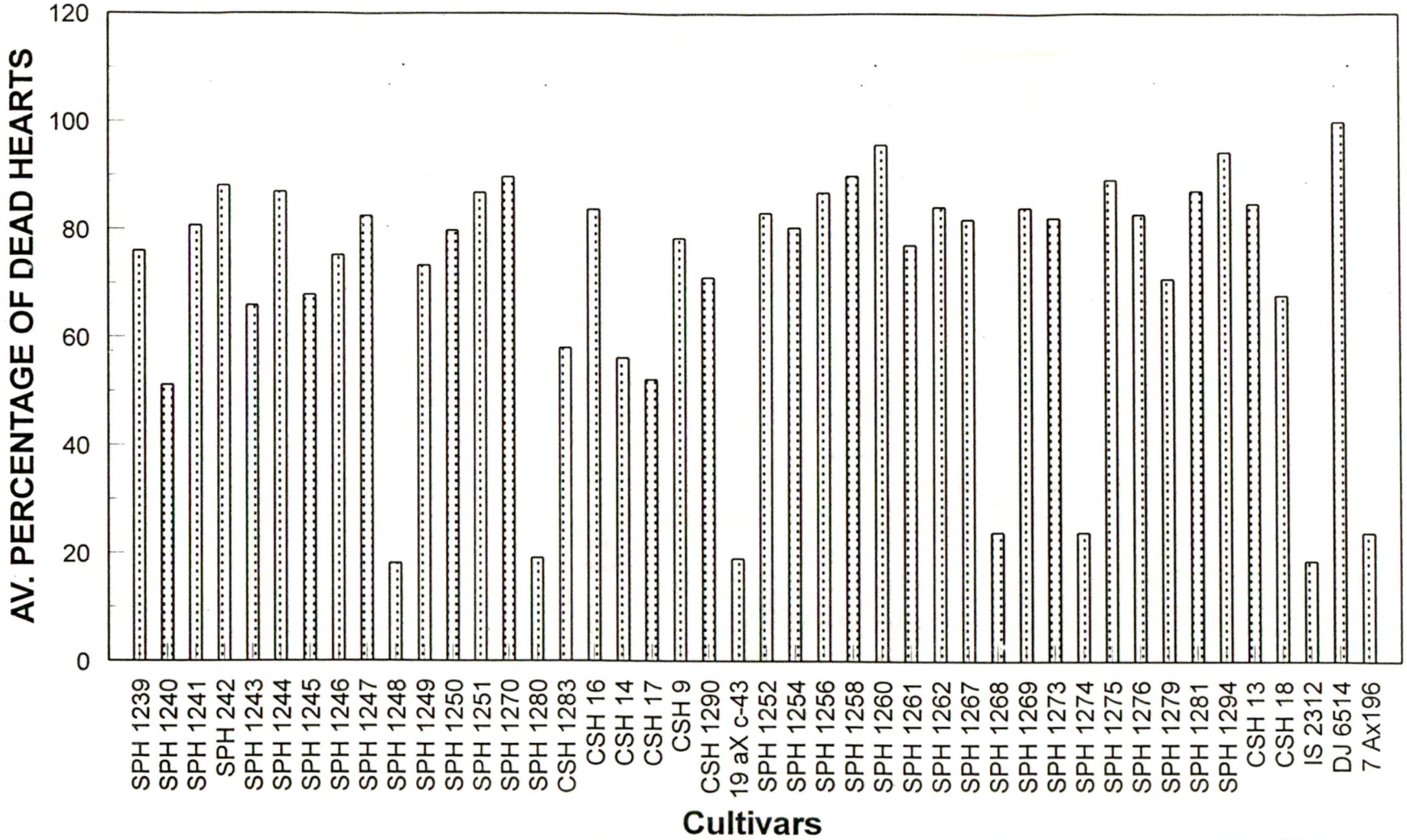


Fig. 2.SHOOT FLY DAMAGE IN DIFFERENT SORGHUM ENTRIES ON 28th DAY AFTER EMERGENC

1242 and SPH 1270. The remaining entries occupied intermediate positions.

On the 21st day after emergence the percentage of dead hearts ranged from 8.16 to 48.14. Significantly less percentage of dead hearts were recorded on the resistant check IS 2312 (8.16 per cent), than the rest of the entries. It was at par with the entries SPH 1248, SPH 1280 and 19 A x C-43. Maximum infestation was recorded on the entry DJ 6514 (48.14 per cent) and was significantly higher than the rest of the entries. The remaining entries occupied intermediate positions.

The percentage of dead hearts on the 28th day after emergence ranged from 18.57 to 100. The minimum infestation was recorded on the resistant check IS 2312 (18.57 per cent) which was significantly less than the rest of the entries. It was at par with the entries SPH 1248, 19 A x C-43, and SPH 1280. Maximum infestation was recorded on the susceptible check DJ 6514 (100 per cent) and was significantly higher than the rest of the entries. The remaining entries occupied intermediate positions.

4.1.3 Morphological characters of different sorghum entries associated with shoot fly infestation.

4.1.3.1 Plant height

The data on plant height are presented in Table 3. The average plant height on the 7th day after

emergence ranged from 3.8 to 7.6 cm. Maximum plant height was recorded on the resistant check IS 2312 and SPH 1280 (7.6 cm) which was significantly more than the rest of the entries except the entry 19A x C-43. Minimum plant height was recorded on the entries SPH 1294 and SPH 1260 (3.8 cm), which was significantly less than than rest of the entries. These were at par with the entries SPH 1258, CSH 13, SPH 1254, susceptible check DJ 6514, 1251 and 1270. The remaining entries occupied intermediate positions.

On the 14th day after emergence average plant height ranged from 9.46 to 19.20 cm. Maximum plant height was recorded on the entries IS 2312 and SPH 1280 (19.20 cm), which was significantly more than the rest of the entries and these were at par with the entries SPH 1248 and 19 A x C-43. Minimum plant height was recorded on the suseptible check DJ 6514 (9.46 cm) which was significantly less than the rest of the entries. The remaining entries occupied intermediate positions.

The average plant height on 21st day after emergence ranged from 18.33 to 29.10 cm. Maximum plant height was recorded on the resistant check IS 2312 and SPH 1248 (29.10 cm), which was significantly more than rest of the entries except the entries SPH 1280 and 19 A x C-43. The plant height was significantly less in the susceptible check DJ 6514 (18.33 cm), than all other entries. The remaining entries occupied intermediate positions.

Table 3. Plant height at weekly interval in different sorghum entries

Sr. No.	Entries	Average plant height (cm)			
		Days after emergence			
		7	14	21	28
1	SPH 1239	4.10	13.93	19.70	32.50
2	SPH 1240	5.06	10.40	21.60	34.66
3	SPH 1241	5.80	11.60	19.53	28.86
4	SPH 1242	4.00	9.96	20.10	28.20
5	SPH 1243	5.13	10.50	20.16	30.10
6	SPH 1244	5.96	10.33	20.06	28.63
7	SPH 1245	4.96	12.30	23.06	31.80
8	SPH 1246	4.96	13.50	20.50	29.63
9	SPH 1247	4.90	10.50	19.66	28.86
10	SPH 1248	7.40	19.16	29.10	39.30
11	SPH 1249	5.00	15.30	20.00	29.33
12	SPH 1250	5.20	12.30	21.83	28.86
13	SPH 1251	3.96	10.93	19.63	28.40
14	SPH 1270	3.96	9.70	18.73	27.63
15	SPH 1280	7.60	19.20	29.16	39.26
16	CSH 1283	5.06	15.83	24.50	32.50
17	CSH 16	4.20	10.83	25.16	31.80
18	CSH 14	4.00	9.86	20.16	28.93
19	CSH 17	4.00	10.46	20.73	28.63
20	CSH 9	4.00	10.66	20.33	29.00
21	CSH 1290	6.00	10.00	19.70	30.00
22	19AxC 43	7.50	19.10	29.00	39.23
23	SPH 1252	4.00	12.83	23.30	30.00
24	SPH 1254	3.86	11.50	21.20	28.30
25	SPH 1256	5.06	11.86	22.76	29.10

Table 3. Contd...

Sr. No.	Entries	Average plant height (cm)			
		Days after emergence			
		7	14	21	28
26	SPH 1258	3.83	12.10	21.00	27.10
27	SPH 1260	3.80	11.23	20.16	27.76
28	SPH 1261	4.06	12.00	20.93	27.66
29	SP 1262	4.06	13.50	24.20	29.46
30	SPH 1267	5.10	11.46	21.00	29.16
31	SPH 1268	6.80	18.20	28.63	39.16
32	SPH 1269	6.66	17.46	28.46	29.23
33	SPH 1273	3.96	13.16	20.33	29.06
34	SPH 1274	6.76	18.23	28.60	39.20
35	SPH 1275	3.93	13.00	20.83	29.10
36	SPH 1276	5.10	11.53	20.46	27.83
37	SPH 1279	5.13	11.53	20.20	30.83
38	SPH 1281	3.93	13.66	22.53	29.53
39	SPH 1294	3.80	10.76	20.10	27.76
40	CSH 13	3.86	11.83	22.83	29.80
41	CSH 18	4.10	16.10	26.00	36.66
42	7Ax196	6.70	18.30	24.46	39.13
43	IS 2312 (RC)	7.60	19.20	29.10	39.40
44	DJ 6514 (SC)	3.90	9.46	20.33	27.50
	SE ±	0.060	0.066	0.057	0.084
	CD at 5%	0.166	0.184	0.159	0.235

RC - Resistant check

SC - Susceptible check

On the 28th day after emergence plant height ranged from 27.5 to 39.40 cm. Maximum plant height was recorded on the resistant check IS 2312 (39.40 cm), which was significantly more than the rest of the entries. It was at par with the entries SPH 1248, SPH 1280, 19A x C-43, SPH 1269 and SPH 1274. The plant height was significantly less in the entry DJ 6514 (27.5 cm), than the rest of the entries except the entries SPH 1270 and SPH 1261. The remaining entries occupied intermediate positions.

