GROUNDNUT ENTOMOLOGY
PROGRESS REPORT 2
PROJECT GENT-3

GROUNDNUT ENTOMOLOGY

STUDIES ON ARTHROPOD VECTORS OF GROUNDNUT VIRUSES, THEIR ECOLOGY AND CONTROL

REPORT OF WORK DONE FROM 1978 TO 1983

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PART I

Bud Necrosis Disease : Distribution, Economic importance, Epidemiology and Control

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PART I

Bud Necrosis Disease : Distribution, Economic importance, Epidemiology and Control

1. Introduction:

Bud necrosis disease (BND) of groundnut is caused by tomato spotted wilt virus (TSWV) and is economically important in India on groundnut and other crop plants such as tomato, mungbean, urdbean, peas, and beans. The casual virus was identified by virology group at ICRISAT in 1974. Detailed investigations were conducted from 1978-1983 to understand the epidemiology of BND in relation to groundnut and formulate measures of control. In this report relevant data and conclusions drawn therefrom are given along with the suggestions for additional research needs.

The data presented in this report are based on the studies at ICRISAT research farm and the conclusions drawn are thus applicable to ICRISAT conditions. Before general recommendations can be made for other regions, such studies need to be carried out there.

2. Distribution and economic importance:

Bud necrosis disease of groundnut is widely distributed in India. Several roving surveys of groundnut growing areas were carried out to record the BND incidence. In a given field, 1 sq.m. quadrants were used to demarcate sampling area, and numbers of healthy and infected

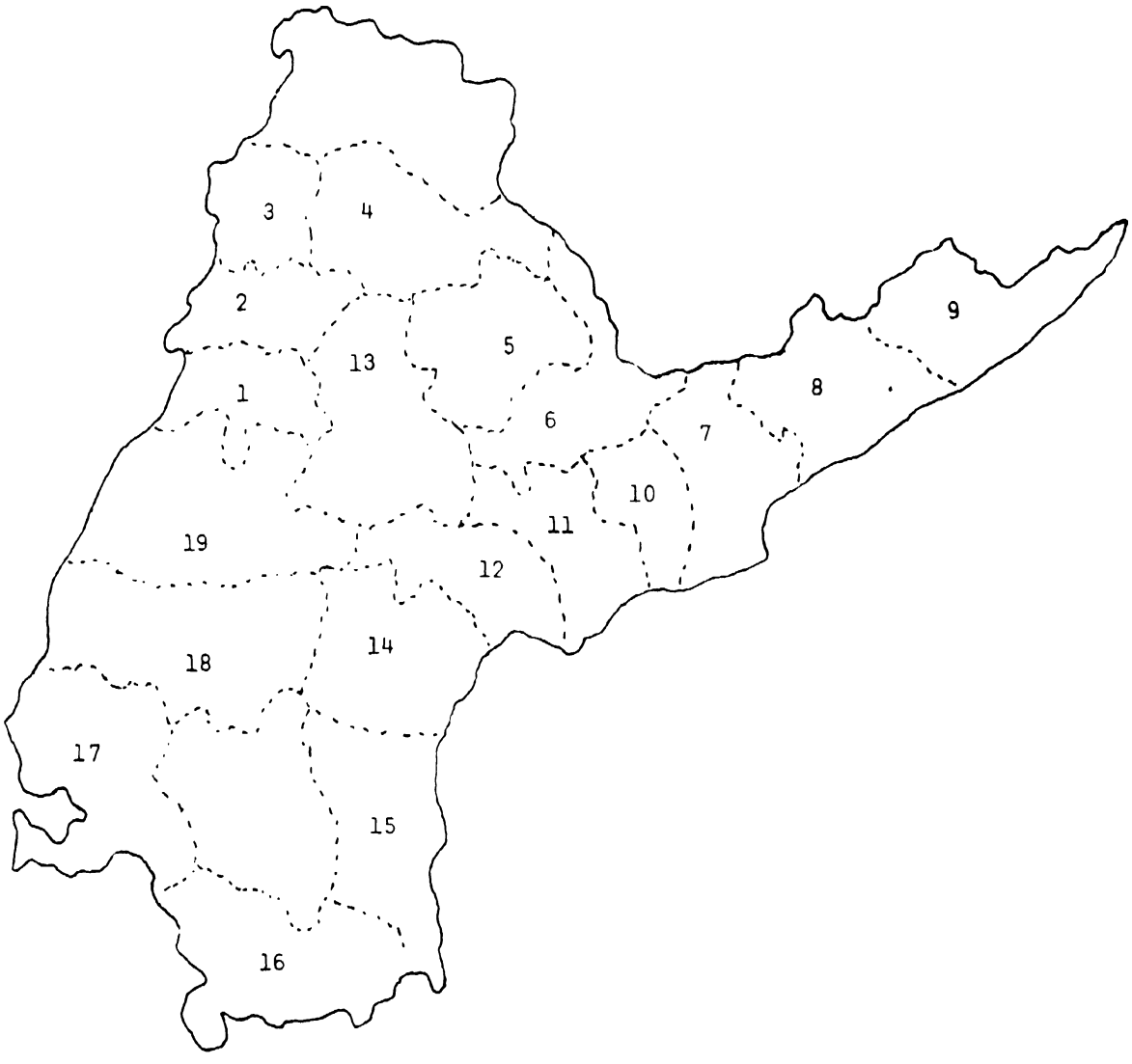
plants were recorded in such quadrants at different locations. The approximate age when plants were infected was also recorded. The data on variety, sowing date, plant density and pest control measures adopted by farmers were recorded. Surveys were carried out in the rainy season of 1980 in the States of Maharashtra, Gujarat, Rajasthan and Madhya Pradesh and in the postrainy season of 1980-81 in Andhra Pradesh and Karnataka States.

Andhra Pradesh (Fig. 1): A total of 33 fields were visited in various districts in February 1981 and over 60 fields in March 1982. In the 1981 surveys the BND incidence ranged from 0-10% in Kurnool, 2-25% in Anantapur, <1% in Chittoor and Nellore, 0-15% in Prakasham, <1% in Guntur and 0-20% in Nalgonda districts. In 1982 surveys, the BND incidence was recorded at 5-60% in Nizamabad, 33% in Karimnagar, 1-10% in Khammam, 10-60% in Guntur, <5-15% in Prakasam, 0-10% in Nellore, 1-10% in Chittoor, 5-33% in Anantapur, 0-5% in Kurnool, 1-30% in Mahboobnagar and 20-60% in Nalgonda districts. The BND incidence was high in crops sown in the month of December than those sown in either November or January. In Nizamabad District groundnut is usually sown in the month of January to avoid high BND incidence in December sown crops. The BND incidence was higher in fields with less than optimum plant population. Except for Nellore, Chittoor and coastal districts of West Godavari, Visakhapatnam and Srikakulam BND is economically important in other districts of Andhra Pradesh.

Surveys carried out in February 1979 in 15 districts revealed high incidence of BND in Nalgonda, Guntur, Krishna, and Hyderabad districts. BND incidence was negligible in West Godavari, East

Fig. 1. Bud necrosis disease incidence in groundnut

Andhra Pradesh (Postrainy 1982-83)



Legend

No.	District	BND (%
1	Hyderabad	50-90%
2	Medak	NS
3	Nizamabad	10-60
4	Karimnagar	1-10
5	Warangal	NS
6	Khammam	1-10
7	East Godavari	1-5
8	Visakhapatnam	1-5
9	Srikakulam	1-2
10	N.S.	

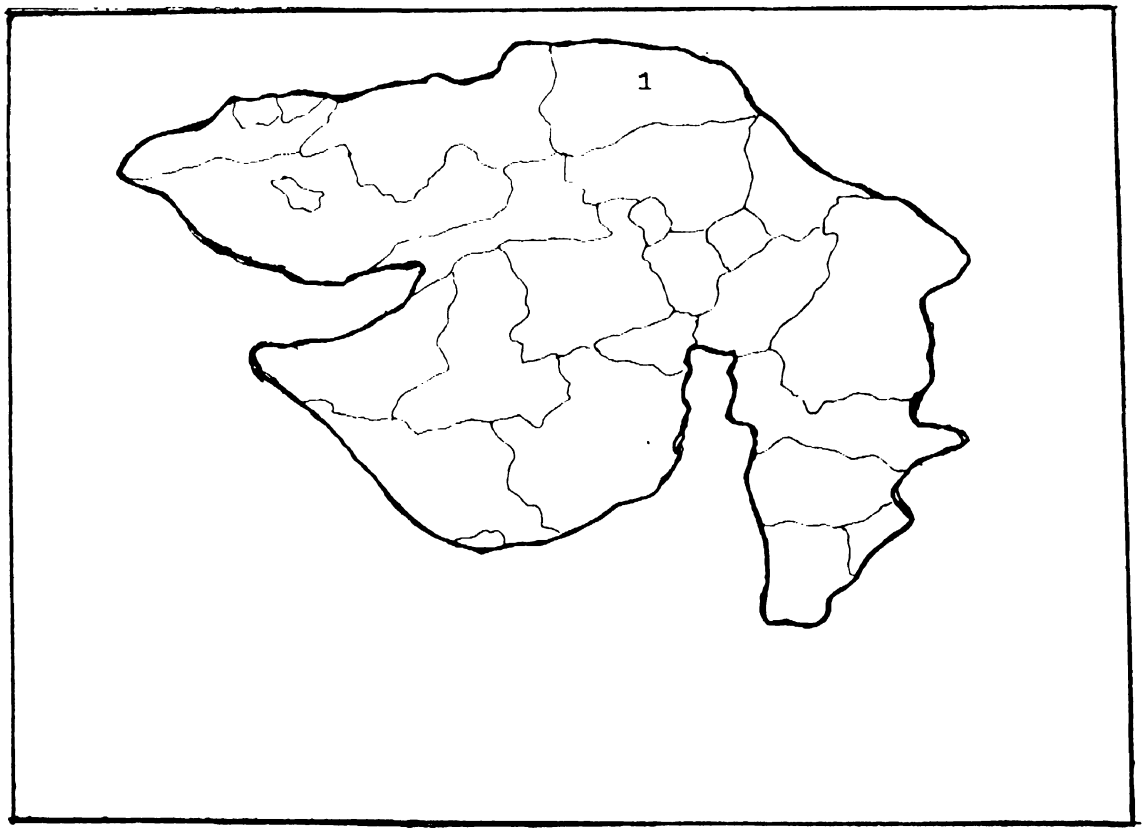
No	District	BND (%)
11	Krishna	5-60
12	Guntur	10-60
13	Nalgonda	20-60
14	Prakasaam	0-10
15	Nellore	0-10
16	Chittoor	0-10
17	Anantapur	5-30
18	Kurnool	0-15
19	Mahboobnagar	1-30

Godavari, Visakhapatnam, Srikakulam, Nellore and Chittoor districts.

During our surveys, we noticed large scale mortality of seedlings from soil-borne diseases which was wrongly attributed to bud necrosis disease. Such seedling mortality occurred in groundnut grown on heavy soils during the months of February and March particularly after each irrigation. This seedling mortality was often attributed to BND. Therefore the disease symptoms of BND were shown to extension staff to clearly distinguish between mortality caused by BND infection and that from other pathogens. It was also emphasized that large scale seedling mortality from soil-borne diseases resulted in sparse plant stand and crops in such fields incurred more BND than in fields with uniform plant stand at optimum plant density.

Gujarat: (Fig. 2) A total of 14 fields were surveyed in Sabarkantha district. The BND incidence was high (over 50%) at Talod research farm and some fields in Modasa village but much lower in fields in other areas. In recent years due to severe damage from white grubs pests in this district, more and more farmers have shifted from rainfed to irrigated groundnut. The BND incidence has increased in recent years. During our previous surveys in September 1978 we observed less than 1% BND incidence in a few fields in this area but now BND is widely distributed. Other than summer groundnut, crops such as mungbean and cowpea are also increasingly grown. These crop plants are hosts of BND and its thrips vector. With more and more areas in Gujarat coming under irrigated groundnut (25,000 ha in 1978, 200,000 ha in 1983), BND incidence is likely to increase further in this State.

Fig. 2. Bud necrosis disease incidence in groundnut
Gujarat state
(Postrainy season, 1981)



No.	District	BND incidence (%)
1	Sabarkantha	0-50

Karnataka: (Fig. 3) A total of 34 fields in 6 districts of Karnataka were surveyed in March 1981. In Bijapur district the BND incidence was negligible in both poorly managed and well managed fields. In Belgaum district the BND incidence ranged from 1-15%, the higher disease incidence occurring in gappy fields. In north Canara district, the plant stand was unusually high (3,00,000 - 5,00,000 plants/ha). The BND incidence was negligible. In Raichur district, the BND incidence ranged from 1-8% in farmers' fields while at the Agricultural Research Farm it was between 40% to 50 %

Madhya Pradesh: (Fig. 4) Major groundnut growing areas are in Indore and Nimar districts. There were isolated fields of groundnut, while other crops mainly sorghum, cotton, pigeonpea, mungbean and soybean, were more common. BND incidence was negligible in 12 fields we visited in Indore district. An earlier visit in the 1979 rainy season in Nimar district also showed BND incidence to be negligible. In all these areas only a single crop of groundnut and other legumes is taken in the rainy season.

Maharashtra: (Fig.5) A total of 14 fields were surveyed in the Dhulia district. The BND incidence ranged between 30-60% in several fields at Nardana and Gorana taluks. The BND has only recently become important in this area apparently because of recent increases in irrigated summer groundnuts and other legumes which may have resulted in availability of susceptible hosts throughout the year for multiplication of BND reservoirs and its vectors. A similar situation was observed in Jalgaon district where BND has recently become important. We have not surveyed Parbhani district but from here also,

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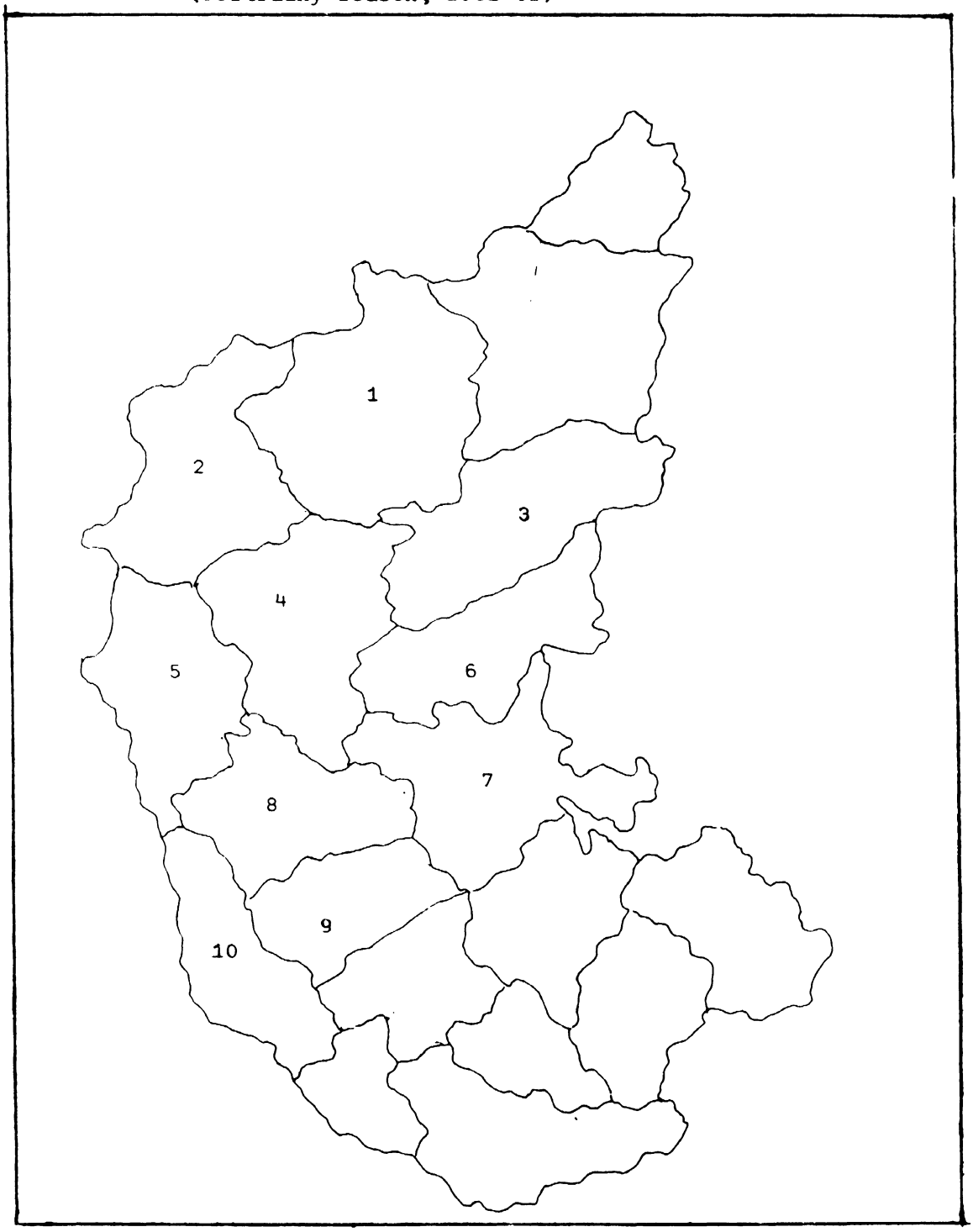
Fig. 3. Bud necrosis disease incidence in groundnut

Karnataka State

(Postrainy season, 1981-82)



No.	District	BND incidence (%)	No.	District	BND inci
1	Bijapur	1-2	6	Bellary	1-4
2	Belgaum	1-6	7	Chitradurga	0-2
3	Raichur	1-50	8	Shimoga	0-1
4	Dharwad	1-2	9	Chicmagalur	0-1
5	North Canara	0-1	10	South Canara	0-1

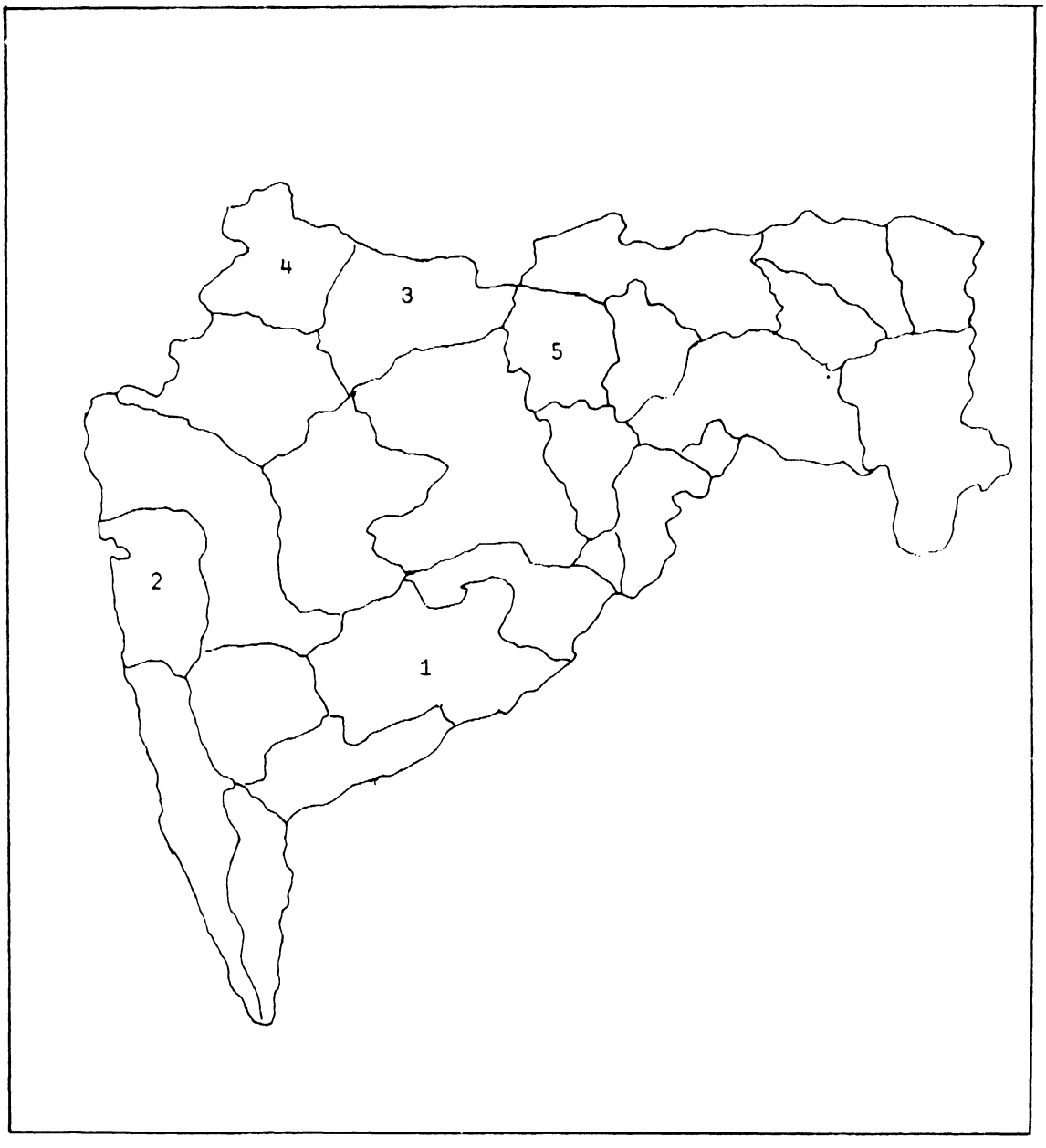
Fig.4. Bud necrosis disease incidence in groundnut

Madhya Pradesh State

(Rainy season, 1981)

No.	District	BND incidence (%)
1	Indore	0-5

Fig. 5. Bud necrosis disease incidence in groundnut
Maharashtra State
(Rainy season, 1981)



No.	District	BND incidence (%)
1	Sholapur	0-1
2.	Pune	5-10
3.	Jalagaon	10-50
4.	Dhulia	10-50
5.	Parbhani	10-20

high incidence of BND has been reported in recent years.

Rajasthan: (Fig. 6) A total of 8 fields were surveyed in this State in Udaipur and Jaipur districts. BND incidence was sporadic. In one field near Chittaurgarh, the BND incidence was about 30%. In other fields in this area, it was less than 2%. In Lalsot area on Durgapura Research farm, the BND incidence was about 30% and in 2 fields near Bharatpur it was also about 20%. In other fields, it was less than 5%. In the district of Bikaner, under Rajasthan canal and Gang-Bhakra canal projects, over 3,000 ha were planted under irrigation. BND may be of potential importance in this area.

Uttar Pradesh: Only a few districts in western Uttar Pradesh were surveyed in 1979 by Drs. D.V.R. Reddy and D. McDonald and in 1980 by us. During 1979, the disease incidence was extremely high (over 50%) while in 1980 it was negligible. Very heavy rainfall (1100 mm above normal) in 1980 may have caused reduction in BND incidence.

Conclusions:

Accentuation of BND problem in areas previously free from this disease has probably resulted from changes in cropping pattern brought about by the availability of irrigation. The disease has become important in Andhra Pradesh, Maharashtra, Rajasthan and Gujarat states after adoption of double cropping of groundnut and other susceptible legumes and solanaceous crops. The disease is particularly devastating in late sown crops and in fields with less than optimum plant stand. The incidence and spread of this disease is likely to

Fig. 6. Bud necrosis disease incidence in groundnut
Rajasthan State
Rainy season, 1981

District	BND incidence (%)
Jaipur	10-50
Chittaurgarh	1-50

increase as more and more groundnut and other susceptible crop are cultivated under irrigation. A similar effect can result from perpetuation of weed hosts under irrigation. This factor needs assessment.

In many areas seedling mortality resulting from soil-borne fungi was confused with that resulting from BND. This seedling mortality occurred in the months from February to April after each irrigation. This resulted in sparse plant stand and resultant high BND incidence.

The groundnut crops in Orissa, Tamilnadu, Bihar, Uttar Pradesh, Punjab and Hissar and parts of Maharashtra and Gujarat have not been surveyed so far. It will be worthwhile to determine yield losses caused by BND in these areas.

3. Yield losses caused by bud necrosis disease:

3.1. Individual plants:

Effect of BND infection on yield of individual plants was estimated from field infected plants. A large plot of groundnut cv TMV-2 was sown on RPl alfisol field at ICRISAT Center in the 1979-80 postrainy season and was divided into 4 equal parts to form 4 replications. Observations were recorded weekly and individual plants were tagged with the date of infection and they were harvested separately. Healthy plants were also harvested separately and pod yields of diseased and healthy plants were compared. The yield loss was estimated and is given in the Table 1.

Table 1: Yield loss from BND in relation to age of plants when infected (1981 postrainy season)

Age (days) of plants when symptoms were visible	Mean No. of plants	Pod yield (g) per plant	% loss	Kernel yield (g) per plant	% loss
35	68	0.00	100.0	0.00	100.0
42	170	0.00	100.0	0.00	100.0
49	262	0.16	99.6	0.07	99.7
56	359	4.96	87.0	2.70	89.4
64	411	11.40	70.2	6.33	75.1
73	414	20.37	46.7	12.42	51.3
82	396	25.04	34.7	15.66	38.6
86	383	27.09	29.2	17.73	30.4
94	424	33.10	13.6	22.19	12.9
Healthy	772	38.30	-	25.49	-
SE ±		0.67		0.57	
CV %		8.30		11.15	

It is clear from the Table 1 and Fig. 7 that almost total loss of yield occurred if the plants were infected young, i.e. up to the first 50 days comprising vegetative and flowering stages. Thereafter, the losses progressively decreased with delayed infection but some yield loss occured even with late infection. The regression of age of plants at infection on yield shown in Figure 8 clearly shows the high positive correlation for both pod (r=0.96) and kernel yield (r = 0.95).

For yield loss estimation, 90% loss in pod yield of early infected plants and 50% loss in late infected plants are realistic estimates. These estimates were used when we assessed losses in farmers fields.

Fig.7. Pod yield of groundnut plants in relation to the age at infection from bud necrosis disease
(Postrainy season, 1978-79)

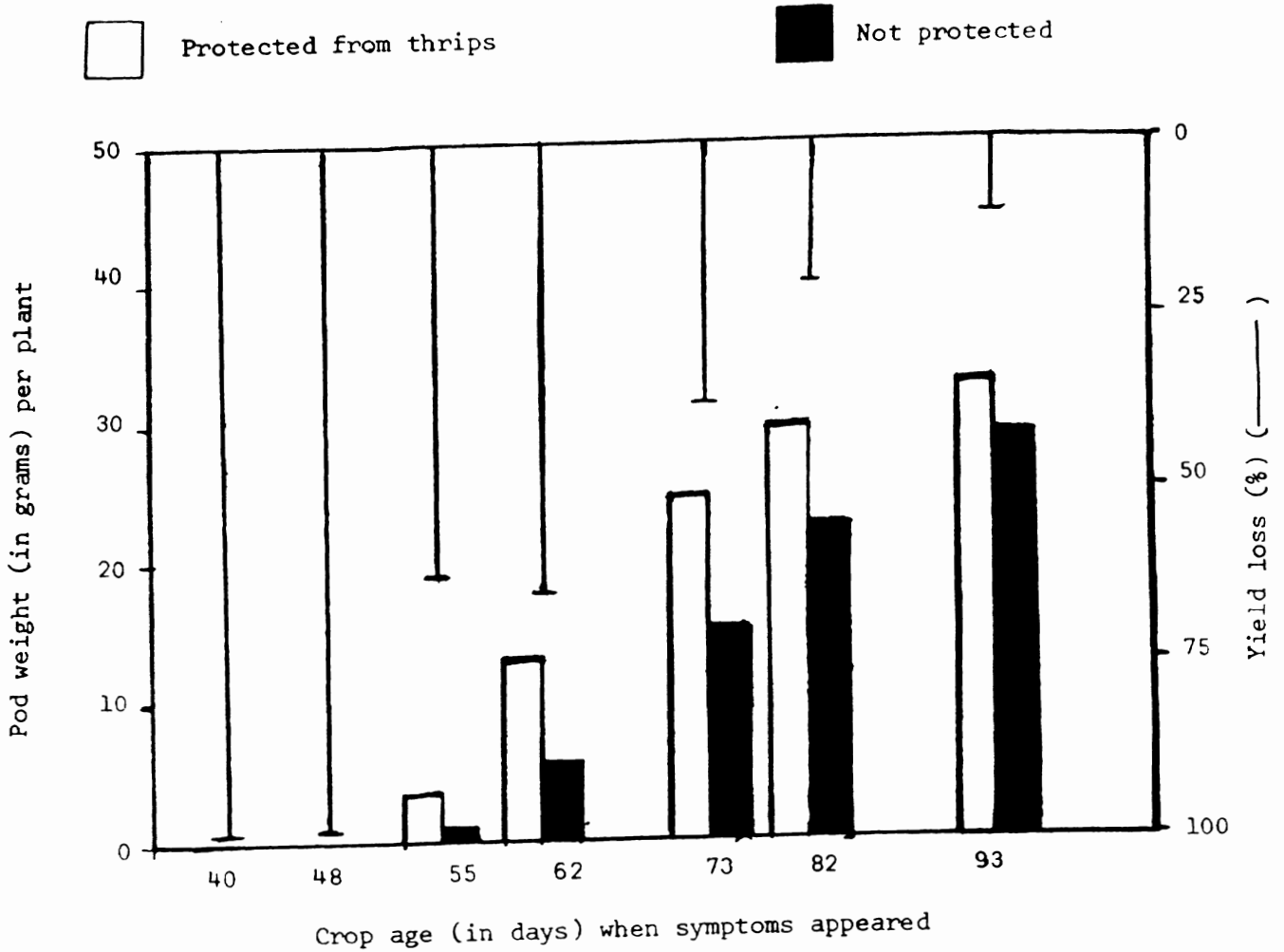
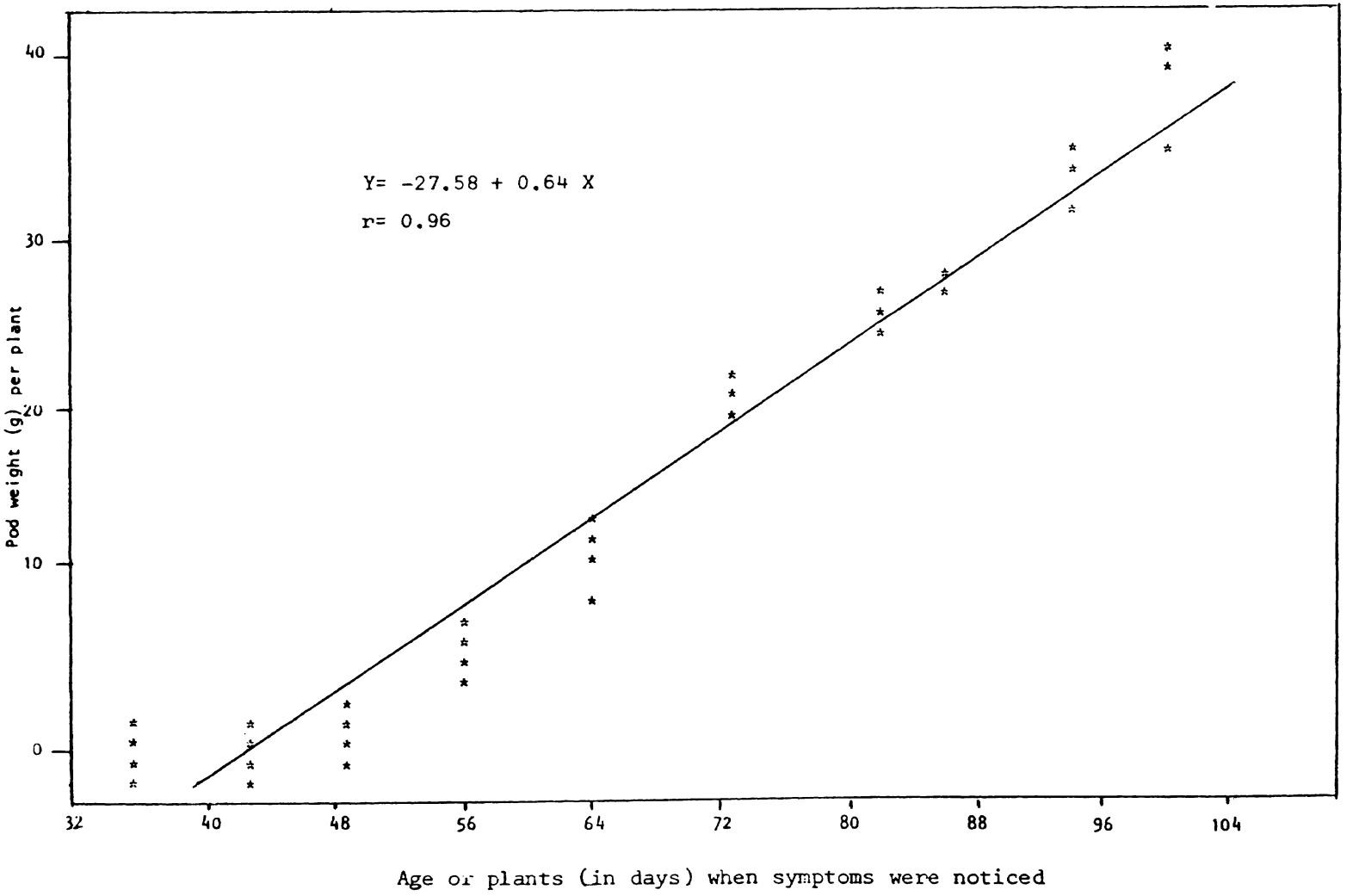


Fig.8. POD YIELD (g) / PLANT OF GROUNDNUT PLANTS INFECTED AT DIFFERENT AGES



The main adverse effect of BND appears to be on flower production. The flower production stops abruptly irrespective of plant age at infection after BND symptoms become noticeable on plants. With delayed infection, more flowers are produced and pegs form pods. The effect of BND on flower production recorded from 50 plants is given in Table 2.

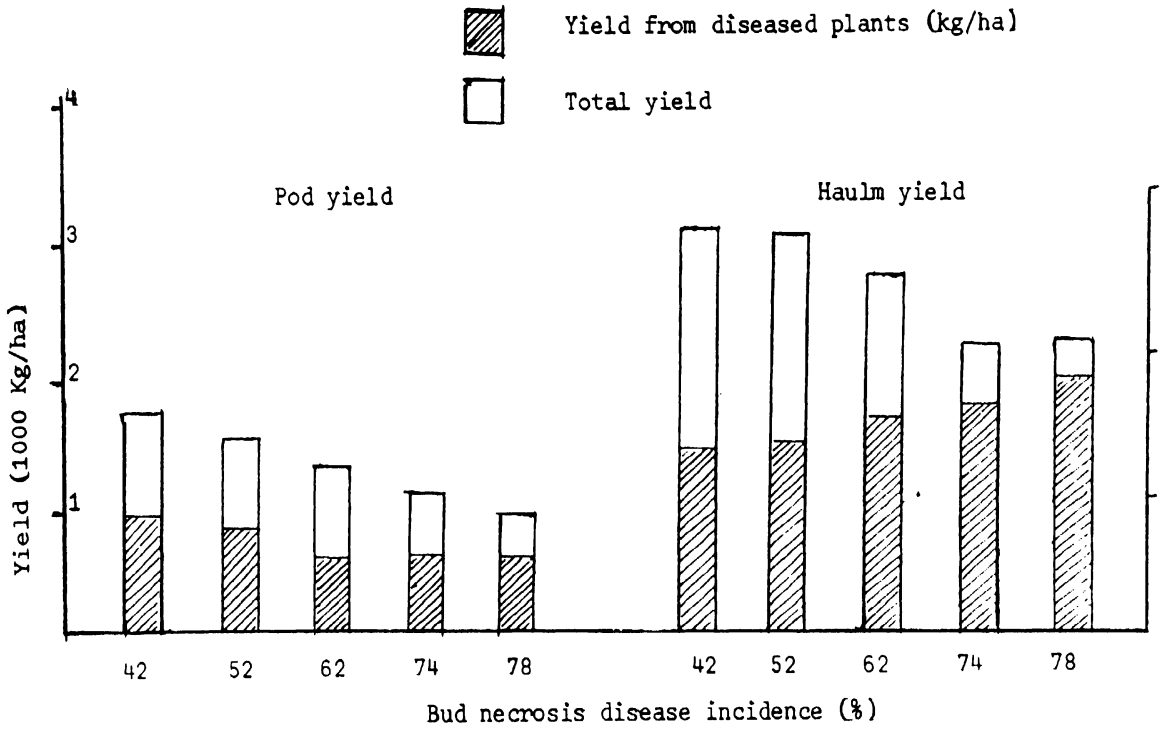
Table 2: Effect of BND on flower production in TMV-2 groundnut

Age of plants when BND symptoms appeared (days after sowing)	Number of flowers produced per plant	
	Before infection	After infection
23-25	1.0	0.0
26-35	34.0	2.4
36-45	23.0	0.0
45-55	37.2	6.0
56-65	47.0	0.5
66-75	72.0	4.7
No infection	.80	

3.2. In crops:

A replicated trial was conducted in the 1982-83 postrainy season in RP2 alfisol field at ICRISAT Center to determine the effects of different levels of BND incidence on crop yield. Cultivar TMV-2 was sown on ridges 75 cm apart with 15 cm between plant spacing in 110 sq.m. plots. BND incidence was influenced by insecticidal treatment by varying frequency and concentration of dimethoate application (Fig. 9). The crop was protected from fungal foliar diseases by 2 applications of Bavistin + dithane M-45. Since no other major insect infestation developed, insecticidal protection was not given. BND incidence was recorded weekly from 26th February till March 3rd, and a final record was taken on 20th April.

Fig. 9. Pod yield of groundnut in relation to different levels of bud necrosis disease incidence (Postrainy season, 1982-83)



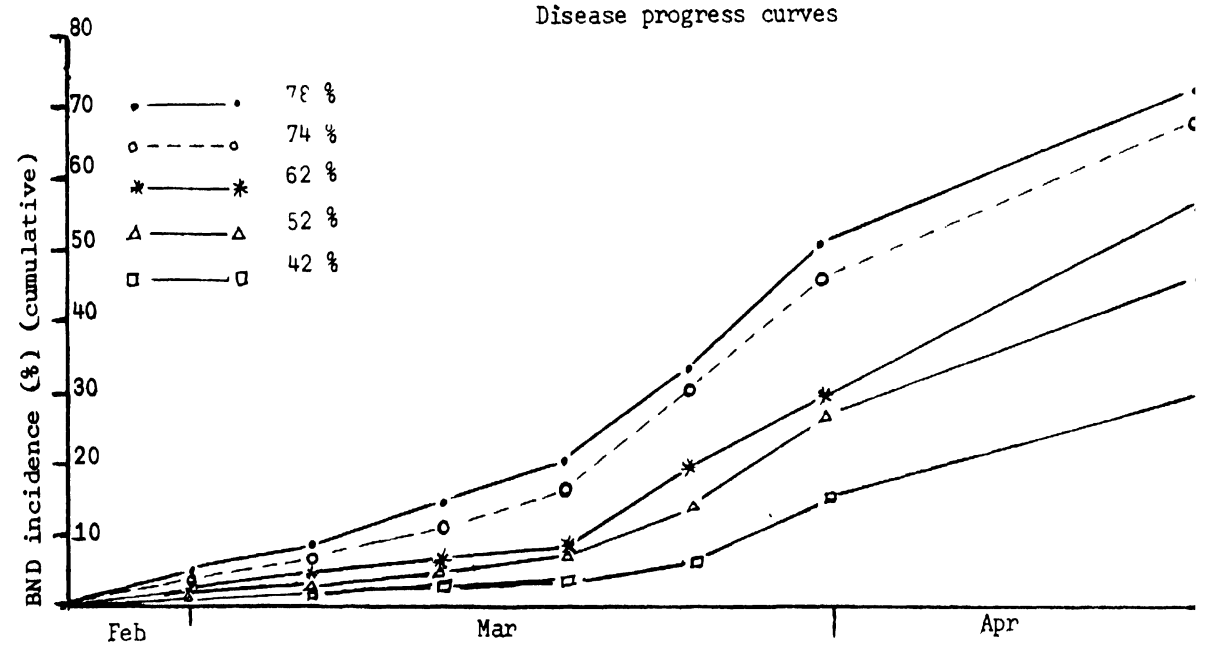
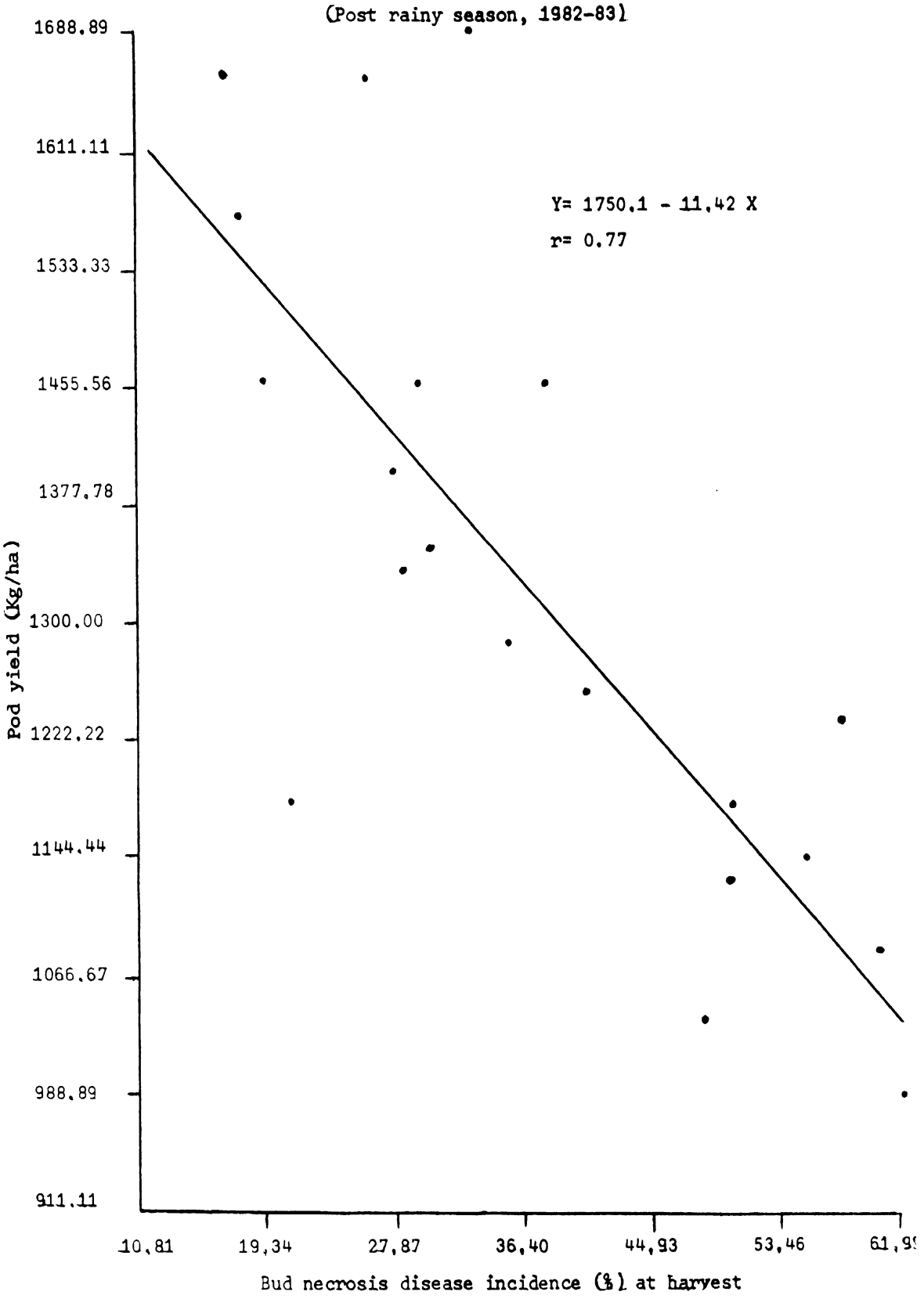


Table 3: Effect of bud necrosis disease incidence on yield of groundnut

Treatment	Frequency of spray application (days)	Number of plants per plot	Cumulative BND incidence (%)							Pod yield from			Haulm yield from		
			26/2	5/3	12/3	19/3	26/3	31/3	20/4	Diseased plants	Healthy plants	Total	Healthy plants	Diseased plants	Total
0.2% dimathoate	3	880	0.93	1.43	2.77	3.84	6.84	16.38	42.00	617	950	1567	1404	1721	3125
0.2% dimethoate	5	879	1.48	2.78	6.95	9.15	15.29	30.12	51.54	656	890	1546	1663	1460	3103
0.2% dimethoate	7	877	1.80	3.38	6.57	9.82	19.66	31.14	61.62	739	578	1317	1810	938	2748
0.05% dimethoate	7	888	2.99	6.66	12.78	18.34	32.04	51.38	74.01	778	361	1139	1804	510	2314
0.05% dimethoate	10	871	2.93	8.29	15.98	21.63	35.26	55.92	78.37	778	294	1072	1904	438	2342
SE ±		8.05	0.38	0.66	1.14	1.49	1.74	2.80	3.23			55.93			93.74
CV%		1.83	37.05	29.22	25.34	23.81	15.92	15.11	10.51			8.43			6.87

Fig. 10. Pod yield (Kg/ha) of groundnut in relation to Bud necrosis disease incidence (Post rainy season, 1982-83)



The crop was harvested on 21st April. The yields of pods and haulms were recorded separately for infected and healthy plants. The results are shown in Table 3.

