

**VARIETAL SCREENING OF SORGHUM
FOR RESISTANCE TO SHOOTFLY
(Atherigona soccata Rondani)**

By

DENGALE BABANRAO DIGAMBAR

Regd. No. 92063

A thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI, DISTRICT : AHMEDNAGAR
MAHARASHTRA (INDIA)

In partial fulfilment to the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ENTOMOLOGY

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY

MAHATMA PHULE KRISHI VIDYAPEETH,

POST GRADUATE INSTITUTE

RAHURI - 413 722.

1994

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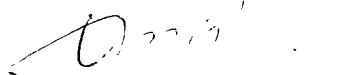
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Dr. B.R. Patil
(Research Guide)



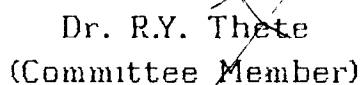
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CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for a Degree or Diploma

Place : Rahuri

Dated : 20th May 1994


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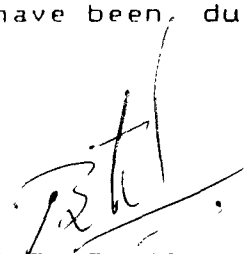
C E R T I F I C A T E

This is to certify that the thesis entitled "VARIETAL SCREENING OF SORGHUM FOR RESISTANCE TO SHOOTFLY (Atherigona soccata Rondani)" submitted in partial fulfilment of the requirements for the award of the degree of MASTER OF SCIENCE (AGRICULTURE) IN AGRICULTURAL ENTOMOLOGY, Faculty of Post-Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, District - Ahmednagar (M.S.) is a faithful record of bona-fide research work carried out by SHRI. DENGAL BABANRAO DIGAMBAR, under my guidance and supervision. I further certify that all the data presented in this dissertation are based on his own observations and no portion thereof has been used in any other thesis for a diploma or degree.

The assistance and help received during the course of investigations and the source of literature have been duly acknowledged.

Place : Rahuri

Date : 20th May 1994.


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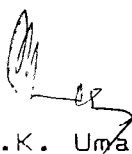
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The assistance and help received during the course of investigations and the source of literature have been duly acknowledged.

Place : Rahuri

Date : 2nd May 1994


(N.K. Umarani)

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While travelling on this path of education, many hands push me forth, lips put elixir in my heart, learned hearts put me on right track, lightened by their knowledge and experience. I ever rest thankfully in debt, to them all.

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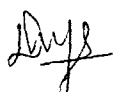

(B.D. Dengale)

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ABSTRACT

Varietal screeningⁿ of sorghum for resistance to
shootfly (Atherigona soccata Rondani)

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1994

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The present investigations were conducted during kharif, 1993 at the Department of Agricultural Entomology, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.) to select the better sources of resistance to shootfly, Atherigona soccata Rondani and to determine the mechanism of resistance to shootfly by studying the morphological (physical) plant characters associated with shootfly resistance. Fifty sorghum entries along with four resistant checks and two susceptible checks were selected and

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statistically laid out, field trial was conducted in kharif 1993. The incidence of shootfly (dead hearts) was recorded to find out less, moderately and highly susceptible entries. The egg laying of shootfly was also recorded. The morphological (physical) plant characters like leaf length, leaf breadth, leaf length and breadth ratio, leaf area, plant height, trichomes, leaf colour, glossiness of leaves, leaf surface wetness, growth habit of the plants and recovery resistance were recorded .

From the percentage of dead hearts ten entries were found to be less susceptible, one entry was highly susceptible and the remaining thirty nine entries as moderately susceptible to shootfly.

The egg laying on the less susceptible entries and resistant checks was observed to be less than the highly susceptible entries and susceptible checks. The positive correlation was observed between egg laying and dead hearts.

Among the morphological (physical) plant characters leaf breadth, leaf area, green leaf colour, leaf surface wetness and spreading growth habit of the plants had a positive correlation with susceptibility and egg laying. On the other hand leaf length, leaf length and breadth ratio,

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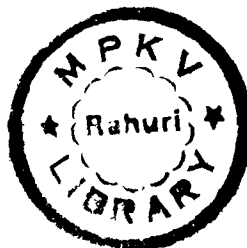
ABST. CONTD..

plant height, trichomes, yellowish green leaf colour, glossiness, and erect growth.habit of the plants exhibited negative correlation with susceptibility and egg laying.

Since less susceptible entries exhibited a high yield potential they need to be harnessed by the breeders for developing a variety resistant to shootfly with desirable agronomic qualities and a good consumer appeal.

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Chapter Opener Page



Introduction

1 . INTRODUCTION

Sorghum (Sorghum bicolor L. Moench) is grown on nearly 42 million hectares in different countries of the world, with the major acreage being in Asia and Africa. In India it is one of the major cereal crops and occupies an area of 16.80 million hectares with a total production of 11 million tons. The important states with sizable acreage are Maharashtra, And^bra Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Gujarat, Rajasthan, Uttar Pradesh and Haryana.

In Maharashtra sorghum contribution to total cereal production is 57.6 per cent of which kharif contributed 38.6 per cent and rabi 19.0 per cent Maharashtra has a total area of 64.3 lakh hectares under sorghum. Out of which 28.1 and 36.2 lakh ha are under kh^rif and rabi seasons respectively. The productivity of sorghum during kharif and rabi is 1584 kg/ha and 603 kg/ha respectively as against the national average of 1049 kg/ha and 597 kg/ha respectively (Anonymous, 1992). Grain is mainly used as staple food by a large population, especially in rural areas and stems and leaves are used as fodder for cattle.

To feed the ever increasing population in the country, efforts have been made to increase food production through developing high yielding varieties and hybrids and improved agronomic practices. Hybrids and varieties of

sorghum, developed and released for commercial cultivation during the last decade and a half, though superior to local varieties in their productivity and earliness in maturity are on the other hand highly susceptible to insect attack.

Damage by insect pests is one of the major limiting factors in sorghum production. As many as 25 pests have been reported to damage sorghum crop in Maharashtra state (Dhumal, 1967) but the important among these are shootfly (Atherigona soccata Rondani), stem borer (Chilo partellus Swinhoe), and earhead midge (Contarinia sorghicola Coquillett), which cause considerable damage in the sorghum growing regions of the country. The hybrids and high yielding varieties are more severely affected than the local ones. In the case of shootfly incidence, a total failure of hybrid crop is also common.

Among several species of shootfly recorded in India, the sorghum shootfly, Atherigona soccata has gained importance with the introduction of high yielding hybrids and varieties. These were found to be highly susceptible to pest. First commercial hybrid CSH-1 and the variety CSV-1 (Swarna) were heavily damaged by this pest on the farmers fields (Jotwani et al., 1970, Raodeo et al., 1972).

Crop sown after 2nd week of July gets badly affected resulting in poor yield. The severity of incidence

of shootfly is mainly confined to late sown kharif crop and early rabi sowing. The fly incidence is much less in areas where a single crop of sorghum is grown per year and sowing is timely i.e. at the beginning of rainy season. Serial planting over several months definitely favours enhancement in fly population which increases infestation on later sowings.

The fly is attracted to 2 to 7 leaf stage seedling, and lays eggs on the under side of the leaves. The maggot of shootfly on hatching from the eggs bores in to the stem of young plant and feeds on them. As a result central shoot becomes pale yellow and subsequently forms dead heart. The tillers may be produced in about 2 weeks old seedlings but these may also get damaged. The losses due to this pest alone are to the tune of 22.11 to 83.94 per cent (Jotwani and Sukhani, 1971; Mote et al., 1981b and 1982).

By following proper time of sowing, it is possible to reduce shootfly menace. However, due to the weather aberrations, proper time of sowing is not feasible. Intensive research work was initiated to develop effective control measures for the pest complex on sorghum. Initially, the major emphasis was given to chemical control but simultaneously long range programmes were undertaken to develop other methods in which costly inputs in the form of insecticides and the hazards of the insecticides and their

limitations in use might be avoided. The importance of developing such methods in the case of crop like sorghum, which is mostly grown by marginal farmers under unirrigated conditions needs no emphasis.

One of the most important and practical methods is the utilization of insect resistance in crops. The concept of host plant resistance is known since long and a lot of work has been done in other countries. However, in India, it has received impetus only during the last decade or so. The sorghum research workers are also paying considerable attention to develop high yielding insect resistant varieties.

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

It is a recognised principle in breeding for insect resistance that there should be variable sources of resistance so that the development of the bio-types may be avoided. Also in a crop like sorghum where there are more than one major pests, identifying and using sources having multiple resistance are highly desirable. The other important aspects of insect resistance in crops is to determine the mechanisms of resistance and the possible morphological (physical) characters which may possibly be associated with resistance mechanism.

Keeping in view the importance of these aspects of shootfly resistance, the present investigations were undertaken with the following main objectives :

1. To select better sources of resistance to shootfly, Atherigona soccata Rondani.
2. To determine the mechanisms of resistance to shootfly and study the morphological (physical) characters like leaf length, leaf width (breadth), leaf length and breadth ratio, leaf area, plant height, trichomes on leaves, leaf colour, glossiness of leaves, leaf surface wetness of central shoot, growth habit of plants, recovery resistance etc., which may be associated with the resistance.

Such studies may ultimately help the breeders to develop and select suitable plant types with the desirable characters so that high yielding, insect resistant varieties may be released for commercial cultivation.

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Chapter Opener Page



Review of Literature

2. REVIEW OF LITERATURE

Utilisation of plant's resistance to insects in pest management programmes has become popular in recent years. This phenomenon involving inter relationship of plants to insects is recorded for about 200 years. It is now realised that wherever possible, resistant varieties of crops should be grown to minimise their losses from the attack of insect pest. This practice is neither antagonistic to nature nor does it involve any limitations that are inherent to other methods of control. It eliminates the use of pesticides and thus risk of environmental pollution. In case of low income crops like cereals where margin of profit is very narrow, use of pesticide becomes prohibitive. Therefore, the only alternative left in such cases is to grow pest resistant varieties. In absence of complete resistance, even the less susceptible varieties need to be promoted to minimise the pesticidal load on the environment. A resistant variety ultimately affects the survival and reproductive potential of insects feeding on them or has the capacity to tolerate insect infestation.

Plant resistance to specific insect pests was discovered as early as 1782, when "Underhill" wheat variety was reported to be resistant to Hessian fly, Mayetiola destructor. The use of resistant apple variety 'Winter Majetin' against woolly aphid is also known for a pretty long time. Besides this some other outstanding examples of insect

resistant varieties developed for several crops are, in grapes against Phylloxera sp. (Painter, 1951), wheat against Hessian fly (Painter, 1968) and stem fly (Luginbill and Knipling, 1969), rice against jassids (Parnell, 1935), plant hopper and leaf hopper. (Pathak, 1969). Numerous review articles on various aspects of plant resistance are available (Snelling, 1941; Auclair, 1957; Painter, 1958; 1968; Beck, 1965; Luginbill, 1969; Leuck, 1970; Pathak, 1970; Sprague and Dahms, 1972).

Sorghum Shootfly (A. soccata) is more destructive and pose greatest problem for control. Losses caused by this pest vary with pest population, season of sowing and nature of cultivar. The damage caused is reported to vary from 0 to 90 per cent (Ramchandra Rao, 1924; Rao and Rao, 1956; Anonymous, 1965; Madhav Rao and Gowda, 1967; Hussaini and Rao, 1967; Usman, 1968; Rao and Quick, 1969; Jotwani et al., 1970; Raodeo and Maqueem, 1971; Raodeo et al., 1972; Mate et al., 1979; Rai and Jotwani, 1979 and Khurana, 1980).

Developing resistant varieties for such serious pests has, therefore, been considered to be most ideal. Dahms (1943) has correctly emphasized the importance of utilization of host plant resistance in pest management programme in sorghum in the following words, "the use of resistant varieties to lessen injury from insects that attack sorghum would appear to deserve more attention because the control of

insects on a crop of low value per acre precludes the use of insecticides. The growing of resistant variety would further reduce the insect population."

The area of development of resistant varieties is therefore receiving increasing attention of the Entomologists all over the world particularly in recent years. As such the literature on resistance in crop plants is increasing by leaps and bounds. However, the review of literature on the host plant resistance and associated aspects has been restricted with special reference to sorghum shootfly. Atherigona soccata Rondani being the topic of present investigation.

The shootfly or Cholam fly was described and named first time by Rondani as early as in 1871. Malloch (1923) identified this fly as Atherigona indica. Although the pest was recorded in India in the year 1907 at Pusa (Fletcher, 1914; Ballard and Ramchandra Rao, 1924), the published literature shows that the research work on varietal resistance to the pest had taken impetus during the last two decades.

The available literature is being reviewed under the following sub headings :

- 2.1 Damage caused and egg laying of shootfly on sorghum plants
- 2.2 Morphological (physical) characters of plants associated with resistance to shootfly

2.1 Damage caused and egg laying of shootfly on sorghum plants

Some plants are more preferred by the shootfly for oviposition, food or shelter or for combination of these when offered a choice of two or more alternative foods. The damage caused by shootfly mainly depends on the preference and non-preference.

Ponnaiya (1951a) screened 214 varieties of sorghum and reported that the attack of the pest in the fourth leaf stage was significantly less in resistant varieties like T-1 and M-47-3 as compared to the susceptible ones even though the eggs were laid in more or less equal numbers on all the varieties. In another experiment (1951b) he reported that the fly lays eggs on the ventral side of leaf blade of the youngest fully emerged leaf at a place nearer the base than the tip. No significant differences between resistant and susceptible varieties were observed by him in number of eggs laid. The maggot which hatched on the third day crawled to the dorsal surface of the leaf blade and entered the space between the leaf sheath and axis and on reaching the base cuts the growing apex causing death of the central shoot, known as 'dead heart'.

Jain and Bhatnagar (1962) observed that the number of eggs laid by shootfly varied from 1 to 8 per plant. In most of the cases 1.0 to 2.0 eggs per plant were laid.

Generally lesser number of eggs were laid on resistant varieties than on susceptible ones. The authors also found significant correlation between the number of infested plants and number of eggs deposited.

Blum (1967) reported that seedling infestation in most resistant lines ranged from 13.2 to 20.6 per cent as compared to 95.7 per cent in the susceptible varieties. The susceptible varieties were preferred for the oviposition, so non-preference for oviposition was concluded to be one of the mechanisms of resistance.

Puttarudrappa et al. (1969) noticed that number of eggs laid by fly were significantly more on CK-60-A, CK-60-B and IS-84 than on other varieties. This clearly indicated the preference of the fly for oviposition. The percentage of dead hearts was also significantly more on these varieties as compared to other varieties. Variety M-35-1 was found less susceptible.

Krishnananda et al. (1970) screened 19 selected varieties and found that the entries like CSH-1, IS-84, CSH-2 and CO-18 were highly susceptible and preferred for oviposition as compared to resistant varieties like IS-5666 and IS-5285. Flies always preferred third and fourth leaf for oviposition. Maximum infestation was noted during third and fourth week after sowing.

~~Jotwani et al. (1971) studied ovipositional preference of shootfly on 24 resistant and 3 susceptible lines of sorghum and found the minimum number of eggs (0.75 to 1.03 per plant) were laid on resistant lines viz., IS-5801, IS-5655, IS-5490 while maximum number of eggs (5.73 per plant) were laid on Swarna which is susceptible.~~

Under the 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 checks and number of eggs laid on promising lines was significantly less than on the susceptible check CSH-1 (Anonymous, 1972).

Twentyfour lines of sorghum resistant to shootfly were tested for oviposition response during the kharif season, 1972. It was noticed that average number of eggs per 10 plants varied from 1.33 to 6.00 on resistant lines as compared to 12.00 in check, Swarna. The percentage of dead hearts in selected lines varied from 8.44 to 30.21 as compared to check, Swarna (66.40 per cent). During rabi season 1972, observations were recorded on oviposition and dead hearts on 6 resistant lines and 4 high yielding parental lines. It was concluded that non-preference to oviposition was one of the major factors responsible for resistance to shootfly under field conditions (Anonymous, 1973).

Six entries were screened in the trial conducted at M.P.K.V., Rahuri in 1974-75. It was observed that the number of eggs laid on promising entries was significantly less than the susceptible checks. All the promising entries showed less number of dead hearts (Anonymous, 1975).

Dalvi (1975) observed the lesser number of eggs and dead hearts on the less susceptible varieties E-302, E-303 and maximum number of eggs and dead hearts on CSH-1 which is susceptible to shootfly.

Narayana (1975) studied 12 promising sorghum varieties for shootfly resistance and indicated significant differences in preference for oviposition. In tolerant varieties, the average number of eggs deposited per plant was less than one, whereas, 2.33 eggs per plant were found on susceptible ones. The percentage of infested plants of the entries tested ranged from 29.6 (IS-5566) to 79.4 (CK-60-B) per cent. The initial infestation in resistant varieties was less than that in the susceptible varieties. In general, there was a lower average infestation at first week and maximum at second and third weeks. Thereafter there was a sudden decrease in the fourth week after seedling emergence. The sorghum variety IS-5566 was more tolerant.

Shivpuje et al. (1976) showed that the tolerance level in six lines ranged from 34 to 44 per cent of dead

hearts. Thirteen lines showed the tolerance level up to 50 to 65 per cent while seven were highly susceptible having infestation of 62 to 82 per cent. Tolerant lines PJ-4K showed shootfly infestation level of 30 per cent. It was concluded that there is possibility of selecting lines from Indian x Exotic crosses, having desirable agronomic characters and moderate levels of shootfly tolerance.

Venugopal et al. (1976a) screened fourteen promising lines and observed that U-358 was the least preferred while five sorghum lines recorded more than 44 per cent damage. In another trial where fortytwo lines tested in kharif and 29 lines in rabi season, SPV-9 (35.7 per cent) showed comparatively less damage while percentage of dead hearts ranged from 40 to 92.2 per cent in other entries (Venugopal et al. 1976b).

