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BREEDING FOR RESISTANCE TO *CHILO PARTELLUS* SWINHOE IN SORGHUM

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Abstract—Host-plant resistance plays an important role in the insect-pest management either alone or in combination with other control methods. A number of sorghum genotypes showing varying levels of resistance to spotted stem borer, *Chilo partellus* Swinhoe have been identified using natural and artificial infestations. Major resistance mechanisms are antibiosis and tolerance, though some genotypes exhibit ovipositional non-preferences. There have been a number of factors involved in spotted stem borer resistance; a resistant genotype possesses either one or a combination of these traits. Progress has been made in developing borer resistant breeding lines with moderate yield and acceptable grain quality. Borer resistance is a quantitatively inherited trait governed by additive and non-additive genes. Epistatic gene effects are more pronounced under artificial borer infestation. Cytoplasmic effects appear to be present.

Key Words: Spotted stem borer, resistance breeding, selection criteria, artificial infestation, resistance mechanisms, ovipositional non-preference, recurrent selection, population breeding

Résumé—Criblage pour la résistance à *Chilo partellus* Swinhoe chez le sorgho. La résistance de la plante-hôte joue un rôle important dans la lutte contre les insectes ravageurs soit toute seule ou en combinaison avec d'autres moyens de lutte. Plusieurs génotypes de sorgho présentant des niveaux différents de résistance au foreur ponctué du sorgho, *Chilo partellus* Swinhoe ont été identifiés à partir des infestations naturelles ou artificielles. L'antibiose et la tolérance constituent les mécanismes importants de la résistance, alors que certains génotypes présentent la non-préférence de ponte. Nombre de facteurs contribuent à la résistance au foreur ponctué, le génotype résistant comportant soit un seul ou une combinaison de ces caractères. Des progrès ont été réalisés dans la mise au point de lignées de sélection résistantes au foreur, ayant des rendements modérés et une qualité acceptable du grain. La résistance au foreur est héritée comme caractère quantitatif qui est déterminé par les gènes additifs et non-additifs. Des effets de gènes épistatiques sont plus accentués sous l'infestation artificielle par la foreur. Des effets cytoplasmiques semblent être présents.

Mots Cléfs: Foreur ponctué du sorgho, criblage pour la résistance, critères de sélection, infestation artificielle, mécanismes de résistance, non-préférence de ponte, sélection récurrente, sélection de populations

INTRODUCTION

Sorghum is an important cereal crop in the semi-arid tropics (SAT). Nearly 150 insect species have been reported as pests or potential pests of sorghum (Young and Teetes, 1977; Seshu Reddy and Davies, 1979a; FAO, 1980). However, the most widespread and devastating insect pests of

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sorghum in the SAT as a whole are shootfly, several species of stem borers, armyworm, midge, head bugs, and head caterpillars.

Stem borers constitute the most widely distributed and serious group of insect pests on sorghum in the world. Among the stem borers, *Chilo partellus* Swinhoe is the predominant species in Asia and Africa, *Busseola fusca* Fuller, *Sesamia calamistis* Hampson and *Eldana saccharina* Walker in Africa, *Sesamia critica* Laderer in Mediterranean Europe and Middle East, and *Diatraea* spp. in southern US, Mexico and New World Tropics (Young, 1970; FAO, 1980). Plant damage is caused by larvae feeding in the leaf whorls or in the stem. Due to their internal feeding habits, larvae are protected to a large extent from natural enemies (predators and parasites), unfavorable environmental conditions and insecticides. Host-plant resistance offers an economic, efficient and a long term solution to manage these insects either alone or in combination with other methods of control. Host-plant resistance has several advantages: it avoids environmental pollution, it is compatible with natural control processes, it integrates effectively with other pest control tactics, and involves no additional costs to the farmer. In this paper, an attempt has been made to present an overview of breeding for resistance to *Chilo partellus* in sorghum.