When BND incidence was plotted against pod yield, an almost linear relation was observed with high correlation (-0.77) between these two factors (Fig. 10). The regression equation gave value of pod yield $y = 1750.1 - 11.42\ x$ (x = BND incidence in %). We however failed to establish threshold level of BND causing yield loss in a crop because the lowest incidence of BND obtained was 42%. BND in plots sprayed with 0.2% dimethoate at 3 days interval. It is essential to establish the threshold of BND incidence at which losses begin to occur. Such information can be of use in several ways, such as, in developing field resistant cultivars or in developing control measures with changes in plant density. Threshold level needs to be determined for different cultivation practices.

3.3. In farmers' fields:

We attempted to quantify losses from BND to groundnut crop in Andhra Pradesh in the postrainy season of 1981-82. The surveys were conducted in farmers' fields. In each district a minimum of six fields were surveyed. In each field, an area of 10 sq.m. at 3-5 locations was demarcated and numbers of healthy and BND infected plants were counted. The approximate age of crops was also determined. Infected plants were grouped into two categories; those infected early (symptoms including stunting, axillary shoot proliferation, leaf deformity and death of plants) and those infected

late (symptoms including ring spots on young leaves and necrosis of terminal bud). For estimating yield loss all early infected plants were assumed to suffer 90% yield loss and the late infected plants 50% yield loss (Table 1).

The information on the area of groundnut production was obtained from officials of the Department of Agriculture. The yield was determined on the basis of 5 years' average from the data supplied by the Directorate of Oilseeds Research, Indian Council of Agriculture Research, Hyderabad.

Loss from BND for each district are given in Table 4. The highest losses were estimated from Nalgonda district followed by Kurnool and Mahboobnagar districts. The losses in Guntur District were low in those fields that had good plant stands. In the same district, the fields with sparse plant stands had over 50% BND incidence resulting in heavy yield loss. The disease incidence in Nellore and Chittoor districts was low irrespective of plant stand and sowing date.

The monetary value of the total yield loss from seven districts was estimated at Rs. 45 million (US $ 4.5 million). The present method of estimation of yield loss based on percent incidence in relation to age of crop is realistic enough for fields in which plant stand is low and much of the infection is late. However, with good uniform stand early infection of crop resulting in stunting of diseased plants may allow the adjacent plants to grow better resulting in slightly higher yields of such plants. This compensation effect is being estimated now.

Table 4: Districtwise estimate of yield loss from bud necrosis disease of groundnut in Andhra Pradesh in the 1981-82 postrainy season

District	Area (ha)	Production (tonnes)	Average yield (kg/ha)	Age (days) of crop when visited	Plants population (100000/ ha)	BND incidence % Early	Late	Yield loss Expected yield %	Amount of yield (tons)	Value (million rupees)
Nizamabad	7,000	7500	1050	60-80	2.4	4.4	17.6	13.0	1000	3.0
Khammam	8,000	11200	1460	40-60	3.0	4.0	7.0	7.5	850	2.5
Guntur	30,000	33000	1100	60-80	4.0	0.7	6.3	3.5	1200	3.6
Prakasham	15,000	16500	1100	40-90	3.0	0.7	6.3	3.5	600	1.8
Nellore	20,000	22000	1100	60-90	4.5	0.1	0.9	Negligible	Negligible	-
Chittoor	18,000	32000	1775	20-60	4.0	0.3	2.7	1.5	Negligible	-
Anantapur	20,000	30000	1487	30-70	2.5	2.0	3.0	3.5	Not estimated*	
Kurnool	50,000	67000	1340	60-100	2.2	1.0	9.0	5.4	3600	10.8
Mahboobnagar	35,000	42000	1200	60-90	2.5	1.0	9.0	5.4	2300	6.9
Nalgonda	25,000	32000	1100	60-80	2.0	10.0	15.0	16.5	5280	16.0
Total									14,830	44.6

* Data for only 3 locations

Early infected plants were expected to produce 90% less yield and late infected plants 50% less yield. Figures on area and production were taken from State Agriculture Department and Directorate of Oilseeds Research, ICAR, Rajendranagar, Hyderabad. Yield/ha is based on an average of five rabi (Postrainy) seasons yields.

4. Transmission: The causal pathogen of BND was identified as tomato spotted wilt virus (TSWV). We investigated the identity of the vector insect. During postrainy seasons, only thrips were major sucking pests. This observation plus the indications (from virology section) that TSWV was the causal virus of bud necrosis disease led us to test thrips as vectors because TSWV is the only virus known to be transmitted by thrips.

4.1. Developing virus-free colonies of different species of thrips:

The cultures were started with field collected thrips from apparently healthy groundnut plants. Three species, Frankliniella schultzei (Trybom), Scirtothrips dorsalis Hood, and Caliothrips indicus (Bagnall) were cultured at 28 C day with 700 Lux x 12 hr photoperiod and 21 C night temperatures in a Percival incubator. Thrips tabaci was collected from nearby onion fields and reared in the glasshouse on onion plants under lantern cages. These thrips multiplied profusely at 30-35 C. Megalurothrips usitatus (Bagnall) was also reared at the above temperatures and light condition but has not been tested so far for TSWV transmission.

Thrips were segregated into species and each species into males and females; male thrips being smaller and paler than females and having an elongated almost parallel sided abdomen which is bluntly rounded at tip. Females have a conspicuous ovipositer. Field populations comprised of more females than males. The reproduction was sexual as well as by parthenogesis, unfertilized eggs gave rise to males only.

Five females, and 2 males, were picked up individually by means of a moistened camel hair brush and released gently into a glass vial 3 cm in length and 1 cm in diameter, held in an inverted position. The thrips moved upward and gathered in the upper portion of the inverted vial. A young leaflet of groundnut (cv. TMV-2) was then introduced into the vial and the vial was closed with a bark cork. The use of larger vials for rearing resulted in rapid drying of the leaflets, and the use of a rubber stopper resulted in excessive water condensation inside the vials, in which a large number of thrips got trapped and killed. The vials were kept in an incubator adjusted to 12 hourly cycles of 28 C with a light period (700 Lux), and dark period at 21 C. The females laid kidney-shaped eggs inside the leaf tissue. After allowing a 24 hr oviposition access, the thrips were dislodged from the leaflet onto the sides of the vial by tapping the individual vial held in an inverted position. After the thrips moved to the upper portion of a vial, the cork was removed and the leaflet was transferred to a new vial for the incubation of eggs. A fresh leaflet was introduced into the original vial for thrips to feed and oviposit. This process was continued for about 10 days during which 90 percent of the total fecundity was accrued.

The longevity and fecundity of F. schultzei was substantially increased when anthers of groundnut and other papilionaceous flowers were added to the leaves (Table 5, Fig. 11) as thrips preferred to feed on pollen rather than on leaves. Anthers were obtained from groundnut flowers by squeezing them with finger nails or tips of forceps. A blob of anthers was then introduced into the individual vial. S. dorsalis and C. indicus did not benefit from the added

diet of anthers and were therefore reared only on a leaf diet.

Table 5: Effect of pollen-supplemented leaf diet on the longevity and [illegible]

Species of thrips	No. of thrips tested	Diet	Maximum adult female longevity (in days)	Mean total (2) progeny per female
F. schultzei	50	Leaves	16	15
	50	Pollen plus leaves	22	29
S. dorsalis	50	Leaves	15	17
	50	Pollen plus leaves	17	17

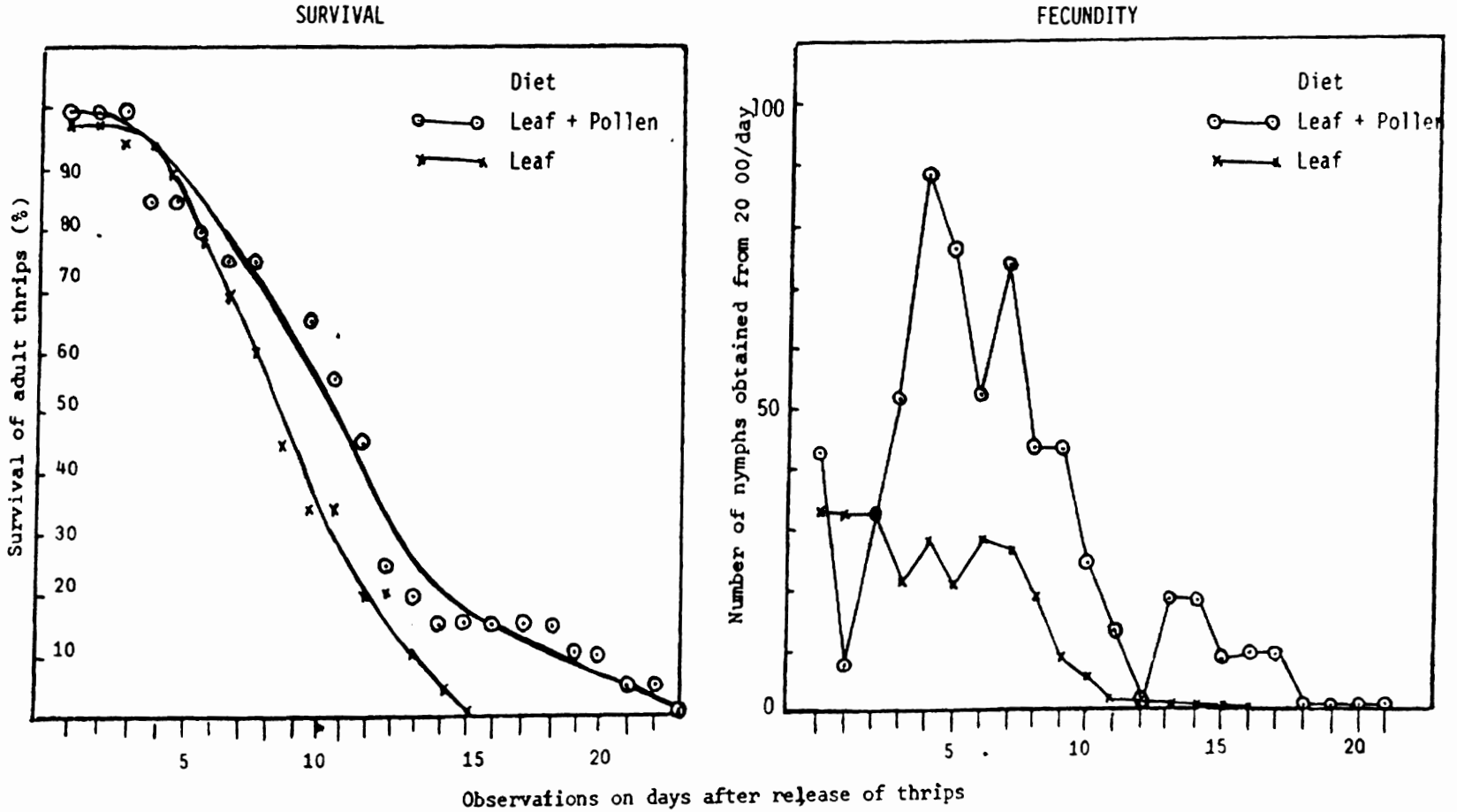
(1) Tests were conducted at 28 C and 21 C coinciding with light (700 Lux) and dark phases of 12 hours each respectively.

(2) Averages are based on 50 F. schultzei and 50 S. dorsalis females.

Thrips tabaci (Lind.) did not survive on groundnut leaves. Therefore, this species was reared on onion Allium cepa of a local variety in a screenhouse at 30 - 35 C. For transmission, in addition to groundnut, cowpea (C-152) and urdbean Vigna mungo (cv. UPU-2) were used as test hosts.

Each thrips culture was numbered and maintained separately. Thrips from these cultures were frequently released to susceptible test plant, urdbean, to ascertain that they were virus-free.

Fig.11. EFFECT OF POLLEN SUPPLEMENTED LEAF DIET ON THE SURVIVAL AND FECUNDITY OF *Frankliniella schultzei*



This method of culturing thrips on detached leaflets rather than on whole plants is simple, requires less space and plants (Fig.12), allows rearing under controlled conditions, avoids contamination and is most appropriate for transmission studies.

4.3.3 Identification of thrips infesting groundnut and their biology (Fig. 13-27).

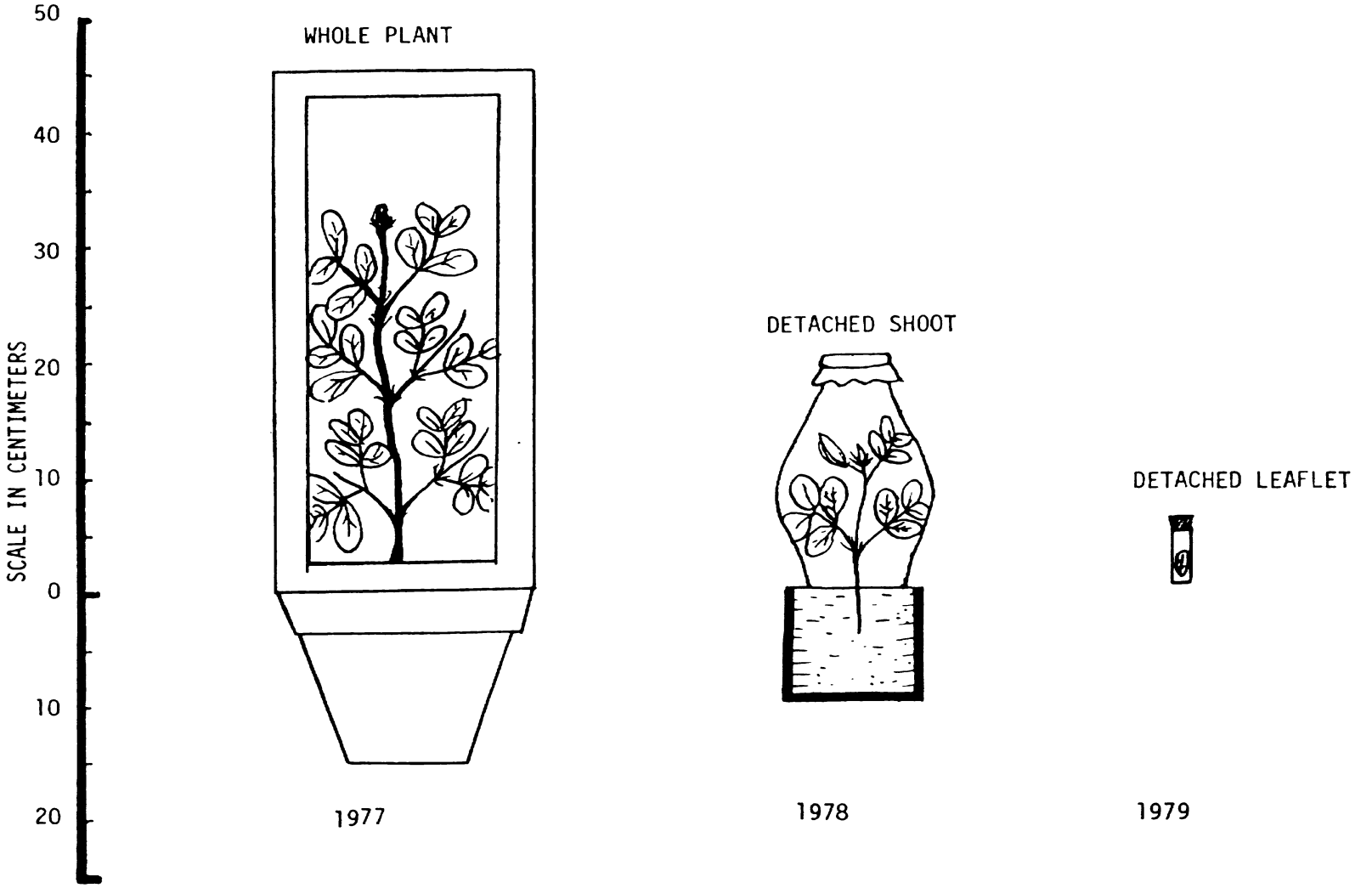
Four of the five species included in this account are commonly found on groundnut plants in India. Caliothrips indicus (Bagnall) is a pest of legumes and feeds mainly on the older leaves of groundnut plants. Scirtothrips dorsalis is a widespread and polyphagous pest, but is most common on legumes and feeds in the terminal shoots, on young leaves. Frankliniella schultzei (Trybom) is a pantropical and polyphagous species which may feed on young leaves but is usually found in flowers. Megalurothrips usitatus (Bagnall) is a flower-living species that is most commonly found on legumes, and is widespread in the Oriental and Australo-Pacific regions.

Thrips tabaci Lindeman has not been recorded on groundnuts in India but is included here as it is a widespread polyphagous pest and is commonly involved in virus transmission experiments.

Key to species

1 Body covered with distinct, reticulate sculpture (figs 13 and 14); wings with 3 pale bands and dark at apex (fig. 23) ..... Caliothrips indicus (Bagnall).

Fig.12. IMPROVEMENTS MADE IN REARING TECHNIQUE OF THRIPS



Body not covered with reticulate sculpture; wings, if banded, with only 2 pale bands (fig. 27) 2

2 Head and pronotum with closely striate, transverse sculpture, pronotal posteroangular setae not distinctly longer than discal setae (fig. 15); abdominal tergites with a dark median patch, tergites (fig. 16) and sternites each with a contrasting dark anterior margin and covered with rows of microtrichia, tergite VIII with a complete comb of long fine microtrichia on posterior margin ..... Scirtothrips dorsalis Hood

- Head and pronotal sculpture not closely striate, pronotum with 2 pairs of long posteroangular setae; abdominal tergites and sternites not densely covered with microtrichia; comb on tergite VIII variable 3

3 Head with only 2 pairs of ocellar setae (pair I absent) (fig. 17); antennae 7-segmented; tergite VIII with a pair of ctenidia (a row of microtrichia along a line of sculpture) situated posteromedially to the spiracle, also a complete comb of long fine microtrichia along posterior margin (fig. 18); forewings pale, usually with 4 (rarely 3 to 7) setae on first vein in distal half (fig. 25) ..... Thrips tabaci Lindeman

4 Forewings pale with 2 complete rows of setae (fig. 26); pronotum with well developed anteroangular and anteromarginal setae and with a pair of small setae between the median posteromarginals (fig. 19); ctenidia on tergite VIII situated anterolateral to

the spiracle, posteromarginal comb usually represented by only a few small teeth laterally (fig. 20) ..... Frankliniella schultzei (Trybom)

- Forewings banded with a gap in the row of first vein setae coinciding with the distal pale band (fig. 27); pronotal anteromarginal setae not well developed, median pair of small posteromarginal setae absent (fig. 21); tergite VIII laterally with microtrichia arranged irregularly, posteromarginal comb of long microtrichia present laterally (fig. 22) ..... Megalurothrips usitatus (Bagnall).

4.2.1. Frankliniella schultzei (Trybom) = F. dampfi Priesner (Karney, 1925) = F. sulphurea Schmutz (Mound, 1968) (Fig. 19-20):

Yellow to pale brown species of Thripinae. Antennae 8-segmented, a forked sense cone on each of segments III and IV; head with 3 pairs of oceallar setae; pronotum with 2 pairs of long posteroangular setae, 1 pair of long anteroangulars, 1 pair of long anteromarginals and a pair of small setae between the median posteromarginals (Fig. 19); forewings pale with 2 complete rows of wing vein setae (Fig. 26); abdominal tergites IV to VIII with lateral ctendidia, those on tergite VIII situated anterolaterally to the spiracles; tergite VIII with posteromarginal comb represented by only a few small teeth laterally (Fig. 20).

This is the only species of Frankliniella known at present from India.

The adult thrips are whitish yellow in colour and measure 0.93 mm - 1.38 mm in length. The body is non-reticulate (Fig. 19) and the forewings bear regular rows of setae on both veins (Fig. 26). The pronotum has 4 strong setae on each side, an anteroangular, an anteromarginal and two postangulars.

Nymphs when young are creamy white in colour but become light yellow with age. They move slowly and bend their abdomens while turning. Both nymphs and adults deposit black excreta on the leaf while feeding. The nymphs feed gregariously.

The cylindrical, slightly kidney-shaped eggs are laid inside the leaf tissue. They average about 0.2 mm in length and 0.10 mm in width. The incubation of eggs is completed in 6-8 days, larval development in 6-8 days, and prepupal and pupal periods in 1-2 days. An adult longevity of up to 23 days was observed in the laboratory. Individual females produced 20-50 progeny with an average of 31. Eggs from unmated females gave rise to males. Both longevity and fecundity was increased when leaf diet was supplemented with pollen. These thrips are commonly found in flowers of many crops and weeds.

Feeding Injury: Adults and nymphs inhabit the terminal portion of groundnut plants and remain hidden in the crevices around the leaf bud. The feeding injury to young unopened leaves or leaf bud appears as light green patches. As the leaves age, this injury develops into white scars. In severe infestations the leaflets remain small, become puckered and their margins are distorted. The affected plants are stunted and lose their normal green colour. The thrips also inhabit flowers and feed on pollen. The August, September, January and

February months were found to be the peak periods of activity at ICRISAT center. Populations declined rapidly after February.

4.2.2. Scirtothrips dorsalis Hood (=Heliothrips minutissimus Bagnall). (Fig. 15, 16 and 24)

Small pale yellow to white, very active species of Thripinae, abdomen with dark tergal and sternal antecostal ridges, tergites with a median dark patch. Antennae 8-segmented, a forked sense cone on each of segments III and IV; head and pronotum with closely striate sculpture; 3 pairs of ocellar setae present; longest setae on posterior margin of pronotum 25 to 30 um long (fig. 15); forewings with few small setae on the veins, hind vein with only 2 setae (fig. 24); tergites with numerous rows of microtrichia laterally and with 3 pairs of discal setae; tergite VIII with a complete comb of long fine microtrichia on posterior margin (fig. 16); abdominal sternites covered with numerous rows of microtrichia.

There are three other species of Scirtothrips known from India but dorsalis may be distinguished from them by the body colour, length of posteroangular setae, extent of sternal microtrichia and the number of tergal discal setae.

S. dorsalis, commonly called chilli thrips, are small insects with yellowish bodies and long wings. They measure 0.74 to 0.77 mm in length and 0.075 to 0.076 mm in width. Both adults and nymphs are active insects moving in a darting fashion.

The eggs are small 0.075 mm in length and 0.07 mm in width and slightly kidney-shaped. They are embedded in the leaf tissue. The incubation period is completed in 6-9 days, the nymphal development in 6-7 days, and the prepupal periods in 1-2 days. Adult longevity is up to 22 days and fecundity up to 60 was observed at 25 C. Reproduction is both by sexual and parthenognetic modes, eggs from unmated females giving rise to male offspring. Addition of pollen to leaf diet did not increase the longevity or fecundity of this species.

Feeding injury: Feeding causes the formation of dull yellowish green patches on the upper surface and brown necrotic areas and silvery sheen on the lower surface of the leaf as in chilli peppers. The leaves become thickened and some curling also occurs. In severe infestations the plants remain stunted and the leaves become blighted. High populations of this thrips occur from January to April, but breeding continues throughout the year and several generations are completed. This thrips species is a major pest of groundnut in the Raichur and Bellary districts of Karnataka, and West Godavari, Visakhapatnam and Srikakulam districts of Andhra Pradesh and in Orissa.

4.2.3. Caliothrips indicus (Bagnall) (=Heliothrips indicus Bagnall Hercothrips indicus Schumsher) (Fig. 13, 14 and 23):

Blackish brown species of Panchaetothripinae with basal stems of antennal segments III and IV yellow, apices of femora and tibiae yellow, and forewings with 3 narrow pale bands and dark apex (fig. 23). Cheeks parallel sided (fig. 13); antennal segments III and IV

with forked sense-cones; tarsi one-segmented; tergal sculpture restricted to lateral thirds comprising elongate reticulations enclosing numerous wrinkles, tergite VIII with posteromarginal comb of microtrichia absent medially (fig. 14).

Three other species of Caliothrips are recorded from India but indicus may be distinguished from them by the colour of the forewings and the form and extent of the tergal sculpture.

Caliothrips indicus is a prolific breeder. As many as 150 progeny are produced by individual females. The incubation period was 7-10 days, the larval period 6-7 days, and the prepupal and pupal periods 2-3 days. The adults lived for up to 20 days at 25 C.

Feeding injury:

Unlike the other two species, C. indicus inhabits the upper surface of the older leaves, injury appearing as small white spots or streaks which resembles stippling. In severe infestations the plants are stunted with stippled leaves and ultimately such leaves dry. High populations of this thrips occur during hot dry periods. In our surveys of Karnataka and Andhra Pradesh States C. indicus infestations were observed to be less common than that of F. schultzei and S. dorsalis.

4.2.4. Thrips tabaci Lind. (Fig. 17, 18 and 25):

Yellow to pale brown species of Thripinae, with ocellar pigment grey instead of red. Head with 2 pairs of ocellar setae (pair I absent) (fig. 17); a forked sense cone on each of antennal segments III and IV; pronotum with 2 pairs of long posteroangular setae; ctenidia present laterally on tergites IV to VIII, those on VIII situated posteromedially to the spiracles (fig. 18).

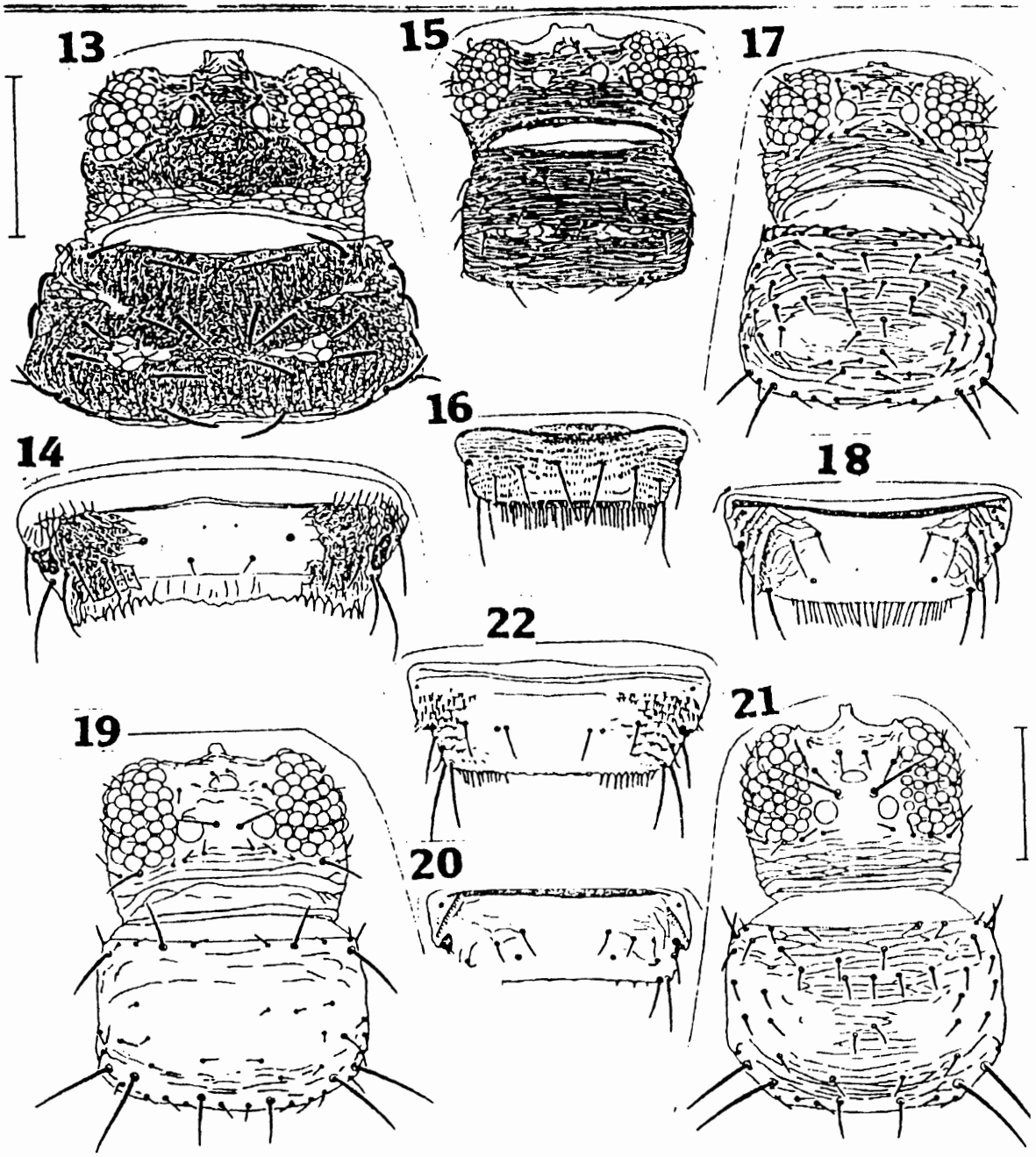
T. tabaci may be distinguished from the many other species of the genus Thrips found in India by the following characteristics.

Antennae 7-segmented; forewings pale with 4 (rarely 3 to 7) distal setae on first vein (fig. 25); abdominal sternites without discal setae; laterotergites with rows of ciliate microtrichia; tergites pale brown or shaded medially; tergite II with 3 lateral marginal setae; tergite VIII with a complete comb of long, fine microtrichia (fig. 18); tergite IX with 1 pair of pores (anterior pair absent).

Thrips tabaci did not infest groundnut.

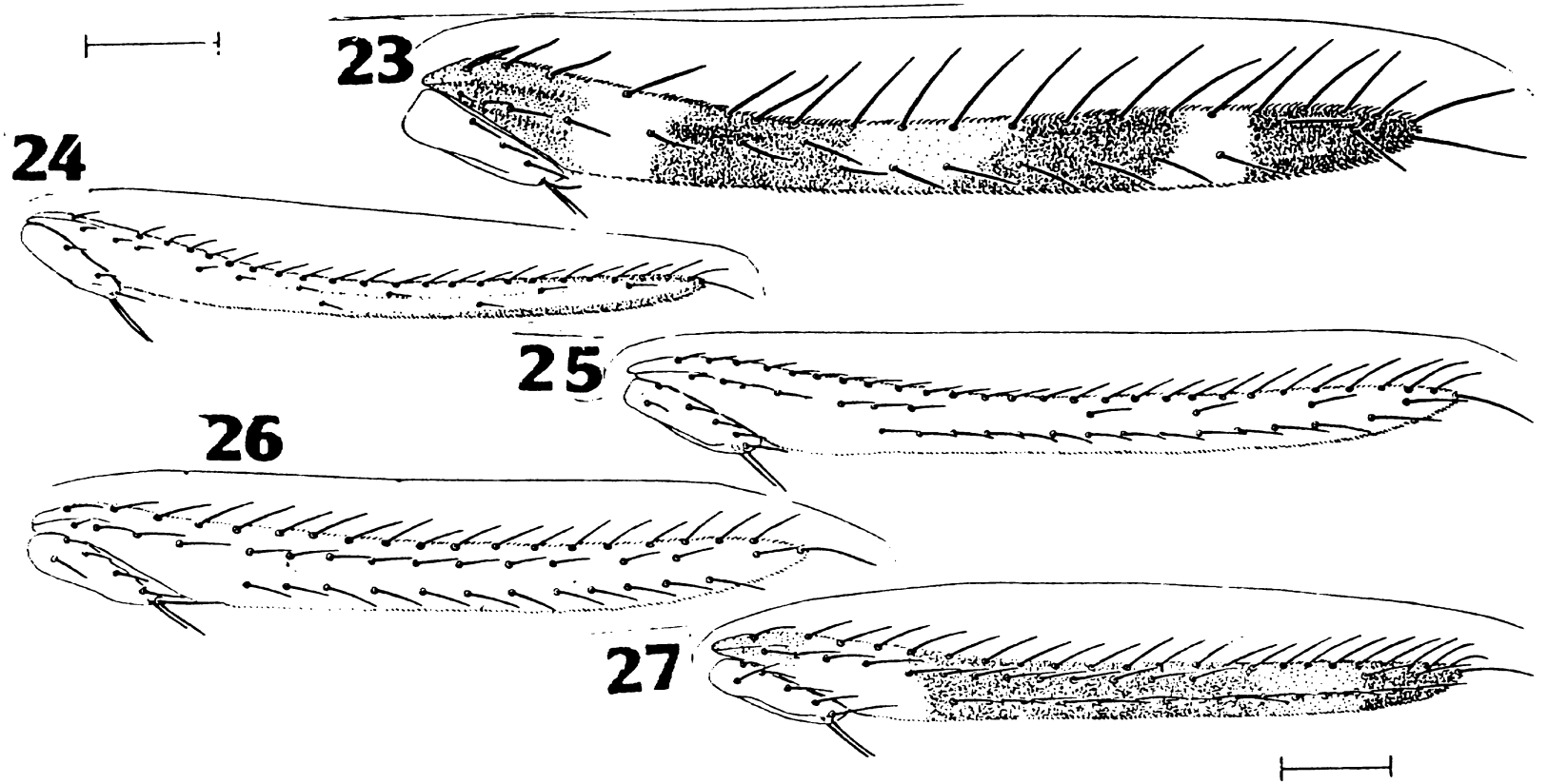
4.2.5. Megalurothrips usitatus (Bagnall) (Fig. 21, 22 and 27):

Large, dark brown species of Thripinae with banded wings and antennal segment III slightly paler than II or IV. Antennae 8-segmented, a forked sense cone on each of segments III and IV; head with 3 pairs of ocellar setae; pronotum with 2 pairs of long posteroangular setae (fig. 21); forewings with a gap in the row of first vein setae (fig. 27); abdominal tergites without ctendidia;



Legends for text figures

Figs. 13-22, Head and pronotum, ♀ tergite VIII. 13 and 14 Caliothrips indicus, 15 and 16 Scirtothrips dorsalis, 17 and 18 Thrips tabaci, 19 and 20 Franklinella schultzei, 21 and 22 Megalurothrips usitatus. All illustrations drawn to same scale except for Megalurothrips. Scale lines represent 0.1 mm.



Figs. 23- -27, Forewing. 23 Caliothrips indicus, 24 Scirtothrips dorsalis, 25 Thrips tabaci, 26 Frankliniella schultzei, 27 Megalurothrips usitatus. All illustrations drawn to same scale except Megalurothrips. Scale lines represent 0.1 mm.

tergite VIII with an irregular group of microtrichia anterior to the spiracles, posteromarginal comb absent medially (fig. 22).

This species may be distinguished with difficulty from the two other species of Megalurothrips known from India mainly by the colour of the antennae and the extent of the gap in wing vein setae.

4.3. Transmission tests:

4.3.1. Apparatus used in transmission tests are shown in Fig. 28.

Sources of TSWV: Groundnut plants (cv TMV-2) were infected by sap inoculation and the virus was maintained in groundnuts in the screenhouse at 25-30 C. In preliminary experiments, young leaves of infected plants showing faint chlorotic ring spots were found to be the best sources of inoculum. Initially all experiments involved transmission from groundnut to groundnut, but later, urdbean (cv UPU-2) was found to be more susceptible (Table 6) and was therefore routinely used as a test plant.

Table 6: Rates of TSWV transmission from groundnut to groundnut and [illegible]

Source of TSWV	Test Plant	Number of plants Exposed	Infected	% Trans-mission
Groundnut (TMV2)	Groundnut	80	16	20
Groundnut	Urdbean	60	36	60

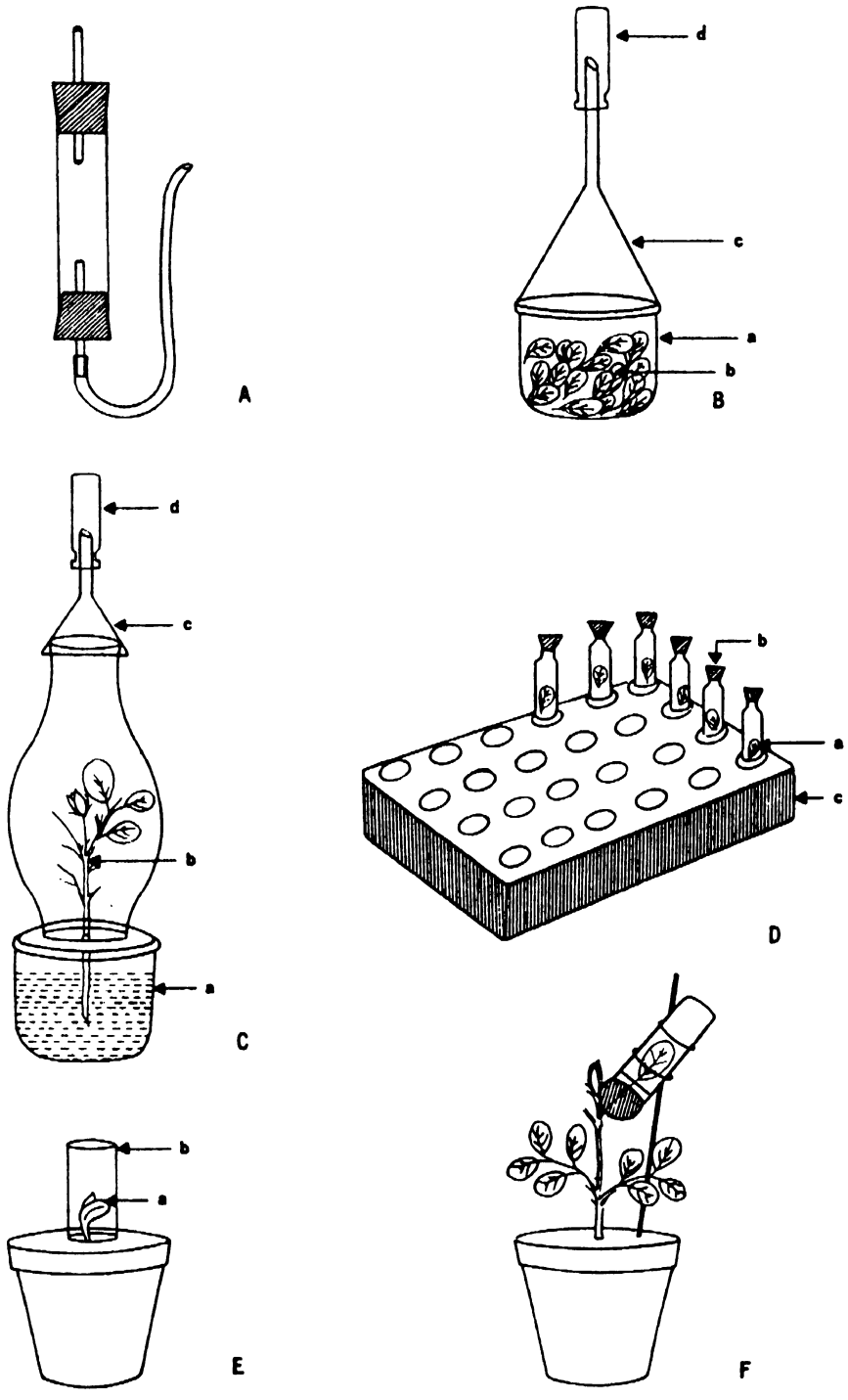


Fig28 A. An aspirator used for collecting thrips. B. An apparatus used for mass collection of thrips. a: plastic jar, b: groundnut leaves, c: glass funnel and d: glass vial. C. An apparatus for rearing of thrips on shoot. a: plastic jar, b: groundnut shoot, c: glass funnel and, d: glass vial. D. Rearing of thrips on detached leaflets. a: glass vials, 3 cm in length by 1 cm width, b: cork bark, c: wooden rack. E. Inoculation access on single plant by individual thrips. a: just emerged seedling, b: glass specimen tube. F. Method used for inoculation access on the portion of the plant.

Acquisition access:

The handling of thrips during acquisition access feeding was done in a separate room. Leaflets, showing faint ring spots were the best sources of inoculum. The leaflets were floated on water in a petridish, and 15 first instar nymphs were released on each leaflet with the help of painter's hair brush. The nymphs were allowed an acquisition access of 24 hours to acquire TSWV. However, when testing unknown thrips as possible vectors, it is well to allow them to feed for as long as possible. After the requisite acquisition access, the nymphs were transferred to small vials containing healthy groundnut leaflets. The latent period of TSWV was completed in 5-11 days, during which time the thrips completed the larval and pupal instars, and emerged as adults. These adult thrips were used in transmission tests. The thrips exposed to healthy leaves were used as controls.

Inoculation access:

Two infective adult thrips were transferred to individual urdbean, or groundnut seedlings, by using a camel hair brush. Just emerged seedlings of groundnut or urdbean were most susceptible. Groundnut seedlings were covered with lantern globes, and urdbean seedlings with specimen tubes 10 cm length by 2.5 cm diameter. The 48 hr inoculation access feeding was adequate. At the end of inoculation access the plants were sprayed with 0.025 per cent demeton-s-methyl (Metasystox (R) Bayer, India) and were transferred to a separate screenhouse for observation. For inoculation access to a specific plant part, the arrangement as shown in Fig. 28F was used.

For *Thrips tabaci*, transmission tests were conducted using groundnut, urdbean and cowpea as test hosts.

The symptoms of TSWV infection appeard in 6-10 days on urd bean and 12-30 days on groundnut. The symptoms in groundnut were numerous ringspots on young leaves, chlorosis of terminal leaves, stunting and a reduction in the size of the leaf lamina. In urdbean chlorosis of primary leaves and necrosed veins were common symptoms.

Assay of virus:

The extract was prepared from 1 gram of symptom-bearing tissue which was ground in a cold mortar containing 9 ml phosphate buffer with 0.02M mercaptoethanol. Cowpea, *Vigna unguiculata* (L) Mlsk. (cv. C-152) and petunia, *Petunia hybrida* (cv Coral Satin), were used as assay hosts. The primary leaves of cowpea, and fully expanded leaves of petunia, were lightly dusted with 600 mesh carborundum. The pestle was dipped in the extract and gently rubbed on the leaf. The inoculated leaves were washed immediately with distilled water, and the plants were kept for observation in a screenhouse at 30 to 35 C. The infection by TSWV resulted in the development of large (up to 4 mm diameter) chlorotic, and sometimes necrotic, ring spots in cowpea and small, irregular necrotic spots in petunia. The symptoms were developed in 5-6 days on groundnut and in 2-3 days on petunia.

4.3.2. Transmission by *F. schultzei*: Transmission of TSWV by various species of thrips is given in the Table 7.

Table 7: Transmission of tomato spotted wilt virus by thrips

Thrips	Source of TSWV	Test plant	No.of plants Tested	Infected
F. schultzei(a)	Groundnut	Groundnut	80	16
	Urdbean	Urdbean	220	87
S. dorsalis (a)	Groundnut	Urdbean	206	2
	Groundnut	Groundnut	119	0
	Urdbean	Urdbean	263	0
	Cowpea	Cowpea	7	0
	Tomato	Urdbean	70	0
	Cowpea	Urdbean	116	0
C. indicus (a)	Groundnut	Groundnut	41	0
	Urdbean	Urdbean	25	0

(a) = Transmission by single thrips
(b) = Transmission by two thrips

Identification of TSWV antigen in vector thrips:

Hemagglutination test: Samples of thrips were collected and held at 13 C for about 1 hr. Insects were then counted and triturated in 500 times their weight of 0.05 M phosphate buffer, pH 7.0, containing 0.02 M 2-mercaptoethanol. The weight of an indiviual insect was assumed to be 2.5 x 10 mg, and the extract was considered to be 1:500 dilution. Each extract was clarified at 2,000 g for 5 min in a refrigerated Remi K-24 centrifuge.

The hemagglutination test was performed as follows: Glutaraldehyde-treated tanned red blood cells were suspended in 0.15 M phosphate buffered saline, pH 7.0, at a 3.0% concentration. One volume of TSWV antibody suspension was added to nine volumes of tanned red blood cells and incubated at 37 C in a water bath for 30 min. The coated cells were resuspended in phosphate buffered saline, pH 7.2, containing 0.5% bovine serum albumin, washed three times, and suspended in the same solution to give a concentration of 3.0% packed cells. Serial twofold dilutions of thrips extract were prepared in the phosphate buffered saline with bovine serum albumin, and 0.5 ml was placed in each well of a lucite plate. Later, 0.08 ml of sensitized cells (3.0%) was added to each well, mixed gently, incubated for 2 hr at room temperature and then overnight at 4 C. In a positive reaction, red cells formed a smooth mat (with serrated margin) on the bottom of the well; a negative reaction resulted in a discrete red ring at the periphery of the well (Fig. 29).