Bapat et al. (1977) tested forty eight sorghum entries and found that the entries viz., M-35-1, CS-3541, CS-168, R-69, R-39-1 were found relatively less susceptible to the attack of shootfly, 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.

Srivastava and Jotwani (1977) studied shootfly resistance in sorghum lines and observed that the dead hearts in resistant lines ranged between 53.33 to 75.00 per cent as against 100 per cent in the susceptible check.

Jotwani (1978a), in the technical report of PL-480 project stated that average number of eggs laid per 10 plants varied from 1.33 to 6.00 in resistant lines as compared to 12.00 in susceptible checks. He further stated that there was no direct correlation between the number of eggs laid and percentage of dead hearts.

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 eggs laying was observed in Muguthi variety (1.80/plant) followed by RSH-1, FR-169, CSH-8, CSH-6 and CSH-5. The local Muguthi was more resistant to shootfly than other hybrids and varieties. The new hybrids RSH-1, CSH-8 and varieties Muguthi and FR-169 were highly resistant.

Bothe (1979) screened 21 varieties during kharif and rabi in 1978-79 and observed that the eggs laid on the resistant varieties were lesser than the eggs laid on susceptible ones. The dead hearts found in resistant varieties were also less as compared with susceptible varieties.

Moholkar (1981) screened 38 ent^ries with two susceptible checks. The overall result of infestation and damage showed that six varieties viz., IS-2122, IS-2162, IS-5469, IS-5604, IS-5613 and IS-5648 possessed moderately high

level of resistance to shootfly. There was positive correlation between oviposition and dead hearts.

Mote et al. (1981a) observed that fewer eggs (0.26 to 0.65 eggs/plant) were laid on resistant varieties as compared to other varieties. They also observed few number of dead hearts (18.53 per cent) in resistant varieties than susceptible ones. Therefore, it indicates non-preference for oviposition as a mechanism of resistance.

Dalvi et al. (1984) observed that the eggs laying on seventh day after germination was low and then there was increase in egg laying gradually and showed a peak on the 21st day after germination. The number of eggs laid on resistant entries were less as compared to susceptible entries. It appears that difference observed in germ plasm is possibly due to non-preference for oviposition.

Raina et al. (1984) observed more ovipositional non-preference of sorghum shootfly, Atherigona soccata (Rondani) for seven selected cultivars of sorghum as compared with that of susceptible hybrid 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 an oviposition substrate but could escape into an outer cage, showed significant non-preference for five test cultivars. Strong preference was observed for CSH-1 plant

as 80 to 82 per cent eggs were laid on them . Fewer eggs per plant on resistant plant was observed as females laid eggs on non preferred cultivars only after laying several eggs on alternate CSH-1 plants.

Patel and Sukhani (1990a) screened 20 sorghum genotypes and observed that eleven genotypes showed less than 1.93 eggs per plant. Minimum eggs (0.78 eggs/plant) were observed on IS-2205, Therefore, these genotypes were considered to be less preferred for oviposition and the remaining nine genotypes were more preferred by shootfly for oviposition. Maximum oviposition (3.94 eggs/plant) was observed on CSV-1, Thus it was concluded that ovipositional non-preference was responsible for resistance to shootfly. Positive and highly significant correlation was observed between shootfly eggs per plant and per cent dead bearts.

2.2 Morphological (physical) characters of plants associated with resistance to shoot fly

2.2.1 Leaf length, leaf width, leaf length and width ratio and leaf area

Singh (1977) observed that leaves of resistant varieties were invariably longer (19.1 to 26.6 cm), erect 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 be providing sufficient space for shootfly to move about and select suitable site for egg laying.

Mate (1978) reported that on 20th day after germination, maximum leaf area per plant was in cultivar M-35-1 followed by CSH-1, SPV-13, IS-5469, SPV-4 and E-302. Rest of the cultivars had significantly less leaf area per plant than CSH-1, indicates plant vigour. The cultivars having more leaf area and vigorous growth were resistant to shootfly.

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

Maiti and Bidinger (1979) observed that lines with trichomes had distinctive characteristics which were evident only in the first three weeks after germination. At that time leaves tended to be more erect and narrower with yellowish appearance. Varieties with erect and yellowish narrow leaves were resistant to shootfly.

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

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.

Jadhav et al. (1986) observed more shootfly infestation in the entries having less leaf length and breadth ratio and observed less infestation in the entries having more leaf length and breadth ratio. There was a strong and negative correlation between leaf length and breadth ratio and dead hearts. Similar results were recorded in the trials conducted at M.P.K.V., Rahuri during ~~kh~~^arif 1985 (Anonymous, 1989b).

2.2.2 Height and growth rate of plants

Blum (1966) reported that forage sorghum hybrids grow at a more faster rate at seedling stage than RS-610 (dwarf variety) and escape the shootfly damage.

Parmeswarappa et al. (1968) at Raichur observed M-35-1 resistant in early stage of growth because of vigorous growth, although later on the side tillers were heavily infested.

Raghunath et al. (1972) screened different sorghum lines for their resistance where in 'Neejola' seemed more

susceptible than other varieties. They also reported that the low incidence in case of CBE-X, might be due to its initial vigorous growth.

Lakshminarayana (1974) noted that the vigour of the plant as evidenced by height could not be taken as dependable factor for assessing the relative resistance of the variety to the shootfly infestation and damage.

Dalvi (1975) observed that the varieties growing vigorously in seedling stage were showing reduced shootfly infestation. The dwarf varieties were more susceptible to the shootfly infestation as compared to taller varieties.

Narayana (1975) observed that IS-5565, a tall variety, was more tolerant to shootfly than the other varieties. Dwarf varieties were relatively more infested by shootfly than the taller varieties.

Sharma (1975) observed that taller varieties were less affected by the shootfly as compared to dwarf varieties and found that the percentage of dead hearts was negatively correlated with seedlings height. Similar results were also reported by Jotwani (1978b).

Bothe (1979) observed that the tolerant varieties had faster growth rate than susceptible ones and were taller than the susceptible varieties.

Mate et al. (1979) observed that resistant varieties were taller and had high growth rate than susceptible types. However, differences in growth rates between resistant and susceptible varieties were non-significant.

Raskar (1979) indicated that differences in height of sorghum plants among different entries on the 21st day after germination were statistically significant. The lowest plant height was observed in CSV-1 (Swarna) which is susceptible to shootfly while it was highest in IS-5469 which is more resistant to shootfly.

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 shootfly.

Singh and Jotwani (1980) reported that on the 17th day after germination, the average height of shootfly susceptible CSH-1 seedlings was 29.13 cm whereas it varied from 38.40 to 39.33 cm in seedlings of IS-5469 and IS-5490; indicating thereby that resistant varieties were fast growing plant types. The differences in growth rates between resistant and susceptible varieties were highly significant.

Moholkar (1981) screened 38 entries with two

susceptible checks. The overall result on the infestation and damage showed that the taller varieties were less affected and showed tolerance to the shootfly.

Dalvi et al. (1984) observed that the height of the plants and width of leaves indicate the plant vigour. The varieties as M-35-1, M-47-3, E-303 and Khedi-2-2-10 were more vigorous and showed reduced pest incidence.

Jadhav et al. (1968) observed that taller varieties were less affected by the shootfly than the dwarf varieties and observed strong and negative correlation between plant height and dead hearts. Similar results were recorded in the trials conducted at M.P.K.V., Rahuri during kharif 1985 (Anonymous, 1989b).

Patel and Sukhani (1990b) observed negative correlation of plant height with shootfly oviposition and dead hearts formation. Resistant genotypes were taller and had higher growth rate than susceptible ones. ✓

2.2.3 Trichomes on sorghum leaves

The role and importance of trichomes in resistance to crop pests has frequently been overlooked. A few earlier workers have mentioned the presence of prickly hair on the leaf sheath in resistant genotypes but it is not clear if these pertain to trichomes (Blum, 1968). Preliminary

informations suggest negative relationship between trichome number on the under surface of leaf and number of shootfly eggs (Anonymous, 1976). Also it has been reported that many lines having resistance to shootfly had trichomes on the abaxial leaf surface (Anonymous, 1977; Maiti, 1977).

Maiti and Bidinger (1979) stated that the trichomes had distinctive characteristics which are evidenced only in the first three weeks after seedling emergence. The presence of trichomes on the leaf surface appeared to confer an advantage in two ways i) by reduction in egg laying on leaf and ii) by reduction in the frequency with which the presence of eggs of the shootfly results in the death of shoot of sorghum. Maiti et al. (1980) further reported that trichomes present in resistant varieties of sorghum were more numerous near the tip of the leaf than at the middle or the base of the leaves. Trichomes may vary in density in different varieties from as many as 45 to as few as five per sq. mm. The trichomes were absent in susceptible varieties. Similar results were obtained by Moholkar (1981).

The results of screening of wild sorghum showed that no flies emerged from Sorghum purpuricsericeum (two accessions) and Sorghum dimidiatum (one accession) in spite of high egg laying (average 5 eggs per plant) against the control CSH-1, that had 100 per cent fly emergence. These resistant lines had high trichome density on the leaves that may be interfering with larval movement (Anonymous 1985).

Jadhav et al. (1986) observed less number of dead hearts in the entries having higher trichome density than the entries having less trichomes. Strong and negative correlation was observed between trichome density and dead hearts. Similar results were recorded in the trials conducted at M.P.K.V., Rahuri during kharif 1985 (Anonymous, 1989b).

Patel and Sukhani (1990b) observed negative correlation of trichome density with oviposition and dead heart formation. The genotypes with higher density of trichomes in seedling stage was observed resistant to shootfly. Similar results were obtained by Swarna Sree et al. 1992.

Taneja and Maiti (1992) observed lower shootfly infestation in genotypes with trichomes on both surfaces. The oviposition was also less on the varieties having trichomes on both surfaces.

2.2.4 Colour of leaves

Vedamoorthy (1967) stated that the varieties possessing foliage with dull green colour and waxy bloom appearance were comparatively more susceptible than those possessing foliage with bright shiny green colour.

Blum (1972) reported that shootfly resistance in sorghum was generally associated with glossy surface and light green colour of leaves of seedlings.

During the rabi season, 1972, observations on leaf colour was recorded on six resistant varieties and four high yielding parental lines showed that, less number of dead hearts and eggs were observed on the varieties having yellowish green colour (Anonymous, 1973).

Six entries were screened in the trial conducted at M.P.K.V., Rahuri in 1974-75. It was observed that all promising lines showed less dead hearts than the check and it was reported that the pale green colour of leaves was possibly associated with the resistance (Anonymous, 1975).

Bapat et al. (1975) observed that released sorghum hybrids were susceptible to shootfly attack. According to them one of the plant characters associated with susceptibility to shootfly was probably deep green colour of leaves. They found that variety No.148 had pale green coloured leaves and was least damaged by shootfly but Swarna and CSH-1, which possess deep green leaves were severely damaged by shootfly.

Chavan (1975) reported that infestation of shootfly was high, in variety, 148, E-302 and Swarna, having dark green coloured leaves on the other hand shootfly infestation was low in M-35-1, IS-5469, IS-4646 which had light green coloured leaves.

Bothe (1979) screened 21 varieties in kharif and



Rabi of 1978-79 and found that the entries with pale green leaves were less preferred for egg laying and less number of dead hearts were observed on these entries. Similar results were observed by Maiti and Bidinger (1979).

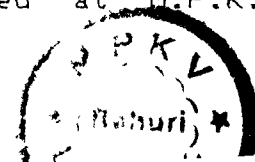
Mate et al. (1979) reported that CSH-1 having dark green colour of leaves was preferred by shootfly for oviposition. However, less eggs were laid on resistant lines like IS-5469 and M-35-1 having leaves of light green colour.

Kulkarni et al. (1981) stated that the varieties possessing foliage with light green colour were comparatively less susceptible than those possessing foliage with dark green colour. Even though the majority of the shootfly resistant genotypes are light green coloured, these are susceptible genotypes with this character.

Moholkar (1981) observed that the resistant varieties were with lighter colour shades as compared to the susceptible checks.

Jadhav et al. (1986) reported that the varieties with yellowish green colour foliage were highly resistant and the varieties with dark green colour foliage were highly susceptible. There was strong and positive correlation between yellowish green colour of leaves and dead hearts. Similar results were observed in the trials conducted at M.P.K.V., Rahuri during kharif 1985 (Anonymous, 1989b).

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Patel and Sukhani (1990b) observed that there was positive correlation of dark green leaf colour with shootfly oviposition and dead hearts formation. The genotypes with yellowish green colour of leaves in seedling stage were found to be resistant to shootfly. ✓

2.2.5 Glossy and non-glossy characters of leaves

Glossiness is one of the physical plant characters associated with resistance to shootfly. Sorghum varieties with glossy leaves were less preferred for oviposition and less damage by the shootfly. Generally all the resistant varieties were found glossy, susceptible varieties were non-glossy, with dark green colour leaves. There was a negative correlation between glossiness and dead hearts. (Vedamoorthy, 1967; Narayana, 1975; Kulkarni et al. 1981; Jadhav et al. 1986; Anonymous, 1988; Anonymous 1989b; Nwanze et al. 1991 and Taneja and Maiti, 1992).

2.2.6 Leaf surface wetness

In the investigation on the relationship between leaf surface wetness and glossy leaf character it was found that the leaf surface wetness was very low in glossy resistant lines and high leaf surface wetness observed in non-glossy genotypes which were more susceptible (Anonymous, 1988).

Moisture accumulation on the central shoot leaf of sorghum seedling is due to gutation and not due to the

condensation of atmospheric moisture. The highest leaf surface wetness occurred between midnight and 4.00 hrs. in both resistant and susceptible genotype with sharp decline with a sunrise. Leaf surface wetness was highest in the second week of August. Highest leaf surface wetness (7mg) was recorded on the shootfly susceptible genotype CSH-1 and the lowest (<0.5 mg) was on resistant genotype IS-18551. Also observed that leaf surface wetness is more important factor in shootfly resistance than the glossy leaf character and trichome density (Anonymous, 1989a).

Nwanze et al. (1990) observed that leaf surface wetness of central shoot was much higher in susceptible sorghum genotype CSH-1 than in resistant genotype IS-2146. They also observed that leaf surface wetness is more reliable parameter of resistance than glossy leaf trait or trichome density. ✓

Nwanze et al. (1991) observed that the leaf surface wetness was associated with density of wax crystals and decreased with seedling age and leaf position. Water droplets on susceptible genotypes showed spreading at edges indicating a tendency to wet easily while in resistant genotype they remains tightly spherical and did not spread.

Swarna Sree et al. (1992) observed more leaf surface wetness between 0300 to 0500 hours. Similarly it was more in susceptible varieties than the resistant varieties.

2.2.7 Recovery Resistance or Tolerance

According to Kogan (1975) tolerance is the ability of plants to repair injury or ability to grow and produce adequate yield despite supporting an insect population at a level capable of damaging a more susceptible host. Tolerance may be due to general vigour of the plant or regeneration of damaged tissues or strength of stems and resistant to lodging or production of additional branches or efficient utilization by the insects of non vital plant parts or lateral compensation by neighbouring plants or combination of two or more of these factors.

Blum (1969) observed that in resistant varieties, the walls of cells, enclosing vascular bundles, in central leaf whorl, were lignified and that tillers of these resistant varieties grew faster than susceptible ones. Therefore, it was concluded that tillers survival in shootfly resistant sorghum is associated with lignified tissues in central whorl of leaves and fast growth rate of tillers.

Doggett et al. (1970) and Doggett (1972) reported that East African Resistant Varieties Serena and Namatere showed good recovery (tolerance) from shootfly damage and gave normal yield, due to their habit of tillering profusely.

Sharma (1975) showed that percentage of dead hearts was negatively correlated with plant recovery and yield per

plant. The number of tillers per 100 plants, the number of effective tillers, plant recovery and yield were positively associated with each others, indicating that tillering character contributed to yield rather than to shootfly resistance.

Seshu Reddy and Davies (1978) reported existence of tolerance in some of the lines screened at ICRISAT Patancheru P.O. The more recovery was observed in the resistant varieties but clearcut correlation was not observed between percentage of dead hearts and recovery resistance.

Kadam and Mote (1983) observed that some advanced hybrids SPH-196, SPH-225, CSH-1, CSH-5, CSH-9, SPV Nos. 115, 126, 351, 386 and 472 showed high susceptibility to shootfly in the initial stage, but possessed high recovery resistance which was reflected in grain yield.

Mote et al. (1985) observed more recovery of damaged plants in the resistant varieties while low recovery in the susceptible varieties. The correlation between percentage of dead hearts and recovered plants was not observed probably due to independent genetic control.

Chapter Opener Page



Material and methods

3. MATERIAL AND METHODS

The field trial was conducted at the All India Co-ordinated Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri, in Kharif, 1993.

Fifty sorghum entries reported to possess low to moderate levels of shootfly resistance along with 2 susceptible checks viz., CSH-9 and DJ-6514, and 4 resistant checks viz., IS-2205, IS-5490, IS-18551 and ICSV-705 were screened. The seeds of these entries were obtained from the Sorghum Breeder, M.P.K.V., Rahuri. The details are given below.

3.1 List of the sorghum entries used for screening

The entries used for screening are given in Table 1.