NATURE OF DAMAGE AND BIOLOGY

Chilo partellus attacks sorghum from 2 weeks after germination until crop harvest and affects all above ground plant parts. The first symptoms of attack are the "shot holes" or irregular-shaped holes on the leaves caused by the early instar larval feeding in the whorl. The older larvae leave the whorl and bore into the stem. In young plants, the larvae destroy the growing point and cause the characteristic dead heart symptoms. However, in older plants, the larvae feed inside the stem causing extensive tunnelling. It may also tunnel the peduncle and move up to the panicle. Thus, while early attack by borers may kill young plants by causing dead hearts, thereby reducing the crop stand, the attack during later stages results in reduced yield due to larval feeding inside the stems. Tunnelling weakens stems, which may cause lodging and also interferes with supply of nutrients to the developing grains, resulting in chaffy panicles.

The spotted stem borer female lays eggs in batches (50–100 eggs/batch), mostly on the basal leaves of sorghum plants. Eggs hatch in about 4–6 days. The larval period is mostly spent in the leaf whorls and stems, which lasts for 2 or 3 weeks. Pupation takes place in the stem and it takes about a week for adult emergence. Thus, the insect completes one life cycle in about a month and 3–4 overlapping generations in a crop season. In northern India, the larvae enter into diapause during the winter (December–March) in stalks and stubbles, however, in southern India where temperatures do not fall too low in winter, it remains active throughout the year. Besides sorghum, *C. partellus* infests maize, pearl millet, rice and sugar-cane, and also some wild plants, namely, *Sorghum halepense*, *S. verticilliflorum*, *Penisetum purpureum* and *Panicum maximum*.

HOST-PLANT RESISTANCE

An effective host-plant resistance programme must be based on a series of stepwise activities. It deals with the studies on the bio-ecology and behaviour in relation to crop and environment, development of an effective and reliable screening technique, reliable criteria for measuring resistance, identification of stable sources of resistance, and finally incorporation of resistance into elite agronomic backgrounds.

The earliest report on sorghum cultivars resistant to spotted stem borer was by Trehan and Butani (1949). Pant et al. (1961) and Swarup and Chaugale (1962) reported certain sorghum varieties to be relatively less damaged by the stem borer than others. A systematic screening of the world sorghum collection against stem borer was started in 1962 in India under the co-operative efforts of the Accelerated Hybrid Sorghum Project, ICAR; the Entomology Division of the Indian Agricultural Research Institute; and the Rockefeller Foundation (Singh et al., 1968; Pradhan, 1971; Jotwani, 1978). This work has been continued by the All India Coordinated Sorghum Improvement Project (AICSIP) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

SELECTION CRITERIA

The symptoms of stem borer attack in sorghum are leaf injury, dead heart formation, and stem and peduncle tunnelling. All these symptoms of attack are not necessarily related to the grain yield loss. Although leaf injury is the first indication of borer attack, it has no clear relationship with yield loss (Singh et al., 1983). Leaf injury score varies over time, because the plant recovers by producing new leaves. However, Singh and Sajjan (1982) observed a positive relationship between leaf injury score and grain yield loss in maize.

Stem tunnelling by borer is also not related to grain yield reduction in sorghum (Singh et al., 1983; Pathak and Olela, 1983; Taneja and Leuschner, 1985). However, the stem and peduncle damage can be critical under two situations: (i) breakage of stem or peduncle due to tunnelling and (ii) interference with nutrient supply by destroying the plant vascular system in the stalk, resulting in chaffy panicles. These two situations depend on the critical stage of crop at the time of infestation and borer density.

The most critical damage by the stem borer that results in significant grain yield loss is the formation of dead hearts resulting in low plant stand. Taneja and Leuschner (1985) observed highly significant and negative relationship between number of dead hearts and grain yield of sorghum (r = -0.9). Singh et al. (1968) indicated that per cent dead heart as parameter of stem borer attack was the most stable criterion for differentiating degrees of resistance. Therefore, resistance screening should be mainly based on dead hearts, followed by leaf injury and peduncle damage in grain sorghums. However, stem tunnelling should also be included for evaluation of fodder/forage sorghums. The following observations should be recorded for evaluation of borer resistance as decided during the International Workshop on Sorghum Stem Borers held at ICRISAT Center, 17–20 Oct. 1987.