Conclusions:

Both S. dorsalis and F. schultzei transmitted TSWV, but S. dorsalis was the much less efficient vector (Table 1). Thrips tabaci which is a vector of TSWV world over, did not transmit TSWV in our trials. The virus was detected by the hemagglutination technique in S. dorsalis in three separate tests using 80, 40, and 20 insects and in F. schultzei in a test using 11 insects. Extracts from virus-free S. dorsalis and F. schultzei gave nonspecific agglutination at dilutions of 1:500 to 1:1,000. The extracts prepared from exposed S. dorsalis gave hemagglutination titers of 1:4,000 to 1:8,000 and that

Fig. 29. Hemagglutination test showing positive reaction of: (A) Healthy leaf extract. (B) Extract from leaf infected with tomato spotted wilt virus. (C) Extracts from *Scirtothrips dorsalis* exposed to infected leaves. (D) Extract from thrips not exposed to infected leaves.

of F. schultzei gave titers of 1:4,000.

The results indicated that F. schultzei was a major vector of TSWV and played an important role in epidemiology of bud necrosis disease. Therefore, future studies were conducted with this species.

4.3.4 Virus vector relationship:

Acquisition access threshold: 1 day old nymphs were tested for acquisition access threshold by giving various acquisition access to BND infected leaves. The table 8 shows the results of this test.

Table 8: Acquisition access threshold of TSWV by F. schultzei

Acquisition access (larvae)	Inoculation* period	No.of plants** exposed	infected	% transmission***
5 m	4 days	131	19	14
10 m	"	63	8	13
15 m	"	48	12	25
30 m	"	46	4	9
1 h	"	126	19	15
3 h	"	84	19	23
6 h	"	50	28	56
24 h	"	127	77	60
48 h	"	141	105	75

* After the adult thrips have emerged

** Single thrips were released on individual test plants

***Urdbean was used as test host

As seen from table 8, the nymphs are capable of acquiring TSWV in 5 minutes but with increased acquisition access the transmission rates increase considerably.

Latent period: The nymphs were unable to transmit TSWV during the first instar (3 days) but a few were able to transmit when 5-6 days old (nearing completion of 2nd instar). After completion of prepupal and pupal periods (2-3 days), adults emerged and readily transmited TSWV. It appears that there is a well defined latent period of 5-8 days before the virus can be transmitted.

Inoculation access threshold: 1 day old nymphs were given acquisition access of 2 days and then maintained on healthy groundnut leaves until they became adults. Just emerged adults were given various inoculation access periods ranging from 5 minutes to 3 days on urdbean as test plant. The results (Table 9) showed that thrips were able to infect plants during 5 minutes of inoculation access but rates of transmission were small. With increased inoculation access, the rates of transmission increased considerably.

Table 9: Inoculation threshold of TSWV by *F. schultzei*

Inoculation access period	No.of plants Tested	Infected	% transmission*
5 m	73	7	10
10 m	72	8	11
15 m	54	4	7
30 m	52	1	2
1 h	56	4	7
3 h	62	18	29
6 h	56	19	34
24 h	93	14	15
72 h	11	5	45

* Single thrips were released on individual urdbean seedlings

Serial transmission:

Tests were conducted to study virus retention in F. schultzei. Nymphs were given acquisition access period of 2 days and then maintained on healthy leaves of TMV-2 until they became adults. Adult thrips were then transferred serially to urd bean seedlings at 24 hr intervals. A total of 130 thrips were tested of which 32 transmitted the TSWV at least once. Table 10 gives the results of the serial transmission experiment on 32 thrips.

As can be seen from the Table 10, the pattern of transmission was erratic. However, a few insects transmitted to all plants until they died. This erratic pattern of transmission suggests non-multiplication of TSWV in F. schultzei. For most propogative viruses, the pattern of transmission is uniform and not erratic.

In general, the mortality of thrips was high and most survived only 4-5 serial transfers. A few survived upto 10 serial transfers. Working with whole plants create problem of locating thrips. A better technique involving serial transfers on single leaflets in glass vials has been developed. The experiment can be conducted in controlled temperature and light conditions and the experiment is being repeated.

Table 10: Studies of serial transmission of TSWV by *F. schultzei*

Thrips	Transmission during serial transfer (+)									
	1	2	3	4	5	6	7	8	9	10
1	+	+	+	+	(d)					
2	+	-	-	-	(d)					
3	+	-	-	-	-	-	(d)			
4	-	-	-	+	(d)					
5	-	+	-	+	+	-	+	(d)		
6	+	-	+	-	+	-	(d)			
7	-	-	+	(d)						
8	-	+	+	+	-	-	+	+	+	(d)
9	+	+	-	-	(d)					
10	-	+	(M)							
11	+	+	PD	-	-	-	(d)			
12	PD	+	+	(M)						
13	+	+	+	(M)						
14	+	PD	+	+	+	+	+	+	(d)	
15	+	(M)								
16	+	+	-	(d)						
17	-	+	(M)							
18	+	(M)								
19	+	(M)								
20	+	+	+	(M)						
21	-	+	(M)							
22	+	+	(M)							
23	+	PD	+	+	+	+	+	(d)		
24	+	+	(M)							
25	+	-	+	(M)						
26	-	+	-	(M)						
27	-	+	+	(M)						
28	+	+	(d)							
29	+		+	(M)						
30	+	+	+	-	+	+	(d)			
31	+	+	(M)							
32	-	-	+	(M)						

PD = test plant died

(M) = thrips missing

(d) = thrips died

5. Epidemiology of bud necrosis disease:

5.1. BND incidence in different seasons:

BND incidence in cultivar TMV-2 was monitored in different seasons from 1978 to 1982-83. TMV-2 was grown on 100 sq.m. plots at 75 cm row and 15 cm plant spacing. From 1978 through 1980 TMV-2 was grown in 3-4 replications. Data from 1981 onwards was taken in unsprayed plots from other experiments.

As seen from Fig. 30, the incidence of BND was near 100% in 1979 and 1980 rainy seasons, and was 62% in 1978, 50% in 1981 and 45% in 1982 seasons. In postrainy seasons lowest BND incidence (18%) was observed in 1980-81 season and highest (62%) in two seasons 1981-82 and 1982-83. In 1978-79 season BND incidence was 56% and in 1979-80 season 28%. BND incidence was generally low in postrainy seasons following high incidence rainy seasons of 1979 and 1980. BND incidence level was higher in postrainy seasons of 1981-82 and 1982-83 than the correspoding rainy seasons of 1981 and 1982. It was similar in both 1978 and 1978-79 seasons.

Among different rainy seasons, BND incidence was very high in the low rainfall years of 1979 and 1980. 1978 and 1981 were the good rainfall years. The disease level was comparatively lower in these years than in 1979 and 1980. In the 1978 rainy season, over 500 m rainfall was received during August and the disease incidence was low. On 12-14 August, the rainfall received was over 150 mm and thrips population was drastically reduced (Fig. 59) and so was the BND incidence. The effect of rainfall on BND incidence was very clearly seen in western Uttar Pradesh. In 1978, the rainfall was 1287 mm from

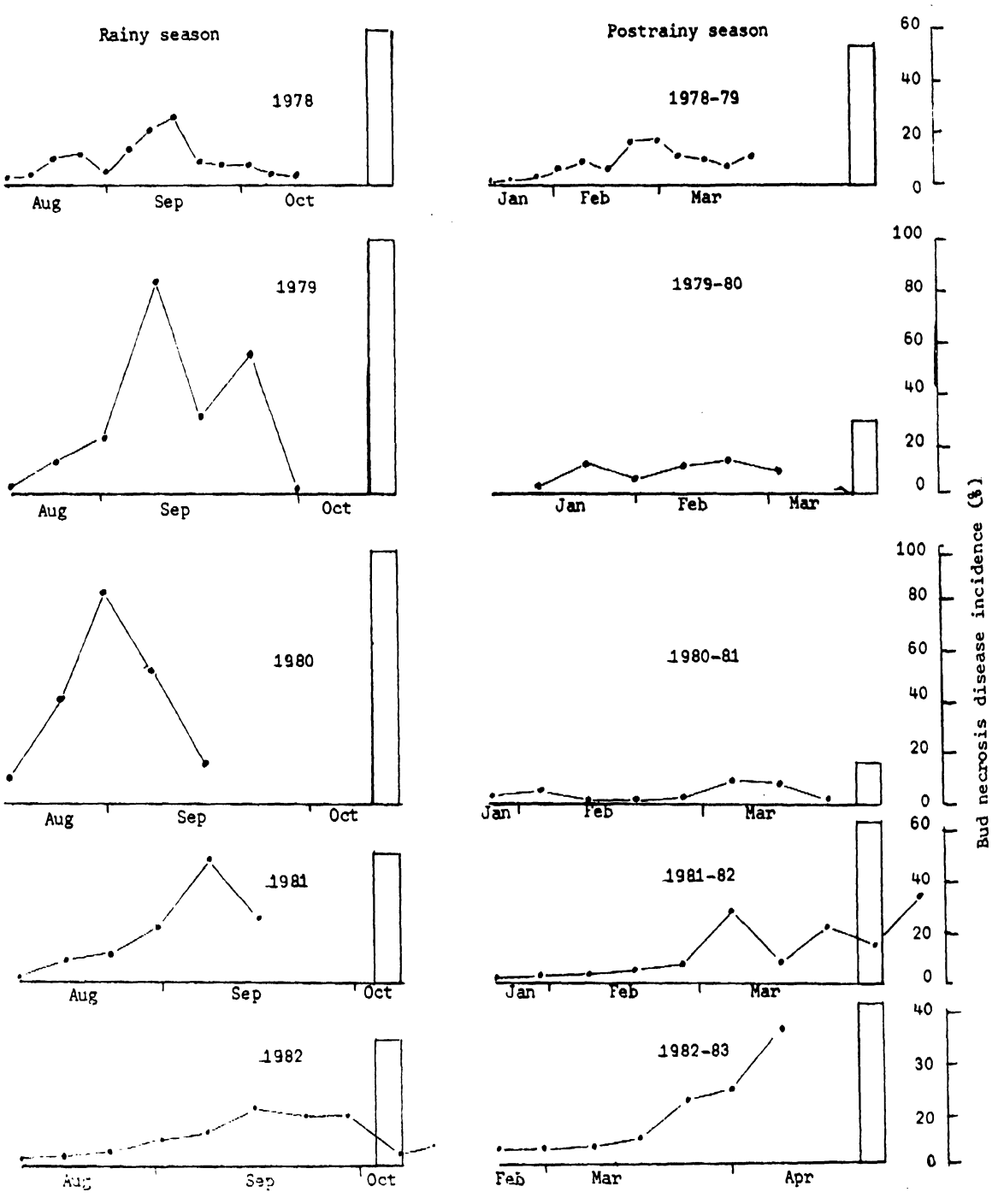


Figure 30. Incidence of bud necrosis disease in different seasons.

1st June to 30th September and the BND incidence was 10-25%, in 1979 season the rainfall was only 324 mm (333 mm below normal) and the disease incidence was over 70%, in 1980 however, the rainfall was 2000 mm (1173 mm above normal) and the BND incidence was less than 2%.

5.2. Incidence of BND in different months of rainy and postrainy seasons (Fig. 30):

In rainy seasons, most infection of BND occurred in the months of August and September. For example, in the rainy season of 1978, of the total BND incidence of 62%, approximately 10% BND incidence occurred from 24th August to 28th August and 30% from 4th September to 12th September. In the 1979 rainy season, 90% of the total of 100% incidence occurred between 23rd August and 20th September. In the 1980 rainy season, 95% BND incidence of the total of 100% incidence occurred between 1st August and 12th September. In the 1981 rainy season very little infection occurred in August and 45% of the 50% during September. In the 1982 season, the majority of spread (35% of the total 48%) occurred during September. In post rainy seasons, pattern of spread was variable. In 1978-79, 1979-80, and 1980-81, most spread occurred during the months of February and March, whereas in 1981-82 and 1982-83 the most spread occurred in March and April.

Pattern of spread of BND closely follows that of thrips infestation as seen from the Fig. 55 and 56 for rainy 1979 and postrainy 1979-80.

5.3. BND incidence in different groundnut cultivars:

BND incidence was monitored in 10 x 10 m plots of three common cultivars, TMV-2, Robut 33-1 and M-13 from 1978-1981 in rainy as well as postrainy seasons. Each cultivar was planted at 75 cm row and 15 cm plant spacing with 3 or 4 replications in randomized block design. The results are shown in Table 11.

Table 11: Incidence of BND in Robut 33-1, TMV-2 and M-13 cultivars in different seasons

Cultivar	Rainy season			Postrainy season		
	1978	1979	1980	1981	1978-79	1979-80
TMV-2	71 (58)	100 (90)	93 (75)	59 (51)	82 (66)	35 (36)
Robut 33-1	39 (38)	50 (45)	35 (36)	3 (11)	51 (45)	22 (28)
M-13	55 (48)	58 (50)	41 (40)	8 (16)	72 (58)	30 (33)
SE ±	(1.5)	(0.9)	(2.8)	(2.0)	(3.5)	(0.8)
CV %	(5.4)	(2.6)	(9.5)	(13.5)	(10.6)	(4.3)

Figures in parentheses are arcsin transformed values

5.4. BND incidence in relation to growth habits:

It was indicated from the results of 1978 and 1979 trials for screening against BND that cultivars of upright bunch habit are in general more susceptible to BND than cultivars of spreading bunch or runner growth habits.

To determine the effect of different growth habits on BND incidence, a trial was conducted by planting 31 cultivars of different growth habits in 4 row x 4 m plots in 3 replications. The BND incidence was recorded on the 100th day after emergence. The cultivars along with their growth habit, branching and pod characteristics were supplied by Genetic Resources Unit.

It can be seen from Table 12 that the upright genotypes, either spanish bunch, valencia, or natal had BND incidence in the range of 68-92%. Virginia bunch cultivars with spreading bunch growth habit suffered low BND incidence between 11-30% and prostrate cultivars had BND incidence between 26-46%. Infected plants of all cultivars showed all the common symptoms of BND and therefore, were susceptible to virus. The differences in BND incidence appear to result from vector preference rather than differential susceptibility to the virus. The preference appears to be for cultivars of upright bunch growth habit and such cultivars had high incidence of BND. Most of such cultivars have light green foliage. The spreading bunch and runner types have dark green leaves. It is known that thrips prefer light green over dark green colour.

Several cultivars with low BND incidence and high yield were identified in spreading bunch and runner types. These include MK 374, Robut 33-1, NC Ac 343 and M-13. It appears that chances of breeding field resistant cultivars of virginia bunch growth habit are better than those of valencia or upright bunch cultivars. Robut 33-1, M-13 and MK 374 can be useful cultivars as they are high yielders and had low BND incidence.

Table 12: BND incidence in genotypes belonging to different growth habits

Genotype	Growth habit	Branching	Pods	% BND
TMV-2	Upright bunch	Sequential	Spanish	82
J-11			"	92
Pol-2			"	88
Argentine			"	72
U-4-7-7			"	68
NC Ac 16453			Valencia	78
NC Ac 1337			"	87
NC Ac 10054			"	79
45-29			"	77
NC Ac 10088			"	84
NC Ac 16077			"	82
53			Natal	79
NC Ac 109276			"	82
Ah 7777			"	68
NC Ac 16442	SB	Alternate	Fung bunch	50
NC Ac 17890			"	42
NC Ac 17893			"	42
NC Ac 17538			"	48
NC Ac 16911			Castle Cary	48
Ah 7829			"	70
NC Ac 16949			"	35
Robut 33-1			V.bunch	30
MK 374			"	11
NC Ac 2575			"	27
NC Ac 2557			"	22
M-13	Prostrate	"	Jumbo runner	28
NC Ac 2232	"	"	"	26
RS-14	"	"	Indian runner	29
F-13	"	"	"	49
A 24-11	"	"	"	46
Kadiri 71-1	"	"	"	31
SE ±				4.7
CV %				17.2

5.5. Distribution of BND infected plants in small and large plots of groundnut:

It was observed that in small plot the distribution of BND infected plants was random and no aggregation or clustering was observed. This was the pattern in 1978-79 (Fig. 31) in plot size of 10 m x 15 m size and in 1979-80 (Fig. 32) in plot of 20 m x 20 m size. But in larger plots, some gradient was observed. In 1979-80, a plot of 30 x 100 meters was sown to TMV-2 at 75 cm x 15 cm spacing. The plot was divided into 10 sections of 30 x 10 m each and BND infected plants were recorded in alternate rows on different dates. Fig. 33 gives the data on distribution of BND infected plants. As can be seen the number of BND infected plants was low in the first 10 m section but was similar in others.

The lack of very strong border effect on BND infected plants indicates distant source of inoculum. The strong border effects are known for some aphid borne viruses which result from early source of inoculum.

5.6. Host range of thrips and TSWV:

Surveys were conducted in the month of February, 1982 to collect thrips from crop and weed plants and also to collect samples of plants showing BND. A total of 56 samples of thrips were collected and the species of thrips were identified. Plants suspected of virus symptoms were assayed on cowpea, Vigna unguiculata and the disease symptoms were recorded.

Fig.31 . Distribution of bud necrosis diseased plants in small plots groundnut (Pe[illegible] 1979-[illegible])

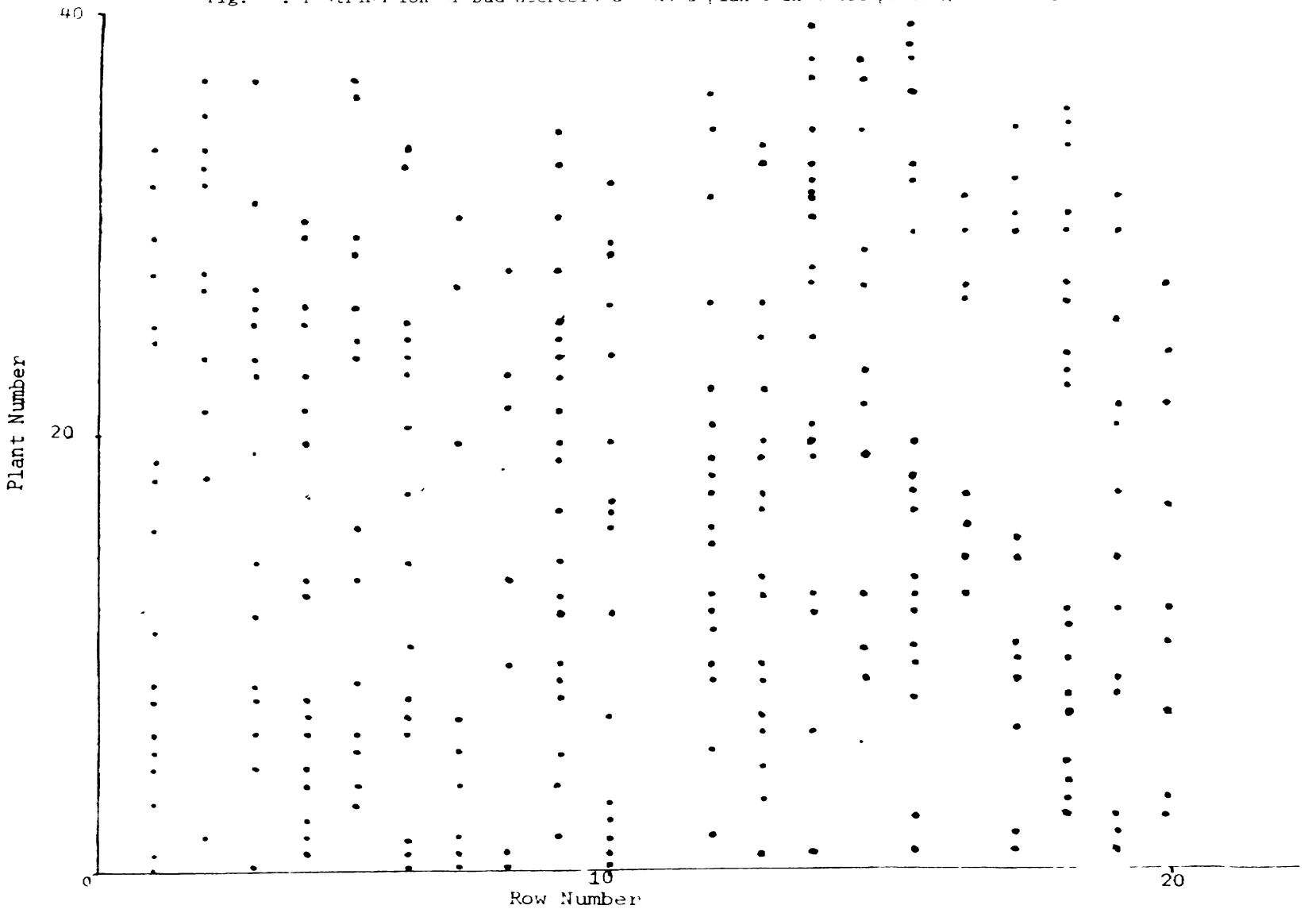


Fig. 32. Distribution of bud necrosis diseased plants in small plots (400 sq.m.) of groundnut (Postrainy season, 1979-80)

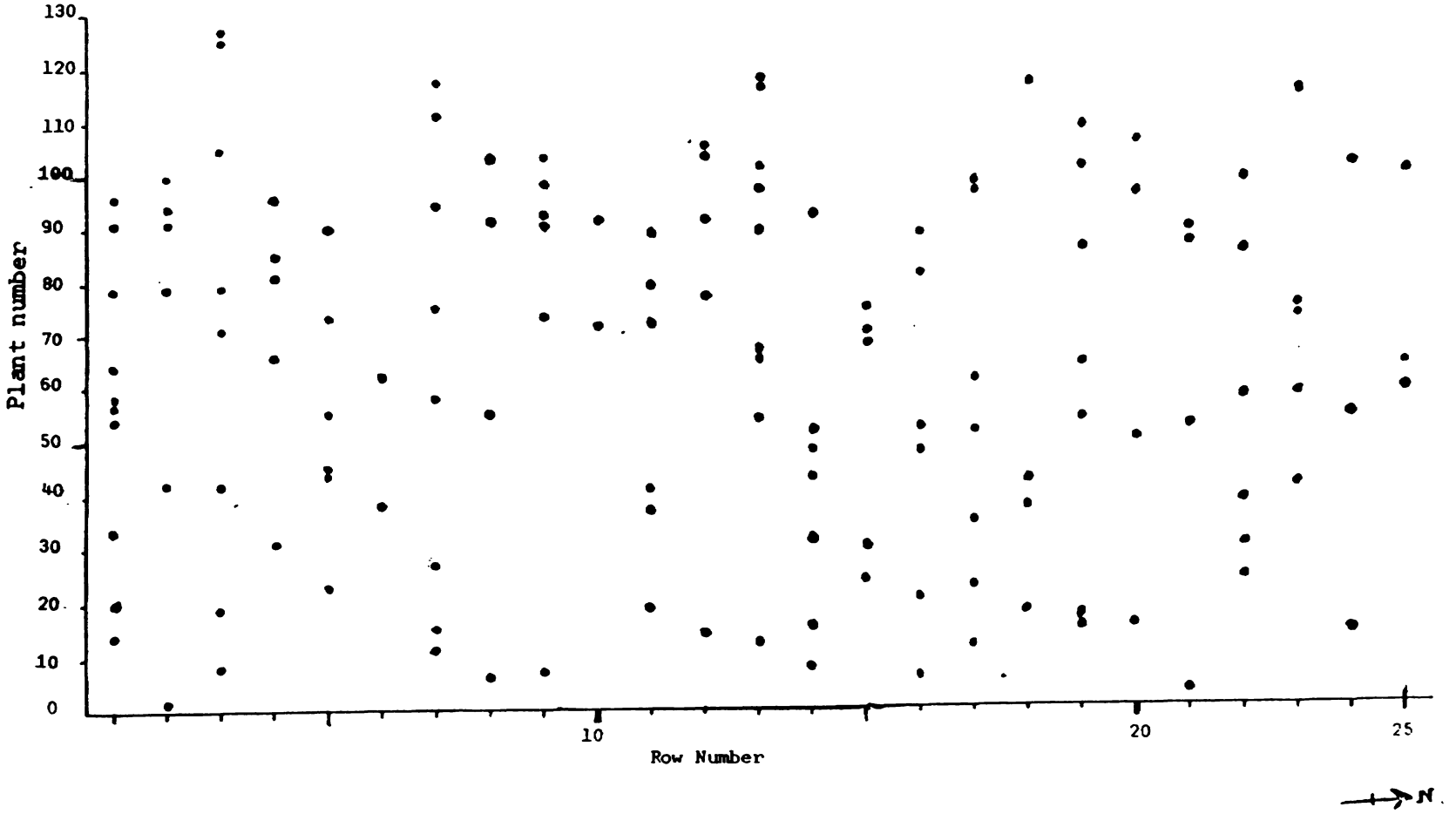
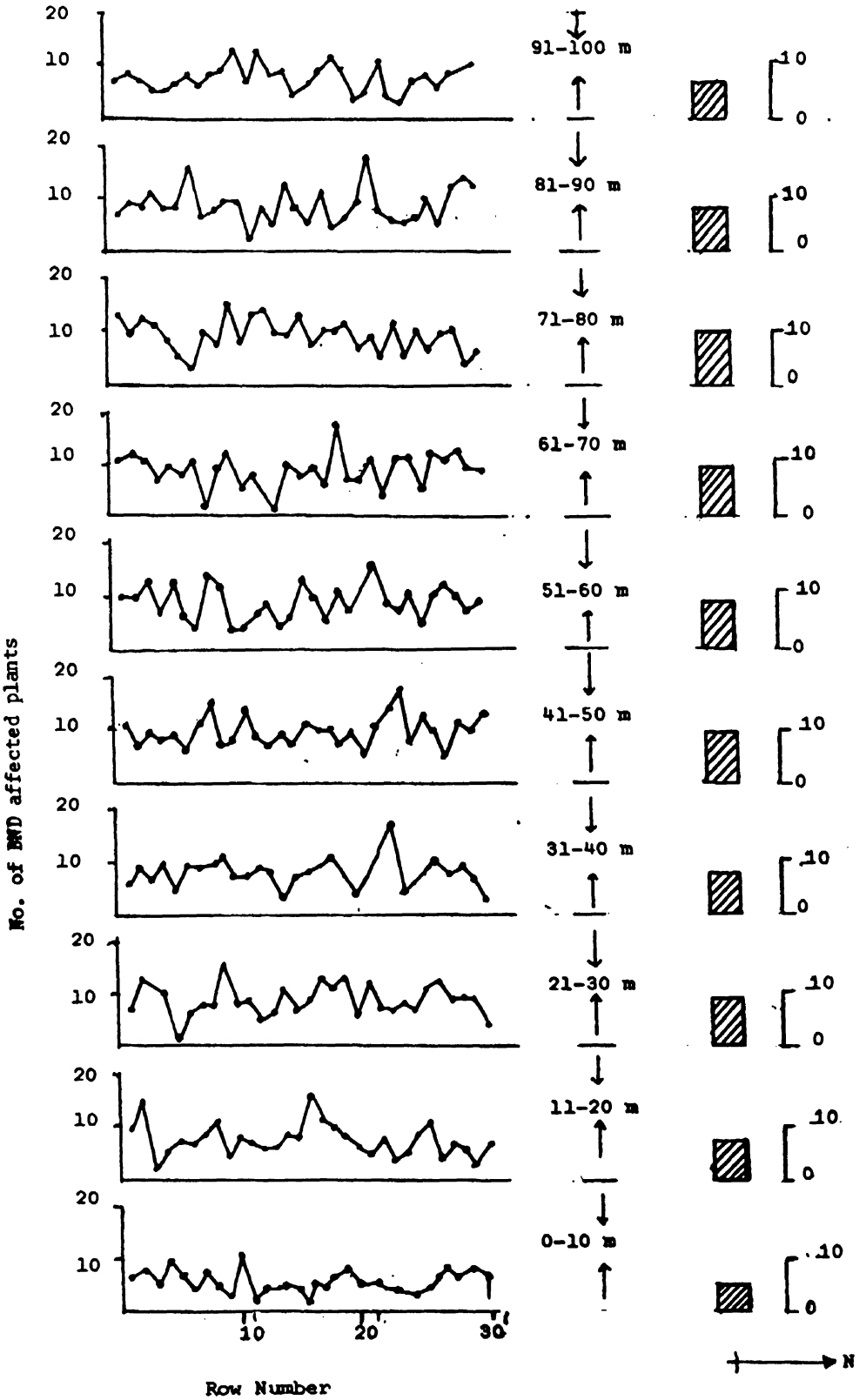


Fig.33. . Number and % Bud necrosis incidence in large plot (Postrainy



F. schultzei was collected from several host plants including, crops, ornamentals and weeds many of which were susceptible to TSWV (Table 13). Crop plants such as mungbean and urdbean were highly susceptible to both the virus and the vector, and large scale cultivation of these short duration legumes may help to perpetuate virus and vector. Tomatos, beans, peas and ornamentals such as zinnia and chrysanthemum which were susceptible to both TSWV and F. schultzei are commonly grown during the summer season. Ageratum conyzoides, Cassia tora, Acanthospermum hispidum, Lagasca molhis and Desmodium triflorum are common weeds in groundnut fields which harbour numerous F. schultzei and are susceptible to TSWV. These weeds are usually abundant soon after early monsoon showers and are likely to provide sources of inoculum for subsequent crops.

The situation in tomato is not clear. While BND infection occurs, tomato harbours very few thrips, mainly in flowers. In repeated screenhouse and laboratory trials, F. schultzei failed to survive on tomato (cv Pusa Ruby) and none of the 50 plants that were fed upon by infective thrips developed disease symptoms. Under such circumstances it appears likely that the BND infection of tomato crops may have resulted from transitory invasion of the crop and there may not be any secondary spread. Further work is necessary to confirm this. Though wide host range of TSWV and thrips is known, the relative importance of individual crop and weed plants needs to be assessed.

ble 13: Plant hosts of Frankliniella schultzei and tomato spotted wilt virus (TSWV)

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pilionaceae: Arachis hypogaea (C)(T)(V), Canavalia gladiata (C)(T)(V), Crotalaria juncea (C)(T)(V), Desmodium triflorum (W)(T)(V), Glycine max (C)(T)(V), Pisum sativum (C)(T)(V), Tephrosia purpurea (W)(T), Vicia faba (C)(T)(V), Vigna mungo (C)(T)(V), V. radiata (C)(T)(V), V. unguiculata (C)(T)(V).

mpositae: Acanthospermum hispidum (W)(T)(V), Ageratum conyzoides (W)(T)(V), Carthamus tinctorius (C)(T), Chrysanthemum indicum (O)(T), Cosmos bipinstatus (O)(T)(O), Helianthus annuus (C)(T), Lagasca mollis (W)(T)(V), Tridax procumbens (W)(T), Xanthium strumorium (W)(T)(V), Zinnia elegans (O)(T)(V).

lanaceae: Lycopersicon esculentum (C)(T)(V), Nicotiana tabacum (C)(T), Solanum melongena (C)(T)(V), S. tuberosum (C)(T)(V).

salpiniceae: Cassia tora (W)(T)(V), C. obtusifolia (W)(T)(V), C. occidentalis (W)(T).

liaceae: Allium cepa (C)(T).

volvulaceae: Datura stramonium (W)(T).

iateae: Leucas aspara (W)(T).

averaceae: Papaver sp. (W)(T).

gophyllaceae: Tribulus triticus (W)(T)

lepidaceae: Calotropis gigantica (W)(T)(V)

ranthaceae: Celosia argentea (W)(T).

Crop V = Host of TSWV
Ornamental T = Host of F. schultzei
Weed

5.7. Primary vs secondary spread:

An attempt was made to determine whether BND spread in the field was random (mainly primary) or otherwise (mainly secondary). These trials were conducted in the postrainy season only as it was clear that in the rainy season, the major spread was primary resulting from the incoming thrips. In the postrainy 1978-79 season plots of groundnut 10 m x 7m were sown to cultivar TMV-2 on ridges 75 cm apart with plant spacing of 15 cm. All plants in individual rows were numbered and the individual plants showing symptoms of BND were tagged.

The data were first analysed by Van der Plank's method which is based on the assumption that if the disease spread is secondary i.e. if the disease spreads from one plant to another, plants adjacent to diseased plants should contract the infection resulting in pairs of diseased plants. He used the formula:

$$p = x \frac{(x-1)}{n} \text{ with standard error of } \sqrt{p}$$

However, this method of analysis was originally devised for aphid-borne viruses and was not suitable for thrips-borne viruses because of persistent transmission by thrips with well defined latent period. For secondary spread to result, the thrips larvae must acquire virus from diseased plant, the virus must go through 7 days of latent period in thrips before emerging adults can transmit it. Once the virus is introduced into a plant, it takes about 10-12 days for symptoms to become noticeable. Therefore, any plant that is adjacent to diseased plant and shows symptoms within 17-19 days of the symptoms

produced on the original infected plant cannot be regarded as having contracted the disease from the original source plant.

Therefore, a modified method was devised to investigate the nature of spread of BND in the groundnut crop. All the plants in each row were counted and numbered. Individual plants were inspected once every week and those having disease symptoms were tagged giving dates of symptoms appearance. The plants that were adjacent to infected plants and also showed symptoms after about 2 weeks from the date of appearance of symptoms in the original infected plants were recorded separately. The procedure of recording data is shown in Table 14.

Table 15: Two way table for X test

	Infected	Non-infected	Total
No.of plants adjacent to diseased plants	0 A	20 B	20
No.of plants non-adjacent to diseased plants	16 C	6 D	22
Total	16	26	42

The analysis was done by the following formulae:

$$\chi = \frac{[(AXD)-(BXC)]}{(A+B)\ (A+C)\ (B+D)\ (C+D)} \times (A+B+C+D)$$

$$= \frac{[(0x6) - (20x16)]}{(20)\,(16)\,(26)\,(22)} \times 42 = \frac{4300800}{183040} = 23.49$$

χ 1 df at .05 p = 3.841

It is clear from the analysis that more plants that were not adjacent to diseased plants were infected than were plants close to

Table 14: Procedure for recording BND infected and adjacent plants.

Date when symptoms appeared	No. of plants infected	Individual Plant No. in a row	Plants adjacent to diseased plants			Plants not-adjacent to diseased plants	
			Available for infection	Nos. infected	Adjusted*	Number of plants available for infection **	Subsequently infected
23.12.77	1	20	19,21	(2)	0	39	1
29.12.77	2	35,42	34,36,41	(3)	0	34	2
6.1.78	6	1,8,14,31 37,40	2,7,9 13,15,30		0		
11.1.78	6	6,7,10;11 23,24	32,36,38 5,8,9,12	(9)	1	19	6
19.1.78	1	4	22,25	(5)	0	8	6
			3	(1)	0	6	1
Total	16			20	1		16

0

* Adjusted to account for latent period of 7 days in vector and 10 days time required for symptom development. Since plant No.7 which was adjacent to diseased plant no.8 of 6.1.78 and developed infection within 5days of that of plant no.8 the plant no.8 could not have served as a disease source for this plant. Therefore, this record was disregarded.

** Total number of plants in this row were 42. Of these 20 were adjacent to diseased plants and 22 were not.

those originally infected, indicating that direct spread from one plant to another was minimal.

We applied this method to analyse disease spread in one of the plots having 10 rows. The plants infected with BND along with the date of infection were recorded. The results of analysis are given in Table 16.

Table 16: Two way table for number of infected and non-infected plants adjacent to BND infected plants (postrainy season, 1977-78)

	Infected	Not infected	Total
Plants adjacent to BND infected plant	17 A	156 B	173
Plants not adjacent to BND infected plants	70 C	147 D	217
Total	87	303	390

$$X = \frac{(AD-BC)}{(A+B)(A+C)(B+D)(C+D)} \times (A+B+C+D) = \frac{[17\times147)-(70\times156)]}{(173)(87)(303)(217)} \times (390) = 27.946$$

X = df, .05 p = 3.841

The calculated value of X (27.9) was higher than the table value at 1 d.f. (3.841). It, therefore, appears that differences in the proportions of infected plants from adjacent and non-adjacent plants are significant. It appears that more plants which are not in the vicinity of diseased plants, get infected as compared to the plants near to the diseased plants. Therefore, the spread between plants is less important.

5.8. BND incidence in relation to sowing dates:

The peak period when the majority of BND infection occurs is in the months of September in the rainy season and February/March in the postrainy season. But the level of disease incidence depends upon the susceptibility of plants; the younger plants more susceptible they are.

Fig. 34 shows the levels of BND incidence in crops sown in different months. In the June sown crop, the majority of infection occurred in the month of September and October when the crop was over 80 days old and was nearing maturity. Therefore, the disease incidence remained low (12%). The direct losses based on number of infected plants may have been 12% if all infected plants produced no pods. But because these plants contracted infection very late, the yield loss from individual infected plants was much less than if the plants had been infected young (Table 1). The July and August sown crops suffered most because of rapid build up of disease in the young crops (Fig. 35). Monitoring of thrips on crops sown on 15th June and 15th July revealed that thrips populations were similar on crops sown on these two dates (Fig. 36 and 37). Therefore, the lower incidence of BND on the earlier sown crop appears to be due to the lower susceptibility of well grown plants to BND infection when mass migrations of thrips occur in the month of August. Crops sown in July and August are exposed to infection in seedling stage and contract high level of disease incidence.