3.2 Sowing and other agronomic practices

Normal tillage operations were undertaken to prepare the experimental plots. The flat beds of 3 x 5 m gross size were prepared. Recommended doses of fertilizers were applied i.e. nitrogen at the rate of 80 kg/ha (40 kg at sowing time + 40 kg 35 days after germination), phosphorus 40 kg/ha and potash 40 kg/ha at the time of sowing. Three to four fresh and healthy seeds were dibbled in separate rows at 15 cm apart with row to row distance of 45 cm. To have a good shootfly population a row of susceptible check as a spreader was dibbled after every five test rows eight days prior to the test entries. Seeds were not treated with any insecticide. By

Table 1. List of sorghum entries used for screening

Sr.No.	Entry	Sr.No.	Entry
RSE entries			
1.	RSE 90 - 4 - 7 - 3	30.	RSE 90 - 7 - 9 - 1
2.	RSE 90 - 5 - 8 - 1	31.	RSE 90 - 7 - 16 - 1
3.	RSE 90 - 4 - 3 - 1	32.	RSE 90 - 4 - 8 - 1
4.	RSE 90 - 5 - 7 - 1	33.	RSE 90 - 5 - 11 - 1
5.	RSE 90 - 7 - 12 - 2	34.	RSE 90 - 5 - 12 - 1
6.	RSE 90 - 4 - 6 - 2	35.	RSE 90 - 5 - 12 - 2
7.	RSE 90 - 3 - 4 - 1	36.	RSE 90 - 7 - 6 - 1
8.	RSE 90 - 3 - 6 - 1	37.	RSE 90 - 6 - 8 - 2
9.	RSE 90 - 4 - 6 - 1	38.	RSE 90 - 7 - 4 - 3
10.	RSE 90 - 4 - 4 - 1	39.	RSE 90 - 7 - 8 - 1
11.	RSE 90 - 4 - 9 - 1	40.	RSE 90 - 5 - 3 - 1
12.	RSE 90 - 5 - 4 - 2	41.	RSE 90 - 7 - 16 - 3
13.	RSE 90 - 6 - 6 - 2	42.	RSE 90 - 7 - 13 - 2
14.	RSE 90 - 5 - 9 - 2	43.	RSE 90 - 3 - 4 - 2
15.	RSE 90 - 5 - 10 - 1	44.	RSE 90 - 8 - 4 - 1
16.	RSE 90 - 4 - 1 - 1	45.	RSE 90 - 5 - 2 - 1
17.	RSE 90 - 7 - 4 - 2	46.	RSE 90 - 3 - 2 - 1
18.	RSE 90 - 7 - 3 - 1	47.	RSE 90 - 2 - 5 - 1
19.	RSE 90 - 6 - 17 - 1	48.	RSE 90 - 1 - 11 - 1
20.	RSE 90 - 4 - 12 - 1	49.	RSE 90 - 1 - 5 - 1
21.	RSE 90 - 5 - 1 - 1	50.	RSE 90 - 2 - 3 - 1
22.	RSE 90 - 6 - 8 - 1	Resistant checks	
23.	RSE 90 - 5 - 1 - 2	51.	IS - 18551
24.	RSE 90 - 5 - 3 - 2	52.	IS - 5490
25.	RSE 90 - 7 - 16 - 2	53.	IS - 2205
26.	RSE 90 - 3 - 9 - 1	54.	ICSV - 705
27.	RSE 90 - 4 - 5 - 1	Susceptible checks	
28.	RSE 90 - 7 - 11 - 2	55.	CSH-9
29.	RSE 90 - 3 - 12 - 1	56.	DJ-6514

RSE = Rahuri Sorghum Entomology

keeping a single plant at each hill the excess plants were thinned on the 6th day after germination. The sowing was purposely delayed beyond the recommended time, so as to ensure a definite shootfly attack. Irrigations were given as and when required.

3.3 Details of operation and observations

The detailed information about operation and observations are given in Table 2.

3.4 Methods of recording observations

The observations were recorded on the following parameters for assessment of the entries.

3.4.1 Field screening of sorghum entries for shootfly infestation and damage

3.4.1.1 Shootfly damage as indicated by dead hearts

An usual method to assess the damage caused by shootfly, is to record dead hearts caused by its feeding. The total number of plant showing dead hearts on main shoot were counted at each observation recorded at 7 days interval starting from the 7th day after germination till the 28th day after germination. The percentage of shootfly damage was calculated and subjected to angular transformation and the data were statistically analysed.

Table 2. Details of field operation and observations

Details of operations and observations	Kharif 1993	
Operations		
Preparation of land	Normal field operation	
Fertilizers : N @ 80 kg/ha (40 kg at sowing time + 40 kg 35 days after germination)	12-07-1993	22-08-1993
P ₂ O ₅ 40 kg/ha and K ₂ O 40 kg/ha along with first dose of nitrogen		
Seed Material	fresh seed	
Design used	Randomised Block Design	
Number of replications	Three	
Number of entries	56	
Spacing	45 x 15 cm Single row of 5 m. length	
Sowing date	12-07-1993	
Sowing method	Dibbling	
Date of thinning	21-07-1993	
Observations		
Germination	17-07-1993	
Oviposition count days after germination	7	24-07-1993
	14	31-07-1993
	21	07-08-1993
	28	14-08-1993
Dead heart count days after germination	7	24-07-1993
	14	31-07-1993
	21	07-08-1993
	28	14-08-1993

(Contd..)

Leaf length days after germination	7	24-07-1993
	14	31-07-1993
	21	07-08-1993
	28	14-08-1993
Leaf breadth days after germination	7	24-07-1993
	14	31-07-1993
	21	07-08-1993
	28	14-08-1993
Height of plant days after germination	7	24-07-1993
	14	31-07-1993
	21	07-08-1993
	28	14-08-1993
Trichomes (Microscopic hair) on leaves on the 14 th day after germination		31-07-1993
Leaf colour on the 14 th day after germination		31-07-1993
Glossiness of leaves on the 14 th day after germination		31-07-1993
Leaf surface wetness on the 14 th day after germination		31-07-1993
Growth habit of the plant on the 14 th day after germination		31-07-1993

3.4.1.2 Egg laying

The varietal resistance may be due to several factors, one of these is the preference for egg laying. The observations regarding egg laying were recorded at 7 days interval starting from the 7th day after germination till the 28th day after germination. Only freshly laid and unhatched eggs were counted on five randomly selected plants from each entry. The data were tabulated and statistically analysed.

3.4.2. Morphological (Physical) plant characters of different sorghum entries associated with shootfly resistance

3.4.2.1 Leaf length, leaf breadth, leaf length and breadth ratio and leaf area

The observations on the leaf length and leaf breadth were recorded on five randomly selected plants at seven days interval, starting from the 7th day after germination and continued upto the 28th day after germination. As far as possible middle leaves were randomly selected for measurement. The leaf length was measured along the mid rib and leaf breadth was measured at the broadest point of the same leaf by using centimeter scale. Leaf area was calculated by using the following formula. The leaf length and leaf breadth ratio was calculated. The means of leaf length, leaf breadth, leaf length and breadth ratio and leaf area were worked out. The data were statistically analysed.

$$L. A. = L \times B \times 0.747$$

where, L.A. = leaf area

L = leaf length

B = leaf breadth or width.

0.747 = constant factor (Mate, 1978)

3.4.2.2 Plant height

Five plants of each entry were selected at random and observations were recorded on plant height on the 7th, 14th, 21st and 28th day after germination. The height of shoot was measured from the soil surface to the base of the last fully opened leaf and average height per plant was calculated at each stage. The data thus collected were statistically analysed.

3.4.2.3 Trichomes on leaves

Trichomes are microscopic hair on leaf surface, presence of these hair was studied as per procedure described by Maiti et al. (1980).

The plant samples were taken on the 14th day after germination and thoroughly washed with water to remove soil on the plant surface. The roots were cut and discarded. The samples were kept in glass jars (250 ml capacity) containing formalin, alcohol and acetic acid (GAA) solution for fixing. The fixative was prepared by mixing ingredients in the following proportion.

- i. Ethylalcohol (70 per cent) = 90 ml
- ii. Acetic acid (Glacial) = 5 ml
- iii. Formalin = 5 ml

After keeping the samples in fixative for one week, these were taken out and kept for preservation in 70 per cent ethyl alcohol.

Pieces measuring 1 to 2 sq cm were cut out from the preserved leaves and heated in 20 ml of water in small glass vials (2.0 cm x 7.5 cm) for 15 minutes by keeping in an oven set at 85 °C. The water was then poured out and 20 ml of 95 per cent ethyl alcohol was added and the tubes were again kept in oven for approximately 20 minutes. The alcohol was poured out and fresh alcohol was added and the boiling procedure was repeated till chlorophyll was completely removed. The alcohol remaining in the glass vials was poured off and 20 ml of concentrated (90 per cent) lactic acid was added. The vials were properly stoppered and heated again at 85 °C until the leaf pieces were clear (approximately 45 minutes). The vials were cooled and stored till the observations were recorded.

Each leaf piece was mounted on a glass slide in a drop of lactic acid, covered with cover slip and observed under compound microscope at X 160 magnification. The number of trichomes were recorded in randomly selected microscopic fields of 1.0 sq. mm.

3.4.2.4 Leaf colour

The observations on leaf colour were recorded on the 14th day after germination on the basis of visual colour grading (Bapat et al. 1975). The leaves were differentiated as dark green, green and yellowish green.

3.4.2.5 Glossiness of leaves

Glossiness is one of the most important morphological (physical) plant characters associated with shootfly resistance. Glossiness of the leaves was recorded on the 14th day after germination. The leaves of entries were differentiated as, glossy and non-glossy.

3.4.2.6 Leaf surface wetness

Leaf surface wetness of leaves in central whorl of sorghum was recorded early in the morning between 0500 to 0600 am., under compound microscope. The observation of leaf surface wetness was recorded on the 14th day after germination and graded as, high, medium and low leaf surface wetness.

3.4.2.7 Growth habit of the plants

The observations on growth habit of plants were recorded on the 14th day after germination. The growth habit of the plants were differentiated as, erect, medium spreading and spreading. This rating was done on visual observations.

3.4.2.8 Recovery resistance

Recovery resistance is a helpful character of the variety of sorghum for good yield and it is calculated by using the following formula.

$$\text{Per cent recovery resistance} = \frac{\text{Number of plants recovered at harvest}}{\text{Number of dead hearts recorded on the 28}^{\text{th}} \text{ day after germination}} \times 100$$

Chapter Opener Page



**RESULTS AND
DISCUSSION**

4. RESULTS AND DISCUSSION

Investigations were conducted using different sorghum entries to identify the resistant entries and to determine the possible mechanisms associated with resistance to shootfly, Atherigona soccata Rondani.

During kharif 1993, 50 sorghum entries along with two susceptible checks viz., CSH-9 and DJ-6514, and four resistant checks viz., IS-2205, IS-5490, IS-18551 and ICSV-705 were screened under natural infestation. The data on different parameters studied are presented and discussed in this chapter under the following headings.

4.1 Field screening of sorghum entries for shootfly infestation and damage

4.1.1. Shootfly damage as indicated by dead hearts

The observations regarding the percentage of dead hearts caused due to shootfly attack were recorded at 7 days interval starting from the 7th day after germination and continued upto the 28th day after germination are presented in Table 3.

There were no dead hearts on the 7th day after germination on the both resistant and susceptible checks but some dead hearts were observed on RSE entries which were statistically non significant.

Table 3. Shootfly infestation and damage as indicated by dead hearts and percentage of recovery in different entries of sorghum (Kharif 1993)

Sr. No.	Entry	Average percentage dead hearts				Average % recovery
		Days after germination				
		7	14	21	28	
RSE entries						
1.	RSE 90 - 4 - 7 - 3	00.00 (00.00)	19.21 (25.37)	31.68 (33.00)	34.53 (35.17)	57.61 (49.39)
2.	RSE 90 - 5 - 8 - 1	01.67 (04.31)	20.49 (26.65)	38.02 (38.03)	41.08 (39.84)	61.02 (51.38)
3.	RSE 90 - 4 - 3 - 1	00.00 (00.00)	30.31 (32.47)	40.33 (38.43)	43.24 (40.16)	54.26 (47.47)
4.	RSE 90 - 5 - 7 - 1	00.00 (00.00)	26.47 (30.93)	40.88 (39.66)	45.66 (42.47)	58.86 (50.13)
5.	RSE 90 - 7 - 12 - 2	00.00 (00.00)	24.36 (29.57)	43.59 (41.28)	46.15 (42.80)	33.47 (35.34)
6.	RSE 90 - 4 - 6 - 2	00.00 (00.00)	22.82 (23.84)	43.84 (42.26)	48.09 (43.84)	33.38 (35.33)
7.	RSE 90 - 3 - 4 - 1	00.00 (00.00)	32.25 (34.10)	46.51 (42.87)	50.41 (45.18)	21.44 (27.78)
8.	RSE 90 - 3 - 6 - 1	00.00 (00.00)	32.48 (34.65)	48.81 (44.31)	51.33 (45.75)	41.01 (39.75)
9.	RSE 90 - 4 - 6 - 1	01.33 (03.85)	29.76 (32.16)	48.04 (43.83)	52.23 (46.29)	45.48 (42.40)
10.	RSE 90 - 4 - 4 - 1	01.66 (03.59)	31.38 (33.61)	51.29 (45.73)	55.01 (47.92)	26.25 (30.79)
11.	RSE 90 - 4 - 9 - 1	00.00 (00.00)	31.66 (34.15)	50.94 (45.54)	55.33 (48.07)	39.90 (39.12)
12.	RSE 90 - 5 - 4 - 2	00.00 (00.00)	37.41 (37.61)	53.16 (46.85)	57.36 (49.33)	55.36 (48.21)
13.	RSE 90 - 6 - 6 - 2	01.75 (03.77)	44.38 (41.72)	53.54 (47.07)	57.76 (49.54)	28.37 (32.10)
14.	RSE 90 - 5 - 9 - 2	01.52 (04.13)	36.53 (37.09)	55.22 (48.05)	59.20 (50.36)	43.72 (41.35)
15.	RSE 90 - 5 - 10 - 1	02.56 (05.37)	37.59 (37.72)	55.53 (48.23)	59.33 (50.48)	44.46 (41.81)
16.	RSE 90 - 4 - 1 - 1	00.00 (00.00)	34.65 (36.05)	55.10 (48.31)	59.34 (50.72)	57.46 (49.28)
17.	RSE 90 - 4 - 4 - 2	01.28 (03.80)	31.09 (33.69)	55.55 (48.22)	59.61 (50.73)	22.31 (28.08)
18.	RSE 90 - 7 - 3 - 1	00.00 (00.00)	37.54 (37.44)	56.34 (49.43)	59.61 (50.73)	30.43 (33.35)
19.	RSE 90 - 6 - 17 - 1	01.33 (03.85)	46.56 (43.02)	56.14 (48.56)	60.16 (50.89)	42.81 (40.79)
20.	RSE 90 - 4 - 12 - 1	00.00 (00.00)	32.54 (34.69)	57.93 (49.61)	60.36 (51.06)	38.78 (38.47)
21.	RSE 90 - 5 - 1 - 1	01.23 (03.70)	43.05 (40.91)	56.32 (48.75)	60.36 (51.17)	47.81 (43.73)
22.	RSE 90 - 6 - 8 - 1	00.00 (00.00)	28.97 (32.25)	56.76 (48.92)	60.72 (51.21)	43.55 (41.28)
23.	RSE 90 - 5 - 1 - 2	00.00 (00.00)	29.74 (32.78)	56.03 (48.71)	60.72 (51.21)	55.55 (48.25)
24.	RSE 90 - 5 - 3 - 2	00.00 (00.00)	29.79 (32.79)	56.78 (48.92)	60.72 (51.21)	41.66 (40.14)
25.	RSE 90 - 7 - 16 - 2	01.52 (04.13)	39.09 (38.51)	53.88 (47.24)	61.50 (51.57)	32.29 (34.30)
26.	RSE 90 - 3 - 9 - 1	00.00 (00.00)	44.04 (41.49)	58.90 (49.78)	61.62 (51.81)	34.40 (35.90)
27.	RSE 90 - 4 - 5 - 1	01.39 (03.94)	41.78 (40.22)	59.40 (50.47)	62.07 (52.05)	42.43 (40.62)
28.	RSE 90 - 7 - 11 - 2	01.52 (04.13)	37.24 (37.35)	57.70 (49.47)	62.42 (52.26)	33.62 (35.52)
29.	RSE 90 - 3 - 12 - 1	00.00 (00.00)	39.97 (39.14)	58.06 (49.40)	62.42 (52.26)	52.44 (46.40)
30.	RSE 90 - 7 - 9 - 1	02.56 (05.37)	51.95 (46.13)	58.98 (50.20)	63.00 (52.49)	40.88 (39.73)
31.	RSE 90 - 7 - 16 - 1	00.00 (00.00)	34.68 (36.02)	59.50 (50.68)	63.21 (53.19)	22.54 (28.10)
32.	RSE 90 - 4 - 8 - 1	01.45 (04.04)	34.61 (35.64)	60.46 (51.08)	64.60 (53.61)	45.84 (42.61)
33.	RSE 90 - 5 - 11 - 1	01.39 (03.94)	41.46 (40.02)	61.11 (51.95)	65.08 (54.22)	40.09 (39.21)
34.	RSE 90 - 5 - 12 - 1	01.28 (03.79)	34.24 (35.79)	61.45 (51.65)	65.99 (54.35)	41.29 (39.90)
35.	RSE 90 - 5 - 12 - 2	00.00 (00.00)	38.84 (38.48)	61.88 (51.89)	66.36 (54.56)	35.93 (35.99)
36.	RSE 90 - 7 - 6 - 1	00.00 (00.00)	39.97 (39.21)	64.20 (53.29)	68.20 (55.71)	28.74 (32.17)
37.	RSE 90 - 6 - 8 - 2	00.00 (00.00)	45.85 (42.59)	63.06 (52.67)	68.71 (56.06)	37.21 (37.51)
38.	RSE 90 - 7 - 4 - 3	02.90 (08.07)	32.85 (34.54)	64.13 (53.52)	68.71 (56.28)	36.07 (36.87)
39.	RSE 90 - 7 - 8 - 1	00.00 (00.00)	48.51 (44.09)	64.05 (53.20)	69.00 (56.34)	57.75 (49.97)

(Contd..)