Oviposition

To be taken 3, 4 and 5 weeks after crop emergence by recording number of plants, plants with egg masses and number of egg masses.

Leaf feeding

To be taken 1 week after artificial infestation, and 3 and 6 weeks under natural infestation by recording number of plants, plants showing leaf damage, and leaf damage score (1–9 scale): 1 = very few small pin holes on 1 or 2 leaves and 9 = severe leaf damage with big elongated holes on 4–5 leaves.

Dead hearts

To be taken 2–3 weeks after artificial infestation, and 4 and 6 weeks after crop emergence under natural infestation. Number of plants with borer dead hearts have to be recorded.

Harvest count

To be taken at harvest by recording number of healthy panicles, number of partially and complete chaffy panicles, internodes bored and holes in stem/peduncle, stem tunnelling (%) and grain weight.

SCREENING TECHNIQUES

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

The screening of sorghum cultivars for *C. partellus* resistance under artificial infestation has been carried out by rearing insects on natural (Singh et al., 1983) and synthetic diets (Chatterji et al., 1968; Dang et al., 1970; Laxminarayana and Soto, 1971; Siddiqui and Chatterji, 1972; Siddiqui et al., 1977; Sharma and Sarup, 1978; Seshu Reddy and Davies, 1979b). Taneja and Leuschner (1985) have described rearing, field infestation and evaluation methods for *C. partellus* resistance in sorghum.

IDENTIFICATION OF RESISTANT SOURCES

A number of sorghum germplasm lines and their derivatives have been reported to be resistant to spotted stem borer, *C. partellus* by various workers in India and elsewhere (Singh et al., 1968; Pradhan, 1971; Jotwani et al., 1979; Singh et al., 1980; Dalvi et al., 1983; Singh et al., 1983; Sharma et al., 1983; Taneja and Leuschner, 1985).

At ICRISAT, stem borer resistance work started in 1979 using artificial infestation (Seshu Reddy and Davies, 1979b). Later on, testing of the material was also started at Hisar under natural infestation. Out of nearly 16,000 germplasm accessions tested over several seasons, 72 genotypes have been found to be resistant (Table 1). Most of these sources are of Indian origin, however some genotypes are from Nigeria, USA, Sudan, Uganda, E. Germany, Pakistan, Yemen Arab Republic and Zimbabwe. Stability analysis of 61 resistant genotypes in terms of resistance were IS Nos. 5470, 5604, 8320 and 18573 (Taneja and Leuschner, 1985). The following 24 genotypes showed borer resistance with moderate level of stability: IS Nos. 1044, 2122, 2123, 2263, 2291, 2309, 2312, 4756, 4776, 5469, 5480, 5538, 5566, 5571, 5585, 10711, 12308, 13100, 13674, 18551, 18577, 18579, 18662 and SB 8530. The resistant sources identified at ICRISAT have also been tested in AICSIP trials and the following genotypes have shown promise during 1979–1985: IS Nos. 1082, 1119, 2123, 2195, 2205, 2309, 2312, 5469, 5604, 7224, 12308, 17966, 18551, 18573, 18577, 18578, 18579, 18580, 18584 and 18677.

MECHANISMS OF RESISTANCE

Although, ovipositional nonpreference, is not a strong resistance mechanism against stem borers, some cultivars have been reported to be less preferred by the *C. partellus* moths for egg laying (Rana and Murty, 1971; Lal and Pant, 1980a; Singh and Rana, 1984). The main mechanisms of resistance to *C. partellus* in sorghum have been reported to be antibiosis and tolerance (Pant et al., 1961; Kalode and Pant, 1967; Jotwani et al., 1971; Jotwani, 1976; Pathak and Olela, 1983; Singh and Rana, 1984). High mortality in larval stages (Jotwani et al., 1978; Lal and Pant, 1980b) have been reported in resistant cultivars. Dabrowski and Kidiavai (1983) have found that ovipositional nonpreference, reduced leaf feeding, low dead hearts and stem tunnelling, and tolerance to leaf and stem feeding contribute to resistance. Marked differences in the establishment of first instar larvae among resistant and susceptible cultivars have been reported by Chapman et al. (1983) and Bernays et al. (1983). Surface waxes on the leaf and stem probably affect the movement of first instar larvae, and some components act as feeding deterrents (Woodhead, 1983). Low sugar content (Swarup and Chaugale, 1962), amino acids, total