4.1.3.2 Leaf length

The data on leaf length are presented in Table 4.

The leaf length on the 14th day after emergence ranged from 17.45 to 26.40 cm. Maximum leaf length was recorded on the resistant check IS 2312 (26.40 cm), which was significantly more than the rest of the entries except the entries SPH 1248, 7 A x 196 and SPH 1280. The minimum leaf length was recorded on the susceptible check DJ 6514 (17.45 cm), which was significantly less than rest of the entries. The remaining entries occupied intermediate positions.

On the 21st day after emergence leaf length ranged from 28.01 to 38.86 cm. Maximum leaf length was recorded on the entry IS 2312 (38.86 cm) which was significantly more than the rest of the entries. It was on par with the entries SPH 1280, 19 A x C 43 and SPH 1248. The minimum

Table 4. Leaf length at weekly interval in different sorghum entries.

Sr. No.	Entries	Average leaf length (cm)		
		Days after emergence		
		14	21	28
1	SPH 1239	24.80	32.60	38.53
2	SPH 1240	23.00	31.40	40.60
3	SPH 1241	22.50	30.53	36.53
4	SPH 1242	21.00	30.46	36.10
5	SPH 1243	21.16	30.30	36.96
6	SPH 1244	21.16	30.40	36.60
7	SPH 1245	24.15	32.93	39.40
8	SPH 1246	23.80	31.06	36.80
9	SPH 1247	22.00	31.80	36.40
10	SPH 1248	26.33	38.60	46.20
11	SPH 1249	24.20	30.93	37.60
12	SPH 1250	23.45	33.00	37.00
13	SPH 1251	20.85	30.10	35.46
14	SPH 1270	20.45	29.13	35.86
15	SPH 1280	26.30	38.73	46.26
16	CSH 1283	25.00	34.00	38.26
17	CSH 16	24.50	33.26	37.13
18	CSH 14	20.80	29.73	46.46
19	CSH 17	21.90	30.20	35.86
20	CSH 9	23.85	30.93	36.26
21	CSH 1290	22.80	32.73	39.00
22	19AxC 43	26.10	38.50	46.10
23	SPH 1252	23.60	32.46	37.60
24	SPH 1254	21.83	29.33	36.20
25	SPH 1256	22.20	30.06	38.23

Table 4. Contd....

Sr. No.	Entries	Average leaf length (cm)		
		Days after emergence		
		14	21	28
26	SPH 1258	23.80	32.76	36.0
27	SPH 1260	21.60	30.13	34.86
28	SPH 1261	21.60	30.66	38.33
29	SP 1262	22.26	32.73	36.21
30	SPH 1267	23.46	31.06	37.26
31	SPH 1268	26.30	37.93	45.00
32	SPH 1269	26.10	37.86	45.06
33	SPH 1273	24.33	32.33	36.00
34	SPH 1274	26.26	38.06	45.26
35	SPH 1275	22.73	29.86	36.66
36	SPH 1276	22.26	29.93	35.73
37	SPH 1279	21.33	29.26	40.80
38	SPH 1281	23.80	30.26	36.86
39	SPH 1294	21.40	29.86	34.60
40	CSH 13	23.10	32.66	37.00
41	CSH 18	24.33	36.93	43.00
42	7Ax196	26.33	38.00	46.10
43	IS 2312 (RC)	26.40	38.86	46.30
44	DJ 6514 (SC)	17.45	28.01	34.40
	SE ±	0.167	0.184	0.169
	CD at 5%	0.463	0.511	0.469

RC - Resistant check

SC - Susceptible check

leaf length was recorded on the entry DJ 6514 (8.01 cm), which was significantly less than the rest of the entries. The remaining entries occupied intermediate positions.

On the 28th day after emergence the leaf length ranged from 34.40 to 46.30 cm. The maximum leaf length was recorded on the resistant check IS 2312 (46.30 cm), which was significantly more than the rest of the entries except the entries SPH 1280, SPH 1248, 7 A x 196 and 19A x C-43. The minimum leaf length was recorded on the susceptible check DJ 6514 (34.40 cm), which was significantly less than the rest of the entries. It was at par with the entries CSH 14, SPH 1294 and SPH 1260. The remaining entries occupied intermediate positions.

4.1.3.3 Leaf breadth

The data on leaf breadth are presented in Table 5.

On 14th day after emergence leaf breadth ranged from 1.83 to 3.96 cm. Minimum leaf breadth was recorded on the resistant check IS 2312 (1.83 cm) and was significantly less than the rest of the entries except the entry SPH 1248. Maximum leaf breadth was recorded on the susceptible check DJ 6514 (3.96 cm). It was at par with the entries SPH 1294, SPH 1279, SPH 1276, and SPH 1260. The remaining entries occupied intermediate positions.

The average leaf breadth on the 21st day after emergence ranged from 3.10 to 5.40 cm. The minimum leaf

Table 5. Leaf breadth at weekly interval in different sorghum entries.

Sr. No.	Entries	Average leaf breadth (cm)		
		Days after emergence		
		14	21	28
1	SPH 1239	2.92	3.85	5.10
2	SPH 1240	3.05	3.70	4.48
3	SPH 1241	2.85	4.60	5.46
4	SPH 1242	3.50	4.60	5.93
5	SPH 1243	3.10	4.72	5.53
6	SPH 1244	2.86	4.85	5.80
7	SPH 1245	2.80	3.80	4.66
8	SPH 1246	2.75	4.73	5.15
9	SPH 1247	3.25	4.93	5.25
10	SPH 1248	2.00	3.20	4.16
11	SPH 1249	2.40	4.60	5.76
12	SPH 1250	2.80	4.20	5.83
13	SPH 1251	2.15	4.33	5.66
14	SPH 1270	3.05	5.10	6.00
15	SPH 1280	2.15	3.10	4.10
16	CSH 1283	2.30	4.40	5.15
17	CSH 16	2.76	3.95	5.95
18	CSH 14	2.73	4.60	5.10
19	CSH 17	3.10	5.00	5.83
20	CSH 9	3.25	4.60	6.10
21	CSH 1290	3.00	4.73	5.73
22	19AxC 43	2.12	3.16	4.10
23	SPH 1252	3.10	4.40	5.50
24	SPH 1254	3.75	4.75	5.60
25	SPH 1256	3.00	4.33	5.70

Table 5. Contd...

Sr. No.	Entries	Average leaf breadth (cm)		
		Days after emergence		
		14	21	28
26	SPH 1258	3.13	4.50	5.75
27	SPH 1260	3.80	4.80	5.85
28	SPH 1261	3.25	4.80	5.50
29	SP 1262	2.90	4.20	5.80
30	SPH 1267	3.05	4.60	5.80
31	SPH 1268	2.15	3.20	4.20
32	SPH 1269	2.33	3.45	4.30
33	SPH 1273	2.65	4.33	5.50
34	SPH 1274	2.10	3.15	4.15
35	SPH 1275	3.14	4.50	5.60
36	SPH 1276	3.80	4.80	5.90
37	SPH 1279	3.80	5.10	6.00
38	SPH 1281	3.15	4.40	5.75
39	SPH 1294	3.80	4.90	5.90
40	CSH 13	3.10	4.63	5.36
41	CSH 18	2.90	4.40	5.70
42	7Ax196	2.13	3.10	4.10
43	IS 2312 (RC)	1.82	3.10	4.00
44	DJ 6514 (SC)	3.96	5.40	6.63
	SE ±	0.066	0.095	0.099
	CD at 5%	0.185	0.265	0.275

RC - Resistant check

SC - Susceptible check

breadth was recorded on the entries SPH 1280 and IS 2312 (3.10 cm), which was significantly less than the rest of the entries. It was on par with the entries 7A x 196, SPH 1274, 19A x C-43, SPH 1268 and SPH 1248. Maximum leaf breadth was recorded on the susceptible check DJ 6514 (5.40 cm), which was significantly more than the rest of the entries. The remaining entries occupied intermediate positions.

The average leaf breadth on the 28th day after emergence ranged from 4.0 to 6.63 cm. The minimum leaf breadth was recorded on the entry IS 2312 (4.00 cm) which was significantly less than the rest of the entries except the entries SPH 1280, 7A x 196, 19A x C-43, SPH 1248, and SPH 1268. The maximum leaf breadth was recorded on the entry DJ 6514 (6.63 cm) and was significantly more than the rest of the entries. The remaining entries occupied intermediate positions.

4.1.4 Correlations between different morphological characters and attack of sorghum shoot fly

The values of correlation coefficient (r) of different morphological plant characters with egg laying and dead hearts of sorghum shoot fly are presented in Table 6.

The results revealed that the correlations between morphological characters and shootfly attack were found

Table 6. Correlations of different morphological characters with attack of sorghum shoot fly.

Sr. No.	Morphological characters	No.of eggs laid per plant	Percentage of dead hearts
1.	Plant height	-0.657**	-0.792**
2.	Leaf length	-0.660**	-0.809**
3.	Leaf breadth	0.637**	0.771**
4.	Egg laying	--	0.716**

** Significant at 1 % level.

significant. The correlations of plant height and leaf length with number of eggs per plant (-0.657 and -0.660, respectively) and percentage of dead hearts (-0.792 and -0.809, respectively) were significant and negative indicating thereby that the entries with more plant height and leaf length were associated with less number of eggs and percentage of dead hearts.