40.	RSE 90 - 5 - 3 - 1	00.00 (00.00)	35.58 (36.60)	69.41 (56.43)	71.30 (57.75)	59.96 (51.17)
41.	RSE 90 - 7 - 16 - 3	01.45 (04.04)	35.12 (35.48)	68.37 (56.39)	72.50 (59.39)	26.89 (31.12)
42.	RSE 90 - 7 - 13 - 2	00.00 (00.00)	46.42 (42.88)	70.25 (57.06)	74.54 (59.84)	57.65 (49.45)
43.	RSE 90 - 3 - 4 - 2	00.00 (00.00)	41.86 (40.29)	70.73 (57.92)	75.31 (61.14)	37.23 (37.54)
44.	RSE 90 - 8 - 4 - 1	01.28 (03.80)	49.62 (44.82)	72.54 (58.66)	76.61 (61.39)	39.36 (38.81)
45.	RSE 90 - 5 - 2 - 1	01.52 (04.13)	40.18 (39.27)	75.17 (61.77)	78.28 (63.67)	36.71 (37.11)
46.	RSE 90 - 3 - 2 - 1	00.00 (00.00)	54.41 (46.07)	80.64 (64.74)	83.06 (66.42)	27.27 (31.40)
47.	RSE 90 - 2 - 5 - 1	02.43 (07.39)	58.83 (50.15)	84.14 (66.68)	86.52 (68.80)	26.92 (31.26)
48.	RSE 90 - 1 - 11 - 1	01.96 (04.69)	59.60 (50.59)	86.82 (69.38)	91.40 (74.04)	23.20 (28.70)
49.	RSE 90 - 1 - 5 - 1	01.28 (03.80)	48.78 (44.30)	87.85 (73.21)	91.76 (75.59)	13.32 (21.34)
50.	RSE 90 - 2 - 3 - 1	01.39 (03.94)	76.68 (61.57)	97.22 (82.11)	97.22 (82.11)	24.31 (29.37)
Resistant checks						
51.	IS - 18551	00.00 (00.00)	19.09 (25.21)	39.85 (39.11)	39.85 (39.11)	34.45 (35.68)
52.	IS - 5490	00.00 (00.00)	35.47 (36.31)	46.72 (42.99)	46.73 (42.99)	50.66 (45.34)
53.	IS - 2205	00.00 (00.00)	19.30 (25.64)	44.57 (41.65)	48.53 (44.03)	31.15 (33.88)
54.	ICSV - 705	00.00 (00.00)	28.55 (31.76)	59.07 (50.57)	60.58 (51.46)	44.32 (41.74)
Susceptible checks						
55.	CSH-9	00.00 (00.00)	72.84 (58.69)	97.53 (84.74)	100.0 (90.00)	49.26 (44.57)
56.	DJ-6514	00.00 (00.00)	43.21 (40.93)	97.33 (84.52)	100.0 (90.00)	00.00 (00.00)

S.E. \pm	02.69	04.22	04.66	04.57	03.47
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C.D. at 5% level	N.S.	11.84	13.09	12.83	09.75
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* Figures in parentheses are the Arc Sin value.

PLATE 1.



RSE - 90-4-7-3

PLATE 2.

7-3101



RSE - 90-5-8-1, DJ - 6514 and CSH - 9

The dead hearts on the 14th day after germination ranged from 19.09 to 76.68 per cent. The minimum incidence was recorded on the entry IS-18551 (19.09 per cent), which was significantly lower than the rest of the entries. However, it was on par with the entries at Sr. No. 1 to 11, 16, 17, 20, 22, 23, 24, 31, 32, 34, 38, 40, 41 and 52 to 54. The maximum incidence was recorded on the entry RSE-90-2-3-1 (76.68 per cent), which was significantly higher than the rest of the entries. However, it was on par with the entries at Sr. No. 47, 48 and 55. The remaining entries occupied intermediate positions.

On the 21st day after germination dead hearts ranged from 31.68 to 97.53 per cent. The minimum incidence was recorded on the entry RSE-90-4-7-3 (31.68 per cent), which was significantly lower than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 11 and 51 to 53. The maximum incidence was recorded on the entry CSH-9 (97.53 per cent), which was significantly higher than the rest of the entries. However, it was on par with the entries at Sr. No. 49, 50 and 56. The remaining entries occupied intermediate positions.

The dead hearts on the 28th day after germination ranged from 34.53 to 100.00 per cent. The minimum incidence was recorded on the entry RSE-90-4-7-3 (34.53 per cent), which was significantly lower than the rest of the entries.

ENTRIES

1. RSE-90-4-7-3
2. IS -18551
3. RSE-90-5-8-1
4. RSE-90-4-3-1
5. RSE-90-5-7-1
6. RSE-90-7-12-2
7. IS -5490
8. RSE-90-4-6-2
9. IS -2205
10. RSE-90-3-4-1
11. RSE-90-3-6-1
12. ICSV-705
13. RSE-90-3-4-2
14. RSE-90-8-4-1
15. RSE-90-5-2-1
16. RSE-90-3-2-1
17. RSE-90-2-5-1
18. RSE-90-1-11-1
19. RSE-90-1-5-1
20. RSE-90-2-3-1
21. CSH-9
22. DJ-6514

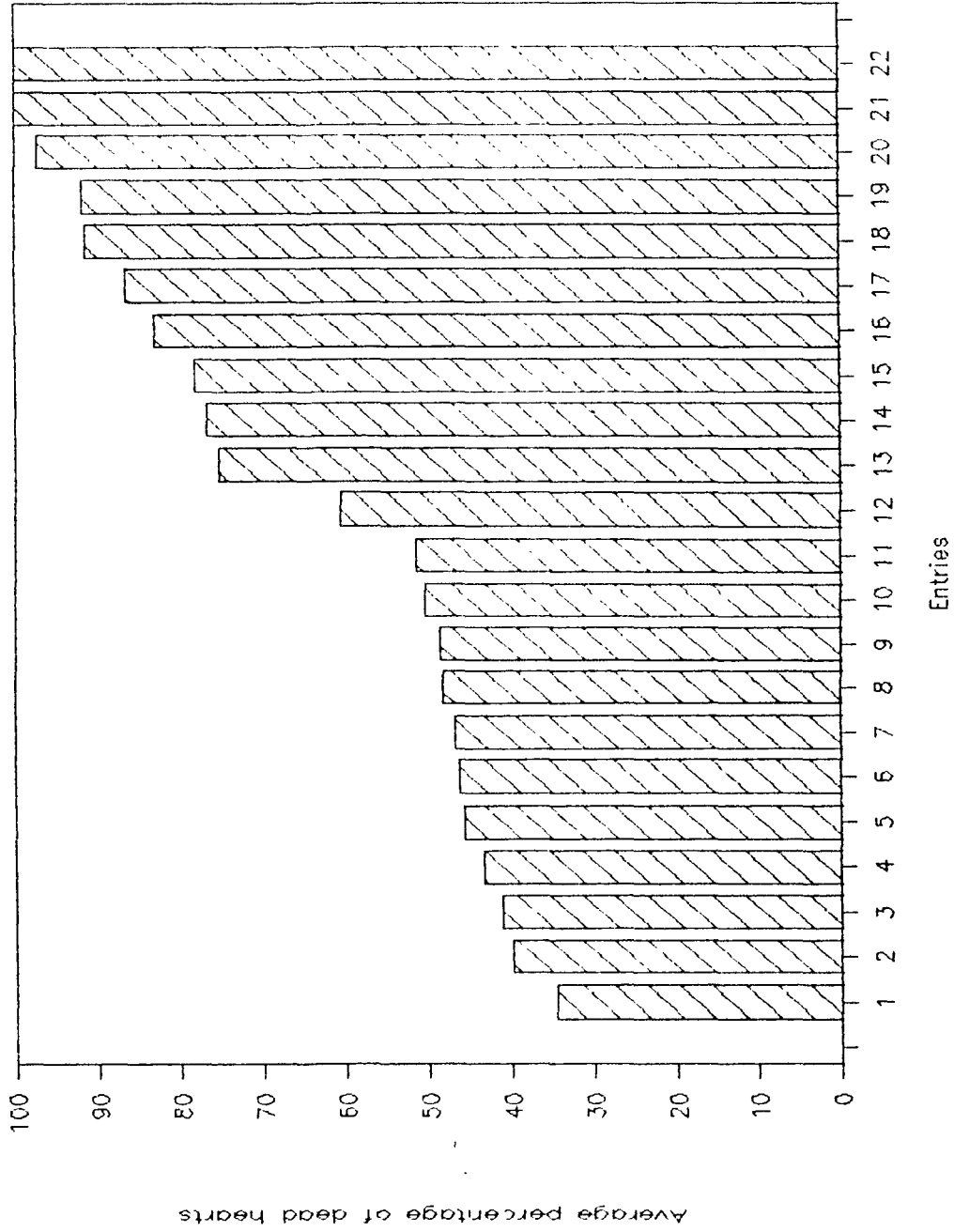


Fig.1. Average percentage of dead hearts caused by shootfly on some sorghum entries (Kharif 1993)

PLATE 3.



RSE - 90-5-7-1 and CSH - 9

PLATE 4.



IS - 2205, CSH - 9 and DJ - 6514

However, it was on par with the entries at Sr.No. 2 to 10 and 51 to 53. These all entries are grouped as less susceptible. The maximum incidence was recorded on the entries CSH-9 and DJ-6514 (100.00 per cent), which was significantly higher than the rest of the entries. However, it was on par with the entry at Sr. No. 50 which are grouped as highly susceptible. The remaining entries occupied intermediate positions and considered as moderately susceptible. The average percentage of dead hearts caused by shootfly on the 28th day after germination on some sorghum entries are graphically presented in fig. 1.

On the basis of dead hearts recorded on the 28th day after germination all the test entries were grouped into three categories viz.,

Less susceptible

Moderately susceptible and

Highly susceptible.

The incidence started from first week and increased upto fourth week. The maximum incidence was observed during second and third week after germination. Similar observations were reported by Krishnananda et al. (1975), Dalvi (1975), Narayana (1975), Sangappa et al. (1978), Moholkar (1981) and Patel and Sukhani (1990a).

4.1.2 Number of eggs laid

The data in respect of the average number of eggs

laid per plant on each entry recorded at seven days interval starting from the 7th day after germination and continued upto the 28th day after germination are presented in Table 4.

The differences in number of eggs laid on all the entries on the 7th day after germination were statistically non-significant.

The egg laying on the 14th day after germination ranged from 0.27 to 4.77 eggs per plant. The minimum number of eggs per plant was recorded on entry IS-2205 (0.27 eggs per plant), which was significantly lower than the rest of the entries. However, it was on par with the entries at Sr. No. 1 to 11, 14 to 17, 20, 22, 23, 24, 31, 32, 34, 38, 40, 51, 52 and 54. The maximum number of eggs per plant was recorded on the entry RSE-90-2-3-1 (4.77 eggs per plant), which was significantly higher than the rest of the entries. However, it was on par with the entries at Sr. No. 46, 47, 48, 55 and 56. The remaining entries occupied intermediate positions.

The egg laying on the 21st day after germination ranged from 1.73 to 6.80 eggs per plant. The minimum number of eggs per plant was recorded on the entry RSE-90-4-7-3 (1.73 eggs per plant), which was significantly lower than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 13, 15, 28 and 51 to 54. The maximum number of eggs per plant was recorded on the entries RSE-90-2-3-1 and CSH-9 (6.80 eggs per plant), which was significantly higher than the

Table 4. Number of eggs laid by shootfly on different entries of sorghum (Kharif 1993)

Sr. No.	Entry	Average number of eggs laid per plant			
		Days after germination			
		7	14	21	28
RSE entries					
1.	RSE 90 - 4 - 7 - 3	0.00	0.67	1.73	1.87
2.	RSE 90 - 5 - 8 - 1	0.10	0.67	1.87	2.20
3.	RSE 90 - 4 - 3 - 1	0.00	1.46	2.13	2.66
4.	RSE 90 - 5 - 7 - 1	0.00	0.93	2.47	2.73
5.	RSE 90 - 7 - 12 - 2	0.00	0.87	2.47	2.80
6.	RSE 90 - 4 - 6 - 2	0.00	1.07	2.60	2.86
7.	RSE 90 - 3 - 4 - 1	0.00	1.60	2.73	3.07
8.	RSE 90 - 3 - 6 - 1	0.00	1.47	2.93	3.20
9.	RSE 90 - 4 - 6 - 1	0.13	1.40	2.87	3.27
10.	RSE 90 - 4 - 4 - 1	0.10	1.53	3.13	3.53
11.	RSE 90 - 4 - 9 - 1	0.00	1.33	3.20	3.53
12.	RSE 90 - 5 - 4 - 2	0.00	1.87	3.40	3.80
13.	RSE 90 - 6 - 6 - 2	0.33	2.53	3.47	3.87
14.	RSE 90 - 5 - 9 - 2	0.13	1.73	3.67	3.93
15.	RSE 90 - 5 - 10 - 1	0.07	1.80	3.53	4.00
16.	RSE 90 - 4 - 1 - 1	0.00	1.53	3.67	4.00
17.	RSE 90 - 7 - 4 - 2	0.33	1.40	3.67	4.00
18.	RSE 90 - 7 - 3 - 1	0.00	2.13	3.80	4.07
19.	RSE 90 - 6 - 17 - 1	0.13	2.67	3.66	4.07
20.	RSE 90 - 4 - 12 - 1	0.00	0.93	3.66	4.07
21.	RSE 90 - 5 - 1 - 1	0.13	2.33	3.73	4.13
22.	RSE 90 - 6 - 8 - 1	0.00	1.33	3.67	4.14
23.	RSE 90 - 5 - 1 - 2	0.00	1.55	3.88	4.15
24.	RSE 90 - 5 - 3 - 2	0.00	1.33	3.73	4.15
25.	RSE 90 - 7 - 16 - 2	0.23	2.00	3.73	4.27
26.	RSE 90 - 3 - 9 - 1	0.00	2.47	3.93	4.33
27.	RSE 90 - 4 - 5 - 1	0.20	2.67	4.00	4.34
28.	RSE 90 - 7 - 11 - 2	0.27	2.00	3.47	4.35
29.	RSE 90 - 3 - 12 - 1	0.00	2.07	3.80	4.37
30.	RSE 90 - 7 - 9 - 1	0.53	3.20	3.93	4.37
31.	RSE 90 - 7 - 16 - 1	0.00	1.60	4.00	4.47
32.	RSE 90 - 4 - 8 - 1	0.20	1.80	4.13	4.53
33.	RSE 90 - 5 - 11 - 1	0.20	1.93	4.20	4.60
34.	RSE 90 - 5 - 12 - 1	0.13	1.53	4.20	4.67
35.	RSE 90 - 5 - 12 - 2	0.00	1.93	4.27	4.73
36.	RSE 90 - 7 - 6 - 1	0.00	2.07	4.40	5.93
37.	RSE 90 - 6 - 8 - 2	0.00	2.73	4.53	5.96

(Contd..)

38.	RSE 90 - 7 - 4 - 3	0.27	1.60	4.47	5.99
39.	RSE 90 - 7 - 8 - 1	0.00	2.93	4.53	6.18
40.	RSE 90 - 5 - 3 - 1	0.00	1.60	5.00	6.32
41.	RSE 90 - 7 - 16 - 3	0.20	1.93	5.13	6.38
42.	RSE 90 - 7 - 13 - 2	0.00	2.73	4.93	6.42
43.	RSE 90 - 3 - 4 - 2	0.00	2.27	5.13	6.48
44.	RSE 90 - 8 - 4 - 1	0.10	3.00	5.33	6.56
45.	RSE 90 - 5 - 2 - 1	0.27	2.13	5.60	6.72
46.	RSE 90 - 3 - 2 - 1	0.00	3.20	6.13	6.80
47.	RSE 90 - 2 - 5 - 1	0.33	4.00	6.53	6.85
48.	RSE 90 - 1 - 11 - 1	0.13	4.07	6.73	6.97
49.	RSE 90 - 1 - 5 - 1	0.27	2.93	6.73	7.26
50.	RSE 90 - 2 - 3 - 1	0.20	4.77	6.80	7.73
Resistant checks					
51.	IS - 18551	0.00	0.60	2.07	2.07
52.	IS - 5490	0.00	1.73	2.67	3.12
53.	IS - 2205	0.00	0.27	3.07	3.40
54.	ICSV - 705	0.00	1.27	3.60	3.73
Susceptible checks					
55.	CSH-9	0.27	4.40	6.80	8.00
56.	DJ-6514	0.20	4.20	6.73	8.00

	S.E. \pm	0.00	0.56	0.67	0.68
	C.D. at 5% level	N.S.	1.57	1.90	1.91

rest of the entries. However, it was on par with the entries at Sr. No. 40 to 49 and 56. The remaining entries occupied intermediate positions.

On the 28th day after germination egg laying ranged from 1.87 to 8.00 eggs per plant. The minimum number of eggs per plant was recorded on entry RSE-90-4-7-3 (1.87 eggs per plant), which was significantly lower than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 11 and 51 to 54 which are less susceptible entries. The maximum number of eggs per plant was recorded on the entries CSH-9 and DJ-6514 (8.00 eggs per plant), which was significantly higher than the rest of the entries, which are more susceptible to shootfly. Among the test entries the highest number of eggs per plant (7.73 eggs per plant) was recorded on the entry RSE-90-2-3-1. However, it was statistically on par with the entries at Sr. No. 36 to 49. The remaining entries occupied intermediate positions which are moderately susceptible.