Table 1. Sources of resistance to spotted stem borer identified at ICRISAT, 1979–1986

Origin	IS Number
India	1044, 1082, 1119, 2195, 2205, 2375, 2376, 4273, 4546, 4637, 4756, 4757, 4776, 4881, 4981, 5075, 5253, 5429, 5469, 5470, 5480, 5538, 5566, 5571, 5585, 5604, 5619, 5622, 8320, 13100, 17742, 17745, 17747, 17750, 17948, 17966, 18333, 18366, 18662, 18667, 21969, 22039, 22091, 22145, 23411
Nigeria	7224, 18573, 18577, 18578, 18579, 18580,18584, 18585
USA	2122, 2123, 2146, 2168, 2269, 10711, 20643
Sudan	2263, 2291, 2309, 2312, 22507
Uganda	8811, 13674
E. Germany	24027
Ethiopia	18551
Pakistan	9608
YAR	23962
Zimbabwe	12308

(Source: Taneja and Leuschner, 1985).

sugars, tannins, total phenols, neutral detergent fiber (NDF), acid detergent fibre (ADF), lignins (Khurana and Verma, 1982 and 1983), and high silica content (Narwal, 1973) have also been reported to be associated with *C. partellus* resistance in sorghum. According to Taneja and Woodhead (1989), resistance to spotted stem borer is attributed to ovipositional non-preference and antibiosis. The major plant characters imparting resistance were early panicle initiation and rapid internode elongation. Studies on the behaviour of the stem borer on resistant genotypes have indicated a lower proportion of the first instar larval establishment in the leaf whorl, longer time interval between larval hatching and stem boring, and lower larval mass and survival rate. Resistant genotypes possess different combinations of these factors (Table 2).

GENETICS OF RESISTANCE

Rana and Murty (1971) and Haji (1984) reported that resistance to stem borer is polygenically inherited. They found that resistance to primary damage (leaf feeding) was governed by additive and additive x additive type of gene action, while additive and non-additive type gene action were important for secondary damage (stem tunnelling). Resistance to *Chilo partellus* for primary damage i.e. % dead hearts was governed by both additive and non additive type of gene actions while for secondary damage

Table 2. Factors associated with spotted stem borer resistance in sorghum rainy season, ICRISAT Center, 1985

Genotype	Days for PI*	Shoot length (cm) 28 DAI+	% Larvae recovered in: Whorl I DAI+	% Larvae recovered in: Stem 10 DAI+	Larval weight (mg) 21 DAI+	Pupal weight (males) (mg)	Insect recovery (%) 28 DAI+
IS 1044	53	15	54	9	92	109	28
IS 2123	33	21	54	7	93	110	15
IS 2205	39	13	57	16	103	101	9
IS 2269	33	11	40	17	127	107	22
IS 2309	30	14	53	35	85	94	8
IS 4776	40	9	44	10	109	99	20
IS 5469	33	26	57	11	98	107	25
IS 5538	56	6	56	12	99	100	22
IS 5585	33	19	41	9	85	103	15
IS 12308	17	50	25	31	89	95	21
IS 13100	25	46	39	7	88	89	18
IS 13674	28	24	64	24	101	100	26
IS 18333	53	10	58	21	85	103	10
IS 18551	38	12	62	10	109	89	23
IS 18573	56	6	77	10	140	95	20
IS 18577	51	8	41	21	84	98	21
IS 18579	40	8	42	13	92	101	15
IS 18580	40	11	57	12	99	109	19
ICSV 1	33	10	51	17	115	112	20
CSH 1	28	9	42	13	94	97	24
Mean			15	15	99	101	19
S.E.			±6.5	±4.3	±6.5	±6.5	±4.5
CV (%)			18	45	9	8	33

*PI = Panicle initiation.
+DAI = Days after infestation.

i.e. stem tunnelling was governed predominantly by additive gene action (Kulkarni and Murty, 1981; Pathak and Olela, 1983). It was also noted that the inheritance pattern of primary and secondary damage were different. The epistatic gene effects were more pronounced under artificial borer infestation (Haji, 1984). He also noticed that under natural infestation, resistance was controlled by additive and dominant major gene effects. Cytoplasmic influences appeared to be present, which may play an important rôle for the inheritance of stem borer resistance.