Fig. 34. Bud necrosis disease incidence in relation to sowing dates

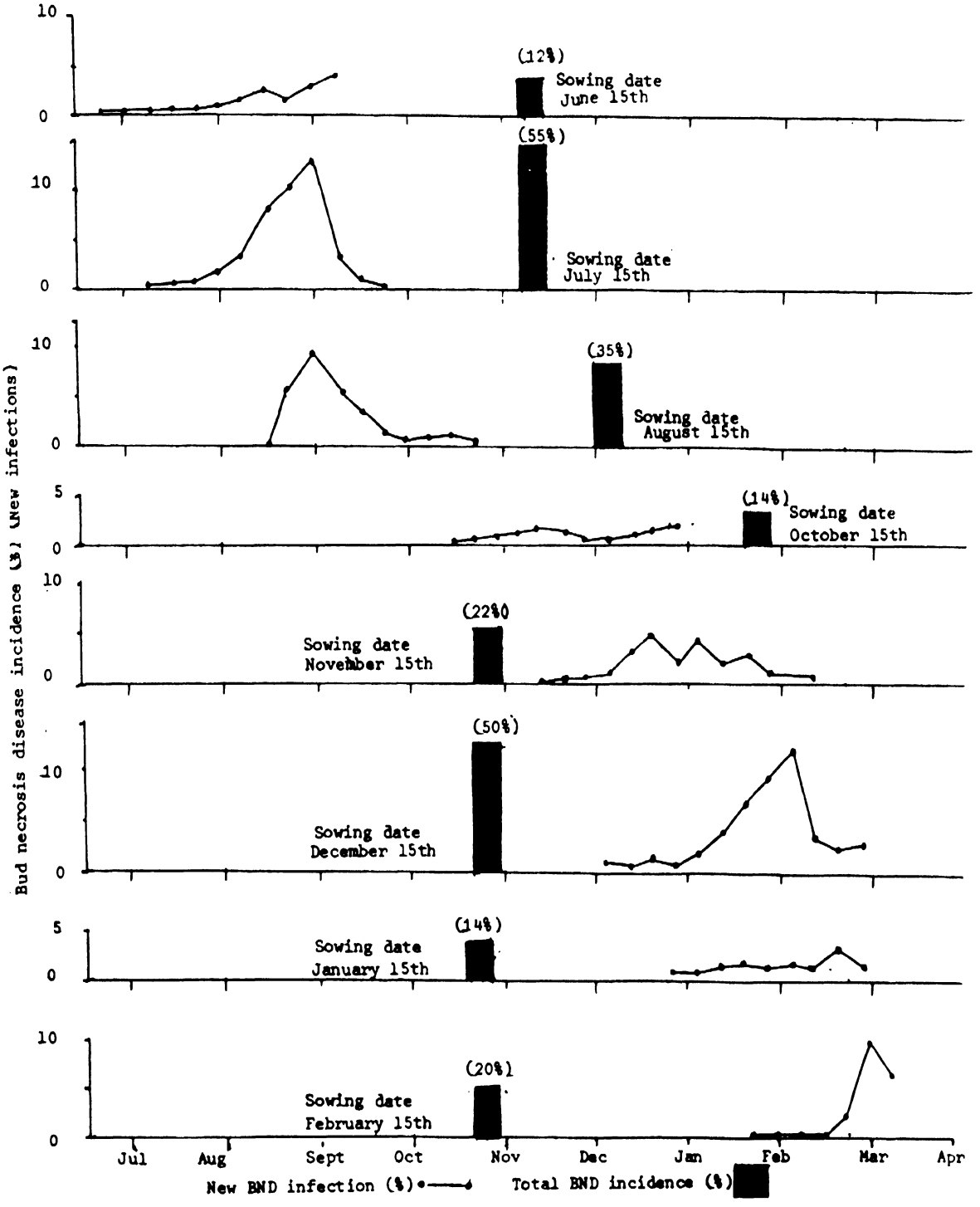


Fig.35 . Effect of sowing dates on bud necrosis disease incidence

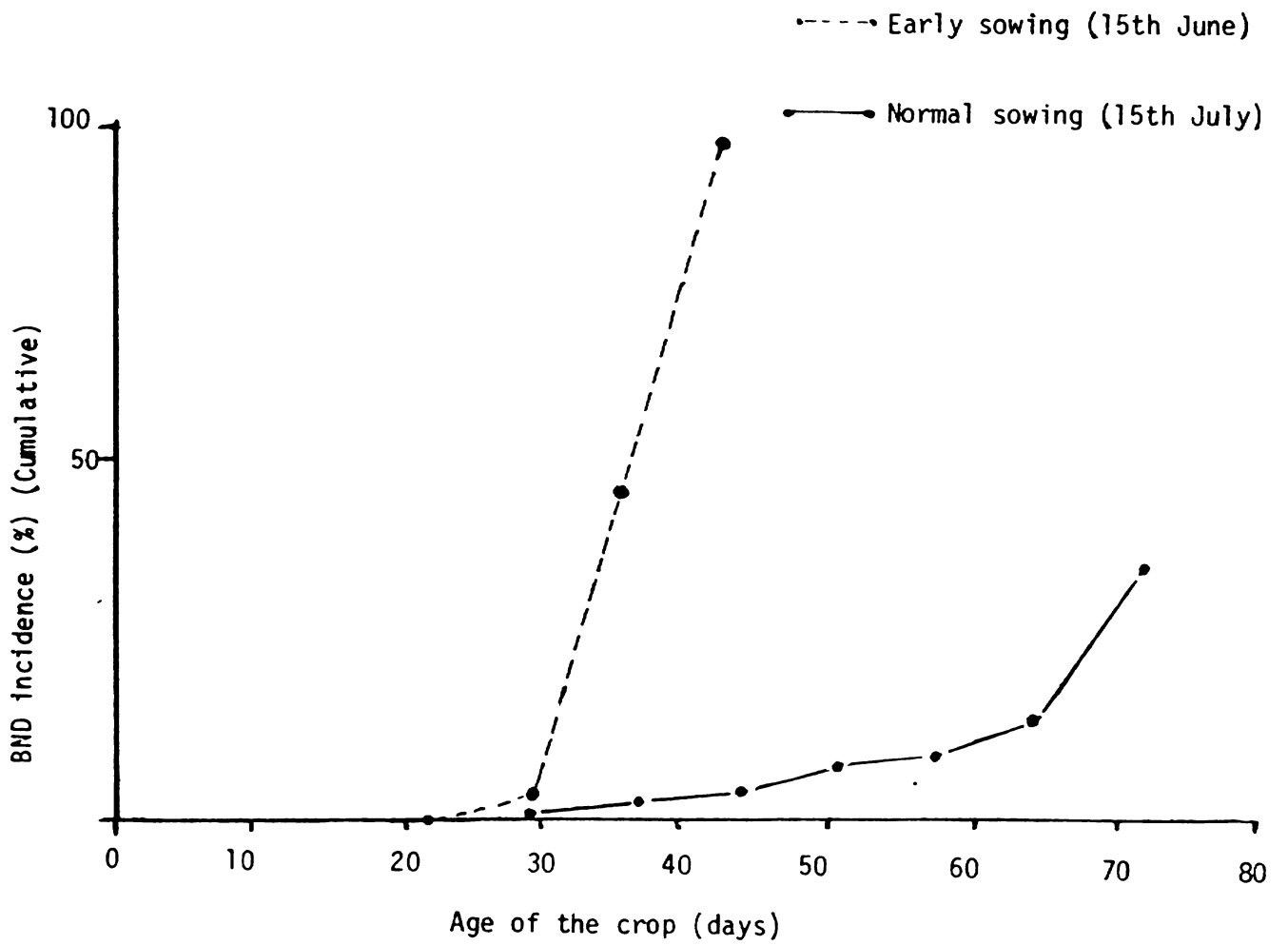
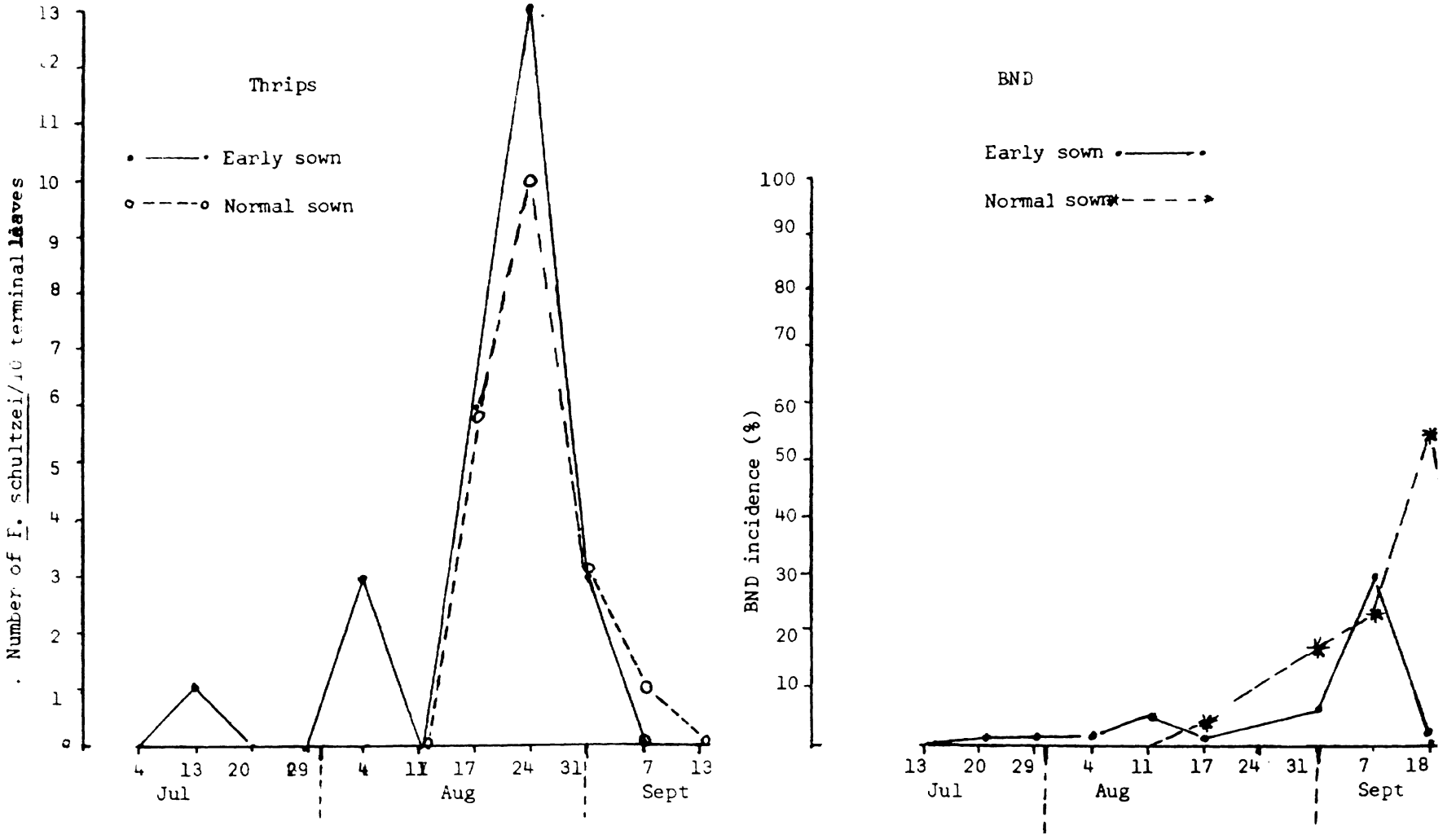
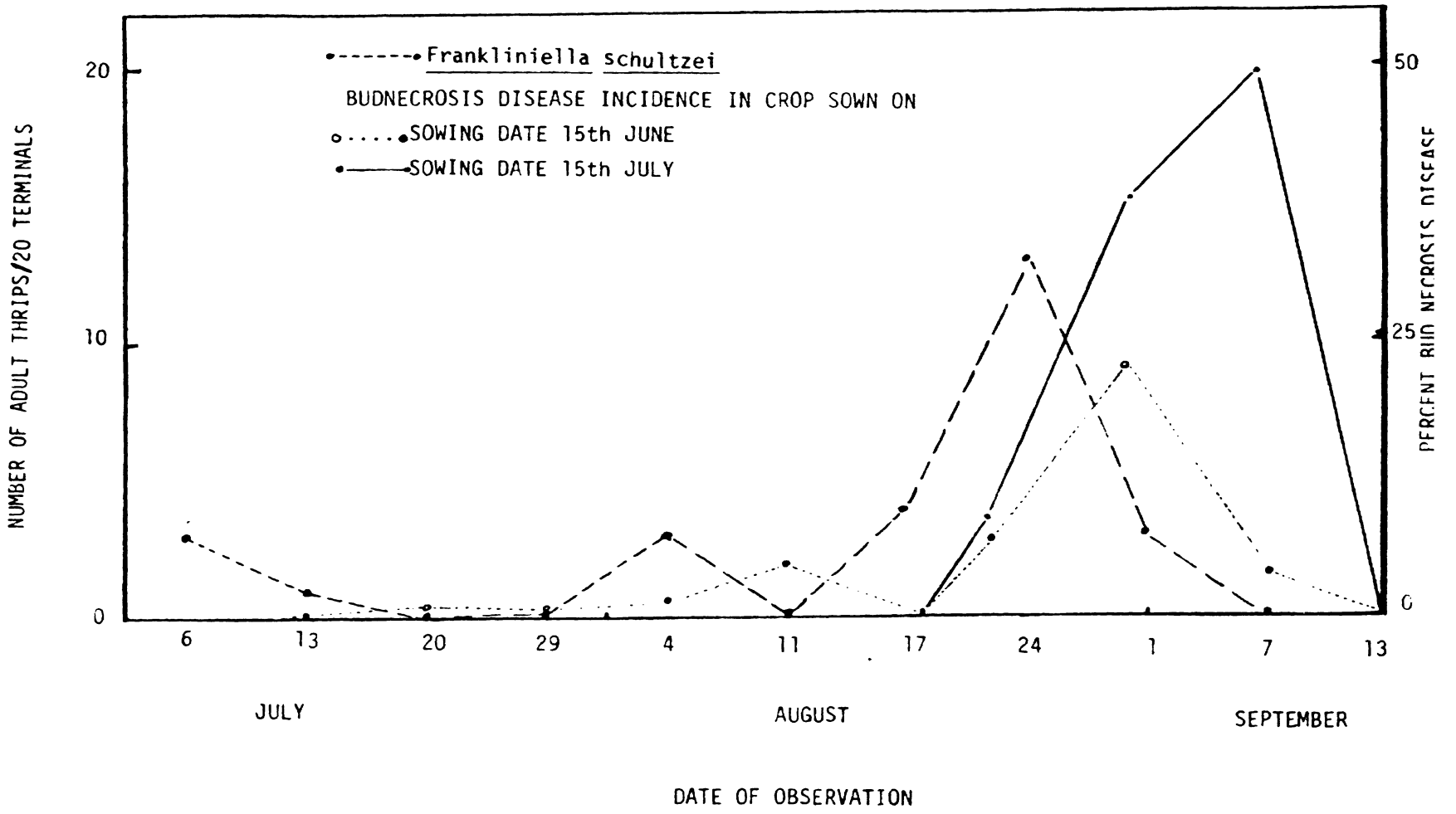


Fig. 36 Thrips and bud necrosis disease incidence in early and late sown groundnut (Rainy 1979 season)



Fif. 37. EFFECT OF SOWING DATES ON BUDNECROSIS DISEASE INCIDENCE
(RAINY SEASON 1979)



Among the postrainy season crops, those sown in the months of October, November, January and February suffered less damage from BND than December sown crop. Low disease incidence in October sown crop was because of escape from mass influx of vector thrips in September. The situation in November sown crop was similar to the June sown crop, the majority of infection occurred in the months of February and March when plants were well grown and developed field resistance. January and February sown crop suffered less because they escaped from the influx of thrips in December and part of January and had thrips infestation for a short period upto the 3rd week of February.

5.9. BND incidence in relation to intercropping and barriers:

Several trials were conducted to elucidate effect of intercropping groundnut with different crops such as pearlmillet, sorghum, maize, castor, sunflower and pigeonpea. Of these groundnut intercropped with pearlmillet had the lowest BND incidence (Tables 58,59,60).

In the 1981 trial (Fig. 38) the thrips incidence was generally lower on intercropped groundnut than on sole crop but the difference was more during migration of thrips, i.e. from 28 August to 12 September. This may have resulted in lower BND incidence on intercropped groundnut. However, when numbers of BND infected plants were recorded in alternate rows, it was observed that row to row variation was little (Fig. 39) though overall incidence was lower in pearlmillet-groundnut intercrop than in sole groundnut. This may have resulted from arrangement of the barrier crop. In this trial, ridges of pearlmillet and groundnut were not directly across the prevailing

Fig.38. . Effect of intercropping on thrips incidence

(Rainy 1981 season)

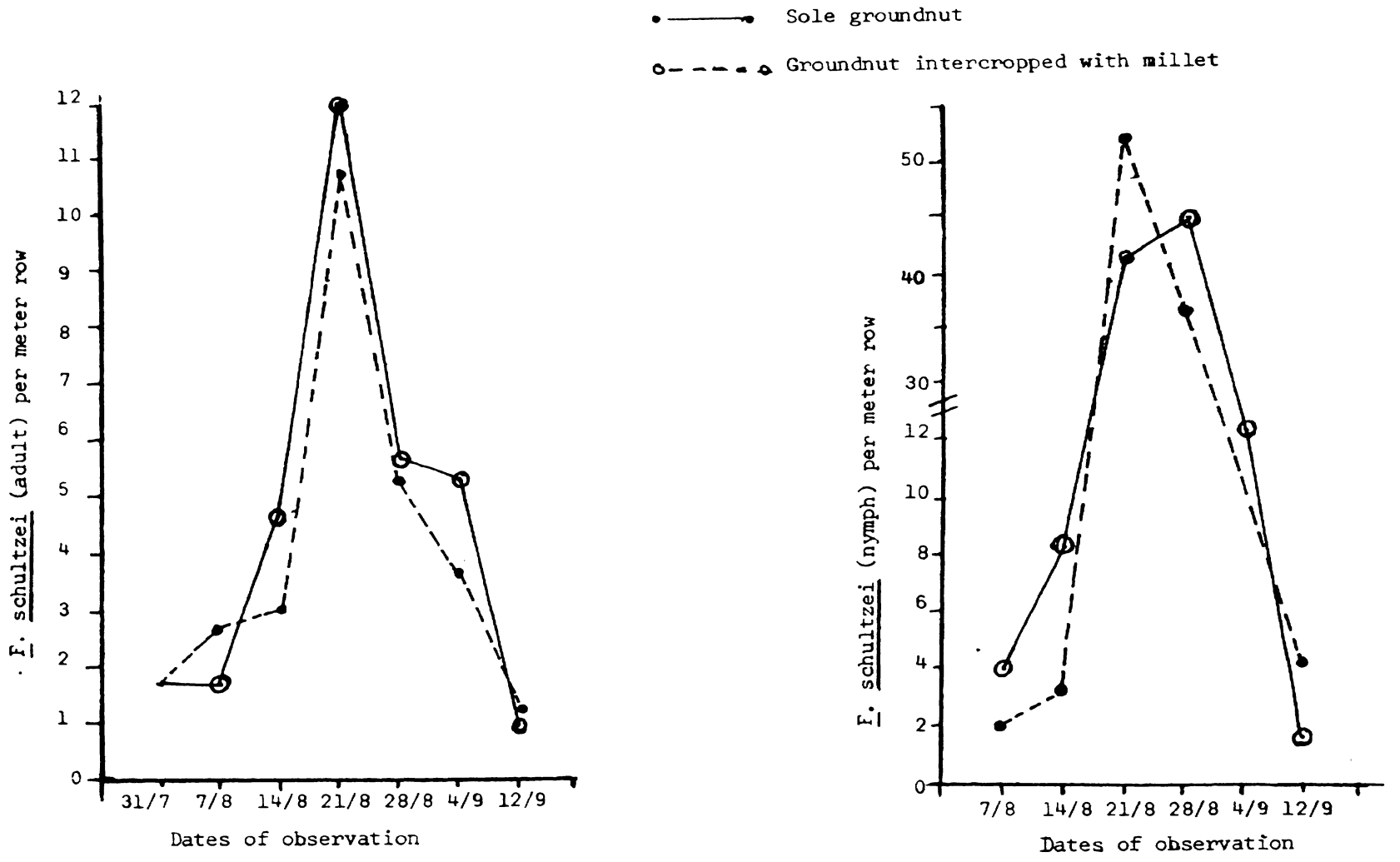
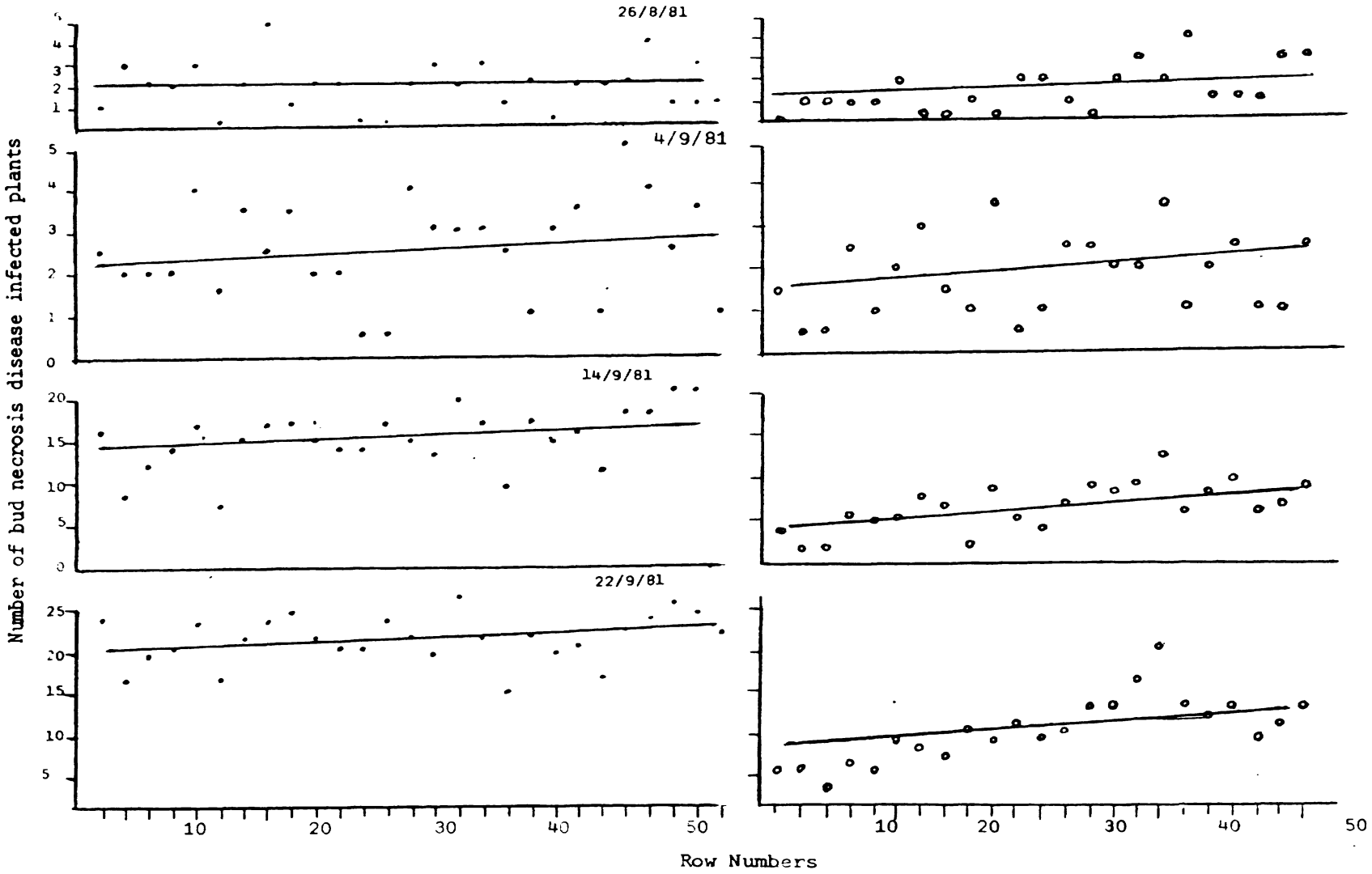


Fig. 39. Rowwise number of BND affected plants in sole and intercropped groundnut (Rainy season, 1981)



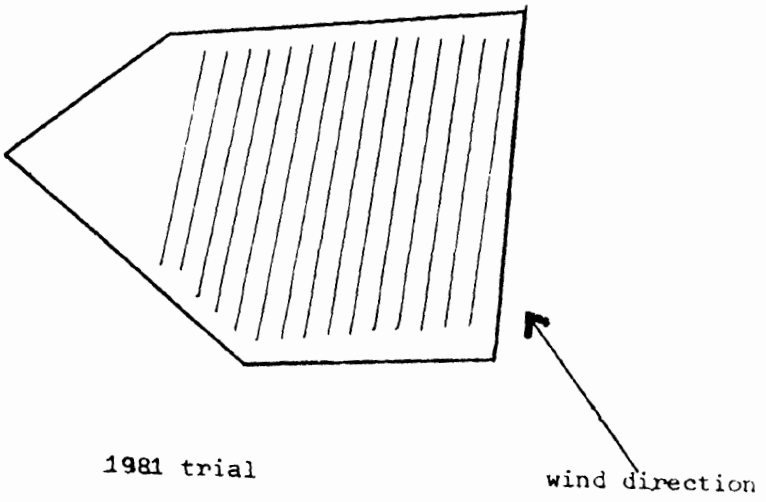
wind direction (Fig. 40), therefore pearlmillet may have been less effective as a barrier than in the 1982 trial.

In the 1982 rainy season trial, the numbers of BND infected plants were recorded in alternate rows of groundnut in the entire plot on 3 different dates coinciding with the peak periods of disease spread. This was plotted against BND spread in the sole plot (Fig. 41). It was seen that in the initial stage of crop growth in groundnut/pearlmillet intercrops the disease spread was less than in sole crops, but the distribution of BND infected plants in different rows was at random. By the third observation, when pearlmillet was well grown and formed the barrier, BND incidence had decreased progressively in intercropped rows indicating that the barrier effect was greater in central rows than in the border rows.

Thrips population was also less on intercropped groundnuts from August 31 to September 21st which is the peak period of migration (Fig. 42). Overall reduction of BND in the pearlmillet intercrop was more in the 1982 than in the 1981 trial. One possible reason could be the arrangement of the pearlmillet rows across the wind direction (Fig. 40) which served as barrier. Such barriers affected greatly the thrips deposition (Fig. 43).

In the 1983 season, sowing of intercrops had to be delayed because of delayed onset of monsoon rains. Therefore, pearlmillet reached only to a height of 1 m during the period of thrips migration. No reduction in BND incidence was observed.

Fig. 40. Arrangement of pearl millet rows in relation to wind direction in intercropping experiments



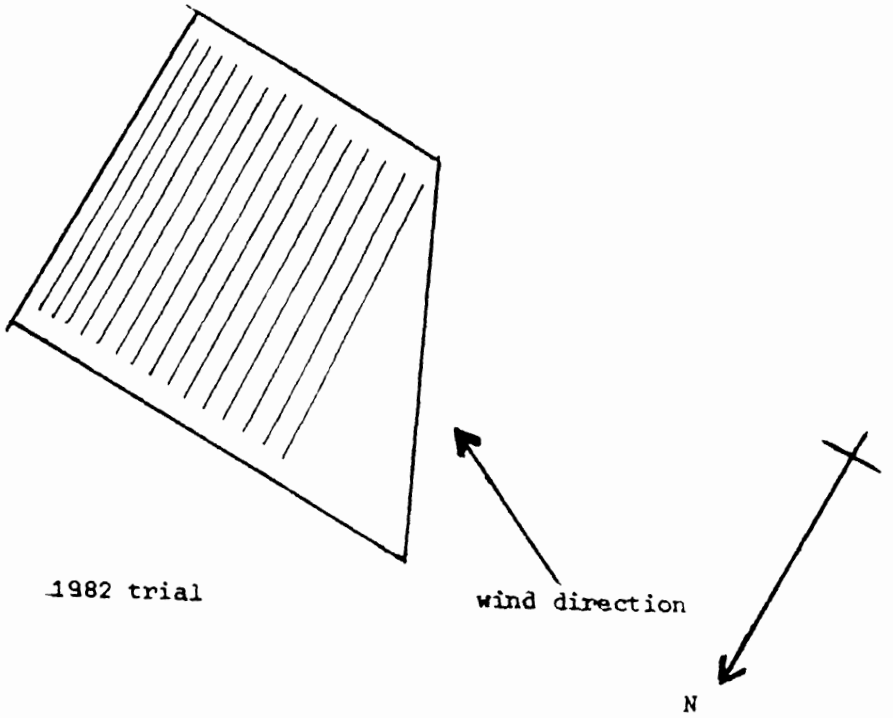


Fig. 41 . Bud necrosis disease incidence in different rows of sole intercropped groundnut
(Rainy 1982 season)

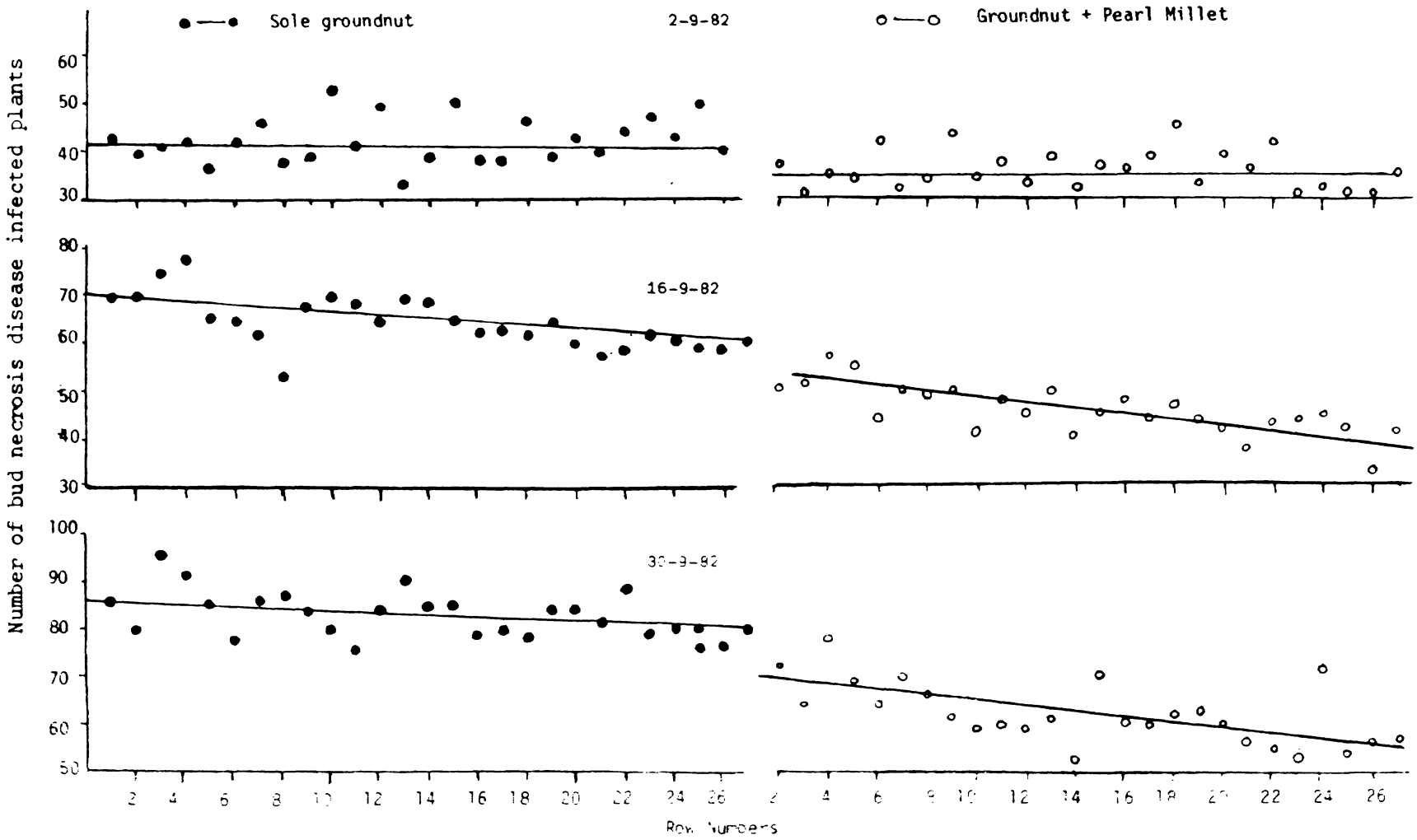


Fig. 42. Effect of intercropping on thrips incidence (Rainy 1982 season)

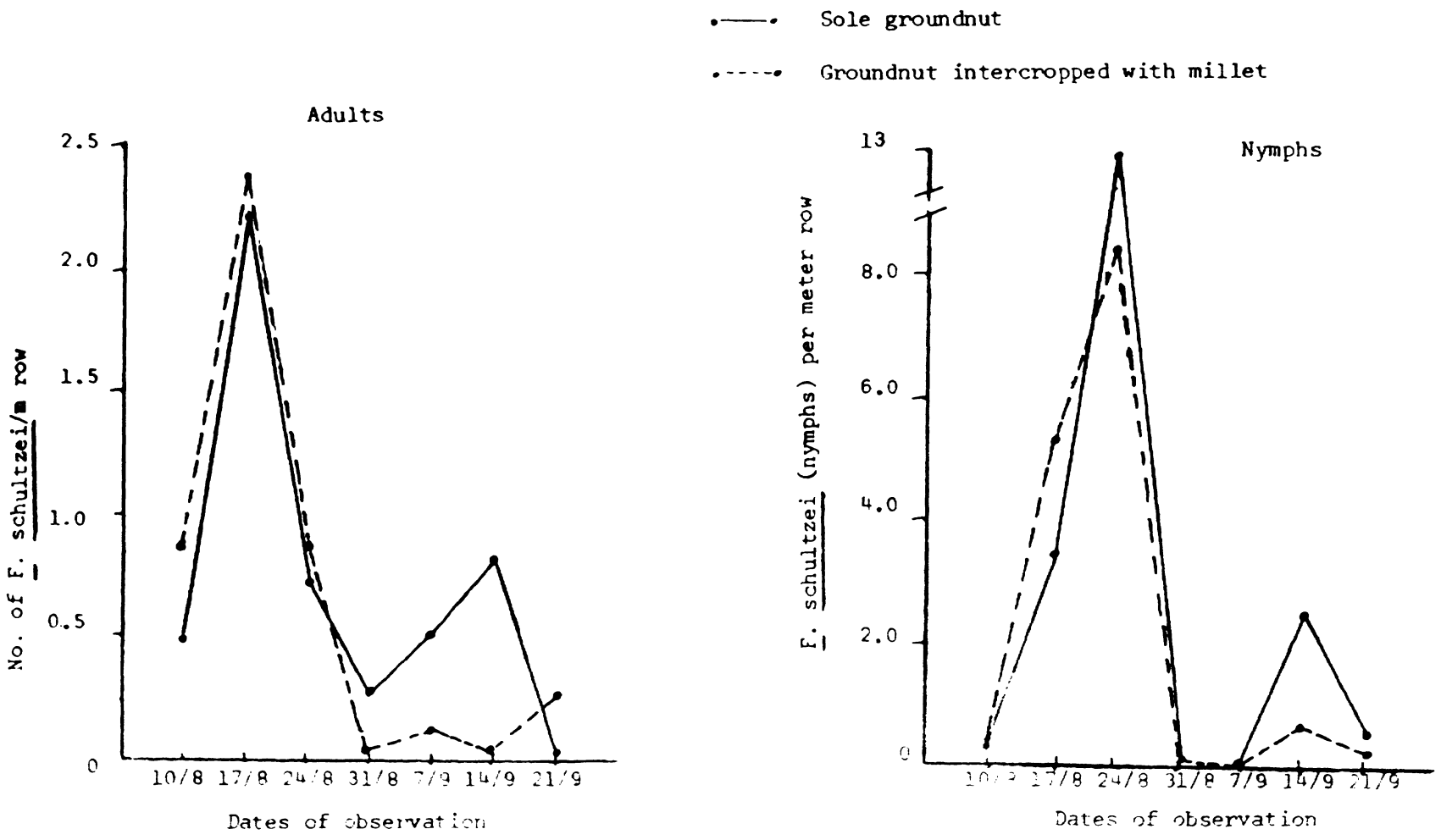
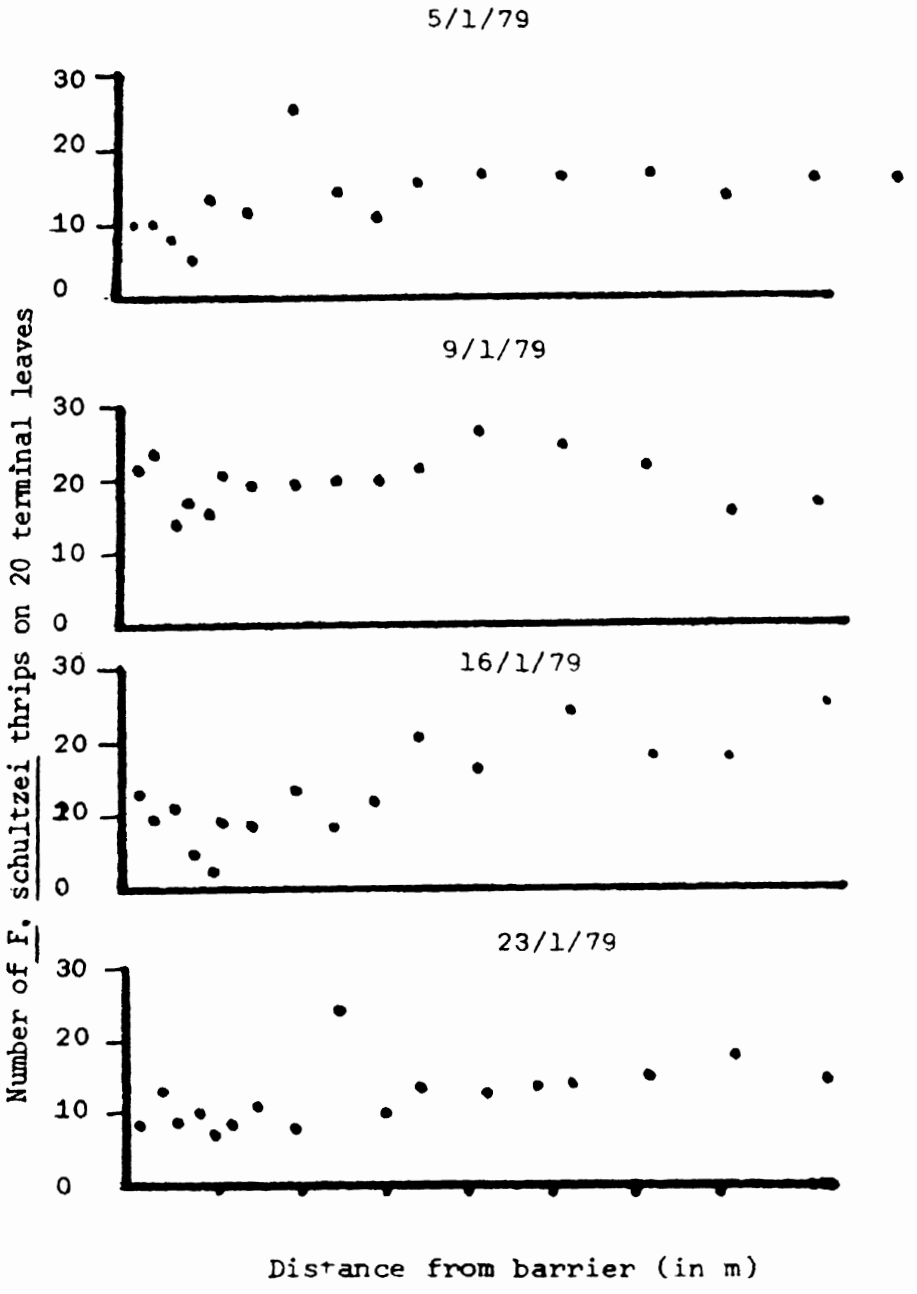


Fig. 43. Distribution of thrips in relation to barrier (2.5 m/h)
(Postrainy 1978-79)



It appears from the above three trials that the reduction in BND incidence in pearlmillet:groundnut intercrop results from the physical barrier provided by the pearlmillet crop. The effect can further be increased if (1) pearlmillet is planted thick, (2) has more tillering habit, (3) grows tall, (4) is grown across the prevailing wind direction.

5.10. BND incidence in relation to plant density

It was observed that in dense crops, thrips infestation was usually higher if one considers unit area though on a per plant basis it was lower than in sparse crops. This was reflected in BND incidence. In dense crops more plants were infected per unit area as compared to sparse crops.

In 1980, a trial was conducted to determine the effect of plant density on BND incidence with different plant spacings. As seen from Table 17 and Fig. 44, the number of BND infected plants increased with higher plant stand.

Similar results (Table 18) were obtained in the 1980 trial with 3 cultivars, TMV-2, Robut 33-1 and M-13 sown at 75 x 15 cm spacing or 30 x 10 cm spacing. In cultivar TMV-2, 340 plants were infected out of 1680 plants at 30 x 10 cm spacing while 288 got infected out of 503 plants at 75 x 15 cm spacing. Similar patterns of high number of BND infected plants at higher plant population were observed in other trials. However, the overall disease incidence in terms of the percentage of diseased plants is less at higher plant density. This because the increase in diseased plants was not proportional to increased plant density.

Table 17: Effect of plant density on BND incidence (rainy season, 1980)

Spacing (cm)	No.of plants per plot	No.of BND infected plants	% BND
75x15x1 seed	201	108	54 (47)
75x15x2 seeds	392	117	25 (30)
60x20x1 seed	187	88	47 (44)
60x20x2 seeds	349	149	46 (42)
30x10x1 seeds	522	222	42 (41)
30x10x2 seeds	1289	246	19 (26)
15x5x1 seed	1623	482	30 (33)
15x5x2 seeds	3617	402	11 (20)
SE ±	88.5		(2.25)
CV %	14.8		(11.06)

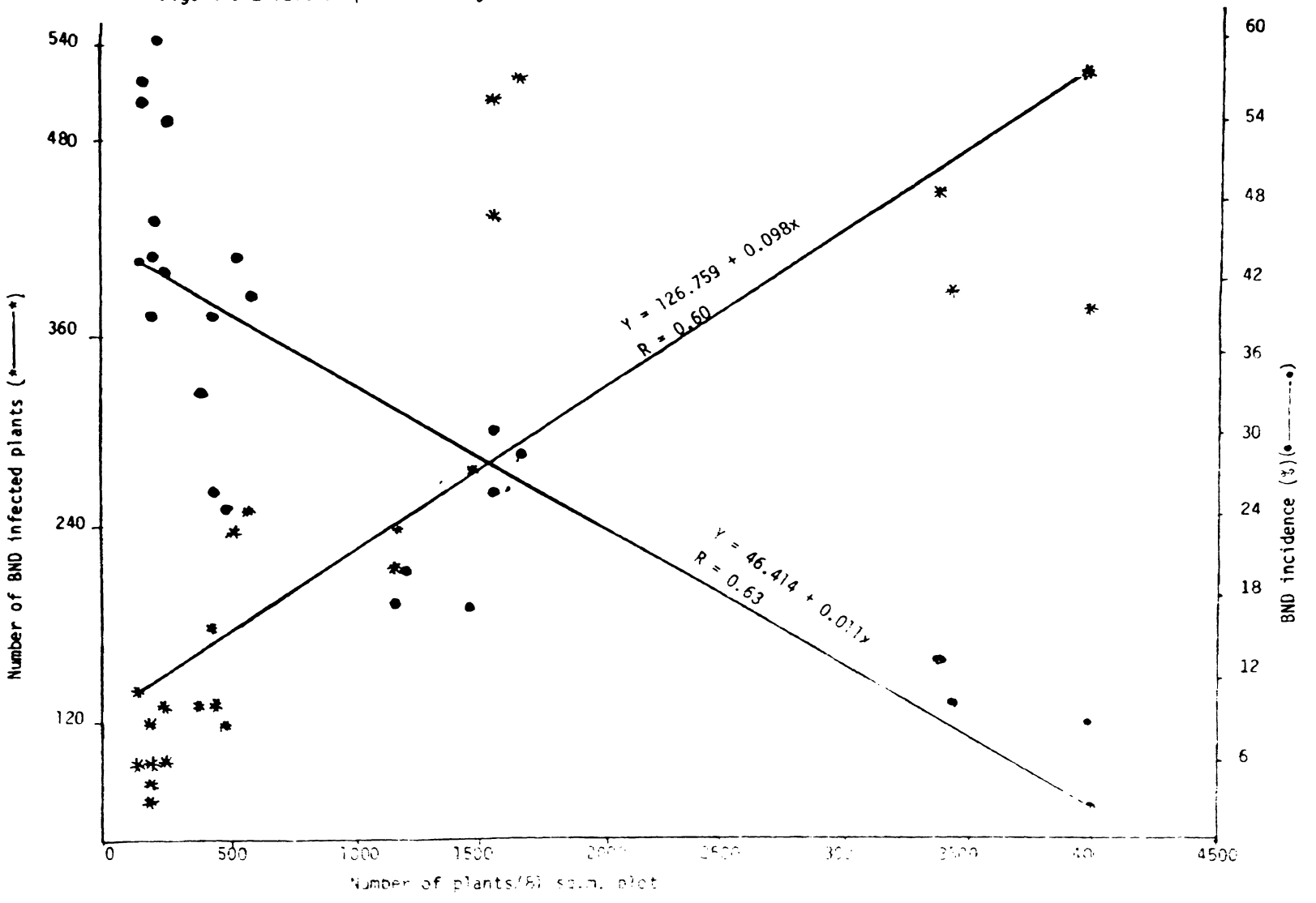
() = arcsine transformed values

Table 18: Effect of row and plant spacing on the number of BND infected plants (rainy season, 1981)

Cultivar	Spacing between rows	plants	No.of plants per plot	No.of plants infected with BND	% BND incidence
TMV 2	30	10	503	288	20.3(26.6)
	75	15	1680	340	57.3(49.3)
Robut 33-1	30	10	640	22	2.2(8.5)
	75	15	1966	47	3.4(11.0)
M-13	30	10	488	50	4.4(12.0)
	75	15	1556	71	10.3(18.2)
S.E. ±			39.7		(1.77)
CV %			7.0		(16.93)

= arcsine transformed values.

Fig. 44. Effect of plant density on bud necrosis disease incidence



5.11. BND incidence in relation to crop canopy:

In 1980 trial: In the experiment on spacing effect on BND incidence the canopy measurements were recorded at different dates and amount of ground coverage was estimated. The number of plants infected with BND and number of thrips/m row were recorded weekly. Results showed that numbers of BND infected plants per unit area were more in dense crops than in sparse crops but on a per plant basis, thrips were fewer in dense crops. The numbers of thrips per unit area were also more in dense crops than in sparse crops. When ground coverage was plotted against number of BND infected plants, a strong correlation was observed (Fig. 45).

1981-82 trial:

In the postrainy season of 1981-82, a trial was conducted to determine the effect of canopy of crop on BND incidence. TMV-2 cultivar was sown in plots of 10 x 10 m size on ridges 75 cm apart and at 15 cm between plants. There were 4 replications. In one plot, the canopy remained full, in the 2nd plot, canopy was reduced to half by removing branches. In the third plot, the canopy was reduced to one-fourth. The canopy reductions were done at weekly intervals. In the fourth plot, which was sown late mainly to study the effect of age on BND incidence, the canopy was not reduced. The sowing date for the first three plots was 10.12.81 and for the fourth plot was 22.12.81.

Canopy measurements, and thrips incidence were recorded weekly in one meter row. BND incidence was recorded in whole plot.

Results (Table 19) showed that the crop with full canopy had higher disease incidence. These plots also had higher thrips populations. Both the thrips numbers and the BND incidence were less in plots with reduced canopy. For example, in the full canopy plot total BND incidence was 63% compared to 43% in half canopy and 36% in one-fourth canopy. In late sown crop with full canopy the BND incidence was 47%.

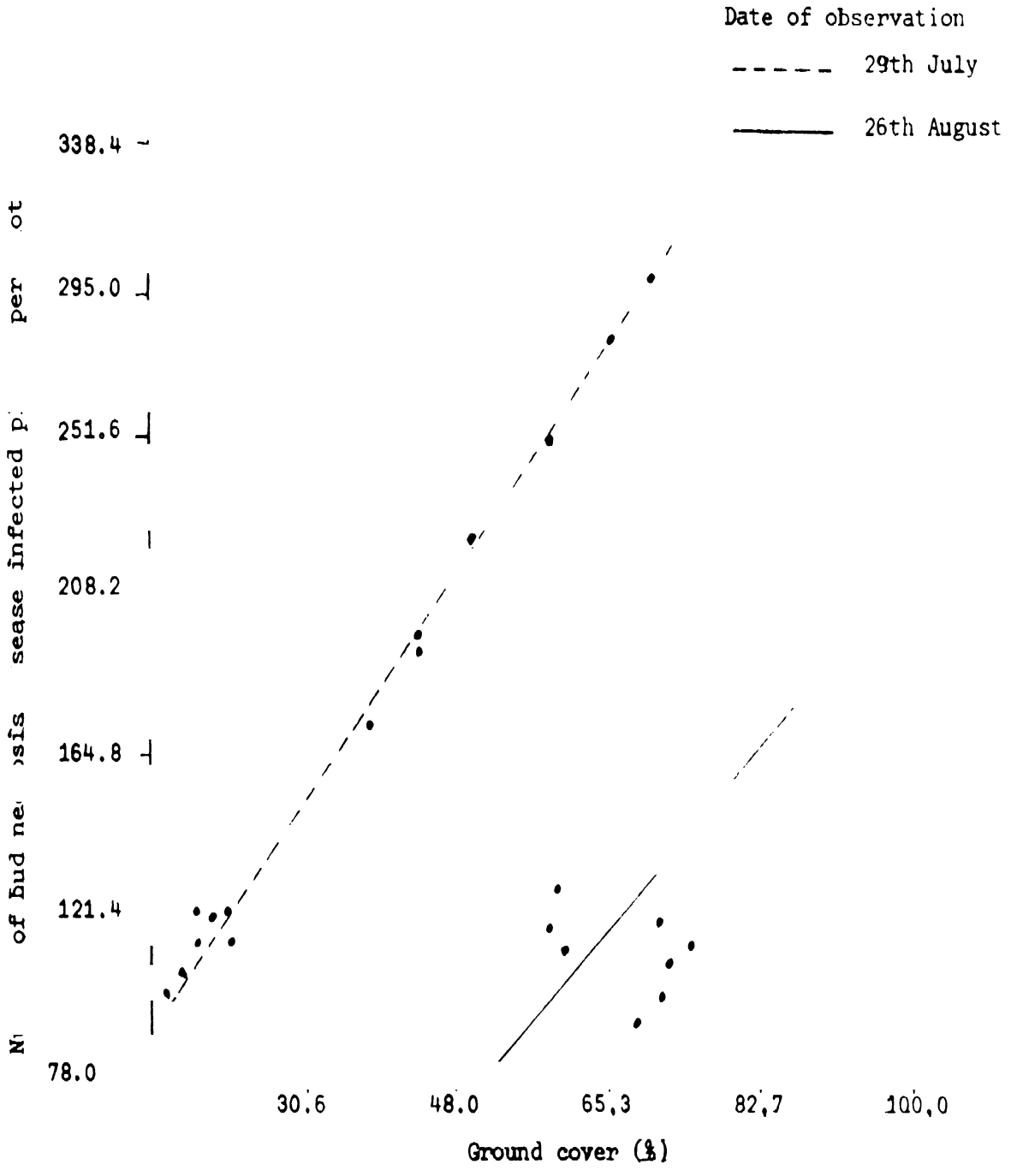
Table 19: Effect of canopy on BND incidence (1980-81 postrainy season)

Date of sowing	Canopy	Plants per plot	BND incidence (%)
10.12.80	Full	406	72
	Half	403	47
	one-fourth	403	43
22.12.80	Full	368	47
SE ±		23.8	2.9
CV %		12.0	12.2

5.12. Compensation effects:

Most yield loss estimation trials lack estimates of compensation effect. We set out to estimate compensation effects in healthy plants adjacent to infected plants. Two trials were conducted in the 1981 rainy season by sowing crops early (15th June sowing) and also late (15th July). Individual plants were labelled with date of symptom appearance and the weight of pods from all plants was recorded. The data from over 10,000 individual plants is being analysed for compensation effect.