As regards leaf breadth the correlation with rthe number of eggs laid per plant and the percentage of dead hearts was significant and positive (0.637 and 0.771, respectively) indicating the entries with more leaf breadth are associated with more damage due to shootfly.

There was strong and positive correlation between egg laying and dead hearts (0.716).

4.2 Reaction of different sorghum entries to stem borer

4.2.1 Stem borer damage as indicated by leaf injury in different sorghum entries

The data regarding the percentage of plants with leaf injury by stem borer are presented in Table 7.

On the 35th day after emergence plants with the leaf injury caused by stem borer ranged between 6.0 to 37.05 per cent. The minimum leaf injury was recorded on the entry IS 2312 and SPH 1240 (6.0 per cent) and these were significantly superior than rest of the entries and

Table 7. Stem borer damage as indicated by leaf injury and dead hearts in different sorghum entries

Sr. No.	Entries	Average percentage of damage	
		Per cent plants with leaf injury at 35 days after emergence	Per cent plants with dead hearts at 60 days after emergence
1	SPH 1239	11.53 (19.85)	15.81 (23.43)
2	SPH 1240	6.00 (14.17)	6.20 (14.41)
3	SPH 1241	14.30 (22.21)	11.39 (19.72)
4	SPH 1242	17.05 (24.38)	19.21 (25.99)
5	SPH 1243	12.13 (20.38)	11.46 (19.79)
6	SPH 1244	19.05 (25.87)	16.11 (23.66)
7	SPH 1245	30.22 (33.34)	37.05 (37.57)
8	SPH 1246	23.40 (28.92)	10.72 (19.10)
9	SPH 1247	15.05 (22.82)	16.25 (23.77)
10	SPH 1248	6.10 (14.29)	6.16 (14.37)
11	SPH 1249	16.48 (23.94)	19.50 (26.20)
12	SPH 1250	15.90 (23.49)	16.38 (23.86)
13	SPH 1251	18.85 (25.72)	11.21 (19.55)
14	SPH 1270	12.98 (21.11)	12.02 (20.28)
15	SPH 1280	15.10 (22.86)	16.65 (24.04)
16	CSH 1283	31.17 (33.93)	25.17 (30.11)
17	CSH 16	15.92 (23.51)	10.38 (18.86)
18	CSH 14	14.00 (21.97)	15.20 (22.94)
19	CSH 17	18.69 (25.61)	12.55 (20.74)
20	CSH 9	12.74 (20.90)	11.69 (19.97)
21	CSH 1290	16.29 (23.80)	16.19 (23.72)
22	19AxC 43	6.10 (14.29)	6.20 (14.41)
23	SPH 1252	20.43 (26.87)	26.31 (30.85)
24	SPH 1254	28.33 (32.15)	28.96 (32.55)

Table 7. Contd...

Sr. No.	Entries	Average percentage of damage	
		Per cent plants with leaf injury at 35 days after emergence	Per cent plant with dead hearts at 60 days after emergence
25	SPH 1256	32.88 (34.98)	40.81 (39.69)
26	SPH 1258	17.34 (24.60)	26.33 (30.80)
27	SPH 1260	20.88 (27.18)	27.38 (31.54)
28	SPH 1261	12.77 (20.94)	17.69 (24.86)
29	SP 1262	34.16 (35.76)	50.57 (45.15)
30	SPH 1267	18.89 (25.75)	25.00 (29.99)
31	SPH 1268	8.91 (17.36)	9.38 (17.83)
32	SPH 1269	10.37 (18.77)	18.47 (25.44)
33	SPH 1273	18.80 (25.69)	21.80 (27.83)
34	SPH 1274	9.00 (17.45)	9.27 (17.72)
35	SPH 1275	9.16 (17.62)	9.56 (18.01)
36	SPH 1276	13.88 (21.87)	12.50 (20.70)
37	SPH 1279	10.83 (19.21)	11.39 (19.72)
38	SPH 1281	9.30 (17.75)	16.95 (24.30)
39	SPH 1294	20.00 (26.56)	30.00 (33.20)
40	CSH 13	9.69 (18.13)	21.06 (27.31)
41	CSH 18	14.85 (22.66)	17.39 (24.64)
42	7Ax196	9.10 (17.55)	9.40 (17.85)
43	IS 2312 (RC)	6.00 (14.17)	6.10 (14.29)
44	DJ 6514 (SC)	37.05 (37.57)	51.83 (46.04)
	SE ±	0.151	0.191
	CD at 5%	0.418	0.531

Figures in parentheses are angular transformed values

RC - Resistant check

SC - Susceptible check

were at par with the entries SPH 1248 and 19 A x C-43. The maximum leaf injury was observed in the entry DJ 6514 (37.05 per cent), which was significantly more than rest of the entries. The remaining entries occupied intermediate positions.

4.2.2 Stem borer damage as indicated by dead hearts in different sorghum entries

The data regarding the percentage of dead hearts by stem borer are presented in Table 7 and graphically depicted in Fig. 3.

On 60th day after emergence the dead hearts caused by stem borer ranged from 6.10 to 51.83 per cent. The minimum dead hearts were recorded on the entry IS 2312 (6.10 per cent), which was significantly less than the rest of the entries. It was on par with the entries SPH 1248, SPH 1240, 19 A x C-43. The maximum dead hearts were recorded on the entry DJ 6514 (51.83 per cent), which was significantly more than the rest of the entries. The remaining entries occupied intermediate positions.

4.2.3 Length of tunneling by stem borer

The data regarding the length of tunneling in stalk and peduncle due to stem borer attack are presented in Table 8.

Table 8. Length of tunneling, stalk and peduncle damage at harvest by stem borer in different sorghum entries

Sr. No.	Entries	Per cent tunneling	% plants with Stem damage	% plants with Peduncle damage
1	SPH 1239	62.47 (52.21)	86.66 (68.57)	88.00 (69.72)
2	SPH 1240	23.06 (28.70)	27.55 (31.65)	27.02 (31.31)
3	SPH 1241	60.11 (50.82)	82.07 (54.94)	86.30 (68.26)
4	SPH 1242	62.94 (52.49)	74.00 (59.33)	76.66 (61.10)
5	SPH 1243	53.10 (46.77)	68.00 (55.54)	76.66 (61.10)
6	SPH 1244	58.73 (50.02)	76.00 (60.66)	77.40 (61.60)
7	SPH 1245	55.47 (48.13)	73.83 (59.22)	85.83 (67.88)
8	SPH 1246	45.35 (42.32)	63.00 (52.52)	68.33 (55.74)
9	SPH 1247	65.46 (53.99)	87.40 (59.20)	87.40 (69.20)
10	SPH 1248	22.52 (28.32)	26.45 (30.94)	26.45 (30.94)
11	SPH 1249	58.17 (49.69)	89.16 (70.77)	85.83 (67.60)
12	SPH 1250	64.57 (53.46)	93.33 (75.04)	86.66 (68.57)
13	SPH 1251	49.65 (44.79)	60.33 (50.95)	75.00 (59.99)
14	SPH 1270	51.37 (45.78)	56.34 (48.63)	68.78 (56.02)
15	SPH 1280	57.09 (49.07)	82.22 (65.05)	78.88 (62.63)
16	CSH 1283	53.09 (46.76)	83.33 (65.90)	80.00 (63.42)
17	CSH 16	33.00 (35.05)	51.10 (45.54)	51.10 (45.54)
18	CSH 14	31.00 (33.82)	52.90 (46.02)	52.90 (46.02)
19	CSH 17	51.83 (46.04)	69.62 (56.54)	70.92 (57.36)
20	CSH 9	41.64 (40.18)	72.05 (58.07)	73.88 (59.26)
21	CSH 1290	62.81 (52.41)	84.40 (66.72)	81.07 (64.20)
22	19AxC 43	22.69 (28.44)	27.12 (31.38)	27.02 (31.31)
23	SPH 1252	39.34 (38.83)	68.33 (55.74)	68.33 (55.74)
24	SPH 1254	58.27 (49.75)	91.11 (72.64)	91.11 (72.65)
25	SPH 1256	52.66 (46.44)	88.88 (70.51)	77.77 (61.86)

Table 8. Contd...

Sr. No.	Entries	Per cent tunneling	% plants with Stem damage	% plants with Peduncle damage
26	SPH 1258	64.43 (53.38)	63.88 (53.04)	65.52 (54.03)
27	SPH 1260	59.45 (50.44)	68.00 (55.54)	65.00 (53.72)
28	SPH 1261	42.19 (40.50)	57.86 (51.49)	57.86 (59.52)
29	SP 1262	59.52 (50.48)	86.11 (68.11)	86.11 (68.11)
30	SPH 1267	65.41 (54.00)	91.33 (72.87)	83.33 (65.89)
31	SPH 1268	28.70 (32.22)	42.10 (40.44)	42.50 (40.29)
32	SPH 1269	61.52 (51.65)	75.83 (60.77)	75.83 (60.48)
33	SPH 1273	65.39 (53.95)	70.32 (56.98)	70.32 (56.98)
34	SPH 1274	28.80 (32.45)	42.50 (40.68)	42.10 (40.44)
35	SPH 1275	28.91 (32.52)	42.66 (40.77)	42.20 (40.50)
36	SPH 1276	41.83 (40.29)	61.11 (51.41)	61.11 (51.41)
37	SPH 1279	52.23 (46.27)	65.71 (54.15)	75.71 (60.46)
38	SPH 1281	50.02 (45.00)	70.55 (57.12)	70.55 (57.12)
39	SPH 1294	67.01 (54.93)	90.00 (71.55)	60.00 (50.76)
40	CSH 13	59.87 (50.74)	72.22 (58.18)	72.22 (58.18)
41	CSH 18	48.83 (46.24)	66.66 (54.72)	66.66 (54.72)
42	7Ax196	29.00 (32.57)	42.20 (40.50)	42.66 (40.77)
43	IS 2312 (RC)	23.12 (28.73)	27.02 (31.31)	27.12 (31.38)
44	DJ 6514 (SC)	70.04 (56.80)	96.29 (78.91)	96.29 (78.89)
	SE ±	0.304	0.392	0.204
	CD at 5%	0.842	1.085	0.565

Figures in parentheses are angular transformed values.