BREEDING FOR RESISTANCE

The quantitative nature of inheritance of resistance to stem borers makes the breeding task difficult because both resistance and yields are quantitative traits. Starks and Dogget (1970) described the breeding methodology to incorporate resistance to stem borer in sorghum. They suggested that an effective method of developing cultivars possessing resistance to *C. partellus* should involve population breeding. All plants in a composite population or the S_1 lines from a composite population should be infested with egg masses 20 days after plant emergence. The crop should then be evaluated for yield using recurrent selection.

Both pedigree and population breeding methods have been used to incorporate resistance into good agronomic backgrounds. Pedigree breeding has been used at ICRISAT Center as a short term approach. The use of broad-based, random mating pest resistant populations is a long term approach for breeding sorghums resistant to stem borers (Agrawal and House, 1982).

Breeding for stem borer resistance started in 1966 in India, when a number of resistant parents were included in the breeding programme (Pradhan, 1971). Since then a number of identified sources of resistance have been used by crossing with dwarf exotic types that were highly susceptible to borer, but were agronomically desirable parents. A list of promising derivatives and their parents have been given in Table 3. BP 53, a borer resistant parent has produced a good number of derivatives particularly when crossed with IS 2954. Other good resistant sources have been Aispuri, M 35-1 and Karad Local. Stem borer resistant sources have also been used in developing high yielding varieties and hybrids in AICSIP (Table 4).

Table 3. Most productive spotted stem borer resistant source parents and their promising derivatives

Resistant source	Other parent	Promising derivatives
BP 53	IS 2954	Selection Nos. 165, 169, 174, 177, 300, 364, 384, 434, 446, 468, D Nos. 124, 167, 168, 172, 175, 244, 259, 350, 358, 365, 366, 367, 609, DU Nos. 98, 135, 245, 293, P Nos. 108, 151, 235, U 376
	IS 84	Selection No. 602
	IS 3691	DU 291, U 369
	CK 60B	E 302, U Nos. 37, 218, 35, 373
	IS 3954	E 303
Aispuri	IS 3922	Selection Nos. 829, 835, D832
M 35-1	IS 539	DU 19
	IS 531	U 83
IS 4906	CK 60A	P 37
IS 5837	CK 60A	P 82
IS 10327	CK 60A	P 90

(Source : AICSIP Progress Reports, 1972–1985).

Table 4. Spotted stem borer resistant sources utilized in AICSIP

Resistant source	Genotype
Aispuri and its derivatives	CSV 5, SPV Nos. 14, 58, 80, 96, 99, 101, 102, 104, 105, 107, 108, 110, 115, 168, 265, 270, 271, 374, 378, 475, 513, 516, 716, 727, 743, 744, CSH 7R
IS 3541 (CS 3541)	CSV 4, SPV Nos. 60, 104, 122,126, 245, 292, 297, 303, 312, 346, 351, 354, 371, 386, 741
M 35-1 (IS 1054)	CSV 7R, SPV Nos. 19, 270, 364, 440, 510, 727
GM 1-5	SPV Nos. 9, 33, 34, 183, 268
Karad Local	CSV Nos. 2, 6, SPV Nos. 8, 13, 17
BP 53 (IS 1055)	CSV 3, 26, 70, 513, 688
PD 3-1	CSH 8R

(Source: AICSIP Progress Reports, 1975–1985).

Stem borer resistance programme was initiated at ICRISAT in 1977 with the following objectives: (1) to strengthen the sources of resistance by accumulating diverse genes from different sources, (2) to transfer resistance into improved and adapted cultivars, and (3) to generate basic genetic information for formulating an effective breeding programme.