The minimum number of eggs was laid on the less susceptible entries as compared to the highly susceptible entries. The results of the egg laying indicated that non-preference for oviposition may be one of the characters for varietal resistance to shootfly. Similar results were observed by various workers Jain and Bhatnagar (1962), Blum (1967), Jotwani et al. (1971), Dalvi (1975), Narayana (1975),

Entries

- | | |
|----------------------|----------------------|
| ●—● RSE - 90-4-7-3 | ○---○ RSE - 90-1-5-1 |
| ●—● IS - 18551 | ○---○ RSE - 90-2-3-1 |
| ○---○ RSE - 90-5-8-1 | ○ ○ CSH - 9 |
| ○—○ ICSV - 705 | ○---○ DJ - 6514 |

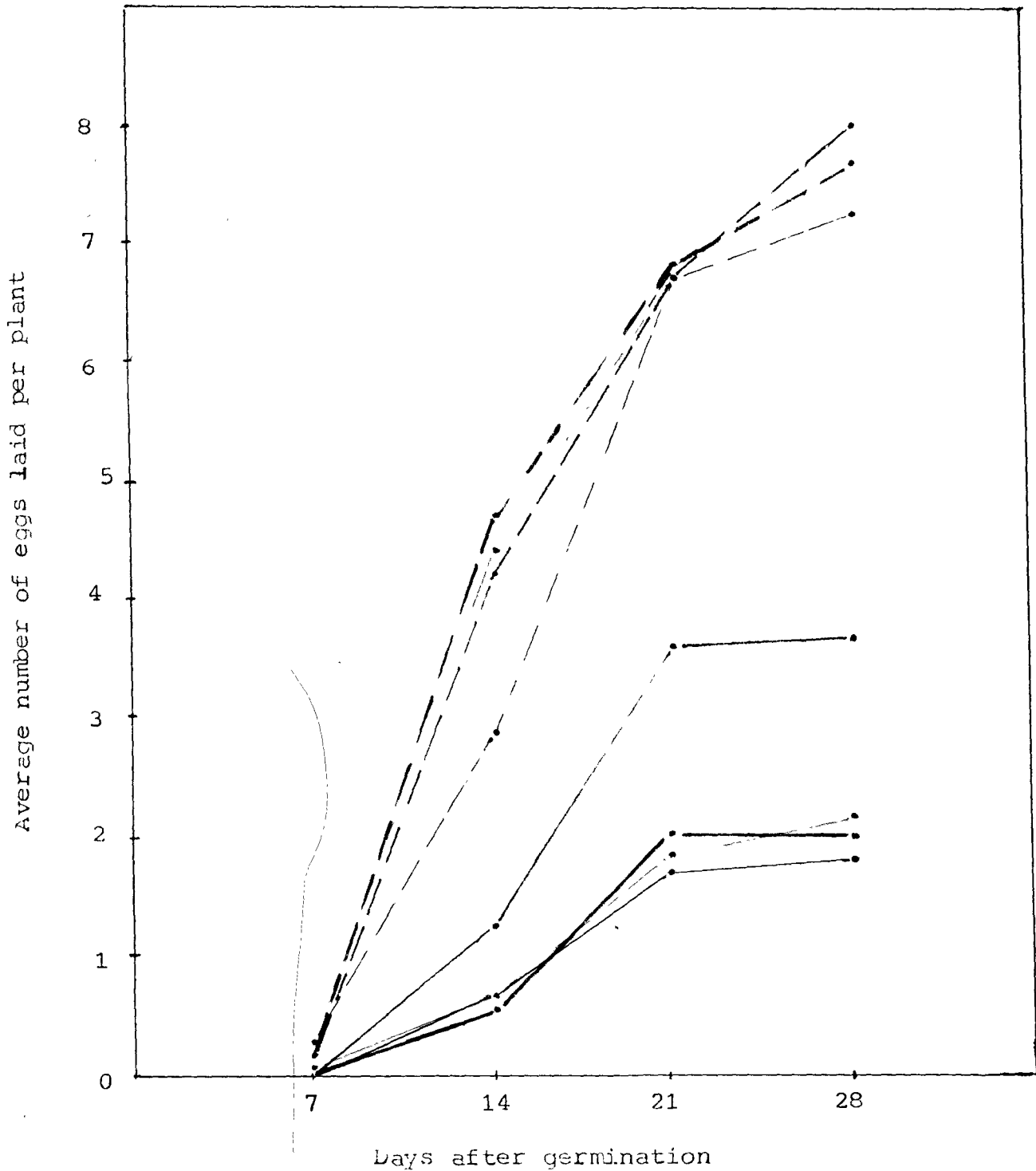


Fig.2. Average number of eggs laid per plant by shootfly at different growth stages on some sorghum entries (Kharif 1993).

Jotwani (1978a), Mote et al. (1981a), Raina et al. (1984), Patel and Sukhani (1990a). The observations however, differ from Ponnaiya (1951 b) who reported that equal number of eggs were laid on the resistant as well as susceptible entries. It was further observed that number of eggs laid was less during the first week after germination which reached maximum in third and fourth week after germination (Fig. 2).

4.2 Morphological (Physical) plant characters of different sorghum entries associated with shootfly resistance

4.2.1 Leaf length

The data in respect of the average leaf length of each entry recorded at 7 days interval starting from the 7th day after germination and continued upto the 28th day after germination are presented in Table 5.

The average leaf length on the 7th day after germination ranged from 12.29 to 14.95 cm. The minimum leaf length was recorded on the entry RSE-90-2-3-1 (12.29 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2, 3, 5, 6, 9, 12, 35, 55 and 56. The maximum leaf length was recorded on the entry RSE-90-4-6-2 (14.95 cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 8, 10, 11, 13, 14, 19, 24, 27, 28, 30, 32, 34, 38, 39, 42 to 46, 49, 50 and 52 to 54. The

12.29
~~12.64~~
 12.93

Table 5. Leaf length at different growth stages in different entries of sorghum (Kharif 1993)

Sr. No.	Entry	Average leaf length in cm			
		Days after germination			
		7	14	21	28
RSE entries					
1.	RSE 90 - 2 - 3 - 1	12.29	17.69	28.86	40.86
2.	RSE 90 - 1 - 5 - 1	12.58	18.33	28.88	40.91
3.	RSE 90 - 1 - 11 - 1	12.65	20.23	29.38	41.49
4.	RSE 90 - 2 - 5 - 1	14.00	19.47	29.64	41.66
5.	RSE 90 - 3 - 2 - 1	12.83	18.32	29.78	41.84
6.	RSE 90 - 5 - 2 - 1	12.91	17.66	29.86	41.92
7.	RSE 90 - 8 - 4 - 1	14.06	19.59	30.56	42.50
8.	RSE 90 - 3 - 4 - 2	14.31	19.65	30.72	42.69
9.	RSE 90 - 7 - 13 - 2	12.90	19.47	30.88	42.93
10.	RSE 90 - 7 - 16 - 3	14.42	19.49	30.99	42.99
11.	RSE 90 - 5 - 3 - 1	14.52	19.57	31.38	43.35
12.	RSE 90 - 7 - 8 - 1	12.60	21.81	31.72	43.70
13.	RSE 90 - 7 - 4 - 3	14.78	22.86	32.15	44.03
14.	RSE 90 - 6 - 8 - 2	14.45	21.78	32.29	44.17
15.	RSE 90 - 7 - 6 - 1	14.04	21.98	32.46	40.40
16.	RSE 90 - 5 - 12 - 2	13.60	21.28	33.44	45.38
17.	RSE 90 - 5 - 12 - 1	13.49	19.41	33.56	45.52
18.	RSE 90 - 5 - 11 - 1	13.47	21.78	33.72	45.67
19.	RSE 90 - 4 - 8 - 1	14.61	24.02	34.25	46.27
20.	RSE 90 - 7 - 16 - 1	13.00	19.62	34.38	46.32
21.	RSE 90 - 7 - 9 - 1	14.06	23.78	34.48	46.44
22.	RSE 90 - 3 - 12 - 1	13.81	19.97	34.74	46.72
23.	RSE 90 - 7 - 11 - 2	13.15	19.19	34.84	46.80
24.	RSE 90 - 4 - 5 - 1	14.34	20.06	35.22	47.25
25.	RSE 90 - 3 - 9 - 1	12.94	23.76	35.52	47.48
26.	RSE 90 - 7 - 16 - 2	14.03	24.24	35.78	47.74
27.	RSE 90 - 5 - 3 - 2	14.36	23.78	35.94	47.92
28.	RSE 90 - 5 - 1 - 2	14.66	21.88	36.24	48.20
29.	RSE 90 - 6 - 8 - 1	13.56	23.48	36.42	48.39
30.	RSE 90 - 5 - 1 - 1	14.34	24.00	36.68	48.72
31.	RSE 90 - 4 - 12 - 1	13.62	21.28	37.98	49.92
32.	RSE 90 - 6 - 17 - 1	14.57	19.80	39.19	51.12
33.	RSE 90 - 7 - 3 - 1	13.60	23.60	39.57	51.51
34.	RSE 90 - 7 - 4 - 2	14.39	19.90	39.81	51.82
35.	RSE 90 - 4 - 1 - 1	12.67	23.72	40.16	52.14
36.	RSE 90 - 5 - 10 - 1	13.87	23.38	40.32	52.27
37.	RSE 90 - 5 - 9 - 2	13.83	24.26	40.50	52.54
38.	RSE 90 - 6 - 6 - 2	14.90	19.62	40.56	52.56
39.	RSE 90 - 5 - 4 - 2	14.87	24.29	40.72	52.74
40.	RSE 90 - 4 - 9 - 1	13.96	23.89	41.35	53.33
41.	RSE 90 - 4 - 4 - 1	13.52	21.58	41.64	53.69
42.	RSE 90 - 4 - 6 - 1	14.90	24.34	42.48	54.49
43.	RSE 90 - 3 - 6 - 1	14.84	22.06	42.69	54.71
44.	RSE 90 - 3 - 4 - 1	14.80	24.36	42.94	54.97

(Contd..)

45.	RSE 90 - 4 - 6 - 2	14.95	22.98	43.18	55.21
46.	RSE 90 - 7 - 12 - 2	14.73	24.78	43.32	55.35
47.	RSE 90 - 5 - 7 - 1	14.92	24.88	43.45	55.48
48.	RSE 90 - 4 - 3 - 1	13.93	24.92	43.52	55.54
49.	RSE 90 - 5 - 8 - 1	14.91	24.30	43.56	55.58
50.	RSE 90 - 4 - 7 - 3	14.92	24.98	43.60	55.62
Resistant checks					
51.	ICSV - 705	13.98	24.82	42.94	54.79
52.	IS - 2205	14.76	24.89	43.36	55.11
53.	IS - 5490	14.82	24.94	43.42	55.38
54.	IS - 18551	14.95	24.97	43.45	55.43
Susceptible checks					
55.	DJ - 6514	12.32	17.71	28.87	40.89
56.	CSH - 9	12.49	17.69	29.03	41.02

	S.E. \pm	00.23	00.39	00.66	01.07
	C.D. at 5% level	00.64	01.09	02.42	02.99

remaining entries occupied intermediate positions.

On the 14th day after germination average leaf length ranged from 17.66 to 24.98 cm. The minimum leaf length was recorded on the entry RSE-90-5-2-1 (17.66 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 1, 2, 5, 55 and 56. The maximum leaf length was recorded on the entry RSE-90-4-7-3 (24.98 cm), which was significantly more than the rest of the entries. However it was on par with the entries at Sr. No. 19, 26, 30, 37, 39, 40, 42, 44, 46 to 49 and 51 to 54. The remaining entries occupied intermediate positions.

The average leaf length on the 21st and 28th day after germination ranged from 28.86 to 43.60 cm and 40.86 to 55.62 cm respectively. The minimum leaf length on the 21st and 28th day after germination was recorded on the entry RSE-90-2-3-1 (28.86 cm and 40.86 cm respectively), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 10, 55 and 56 and Sr. No. 2 to 12, 55 and 56 respectively. On the 21st and 28th day after germination maximum leaf length was recorded on the entry RSE-90-4-7-3 (43.60 cm and 55.62 cm respectively), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 40 to 49 and 51 to 54 and Sr. No. 39 to 49 and 51 to 54 respectively. The remaining entries occupied intermediate positions.

The entries having more leaf length were found to be less susceptible than the entries having less leaf length. The egg laying was also found to be less on the entries having more leaf length. Less number of dead hearts was observed on these entries. Similar observations were recorded by Singh (1977), Mate (1978), Maiti and Bidinger (1979).

4.2.2 Leaf breadth

The observations on leaf breadth were recorded at 7 days interval starting from the 7th day after germination and continued upto the 28th day after germination are presented in Table 6.

The average leaf breadth on the 7th day after germination ranged from 0.62 to 1.24 cm. The minimum leaf breadth was recorded on the entries RSE-90-4-7-3, RSE-90-4-12-1, RSE-90-5-8-1 and IS-18551 (0.62 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 4 to 9, 12, 22 to 24 and 52 to 54. The maximum leaf breadth was recorded on the entry RSE-90-2-3-1 (1.24 cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 44 and 46 to 49. The remaining entries occupied intermediate positions.

The average leaf breadth on the 14th and 21st day after germination ranged from 1.30 to 3.48 cm and 2.22 to 4.46

Table 6. Leaf breadth (width) at different growth stages in different entries of sorghum (Khrif, 1993)

Sr. No.	Entry	Average leaf breadth (width) in cm			
		Days after germination			
		7	14	21	28
RSE entries					
1.	RSE 90 - 4 - 7 - 3	0.62	1.30	2.22	3.00
2.	RSE 90 - 5 - 8 - 1	0.62	1.31	2.22	3.10
3.	RSE 90 - 4 - 3 - 1	0.70	1.91	2.23	3.17
4.	RSE 90 - 5 - 7 - 1	0.64	1.38	2.27	3.22
5.	RSE 90 - 7 - 12 - 2	0.63	1.35	2.32	3.29
6.	RSE 90 - 4 - 6 - 2	0.64	1.40	2.34	3.30
7.	RSE 90 - 3 - 4 - 1	0.66	1.42	2.36	3.32
8.	RSE 90 - 3 - 6 - 1	0.67	1.40	2.37	3.37
9.	RSE 90 - 4 - 6 - 1	0.67	1.43	2.39	3.41
10.	RSE 90 - 4 - 4 - 1	0.72	1.60	2.40	3.45
11.	RSE 90 - 4 - 9 - 1	0.69	1.40	2.42	3.49
12.	RSE 90 - 5 - 4 - 2	0.67	1.38	2.46	3.55
13.	RSE 90 - 6 - 6 - 2	0.86	1.99	2.50	3.66
14.	RSE 90 - 5 - 9 - 2	0.79	1.73	2.59	3.74
15.	RSE 90 - 5 - 10 - 1	0.79	1.80	2.64	3.86
16.	RSE 90 - 4 - 1 - 1	0.69	1.53	2.68	3.92
17.	RSE 90 - 7 - 4 - 2	0.78	1.80	2.90	4.00
18.	RSE 90 - 7 - 3 - 1	0.94	2.44	2.98	4.09
19.	RSE 90 - 6 - 17 - 1	0.95	2.66	3.09	4.16
20.	RSE 90 - 4 - 12 - 1	0.62	1.36	3.13	4.21
21.	RSE 90 - 5 - 1 - 1	0.98	2.80	3.14	4.25
22.	RSE 90 - 6 - 8 - 1	0.63	1.55	3.19	4.34
23.	RSE 90 - 5 - 1 - 2	0.65	1.65	3.22	4.42
24.	RSE 90 - 5 - 3 - 2	0.63	1.36	3.25	4.48
25.	RSE 90 - 7 - 16 - 2	0.90	2.76	3.28	4.54
26.	RSE 90 - 3 - 9 - 1	0.92	2.84	3.29	4.58
27.	RSE 90 - 4 - 5 - 1	0.97	2.90	3.30	4.64
28.	RSE 90 - 7 - 11 - 2	0.81	2.21	3.35	4.74
29.	RSE 90 - 3 - 12 - 1	0.85	2.27	3.41	4.84
30.	RSE 90 - 7 - 9 - 1	1.03	3.00	3.44	4.48
31.	RSE 90 - 7 - 16 - 1	0.80	2.09	3.46	4.92
32.	RSE 90 - 4 - 8 - 1	0.82	2.12	3.92	5.00
33.	RSE 90 - 5 - 11 - 1	0.84	2.14	4.00	5.04
34.	RSE 90 - 5 - 12 - 1	0.82	2.00	4.04	5.08
35.	RSE 90 - 5 - 12 - 2	0.90	2.07	4.06	5.12
36.	RSE 90 - 7 - 6 - 1	1.06	3.09	4.10	5.17
37.	RSE 90 - 6 - 8 - 2	1.10	3.18	4.13	5.27

(Contd...)