RC - Resistant check

SC - Susceptible check

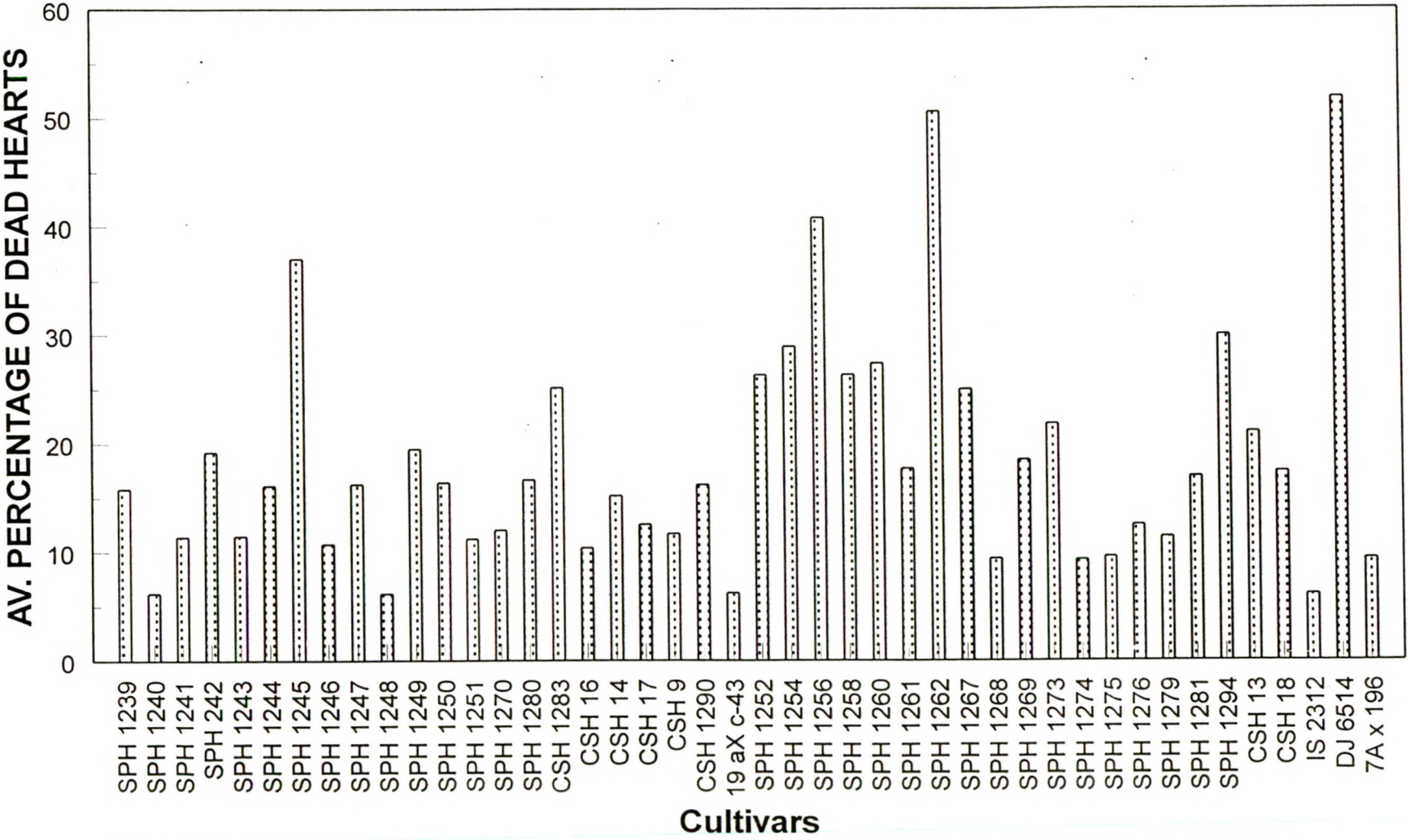


Fig. 3. STEM BORER DAMAGE AS INDICATED BY DEAD HEARTS AT 60 DAYS AFTER EMERGENC

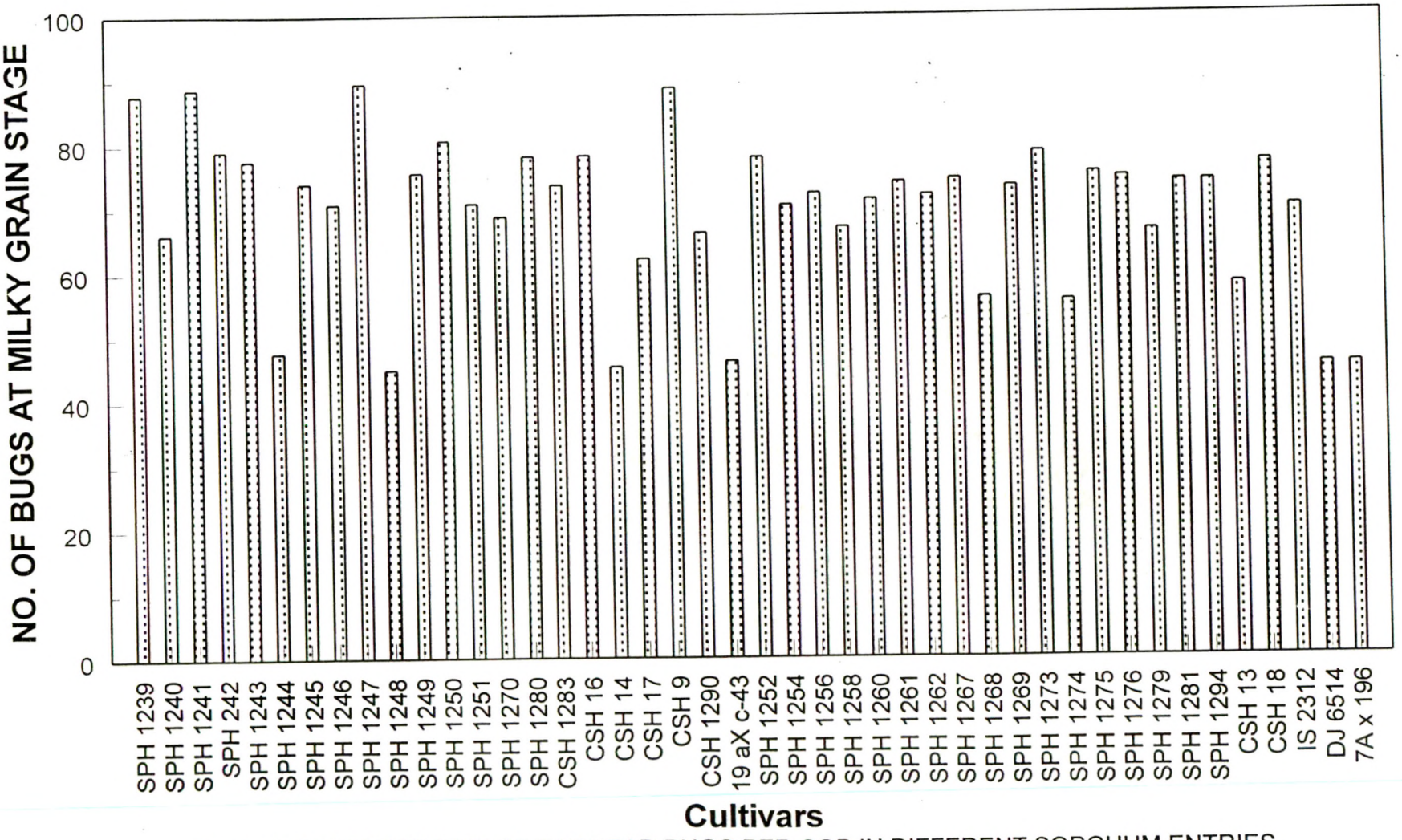


Fig. 4. AVERAGE NUMBER OF EARHEAD BUGS PER COB IN DIFFERENT SORGHUM ENTRIES

The length of tunneling in stalk and peduncle ranged from 22.52 to 70.04 per cent. The minimum tunneling was recorded in the entry SPH 1248 (22.52 per cent) which was significantly lower than the rest of the entries except the entries 19A x C-43, SPH 1240 and IS 2312. The maximum length of tunneling was recorded in the entry DJ 6514 (70.04 per cent) and was significantly more than the rest of the entries. The remaining entries occupied intermediate positions.

4.2.4 Stem and peduncle damage

The data regarding the percentage of stem and peduncle damage are presented in Table 8.

Stem damage

Stem damage ranged from 26.45 to 96.29 per cent. The minimum stem damage was recorded on the entry SPH 1248 (26.45 per cent) which was significantly less than the rest of the entries. It was at par with the entries IS 2312, 19 A x C 43 and SPH 1240. Significantly high percentage of stem damage was recorded on the entry DJ 6514 (96.29 per cent) than the rest of the entries. The remaining entries occupied intermediate positions.

Peduncle damage

The peduncle damage ranged from 26.45 to 96.29 per

cent. The minimum peduncle damage was recorded on the entry SPH 1248 (26.45 per cent) which was significantly less than the rest of the entries except IS 2312, 19 A x C 43 and SPH 1240. Significantly high percentage of peduncle damage was recorded on the entry DJ 6514 (96.29 per cent) than the rest of the entries. The remaining entries occupied intermediate positions.