To meet the first objective, a population breeding approach was chosen. A shoot pest (shootfly and stem borer) sorghum population (ICSP 118) was developed using ms_3 and ms_7 male-sterility genes. So far, a total of 175 genotypes (85 stem borer resistant sources and their derivatives, 76 shootfly resistant sources and their derivatives and 14 elite genotypes) have been fed into this population. After six cycles of random mating under borer infested condition, this population was evaluated for resistance to stem borers under natural infestation at Hisar, and under artificial infestation at ICRISAT Center during the 1987 rainy season. It was noticed that there was no significant decrease in the percentage of stem borer dead hearts from Cycle 1 to 3 and a slight decrease from Cycle 4 to 6 under natural infestation, but there was an increase in the percentage from Cycle 1 to 6 under artificial infestation. The percentage of stem borer dead hearts of ICSP 118 in Cycle 6 was 63.3% under natural infestation compared to 16.6% for IS 2205

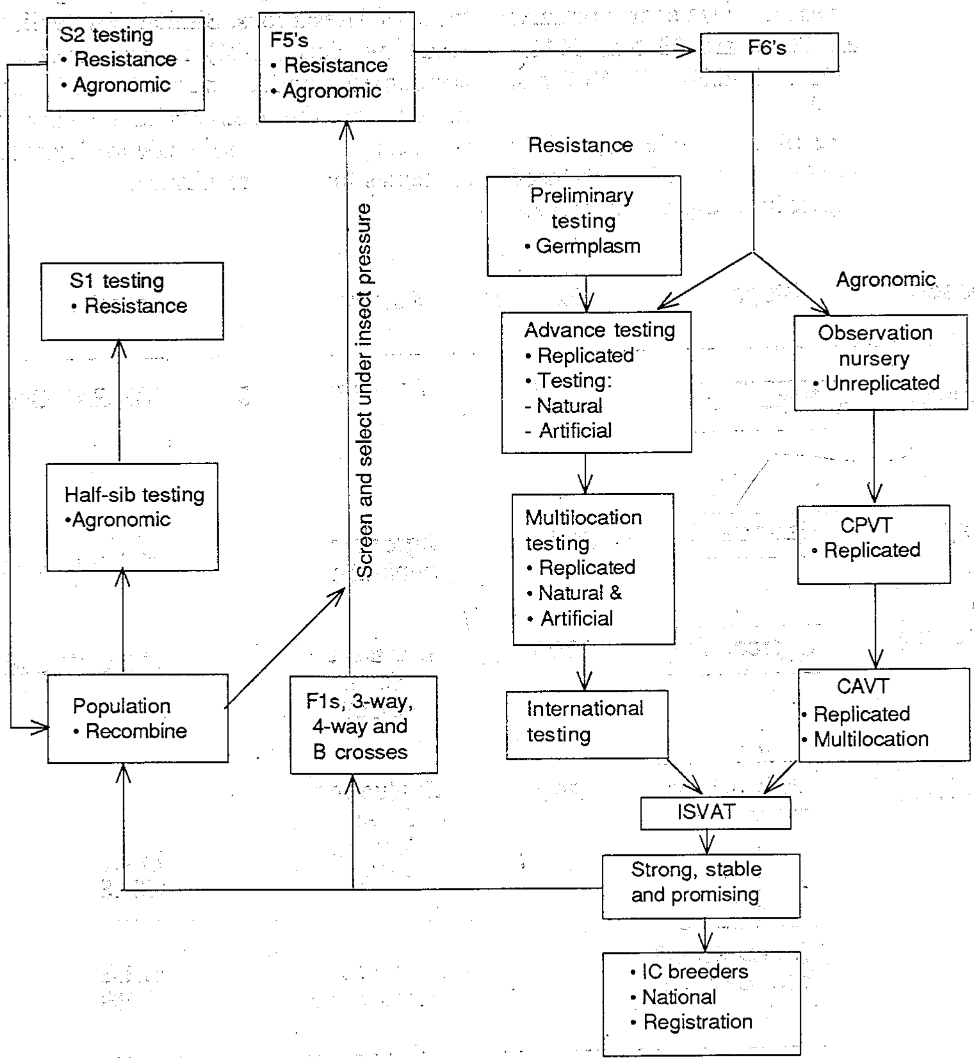


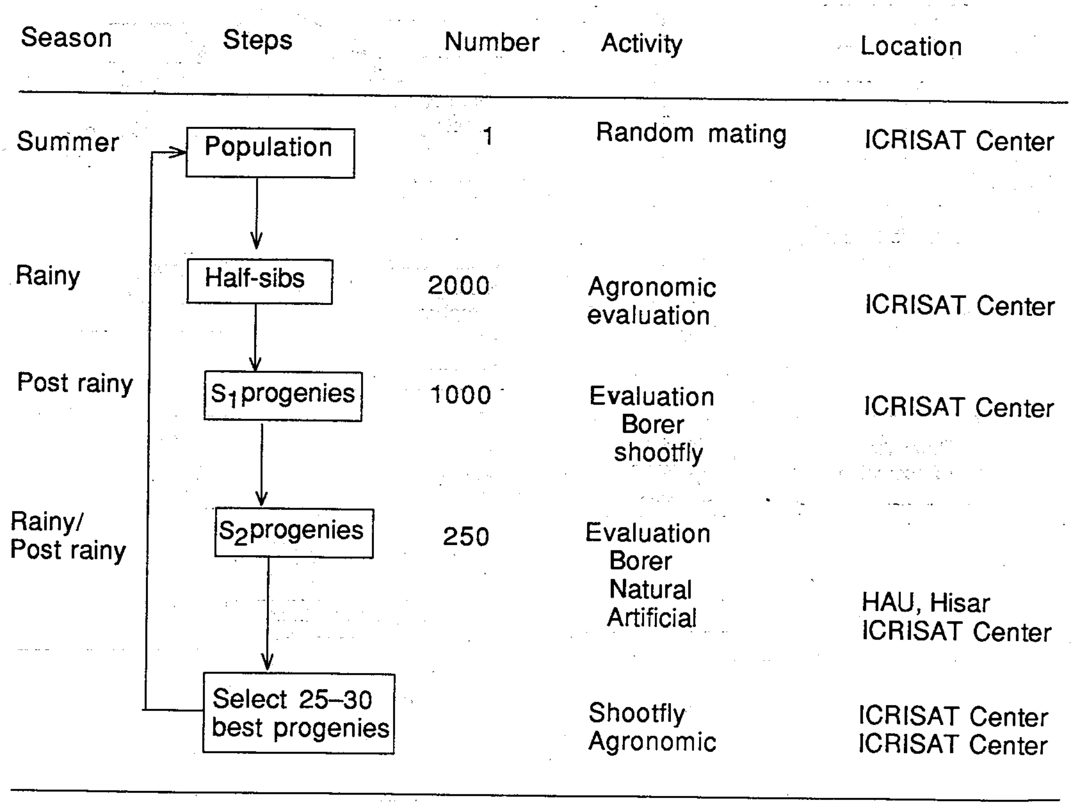
Fig. 1. Screening and breeding for insect pests resistance.

and 96.1% for CSH 1. We believe that mass selection for stem borer resistance was perhaps not effective and therefore decided to use the S_2 recurrent selection method in an attempt to improve stem borer resistance in this population (ICSP 118). This population now is being advanced by using S_2 cyclic recurrent selection as outlined in Fig. 2. The first S_2 cycle is completed.

Transfer of resistance into improved genotypes was initiated through pedigree breeding approach (Fig. 1). A number of resistant sources have been used (Table 5) and the most productive ones are IS Nos 1082, 3962, 5604 and 5622. The most promising derivatives are PB Nos 10365-1, 10337-1, 10445, 10446, 12687-1, 12687-8, 12689-1 and 12693-2. A number of shootfly resistant lines have also shown promise against stem borer. These are PS Nos 14413, 14454, 18527, 18601-2, 18822-4, 19663-2 and 21113-1.