38.	RSE 90 - 7 - 4 - 3	0.97	2.65	4.15	5.29
39.	RSE 90 - 7 - 8 - 1	1.09	3.20	4.17	5.34
40.	RSE 90 - 5 - 3 - 1	0.70	1.65	4.20	5.38
41.	RSE 90 - 7 - 16 - 3	0.99	2.75	4.24	5.42
42.	RSE 90 - 7 - 13 - 2	1.09	3.25	4.27	5.54
43.	RSE 90 - 3 - 4 - 2	1.14	3.25	4.30	5.62
44.	RSE 90 - 8 - 4 - 1	1.19	3.39	4.33	5.69
45.	RSE 90 - 5 - 2 - 1	1.05	3.10	4.35	5.76
46.	RSE 90 - 3 - 2 - 1	1.20	3.40	4.38	5.80
47.	RSE 90 - 2 - 5 - 1	1.20	3.42	4.41	5.87
48.	RSE 90 - 1 - 11 - 1	1.22	3.45	4.43	5.89
49.	RSE 90 - 1 - 5 - 1	1.23	3.45	4.44	5.93
50.	RSE 90 - 2 - 3 - 1	1.24	3.48	4.46	5.97
	Resistant checks				
51.	IS - 18551	0.62	1.31	2.27	3.28
52.	IS - 5490	0.63	1.33	2.34	3.34
53.	IS - 2205	0.64	1.36	2.42	3.45
54.	ICSV - 705	0.66	1.40	2.49	3.53
	Susceptible checks				
55.	CSH-9	1.00	3.32	4.27	5.42
56.	DJ-6514	1.17	3.30	4.35	5.53
	S.E. \pm	0.03	0.07	0.11	0.15
	C.D. at 5% level	0.05	0.19	0.26	0.68

cm respectively. On the 14th day after germination minimum leaf breadth was recorded on the entry RSE-90-4-7-3 (1.30 cm), while on the 21st day after germination minimum leaf breadth was recorded on the entries RSE-90-4-7-3 and RSE-90-5-8-1 (2.22 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2, 4 to 9, 11, 12, 20, 24 and 51 to 54 on the 14th day after germination and Sr. No. 3 to 12 and 51 to 53 on the 21st day after germination. The maximum leaf breadth on the 14th and 21st day after germination was recorded on the entry RSE-90-2-3-1 (3.48 cm and 4.46 cm respectively), which was significantly more than the rest of the entries. However, it was on par with entries at Sr. No. 44, 46 to 49, 55 and 56 on the 14th day after germination and Sr. No. 40 to 49, 55 and 56 on the 21st day after germination. The remaining entries occupied intermediate positions.

On the 28th day after germination average leaf breadth ranged from 3.00 to 5.97 cm. The minimum leaf breadth was recorded on the entry RSE-90-4-7-3 (3.00 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 13 and 51 to 54. The maximum leaf breadth was recorded on the entry RSE-90-2-3-1 (5.97 cm), which was significantly more than the rest of the entries. However, it was on par with entries at Sr. No. 38 to 49, 55 and 56. The remaining entries occupied intermediate positions.

The entries having less leaf breadth are observed to be less susceptible and the entries having more leaf breadth are observed highly susceptible. This can be explained by the fact that the shootfly gets more area to move about and deposit eggs at a suitable place on the entries having more leaf breadth. The similar results were observed by Singh (1977), Bothe (1979), Maiti and Bidinager (1979), Raskar (1979) and Moholkar (1981).

4.2.3 Leaf length and breadth ratio

The data in respect of average leaf length and breadth ratio calculated from the observations of leaf length and leaf breadth recorded at 7 days interval starting from the 7th day after germination and continued upto the 28th day after germination are presented in table 7.

The average leaf length and breadth ratio on the 7th, 14th, 21st and 28th day after germination ranged from 09.91 to 24.11 cm, 05.08 to 19.21 cm, 06.47 to 19.63 cm and 06.84 to 18.54 cm respectively. On the 7th day after germination minimum leaf length and breadth ratio was recorded on the entry RSE-90-2-3-1 (09.91 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2, 3, 5 and 55. The maximum leaf length and breadth ratio was recorded on the entry IS-18551 (24.11 cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No.

Table 7. Leaf length and breadth ratio at different growth stages in different entries of sorghum (Kharif, 1993)

Sr. No.	Entry	Average leaf length and breadth ratio in cm			
		Days after germination			
		7	14	21	28
RSE entries					
1.	RSE 90 - 2 - 3 - 1	09.91	05.08	06.47	06.84
2.	RSE 90 - 1 - 5 - 1	10.22	05.31	06.50	06.89
3.	RSE 90 - 1 - 11 - 1	10.36	05.86	06.63	07.04
4.	RSE 90 - 2 - 5 - 1	11.66	05.69	06.72	07.09
5.	RSE 90 - 3 - 2 - 1	10.69	05.38	06.79	07.21
6.	RSE 90 - 5 - 2 - 1	12.29	05.69	06.86	07.27
7.	RSE 90 - 8 - 4 - 1	11.81	05.95	07.05	07.46
8.	RSE 90 - 3 - 4 - 2	12.55	06.04	07.14	07.59
9.	RSE 90 - 7 - 13 - 2	11.83	06.06	07.23	07.24
10.	RSE 90 - 7 - 16 - 3	14.56	07.08	07.30	07.93
11.	RSE 90 - 5 - 3 - 1	20.74	11.86	07.47	08.05
12.	RSE 90 - 7 - 8 - 1	11.55	06.81	07.60	08.12
13.	RSE 90 - 7 - 4 - 3	15.23	08.62	07.74	08.24
14.	RSE 90 - 6 - 8 - 2	13.13	06.84	07.81	08.38
15.	RSE 90 - 7 - 6 - 1	13.29	07.11	07.91	08.58
16.	RSE 90 - 5 - 12 - 2	15.11	10.28	08.23	08.86
17.	RSE 90 - 5 - 12 - 1	16.32	09.70	08.30	08.96
18.	RSE 90 - 5 - 11 - 1	16.03	10.17	08.43	09.25
19.	RSE 90 - 4 - 8 - 1	17.81	11.33	08.73	09.25
20.	RSE 90 - 7 - 16 - 1	16.25	09.38	09.93	09.41
21.	RSE 90 - 7 - 9 - 1	13.65	07.92	10.02	09.51
22.	RSE 90 - 3 - 12 - 1	16.24	08.79	10.16	09.65
23.	RSE 90 - 7 - 11 - 2	16.23	09.04	10.40	09.87
24.	RSE 90 - 4 - 5 - 1	14.78	06.91	10.67	10.18
25.	RSE 90 - 3 - 9 - 1	14.07	08.36	10.79	10.36
26.	RSE 90 - 7 - 16 - 2	15.58	08.78	10.90	10.51
27.	RSE 90 - 5 - 3 - 2	22.79	17.48	11.05	10.69
28.	RSE 90 - 5 - 1 - 2	22.55	13.26	11.25	10.90
29.	RSE 90 - 6 - 8 - 1	21.87	15.14	11.41	11.14
30.	RSE 90 - 5 - 1 - 1	14.66	08.57	11.68	11.46
31.	RSE 90 - 4 - 12 - 1	21.96	15.64	12.13	11.85
32.	RSE 90 - 6 - 17 - 1	15.33	07.44	12.68	12.28
33.	RSE 90 - 7 - 3 - 1	14.46	09.67	13.27	12.59
34.	RSE 90 - 7 - 4 - 2	18.44	11.05	13.72	12.95
35.	RSE 90 - 4 - 1 - 1	18.36	15.15	14.98	13.30
36.	RSE 90 - 5 - 10 - 1	17.55	12.98	15.27	13.54
37.	RSE 90 - 5 - 9 - 2	17.50	14.02	15.63	14.04
38.	RSE 90 - 6 - 6 - 2	17.32	09.65	16.32	14.36
39.	RSE 90 - 5 - 4 - 2	22.19	17.60	16.55	14.85
40.	RSE 90 - 4 - 9 - 1	20.23	17.06	17.08	15.28
41.	RSE 90 - 4 - 4 - 1	18.77	13.48	17.35	15.56

(Contd.)

42.	RSE 90 - 4 - 6 - 1	23.23	17.02	17.77	15.97
43.	RSE 90 - 3 - 6 - 1	22.14	15.75	18.01	16.23
44.	RSE 90 - 3 - 4 - 1	22.42	17.15	18.19	16.55
45.	RSE 90 - 4 - 6 - 2	23.35	16.41	18.45	16.73
46.	RSE 90 - 7 - 12 - 2	23.38	18.35	18.67	16.82
47.	RSE 90 - 5 - 7 - 1	23.31	18.03	19.14	17.22
48.	RSE 90 - 4 - 3 - 1	19.90	13.04	19.51	17.52
49.	RSE 90 - 5 - 8 - 1	23.66	11.54	19.62	17.92
50.	RSE 90 - 4 - 7 - 3	24.06	19.21	19.63	18.54
	Resistant checks				
51.	ICSV - 705	21.18	17.72	17.24	15.54
52.	IS - 2205	23.06	18.30	17.91	15.97
53.	IS - 5490	23.52	18.75	18.55	16.58
54.	IS - 18551	24.11	19.06	19.14	16.89
	Susceptible checks				
55.	DJ - 6514	10.52	05.37	06.63	07.39
56.	CSH - 9	11.35	05.32	06.79	07.56
	S.E. \pm	00.91	00.80	00.72	00.64
	C.D. at 5% level	01.38	01.13	00.94	00.72

27, 42, 45, 46, 47, 49, 50, 52 and 53. The remaining entries occupied intermediate positions.

The minimum leaf length and breadth ratio on the 14th day after germination was recorded on the entry RSE-90-2-3-1 (05.08 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 9, 55 and 56. The maximum leaf length and breadth ratio was recorded on the entry RSE-90-4-7-3 (19.21 cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 46 and 52 to 54. The remaining entries occupied intermediate positions.

On the 21st and 28th day after germination minimum leaf length and breadth ratio was recorded on the entry RSE-90-2-3-1 (06.47 cm and 06.84 cm respectively), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 2 to 10, 55 and 56 and Sr. No. 2 to 9, 55 and 56 respectively. The maximum leaf length and breadth ratio was recorded on the entry RSE-90-4-7-3 (19.63 cm and 18.54 cm respectively), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 47 to 49 and 54 on the 21st day after germination and Sr. No. 49 on the 28th day after germination. The remaining entries occupied intermediate positions.

The entries having less leaf length and breadth ratio are observed highly susceptible and the entries having

more leaf length and breadth ratio are observed less susceptible. The more leaf length and breadth ratio indicates the narrowness of the leaves associated with the shootfly resistance. Singh (1977), Bothe (1979), Maiti and Bidinger (1979), Moholkar (1981) and Jadhav et al. (1986) made a general statement that the egg laying ^{was} less on the entries with narrow and long leaves and ^{were} observed ^{to be} less susceptible to shootfly infestation. The same is evidenced during the present course of investigation.

4.2.4 Leaf area

The data in respect of leaf area calculated from leaf length and leaf breadth which was recorded at 7 days interval starting from the 7th day after germination and continued upto the 28th days after germination are presented in table 8.

The average leaf area on the 7th and 14th day after germination ranged from 06.28 to 12.54 sq. cm and 18.59 to 53.29 sq. cm respectively. The minimum leaf area was recorded on the entry RSE-90-6-8-1 (06.28 sq. cm) and RSE-90-5-7-1 (18.59 sq. cm) respectively, which was significantly less than the rest of the entries. However, on the 7th day after germination it was on par with the entries at Sr. No. 1 to 7, 9, 11, 16, 20, 23, 24 and 51 to 54. On the 7th day after germination maximum leaf area was recorded on the entry RSE-90-2-5-1 (12.54 sq. cm), while on the 14th day after germination minimum leaf area was recorded on the entry RSE-

Table 8. Leaf area at different growth stages in different entries of sorghum (Kharif, 1993)

Sr. No.	Entry	Average leaf area in sq. cm			
		Days after germination			
		7	14	21	28
RSE entries					
1.	RSE 90 - 4 - 7 - 3	06.91	24.26	072.30	124.64
2.	RSE 90 - 5 - 8 - 1	07.05	23.78	072.24	128.71
3.	RSE 90 - 4 - 3 - 1	07.28	35.55	072.50	131.52
4.	RSE 90 - 5 - 7 - 1	07.13	18.59	073.68	133.45
5.	RSE 90 - 3 - 4 - 1	07.29	25.83	075.70	135.34
6.	RSE 90 - 7 - 12 - 2	06.93	24.98	075.08	136.09
7.	RSE 90 - 4 - 6 - 2	07.14	24.03	075.48	136.10
8.	RSE 90 - 3 - 4 - 1	07.42	23.07	075.58	137.73
9.	RSE 90 - 4 - 4 - 1	07.27	25.79	074.62	138.37
10.	RSE 90 - 4 - 6 - 1	07.45	26.00	075.84	138.80
11.	RSE 90 - 4 - 9 - 1	07.19	24.98	074.75	139.03
12.	RSE 90 - 5 - 4 - 2	07.44	25.03	074.83	139.86
13.	RSE 90 - 6 - 6 - 2	09.57	29.16	075.75	143.70
14.	RSE 90 - 5 - 9 - 2	08.16	31.35	078.36	146.78
15.	RSE 90 - 5 - 10 - 1	08.18	31.43	079.51	151.58
16.	RSE 90 - 4 - 1 - 1	06.53	27.11	080.40	152.68
17.	RSE 90 - 5 - 1 - 1	10.49	50.19	086.04	154.67
18.	RSE 90 - 7 - 4 - 2	08.38	26.75	086.24	154.84
19.	RSE 90 - 6 - 8 - 1	06.28	27.18	086.79	156.88
20.	RSE 90 - 4 - 12 - 1	06.30	21.61	088.80	156.99
21.	RSE 90 - 7 - 3 - 1	09.54	43.01	088.09	157.37
22.	RSE 90 - 6 - 17 - 1	10.33	39.34	090.46	158.86
23.	RSE 90 - 5 - 1 - 2	07.11	26.96	087.17	159.14
24.	RSE 90 - 5 - 3 - 2	06.75	24.15	087.25	160.37
25.	RSE 90 - 7 - 16 - 2	09.43	49.97	087.37	161.90
26.	RSE 90 - 3 - 9 - 1	08.89	50.40	087.30	162.44
27.	RSE 90 - 4 - 5 - 1	10.39	43.45	086.82	163.77
28.	RSE 90 - 7 - 11 - 2	07.95	33.00	087.19	165.71
29.	RSE 90 - 3 - 12 - 1	08.76	33.86	088.49	168.92
30.	RSE 90 - 7 - 9 - 1	10.81	53.29	088.60	169.29
31.	RSE 90 - 7 - 16 - 1	07.76	30.63	088.86	170.24
32.	RSE 90 - 7 - 6 - 1	11.11	50.73	099.41	171.47
33.	RSE 90 - 5 - 11 - 1	08.85	34.81	100.76	171.94
34.	RSE 90 - 5 - 12 - 1	08.26	28.99	101.28	172.74
35.	RSE 90 - 4 - 8 - 1	08.94	38.03	100.29	172.82
36.	RSE 90 - 5 - 12 - 2	09.14	32.90	101.42	173.56
37.	RSE 90 - 6 - 8 - 2	11.87	51.73	099.62	173.88
38.	RSE 90 - 7 - 4 - 3	10.70	45.25	099.67	173.99
39.	RSE 90 - 7 - 16 - 3	10.66	40.03	098.15	174.06
40.	RSE 90 - 5 - 3 - 1	07.59	24.12	098.45	174.22
41.	RSE 90 - 7 - 8 - 1	10.25	52.13	098.81	174.32
42.	RSE 90 - 7 - 13 - 2	10.50	46.68	098.50	177.66
43.	RSE 90 - 3 - 4 - 2	12.18	47.90	098.68	179.22
44.	RSE 90 - 5 - 2 - 1	10.12	40.89	097.03	180.37
45.	RSE 90 - 8 - 4 - 1	12.49	49.60	098.85	180.64

(Contd..)

46.	RSE 90 - 1 - 5 - 1	11.55	47.23	095.79	181.22
47.	RSE 90 - 3 - 2 - 1	11.50	46.52	097.44	181.28
48.	RSE 90 - 2 - 3 - 1	11.38	45.98	096.16	182.22
49.	RSE 90 - 1 - 11 - 1	11.52	52.13	097.22	182.55
50.	RSE 90 - 2 - 5 - 1	12.54	49.94	097.64	182.67
Resistant checks					
51.	IS - 18551	06.92	24.43	073.68	135.81
52.	IS - 5490	06.97	24.77	075.90	138.17
53.	IS - 2205	07.05	25.28	078.38	142.03
54.	ICSV - 705	06.89	25.95	079.87	144.74
Susceptible checks					
55.	CSH-9	10.26	43.87	092.56	166.08
56.	DJ-6514	10.76	43.66	093.81	168.91

	S.E. ±	00.41	01.97	002.74	003.56
	C.D. at 5% level	01.12	02.38	003.50	005.71

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90-7-9-1 (53.29 sq. cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 37, 43, 45 to 47 and 49 on the 7th day after germination and Sr. No. 37, 41 and 49 on the 14th day after germination. The remaining entries occupied intermediate positions.

The average leaf area on the 21st day after germination ranged from 072.24 to 101.42 sq. cm. The minimum leaf area was recorded on the entry RSE-90-5-8-1 (072.24 sq. cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 1, 3 to 9, 11, 12, and 51. The maximum leaf area was recorded on the entry RSE-90-5-12-2 (101.42 sq. cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 42 to 49. The remaining entries occupied intermediate positions.

On the 28th day after germination average leaf area ranged from 124.64 to 182.67 sq. cm. The minimum leaf area was recorded on the entry RSE-90-4-7-3 (124.64 sq. cm), which was significantly less than the rest of the entries. However, it was on par with the entry at Sr. No. 2. The maximum leaf area was recorded on the entry RSE-90-2-5-1 (182.67 sq. cm), which was significantly higher than the rest of the entries. However, it was on par with the entries at Sr. No. 42 to 49. The remaining entries occupied intermediate positions.

The entries having less leaf area are observed ^{to be} less susceptible to shootfly infestation. Even though the less susceptible entries having more leaf length, less leaf area was recorded on them. This might be due to less leaf breadth. The less number of eggs ~~was~~ laid and less number of dead hearts ~~was~~ observed on the entries having less leaf area. This might be due to the non-preference of the long and narrow leaves for shootfly oviposition as the shootfly does not gets more area to move and deposit eggs at suitable spot. The similar results were recorded by Singh (1977) and Moholkar (1981). The observations however, differ from Mate (1978) who reported that the maximum leaf area indicates plant vigour and cultivars having more leaf area were resistant to shootfly.