Fig. 45. Effect of ground cover on bud necrosis disease incidence
Rainy season, 1980



Correlation matrix			
Ground cover on 29-7-80	1.000		
Ground cover on 26-8-80	0.760	1.000	
BND incidence % at harvest	0.967	0.705	1.000

5.13. **Effect of positioning of cultivars in relation to neighbouring cultivars on BND incidence:**

In the 1982-83 postrainy season, four cultivars were tested in serially balanced design to determine the effect of neighbouring cultivars on BND incidence in test cultivars. The cultivars included in this test were:

(1) TMV-2 - susceptible to thrips and BND
(2) Robut 33-1 - Less susceptible to thrips and BND
(3) NC Ac 2243 - Resistant to thrips
(4) NC Ac 1705 - Resistant to thrips

Each cultivar had all combinations of neighbouring cultivars. There were 36 plots, each cultivar appearing 9 times with different combinations of neighbouring cultivars. Plot size was 4 row x 4 m. 4 m of unsprayed guard row of TMV-2 cultivar was planted on all sides of this plot (Fig. 46).

BND was recorded on the 100th day after sowing. It can be seen that BND incidence was highest in TMV-2 cultivar and lowest in Robut 33-1 (Table 20). Neighbouring cultivars had some effect on BND incidence in test cultivars (Table 21). For example, when TMV-2 was placed in between thrips resistant cultivars BND incidence was higher, 46% when flanked with NC Ac 1705 and NC Ac 2243, 50% when flanked with NC Ac 2243 and NC Ac 1705, 45% when flanked with NC Ac 2243, 43% when flanked with Robut 33-1. For Robut 33-1 BND incidence was highest (23%) when flanked with TMV-2 and 20% when flanked with NC Ac 1705. Lowest incidence (8.6%) was observed when Robut 33-1 was flanked with NC Ac 1705 and TMV-2. For NC Ac 2243 which is highly resistant to

Fig.46. Lay out of serially balanced design to determine the effect of the position of thrips resistant and susceptible cultivars on bud necrosis disease incidence

Cultivars

A = TMV-2 Susceptible
B = Robut 33-1 Susceptible
C = NC Ac 2243 Resistant
D = NC Ac 1705 Resistant

thrips, not much variation was observed in BND incidence which ranged from 14-21%. For NC Ac 1705, highest BND incidence (31.6%) was observed when this cultivar was located between plots of NC Ac 2243. Lowest incidence (14.37%) was observed when this cultivar had NC Ac 2243 and TMV-2 as neighbouring cultivars. Incidence was also low (15.8%) when Robut 31-1 and TMV-2 were as neighbours and 15.7% when TMV-2 and Robut 33-1 were neighbouring cultivars.

Table 20: The mean BND incidence in different cultivars.

Cultivar	BND incidence %
TMV-2	42.1(40.4)
Robut 33-1	14.9(22.5)
NC Ac 2243 (T)	21.4(27.2)
NC Ac 1705	22.0(27.7)
SE ±	(1.39)
CV %	(14.14)

() = arcsine transformed values

Table 21: Effect of neighbouring cultivars on the BND incidence

Plot No.	Test cultivar	Neighbouring cultivars North side	South side	BND incidence % in test cultivar
1	TMV-2	Robut 33-1	NC Ac 2243	40.6
2	TMV-2	NC Ac 1705	Robut 33-1	37.8
3	TMV-2	NC Ac 1705	NC Ac 2243	46.3
4	TMV-2	NC Ac 2243	NC Ac 1705	50.0
5	TMV-2	NC Ac 1705	NC Ac 1705	37.7
6	TMV-2	NC Ac 2243	NC Ac 2243	45.1
7	TMV-2	NC Ac 2243	Robut 33-1	39.9
8	TMV-2	Robut 33-1	NC Ac 1705	38.3
9	TMV-2	Robut 33-1	Robut 33-1	43.3
10	Robut 33-1	TMV-2	TMV-2	23.3
11	Robut 33-1	TMV-2	NC Ac 2243	14.8
12	Robut 33-1	NC Ac 1705	NC Ac 1705	20.0
13	Robut 33-1	NC Ac 2243	NC Ac 2243	13.1
14	Robut 33-1	NC Ac 1705	NC Ac 2243	11.9
15	Robut 33-1	NC Ac 2243	NC Ac 1705	14.7
16	Robut 33-1	TMV-2	NC Ac 1705	12.8
17	Robut 33-1	NC Ac 1705	TMV-2	8.6
18	Robut 33-1	NC Ac 2243	TMV-2	15.0
19	NC Ac 2243	TMV-2	NC Ac 1705	16.2
20	NC Ac 2243	Robut 33-1	NC Ac 1705	16.2
21	NC Ac 2243	TMV-2	Robut 33-1	14.7
22	NC Ac 2243	Robut 33-1	TMV-2	21.0
23	NC Ac 2243	Robut 33-1	Robut 33-1	17.5
24	NC Ac 2243	NC Ac 1705	TMV-2	19.2
25	NC Ac 2243	TMV-2	TMV-2	18.5
26	NC Ac 2243	NC Ac 1705	NC Ac 1705	20.4
27	NC Ac 2243	NC Ac 1705	Robut 33-1	20.4
28	NC Ac 1705	NC Ac 2243	TMV-2	14.4
29	NC Ac 1705	NC Ac 2243	Robut 33-1	19.5
30	NC Ac 1705	Robut 33-1	TMV-2	15.8
31	NC Ac 1705	TMV-2	TMV-2	22.5
32	NC Ac 1705	TMV-2	Robut 33-1	15.7
33	NC Ac 1705	Robut 33-1	NC Ac 2243	27.0
34	NC Ac 1705	Robut 33-1	Robut 33-1	24.9
35	NC Ac 1705	TMV-2	NC Ac 2243	26.6
36	NC Ac 1705	NC Ac 2243	NC Ac 2243	31.6

Interesting results showing effect of neighbours on BND incidence were obtained when BND incidence was recorded in individual rows of the 4 row plots (Table 22). For example, in TMV-2 cultivar, the row adjoining Robut 33-1 on one side had 50% BND and the row adjoining NC Ac 2243 had 58.0% BND while the central two rows had only 21 and 33% BND. Similarly TMV-2 row adjoining Robut 33-1 had 23.1% BND and the row adjoining NC Ac 1705 had 30.8% while in the central 2 rows it was 57.1 and 42.3%. Tremendous variation in BND incidence in different cultivars in relation to neighbouring cultivars was observed indicating effect of positioning of cultivars on BND incidence. This information can be made use of in screening of groundnut cultivars for BND resistance. In advanced screening a minimum of 4 row plots should be used and only the central two rows should be considered for recording observations.

Table 22: BND incidence in individual rows of test cultivar in relation to neighbouring cultivars

Test cultivar	Northside neighbouring cultivar	BND incidence (%) in rows of test cultivar				Southside neighbouring cultivar
		1	2	3	4	
TMV-2	NC Ac 2243	25.0	46.1	38.5	50.0	Robut 33-1
	NC Ac 1705	20.8	27.6	45.8	56.5	NC Ac 1705
	Robut 33-1	50.0	21.0	33.3	57.9	NC Ac 2243
	NC Ac 1705	40.9	30.4	55.0	25.0	Robut 33-1
	NC Ac 1705	40.9	42.9	62.5	38.9	NC Ac 2243
	NC Ac 2243	47.8	50.0	47.6	54.5	NC Ac 31705
	NC Ac 2243	45.8	38.5	36.4	60.0	NC Ac 2243
	Robut 33-1	23.1	57.1	42.3	30.8	NC Ac 1705
	Robut 33-1	34.6	42.5	53.8	42.3	Robut 33-1
Robut 33-1	TMV-2	28.6	35.3	18.8	10.5	TMV-2
	TMV-2	5.9	13.0	23.8	16.7	NC Ac 2243
	NC Ac 1705	21.0	31.8	9.1	18.2	NC Ac 1705
	NC Ac 2243	9.5	12.5	9.5	21.0	NC Ac 2243
	NC Ac 1705	18.7	11.5	14.3	3.1	NC Ac 2243
	NC Ac 2243	15.4	11.5	16.7	15.4	NC Ac 1705
	TMV-2	9.5	13.0	20.0	8.7	NC Ac 1705
	NC Ac 1705	7.7	3.8	15.4	7.7	TMV-2

	NC Ac 2243	14.3	13.6	12.0	20.0	TMV-2
NC Ac 2243	TMV-2	26.9	7.1	12.5	20.0	NC Ac 1705
	Robut 33-1	15.4	15.0	19.2	15.4	NC Ac 1705
	TMV-2	6.7	20.0	28.0	4.2	Robut 33-1
	Robut 33-1	25.0	4.5	31.8	22.7	TMV-2
	Robut 33-1	4.3	21.7	28.0	15.8	Robut 33-1
	NC Ac 1705	23.8	19.2	22.7	11.1	TMV-2
	TMV-2	20.0	7.7	27.3	19.2	TMV-2
	NC Ac 1705	19.0	21.0	24.0	17.6	NC Ac 1705
	NC Ac 1705	13.6	36.4	13.6	18.2	Robut 33-1
NC Ac 1705	NC Ac 2243	7.7	13.8	21.7	14.3	TMV-2
	NC Ac 2243	22.7	20.0	11.5	23.8	Robut 33-1
	Robut 33-1	8.3	22.2	11.5	21.0	TMV-2
	TMV-2	30.0	10.0	35.0	15.0	TMV-2
	TMV-2	11.8	17.6	4.8	28.6	Robut 33-1
	Robut 33-1	20.0	27.3	25.0	35.7	NC Ac 2243
	Robut 33-1	17.6	33.3	15.4	33.3	Robut 33-1
	TMV-2	44.4	28.6	23.5	10.0	NC Ac 2243
	NC Ac 2243	16.7	33.3	26.3	50.0	NC Ac 2243

5.14. BND incidence in unsprayed plots surrounded by insecticide-sprayed plots.

In several trials involving use of insecticides to control BND, it was essential to know the effect of sprayed plots on adjoining unsprayed plots or what is known as interplot interference. In the 1979-80 postrainy season, a trial was conducted with cultivar TMV-2 planted on ridges 75 cm apart and with plant spacing of 15 cm. This was the trial with treatments that compared the efficacy of different numbers of dimethoate sprays for controlling BND. One of the treatments was an unsprayed control. The thrips and BND incidence in such unsprayed plots was compared with two large plots of groundnut located outside the insecticide trial.

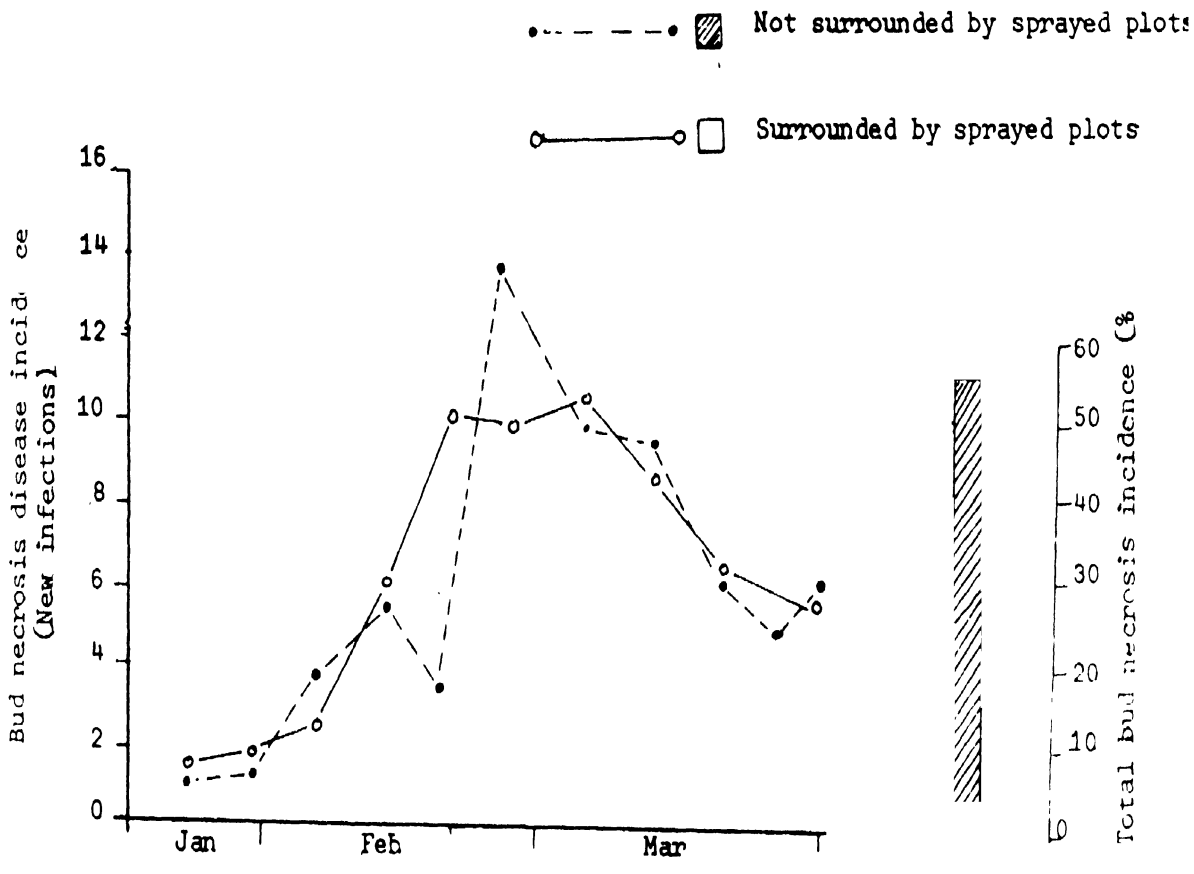
The observations recorded (Fig. 47) clearly showed that BND incidence was less in unsprayed plots surrounded by insecticide treated plots (BND incidence 50%) than in unsprayed plots located outside the insecticide trial (BND incidence 55%). Therefore, in all subsequent trials using pesticides, the control plots were located outside the main trial.

5.15. Sampling of BND infected plants: The distribution of BND infected plants was not random in large plots and therefore, the whole plots were considered when BND infected plants were recorded. In experiments involving studies on the effect of barrier crops BND affected plants were recorded in each row of groundnut crop. In experiments involving insecticide application, the borders of 2-3 meters were left out and the central portion was used for observation. In the insecticide trial, it was observed that unsprayed plots located within the insecticide treated plots had fewer thrips and less BND incidence than unsprayed plots outside the experiment. Therefore, all subsequent trials were conducted with guard rows of unsprayed groundnut surrounding each treatment plot.

In smaller plots, the numbers of BND infected plants were counted at weeks interval. In large plots involving counting of a large number of plants, usually 3-5 observations at weeks interval were recorded. These usually covered observations in young crop as well as old crop.

Fif. 47. Bud necrosis disease incidence in unsprayed groundnut plots surrounded by insecticide-treated plots

Post rainy season 1979-80



6. Ecology of *Frankliniella schultzei*:

6.1. Sampling method:

6.1.1. On plants: Three methods of sampling of thrips on groundnut plants were tested to obtain quantitative estimates of size and distribution of living populations.

(a) Estimates from collected shoots: 5 shoots were collected from the main branches of individual plants and were brought to the laboratory. Each shoot was shaken vigorously in 30% ethyl alcohol and the exposed thrips were counted. The shoots were then carefully examined for the remainder of the thrips. The number of extracted thrips and those remaining on plants are given in Table 23.

It is clear that extracting thrips with alcohol is not a suitable method and large numbers of thrips, particularly the larvae which are slow moving, remain in/on the shoot. Poor extraction results from the habit of thrips of hiding inside the leaf bud.

(b) Estimates from collected shoots exposed to chloroform: Terminal portions of main branches were plucked and thrips were counted on them by carefully opening the leaf buds. Then, the shoots were exposed to chloroform for 15-20 seconds by introducing a cotton swab soaked in chloroform into each polythene bag. Shoots were then removed and thrips were recorded. The inside of the polythene bag was also checked for any thrips wandering on them. The results are shown in Table 24.

Table 23: The efficiency of extraction of different stages of thrips from groundnut using 30% ethyl alcohol.

Date	Extracted in alcohol		No. of thrips remained on shoot		% extracted	
	Adult	Nymphs	Adult	Nymphs	Adult	Nymphs
8.1.81	2	0	1	0	66	-
15.1.81	1	2	2	0	33	100
22.1.81	4	4	4	6	50	40
29.1.81	2	6	0	13	100	31
3.2.81	0	3	0	20	-	13
12.2.81	0	0	1	2	75	0
Total	12	15	8	41		
Average					65	31

TABLE 24. Comparison of in "situ" counts of thrips with those immobilized with chloroform.

Number of shoots sampled	Total number of thrips in "situ"		Exposed to chloroform	
	Adult	Nymphs	Adults	Nymphs
35	146	300	144	366

It is clear from the above results that counting thrips after immobilizing them with chloroform is useful, particularly for counting larvae. However, the method is cumbersome. In addition, longer exposures than a few seconds to chloroform results in leaves becoming flaccid and brown, which makes counting difficult.

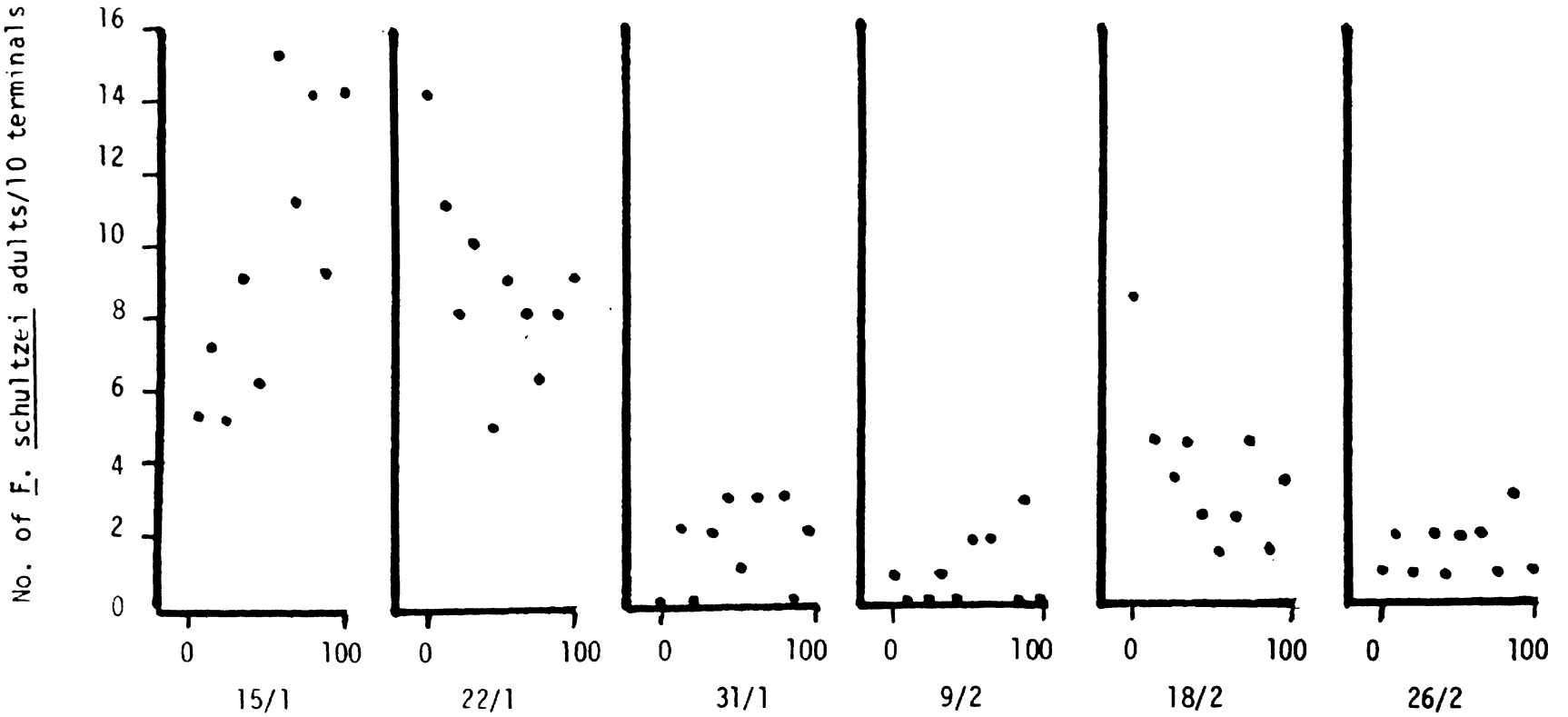
Counting "in situ": As a routine method, counting "in situ" was practiced. This is a quicker method and does not involve removing leaves or shoots from plants and thus is advantageous particularly during early stages of crop growth when there are few leaves and branches. This method however, has the limitation that thrips, being active, do not remain still for long enough to be counted reliably. However, with trained persons, the error can be minimized.

Sample size: In small plots thrips are distributed randomly but in very large plots some gradient was observed on a few dates. For example, in 100 L x 30 W meter plot, thrips showed aggregation on some dates but not on others (Fig. 48). However, most of trials were conducted on plot sizes of 12 sq.m. to 450 sq.m. and on such plots, random distribution of thrips was assumed. To standardize number of sampling units in small plots, a plot of 100 sq.m. was selected having a total of 840 plants at 75 cm row and 15 cm plant spacing. From these plants 42, 17 and 8 shoots were plucked at random to form 5%, 2% and 1% sample size and thrips were counted. The mean numbers of thrips in these three sample units were similar (Table 25) indicating that 1% sample size was adequate for plots of up to 100 sq.m. size.

Table 25: Number of thrips on shoots comprising different sample sizes postrainy season 1977-78

Total No. of plants	No. of plants sampled	Sample size	No. of thrips/shoot (average) Adult	Nymphs
840	42	5%	2.9	4.1
	17	2%	3.0	4.3
	8	1%	3.0	4.0

Fig. 48 . Distribution of thrips in 30 x 100 meter plot on different dates
Postrainy season, 1980-81



In larger plots of more than 100 sq.m. the 5 sampling units of 1 m row each were arranged, one each at the corners and one in the center (Fig. 49). This was done to account for variation in thrips population at different locations in a plot. From Table 26 it can be seen that large variation occurred in thrips population from one location to another in a plot of 450 sq.m. and from one replication to another with coefficient of variation ranging from 50 to 220%. However, use of large samples becomes time consuming for routine observations.

Sampling frequency: Usually, all stages of thrips were found simultaneously on groundnut except during early stages of crop growth when only the adults are found or during late stage of crop when only the nymphs are found. Therefore, frequency of observations could not be phased in with generations of thrips. As a routine practice, sampling was done at weekly intervals.

6.1.2. In air:

Flat Boards: Colour background: Initially attempts were made t sample thrips in air with impaction boards arranged vertically. To obtain information on the effect of colour background on thrips catches, six colours were tested. Flat boards 10 cm in width and 15 cm in length were painted white, blue, red, yellow, green or black and were coated with "tangle foot" sticky materials. They were placed at 1 m height above ground. Of the six colours, white boards caught most thrips followed by blue. The least catches were on black boards (Table 27). Since yellow was found attractive to other insects such as aphids and jassids, boards of this colour were used, to record observations on other insects also.

Fig. 49. Arrangement of one meter row sampling units in a large groundnut plot to record thrips infestation

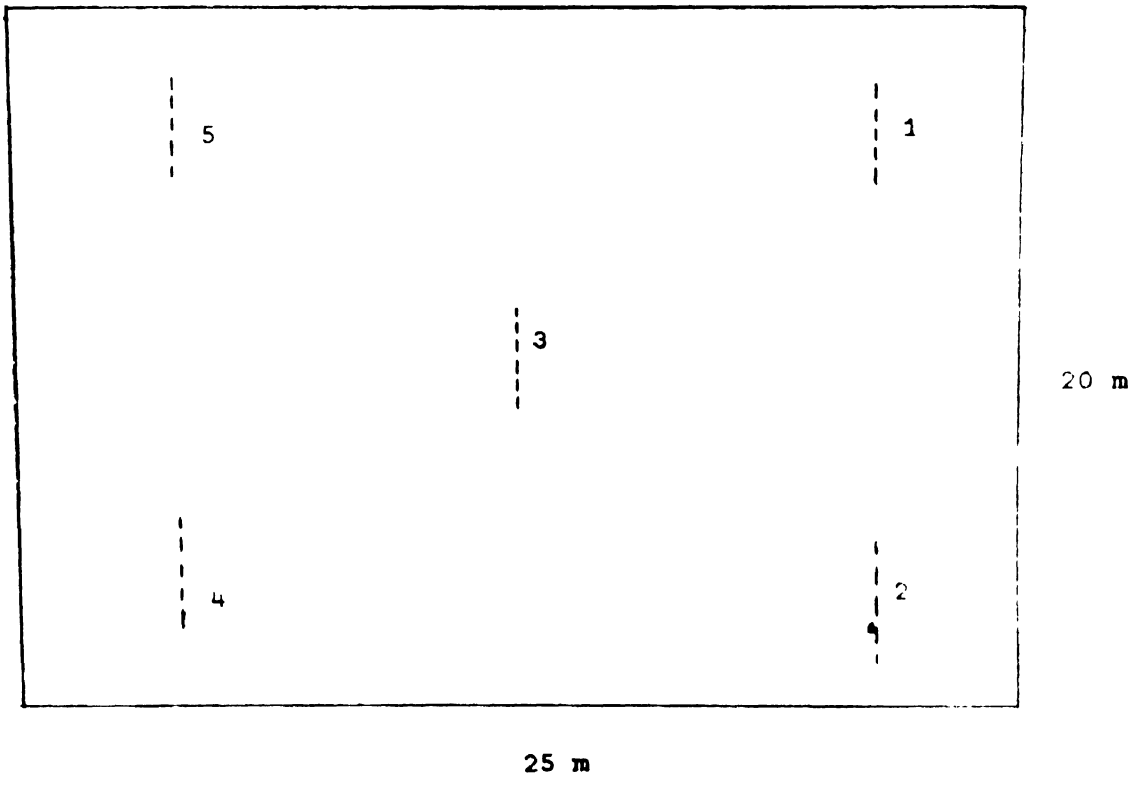


Table 26: Number of *S. dorsalis* and *F. schultzei* thrips at different locations in a large plot (450 sq.m) of TMV-2 groundnut

Location of sampling unit	Date of sampling	Number of thrips adults (A) and nymphs (N)											
		S. dorsalis						*F. schultzei*					
		A	N	A	N	A	N	A	N	A	N	A	N
		RI		RII		RIII		RI		RII		RIII	
South corner		1	60	0	44	10	41	0	4	0	13	0	0
West corner		3	38	4	49	9	88	0	0	0	0	3	4
Central	5.9.81	6	46	3	35	3	47	0	0	5	14	0	2
North corner		2	65	3	34	14	118	0	0	0	4	0	9
East corner		4	56	2	49	10	12	0	0	1	10	0	0
South corner		0	6	1	27	1	35	0	9	2	1	2	2
West corner		3	11	3	24	5	49	0	4	1	0	1	5
Central	12.9.81	0	31	2	29	2	33	0	0	2	0	1	1
North corner		0	11	2	18	2	21	0	1	0	0	3	0
East corner		4	37	0	17	3	31	0	17	0	0	1	2
Corner south		3	5	6	16	2	35	0	0	2	0	0	0
Corner west		1	17	1	10	9	40	0	0	0	0	2	0
Central	19.9.81	2	7	5	12	4	57	1	3	3	0	0	0
Corner north		4	10	6	8	5	7	0	3	0	0	0	0
Corner east		3	14	0	2	6	12	3	0	0	0	0	0
Corner south		0	9	1	7	3	16	1	0	1	0	1	1
Corner west		0	0	0	13	3	8	0	0	0	0	1	2
Central	26.9.81	3	16	0	32	2	13	0	0	0	0	2	0
Corner north		0	3	1	17	2	11	0	0	2	0	3	6
Corner east		0	1	4	24	2	16	0	0	1	0	2	3

Table 27: Effect of colour background on thrips catches

Colour	No. of thrips trapped
White	126
Blue	100
Yellow	84
Green	79
Red	32
Black	14
SE ±	1.45
CD	4.48

Height and Direction: Flat sticky boards of yellow colour were placed at different heights and facing different directions. The total of the catches on 5 days from 3rd to 9th January 1978 are shown (Table 28); traps at 0.5 to 2 meters height gave similar catches while traps placed at 2.5 and 3 m caught fewer thrips.

Table 28: Thrips catches on flat sticky boards placed at different heights and directions (postrainy 1977-78)

Height (m)	Placement of boards Facing Direction				No.of thrips trapped
	S	N	W	E	
0.5	12.4	6.2	11.6	17.8	48.0
1.0	15.0	7.0	5.6	19.0	46.6
1.5	12.0	5.6	2.6	18.8	39.0
2.0	13.0	6.2	4.4	13.2	36.8
2.5	10.4	4.8	2.6	13.6	31.4
3.0	9.4	1.8	2.0	9.0	22.2
Total	72.2	31.6	28.8	91.4	224.0

It is seen from these results that the largest numbers of thrips were caught on boards facing east and south (prevailing wind direction) at heights 0.5 to 2.0 m and on white boards. Similar effects of wind direction on thrips catches was observed in the rainy season of 1978 when most thrips were caught on boards facing west and very little on boards facing east (Table 29, Fig. 50).

However, the use of flat boards was discontinued as these were cumbersome and better alternatives became available.

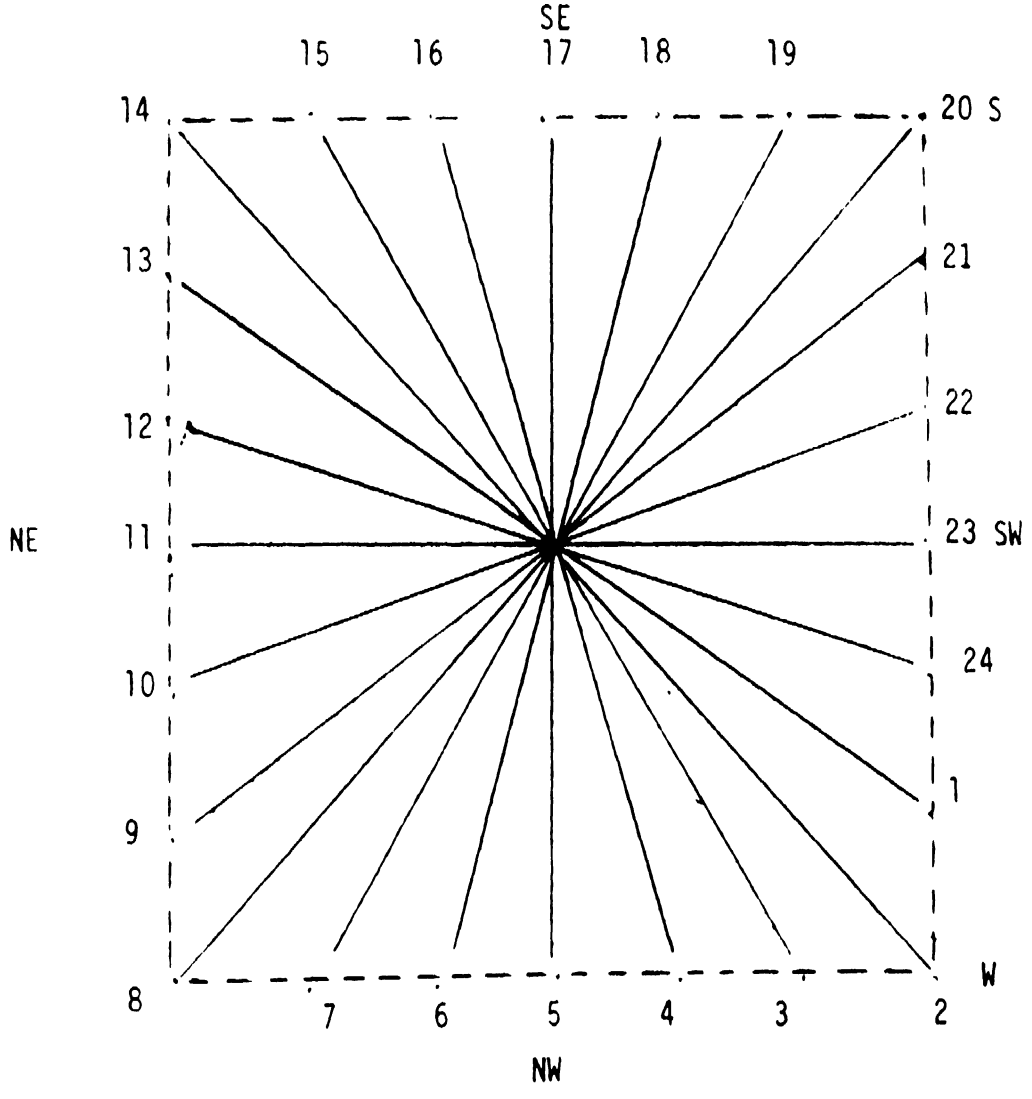
Table 29: Thrips catches on flat boards placed at 1 m height and facing in different directions (rainy season 1978)

Boards facing	Board No.	No.of thrips caught on dates* 25/8	18/8	11/8	4/8	28/7	1/9	Total	
	1-3	87	37	16	7	5	29	181	33.7
NW	4-6	46	71	13	9	2	9	150	28.0
N	7-9	8	31	0	0	0	2	41	7.6
NE	10-12	6	23	1	1	0	1	32	5.9
E	13-15	6	15	0	0	0	1	22	4.1
SE	16-18	3	16	0	0	0	0	19	3.5
S	19-21	3	10	0	0	0	2	15	2.8
SW	22-24	31	28	7	2	2	6	76	14.3

* Prevailing wind direction was from West, North West or South West to East, South East or North East on different dates

Sticky cylinders: To overcome some of the disadvantages of flat boards, they were substituted with sticky cylinders of 25 cm height and 15 cm d. with black paper as background. Black background was used as this colour is not attractive to most species of thrips. Even though cylinders were more efficient and simultaneously gave information on catches from different directions, they were found to be cumbersome and were not suitable for routine observations.

Fig. 50 · Placement of yellow impaction boards to record thrips from different directions



suction trap: Suction traps are most useful for measuring the absolute density of aerial populations and the daily periodicity of flight in relation to weather conditions. From 1978-79, we operated a small suction trap with a 23 cm fan (Fig. 51) delivering about 460 m3 of air per h. The trap was found useful in catching individual thrips in clean and easily identifiable state. The trap was operated daily; catches were recorded at hourly intervals.

Initially, suction traps were run for 24 hr every day. Later when it was found that no thrips were caught from 2000 hrs to 800 hrs, the sampling was restricted to day time. For a short period, the traps were run on two 12-V batteries to avoid the effects of fluctuating voltage but this was later given up because batteries required recharging every day and they were expensive.

A drawback of the suction trap was sorting of thrips from a large number of other insects caught, particularly aphids, jassids, midges and sometimes lepidoptera, and this usually took far more effort than trapping itself. Often mass migrations of midges coincided with the migration time of thrips in the evenings and this created problems of sorting.

The requirement of electricity to run suction traps put restrictions on their setting up near to source of electricity. Though majority of entomological trials were conducted on pesticide-free alfisol, no suction trap could be set up because of high cost of providing electricity in this area in addition to security problems.

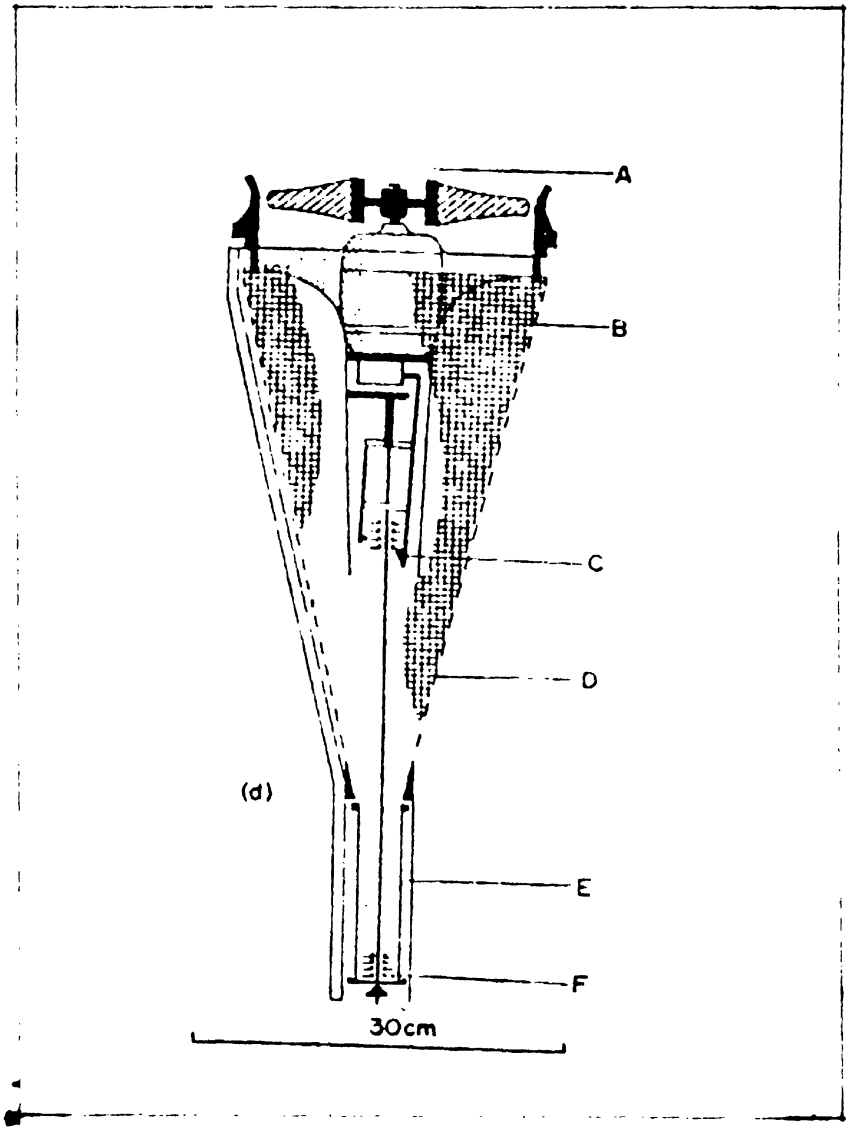


Fig. 51. (d) Suction trap with automatic segregating mechanism for sampling airborne populations (simplified after Taylor, 1951). A: fan inlet; B: fan motor; C: disc-dropping mechanism; D: gauze filter net inside iron framework, E: collecting tube; F: segregating discs.

6.2. Migration of thrips: Most of the information on migration of thrips was obtained from suction trap catches. As can be seen from various figures (Fig. 52-58), the largest number of thrips were caught in the months of August and September in all the three rainy seasons of 1979 (Fig. 52), 1980 (Fig. 53) and 1981 (Fig. 54). Large thrips catches in August and September in suction trap were associated with large catches on plants (Fig. 55) and associated TSWV spread (Fig. 56). The lowest number of thrips were caught in the hot summer months from May-June and in October. In these periods thrips population were lowest on groundnut and other crops. In the postrainy season, thrips catches were large (100 thrips) on 29th December in 1980 (Fig. 57) and on 25th December (98 thrips) in 1981 (Fig. 58). The trap was not operating for the entire month of December in 1982. The high catches in suction trap coincided with high catches of thrips on groundnuts (Fig. 55 and 56). In the 1981 postrainy season, for example, large numbers of thrips were observed on plants after each large catch in the suction trap. This was observed for the period December to the middle of February. Thereafter, thrips populations on plants declined rapidly though suction trap catches remained moderately high indicating that the thrips were leaving the crop.

6.2.1. Factors affecting migration: No analysis has been carried out so far on the effect of weather factors on migration of thrips mainly because of lack of precise data on weather conditions during the period when migration of thrips was happening. However, some indications were obtained by plotting thrips catches and magnitude of maximum and minimum temperatures, wind speed and rainfall. Trap catches on 47 dates from June to September (1980 rainy season) and associated weather parameters are given in Table 30.

It appears from this data that very low catches in the month of June were either related to high temperatures >30 C and wind speeds >20 km/ph or they may also reflect overall low populations on plants. In July, the largest numbers of thrips were caught when maximum temperature was 31 C and wind speed less than 15 kph. The sudden drop in thrips catches from 16 on 22nd July to 1 on July 24 appears to be due to high rainfall on that day. In August, the high catches were on days with very low wind (6-10 kph) with temperatures in the range of 24-32 C. Sudden drop in catches from 88 on 19th August to 10 on 20th August appears to be due to heavy rains (100 mm) on that day. When rainfall ceased and temperature declined, the catches increased again to 48 on 21st August. Catches declined to 20 on 22nd August with rise in temperature and wind velocity. In September, catches were 25 on 1st when temperature was 30 C and wind velocity decreased by 3 km/h to 9 km/h. Highest catches were on 4th September when temperature declined substantially (24 C) and wind velocity was low (11 km/h).

This seems to be the pattern, the thrips catches increase when either temperature or wind velocity declined and rainfall was low (Fig. 56). Detailed data on weather parameters in relation to thrips migration is being collected.