4.3 Reaction of different sorghum entries to earhead bug

4.3.1 Incidence of earhead bug

The data regarding the number of earhead bugs per panicle were recorded at 50 per cent flowering and milky grain stage are presented in Table 9 and graphically depicted in Fig. 4.

Average number of earhead bugs per panicle at 50 per cent flowering ranged from 38.0 to 68.66. The minimum number of earhead bugs were recorded on the entry SPH 1248 (38.0), which was significantly less than rest of the entries. It was on par with the entries 7 A x 196 and CSH 14. Maximum number of bugs were recorded on the entry SPH 1247 (68.66) which was significantly higher than the rest of the entries. The remaining entries occupied intermediate positions.

Average number of bugs at milky grain stage ranged between 45.0 to 89.55 per panicle. The minimum number of

Table 9. Average number of earhead bugs per cob on different sorghum entries.

Sr. No.	Entries	No. of bugs at 50% flowering	No. of bugs at milky grain stage
1	SPH 1239	53.11 (7.32)	87.77 (9.39)
2	SPH 1240	51.55 (7.21)	66.10 (8.16)
3	SPH 1241	56.11 (7.52)	88.77 (9.44)
4	SPH 1242	60.11 (7.78)	79.11 (8.92)
5	SPH 1243	52.11 (7.25)	77.66 (8.84)
6	SPH 1244	40.11 (6.37)	47.66 (8.94)
7	SPH 1245	59.33 (7.73)	74.11 (8.63)
8	SPH 1246	54.88 (7.74)	70.88 (8.64)
9	SPH 1247	68.66 (8.31)	89.55 (9.48)
10	SPH 1248	38.00 (6.20)	45.00 (6.74)
11	SPH 1249	54.33 (7.40)	75.66 (8.72)
12	SPH 1250	55.33 (7.47)	80.66 (9.00)
13	SPH 1251	57.88 (7.64)	70.88 (8.44)
14	SPH 1270	50.33 (7.12)	68.88 (8.32)
15	SPH 1280	50.44 (7.13)	78.22 (8.87)
16	CSH 1283	56.00 (7.51)	73.77 (8.61)
17	CSH 16	56.55 (7.55)	78.33 (8.87)
18	CSH 14	38.40 (6.23)	45.44 (6.77)
19	CSH 17	53.00 (7.31)	62.22 (8.34)
20	CSH 9	65.77 (8.14)	88.77 (9.44)
21	CSH 1290	53.77 (7.36)	66.22 (8.16)
22	19AxC 43	43.00 (6.59)	46.20 (6.83)
23	SPH 1252	57.00 (7.58)	78.00 (8.86)
24	SPH 1254	54.66 (7.42)	70.50 (8.42)
25	SPH 1256	56.00 (7.51)	72.33 (8.53)

Table 9. Contd...

Sr. No.	Entries	No. of bugs at 50% flowering	No. of bugs at milky grain stage
26	SPH 1258	48.00 (6.96)	67.00 (8.21)
27	SPH 1260	50.00 (7.10)	71.33 (8.47)
28	SPH 1261	51.00 (7.17)	74.00 (8.63)
29	SP 1262	55.00 (7.44)	72.00 (8.53)
30	SPH 1267	53.00 (7.07)	74.50 (8.66)
31	SPH 1268	42.00 (6.51)	56.00 (7.38)
32	SPH 1269	52.56 (7.28)	73.30 (8.59)
33	SPH 1273	43.00 (6.59)	78.66 (8.89)
34	SPH 1274	41.50 (6.48)	55.50 (7.44)
35	SPH 1275	56.66 (7.56)	75.33 (8.70)
36	SPH 1276	51.66 (7.22)	74.66 (8.66)
37	SPH 1279	53.00 (7.31)	66.33 (8.17)
38	SPH 1281	52.00 (7.24)	74.00 (8.63)
39	SPH 1294	56.00 (7.51)	74.00 (8.63)
40	CSH 13	43.00 (6.59)	58.00 (7.64)
41	CSH 18	56.66 (7.56)	77.00 (8.80)
42	7Ax196	38.33 (6.23)	45.44 (6.77)
43	IS 2312 (RC)	52.40 (7.27)	70.00 (8.39)
44	DJ 6514 (SC)	38.33 (6.37)	45.44 (6.77)
	SE ±	0.038	0.023
	CD at 5%	0.107	0.065

Figures in parentheses are Poisson values.

RC - Resistant check

SC - Susceptible check

bugs were recorded on the entry SPH 12 48 (45.0) which was significantly less than the rest of the entries. But, it was at par with the entries 7 A x 196, CSH 14 and DJ 6514. The maximum incidence was recorded on the entry SPH 1247 (89.55) which was significantly higher than the rest of entries. The remaining entries occupied intermediate positions.

4.3.2 Chaffy earheads and shrivelled grains

The data regarding the chaffy earheads and shrivelled grains recorded at harvest are presented in Table 10.

Chaffy earheads

The percentage of chaffy earheads in different sorghum entries ranged from 43 to 94.44 per cent. The minimum number of chaffy earheads were recorded on the entry CSH 14 (43 per cent) and was significantly less than the rest of the entries except the entries 7 A x 196, SPH 1248 and DJ 6514. Maximum chaffy earheads were recorded on the entry SPH 1247 (94.44 per cent). The remaining entries occupied intermediate positions.

Shrivelled grains

The percentage of shrivelled grains ranged from 46.2 to 97.40. The minimum shrivelled grains were recorded

Table 10. Chaffy earheads and shrivelled grains caused by earhead bug attack at harvest

Sr. No.	Entries	Per cent chaffy earheads	Per cent shrivelled grains
1	SPH 1239	65.07 (53.76)	84.97 (67.18)
2	SPH 1240	64.00 (53.12)	70.00 (576.78)
3	SPH 1241	70.47 (57.07)	48.25 (43.99)
4	SPH 1242	63.34 (52.73)	82.29 (65.10)
5	SPH 1243	69.72 (56.60)	89.30 (70.89)
6	SPH 1244	49.00 (44.42)	50.50 (45.28)
7	SPH 1245	63.02 (52.54)	87.61 (69.38)
8	SPH 1246	70.02 (56.79)	79.11 (62.79)
9	SPH 1247	94.44 (76.36)	97.40 (80.72)
10	SPH 1248	43.80 (41.43)	46.20 (42.81)
11	SPH 1249	83.53 (66.05)	85.54 (67.84)
12	SPH 1250	61.26 (51.50)	94.84 (76.86)
13	SPH 1251	68.65 (55.94)	82.42 (62.20)
14	SPH 1270	69.72 (56.60)	74.28 (59.51)
15	SPH 1280	84.44 (66.76)	95.31 (77.49)
16	CSH 1283	73.52 (59.03)	91.84 (73.39)
17	CSH 16	74.60 (59.73)	73.00 (58.68)
18	CSH 14	43.00 (40.97)	46.50 (42.98)
19	CSH 17	76.00 (60.62)	87.39 (69.19)
20	CSH 9	87.50 (69.28)	95.65 (77.95)
21	CSH 1290	67.14 (55.01)	84.89 (67.11)
22	19AxC 43	47.00 (43.27)	48.33 (44.88)
23	SPH 1252	47.00 (43.27)	94.38 (76.27)
24	SPH 1254	70.92 (57.25)	74.00 (59.33)
25	SPH 1256	86.11 (68.11)	91.40 (72.95)

Table 10. Contd...

Sr. No.	Entries	Per cent chaffy earheads	Per cent shrivelled grains
26	SPH 1258	51.00 (45.56)	84.38 (66.21)
27	SPH 1260	77.77 (61.86)	87.80 (69.54)
28	SPH 1261	61.66 (51.74)	79.25 (62.89)
29	SP 1262	76.66 (61.10)	94.00 (75.81)
30	SPH 1267	54.44 (47.54)	86.50 (68.43)
31	SPH 1268	47.00 (43.23)	49.38 (44.63)
32	SPH 1269	83.33 (67.13)	91.27 (72.80)
33	SPH 1273	86.66 (68.57)	94.69 (76.55)
34	SPH 1274	47.00 (43.27)	49.00 (44.42)
35	SPH 1275	78.57 (62.41)	93.61 (75.35)
36	SPH 1276	75.55 (60.35)	90.43 (71.97)
37	SPH 1279	71.66 (58.25)	72.00 (60.32)
38	SPH 1281	84.72 (66.98)	88.00 (69.72)
39	SPH 1294	78.25 (62.19)	86.00 (68.02)
40	CSH 13	54.83 (47.76)	52.43 (46.38)
41	CSH 18	82.73 (65.44)	88.88 (70.51)
42	7Ax196	43.10 (41.02)	46.30 (42.87)
43	IS 2312 (RC)	80.00 (63.43)	81.40 (64.44)
44	DJ 6514 (SC)	43.80 (41.43)	46.90 (43.21)
	SE ±	0.276	0.393
	CD at 5%	0.764	1.08

RC - Resistant check

SC - Susceptible check

on the entry SPH 1248 (46.2 per cent) which was significantly less than rest of the entries. It was at par with the entries 7 A x 196, CSH 14 and DJ 6514. The entries SPH 1247 (97.40 per cent) recorded significantly high percentage of shrivelled grains than other entries. The remaining entries occupied intermediate positions.

DISCUSSION

Chapter-V

DISCUSSION

The results obtained in the present investigations are discussed in the light of previous work under the following headings.