The performance of 135 fertile derivatives (S_2) of the shoot pest population and 130 advanced progenies from pedigree breeding were compared for stem borer resistance at ICRISAT Center under artificial infestation and at Hisar under natural infestation. In general, the population derivatives had better levels of resistance under both types of infestations compared to progenies derived through pedigree breeding. Population derivatives (6%) showed a good level of borer resistance as compared to only 0.6% of the pedigree progenies (Fig. 3).

Experience over the years shows little correspondence between the selections made for stem borer resistance under natural and artificial infested conditions. This is perhaps due to the differential expression of resistance mechanisms in these two types of infestations. Some mechanism(s) may not be operating under both types of infestations. Similar observations were made by Haji (1984) in his genetic studies conducted under natural and artificial infestations. This needs critical view and the input of all the participants to decide the future breeding strategies for borer resistance.



HAU: Haryana Agricultural University

ICRISAT: International Crops Research Institute for the Semi-Arid Tropics

Fig. 2. Proposed scheme for recurrent selection.

Table 5. Stem borer resistant sources utilized at ICRISAT and their promising derivatives

Resistant source	Derived genotype
IS 1082	PS 14413, PB 10791, PB 12446
IS 2312	PS 19338, PB 12693
IS 3962	PS 18601, PS 18822, PB 12611, PB 12631
IS 5604	PS Nos. 18527, 19336, 27623 PB Nos. 10365, 12040, 12497, 12687, 12689
IS 5622	PS Nos. 14454, 19295, 19663, 21113, 30768, 30769, 31376, PB Nos. 10337, 10445, 10446
IS 13681	PB 12049, PB 12050
RS/R Pop.	PB Nos. 12034, 12037, 12052, PS 28060
Shoot pest population	PB Nos. 12339, 12342, 12346, 12380, 12387, 12413

(Source: ICRISAT, unpublished).

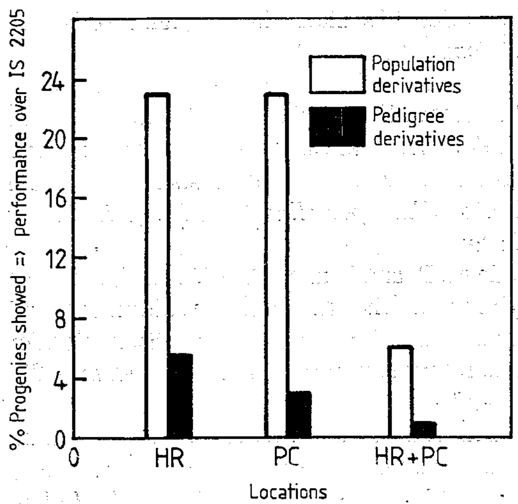


Fig. 3. Performance of pedigree and population derivatives against stem borer.

SUGGESTIONS

Although considerable work on host plant resistance to stem borer has been carried out in India and elsewhere, there is still scope for further improvement. The following aspects need intensive improvement efforts:

(1) Screening techniques:

(a) Natural infestation at specific locations need careful examination of borer population dynamics, planting time, use of overwintering population, fertilizers etc.

(b) Feasibility of artificial infestation should be worked out according to the facilities and support available.

(c) Whether breeding should be carried out under natural or artificial and/or under both types of borer infestations.

(2) Dead hearts as a selection criterion be given prime consideration for the selection of resistant types. Stem tunnelling and leaf injury parameters be used as secondary parameters.

(3) The overall yield potential of the genotypes under insect pressure (tolerance) be given weightage, while breeding for borer resistance.

(4) Cultivars with multiple resistance according to the need of the concerned region be developed if possible.

(5) Generate more genetic information on individual resistance factors/mechanisms/ resistance *per se*.

(6) Develop resistant parents (male and female both) for the development of resistant hybrids.

FUTURE PLANS

(1) Continue to improve the resistant population to shoot pests both stem borers and shootfly.

(2) Continue to develop high-yielding cultivars with better resistance/tolerance.

(3) Find resistant parents for developing resistant hybrids.

(4) Generate more genetic information on individual resistance mechanisms/associated factors and resistance *per se*.

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