Fig.52 . No. of Frankliniella schultzei caught in suction trap

December 1978, January-December 1979 and December-January 1980

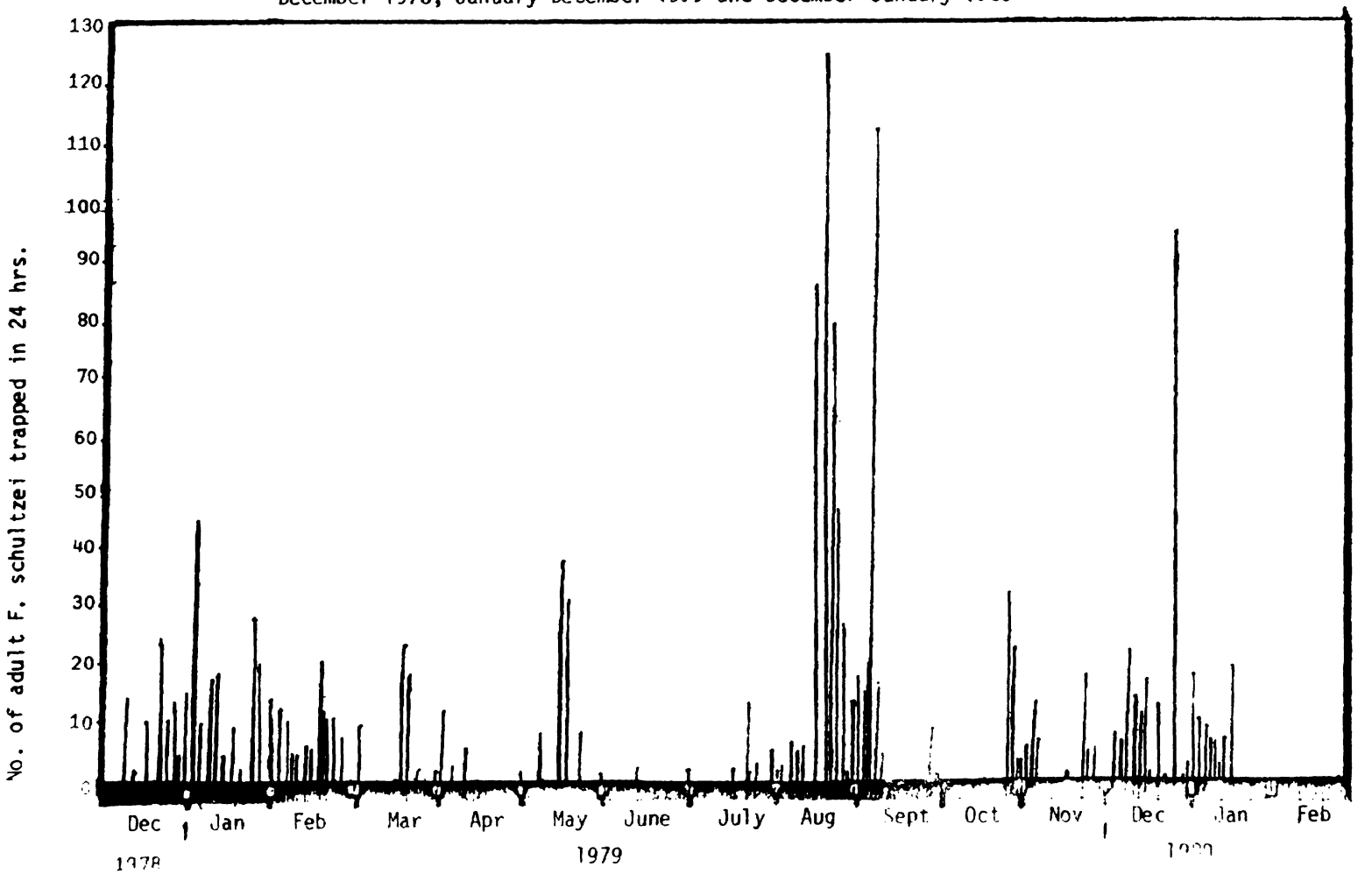


Fig 53 . Temperature, wind velocity and rainfall in relation to catches of F. schultzei in suction trap (Rainy 1980 season)

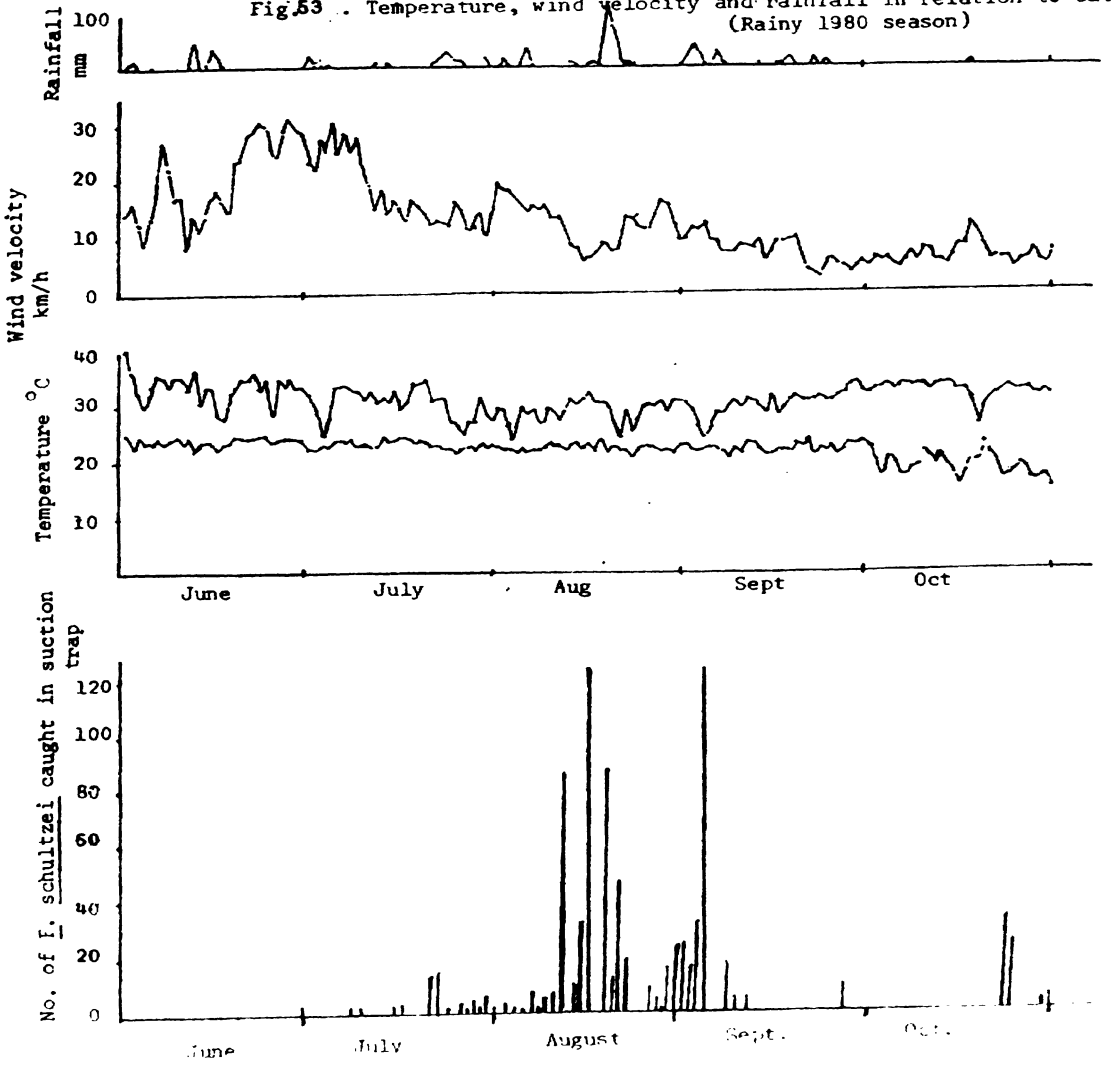


Fig. 54. Number of Frankliniella schultzei adult thrips caught in suction trap from July to December, 1981

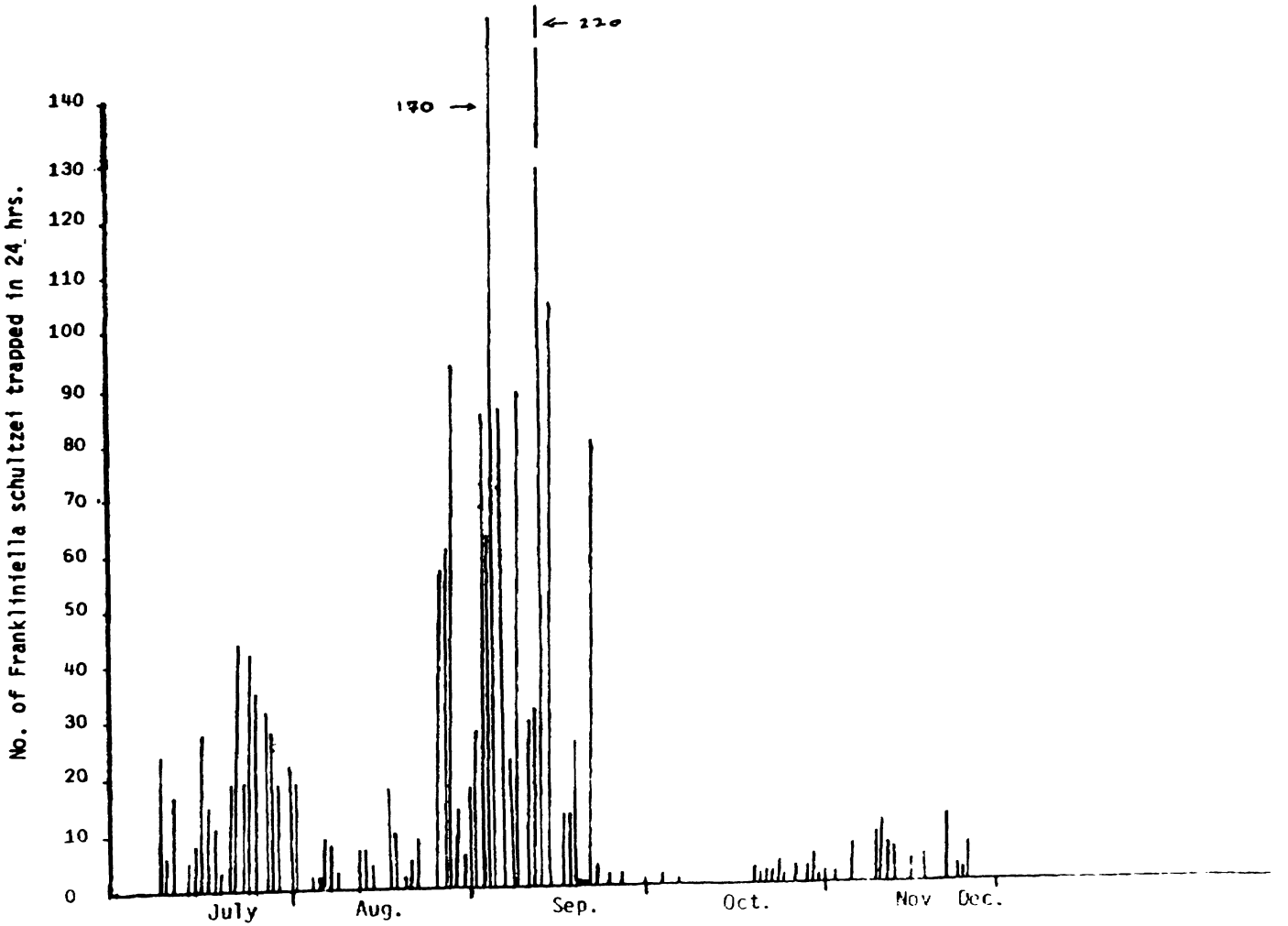
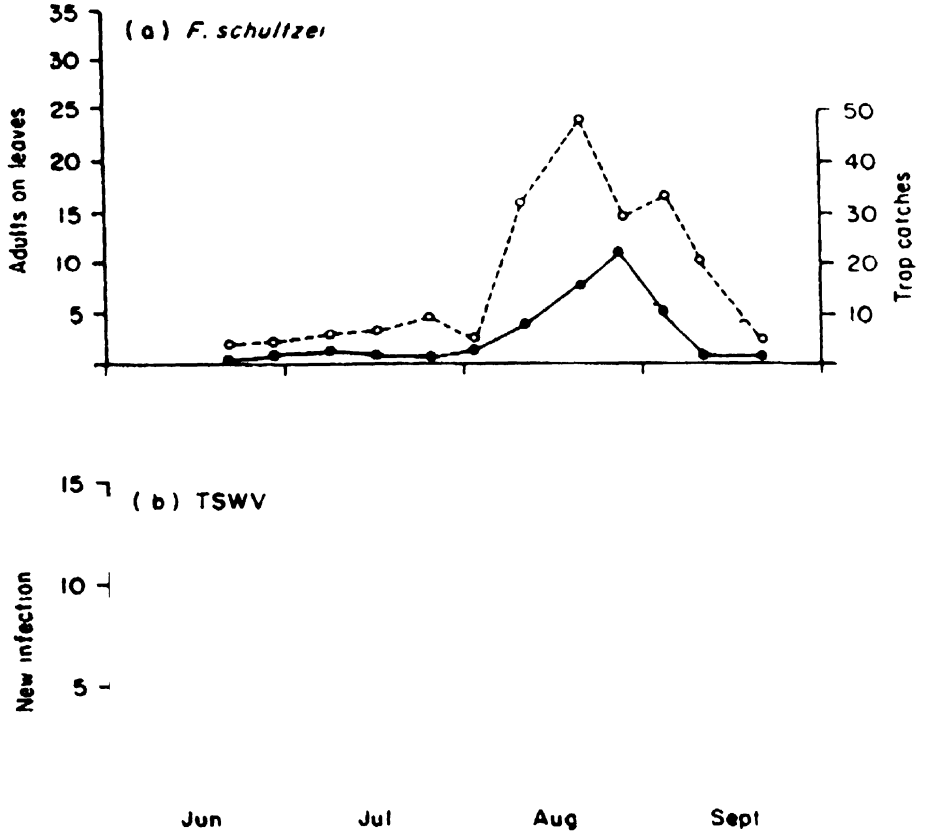
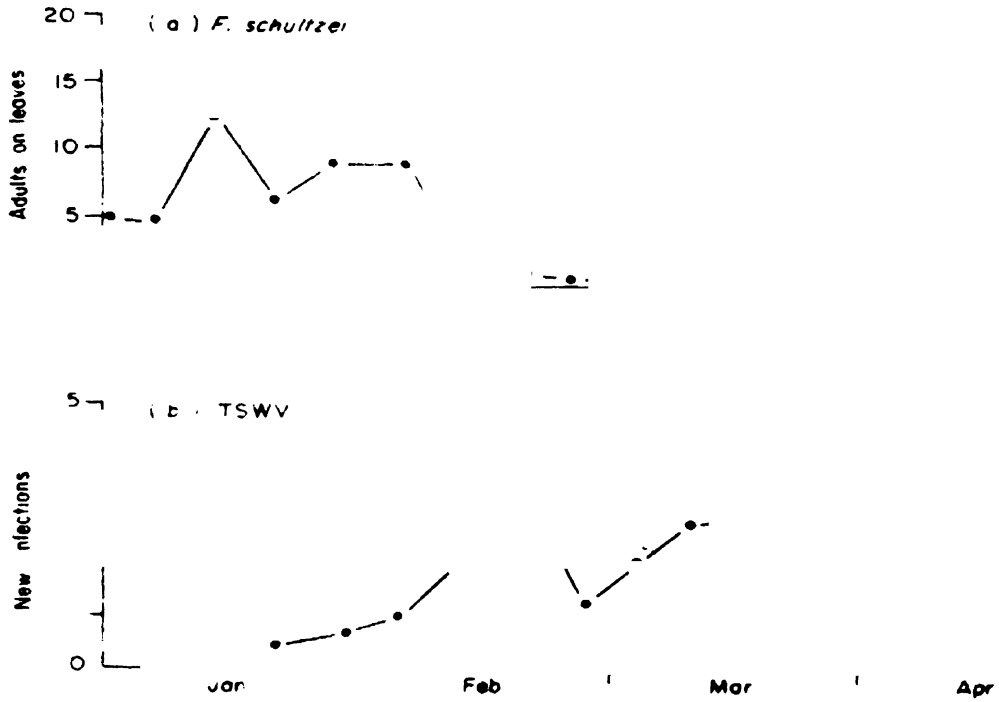


Fig. 55.. Thrips F. schultzei on plants and in suction trap and associated bud necrosis disease spread (Rainy season, 1979)



(a) Adult *F. schultzei* collected during June-September, 1979, on the ICRISAT farm. In suction traps O---O and on ten terminal leaves ●——●.
(b) Percentage of crop stand first showing symptoms of tomato spotted wilt virus.

Fig. 56. Thrips F. schultzei on plants and associated bud necrosis disease spread
(Postrainy season, 1979-80)



(a) Adult *F. schultzei* counted on plants during January-April, 1980, on the ICRISAT farm.
(b) Percentage of crop stand first showing symptoms of tomato spotted wilt virus.

Fig.57 . Temperature, wind velocity and rainfall in relation to catches of F. schultzei in suction traps and on plants (postrainy 1980-81)

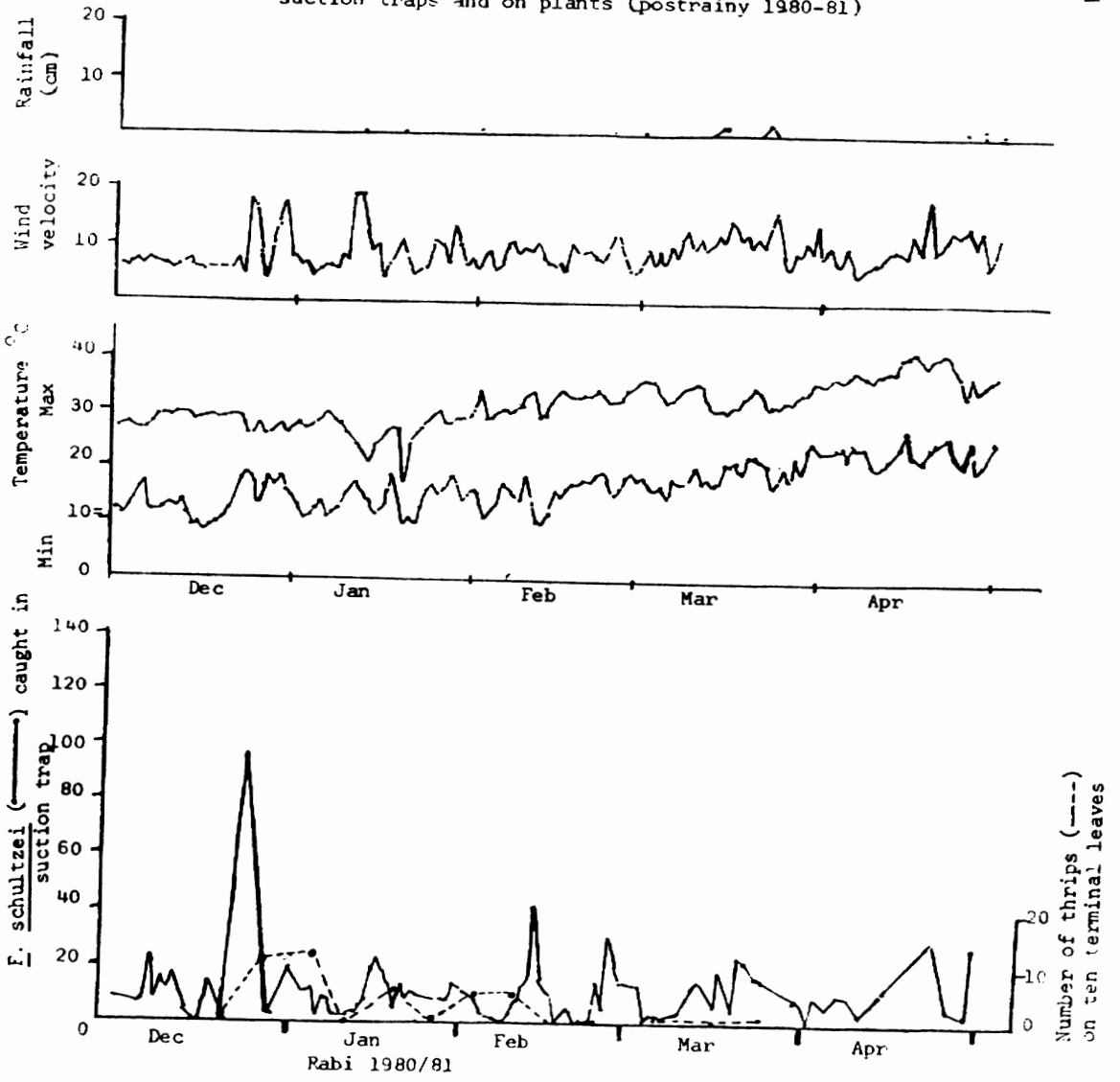


Fig. 58 . Number of Frankliniella schultzei caught in suction trap
January to June 1981

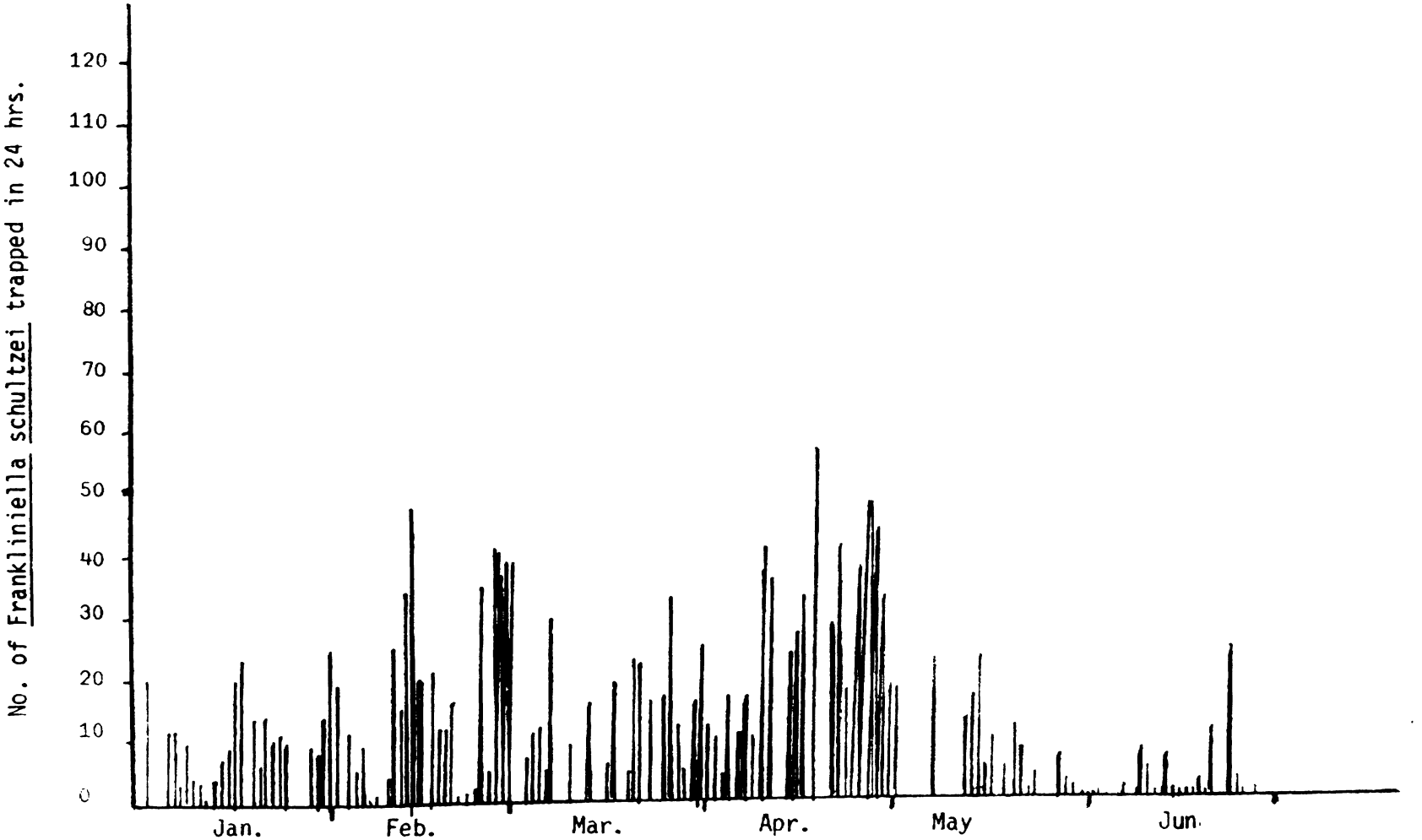


Table 30: Thrips catches in relation to prevailing weather conditions (Rainy, 1980)

Date	Number of thrips	Temperature C Max.	Min.	Wind speed km/ph	Rainfall mm
June 11	0	35	24	17	0
12	2	33(-2)	22(-2)	8(-9)	0
13	0	33	23(+1)	15(+7)	0
29	0	34(+1)	25(+2)	23(+8)	0
30	0	35(+1)	24(-1)	29(+6)	0
July 3	0	28(-7)	23(-1)	30(+1)	0
7	0	33(+5)	23	25(-5)	0
8	0	32(-1)	23	28(+3)	0
9	0	31(-1)	23	27(-1)	0
15	4	33(+2)	23	17(-10)	0
16	5	29(-4)	23	15(-2)	0
21	14	30(+1)	23	12(-3)	0
22	16	31(+1)	22(-1)	14(+2)	0
24	1	26(-5)	22	17(+3)	30
26	3	24(-2)	22	15(-2)	10
27	0	27(+3)	22	12(-3)	0
28	4	27	22	12	0
29	0	31(+4)	22	15(+3)	0
30	6	28(-3)	22	10(-5)	15
31	0	28	22	15(+3)	0
Aug 2	4	27(-1)	22	19(+4)	0
5	0	29(+2)	21(-1)	16(-3)	0.5
7	8	28(-1)	21	15(-1)	0
8	0	26(-2)	21	15	0
9	5	29(+3)	22(+1)	15	0
10	6	27(-2)	22	13(-2)	0
12	88	28(+1)	21(-1)	10(-3)	0
14	9	30(+2)	23(+2)	8(-2)	10
15	32	31(+1)	22(-1)	5(-3)	0
16	124	32(+1)	22	6(+1)	0
19	88	29(-3)	21(-1)	8(+2)	0
20	10	27(-2)	22(+1)	7(-1)	100
21	48	24(-3)	22	8(+1)	10
22	20	28(+4)	20(-2)	14(+6)	5
26	8	30(=2)	22(+2)	11(-3)	0
27	4	30(+1)	21(-1)	17(+4)	0
28	0	30(+1)	21(-1)	17(+4)	0
29	16	29(-1)	21	15(-2)	0
31	24	30(+1	22(+1)	12(-3)	0
Sept 1	25	30	22	9(-3)	0
2	16	29(-1)	21(-1)	12(+3)	30
3	32	26(-3)	21	11(-1)	20
4	124	24(-2)	21	11	5
9	18	30(+6)	20(-1)	7(-4)	0
10	4	30	21(+1)	7	0
12	4	31(+1)	23(+2)	7	0

( ) = change from previous observation

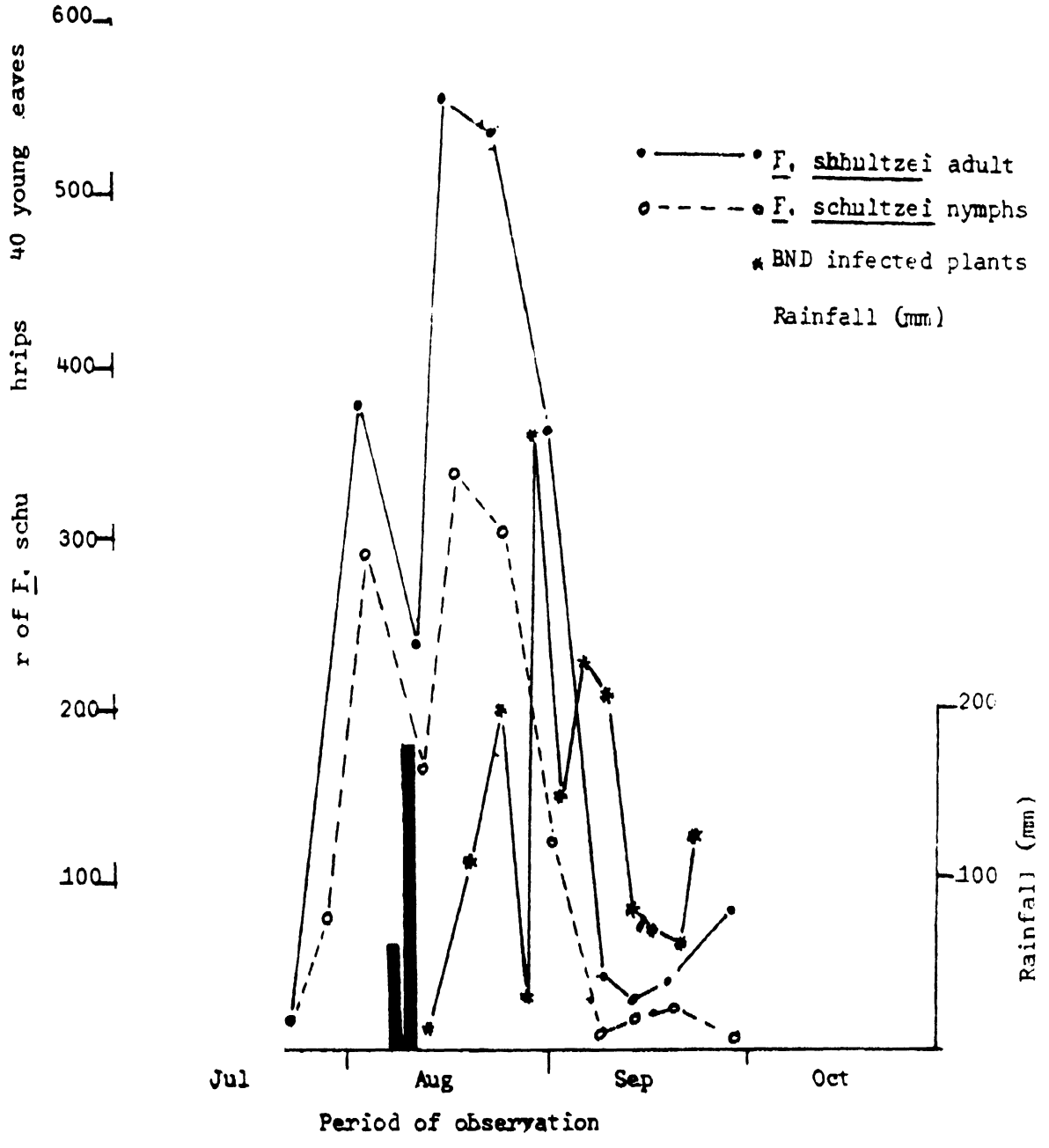
Effect of weather on thrips catches in suction trap

Month	Week	Temperture C Max.	Min.	Wind speed km/ph	Rainfall mm	No.of thrips caught
June	4 dates	34	23	18.6	0.0	0.4
July	1st week	30	23	27.5	0.0	0.0
	2nd week	32	23	22	0.0	1.3
	3rd week	30.6	23	15	0.0	6.3
	4th week	28.0	22	14	7.0	3.4
August	1st week	27.7	21	16.7	0.1	4.0
	2nd week	28.5	21.8	11.0	0.6	28.0
	3rd week	28.0	22.0	7.25	28.75	67.5
	4th week	29.5	21.0	16.0	0.0	12.0
Sept.	1st week	22.5	21.0	10.75	13.75	49.5
	2nd week	30.3	21.3	7.0	0.0	8.6

6.2.2 Effect of rainfall on thrips population and BND incidence:

In the 1978 rainy season population of thrips was monitored in a 100 sq. m. plot of TMV-2 planted at 75 cm row spacing and 15 cm plant spacing. On August 11th and 12th there was a heavy rainall of 172 mm. Thrips population declined drastically following the rainfall but increased again after heavy rains ceased (Fig. 59). BND incidence also showed a similar pattern. The association of rainfall and BND incidence is discussed in the section 5.1.

Fig. 59. Effect of heavy rains on thrips infestation and bud necrosis disease incidence
(Rainy season, 1978)



6.3. Host range: Surveys were conducted in the 1980-81 postrainy season. Thrips on various plant species in groundnut fields were collected and identified. Plants were collected in polythene bags and were assayed for TSWV on cowpea C-152 in the laboratory. Several plants were affected by TSWV. The host range appears to be large for vector Frankliniella schultzei as well as TSWV and occurs in several families (Table 13). Crop plants such as mungbean, urdbean, cowpea, soybean, beans, groundnut, tomatoes and peas are highly susceptible to both virus and vector. However, tomato as host needs further investigation. Tomato plants harbour very low number of thrips. Therefore, infection of TSWV is likely to occur from migrating thrips probing tomato plants during brief alighting on them. In our laboratory, over 40 tomato seedlings (cv Pusa Ruby) were exposed to viruliferous thrips, 2 per plant, but none developed infection and the thrips died within two days on this host. Our surveys also showed tobacco to be a non-host of thrips and when released on tobacco nymphs and adults died within less than 2 days. Further work is required to study transmission of TSWV to tomato and tobacco.

Many ornamental plants such as Zinnia, Cosmos, harbour large numbers of thrips and are highly susceptible to TSWV. Weeds such as Ageratum conyzoides, Cassia tora, Acanthospermum hispidum, Desmodium triflorum and Lagasca mollis are susceptible to TSWV (Table 13).

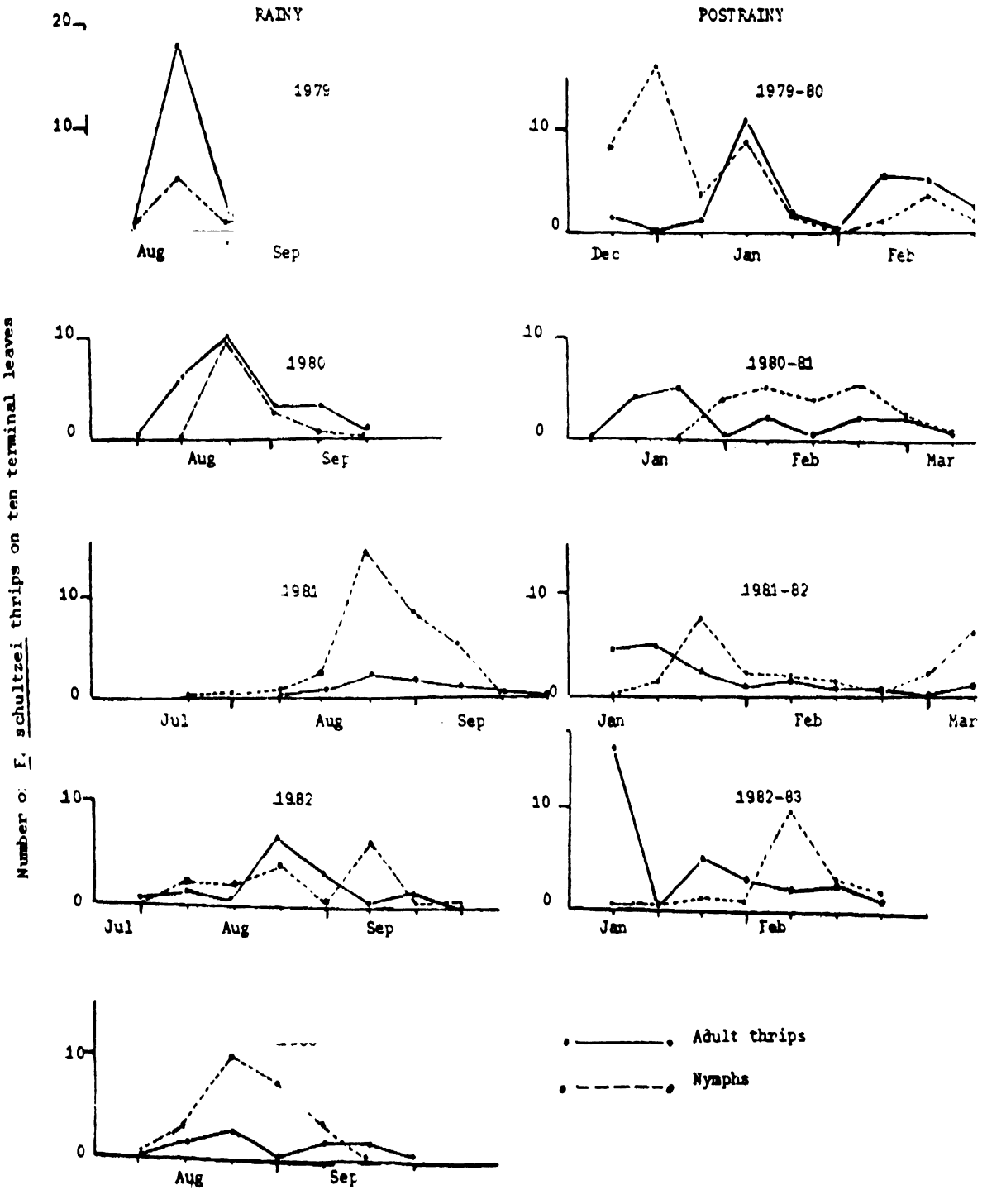
6.4. Thrips populations in different seasons:

Thrips populations were monitored during different seasons from 1978 to 1981-82 in cultivar TMV-2. Plot size was 100 sq.m. with plant spacing of 15 cm and row spacing of 75 cm. In general, the thrips population was higher in the rainy seasons than in the postrainy seasons (Fig. 60). In the high rainfall years of 1978, 1981, and 1982, population was low but in low rainfall years population was higher. In low rainfall years when weeds became scarce and crop plants were either sown late or not sown, more thrips migrated and these may have invaded available crop plants resulting in higher populations of thrips on groundnut at ICRISAT. In good rainfall years, populations of thrips may be distributed on a large number of crop and weed plants. In the postrainy season relatively higher populations occurred on groundnut following good monsoon seasons than poor monsoon seasons.

6.5. Thrips population in relation to sowing dates:

Thrips populations were monitored on TMV-2 groundnut crop sown in different months. The plot size was 100 sq.m. with 75 cm between rows and 15 cm between plant spacing. As seen from the Fig. 61, in the June 15th sown crop population remained low in the months of June, July and the first two weeks of August. The highest population was in the third week of August. In the July sown crop, highest population was also in the 3rd week of August. In the October sown crop population was low during October, November and December months and reached a peak in the middle of January, and remained high until February. In the November sown crop, population was low during

Fig. 60. Number of Frankliniella schultzei thrips recorded on groundnut in different seasons



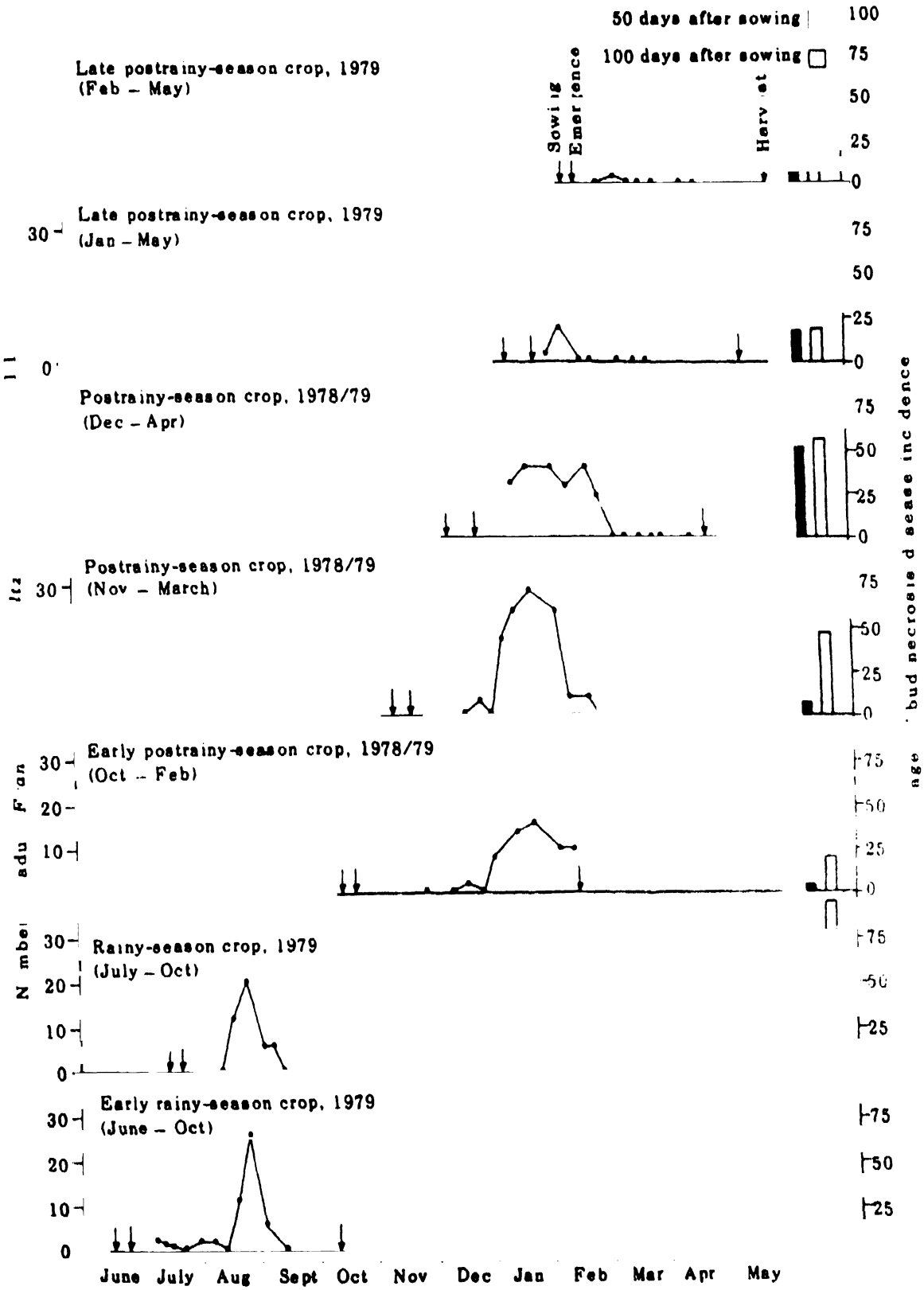


Fig. 61. *Frankliniella schultzei populations on groundnuts sown on different dates and the percentage of bud necrosis disease incidence at 50 and 100 days after sowing at ICRISAT Center.*

November and December, reached a peak in the middle of January, and declined after the middle of February. In the December sown crop, population was high from January till the 3rd week of February and then declined rapidly. In the January sown crop, population was low overall. The February sown crop suffered very little from thrips infestation.

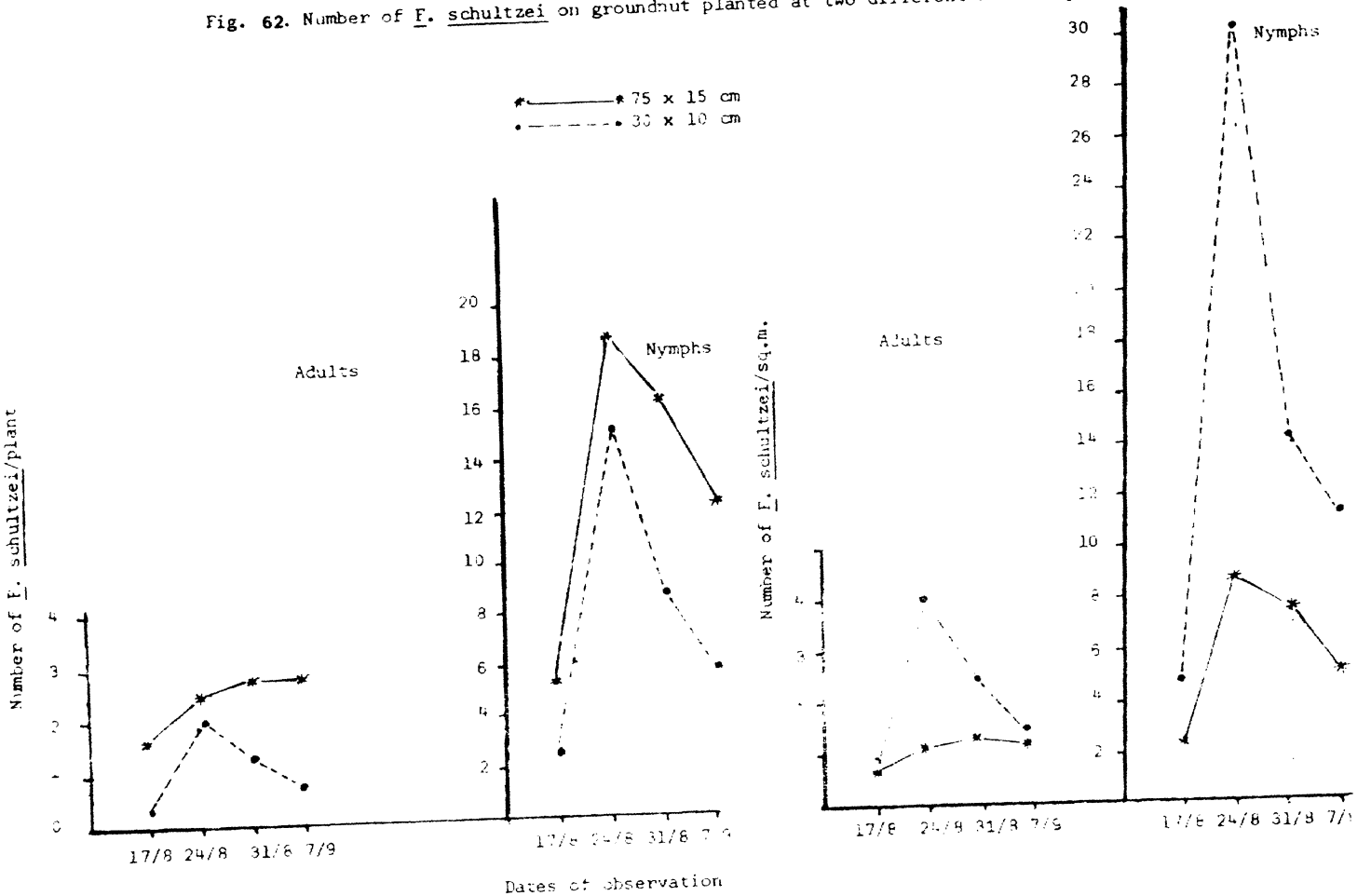
There data fit in with the migration of thrips as judged from the suction trap catches. In the rainy season, migrations occur in the month of August and September and in postrainy season during January and February.

6.6. Thrips populations in relation to plant density:

Several experiments were conducted to determine the effect of plant and row spacing on thrips incidence. Two parameters were considered: Thrips population per plant and thrips population per unit area.

In general, with closer spacing, the populations of thrips were high per unit area but low on individual plants. In the 1981 rainy season trial with two spacings of 75 x 15 and 30 x 10 cm, this was clearly seen (Fig. 62, 63). A similar trend was observed in the rainy seasons of 1981 and 1983. In the postrainy season of 1979-80, more thrips infested individual plants in the 75 x 15 spacing plots than in the 37.5 x 5 cm spacing plots. This was reflected in numbers of BND infected plants. In closer spacing, the number of BND infected plants was generally higher than in widely spaced plants (Fig. 44) (Table 17 and 18).

Fig. 62. Number of F. schultzei on groundnut planted at two different row and plant spacings



6.7. Thrips population in relation to canopy of plants:

An experiment was conducted in the 1981-82 postrainy season to determine the effect of plant canopy on thrips infestation. Plots of cultivar TMV-2 were sown on 10th December. The plot size was 10x10 m with 75 cm between rows and 15 cm between plants. There were 4 treatments: (1) plants with full canopy, (2) plants with half canopy, (3) plants with 1/4th canopy, and (4) plants sown late on 22nd December. The last treatment was included to determine the effect of age on thrips infestation and BND incidence. Canopy was reduced by cutting branches from individual plants at weekly intervals to approximately 1/2 or 1/4th of the normal plant canopy. The branches that were cut were spread in the same plot near to the plants to facilitate movement of thrips to the nearby plants. Canopy reduction was done at weekly intervals. Canopy measurements were taken on all plants by recording diameter of individual plants at 4 diagonals. Flowers were removed from all plants and distributed in the same plot to avoid the effect of flower attraction in early sown plots in relation to late sown crop. Once the late sown crop started produced flowers, removal of flowers was stopped. Thrips numbers were recorded on 2 rows of 1 meter each in a plot.

As seen from the data (Table 31 and Fig. 64), thrips population was larger on full canopy, lower on 1/2 canopy and lowest on 1/4th canopy.