5.1 Reaction of different sorghum entries to shoot fly

5.2 Reaction of different sorghum entries to stem borer.

5.3 Reaction of different sorghum entries to earhead bug

5.4 Multiple resistance to shoot fly, stem borer and earhead bug

5.1 Reaction of different sorghum entries to shoot fly

5.1.1 Oviposition of shoot fly on different sorghum entries

The studies on the oviposition of shoot fly indicated that significantly less number of eggs were observed on the entries 19 A x C-43, 7A x 196, SPH 1280, SPH 1268, SPH 1274, SPH 1269 and SPH 1248 which were at par with the resistant check IS 2312. It was noticed that the susceptible check DJ 6514 had the highest number of egg laying which was at par with SPH 1270 indicating thereby

the non preference of resistant entries may be one of the characters for oviposition.

It was observed that number of eggs laid were less on 7th day after emergence. on 14th and 21st day after emergence number of eggs laid were more and reduced at 28 days after emergence.

Dalvi *et al.* (1984) , observed that less number of egg laid on 7th day after emergence and there was increase in egg laying gradually and showed a peak on 21st day after emergence, which confirms the present findings.

Literature pertaining to the entries under study is very scarce.

Krishnanda *et al.* (1970), Jotwani *et al.* (1971), Narayana (1975), Sangappa, (1978), Singh and Narayana (1978), Raina (1984), Dalvi et al (1990), Patel and Sukhani (1990) reported higher number of eggs on susceptible entries than on the resistant ones.

5.1.2 Shoot fly damage on different sorghum entries

Significantly less percentage of dead hearts were recorded on the entries SPH 1248, 19A x C-43, SPH 1280 and resistant check IS 2312 and are less susceptible. The susceptible check DJ 6514 recorded significantly higher percentage of dead hearts (100 per cent) as compared to rest of the entries. The remaining entries were grouped as moderately susceptible.

The data revealed that the incidence started from first week of emergence and increased upto 4th week. More number of dead hearts were observed during 3rd and 4th week after emergence. These results confirm the studies carried out by Krishnanda *et al.* (1970).

Anonymous(1972), Bapat (1977), Mote *et al.* (1981), Observed less number of dead hearts in resistant entries than in susceptible ones.

5.1.3 Morphological characters of sorghum entries associated with resistance to shoot fly

5.1.3.1 Plant height

Significantly more plant height was recorded in the entries SPH 1248, SPH 1280, 19A x C-43 and the resistant check IS 2312 and these entries recorded less number of eggs per plant(1.65, 1.55, 1.5 and 1.6) respectively and also less percentage of dead hearts.Significantly lowest plant height was recorded in susceptible check DJ 6514 which recorded 7.1 eggs per plant and 100 per cent dead hearts.

In general it was observed that the entries with more height were found to be less susceptible to shoot fly then the dwarf entries. This might due to slow growth of plants. Similar results were reported by Blum (1966), Raghunath *et al.*(1972), Narayana (1975), Bothe (1979),

, Rasker (1979), and Khurana (1980).

5.1.3.2 Leaf length

Significantly more leaf length was recorded on the entries SPH 1280, 19A x C-43, SPH 1248, and the resistant check IS 2312 and these entries recorded less number of eggs per plant (1.55, 1.65, 1.5 and 1.6 respectively.Less number of dead hearts were also recorded on these entries. Significantly lowest leaf length was recorded on the susceptible check DJ 6514 which recorded 7.1 eggs per plant and highest percentage of dead hearts. The entries having more leaf length were observed less susceptible and the entries having less leaf length were observed highly susceptible. Similar results were recorded by Singh (1977), Maiti and Bidinger (1979) and Singh (1998), which supports the present findings.

5.1.3.3 Leaf width

Significantly less leaf width was recorded on the entries SPH 1280, 7A x 196, SPH 1274, 19A x C-43, SPH 1268, SPH 1248 and the resistant check IS 2312 and these entries recorded significantly less number of eggs per plant (1.55, 1.5, 1.6, 1.5, 1.6, 1.65 and 1.6 respectively) and also less percentage of dead hearts. Significantly more

leaf width was recorded on the susceptible check DJ 6514 which recorded 7.1 eggs per plant and highest percentage of dead hearts (100%). The entries having less leaf width are observed to be less susceptible and the entries having more leaf width were observed susceptible to the shoot fly. This can be explained by the fact that the shoot fly gets more area to move about and deposit eggs at suitable place on the entries having more leaf width.

Singh (1977), Rasker (197), Bothe (1979) and Moholkar (1981), also reported more shoot fly attack on the plants with more leaf width.

5.1.4 Correlation between different morphological characters and attack of shoot fly

The correlations between plant heuight and leaf length with egg laying (0.657 and -0.660 respectively) and dead hearts (-0.792 and -0.809, respectively) were significant and negative indicating thereby that the entries with more plant height and leaf length were associated with less number of eggs and percentage of dead hearts. There was a significant positive correlation of leaf breadth with dead hearts (0.771) and egg laying (0.637) indicating the entries with more leaf breadth are associated with more damage due to shoot fly. There was strong and positive correlation between egg laying and dead hearts (0.716).

Raskaer (1979) and Moholkar (1981) found positive correlation between leaf width, oviposition and dead hearts.

Sharma (1975) and Dalvi *et al.* (1984) found that the percentage of dead hearts was negatively correlated with plant height.

Moholkar (1981) and Patel and Sukhani (1990) found that there was positive correlation between oviposition and dead hearts.

These findings supports the present findings.

5.2 Reaction of different sorghum entries to stem borer

5.2.1 Leaf injury

The observations on leaf injury in different entries were significant. It was significantly less on SPH 1240, SPH 1248, 19A x C-43 and resistant check IS 2312. These entries recorded less percentage of dead hearts and are less susceptible. Maximum leaf injured plants were observed in the susceptible check DJ 6514 followed by SPH 1262, SPH 1256, CSH 1283 and SPH 1245. These entries also recorded more percentage of dead hearts.

Kishore and Jotwani (1982) reported less number of leaf injured plants in resistant entries SPV 17, SPV 19, and SPV 58 resistant to Chilo.

Singh *et al.* (1991) also reported that IS 2123, IS 5469 were resistant to chilo on the basis of leaf injury.

5.2.2 Dead heart count

Significantly less dead hearts were observed on the entries, SPH 1248, SPH 1240, 19A x C-43 and the resistant check IS 2312. Maximum dead hearts percentage was recorded on the susceptible check DJ 6514 followed by the entries SPH 1262, SPH 1256 and SPH 1245.

Dobrawaski and Kidvai (1983) , Singh *et al.* (1991) and Patel *et al.* (1996) reported less percentage of dead hearts in resistant entries.

Singh and Grewal (1997) recorded less percentage of dead hearts (20) in IS 2312 as compared to other entries.

5.2.3 Length of tunneling

The entries SPH 1248, 19A x C-43 SPH 1240 and the resistant check IS 2312 recorded significantly less length of tunnelling than other entries. Maximum tunnelling was recorded on susceptible check DJ 6514 followed by SPH 1294.

Dobrawaski and Kidwai (1983), Singh (1983), Anonymous (1995), Patel *et al.* (1996) and Singh *et al.* (1991) reported less percentage of length of tunneling in resistant entries.

5.2.4 Stem and peduncle damage

Significantly less percentage of plants with stem and peduncle damage were recorded in the entries SPH 1248, 19A x C-43, SPH 1240 and the resistant check IS 2312. Maximum damage was recorded in the susceptible check DJ 6514.

Dalvi *et al.* (1983), Anonymous (1995) and Anonymous (1998) also reported the susceptibility of entries on the basis of stem and peduncle damage.

5.3 Reaction of different sorghum entries to earhead bug

5.3.1 Number of bugs per panicle

Significantly less number of bugs per panicle were recorded on the entries CSH 14, SPH 1248,7Ax 196,and DJ 6514 as compared to other entries at 50 per cent flowering and milky grain stage. Significantly highest number of bugs were recorded on the entry SPH 1247 followed by CSH 9. Higher incidence of bugs was recorded at milky grain stage than at flowering stage.

Paul (1976) observed that earhead bug appears during milky stage of the crop and severe infestation results in chaffy earheads.

Sharma and Lopez (1991) and Sharma *et al.* (1993) reported that CSH 9 was more susceptible to earhead bug. Less number of bugs per panicle was observed on CSH 14 and SPH 1182 (Anonymous, 2000b).

5.3.2 Chaffy earheads and shrivelled grains caused by earhead bug attack

The entries CSH14, 7A x 196,SPH 1248 and DJ 6514 recorded significantly less percentage of chaffy earheads and shrivelled grains as compared to other entries. Significantly more percentage of chaffy earheads and Shrivelled grains were recorded on SPH 1247 followed by CSH 9.

Sharma (1991) and Sharma and Lopez (1991) reported that CSH 5 and CSH 9 suffered more grain damage due to earhead bug as has been observed in the present studies.

5.4 Multiple resistance to shoot fly, stem borer and earhead bug

On the basis of dead hearts due to shoot fly and stem borer the entries SPH 1248, 19 A x C-43 and the resistant check IS 2312 recorded less percentage of dead hearts and were found less susceptible to both the pests.

The entry SPH 1248 recorded significantly less percentage of dead hearts due to shoot fly and stem borer and less number of earhead bug, shrivelled grains and chaffy earheads exhibiting resistance to all the three pests.

SUMMARY

Chapter-VI

SUMMARY

Sorghum is an important food and fodder crop of Maharashtra State. Insect pests are one of the major yield reducing factors in sorghum which is attacked by number of pests species.

The sorghum shoot fly (*Atherigona soccata* Rondani), stem borer (*Chilo partellus* Swinhoe) and earhead bug (*Calocoris angustatus* Leth) are important pests of sorghum and cause heavy losses.