4.2.5 Plant height

The observations on plant height were recorded at 7 days interval starting from the 7th day after germination and continued upto the 28th day after germination are presented in table 9.

The average plant height on the 7th day after germination ranged from 04.42 to 06.93 cm. The minimum plant height was recorded on the entry RSE-90-1-5-1 (04.42 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 1, 3, 4, 6, 11, 14, 28, 55 and 56. The maximum plant height was recorded on the entry RSE-90-3-6-1 (06.93 cm), which was significantly

Table 9. Plant height at different growth stages in different entries of sorghum (Kharif 1993)

Sr. No.	Entry	Average plant height in cm			
		Days after germination			
		7	14	21	28
RSE entries					
1.	RSE 90 - 2 - 3 - 1	04.97	10.01	10.61	24.00
2.	RSE 90 - 1 - 5 - 1	04.42	10.70	16.05	24.01
3.	RSE 90 - 1 - 11 - 1	04.87	10.94	18.56	24.08
4.	RSE 90 - 2 - 5 - 1	05.17	10.51	17.12	24.13
5.	RSE 90 - 3 - 2 - 1	05.81	11.33	21.70	24.44
6.	RSE 90 - 5 - 2 - 1	05.13	09.92	17.37	25.79
7.	RSE 90 - 8 - 4 - 1	05.21	11.73	23.49	26.14
8.	RSE 90 - 3 - 4 - 2	06.12	11.11	17.48	26.58
9.	RSE 90 - 7 - 13 - 2	05.56	10.52	20.26	27.28
10.	RSE 90 - 7 - 16 - 3	05.27	11.28	19.82	27.29
11.	RSE 90 - 5 - 3 - 1	04.90	11.55	19.03	27.45
12.	RSE 90 - 7 - 8 - 1	06.03	11.68	20.97	27.61
13.	RSE 90 - 7 - 4 - 3	05.27	11.47	19.04	27.68
14.	RSE 90 - 6 - 8 - 2	04.89	10.97	19.95	27.94
15.	RSE 90 - 7 - 6 - 1	05.51	11.05	22.91	28.01
16.	RSE 90 - 5 - 12 - 2	05.65	12.72	24.20	28.21
17.	RSE 90 - 5 - 12 - 1	05.73	10.94	20.79	28.69
18.	RSE 90 - 5 - 11 - 1	05.51	11.95	25.27	28.80
19.	RSE 90 - 4 - 8 - 1	05.87	11.36	21.97	28.90
20.	RSE 90 - 7 - 16 - 1	06.17	12.11	17.56	29.05
21.	RSE 90 - 7 - 9 - 1	05.13	10.67	26.35	29.25
22.	RSE 90 - 3 - 12 - 1	05.77	12.59	21.90	29.27
23.	RSE 90 - 7 - 11 - 2	05.74	12.51	24.61	29.46
24.	RSE 90 - 4 - 5 - 1	06.21	11.52	21.95	29.76
25.	RSE 90 - 3 - 9 - 1	05.73	11.61	24.63	29.86
26.	RSE 90 - 7 - 16 - 2	05.99	11.00	22.17	30.27
27.	RSE 90 - 5 - 3 - 2	06.17	11.86	21.11	30.31
28.	RSE 90 - 5 - 1 - 2	04.77	11.93	25.51	30.39
29.	RSE 90 - 6 - 8 - 1	05.92	12.24	29.76	31.68
30.	RSE 90 - 5 - 1 - 1	05.23	11.33	21.56	31.87
31.	RSE 90 - 4 - 12 - 1	05.92	10.85	21.77	31.97
32.	RSE 90 - 6 - 17 - 1	05.45	11.43	26.71	32.24
33.	RSE 90 - 7 - 3 - 1	06.07	11.15	24.42	32.67
34.	RSE 90 - 7 - 4 - 2	05.77	12.24	25.75	32.76
35.	RSE 90 - 4 - 1 - 1	05.93	11.61	24.39	33.31
36.	RSE 90 - 5 - 10 - 1	06.23	13.07	21.72	33.59
37.	RSE 90 - 5 - 9 - 2	06.73	11.19	29.77	33.89
38.	RSE 90 - 6 - 6 - 2	06.17	10.86	23.21	33.94
39.	RSE 90 - 5 - 4 - 2	06.21	11.62	20.76	34.09
40.	RSE 90 - 4 - 9 - 1	06.74	11.89	29.55	34.25
41.	RSE 90 - 4 - 4 - 1	06.30	11.43	29.37	34.39
42.	RSE 90 - 4 - 6 - 1	06.55	11.74	29.21	35.73
43.	RSE 90 - 3 - 6 - 1	06.93	11.05	29.79	36.80

(Contd..)

			16		26 69
44.	RSE 90 - 3 - 4 - 1	06.06	10.69	29.31	37.35
45.	RSE 90 - 4 - 6 - 2	06.57	11.11	29.77	37.51
46.	RSE 90 - 7 - 12 - 2	06.87	11.62	29.35	37.70
47.	RSE 90 - 5 - 7 - 1	06.77	10.87	30.79	38.13
48.	RSE 90 - 4 - 3 - 1	06.51	11.30	29.13	38.21
49.	RSE 90 - 5 - 8 - 1	06.52	12.79	30.21	38.26
50.	RSE 90 - 4 - 7 - 3	06.64	12.87	31.43	38.92
	Resistant checks				
51.	ICSV - 705	06.90	11.55	18.64	31.60
52.	IS - 2205	06.77	12.19	28.93	36.35
53.	IS - 5490	06.21	11.77	29.25	36.50
54.	IS - 18551	06.74	13.20	29.28	36.95
	Susceptible checks				
55.	DJ - 6514	04.45	10.74	10.97	24.71
56.	CSH - 9	05.15	10.64	13.18	24.76

	S.E. ±	00.27	00.27	00.91	00.96
	C.D. at 5% level	00.77	00.76	02.57	02.69

more than the rest of the entries. However, it was on par with the entries at Sr. No. 20, 24, 27, 36 to 42, 44 to 50 and 51 to 54. The remaining entries occupied intermediate positions.

On the 14th day after germination average plant height ranged from 09.92 to 13.20 cm. The minimum plant height was recorded on the entry RSE-90-5-2-1 (09.92 cm), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 1, 4, 9, 21 and 56. The maximum plant height was recorded on the entry IS-18551 (13.20 cm), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 16, 22, 23, 36, 49 and 50. The remaining entries occupied intermediate positions.

The average plant height on the 21st and 28th day after germination ranged from 10.61 to 31.43 cm and 24.00 to 38.92 cm respectively. The minimum plant height was recorded on the entry RSE-90-2-3-1 (10.61 cm and 24.00 cm respectively), which was significantly less than the rest of the entries. However, it was on par with the entries at Sr. No. 55 and 56 on the 21st day after germination and Sr. No. 2 to 8, 55 and 56 on the 28th day after germination. The maximum plant height was recorded on the entry RSE-90-4-7-3 (31.43 cm and 38.92 cm respectively), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No. 29, 37, 40 to 49 and 52 to 54 on the 21st

day after germination and Sr. No. 42 to 49 and 52 to 54 on the 28th day after germination. The remaining entries occupied intermediate positions.

The entries having more height are observed less susceptible to shootfly infestation than the dwarf varieties. The dwarf varieties are observed highly susceptible. This might be due to the slow growth of plants. Similar results were recorded by Blum (1966), Parameswarappa et al. (1968), Raghunath et al. (1972), Lakshminarayana (1974), Dalvi (1975), Narayana (1975), Sharma (1975), Jotwani (1978b), Bothe (1979), Mate et al. (1979), Raskar (1979), Kh^urana (1980), Singh and Jotwani (1980), Moholkar (1981), Dalvi et al. (1984), Jadhav et al. (1986) and Patel and Sukhani (1990b).

4.2.6 Trichomes on sorghum leaves

The observations on the presence of the number of trichomes, the microscopic hair per sq. mm on the leaf surface of sorghum was recorded on the 14th day after germination are presented in table 10.

The number of trichomes ranged from 04.20 to 47.80 per sq. mm. The trichomes were not present on the leaves of susceptible checks CSH-9 and DJ-6514. The minimum number of trichomes was recorded on the entry RSE-90-2-3-1 (04.20 per sq. mm), which was significantly lower than the rest of the entries. The maximum number of trichomes were recorded on

Table 10. Certain plant characters of different sorghum entries recorded on the 14th day after germination (Kharif - 1993).

Sr. No.	Entry	Trichome Density in sq. mm	Leaf colour	Glossiness of leaves	Leaf surface wetness	Growth habit of plant
1.	RSE 90 - 2 - 3 - 1	04.20	Dark-green	Non-glossy	High	Spreading
2.	RSE 90 - 1 - 11 - 1	05.16	Dark-green	Non-glossy	High	Spreading
3.	RSE 90 - 1 - 5 - 1	06.20	Dark-green	Non-glossy	High	Spreading
4.	RSE 90 - 3 - 2 - 1	12.80	Dark-green	Non-glossy	High	Spreading
5.	RSE 90 - 2 - 5 - 1	14.60	Dark-green	Non-glossy	High	Spreading
6.	RSE 90 - 5 - 2 - 1	16.08	Dark-green	Non-glossy	High	Spreading
7.	RSE 90 - 3 - 4 - 2	20.00	Dark-green	Non-glossy	High	Spreading
8.	RSE 90 - 8 - 4 - 1	20.12	Dark-green	Non-glossy	High	Spreading
9.	RSE 90 - 7 - 13 - 2	21.93	Dark-green	Non-glossy	High	Spreading
10.	RSE 90 - 7 - 16 - 3	24.08	Dark-green	Non-glossy	High	Spreading
11.	RSE 90 - 5 - 3 - 1	24.40	Dark-green	Non-glossy	High	Spreading
12.	RSE 90 - 7 - 8 - 1	26.02	Dark-green	Non-glossy	High	Spreading
13.	RSE 90 - 6 - 8 - 2	26.12	Green	Glossy	Medium	Medium Spreading
14.	RSE 90 - 7 - 4 - 3	26.16	Green	Glossy	Medium	Medium Spreading

RSE entries

(Contd..)

15.	RSE 90	-	7	-	6	-	1	26.18	Green	Glossy	Medium	Medium Spreading
16.	RSE 90	-	5	-	12	-	2	27.02	Green	Glossy	Medium	Medium Spreading
17.	RSE 90	-	5	-	12	-	1	28.00	Green	Glossy	Medium	Medium Spreading
18.	RSE 90	-	5	-	11	-	1	28.12	Green	Glossy	Medium	Medium Spreading
19.	RSE 90	-	4	-	8	-	1	28.12	Green	Glossy	Medium	Medium Spreading
20.	RSE 90	-	7	-	9	-	1	29.06	Green	Glossy	Medium	Medium Spreading
21.	RSE 90	-	7	-	11	-	2	29.12	Green	Glossy	Medium	Medium Spreading
22.	RSE 90	-	4	-	12	-	1	29.14	Green	Glossy	Medium	Medium Spreading
23.	RSE 90	-	7	-	16	-	1	29.22	Green	Glossy	Medium	Medium Spreading
24.	RSE 90	-	3	-	12	-	1	29.26	Green	Glossy	Medium	Medium Spreading
25.	RSE 90	-	5	-	1	-	1	30.00	Green	Glossy	Medium	Medium Spreading
26.	RSE 90	-	5	-	1	-	2	30.00	Green	Glossy	Medium	Medium Spreading
27.	RSE 90	-	3	-	9	-	1	30.12	Green	Glossy	Medium	Medium Spreading
28.	RSE 90	-	6	-	17	-	1	30.24	Green	Glossy	Medium	Medium Spreading
29.	RSE 90	-	4	-	5	-	1	30.28	Green	Glossy	Medium	Medium Spreading
30.	RSE 90	-	6	-	8	-	1	30.34	Green	Glossy	Medium	Medium Spreading
31.	RSE 90	-	7	-	16	-	2	30.60	Green	Glossy	Medium	Medium Spreading
32.	RSE 90	-	5	-	3	-	2	30.64	Green	Glossy	Medium	Medium Spreading
33.	RSE 90	-	5	-	9	-	2	31.00	Yellowish-green	Glossy	Low	Erect
34.	RSE 90	-	7	-	4	-	2	31.02	Yellowish-green	Glossy	Low	Erect
35.	RSE 90	-	4	-	1	-	1	31.02	Yellowish-green	Glossy	Low	Erect
36.	RSE 90	-	5	-	10	-	1	31.02	Yellowish-green	Glossy	Low	Erect
37.	RSE 90	-	7	-	3	-	1	31.36	Yellowish-green	Glossy	Low	Erect
38.	RSE 90	-	6	-	6	-	2	32.04	Yellowish-green	Glossy	Low	Erect
39.	RSE 90	-	5	-	4	-	2	32.14	Yellowish-green	Glossy	Low	Erect
40.	RSE 90	-	4	-	4	-	1	33.06	Yellowish-green	Glossy	Low	Erect

(Contd..)

41.	RSE 90 - 4 - 9 - 1	33.24	Yellowish-green	Glossy	Low	Erect	
42.	RSE 90 - 4 - 6 - 1	34.06	Yellowish-green	Glossy	Low	Erect	
43.	RSE 90 - 3 - 6 - 1	35.08	Yellowish-green	Glossy	Low	Erect	
44.	RSE 90 - 3 - 4 - 1	35.32	Yellowish-green	Glossy	Low	Erect	
45.	RSE 90 - 4 - 6 - 2	36.12	Yellowish-green	Glossy	Low	Erect	
46.	RSE 90 - 7 - 12 - 2	37.14	Yellowish-green	Glossy	Low	Erect	
47.	RSE 90 - 5 - 7 - 1	38.12	Yellowish-green	Glossy	Low	Erect	
48.	RSE 90 - 4 - 3 - 1	39.18	Yellowish-green	Glossy	Low	Erect	
49.	RSE 90 - 5 - 9 - 1	40.22	Yellowish-green	Glossy	Low	Erect	
50.	RSE 90 - 4 - 7 - 3	47.08	Yellowish-green	Glossy	Low	Erect	
	Resistant checks						
51.	ICSV - 705	31.24	Yellowish-green	Glossy	Low	Erect	
52.	IS - 2205	37.28	Yellowish-green	Glossy	Low	Erect	
53.	IS - 18551	47.08	Yellowish-green	Glossy	Low	Erect	
54.	IS - 5490	47.48	Yellowish-green	Glossy	Low	Erect	
	Susceptible checks						
55.	CSH-9	00.00	Dark-green	Non-glossy	High	Spreading	
56.	DJ-6514	00.00	Dark-green	Non-glossy	High	Spreading	
	S.E. ±						
	C.D. at 5% level						

the entry IS-5490 (47.48 per sq. mm), which was significantly higher than the rest of the entries.

There is an indication that this parameter may be playing an important role in the infestation and damage caused by shootfly. The trichomes were absent in both the susceptible checks, but these were present in all the resistant checks. The number of trichomes were more on the less susceptible entries than the highly susceptible entries which were screened for the shootfly resistance. The shootfly damage and egg laying was observed to be reduced in the entries having more trichomes. The presence of trichomes on leaf surface may confer an advantage in two ways, i) by reduction in egg laying on leaf and ii) by reduction in the frequency with which the presence of eggs of shootfly results in the death of shoot of sorghum. Similar results were reported by Maiti and Bidinger (1979), Maiti et al. (1980), Moholkar (1981), Jadhav et al. (1986), Patel and Sukhani (1990b), Swarna Sree et al. (1992) and Taneja and Maiti (1992).

4.2.7. Leaf colour

The observations on leaf colour was recorded on the 14th day after germination are presented in Table 10.

The entries at Sr. No. 1 to 12, 55 and 56 showed dark green colour, while green coloured leaves were observed on the entries at Sr. No. 13 to 32. The rest of the entries at Sr. No. 33 to 54 showed yellowish green coloured leaves.

The colour of the leaves appeared to be one of the morphological characters responsible for varied reaction of a sorghum entries to the attack of shootfly. The yellowish green coloured leaves were observed on the all resistant check and less susceptible RSE entries, while dark green coloured leaves were observed on the susceptible checks and highly susceptible RSE entries. The RSE entries which showed moderate level of infestation have green coloured leaves. The similar observations were recorded by Vedamoorthy (1967), Bapat et al. (1975), Chavan (1975), Bothe (1979), Mate et al. (1979), Kulkarni et al. (1981), Moholkar (1981), Jadhav et al. (1986) and Patel and Sukhani (1990b).

4.2.8 Glossiness of leaves

The observations on glossiness of leaves was recorded on the 14th day after germination are presented in Table 10.

The leaves of the entries at Sr. No. 1 to 12, 55 and 56 were observed to be non-glossy, while glossy leaves were observed on the entries at Sr. No. 13 to 54.

The glossiness of leaves appeared to be one of the morphological characters responsible for shootfly damage in sorghum. The resistant checks and the RSE entries which showed moderate to less susceptibility showed shiny or glossy leaf appearance, while the non-glossy leaves were observed on the susceptible checks and highly susceptible RSE entries.

The minimum egg laying and infestation was observed on the entries having glossy leaves. Similar results were recorded by Vedamoorthy (1967), Narayana (1975), Kulkarni ^{et al.} (1981), Jadhav et al. (1986), Nwanze et al. (1991) and Taneja and Maiti (1992).

4.2.9 Leaf surface wetness

The observations on leaf surface wetness was recorded on the 14th day after germination are presented in table 10.

The entries at Sr. No. 1 to 12, 55 and 56 showed high leaf surface wetness, while medium leaf surface wetness was observed on the entries at Sr. No. 13 to 32. The rest of the entries at Sr. No. 33 to 54 showed low leaf surface wetness.