Fig. 63. Number of F. schultzei on 20 plants in plots of groundnut at 2 different row and plant spacing (postrainy 1979-80)

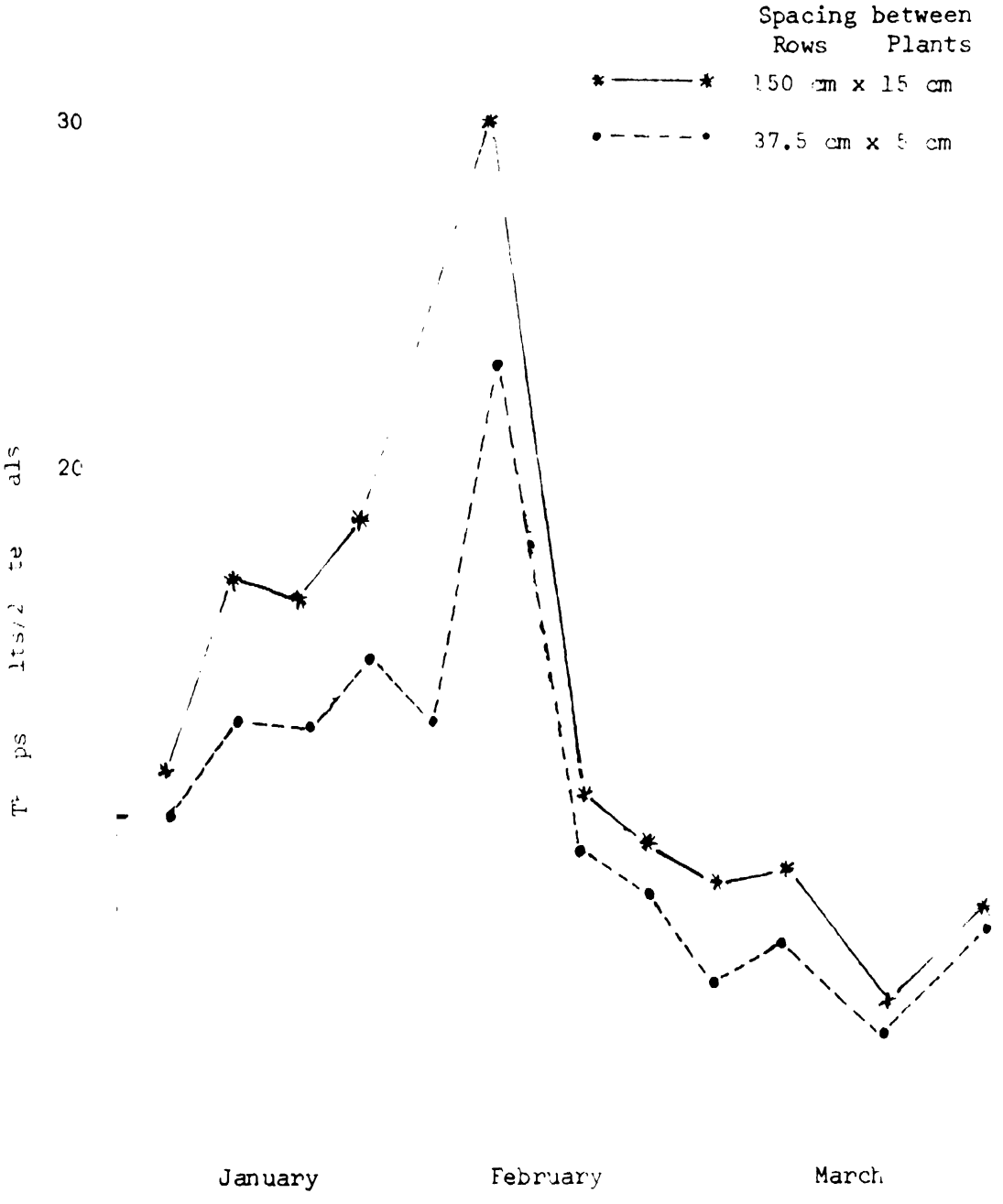


Fig. 64. Thrips infestation on plants with different canopy (Postrainy season, 1981-82)

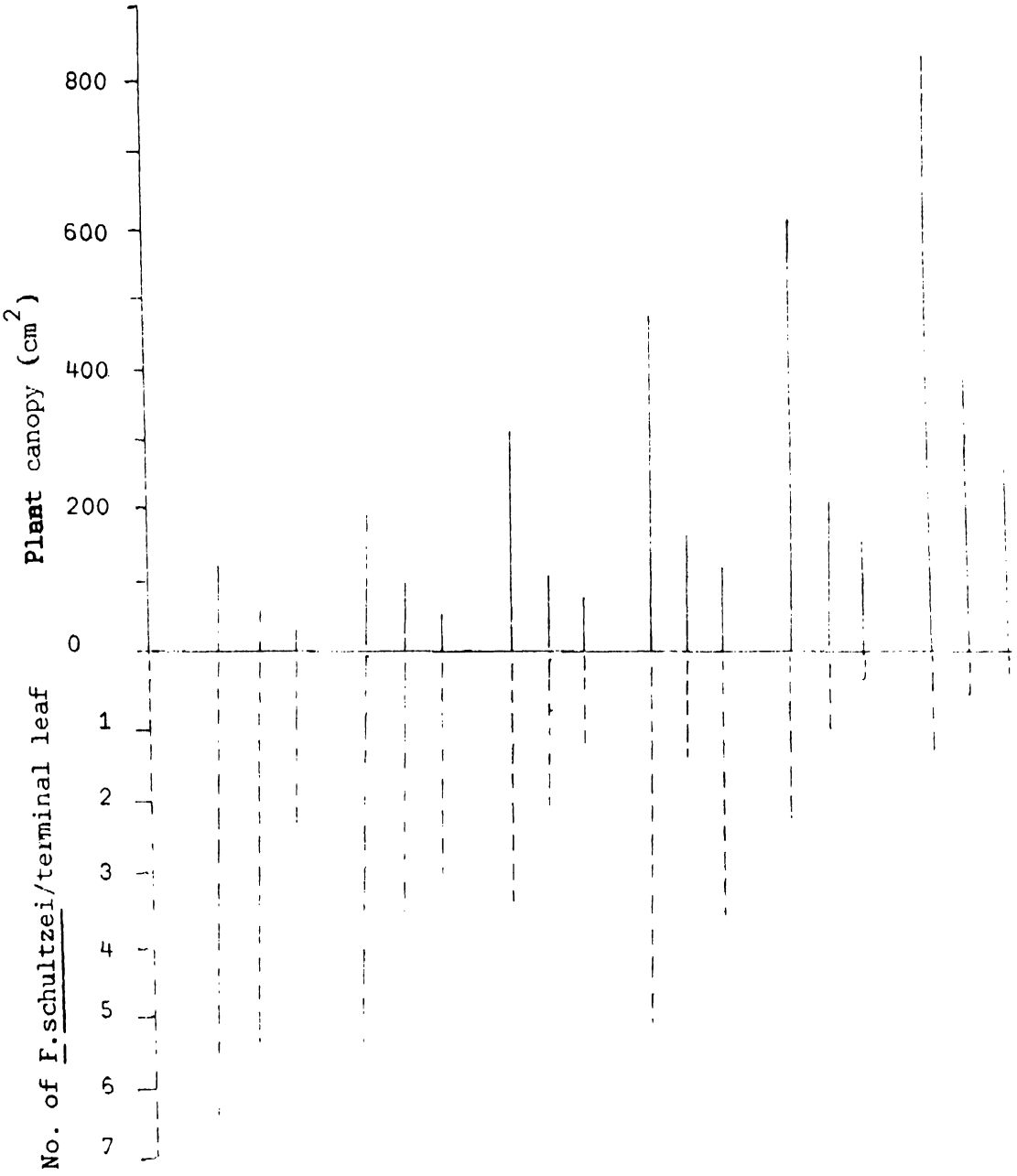


Table 31. Effect of crop canopy on thrips populations on groundnu
(1981-82 postrainy season trial)

Canopy	Canopy coverage (sq.cm) and thrips numbers/plant on different dates											
	21.1		28.1		5/2		11/2		18/2		26/2	
	C	T	C	T	C	T	C	T	C	T	C	T
Full	118	5.7	200	3.5	303	5.2	466	2.5	586	1.5	827	0.50
one-half	48	3.7	87	2.5	104	1.5	156	1.5	199	0.7	343	0.00
one-fourth	22	3.0	43	2.0	77	3.7	114	0.7	166	0.7	258	0.50
Full (late sown)	42	2.5	80	3.7	142	1.5	156	0.7	199	0.2	473	0.7
SE ±	11.8	1.19	10.2	0.49	22.1	0.81	48.6	0.71	39.5	0.45	44.7	0.52

C = Canopy sq.cm. T = Adult thrips/plant

6.8. Thrips population in relation to barriers:

Observations were taken in a large unsprayed plot (30 m x 100 m) which was in the vicinity of an earthen bund 2.5 m high. This barrier was across the prevailing wind direction of East to West. Plots were divided into sections of 2.5 m to 20 m. Observations on thrips infestation were recorded weekly. As seen from the Fig. 62, thrips deposition was greatly affected by the barrier. Thrips infestation was lowest in the first 10 meters but progressively increased with distance from the barrier. The BND affected plants were also more on the crop away from the barrier. To avoid this adverse barrier effect, all subsequent experimental plots were kept away from bunds.

7. Control:

7.1. Insecticides: Several pot culture and field experiments were conducted to determine the effect of insecticides on thrips and on bud necrosis disease control.

7.1.1. Pot culture experiments:

1. Efficacy of different insecticides against thrips:

This trial was conducted on potted plants during September 1977. Five insecticides were selected for the purpose. Demeton methyl was sprayed at 0.09% concentration, dichlorovos at 0.22%, dimethoate at 0.25%, endosulfan at 0.35% and formathion at 0.3%

Seeds of cultivar TMV-2 were sown in large pots on 10.9.77. The plants were kept under observation for thrips incidence. After the thrips infestation was noticed, the insecticides were applied with a hand sprayer. Numbers of thrips were recorded 3, 7, 10, and 13 days after spraying. The results of this trial (Table 32) indicated dimethoate, demeton-s-methyl and formathion were effective in reducing thrips infestation. Nuvan or dichlorovos, a insecticide with quick knock down property was not effective. Endosulfan was also not effective.

Table 32: Efficacy of different insecticides against groundnut thrips

Treatment	Number of thrips present on 30 plants Before spraying		Days after spraying							
			3		7		10		13	
	A	N	A	N	A	N	A	N	A	N
T1 demeton methyl 0.09% (180 ml/ha)	158	86	0	4	1	16	2	4	13	12
T2 dichlorovos 0.225% (450 ml/ha)	155	52	5	379	14	183	1	26	15	35
T3 dimethoate 0.25% (500 ml/ha)	174	68	0	3	1	0	0	0	7	2
T4 endosulfan 0.35% (700 ml/ha)	128	47	7	85	4	116	4	37	16	40
T5 formathion 0.3% (600 ml/ha)	101	35	0	8	0	42	4	2	12	8
T6 Control	125	53	6	77	5	218	11	64	12	46

A = adults, N = nymphs

2. Effect of different systemic soil and foliar insecticides on the thrips:

This trial was conducted on potted plants with 9 treatments viz., two concentrations each of dimethoate, demeton-s-methyl, alicarb and furadan and a non-treated control. Dimethoate was sprayed at 0.20 and 0.25%, demeton methyl was sprayed at 0.135 and 0.18% concentrations. Aldicarb 10G granules were applied with seeds @ 0.12 and 0.18 gms/plant and furadan 3G was applied @ 0.4 and 0.6 gms/plant.

There were 3 replications, each with 10 plants per treatment. The observations on the number of thrips - adults and nymphs, were taken before spraying and 1, 4, 7, 10, 13 and 17 days after spraying. The results are given in Table 33.

Table 33: Effect of different systemic soil and foliar insecticides on thrips

Treatment	Before spray		No. of thrips/30 Plants Days after spray 1		4		7		10		12		17	
	A	N	A	N	A	N	A	N	A	N	A	N	A	N
T1 dimethoate 0.20%	44	31	0	0	0	0	8	4	9	0	15	1	22	17
T2 dimethoate 0.25%	48	15	0	0	1	0	7	5	12	1	26	3	28	8
T3 demeton methyl 0.135%	49	36	0	0	0	8	12	11	10	4	28	2	23	15
T4 demeton methyl 0.18%	48	53	0	0	2	2	12	16	8	1	17	0	13	14
T5 Aldicarb 10G 0.12 gm/plant	-	-	2	0	8	1	8	9	11	15	30	28	30	26
T6 Aldicarb 10G 0.18 gm/plant	-	-	1	0	5	0	15	0	11	5	29	15	15	13
T7 Furadan 3G 0.4 gm/plant	-	-	0	0	0	0	2	0	7	0	19	0	18	1
T8 Furadan 3G 0.6 gm/plant	-	-	0	0	0	0	2	0	5	0	17	0	19	8
T9 Control	48	32	32	53	13	141	4	225	5	133	14	19	10	9

Results showed that dimethoate at both concentrations was more effective than demeton-s-methyl during the first 7 days after spray application and carbofuran was more effective than aldicarb. However, both dimethoate and carbofuran had much shorter periods of effectiveness than expected. Dimethoate spray gave near 100% mortality of adults and nymphs on the 4th day while on carbofuran treated plants, no thrips were observed on the 4th day after emergence and only 2 adults on the 7th day. Carbofuran had longer residual effect on nymphs which lasted for over 13 days.

3. Effect of carbofuran on the survival of thrips:

A trial was set up to study the residual effect of furadan. Furadan 3G was applied with seeds @ 0.4 gms per plant. Nineteen days after sowing or about 13 days after emergence 10 adults and 10 nymphs were released on a single leaf contained in a specimen tube. Observations were recorded at hourly interval for up to 5 hours each on 5th, 9th, 13th, 17th and 20th day after emergence of plants. Leaves from untreated plants served as control. The results showed carbofuran to be highly effective for up to 9 days (Table 34) by causing rapid mortality of adults as well as nymphs released on them. As the time period between carbofuran application and thrips infestation increased, it took longer to cause mortality of thrips. By the 20th day after emergence the effectiveness of carbofuran had declined considerably.

Table 33: Effect of Carbofuran on thrips survival

Days after emergence	No. of thrips per leaflet		Nos. surviving after 1 hr	2 hr	3 hr	4 hr	5 hr
5	Adults	10 0	-	-	-	-	
	Nymphs	10 0	-	-	-	-	
9	Adult	10 0	-	-	-	-	
	Nymphs	20 0	-	-	-	-	
13	Adults	5 5	3	0	-	-	
	Nymphs	10 10	5	3	0	-	
17	Adult	10 10	6	5	0	0	
	Nymphs	10 9	9	8	5	0	
20	Adult	10 10	10	10	10	7	
	Nymphs	10 10	10	10	10	5	

Survival on untreated leaves was between 90-100% during all these tests

4. Effect of dimethoate on the survival of thrips:

In this trial, 2 week old seedlings of groundnut were sprayed with 0.2% dimethoate. Twenty-four hours after spray application, 10 adults and 10 nymphs were released on the seedlings every day, and their survival was recorded after 2 hours, 4 hours, 6 hours, 24 hours and 48 hours. It was observed that 100% mortality occurred within 6 hours of release up to the 5th day after dimethoate spray but no mortality occurred on the 8th day after spray thereby indicating that effect of dimethoate lasted only for 5 - 6 days.

5. Seed treatment: In an attempt to see if systemic insecticides could be used to protect plants from thrips during early stages of crop growth, seeds of cultivar TMV-2 were soaked in different concentrations of dimethoate and demeton-s-methyl for 24 hours and then germinated in petridishes. The results (Table 34) indicated that root length was adversely affected in seeds soaked in dimethoate but not by demeton-s-methyl but the germination was not affected.

Table 34: Effect of soaking of seeds in dimethoate and demeton-s-methyl on germination and root length

Concentration	Demeton-s-methyl		Dimethoate	
	% germination	root length (mm)*	% germination	root length (mm)*
Water	100	32.7	100	32.1
0.005	100	34.5	100	39.0
0.01	100	37.6	100	30.4
0.02	100	32.3	100	29.7
0.05	100	37.4	90	20.0

* Observations on 10 seeds in each treatment after 6 days

We further tested effect of seed soaking in demeton-s-methyl in a pot culture experiment. The experiment was conducted in February 1978 with the following treatments:

T1 demeton-s-methyl 0.05%

T2 " 0.1%

T3 " 0.2%

T4 water

T5 dry seeds

Seeds were sown in pots 20 seeds per pot after 24 hr soaking. Germination counts were taken every day and thrips numbers were recorded at 4 day intervals.

Table 35: Effect of seed soaked in demeton-s-methyl on thrips infestation

Treatment		Germination %	No. of thrips 17/3 A-N	21/3 A-N	24/3 A-N
Demeton-s-methyl	0.05%	90	9-0	4-26	5-20
	0.1%	100	9-0	5-25	3-7
	0.2%	100	10-0	4-11	3-21
Water	-	100	11-0	1-27	3-29
Dry seeds	-	100	7-0	3-29	2-6

A = adult thrips, N = nymphs

While germination was not affected, thrips numbers were also not reduced in plants resulting from insecticide- soaked seeds (Table 35). Therefore, this approach was not found useful.

7.1.2. Field Experiments:

Expt. 1: Effect of dimethoate application on different days after germination and at different frequencies:

An experiment was laid out during the 1977-78 postrainy season to study the effect of dimethoate application on the incidence of bud necrosis disease in TMV 2 cultivar. Dimethoate, 0.2%, was sprayed at 1 week, 2 weeks and 3 weeks after emergence at 7, 10, 15 and 30 days' interval. The design of experiment was split plot with 3 main treatments (beginning of insecticide application, 1, 2, and 3 weeks after emergence) and 5 subtreatments (viz. insecticide application once every 7, 10, 15 and 30 days interval) and 4 replications. The main plot size was 15 x 26 m and sub plot size was 5 x 5.25 m. The results of this trial are shown in Tables 36, 37 and 38.

It can be seen from the above results that dimethoate application at 7 day intervals significantly reduced the incidence of bud necrosis. Application of insecticide at 10 day intervals also reduced the incidence but not significantly more than the 15 day intervals insecticide application. However, this treatment was more effective than the treatment where insecticide was applied at 30 day intervals.

Table 36: Effect of dimethoate application on bud necrosis disease incidence (postrainy season 1977-78)

Spray application DAE	Spray interval	BND incidence %	SE ±	Yield kg/ha	No.of plants/ net plot
7	7	25.3 (29.8)		2290	47
	10	37.6 (37.4)		2284	42
	15	48.5 (44.2)		2034	39
	30	49.0 (44.4)		2386	47
	no spray	66.1 (55.8)	SE±	1363	40
Mean		45.3 (42.3)			
15	7	29.1 (32.4)	(3.47)	2884	50
	10	40.2 (38.8)		2313	40
	15	42.0 (40.4)	CV%11.0	2313	45
	30	49.8 (44.8)		2336	46
	No spray	50.9 (45.5)		2710	46
Mean		42.4 (40.4)			
30	7	36.5 (36.8)		2695	44
	10	39.4 (38.4)		2589	32
	15	44.8 (41.9)		2342	46
	30	61.2 (51.6)		1782	41
	No spray	57.7 (50.1)		1884	44
Mean		47.9 (43.7)			
$\bar{S}$		(7.00)		550.0	4.8
CV %		(25.91)		21.7	15.7

( ) = Arcsine transformed value.
DAE = Days after emergence

Table 37: Effect of dimethoate application on different days after emergence on bud necrosis disease incidence (postrainy season 1977-78)

Spray	% BND incidence	Yield kg/ha
7	45 (42.3)	2072
15	42 (40.4)	2512
30	48 (43.7)	2258
SED	(3.4)	174.2
CV %	(10.9)	21.7
LSD	(5.3)	426.3

() = arcsine transformed values

Table 38: Effect of different intervals of dimethoate applications on bud necrosis disease incidence (postrainy season 1977-78)

Days	BND incidence %		Yield kg/ha
7	30.3 (33.0)	2623	
10	39.7 (38.2)	2396	
15	45.1 (42.1)	2230	
30	53.3 (46.9)	2168	
No spray	58.2	(50.4)	1986
SE ±		(2.5)	
CV %		(14.9)	

() = arcsine transformed values

Expt. 2: Effect of combination of carbofuran, dimethoate and rogueing on the incidence of bud necrosis disease

This experiment was conducted in the 1977-78 postrainy season in a randomized block design with 12 treatments and 3 replications. The treatments were as follows:

T1 - Carbofuran applied @ 1 kg/ha ai during sowing
T2 - T1 + roguing of infected plants 30 days after germination
T3 - T1 + roguing of infected plant at 30 and 45 days after germination
T4 - T2 + dimethoate 0.2% spray at 30 days after germination
T5 - T3 + dimethoate sprays at 30 and 45 days after germination
T6 - Roguing of infected plants, 30 days after germination
T7 - Roguing of infected plants 30 and 45 days after germination
T8 - Roguing of infected plants and application of dimethoate 30 days after germination
T9 - Roguing of infected plants and application of dimethoate at 30 and 45 days after germination
T10 - Application of dimethoate, 30 days after germination
T11 - Application of dimethoate, 30 and 45 days after germination
T12 - Control

The plot size was 5 x 6.75 m. The central 3 rows were taken for observation on bud necrosis disease infection.

The results (Table 39) indicated that none of the treatments reduced BND incidence substantially. Rogueing of infected plants is often advocated to reduce BND incidence. Our trial indicates that this is not a useful practice.

Table 39: Effect of carbofuran and dimethoate application with or without roguing on bud necrosis incidence (postrainy season 1977-78)

Treatment	Plants/ plot	BND incidence %		Yield kg/ha
Carbofuran 1 kg ai/ha	76	24.7	(29.0)	825
Carbofuran + roguing	77	19.3	(25.8)	744
Carbofuran + 2 roguings	74	17.5	(24.6)	680
Carbofuran+1 roguing + 1 spray	76	20.7	(26.9)	805
Carbofuran+2 roguings + 2 sprays	79	23.0	(28.4)	794
1 roguing	64	25.3	(29.8)	704
2 roguings	68	31.2	(33.9)	633
1 roguing + 1 spray	69	26.9	(30.9)	651
2 roguings + 2 sprays	72	16.9	(24.1)	721
1 spray	67	29.1	(32.6)	713
2 sprays	67	24.9	(29.4)	873
Untreated control	69	35.3	(36.4)	753
SE ±	4.7		(2.9)	74.6
CV %	11.6	(17.5)		17.4

Carbofuran was applied @ 1 kg ai/ha with seed. Roguing of BND infected plants was done 50 and 75 days after emergence. Dimethoate was applied @ 450 ml/ha on 50th or 75th days after emergence.

Figures in parentheses are arcsin transformed values.

Conclusions: The results of preliminary trials indicated that of the insecticides tested, dimethoate @ 400 ml/ha was better though the effectiveness against thrips lasted for only 7 days. Carbofuran was more effective than aldicarb at 1 kg ai/ha applied with seed. Roguing of infected plants did not reduce BND substantially. This was probably due to secondary spread being less important.

Therefore, field experiments were conducted using these two insecticides.

1) 1978-79 trial:

A field trial was conducted in split plot design to determine the effet of carbofuran and dimethoate applications on BND incidence. Each treatment comprised a 14 x 10 m plot with 75 cm between rows and 15 cm between plants. There were 4 replications. The results indicated (Table 40) that BND incidence was marginally reduced in plots that received 8 sprays and carbofuran. Application of carbofuran caused reduction of BND in the early stages of crop growth; in such plots BND incidence was lower than in plots that did not receive carbouran.

Table 40: Effect of Carbofuran and different number of dimethoate sprays on BND incidence

Treatment	No.of sprays	% BND 50th day	100th day
Carbofuran	0	18.9	62.1
	2	15.5	58.7
	4	14.2	59.6
	6	13.4	58.4
	8	10.0	47.5
Mean		14.4	57.3
No carbofuran	0	23.4	62.8
	2	19.3	61.6
	4	14.7	56.2
	6	13.8	57.9
	8	14.0	51.3
Mean		17.0	58.0
SED of main plot means		0.24	1.65
CV %		4.97	9.08
SED of between two subplot treatments		1.60	2.66
CV %		14.60	6.52

2) 1979 trial: In the 1979 rainy season, a trial was conducted on G3 field in which a combination of two sowing dates, two levels of carbofuran and 2 levels of dimethoate sprays was tested to see the effect on BND incidence. The effects of carbofuran and dimethoate sprays are given here.

It is seen (Table 41) that carbofuran application made marginal reduction of BND incidence in early stages of crop growth only. Number of sprays either 4 or 8 did not affect the BND incidence.

It appears that in the rainy season, neither carbofuran nor dimethoate are effective in reducing BND incidence.

Table 41: Effect of carbofuran and dimethoate application on BND incidence (Rainy season, 1979)

Treatment	Plants/ Plot	BND incidence (%) 50th day	100th day	Yield* Kg/ha
Carbofuran	428	49	76	313
No Carbofuran	435	51	75	397
SE ±	7.0	0.4	1.2	20.0
CV %	6.5	3.9	6.4	22.5
	4 sprays x 8 sprays			
4 sprays	433	49	77	360
8 sprays	430	51	74	350
SE ±	2.9	0.6	1.0	30.8
CV%	2.6	4.8	5.6	34.7

* Yield were low because of very severe incidence of BND

3) 1982-83 trial: Effect of reduced frequency and sublethal concentrations of dimethoate on bud necrosis disease incidence

In order to determine the effect of more frequent application or lower concentrations of dimethoate than the presently used weekly sprays of 0.2% dimethoate, a trial was conducted in the postrainy season of 1982-83. The plot size was 110 sq.m. with spacing between ridges being 75 cm and between plants being 15 cm.

Here also, (Table 42) insecticides when applied at 3 day or 5 day intervals reduced BND incidence but was uneconomic. Sublethal doses of dimethoate at 0.05 % concentration actually increased the BND incidence.

Table 42: Effect of dimethoate application at lower dose and reduced frequency on BND incidence

Treatment dimethoate	Frequency of application	Plants/ plot	% BND incidence on 50th day	100th day
0.2	3 days	880	0.9	42.0
0.2	5 days	879	1.5	51.5
0.2	7 days	877	1.8	61.6
0.05	7 days	888	3.0	74.0
0.05	10 days	871	2.9	78.4
SE ±		8.05	0.38	3.23
CV %		1.83	37.05	10.51

4. 1982-83 trial: Application of dimethoate at low concentration (0.1%) and at 15 day intervals increased the BND incidence substantially (Table 43). This was an important observation. To confirm this a trial was made in the 1982 rainy season, on 3 varieties each in upright bunch, spreading bunch and runner growth habits. The trial was conducted on small plots of 4 x 4 m with 3 replications. Spacing was 75 cm between rows and 15 cm between plants. Dimethoate was applied at 0.1% concentration at 15 day intervals. The results (Table 43) clearly showed that at lower concentration and increased frequency, dimethoate application resulted in increased BND incidence.

Table 43: Effect of low concentration of dimethoate on BND incidence in 3 cultivars of 3 different growth habits

Growth habit	Variety	% BND in plots	
		Sprayed	Unsprayed
Upright Bunch	TMV 2	71	58
	NC Ac 1308	24	16
	NC Ac 489	85	56
Spreading Bunch	NC Ac 2575	31	15
	NC Ac 2462	33	19
	NC Ac 2144	48	12
Runner	M 13	25	18
	Ah 54	35	17
	NC Ac 2230	54	37

5. 1978 trial: Effect of nonphytotoxic oils (0.2%) on bud necrosis disease incidence.

Oils are generally useful in reducing virus disease incidence, particularly those of aphid-borne virus diseases. We tested the effect of oil on BND incidence. In the 1978 rainy season we applied two non-phytotoxic oils - Sunoco 7E and JMS. JMS oil accumulates in the interveinal areas while Sunoco 7E sreads evenly on the leaf surface. This trial was conducted on two large plots of 40 x 45 m, one plot was sprayed with oil and the other was not treated. The results (Table 44) clearly showed that oils alone were not effective in reducing BND incidence.

Table 44: Effect of oil on bud necrosis disease incidence (rainy season 1978)

Treatment*	BND incidence (%)
JMS oil (0.2%)	53.3
Control	52.4
Sunoco 7E (0.2%)	56.5
Control	55.5

* Oil was applied at weekly interval starting 15 days after emergence A total of 6 sprays were given

6. 1978-79 trial: In 1978-79 JMS oil was tested in combination with of dimethoate to see if this was effective. Results (Table 45) showed that this was not effective in reducing BND incidence.

Table 45: Effect of dimethoate and oil on BND incidence

Treatment*	No.of plants per plot	BND incidence (%)
Dimethoate 0.2%	146	78.2 (56.3)
Dimethoate + JMS oil (0.2%)	140	86.0 (62.9)
Control	141	69.2 (67.9)
SE ±		(3.10)
CV %		(9.94)

* Sprays were applied on 19/1, 2/2, 19/2 and 16/3, 1980.

7. 1980 rainy season trial: Effect of different insecticides on bud necrosis disease incidence

A replicated trial was conducted with 4 insecticides to find a more effective insecticide than dimethoate. Three insecticides tested were accothion, monocrotophos and formathion, at different concentrations. Weekly sprays were applied. The plot size was 8 x 9 m with 75 cm between rows and 15 cm between plant spacings of cultivar TMV-2 with 4 replications in a randomized block design.

The results (Table 46) clearly indicated that none was superior to dimethoate in reducing BND incidence

Table 46: Effect of different insecticides on bud necrosis disease incidence (rainy season 1980)

Insecticide	No.of plants/ plot	BND incidence % at harvest
Dimethoate 0.2%	590	91
Formathion 0.1%	584	92
Monocrotophos 0.075%	603	88
Accothion 0.1%	544	89
SE	11.8	4.6
CV%	3.5	9.0

CONCLUSIONS: Insecticides or oils were not effective in reducing BND incidence. Carbofuran was effective for a short period when applied with seed but the effect was decreased considerably when major thrips invasion occurred in August and September. Dimethoate reduced BND incidence in the postrainy season but was not useful in the rainy season.

7.2. Effects of sowing dates:

7.2.1. 1979 rainy season trial:

The trial was planted on field RP 14-A. Cultivar TMV-2 was sown on 15th June and 15th July with 4 replications. This trial also combined effects of insecticides in relation to sowing date. The plot size was 14 x 14 m with 4 replications. The observation plot was in which BND incidence was recorded was 10 rows of 8 m each. The plant stand was normal in the early sown crop but was 23% less in the late sown crop. However, clear indications of considerable reduction in BND in the early sown crop were obtained. Also, the early sown crop gave 8-fold higher yield than the late sown crop (Table 47).

The main difference appears to be due to high incidence of BND in the young crop in late sown plots (86%) against very low (14%) incidence in young crop of early sown plots. Thrips population was similar on early and late sown crops; therefore, overall low incidence of BND in the early sown crop appears to be due to increased resistance of plants with age. Low incidence of BND in young crop resulted in much lower magnitude of loss. In late sown crop the drastic reduction in yield resulted from high proportion of (86%) plants affected by BND before flowering was completed.

Overall incidence of 60% in the early sown crop as compared to 91% in late sown crop appears to be related to age of plants and not to differences in thrips infestation. Population of thrips was similar in early sown and late sown crops (Fig. 37) but plants were of 7 weeks age when they were exposed to thrips infestation whereas in late sown crop they were only 4 weeks old.

Table 47: Effect of sowing date on bud necrosis disease incidence (Rainy, season 1979)

Sowing date	BND (%) 50 days	100 days	Yield kg/ha
15 June	14 (22)	60 (51)	631
10 July	86 (68)	91 (74)	79
SE m	0.8(0.7)	3.2(2.8)	28.3
CV %	6.5(6.1)	16.9(18.3)	31.8

7.2.2. 1979-80 postrainy season trial:

A trial was conducted to see the effect of sowing dates in two genotypes on BND incidence in the postrainy season. Robut 33-1 and TMV-2 cultivars were sown on 10th November and 10th December. The results (Table 48) confirmed earlier findings (Fig. 30) that the November sown crop has a lower disease incidence than the December sown crop.

The December sown crop suffered from a higher disease incidence than the January sown crop. The trials in farmers fields in Nizamabad district also showed similar results (Table 49).

Table 48: Effect of sowing dates on incidence of bud necrosis disease in TMV-2 and Robut 33-1 cultivars (postrainy season 1979-80)

Sowing date	BND (%) TMV-2	Robut 33-1	Mean BND %	SE ±	CV%
10th Nov.	15	13	14	1.2	20.6
10th Dec.	34	20	22		
Mean	24.5	16.5			
SE ±		0.9			
CV %		18.4			

Table 49. Effect of sowing dates on BND incidence in TMV-2 cultivar in farmers' fields

Sowing date	% BND* 50th day	100th day
December 27th	24.7	27.0
January 27th	10.6	14.5

* Mean of 7 replications

7.2.3. 1980 rainy season trial:

This trial was conducted with two dates of sowing, 15th June and 15th July, with two cultivars, TMV-2 and Robut 33-1. Plot size was 14 x 14 m with 75 cm between rows and 15 cm between plants. The results (Table 49) were similar to those of the 1979 trial. Cultivar Robut 33-1 had much lower incidence of BND than had cultivar TMV-2. Higher yields were obtained in early sown Robut 33-1 (1455 kg/ha) followed by early sown TMV-2 (940 kg/ha). Late sown Robut 33-1 gave pod yield of 260 kg/ha, apparently because of 32% BND incidence in the young crop and overall incidence of 60%. Late sown TMV-2 suffered most, 70% plants being infected by BND before flowering was completed and 94% between flowering and maturity. Consequently yield level was only 75 kg dry pods/ha (Table 50).

Table 50: Effect of sowing dates on yield of TMV-2 and Robut 33-1 cultivars

Sowing date	Pod yield (kg)/ha		Mean	SE ±
	TMV-2	Robut 33-1		
15th June	942	1455	1199	
				27.7
15th July	74	254	164	
Mean	508.7	855.1		
SE ±	17.0			

Table 49: Effect of sowing date on bud necrosis disease incidence in TMV-2 and Robut 33-1 cultivars (rainy season 1980)

Sowing date	BND incidence (%) in TMV-2		Robut 33-1		Mean BND incidence %		SE ±	
	50 DAE	100 DAE	50 DAE	100 DAE	50 DAE	100 DAE	50 DAE	100 DAE
15th June	12.86	70.82	3.96	30.73	8.40	50.63	1.9	1.2
							CV %	CV %
							17.5	8.8
15th July	69.10	94.14	32.35	58.47	50.7	76.32		
Means for genotype	40.98	82.33	18.15	44.5				
SE + 50 DAE		0.84	100 DAE	1.13				
CV% 50 DAE	11.57	100 DAE	8.45					

DAE = Days after emergence

7.2.4. 1981 rainy season trials:

Two trials were conducted at two locations on ICRISAT farm, one in RP5 field and the other on RCW18 field, each with 8 replications. The spacing was 75 cm between rows and 10 cm between plants. The individual plot size was 8 m x 8 m in RP5 field and 14 m x 8 m in RCW18 field.

The results (Tables 51 and 52) were essentially similar to those of the previous trial. Early sown crops escaping from high incidence of disease during early stages of crop growth while late sown crops were exposed to high incidence of BND during initial of crop growth.

Conclusions: (1) Changes in sowing dates affect BND incidence. Crops sown 6-7 weeks (15th June) before thrips invasion (last week of August) reduced BND incidence substantially over late sown crops (15th July). Early sown crops gave substantially higher yields than late sown crop. In postrainy season November or January sown crops had lower incidence of BND than the December sown crop. Early sowing may be difficult to practice for rainfed crops because sowing depends upon rainfall. However, for irrigated crops, this is possible. For example, in Nizamabad district, release and termination of canal water was adjusted to sowing dates in January to avoid high disease incidence in January sown crop. This practice reduced overall BND incidence in this area.

Table 51: Effect of sowing date on bud necrosis disease incidence (RCW 18 - rainy 1981 season)

Sowing date	Plants per plot	BND incidence (%) weeks after emergence 3	4	5	6	7	8	9	10	11	12	Total BND incidence %
15th June	1337	0.3	0.7	1.2	1.1	2.5	1.2	3.4	16.2	7.6	6.1	40.5
		(2.5)	(4.6)	(6.0)	(6.0)	(8.9)	(6.2)	(10.4)	(23.4)	(15.7)	(14.1)	
15th July	1371	0.1	1.7	8.1	9.7	15.7	11.7	7.3	3.6	1.0	0.9	59.9
		(1.7)	(7.5)	(16.4)	(17.8)	(23.2)	(19.8)	(15.6)	(10.9)	(5.7)	(5.2)	
SE ±	37.3	0.5	0.3	0.6	1.1	1.04	0.7	0.5	1.3	1.0	0.5	
CV%		66.9	16.0	14.5	26.2	18.4	14.2	11.1	21.2	27.4	13.9	

Table 52: Effect of sowing date on bud necrosis disease incidence (RP 5 - rainy season 1981)

Sowing date	Plant population	BND INCIDENCE (%) weeks after emergence 3	4	5	6	7	8	9	10	11	12	Total BND incidence %
15th June	807	0.6	1.2	1.0	0.8	1.8	1.7	2.3	8.0	11.3	6.8	35.5
		(3.4)	(6.3)	(5.6)	(5.0)	(7.6)	(7.4)	(8.6)	(16.3)	(19.6)	(15.1)	
15th July	793	0.4	1.7	7.2	10.3	10.1	12.5	10.7	10.6	1.8	2.7	68.0
		(3.7)	(7.0)	(14.8)	(18.0)	(18.3)	(20.6)	(19.0)	(18.9)	(7.6)	(9.2)	
SE ±		0.5	0.9	1.4	1.5	0.8	0.7	0.6	0.8	0.6	0.8	
CV%		37.0	38.7	39.4	36.8	16.9	14.5	12.1	12.8	12.3	18.4	

7.3. Effects of plant density

A few trials were conducted to determine the effects of spacing of groundnut crop on BND incidence.

7.3.1. 1979 rainy season trial: Different plant densities were obtained by changing plant spacing or by sowing more than one seed per hill. The treatments were (1) 75 cm row x 20 cm plant spacing, (2) 75 x 20 x 2 seeds/ hill, (3) 75 x 20 x 4 seeds per hill, (4) 75 x 10 (equivalent to 75 x 20 x 2 seeds), and (5) 75 x 5 (equivalent to 75 x 20 x 4 seeds). Plot size was 10 rows x 10 m with 4 replications in randomized block design. As expected, the BND incidence was more in the sparse plant stand (75 x 20 cm) (Table 53). Increasing number of seeds per hill was decidedly more advantageous. For example, in 75 x 20 x 4 seeds plot the BND incidence was 25% compared to 75 x 5 cm spacing (47%). Yield was also highest in plots with 75 x 20 x 4 seeds.

Table 53: Effect of spacing on bud necrosis disease incidence (rainy season 1979)

Spacing (cm) Rows	between Plants	No.of seeds/ hill	No.of plants/ plot	BND incidence (%)	Yield kg/ha
75	20	1	482	90.4 (72.1)	185
75	20	2	1003	49.8 (44.9)	472
75	20	4	1996	24.7 (29.8)	943
75	10	1	910	72.8 (58.7)	430
75	5	1	1550	46.8 (43.1)	907
SE ±			48.7	(1.8)	121.5
CV %			7.1	(6.4)	35.8

7.3.2. 1980 rainy season trials:

(a) In a separate replicated trial, effect of increased plant population on BND incidence was tested by sowing more than one seed on each hill. A detailed record of BND infected plants per hill was kept.

The results (Table 54) clearly showed that planting more seeds per hill had advantage over single seed; not all plants at each hill were infected, thus resulting in more number of healthy plants per plot.

Table 54: Effect of sowing more than one seed per hill on BND incidence - 1980 rainy season trial

Treatment	No.of hills/ plot	No.of plants infected from 4 plants*					No.of healthy plants/plot
		4	3	2	1	0	
T1 1 seed	149	-	-	-	73	27	46
T2 2 seeds	185	-	-	38	55	7	127
T3 4 seeds	200	9	22	36	27	6	402

From sample of 100 hills

(b) Eight treatment plots were planted with cultivar TMV-2 in a randomized block design with individual plot size of 10 x 8 m and 4 replications. The observations on BND incidence were recorded in nett plots of 5 x 4 m size. As expected, the BND incidence (%) decreased with closer spacing but more plants were infected at closer spacing (Table 55).

Table 55: Effect of spacing on bud necrosis disease incidence (rainy season 1980)

Spacing (cm)	No.of plants in net plot	BND incidence		
		Number	%	Arcsine transformed
75 x 15 x 1	201	108	53.6	(47.3)
75 x 15 x 2	392	117	29.8	(29.9)
60 x 20 x 1	187	88	47.0	(43.6)
60 x 20 x 2	348	149	42.1	(42.4)
30 x 10 x 1	522	222	42.6	(40.6)
30 x 10 x 2	1289	246	19.1	(25.9)
15 x 15 x 1	1622	482	29.7	(33.0)
15 x 15 x 2	3617	402	11.0	(19.5)
SE ±	92.5			(2.25)
CV %	15.6			(11.06)

7.3.4. 1981 rainy season trial:

1. In an intercropping experiment, 2 spacings, 30 x 10 and 30 x 20 were tested in a pesticide-free alfisol field. The gross plot size was 20 m x 25 m with two different plant spacings - 20 cm or 10 cm with row spacing of 30 cm. Cultivars TMV-2 and Robut 33-1 were grown. There were 3 replications.

The results (Table 56) showed that BND incidence was lower in both cultivars at 10 cm spacing than at 20 cm spacing. However, numbers of BND infected plants were more at closer spacing than at wider spacing. Yield was generally low as no fungicides could be applied to control fungal diseases.

Table 56: Effect of spacing on bud necrosis disease incidence (rainy season 1981)

Cultivar	Spacing (cm)	No.of plants per plot	No.of plants with BND	% BND incidence	Yield kg/ha
TMV-2	30x10	10640	2406	22.6 (28.0)	555
	30x20	5930	2141	36.1 (35.7)	383
Robut 33-1	30x10	12910	192	1.4 (6.9)	566
	30x20	5926	267	4.5 (2.1)	535
SE ±		505.8		(3.7)	34.0
CV %		11.0		(33.1)	13.0

( ) = Arcsine transformed values

2. In another trial 3 common cultivars were tested at two spacings. TMV-2, Robut 33-1 and M-13 were planted at 30 cm row x 10 cm plant or 75 cm row x 15 cm plant spacings. Here again (Table 57) the advantage of close spacing was clearly seen. TMV-2 at closer row and plant spacing had 20% BND incidence compared to 57% in wider row and plant spacing. A similar trend was observed in the other cultures though of much lower magnitude, both Robut 33-1 and M-13 having greater field resistance to BND. M-13 yielded highest because of very favourable monsoon season with well distributed and high rainfall.

Table 57: Effect of spacing on BND incidence (1981 rainy season)

Cultivar	Spacing (cm)	plants per plot	No.of plants infected	% BND	Yield kg/ha
TMV-2	30x10	1680	340	20.2 (26.6)	355
	75x15	503	288	57.3 (49.2)	202
Robut 33-1	30x10	1966	47	2.1 (8.4)	583
	75x15	640	22	3.4 (10.6)	273
M-13	30x10	1556	71	4.3 (11.9)	821
	75x15	488	50	10.2 (18.2)	437
SE ±		39.7		(1.77)	41.05
CV %		6.9		(16.93)	18.43

Conclusions:

BND incidence can be reduced considerably by close spacing. Plant population if maintained at 300,000 per ha (30 x 10 spacing) as recommended can be useful both in terms of reduced BND incidence and higher yield. However, to derive full advantage from close spacing it is essential to have a uniform plant stand with no gaps. In farmers' fields, plant stand is usually gappy even though high seed rates are used. This results from uneven distribution of seeds by the sowing drill. Another reason is lack of seed dressing. Seeds that are not treated with fungicides are exposed to fungal infection with resultant seeding mortality. Therefore, seed dressing can give additional plants without increasing seed rates.

The occurrence of higher numbers of BND infected plants at close spacing is not surprising as more thrips initially infest dense crops causing more initial BND spread in such crops than in sparse crops.

7.4. Effect of barrier crops/intercrops on Bud Necrosis Disease incidence:

7.4.1. 1978 rainy season experiment: A trial was conducted to determine the effect of a barrier crop (sorghum) on BND incidence in groundnut cv TMV-2. The design of experiment was a 4 x 4 latin square with 10x10 m plot size and 75 x 15 cm plant spacing. Each plot was separated from other by 10 m barren land. There were four treatments: (1) sole groundnut, (2) groundnut bordered on all sides by 3 rows of sorghum, (3) groundnut bordered on all sides by 3 rows of sorghum plus 3 rows of sorghum (W-E) in the centre, and (4) 3 rows of sorghum in the center. Crops were sown on 5th July. Sorghum was sown thick and was thinned to 10 cm spacing between plants on 30 DAE. Some mortality of seedlings was caused by sorghum shoot fly but overall stand was satisfactory. Detailed observations were recorded on BND incidence in each row of groundnut.

Plots of groundnut surrounded by sorghum plus 3 rows of sorghum in the center had the lowest numbers of BND infected plants and also lowest % of BND incidence (Table 58). The sole groundnut had the highest BND incidence.