In the present investigations attempts were made to screen the sorghum entries, to study possible correlation between morphological plant characters and resistance to these pests, and to identify multiple resistant entries.

Investigations were carried out to study the reaction of 44 entries of the sorghum hybrids to the shoot fly, stem borer and earhead bug at Sorghum Research Station, M.A.U. Parbhani during kharif 2000. The experiment was laid out in randomised block design with 3 replications and 44 entries as treatments. Single row of 4.5 m length for each entry was sown at the spacing of 45 x 15 cm.

Observations were recorded on oviposition, dead hearts and plant characters (plant height, leaf length and

leaf breadth) associated with shoot fly resistance, stem borer (leaf and shoot damage, length of tunneling and peduncle and stem damage) and the earhead bug (incidence, shrivelled grains and chaffy earheads.

The results obtained are summerised as under.

Shoot fly

The entries 19 A x C-43, 7A x 196, SPH 1280, SPH 1268, SPH 1274, SPH 1269, and SPH 1248 recorded significantly less number of eggs per plant which were at par with the resistant check IS 2312. Significantly highest number of eggs were recorded on susceptible check DJ 6514 followed by SPH 1270.

The entries SPH 1248, 19A x C-43, SPH 1280 and resistant check IS 2312 recorded significantly less percentage of dead hearts as compared to other entries. The dead hearts percentage was highest in susceptible check DJ 6514.

Significantly more plant height was recorded in the entries SPH 1248, SPH 1280, 19A x C-43 and the resistant check IS 2312 indicating there by that the taller entries exhibited the resistance to the shoot fly and the plant height was significantly less in the susceptible check DJ 6514.

The entries SPH 1280, 19A x C-43, SPH 1248 and the resistant check IS 2312 with more leaf length were found

less susceptible and the entry DJ 6514 with minimum leaf length exhibited higher shoot fly attack.

As regards leaf width, the entries SPH 1280, 7A x 196, SPH 1274, 19A x C-43, SPH 1248, SPH 1268 and the resistant check IS 2312 with less leaf width recorded less damage than rest of the entries and susceptible check DJ 6514 with more leaf width recorded more damage than other entries.

There was negative and significant correlation of plant height and leaf length with oviposition and dead hearts of shootfly. Positive and significant correlation was found in leaf breadth with oviposition and dead hearts of shootfly. Correlation between ovisposition and dea dhearts was positive and significant.

Stem borer

The entries SPH 1240, SPH 1248, 19A x C-43 and the resistant check IS 2312 were observed less susceptible to *Chilo partellus* on the basis of leaf injury length of tunneling, dead hearts and stem and peduncle damage. susceptible check DJ 6514 recorded highest damage.

Earhead bug

The entries SPH 1248, 7A x 196, CSH 14 and DJ 6514 were observed less susceptible to earhead bug attack on the basis of chaffy earheads and shrivelled grains.

Multiple resistance

The entries SPH 1248, 19A x C-43 and IS 2312 were found less susceptible to both the pests, shoot fly and stem borer.

The entry SPH 1248 was observed less susceptible to all these three pests shoot fly, stem borer and earhead bug.

Considering all the parameters it was observed that the entries SPH 1248, 19A x C-43 and IS 2312 were found less susceptible to shoot fly and stem borer and can be used for studies on breeding for resistance to the above pests. As regards the reaction of different entries to earhead bug, the entries SPH 1248, 7A x 196, CSH 14 and DJ 6514 were found less susceptible which can be used for breeding programme for resistance to earhead bug.

LITERATURE CITED

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Anonymous. (1972). Screening for resistance against shoot fly *A. soccata* Rond. Progress Report, AICSIP, ICAR, New Delhi, 5 : 44.

Anonymous. (1992). Annual Report of Sorghum Research Station, M.A.U. Parbhani : 32-36.

Anonymous (1995). Evaluation of advanced varietal cum hybrid trial. Annual Report of Sorghum Research, S.R.S., M.A.U. Parbhani : 1-3.

Anonymous (1998). Screening for resistance to major pests of sorghum . annual Report of Sorghum Research, S.R.S., M.A.U., Parbhani : 10-15.

Anonymous (1999). Evaluation of Advance varieties and hybrids for resistance to major pests of sorghum. Annual Report of Sorghum Research, S.R.S., M.A.U., Parbhani : 54-63.

Anonymous (2000a) Screening for resistance to major pests of sorghum. Annual Report of Sorghum Research. , S.R.S., M.A.U. Parbhani : 68-87.

Anonymous (2000b). Development of hybrid crops (NATP mm project). Rabi sorghum progress Report 1998-99, AICSIP group meeting 30th January, to 1st February, 2000 at Directorate of Rice Research, Hyderabad.

Atkine (1983). Sorghum hybrid performance of bug resistant lines. Sorghum News letter : 26-43.

Ayyar, T.V.R. (1963). Handbook or economic entomology for South India, controller of stationary and printing, Madras : 561.

Ballard, B.A. (1916). Bulletin No. 58, Agricultural Research Institute, Pusa, Calcutta Supt. Govt. Printing Press, India : 8.

Balikai, R.A. Kullaiswamy, B.Y. (1999). Evaluation of F2 populations and their parents for resistance to sorghum shoot fly. Insect Environ. 5:2 , 54-55.

Blum, A. (1966). Resistance to sorghum shoot fly. Sorghum Newsletter. 9 : 59.

Bapat, D.R. , Shirole, M. and Murthy, T.K. (1977). Evaluation of breeders material in advanced yield trial for resistance to shoot fly and stem borer. Sorghum Newsletter, 20 : 55.

Bothe, N.N. (1979). Screening of some sorghum lines for resistance to shoot fly, *Atherigona soccata* (Rondani) M. resistance to jowar (*Sorghum vulgar*). M.Sc. (Agri.) Thesis, M.A.U. Parbhani (M.S).

Dalvi, C.S., Dalaya, V.P.and Khanvilkar, V.G. (1983). Screening for some sorghum varieties for resistance to stem borer *Chilo partellus* (Swinhoe). Indian J. Ent., 45 : 266-274.

Dalvi, C.S., Dalaya, V.P. and Khanvilkar, V.G. (1984). Screening of some sorghum varieties for resistance to shoot fly. *A. soccata* (Rond.). Indian J. Ent. , 46 (4) : 421-427.

Dalvi, C.S., Dalaya, V.P. and Khanvilkar, V.G. (1990). Screening of some sorghum varieties for resistance to shoot fly, *Atherigona soccata* (Rond.) Indian J. of Ent. 52 (2) : 279-289.

Dobrowaski, Z.T. and Kidvai, E.L. (1983). Resistance to some sorghum lines to spotted stalk borer, *Chilo partellus* Swinhoe under Western Kenya condition. Insect Sci. and its appli. 4 (1-2) : 119-126.

Hiremath, I.G. (1987). Screening of sorghum genotypes to the damage of sorghum earhead bug, *C. angustatus*. Mysore J. of Agric. Sc. 21 (4) :446-449.

Jadhav, R.B. and Jadhav, L.D. (1979). Studies on the relative susceptibility of hybrids and varieties to shoot fly (*A. soccata* Rond.) Indian J. Agric. Sci. 4 (1) : 44-49.

Jadhav , V.M. (1993). Studies on crop loss assessment and chemical control of sorghum earhead bug *Calocoris angustatus* Leth. M.Sc. thesis submitted to M.A.U. Parbhani.

Jotwani, M.G. (1978). Ovipositional response of shoot fly on promising sorghum resistant lines. Investigation on insect pests sorghum and millets with special reference to host plant resistance. Final Tech. Report (1972-77), 11-12 : Division of Entomology, IARI, New Delhi.

Jotwani, M.G. and Sukhani, T.R. (1971). Seed treatment for the control of sorghum shoot fly. Pesticides, 5 (4) : 13-14.

Jotwani, M.G. , Marawaha, K.K., Shrivastava, K.M. and Young, W.R. (1970). Seasonal incidence of shoot fly *A. varia soccata* (Rond.) in jowar hybrids at New Delhi. Indian J. Ent. 32 (1) : 7-15.

Khurana, A.D. (1980). Studies on resistance in forage sorghum to *Chilo partellus* (Swinhoe) and *Atherigona soccata* (Rond.), Ph.D. thesis , Haryanana Agricultural University, Hissar.

Kishore, P. (1992). Evaluation of twin resistance sources amongst advance generation derivatives in sorghum to shoot fly. *Atherigona soccata* (Rond) and stem borer *Chilo partellus* (Swinhoe) J. of Ent. Res. 16 (3) : 236-241.

Kishore, P. (1994). Development of new dual purpose sorghum germplasm showing resistance to shoot fly, *Atherigona soccata* Rondani and Stem borer, *Chilo partellus* (Swinhoe). J. of Ent. Res., 18 : 3, 279-281.

Kishore, P. and Jotwani, M.G. (1982) . Integrated pest management in sorghum J. Envir. Res., 3 (1) : 1-7.

Krishnanda, N., Jayraj, S. and Subramaniam, T.R. (1970). Resistance in sorghum to stem fly *Atherigona varia soccata* Rond. Madras Agric. J., 57 (11) : 674-676.

Kulkarni, R.A. and Bhuti, S.G. (1983). Grain weight loss in sorghum due to sorghum earhead bug *Calocoris angustatus* Leth. sorghum Newsletter, 26 : 73.

Maiti, R.K. and Bidinger, F.R. (1979). A simple approach to the identification of shoot fly tolerance in sorghum. Indian J. plant Prot., 7 (2) : 135-140.

Moholkar, P.R. (1981). Investigation on the resistance to shoot fly, *Atherigona soccata* (Rondani) and stem borer *Chilo partellus* (Swinhoe) in sorghum. Ph.D. thesis, post Graduate school, IARI, New Delhi.