The low leaf surface wetness of central whorl leaf was observed on the resistant checks and less susceptible RSE entries while high leaf surface wetness was observed on the susceptible checks and highly susceptible RSE entries. The medium leaf surface wetness was observed on the moderately susceptible RSE entries. Similar observations were recorded by Nwanze et al. (1990), Nwanze et al. (1991) and Swarna Sree et al. (1992).

4.2.10 Growth habit of the plants

The observations on the growth habit of the plant was recorded on the 14th day after germination are presented in Table 10.

The entries at Sr. No. 1 to 12, 55 and 56 showed more spreading growth habit, while medium spreading plants was observed in the entries at Sr. No. 13 to 32. The rest of the entries at Sr. No.33 to 54 showed erect growth habit.

The less number of eggs and dead hearts were recorded on the resistant checks and less susceptible RSE entries which having erect growth habit, while more number of eggs and dead hearts were recorded on the susceptible checks and highly susceptible RSE entries having spreading growth habit. While moderate egg laying and infestation was observed on the medium spreading plants of the sorghum. Similar results were observed by Singh (1977) and Maiti and Bidinger (1979).

4.2.11 Recovery Resistance

The data on percentage of recovery are presented in Table 4 ranged from 13.32 to 61.02, while not a single plant was recovered in the entry DJ-6514. The minimum recovery was recorded in the entry RSE-90-1-5-1 (13.32 per cent), which was significantly less than the rest of the entries. However it was on par with the entries at Sr. No.7, 10, 17, 31, 48 and 50. The maximum recovery was recorded in the entry RSE-90-5-8-1 (61.02 per cent), which was significantly more than the rest of the entries. However, it was on par with the entries at Sr. No.1 to 3, 9, 12, 15, 16, 21, 23, 29, 32, 39, 40, 42, 52, 54 and 56. The remaining entries occupied intermediate positions.

As mentioned by Kogan (1975), Blum (1969), Doggett et al. (1970 and 1972), Sharma (1975), Seshu Reddy and Davies (1978), Kadam and Mote (1983) and Mote et al. (1985) recovery of damaged plants is an important factor in resistance breeding programme for getting normal yield. Though, the entries RSE-90-7-8-1, RSE-90-5-3-1 and RSE-90-7-13-2 were severely attacked by the shootfly showed good recovery of 57.75, 59.96 and 57.65 per cent. Though the cent per cent dead hearts were observed in the susceptible check CSH-9, it showed more recovery resistance (49.26 per cent). The injured plants are recovered might be due to more tillering habit, faster growth rate and higher plant vigour. But clear cut correlation could not be obtained between recovery and susceptibility of the plants.

4.3 Correlation of different morphological (Physical) plant characters with incidence and egg laying of sorghum shootfly

The values of correlation coefficient (r) of different morphological (Physical) plant characters with incidence and egg laying of sorghum shootfly are presented in Table 11 and Fig. 3.

It could be seen from the table that there was a strong and positive correlation between dead hearts and egg laying (0.969). Similarly, ^{these} ~~there~~ was a significant negative correlation of leaf length with dead hearts or susceptibility

Table 11. The values of correlation coefficient (r) of different morphological (Physical) plant characters with incidence (susceptibility) and egg laying of sorghum shootfly.

Sr. No.	Morphological characters	Dead hearts or susceptibility	Egg laying
1.	Dead hearts or susceptibility	---	Positive (0.969)**
2.	Egg laying	Positive** (0.969)	---
3.	Leaf length	Negative* (-0.315)	Negative* (-0.315)
4.	Leaf breadth	Positive* (0.294)	Positive* (0.289)
5.	Leaf length and breadth ratio	Negative* (-0.318)	Negative* (-0.317)
6.	Leaf area	Positive* (0.319)	Positive* (0.322)
7.	Plant height	Negative* (-0.335)	Negative* (-0.320)
8.	Trichomes on leaves	Negative** (-0.779)	Negative** (-0.799)
9.	Leaf colour Yellowish green Green	Negative Positive	Negative Positive
10.	Glossiness	Negative	Negative
11.	Leaf surface wetness	Positive	Positive
12.	Growth habit Erect Spreading	Negative Positive	Negative Positive

* Significant at P = 0.05

** Significant at P = 0.01

Morphological plant characters

1. Leaf breadth
2. Leaf area
3. Leaf length
4. Leaf length and breadth ratio
5. Plant height
6. An. enomes

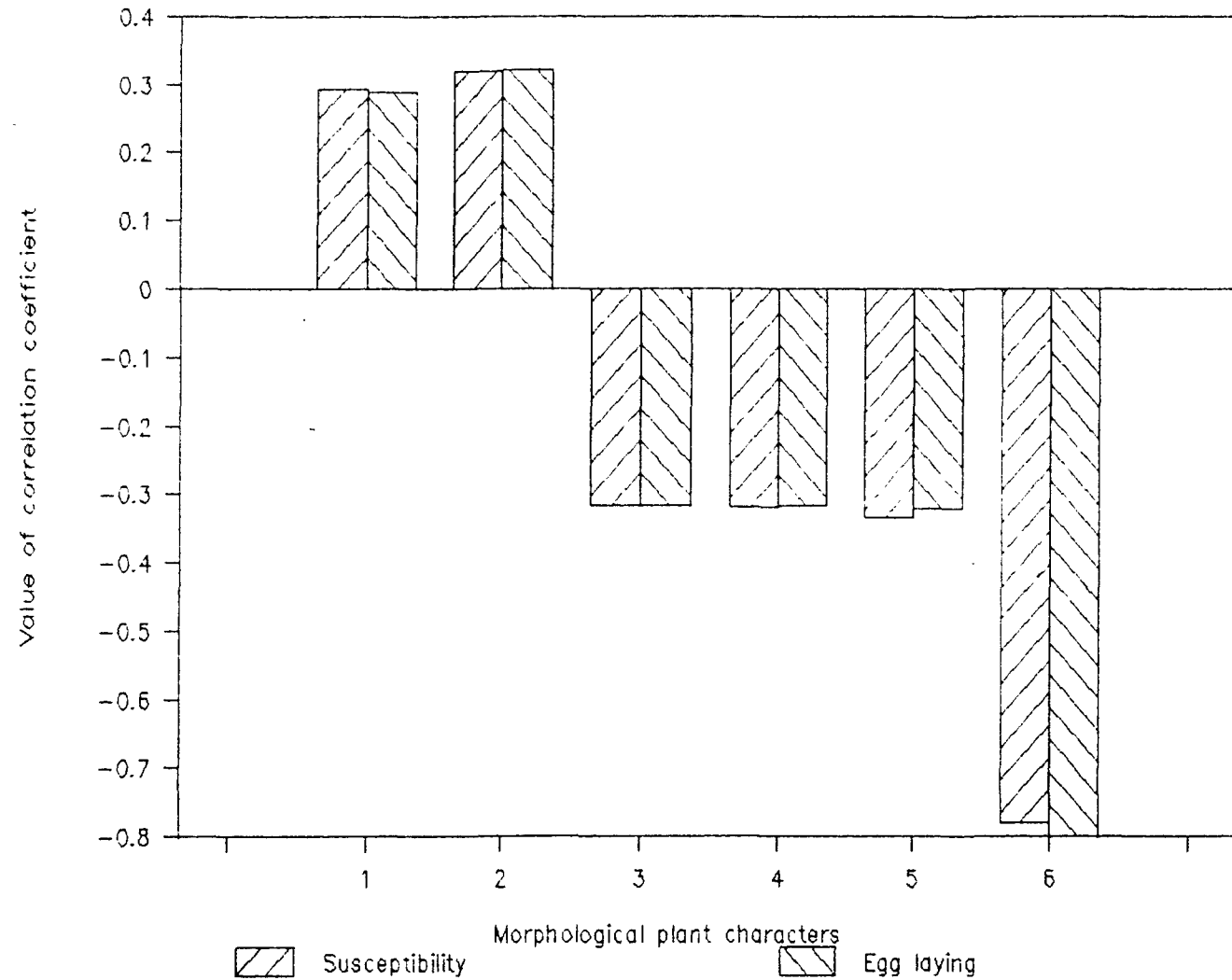


Fig.3. Correlation coefficient (r) of different morphological (physical) plant characters with susceptibility and egg laying of shootfly.

(-0.315) and egg laying (-0.315). There was a significant positive correlation of leaf breadth with susceptibility (0.294) and egg laying (0.289). The significant negative correlation of leaf length and breadth ratio was observed with susceptibility (-0.318) and egg laying (-0.317). Similarly, there was a significant positive correlation of leaf area with susceptibility (0.319) and egg laying (0.322). The significant negative correlation of plant height was observed with susceptibility (-0.335) and egg laying (-0.320). There was a strong and negative correlation of trichomes with susceptibility (-0.779) and egg laying (-0.799). There was a significant negative correlation of yellowish green colour of leaves with susceptibility and egg laying, while significant positive correlation of green colour was observed with susceptibility and egg laying. There was a significant negative correlation of glossiness with susceptibility and egg laying. The significant positive correlation of leaf surface wetness of central whorl shoot was observed with susceptibility and egg laying. There was a significant negative correlation of erect growth habit of the plant with susceptibility and egg laying, while significant positive correlation of spreading growth habit of the plant was observed with susceptibility and egg laying.

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Summary and Conclusion

5 . SUMMARY AND CONCLUSION

Sorghum is an important food crop of Maharashtra and is cultivated in both Kharif and Rabi seasons. Its cultivation in summer is also very common whenever there are irrigation facilities. Although, the efforts to boost the production of the crop have been successful to some extent, it has not been possible to cover major area under high yielding varieties and hybrids because of their high susceptibility to insect pests. Among the various pests, the shootfly is the major one which has in fact gained important pest status with the introduction of high yielding varieties and hybrids.

Several chemicals have been tried for the control of the pest and some of them have been also recommended. These insecticides are not used on large scale because of the several problems associated with their use. The most important problem is the cost involved in their use and in marginal profit crop like jawar, their use becomes prohibitive.

Use of alternate methods to combat the pest problem has become inevitable. Among the other control measures, growing resistant varieties is the cheapest and easy method which can be adopted by all farmers.

Efforts are therefore, already initiated to find out varieties which would escape or resist the shootfly attack

and to determine morphological (physical) characters of the plants associated with resistance to shootfly, if any. Some of the varieties have been also reported to be promising, since the new varieties and hybrids are continuously developed, it was felt necessary to screen some of the promising entries for their resistance to shootfly.

Fifty RSE entries along with four resistant checks and two susceptible checks were screened under field conditions in Kharif 1993 and observations were noted on the incidence of shootfly and some morphological (physical) plant characters.

5.1 Field screening of sorghum entries for shootfly infestation and damage

5.1.1 Shootfly damage as indicated by dead hearts

Observations were recorded on dead hearts caused by shootfly at 7 days interval starting from the 7th day after germination and continued upto the 28th day after germination. The entry RSE-90-4-7-3 (34.53 per cent) showed minimum incidence of shootfly than the resistant checks. The resistant checks IS-18551 and ICSV-705 also showed 39.81 to 60.58 per cent dead hearts. The maximum percentage of dead hearts was noticed on the entry RSE-90-2-3-1 (97.22 per cent) followed by RSE-90-1-5-1 (91.76 per cent) and RSE-90-1-11-1 (91.40 per cent), while the susceptible checks DJ-6514 and CSH-9 showed cent per cent shootfly incidence.

Correlation studies on data indicated strong and positive correlation between shootfly oviposition and dead

hearts (0.969). This indicates the dominance of the non-preference for oviposition mechanism.

5.1.2 Preference for oviposition

Observations recorded on the preference for oviposition showed that resistant checks were significantly less preferred for oviposition than susceptible checks. The egg laying started from 7 days after germination which steadily increased and was maximum on the 21st and 28th day after germination. The maximum number of eggs were observed on susceptible checks DJ-6514 and CSH-9 (8.00 eggs per plant) followed by highly susceptible entries RSE-90-2-3-1 (7.73 eggs per plant), RSE-90-1-11-1 and RSE-90-1-5-1 (7.20 eggs per plant). The resistant checks and some RSE entries which were found less susceptible had least number of eggs as compared to susceptible checks and highly susceptible RSE entries. It indicated the non preference for oviposition.

5.2 Morphological (Physical) plant characters possibly associated with shootfly resistance

5.2.1 Leaf length

This parameter was found to be consistent when observations were recorded at different growth stages. The entries having more leaf length was found to be less susceptible. The less leaf length was recorded on susceptible checks and highly susceptible RSE entries. The more leaf length was observed one of the best characters for shootfly

resistance. The significant negative correlation of leaf length was established with susceptibility ($r = -0.315$) and egg laying ($r = -0.315$).

5.2.2 Leaf breadth

The parameter of leaf breadth was found to be consistent when observations were recorded at different growth stages. The entries having less leaf breadth was found to be less susceptible and less number of eggs were recorded on these entries. The entries having more leaf breadth was found to be highly susceptible. The more leaf breadth was recorded on the susceptible checks and less leaf breadth on the resistant checks. More leaf breadth provides more area to shootfly to move about and select suitable spot for oviposition. The significant positive correlation of leaf breadth was established with susceptibility ($r = 0.294$) and egg laying ($r = 0.289$).

5.2.3 Leaf length and breadth ratio

The less leaf length and breadth ratio was recorded on the susceptible checks and highly susceptible RSE entries. The more leaf length and breadth ratio was recorded on the resistant checks and less susceptible RSE entries. The less egg laying was observed on the entries having more leaf length and breadth ratio than the entries having less leaf length and breadth ratio. The significant negative correlation of leaf length and breadth ratio was established with susceptibility ($r = -0.318$) and egg laying ($r = -0.317$).

5.2.4 Leaf area

The less leaf area was recorded on the resistant checks and less susceptible RSE entries. The more leaf area was recorded on the susceptible checks and highly susceptible RSE entries. The more number of eggs per plant was recorded on the entries having more leaf area than the entries having less leaf area. This might be due to the shootfly gets more area to move about and select suitable spot for oviposition. The significant positive correlation of leaf area was established with susceptibility ($r = 0.319$) and egg laying ($r = 0.322$).

5.2.5 Plant height

The less plant height was recorded on the susceptible checks and highly susceptible RSE entries. The more plant height was recorded on the resistant checks and less susceptible RSE entries. The less number of eggs per plant was recorded on the entries having more plant height than the entries having less plant height. That means the tallness character is responsible for the shootfly resistance. The significant negative correlation of plant height was established with susceptibility ($r = -0.335$) and egg laying ($r = -0.320$).

5.2.6 Trichomes on leaves

The trichomes were not observed on the both susceptible checks. However, the trichomes were observed on

all the RSE entries and resistant checks. It is observed that as the number of trichomes per sq. mm increased, the dead hearts and egg laying decreased. The strong and negative correlation of the presence of trichomes was established with susceptibility ($r = -0.779$) and egg laying ($r = -0.799$). Therefore, it has been suggested that there is a definite association of trichomes on leaves with shootfly resistance and oviposition.

5.2.7 Leaf colour

The yellowish green leaf colour was observed on the resistant checks and less susceptible RSE entries. The less number of eggs per plant was recorded on the entries having yellowish green coloured leaves. The significant negative correlation of yellowish green colour of leaves was established with susceptibility and egg laying. The green coloured leaves were observed on the moderately susceptible entries, while dark-green colour was observed on the susceptible checks and highly susceptible RSE entries. The more number of eggs per plant was laid on these entries. The significant positive correlation of green colour of the leaves was observed with susceptibility and egg laying.

5.2.8 Glossiness of leaves

The glossy leaves were observed on the resistant checks and less to moderately susceptible RSE entries, while non-glossy leaves were observed on the susceptible checks and

highly susceptible RSE entries. The significant negative correlation of glossiness of leaves was observed with susceptibility and egg laying.

5.2.9 Leaf surface wetness

The susceptible checks and highly susceptible RSE entries showed high leaf surface wetness uniformly spread all over the surface, while low leaf surface wetness was observed on the leaves of resistant checks and less susceptible RSE entries. It was not uniform on all over the leaf surface but the water droplets were observed near the margin of leaf in case of resistant checks and less susceptible RSE entries. The medium leaf surface wetness was observed on the leaves of moderately susceptible RSE entries. The less number of eggs per plant was laid on the entries having low leaf surface wetness, while more number of eggs per plant was observed on the entries having high leaf surface wetness. The significant positive correlation of leaf surface wetness was established with susceptibility and egg laying.

5.2.10 Growth habits of the plant

The erect growth habit was observed in the resistant checks and less susceptible RSE entries, while spreading plant habit was observed in the susceptible checks and highly susceptible RSE entries. The less number of eggs per plant was recorded on the entries having erect growth habit and more number of eggs per plant was recorded on the

entries having spreading growth habit. The significant negative correlation of erect growth habit was established with susceptibility and egg laying, while significant positive correlation of spreading growth habit was established with susceptibility and egg laying.

5.2.11 Recovery resistance

The data on percentage of recovery ranged from 13.32 to 61.02. Not a single plant was recovered in susceptible check DJ-6514. The cent per cent dead hearts were recorded in susceptible check CSH-9 of which 49.26 per cent plants were recovered. The recovery of damaged plants is an important factor in resistance breeding programme for getting normal yield. The entries RSE-90-7-8-1, RSE-90-5-3-1 and RSE-90-7-13-2 showed more shootfly incidence but later on good recovery of 57.75, 59.96 and 57.65 per cent was observed in these entries. The injured plants were recovered, which might be due to more tillering habit, faster growth rate and higher plant vigour. But clear cut correlation could not be obtained between recovery and susceptibility of the plants.

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6. LITERATURE CITED

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* Originals not seen.

Chapter Opener Page



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7. VITA

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