Mote, U.N. and Kadam, S.S. (1984). Incidence and losses caused by sorghum head bug. J. Maha. Agric. Univ. (MPKV, Rahuri), India. 15 (1) : 121-122.

Mote, U.N., Shirole, S.M. and Bapat, D.R. (1981). Screening of local kharif varieties of sorghum for resistance to shoot fly. J. Maha. agric. Univ. 6 (2) : 165-166.

Mote, U.N., Bapat, D.R. and Kadam, J.R. (1982). Present status of improvement pests in Maharashtra and their impact on production. Paper presented to sorghum workshop held at College of Agriculture, Pune, May 17-19, 1982.

Naik, L.K. and Bhuti, S.G. (1985). Response of advanced breeders Material to shoot fly incidence , Sorghum Newsletter, 28 : 6.

Narayana, D. (1975). Characters contributing to sorghum shoot fly resistance. Sorghum Newsletter, 18 : 21-22.

Natarajan, N. and Sridhar, R.P. (1988). Grading sorghum entries for their resistance to earhead bug. Madras agric. J. 75 (5-6) : 216-217.

Nour, A.M. (1995). Phenotypic stability of sorghum hybrids for resistance to the spotted stem borer, *Chilo partellus* (Swinhoe). Insect Sci. and its appl. publ. , 16 (3-4) : 279-282.

Patel, G.M., Sukhani, T.R. and Srivastav, K.P. (1989). Studies on multiple resistance to shoot fly and stem borer. Indian J. Ent., 51 (3) : 261.264.

Patel, G.M. and Sukhani, T.R. (1990). Screening of sorghum genotypes for resistance to shoot fly *Atherigona soccata* Rondani. Indian J. Ent. , 52 (1) : 1-8.

Patel, G.M., Sukhani, T.R. Patel, M.B. and Singh, S.P. (1996). Relative susceptibility of promising sorghum genotypes to stem borer in Delhi and Hissar conditions. Indian J.Ent., 57 (3) : 279-284.

Paul, M.D. (1976). Evaluation of certain insecticides for the control of earhead bug *Calocoris angustatus*. Sorghum Newsletter : 19-20.

Pradhan, S. (1971). Investigations on insect pest of sorghum and millets (1965-70). Final Tech. Rep. 157, pp. Division of Entomology, IARI, New Delhi.

Raghunath, G., Rajashekar, B.C. and Krishnamurthy, K. (1972). A short note on varietal differences in incidence of shoot fly in sorghum. Mysore J. agril. sci. 6 (3) : 366-367.

Raina, A.K., Thindwa, H.Z. and Othieno, S.M. (1984). Resistance in sorghum to shoot fly oviposition on selected cultivars. J. Econ. Ent., 77 (3) : 648-651.

Ramesh, P. (1992). A possible source of resistance to the sorghum earhead bug, *Calocoris angustatus*. Indian J. Ent. 54 (3) : 266-271.

Raodeo, A.K., Tikar, D.T. and Chundurwar, R.D. (1972). Records of natural parasites of sorghum shoot fly. Curr. Sci. 41 (11) : 430-431.

Rana, B.S. (1998). Drop in sorghum production during kharif 1997-98. Personal communication.

Rasker, D.S. (1979). Field evaluation of some sorghum selections for resistance to shootfly under different levels of nitrogen. M.Sc. (Agri.) thesis post Graduate school, IARI, New Delhi.

Reddy, K.V.S. and Devies, J.G. (1977). Pests of sorghum and pearl millet and their parasites and predators recorded at ICRISAT Centre upto August, 1997, Cereal Entomology Pogress Report-2, Patancheru, India, 58-61.

Sangappa, H.K., Kachapur, M.D. and Nadgouda, V.B. (1978). Studies on the performance of sorghum hybrids and varieties for resistance to shoot fly. Sorghum Newsletter, 21 : 36-37.

Sharma, H.C. and Lopez, V.F. (1990). Mechanisms of resistance in sorghum to head bug *Calocoris angustatus*. Entomol. Exp. Apli., 57 (3) :285-294.

Sharma, H.C. and Lopez, V.F. (1992a). Screening for plant resistance to sorghum head bug, *Calocoris angustatus*. Insect and its Appli. 13 (3) : 315-325.

Sharma, H.C. and Lopez, V.F. (1992b). Genotypic resistance in sorghum to head bug *Calocoris angustatus*. Euphytica, 58 (3) : 193-200.

Sharma, H.C., Lopez, V.F. and Nwanze , K.F. (1993). Genotypic effects of sorghum accessions on fecundity of sorghum head bug, *Calocoris angustatus*. Euphytica, 65 (3) : 165-175.

Sharma, G.C. (1975). Host plant resistance to the shoot fly *Atherigona soccata* (Rondani) and its genetic analysis. Ent. Newsletter, 5:5-6.

Singh, S.P. (1977). Investigations on sorghum resistance to shoot fly, *Atherigona soccata* (Rondani). Ph.D. Thesis, Agra.Univ. Agra.

Singh, S.P. (1998). Association of sorghum seedling characters with resistance to shoot fly. International sorghum and millets News letter. No. 39 : 115-116.

Singh, S.P. and Grewal, R.P.S. (1997). Relative susceptibility of sorghum against shoot fly and stem borer. International sorghum and millets Newsletter., 1998, 38 : 88-89.

Singh, B.U., Rana,B.S., Reddy, B.D. and Rao, N.G.P. (1983). Host plant resistance to stalk borer, *Chilo partellus* Swin. in sorghum. Insect Sci. and its appli. 5 (4) : 287-296.

Singh, S., Vedamoorthy, G., Thobi, V.V., Jotwani, M.G., Young, W.R., Bolan, J.S., Srivastva, K.P., Sandhu, G.S. and Krishnanda, N. (1968). Resistance to stem borer *Chilo zonellus* (Swinhoe) and shoot fly, *Atherigona varia soccata* (Rond.) in the world sorghum collection in India. Entomological Soc. India Memoir. No. 7 : 79 pp.

Singh, S.P. and Jotwani, M.G. (1980). Mechanism of resistance in sorghum to shoot fly IV. Role of morphological characters of seedlings. Indian J. Ent., 42 (4) : 806-808.

Singh, R. and Narayana, K.L. (1978). Influence of different varieties of sorghum on the biology of shoot fly. Indian J. Agril. Sci. 48 (1) : 8-12.

Singh, S.P., Verma, A.N., Lodhi, G.P. (1991). Screening of sorghum genotypes for resistance to stem borer *Chilo partellus* (Swin). J. of Insect Sci., 4 (2) : 131-134.

Taneja, S.L. and Leuscher , K. (1985). Resistance screening and mechanism of resistance in sorghum shoot fly, pp.115-129. Proceeding of the International sorghum Entomology Workshop. ICRISAT, Patancheru (A.P.), India.

Appendix-I

Meteorological data from May to December 2000, recorded a Meteorological Observatory, Marathwada Agricultural University, Parbhani.

Month	Met. week No.	Dates	Rain-fall (mm)	Rainy days	Temp.oC		Humidity(%)	
					Max.	Min.	A.M.	P.M.
May	19	7-13	0.0	0	38.74	23.20	64.00	30.57
	20	14-20	5.50	1	38.30	24.88	57.28	32.57
	21	21-27	7.10	2	38.40	25.65	63.14	31.28
	22	28-3	71.50	4	36.40	23.35	66.85	35.00
June	23	4-10	87.90	5	31.70	22.95	83.00	59.00
	24	11-17	41.40	3	33.60	23.17	77.28	48.57
	25	18-24	13.30	1	31.10	23.75	75.57	58.85
	26	25-1	59.50	3	32.60	22.70	78.00	59.14
July	27	2-8	36.40	2	31.30	22.28	82.71	59.00
	28	9-15	57.20	6	28.78	22.05	89.14	61.42
	29	16-22	10.90	2	29.85	21.42	86.14	64.14
	30	23-29	0.0	0	32.37	21.62	77.57	48.85
	31	30-5	0.0	0	33.57	22.12	73.71	49.00
Aug.	32	6-12	162.0	6	29.38	21.65	89.14	76.57
	33	13-19	8.80	3	30.78	21.17	84.28	60.42
	34	20-26	234.90	4	28.48	22.08	92.14	74.71
	35	27-02	191.50	6	29.14	20.97	80.28	69.71
Sept.	36	3-9	2.50	2	30.62	21.21	83.14	58.14
	37	10-16	0.0	0	32.10	20.41	83.14	58.14
	38	17-23	2.40	1	33.11	22.02	83.42	51.85
	39	24-30	0.0	0	32.28	20.65	83.00	50.42
Oct.	40	1-7	0.0	0	34.40	19.64	78.85	54.00
	41	8-14	16.70	3	30.92	21.12	75.71	47.28
	42	15-21	0.0	0	34.04	19.35	77.00	39.00
	43	22-28	0.0	0	35.51	16.87	77.42	29.42
	44	28-4	0.0	0	33.41	15.38	77.42	39.00
Nov.	45	5-11	0.0	0	33.22	14.84	75.00	30.14
	46	12-18	0.0	0	32.20	12.84	77.28	31.14
	47	19-25	0.0	0	31.97	12.05	81.28	32.28
	48	26-02	0.0	0	32.76	11.26	78.00	31.00
Dec.	49	3-9	0.0	0	30.30	8.20	70.20	30.00
	50	10-16	0.0	0	31.10	7.40	76.10	23.70
	51	17-23	0.0	0	28.70	7.50	75.10	23.70
	52	24-31	0.0	0	29.00	8.20	71.30	26.10