Table 58: Effect of barrier crop on bud necrosis disease incidence i groundnut (rainy season 1978)

Treatment	No.of groundnut plants/ plot	BND incidence 75 days after emergence No.of plants	%
A. Sole groundnut	1082	641	52.4
B. Groundnut bordered on all sides with sorghum	702	411	50.1
C. Groundnut bordered on all sides with sorghum plus 3 rows of sorghum in the center (W-E)	551	267	44.0
D. 3 rows of sorghum in the center	979	502	45.7
SE ±	53.4	49.9	2.0
CV %	12.9	21.8	8.5

7.4.2. 1981 rainy season trial: This trial was conducted to determine the effect of intercropping on two varieties of groundnut TMV-2 (BND susceptible) and Robut 33-1 (BND field resistant). Pearlmillet hybrid BK 560 was intercropped with groundnut in the row proportion of 1:3. Row spacing was 30 cm for groundnut while plant spacing was either 10 cm or 20 cm. BND incidence was recorded on the 50th and 75th days in alternate rows of groundnut and thrips were recorded in 5 one meter subplots, 1 each at the corners and the 5th in the center of the plot.

Intercropping reduced the incidence of BND in the TMV-2 crop but not in the Robut 33-1 crop which is much more field resistant to BND than is TMV-2. Larger reduction was observed in 30 x 10 spacing and smaller in 30 x 20 spacing (Table 59).

Table 59: Effect of intercropping on BND incidence. (Rainy season 1981*)

Genotype	Cropping	Spacing	pp/plot	% BND
TMV-2	Sole	30x10	2273	22.6 (28.1)**
	Inter	30x10	1742	12.8 (20.9)
	Sole	30x20	1214	37.1 (36.7)
	Inter	30x20	880	32.5 (34.7)
Robut 33-1	Sole	30x10	2547	1.5 (7.0)
	Inter	30x10	1843	1.7 (7.3)
	Sole	30x20	1360	4.5 (12.1)
	Inter	30x20	1170	4.1 (11.4)
	SE ±		98.36	(3.52)
	CV %		10.36	(30.85)

* Groundnut 3 rows intercropped with pearlmillet (BK 560) 1 Row.
** ( ) = Arcsinetransformed values

7.4.3. 1982 rainy season trial: Groundnut was intercropped with different crops that are commonly grown in India. Plot size was 15 x 20 m with spacing between rows of 30 cm and between plants of 10 cm for groundnut. There were 7 treatments (1) sole groundnut (TMV-2), (2) groundnut 3 rows; pearl millet (BK 560) 1 row, (3) groundnut 3 rows: sorghum (CSH-6) 1 row, (4) groundnut 3 rows: maize (Deccan 101) 1 row, (5) groundnut 5 rows: castor (Aruna) 1 row, (6) groundnut 5 rows: sunflower (Morden) 1 row, and (7) groundnut 5 rows: pigeonpea (ICP-1-16) 1 row. Three replicae blocks were separated from each other by 30 m wide strips of unsprayed groundnut. Observations were taken in net plots of 100 m2. in the center of each plot. Numbers of BND infected plants were counted on the 50th, 62nd and 75th days after emergence. Numbers of thrips were recorded weekly on 5 one-meter row subplots, 1 each at the corners and the fifth in the

The BND incidence was lowest in groundnut: Pearl millet intercrop and highest in sole groundnut and groundnut: castor intercrop (Table 60). The effect of the pearl millet component on BND incidence was most pronounced between the 50th day and 62nd DAE; during this period the BND incidence increased by 12% in the pearl millet-groundnut intercrop but 22% in sole groundnut, 18% in pigeonpea-groundnut and castor-groundnut and between 16-18% in other intercrops. The data on thrips infestation also showed that in the pearl millet:groundnut intercrop thrips infestation was much less than in other crops (Fig. 42).

Table 60: Effect of intercropping of groundnut with different crops on bud necrosis disease incidence (rainy 1982 season)

Treatment	No.of groundnut plants/ net plot	BND incidence (%) on 50th day after sowing	62nd day	75th day	% reduction over control
Sole groundnut	3190	35	57	70	-
Groundnut + pearl millet	3128	25	37	47	32.9
Groundnut + sorghum	2938	32	48	60	14.7
Groundnut + maize	3039	32	50	62	10.8
Groundnut + pigeonpea	2800	36	54	67	3.8
Groundnut + sunflower	2955	31	48	62	10.9
Groundnut + castor	2938	39	57	70	-
SE ±		2.6	2.8	1.9	
CV %		13.7	7.5	5.3	

7.4.4. 1983 rainy season trial: The 1982 season trial was repeated in this season but the crop was sown late due to delayed on-set of monsoon rains. The crops were sown in the first week of August and though plant stand was good, the non-groundnut crops did not grow tall, apparently due to low soil fertility.

No useful effects of intercrops were observed in the late sown-crop (Table 61).

Table 61:Effect of intercropping of groundnut with different crops on bud necrosis disease incidence (rainy 1983 season - late sown crop)

Treatment	Groundnut plants/ plot	BND incidence (%) on date 7.9.	26.9	17.10	% reduction in BND over sole groundnu
Sole groundnut	4872	26	50	70	-
Groundnut + pearlmillet	3741	20	44	65	7
Groundnut + sorghum	3801	20	43	68	3
Groundnut + maize	3620	24	46	69	1
Groundnut + pigeonpea	4117	24	45	66	6
Groundnut + sunflower	3944	22	43	66	6
Groundnut + castor	4174	19	40	65	7
SE ±	193.6	3.7	3.5	2.5	
CV %	8.1	28.3	13.8	6.4	

Conclusions: Intercropping with cereal crops particularly pearlmillet reduced BND incidence in groundnut. Pearl millet provided a useful intercrop component for groundnut. In addition to reduced BND in pearlmillet intercrop, groundnut suffered less from moisture stress. This was observed in 1982 trial when there was dry spell during the month of August. This may have been due to reduced winds in pearlmillet intercrop than in sole crop. It appears that pearlmillet acts as barrier crop to reduce landing of wind-borne thrips.

In the pesticide-free low fertility alfisol fields where these trials were conducted, the growth of intercrops was not good and crops such as sorghum could not be protected against the shoot fly pest. The trials, if laid out on fertile soils, should have much better crop growth and show a better effect on BND incidence.

The rows of barrier crops were not exactly across the prevailing wind direction. Effect of barrier crops on BND incidence would be more pronounced if these rows were arranged across the wind direction.

The effect of barrier pearlmillet crop could be increased considerably if pearlmillet is sown earlier than groundnut forming a strong barrier when influx of thrips occurs. Another way would be to plant pearlmillet on ridges so that the height of the plants can be increased to give strong barrier effect.

Measurements on the effect of barrier crops on wind velocity in the crop and thrips deposition need to be undertaken.

7.5. Resistance:

Screening for resistance to BND was done in 1978 and 1978-79 and again in 1982 and 1983. Screening was not done in other seasons because of policy decisions that screening was to be done by virologists.

Methodology: Cultivars were sown as single row plots replicated 3 times with repeated checks of upright bunch, spreading bunch and runner cultivars. The TMV-2 cultivar served as check for upright bunch, Robut 33-1 for spreading bunch and M-13 for runner cultivars. The cultivars were compared with checks after converting the percentage incidence of BND in check cultivars to 100. This was done in 1978 and 1978-79. In 1982-83 such conversions were not made.

Cultivars were planted on ridges 75 cm apart with plant to plant spacing of 15 or 20 cm.

7.5.1. 1978 rainy season trial: A total of 240 cultivars were tested. In general, upright bunch (EB) cultivars were more susceptible than spreading bunch (SB) and runner (R) types. Large differences were found in susceptibility to BND (Table 62). In the upright bunch group, none was found to be markedly less susceptible than TMV-2. Some spreading bunch cultivars showed lower incidence than Robut 33-1. Notable among them were NC Ac 2761. In runner cultivars NC Ac 17123, 9925, 2242, 17287, 546, 2243, 15923, 1105, 1460, 1113, 9975, 2232, 1068, 2542, 2465, 2821, 17273, 1344, 15962, 343 were promising with 50-75% lower incidence than the M-13 check. However, there were large variations within a cultivar. For example,

NC Ac 2242 registered 65% less disease at one place and 52% at other. Larger plot size or more replications were essential.

Table 62: Screening of germplasm for resistance to bud necrosis disease (1978 rainy season)

Cultivar	% BND incidence
NC 56 (EB)	54
TMV-2 (check) (EB)	62
Mean 80 cultivars	90
SE ±	19.3
CV %	37.5
NC Ac 2761 (SB)	12
NC 2935 (SB)	18
NC Ac 2938 (SB)	18
NC Ac 2461 (SB)	19
Robut 33-1 (check)	35
Mean 81 cultivars	43
SE ±	16.1
CV %	75.3
NC 17128 (R)	12
NC 9925 (R)	13
NC 2242 (R)	16
NC 17287 (R)	17
NC 546 (R)	17
NC 2243 (R)	17
NC 15923 (R)	18
NC 1105 (R)	19
NC 1460 (R)	19
NC 1113 (R)	19
NC Ac 9975 (R)	20
NC Ac 2232 (R)	21
NC Ac 2242 (R)	22
M-13 check (R)	46
Mean 81 cultivars	33
SE ±	9.7
CV %	54.4

7.5.2. 1978/79 postrainy season trial: In this trial a total of 291 EB, 287 SB and 296 R cultivars were tested. The disease incidence was lower than in the rainy season and check values were 46% in TMV-2, 27.3% in Robut 33-1 and 17.4% in M-13 (Table 63). In the EB group, EC 243374, Improved Spanish, U-2-1-16, EC 386607, U-2-1-30 had 40-55% lower incidence than TMV-2. In the SB group, EC 76445, Ah 7224, NC Ac 1741, EC 7404 had 25-30% less BND than Robut 33-1. EC 76445 is promising on two counts; it is field resistant to BND and have high yield potential. In pesticide-free low fertility area this cultivar has given substantially higher yields than Robut 33-1. This cultivar has pods similar to Robut 33-1. In the runner group, NC Ac 2883 and C-120 were outstanding with respectively 70 and 80% lower disease incidence than M-13. Other lines with low BND incidence were C-123, Ah 7445, C-108, C-145-12-P7, Ah 641, C-100, C145-12-20, C 107, C-145-12-P-14, C-3, EC 100280, NC Ac 343, C-162, and C-127 with 40-60% lower incidence than M-13 cultivar. Among runner cultivar, M-13 has field resistance to BND. Cultivars such as C-120, C-123, C-108 and NC Ac 343 has high yield potential and are undergoing yield trials. Cultivar NC Ac 343 has resistance to thrips, jassids and pod boring insects.

Table 63: Screening of germplasm for resistance to bud necrosis disease (1978/79 season, 900 cultivars)

Growth habit	Cultivar	% BND
Erect Bunch	Imp. Spanish	18.0
	NC Ac 841	19.0
	U-2-1-46	22.0
	EC 27446	21.0
	U-2-1-30	25.0
	AK 12-24	30.0
	TMV-2	47.0
Spreading bunch	EC 76445	17.0
	Ah 7224	15.0
	NC Ac 1741	19.0
	EC 7404	30.0
	NC Ac 2828	21.0
	Robut 33-1	27.2
Runner	C-120	6.0
	NC Ac 2883	14.0
	C-123	14.0
	Ah 7445	13.0
	C-145-12-P-7	34.0
	C-108	15.0
	EC 100280	9.0
	Ah 6481	23.0
	C-100	28.0
	NC Ac 343	12.0
	M-13 (check)	48.0

In a seperate trial, 20 EB, 23 SB, and 15 R varieties previously selected for insect resistance were tested. Of these, NC Ac 489 and 44 had 40% less BND than TMV-2 (13%) in the VB group; Ah 54, NC Ac 17780, 2772, 1086, 2891, Ah 11, Ah 7054, NC Ac 2575, 841 had 50% lower BND incidence than Robut 33-1 in the SB group; and NC Ac 2232, 9979,

15926, 1113, Ah 7445, NC Ac 0067, Florunner, Ac 145-12-20, NC Ac 546, 2242, C-108, NC Ac 595, C-120 and NC Ac 9975 in the runner group were promising (Table 64).

Table 64: Screening of germplasm for resistance to bud necrosis disease (1979-80 season trial)

Growth habit	Cultivar	BND
EB	NC Ac 489	8
	NC Ac 44	9
	NC Ac 2196	11
	TMV-2 (check)	14
	Mean 20 cultivars	14
	SE ±	3
	CV %	42
SB	Ah 54	0
	NC Ac 17780	1
	NC 2772	1
	NC 1086	3
	NC Ac 2891	3
	Ah 11	3
	Robut 33-1	8
	Mean 23 cultivars	6
	SE ±	3
	CV %	79
Runner	NC Ac 2232	1
	NC Ac 9979	1
	NC Ac 15926	1
	NC 1113	1
	Ah 7445	1
	NC Ac 10067	2
	Florunner	2
	Ac 145-12-20	2
	NC 546	2
	NC 2242	2
	C-108	2
	NC 595	2
	C-120	4
	NC Ac 9975	5
	M-13 check	10
	Mean 15 cultivars	2.
	SE ±	1.1
	CV %	94.0

7.5.3. 1980 Rainy season trial: 22 genotypes from previous trials were tested in small blocks of 4 rows x 4 m and disease incidence was recorded. Several of these had lower disease incidence than check cultivars under high disease pressure (TMV-2 83% BND).

Table 65: Screening of germplasm for BND resistance (1981 rainy season)

S.No.	Identity	% BND incidence
1	NC Ac 2277	1.1
2	NC Ac 343	3.0
3	NC Ac 2214	3.0
4	NC Ac 1705	3.4
5	NC Ac 2242	3.5
6	NC Ac 2240	3.6
7	NC Ac 2243 T	3.8
8	NC Ac 2142	3.9
9	NC 20986	4.6
10	NC Ac 2462	5.6
11	NC Ac 2230	6.0
12	Ah 7215	6.03
13	NC Ac 17888	6.1
14	M-13	6.4
15	Robut 33-1	6.8
16	NC Ac 2575	6.9
17	FESR No.108	7.0
18	NC Ac 17288	7.2
19	NC Ac 1044	7.5
20	NC Ac 9975	7.7
21	NC Ac 1122	8.9
22	NC Ac 2203	8.9
23	RMP 40	9.3
24	Ah 54	9.6
25	NC Ac 2232	11.1
26	NC Ac 2243 (B)	14.0
27	NC Ac 1308	17.3
28	TMV-2	18.2
29	NC Ac 2199	18.9
30	M-127-74	20.5
31	NC Ac 10223	21.5
32	NC Ac 2661	22.0
33	NC Ac 2214	22.2
34	NC 2888	24.0
35	U2-47-5	24.5
36	NC Ac 406	27.6
37	NC Ac 1337	28.1
38	NC 489	28.4
39	NC Ac 2700	34.6
40	NC 2666	38.2
SE ±		6.03
CV %		48.26

7.5.4. 1981 Rainy season trial: Low incidence of BND in several previously selected lines was confirmed in small plots of 4 m x 4 rows replicated 3 times (Table 65).

In a separate trial 40 entries from insect resistant germplasm were screened in 4 x 4 m plots replicated three times. Several previously selected entries showed promise against BND (Table 66).

Table 66: Screening of germplasm for BND resistance (1981 Rainy season)

S.No.	Genotype	% BND incidence
1	NC Ac 2232	0.0
2	NC Ac 2243 B	0.1
3	NC Ac 2230	0.1
4	NC Ac 2243 T	0.2
5	NC Ac 2214	0.2
6	NC Ac 2240	0.7
7	NC Ac 2144	0.8
8	NC Ac 2666	1.5
9	NC Ac 489	1.0
10	NC Ac 1705	1.0
11	NC Ac 2142	2.3
12	NC Ac 2661	2.7
13	NC Ac 1337	2.7
14	NC Ac 343	3.0
15	NC Ac 2242	3.5
16	NC Ac 2700	3.8
17	M-127-74	4.0
18	NC Ac 406	4.7
19	NC Ac 2888	6.7
20	NC Ac 2203	7.3
21	NC Ac 17888	9.7
22	M-13	10.0
23	U-2-47-5	10.0
24	NC Ac 2277	13.3
25	NC Ac 2462	13.3
26	NC Ac 17288	18.3
27	NC Ac 1308	18.3
28	NC Ac 2199	18.9
29	Ah 7215	19.0
30	RMP 40	21.7
31	NC Ac 9975	23.3
32	NC Ac 1044	33.3
33	Robut 33-1	33.3
34	NC Ac 1132	33.3
35	NC Ac 10223	36.7
36	TMV-2	40.0
37	NC 20986	40.0
38	NC Ac 2575	43.3
39	Ah 54	46.7
40	FESR 108	53.3
SE ±		6.03
CV %		48.26

In another trial 36 entries of different growth habits were tested in 4x4 m plots replicated three times. Some entries such as MK 374, NC Ac 2575, NC Ac 2232 were promising (Table 67)

Table 67: Screening for bud necrosis disease resistance, rainy season 1981 (36 entries)

S.No.	ICG No.	Identity	BND % incidence
1	-	MK 374	10
2	7966	NC Ac 2575	21
3		NC Ac 2232	26
4		NC Ac 2575	26
5	156	M-13	27
6	2828	RS 14	29
7	799	Robut 33-1	30
8		K 71-1	31
9	8006	16541	33
10	7662	16949	34
11	2873	Var 34-11-11-3	35
12	6014	17373	35
13	8033	17890	41
14	8032	17890	41
15	4249	A-24-11	46
16	7476	NC Ac 17621	46
17	8093	NC Ac 17538	47
18	6259	NC 16911	47
19	3984	F-13	49
20	8005	NC Ac 16442	50
21	4903	Ah 7829	67
22	1450	U4-7-7	67
23	5511	Ah 7777	68
24	3150	Argentine	71
25	3586	45-29	76
26	8049	NC Ac 16453	78
27	3425	No. 53	78
28	8000	10054	79
29	3631	EC 109276	81
30	221	TMV-2	82
31	8071	16077	82
32	8003	NC Ac 10088	84
33	366	NC Ac 945	84
34		NC Ac 1337	86
35	2260	Pol 2	87
36	1326	J 11	91
	SE ±		4.7
	CV %		17.2

7.5.5. 1982 Rainy season trial: In this trial 213 new lines, 111 selected lines and 92 foliar diseases resistant lines were tested in 4x4 m blocks replicated 3 times. Of the new lines, C-136 and C-102 were outstanding with 4 and 7% BND incidence compared to 20% in Robut 33-1, 43% in M-13 and 89% in TMV-2 (Table 68).

In a separate trial 111 selected entries were tested in 4 m x 4 row plots replicated 3 times. Low incidence of several previously selected lines was confirmed (Table 69).

Among rust resistance breeding lines F2 P107 (4)(A), and F2 P4 (1) were outstanding with 13 and 14% BND incidence respectively compared to 27% in Robut 33-1, and 67% in TMV-2 (Table 70).

Table 68: Screening of groundnut germplasm for resistance to bud necrosis disease, rainy season 1982

(213 entries)

Cultivar	% BND
C-136	4
C-102	7
C-145-12-P-16	14
GO 09	14
C-145-12-P-7	16
C-145-12-P(PL)	18
C-121	18
C-163	18
C-125	18
PI 267076-S	19
69-9	19
C-18	19
C-108	20
Robut 33 (check)	20
TMV-2 (check)	89
PI 14964 (susceptible)	100
Mean 213 cultivars	52
SE ±	8
CV %	29

Table 69 : Screening of groundnut germplasm for resistance to bud necrosis resistance, rainy season, 1982
(111 entries)

Cultivar	% BND incidence
NC Ac 1741	7
C-108	11
NC Ac 841	14
Gujarat narrow leaf	14
NC Ac 1086	15
NC Ac 29	16
NC Ac 7481	17
NC Ac 2203	17
NC Ac 17888	17
Robut 33-1 (check)	18
TMV-2 (check)	67
NC Ac 17011 (susceptible)	93
Mean 111 cultivars	23
SE ±	4.7
CV %	35.3

Table 70 : Screening of pathology material to bud necrosis resistance, rainy season, 1983

(92 entries)

Cultivar	% BND
F2-P107(4)(A)	13
F-P4 (1)	13
F2-B2(1)	21
F2-P14 (1)	21
F2-P52(2) Tan	24
Robut (check)	27
Var OG-75-B (susceptible)	80
Mean 92 cultivars	49
SE ±	6.4
CV %	22.5

7.5.6. 1982/83 postrainy season trials: Of the 111 entries tested, several lines that were found promising showed lower disease incidence than the check cultivar Robut 33-1. However, disease pressure was low, Robut 33-1 had only 12.7% BND incidence and maximum incidence was 50.6% in NC Ac 2679 (Table 71).

Table 71 : Screening of germplasm for resistance to bud necrosis disease (1982-83 postrainy season - 111 entries)

Cultivar	% BND incidence
NC Ac 1741	5
NC Ac 2232 (N)	7
NC Ac 2232 (Q)	9
NC Ac 841	9
NC Ac 2243 T	9
NC Ac 546	10
C 5	10
Ah 54	10
NC Ac 2575	10
EC 76445	10
NC Ac 2242	10
NC Ac 2460	11
NC Ac 2772	11
NC Ac 17888	11
NC Ac 2771	11
Robut 33-1 (check)	12
NC Ac 2679 (susceptible)	50
Mean (111 cultivars)	23
SE ±	4.7
CV %	35.3

7.5.7. 1983 rainy season trials: In this season, a total of 72 entries from thrips-resistant material, 63 ICG lines, 69 entries previously selected as promising against BND, and 150 new germplasm lines were tested. In addition, over 1,000 other lines were tested. The data for these 1,000 lines has not been analysed so far.

Among the insect resistant breeding lines (Mani Pintar x Robut 33-1) x NC Ac 2232 selection had 39% BND incidence compared to 69% in Robut 33-1. The yield was double (607 gms/plot) that of Robut 33-1 (278 gms/plot). Several breeding lines outyielded Robut 33-1. These are shown in Table 72.

Among F8 insect resistant breeding lines several selections from crosses between Robut 33-1 and NC Ac 2214 had lower BND incidence than Robut 33-1. Yieldwise, selection F3-B1-B1-B2-B1-B2 had the highest yield (557 gms/plot) compared to 278 gms/plot of Robut 33-1 (Table 73).

Among 44 breeding lines a selection from (Gangapuri x MK 374) x (Robut 33-1 x NC Ac 2214) had 44% BND when compared well with Robut 33-1 (68%) and yielded slightly less (447 gms/plot) than Robut 33-1 (278 gms/plot). Several lines such as T-24, T-25, and T-30 which gave high yield had low BND incidence. NC Ac 343 had 36% BND incidence, several lines that were susceptible (BND incidence between 90-100%) yielded poorly (Table 74).

Among 37 selections, C-108, NC Ac 17888, 7481, 343, and EC 76445 had lower BND incidence and yielded better than Robut 33-1. EC 76446 produced 407 gms pods/plot compared to 218 g/plot of Robut 33-1 (Table 75). PI 161297 was the outstanding yielder (508 g/plot) in spite of having a high BND level (60%) compared to Robut 33-1 (40%) (Table 76).

Of 63 breeding lines, ICGS37 had the lowest BND (24.5%) followed by ICGS50 (37%), ICGS38 (38%), and ICG 32 (40%); while ICGS10 (97%), ICGS39 (94%), ICGS7 (93%) were susceptible (Table 77). ICGS33 yielded the highest (402 g/plot) and ICGS10 the lowest (61 g/plot) (Table 78).

Among 63 Entomology selections NC Ac 10223 had only 19% BND compared to 35% in Robut 33-1. Other promising lines were C-12-P-10 (22%), 77-83 APAU C-4 (22.5%), PI 153330 (23%), M-145 (23%) and VRR-170 (29%) (Table 79).

Among 69 insect resistant lines C-136 was outstanding with 6% BND compared to 61% in Robut 33-1 and 83% in TMV-2 (Table 80). Another line, C-121, had 6.6% BND and C-107 had 9% BND. These lines appear to have the strongest resistance of the lines tested under high BND pressure.

Among 190 germplasm lines C-107 had the lowest BND incidence (22.6%) compared to 60% in Robut 33-1 and 95% in TMV-2. Other promising lines were Ah 7067 (25%), C-145-12-P-34 (26%), and C-147 (31%) (Table 81).

Among 970 germplasm lines, none of 330 SB lines, 69-9 (32%), C-62, C-134 (14%), Ah 7729 (23%) of 330 runner type and none of 310 EB type were promising.

Among 42 insect resistant selections, a few had moderate BND incidence but yielded much higher than the standard resostamt cultivar Robut 33-1 under low as well as high soil fertility and under close spacing (30x10 cm) (Table 82).

Table 72: Screening of insect resistant breeding lines for resistance to bud necrosis disease (F6 - 14 entries)

Entry	% BND incidence	Yield (g) per plot
1. (Mani pintar x Robut 33-1) x NC Ac 2232 F2-B1-B2-B1-B2	38.59	607
2. Manfredi 68 x NC Ac 343 F2-B1-B1-B1-B2	51.87	483
3. Ah 6279 x NC Ac 2232 F2-B1-B1-B1-B2	56.00	397
4. Manfredi 68 x NC Ac 343 F2-B1-B2-B1-B2 (Tan)	60.07	340
5. NC Ac 2719 x NC Ac 2232 F2-B1-B1-B1-B2	60.63	336
6. Robut 33-1 check	69.19	278
Mean (14 entries)	65.92	319.05
SE ±	8.64	73.67
CV %	22.70	39.99

Table 73: Screening of insect resistant breeding lines for resistance to bud necrosis disease (F8) 19 entries

Entry	% BND incidence	Yield (g) per plot
Robut 33-1 x NC Ac 2214		
F3-B1-B1-B1-B1-B1-B1	30.1	250
F3-B1-B1-B3-B1-B3	42.6	416
F3-B1-B1-B2-B2-B3	46.4	510
F3-B1-B1-B2-B1-B3	52.1	557
F3-B1-B1-B2-B2-B3	54.3	365
Robut 33 (check)	69.2	278
Mean (19 lines)	61.87	283
SE ±	9.66	85
CV %	27.05	52

Table 74: Screening of insect resistant breeding lines for resistance to bud necrosis disease (F7) 44 entries

Entry	% BND incidence	Yield (g) per plot
(Gangapuri x MK 374) x (Robut 33-1 x NC Ac 2214) F6-B3	44.5	447
Robut 33-1 x NC Ac 2214 F8-B2 (2-7)	48.5	403
Robut 33-1 x NC Ac 343 F8-B3	56.8	425
Robut 33-1 x NC Ac 2214 F8-B3 (2-7)	51.2	410
Robut 33-1 (check)	68.0	278
NC Ac 343 (check)	36.8	192
J-11 (check)	99.5	57
JL-24 (check)	98.9	7
Mean (44 entries)	73.73	179
SE ±	7.49	32.2
CV %	17.58	31.1

Table 75: Screening of insect resistant germplasm for resistance to bud necrosis disease 37 entries

Entry	% BND incidence	Yield (g) plot
C-108	13.8	373
NC Ac 17888	19.5	307
NC Ac 7481	29.6	263
NC Ac 343	31.4	322
EC 76445	32.2	407
Robut 33-1 (check)	40.3	218
Spancross (susc.)	93.6	117
Mean (37 cultivars)	58.87	209
SE ±	7.58	52.6
CV %	22.30	43.4

Table 76: Insect resistant entries with low BND incidence and high yield (1983 rainy season)

Entry	% BND incidence	Yield (g) per plot
PI 161297	59.8	508
EC 76445	32.2	407
NC Ac 2772	47.1	387
C-108	13.8	373
Robut 33-1 (check)	40.3	218
NC Ac 10033 (susc.)	76.9	27
Mean (37 entries)	58.9	210
SE ±	7.6	52.6
CV %	22.3	43.4

Table 77: Screening of ICGS lines for resistance to bud necrosis disease (1983 rainy season - 63 cultivars)

ICG line	% BND incidence	Yield (g)/ plot
ICGS 37	24.5	210
ICGS 50	37.0	350
ICGS 38	38.5	342
ICGS 32	39.9	206
ICGS 44	44.6	228
ICGS 46	45.6	340
Robut 33-1 (check)	68.0	278
Mean (63 cultivars)	60.7	224.7
SE ±	7.7	41.0
CV %	22.3	31.6

Table 78: Screening of ICGS lines for high yield (1983 rainy season 63 entries)

ICG line	% BND incidence	Yield(g)/ plot
ICGS 33	66.3	402
ICGS 50	37.0	350
ICGS 49	59.9	348
ICGS 38	38.5	342
ICGS 36	51.8	342
Robut 33-1 (check)	68.0	278
Mean (63 lines)	60.7	224
SE ±	7.7	41
CV %	22	31.6

Table 79: Screening of germplasm for resistance to bud necrosis disease (1983 rainy season - 66 entries)

Entry	% BND incidence
NC Ac 10223	19.1
C-12-P-10	22.2
APAU C-4	22.5
PI 153330	23.3
M-145	23.4
VRR 170	28.9
Ah 7890	32.2
Robut 33-1 (check)	34.6
m-13 (check)	71.2
TMV-2 (check)	96.5
PI 152139 (susc.)	100.0
Mean (66 cultivars)	60.4
SE ±	10.80
CV %	30.97

Table 80: Screening of germplasm for resistance to bud necrosis disease - 69 entries (1983 rainy season)

Entry	% BND incidence
C-136	5.7
C-121	6.6
NC Ac 2232	7.9
C-107	8.7
Gujarat narrow leaf	9.1
NC Ac 2240	9.6
NC Ac 2243 (B)	9.7
C-102	10.8
NC Ac 1741	11.6
NC Ac 2242	12.6
C-145-12-P-16	12.8
GO 09	14.2
C-108	14.4
NC Ac 2243 (T)	15.0
C-163	15.3
NC Ac 2142	16.9
F2 P3 (1) (path)	18.8
F2 P4 (1) (path)	20.6
NC Ac 343 (check)	21.4
Robut 33-1 (check)	60.6
TMV-2 (check)	87.0
Mean (69 cultivars)	28.2
SE ±	6.97
CV %	42.80

Table 81: Screening of germplasm for resistance to bud necrosis disease - 190 entries (1983 rainy season)

Entry	% BND incidence
C-107	22.7
Ah 7067	25.6
C-145-12-P-34	26.3
C-147	31.3
EC 20968	31.5
Robut 33-1 (check)	60.1
TMV-2 (check)	100.0
Mean (190 cultivars)	73.4
SE ±	9.56
CV %	22.56

Table 82: Yield performance and BND incidence in some insect resistant selections (44 entries)

1983 rainy season trial

Entry	% BND	Low fertility Yield (kg/ha)	High fertility Yield (kg/ha)
Robut 33-1 x NC Ac 343 F8-B3	56.8	1500	2656
Robut 33-1 x NC Ac 2214 F8-B3	64.5	1447	2354
Robut 33-1 x NC Ac 2214 F8-B3	51.3	1361	2286
Robut 33-1 x NC Ac 2214 F8-B3	48.5	1263	2073
NC Ac 343 (check)	36.8	1201	2020
Robut 33-1 (check)	68.0	1149	2106
J-11 (check)	99.5	431	1628
JL 24	98.9	531	1510
Mean (44 entries)		812.4	1836.7
SE ±		108.9	105.9
CV %		23.2	11.5

Summary of BND reistance screening of germplasm lines (1978-1983):

High levels of field resistance to BND were observed in several lines. The lines with consistant good performance are listed in the tables and the line C-136 appears to be most promising with 94% less disease incidence than TMV-2 cultivar in two trials. Other promising lines are C-102, C-121, NC Ac 2232, NC Ac 1741, NC Ac 2242, Gujarat narrow leaf and NC Ac 17888 (Table 83).

Among high yielding cultivars, Robut 33-1, NC Ac 343, MK 374, and M-13 appear have low BND incidence and these are being used in crossing.

Table 83 : Germplasm with field resistance to BND

Cultivar	No. of seasons tested	BND incidence %	BND in check (%) (TMV2)	% less BND incidence than check (TMV2)
C-136	2	5	80	93
C-102	2	9	80	88
C-121	2	12	80	84
NC Ac 2232	5	6	44	85
NC Ac 1741	4	11	59	81
NC Ac 2242	5	9	56	82
Gujarat narrow leaf	3	12	70	82
NC Ac 17888	4	13	51	75
NC Ac 343	5	13	51	73
Robut 33-1	5	25	51	50
M-13	5	19	51	62
TMV-2	6	50	-	

Table 84 : Seasonwise BND incidence in some germplasm lines

Sources of	(BND incidence %) 1978/79	1979/80	1981	1982	1982/83	1983	Mean	TMV-2 (Check)
C-136	-	-	-	4.4	-	5.6	5.0	80.6
C-102	-	-	-	7.4	-	10.8	9.1	80.6
C-121	-	-	-	18.4	-	6.6	12.5	80.6
NC Ac 2232	2.4	0.8	11.1	-	7.7	12.6	6.9	44.8
NC Ac 1741	20.7	-	-	7.2	5.3	11.6	11.2	59.6
NC Ac 2242	8.4	2.4	-	11.0	12.9	14.4	9.8	56.8
Gujarat narrow leaf	-	-	14.6	-	13.8	9.1	12.1	78.1
C-108	-	-	-	20.5	12.9	14.4	18.6	70.3
NC Ac 17888	-	6.1	17.9	-	11.5	20.2	13.9	57.3
NC Ac 841	-	-	-	-	9.8	17.8	13.8	66.3
Robut 33-1	27.3	-	10.7	19.0	12.7	60.6	25.3	51.3
M-13	17.3	-	6.4	32.4	12.4	25.0	19.0	51.3
TMV-2 Check	27.3	45.6	18.3	78.4	49.9	82.7	50.4	50.4
NC Ac 343	9.4	-	3.0	21.8	13.0	21.4	13.9	51.3

7.5.8. Screeing of wild species of Arachis for bud necrosis disease resistance:

Several accessions of wild Arachis were tested by caging viruliferous thrips on them. Preliminary screening was done on 1-6 plants by releasing 2 viruliferous adult thrips on them and those accessions that showed clear BND symptoms were eliminated from subsequent screening.

Procedure:

TSWV was maintained in groundnut cv TMV-2 by frequent mechanical sap inoculation. Young leaflets showing chlorotic ring spots were used as sources of inoculum.

Virus-free thrips, F. schultzei, were reared on cultivar TMV-2 plants grown in a Percival incubator maintained at 28 C day (700 Lux) and 21 C night temperatures. Acquisition access period given to larvae was 3 days and inoculation access period of adults was 5 days. Five adult thrips were released on each test plant. TMV-2 and urdbean (UPU-1) were used as susceptible controls.

The results of preliminary as well as advanced screening are given in Table 85.

Results: Inoculation trials with 5 adult thrips were quite successful as indicated by high rates of infection in control plants (23/24 in TMV-2 and 19/19 in urdbean). Of the several accessions only A. chacoense proved to be resistant (0/20). Arachis pusilla showed only a localized infection and the ringspots were very small. 1 out of 12 plants of A. pusilla showed systemic infection. All other species were susceptible.

			plants tested**	plants infected	ELISA	
		A. sp. 30109	4	4	+	
8945		30003	4	4	+	Clear symptoms
8959		30085	4	4	+	Delayed symptoms (mild symptoms)
8197		30062	4	4	+	Hyper sensitive
8201		30069	5	4	+	1 plant dried
8948		30016	2	1	+	
		Manfredi-5	5	4	+	Clear symptoms
8125	338279/33708	408	4	2	+	
8946		30009	4	4	+	
8202		30070	4	4	+	Clear symptoms
8216	262141	A. cardenasii (10017)	4	3	+	
8958		30080	4	4	+	Hyper sensitive
	262808	A. correntina 9530	9	6	+	
8139	262133	10038	4	4	+	
		30134	4	4	+	
8136		30071	4	3	+	
8215		30126	3	3	+	
8210		30081	4	4	+	
8127	261877	9990	4	4	+	Delayed symptoms
8954		30035	4	4	+	
4983	276235	A. chacoense (10602)	20	0	-	
8193		30011	3	3	+	
8128	261878	9993	4	4	+	
8956		30065	4	4	+	Delayed symptoms
8141	338297/338298	C-565-6 Rusty	4	4	+	
8129		10002	3	3	+	
8131		A. pusilla (12922)	10	9	+	Systemic in one plant only
8135	331338/298364	A. monticola (HLP 104)	6	6	+	
8124		A. batizocoi	12	12	+	
8126	338280/337305	A. stenocarpa (HLK 410)	8	6	+	
8125	337308/337309	HLK 409	7	4	+	
	336984/336985	A. villosulicarpa	5	5	+	
		A. sp 10038	6	6	+	
8164		35001	6	5	+	
8198		30063 tan	6	6	+	
8200		30067	7	7	+	
8960		30092	5	5	+	Severe reaction plant rapidly killed
		30036	4	4	+	
		30031	4	4	+	
8957		30074	4	4	+	
8123		A. duranensis	4	4	+	
	Control	Urdbean	19	19	+	
	Control	TMV-2	24	23	+	

* Five viruliferous adult thrips were released on each plant.

7.5.9. Screening of breeding lines for resistance to bud necrosis disease:

Three parents were used by breeders in a crossing program. These were NC Ac 343, Robut 33-1 and M-13. The following crosses were made:

NC Ac 343 x Colorado Manfredi, NC Ac 343 x JH 89 (good yielder), NC Ac 343 x Manfredi 68, NC Ac 343 x TG 1 (bold seed type), NC Ac 343 x SM 5 (good combining ability), NC Ac 343 x (J 11 x JH 89), NC Ac 343 x Robut 33-1, Robut 33-1 x NC Ac 2214, Robut 33-1 x 343, M 13 x NC Ac 2214, Argentine x NC Ac 2214, Florunner x NC Ac 2214, MK 374 x NC Ac 2214, and JL 24 x NC Ac 2214.

NC Ac 343 is a high yielding line with resistance to several insects. Robut 33-1 and M-13 are high yielding cultivars. All three cultivars had 50-70% less BND than TMV-2.

Colorado Manfredi and Manfredi are released cultivars from South America, JH 89 is a high yielding germplasm line, TG1 is bold seed type irradiated mutant from Trombay, J-11 is a high yielding Indian cultivar and NC Ac 2214 is a thrips resistant cultivar. After progenies reached the F6 generation, screening was started. The performance of these lines is given in Table 85.

Observations on BND incidence were recordd at harvest. The result (Table 85) showed considerable variation in BND in different breeding lines. Several breeding lines showed very low BND incidence under high disease pressure indicated by 83% BND in susceptible TMV 2 cultivar.

Table 85: Performance of some breeding lines with field resistance to BND

Pedigree	No.of plants		% BND incidence
	BND infected plants	Total	
1. Manfredi 68 x NC Ac 343 F2-B1-B2-B1-B3-B1	15	306	4
2. Manfredi 68 x NC Ac 343 F2-B1-B2-B1-B1 (SB)	16	217	7
3. M-13 x NC Ac 2214 F2-B2-B1-B1-B2-B2-B2	35	468	
4. Robut 33-1 x NC Ac 2214 F3-B2-B2-B1-B2-B2	36	471	7
5. Robut 33-1 x NC Ac 2214 F3-B2-B1-B2-B1-B3	35	409	8
6. Robut 33-1 x NC Ac 2214 F3-B2-B2-B1-B1-B1	39	396	9
7. Robut 33-1 x NC Ac 2214 F3-B1-B2-B2-B2-B1 (small pod)	29	296	9
8. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B3	25	258	9
9. Robut 33-1 x NC Ac 343 F2-B2-B1-B1-B2-B1,B2	68	629	10
10. Robut 33-1 x NC Ac 2214 F3-B1-B2-B1-B3-B3 ,	8	79	10
11. Robut 33-1 x NC Ac 2214 F2-B1-B1-B2-B1-B3-B3	37	319	11
12. M-13 x NC Ac 2214 F3-B1-B2-B1-B2-B2	20	175	11
13. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B3	24	192	12
14. Robut 33-1 x NC Ac 2214 F3-B1-B1(TVRR)HO-B1-VB-B2-B2	9	73	12
15. Manfredi 68 x NC Ac 343 F2-B1-B1-B2-B2-B1	35	258	13
16. M-13 x NC Ac 2214 F2-B2-B1-B2-B2-B2-B2 (Tan)	36	262	13

17. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B1	68	447	15
18. M-13 x NC Ac 2214 F3-B1-B1-B1-B1-B1-Tan	87	556	15
19. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B2-VB	77	487	15
20. (J 11 x JH 89) x NC Ac 343 F2-B1-B1-B2-B2	31	203	15
21. Robut 33-1 x NC Ac 2214 F3-B0-B1(TVBT) B2-H0-B1(RVBT)B2-B2	16	98	16
22. M-13 x NC Ac 2214 F2-B2-B1-B1-B2-B2-B1 Red	84	494	17
23. Colorado Manfredi x NC Ac 343 F2-B1-B1-B1-B2-VB Tan	44	252	17
24. SM-5 x NC Ac 343 F2-B1-B1-B1-B1-SB	42	230	18
25. Robut 33-1 x NC Ac 2214 F3-B1-B1-B1-B2-B2	44	218	20
26. M-13 x NC Ac 2214 F3-B1-B1-B2-B2-B1	45	215	20
27. M-13 x NC Ac 2214 F3-B1-B1-B2-B2-B2 (Carduroy)	71	337	21
28. M-13 x NC Ac 2214 F2-B2-B1-B2-B2-B2-B2	36	168	21
29. Robut 33-1 x NC Ac 2214 F3-BO-B1T-B2HO-B1-B2 (RVBT)-B2	53	260	20
30. Manfredi 68 x NC Ac 343 F2-B1-B2-B2-B2-VB (Tan)(Smooth pods)	66	296	22
31. Manfredi 68 x NC Ac 343 F2-B1-B1-B1-B2 (Red)	39	172	22
32. Argentine x NC Ac 2214 F2-B1-B1-B2-B1-B3	117	483	24
33. Manfredi 68 x NC Ac 343 F2-B1-B1-B1-B1 (VB)	55	224	24
34. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B2	81	328	24
35. Manfredi 68 x NC Ac 343 F2-B1-B2-B1-B2 VB Tan (Constricted pods)	34	136	25

36. Manfredi 68 x NC Ac 343 F2-B1-B2-B1-B2-VB Tan	62	239	25
37. Robut 33-1 x NC Ac 2214 F3-B1-B1(SVBP)-B2HOP-B1-VB-B2 (RVBP)	58	230	25
38. TG 1 x NC Ac 343 F2-B1-B1-B1-B1 VB Tan	65	248	26
39. Robut 33-1 x NC Ac 2214 F3-B1-T-B1-B3-HO-B1 (RVBT)-B1	55	207	26
40. M-13 x NC Ac 2214 F3-B1-B2-B1-B2-B2	46	167	27
41. Robut 33-1 x NC Ac 2214 F2-P19-P23-B2-B1 (RVBT)-B1-B1	55	196	28
42. Argentine x NC Ac 2214 F2-B1-B1-B2-B1-B1	126	421	29
43. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B2 (RVBT) Purple	64	208	30
44. Robut 33-1 x NC Ac 2214 F2-B1-B1-B2-B1-B2 (RVBT).s 1	48	156	30
45. Manfredi 68 x NC Ac 343 F2-B1-B2-B2-B1, VB Tan	102	312	32
46. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B2	110	330	33
47. Manfredi x NC Ac 343 F2-B1-B2-B2-B2 SB Red	187	66	35
48. Colorado Manfredi x NC Ac 343 F2-B1-B1-B1-B2 SB Tan	100	270	37
49. Florunner x NC Ac 2214 F2-B1-B1-B1-B2-B2 VB	210	525	40
50. MK 374 x NC Ac 2214 F2-B1-B1-B1-B1-B2	128	308	41
51. Robut 33-1 x NC Ac 2214 F2-B1-B2-B1-B1-B1	105	245	42
52. JL 24 x NC Ac 2214 F2-B1-B1-B2-B1-B1	99	225	44
53. JH 89 x NC Ac 343 F2-B1-B1-B1-B2 SB	129	286	45
54. Manfredi 68 x NC Ac 343 F2-B1-B1-B2-B2 VB	143	300	47

55. Colorado Manfredi x NC Ac 343 F2-B1-B1-B1-B1 SB (Tan)	114	204	55
56. JH 89 x NC Ac 343 F2-B1-B1-B1-B1-SB	188	328	57
57. Robut 33-1 x NC Ac 2214 F3-B1-B1-B2-B1-B2 VB	329	540	61
58. SM 5 x NC Ac 343 F2-B1-B1-B2-B2 SB	178	245	72
59. Manfredi 68 x NC Ac 343 F2-B1-B2-B1-B2 SB (Tan)	125	167	74
60. Colorado Manfredi x NC Ac 343 F2-B1-B2-B1-B2 Val. Red	298	342	87
61. TMV-2	500	600	83

7.5.10. Stability of field resistance to BND in Robut 33-1 cultivar under various agronomic practices

Screening trials during 1978-83 indicated that Robut 33-1 and NC Ac 34 were moderately field resistant to bud necrosis disease. These two cultivars had 50-70% less BND incidence than cultivar TMV-2. Both Robut 33-1 and NC Ac 343 are high yielders, and Robut 33-1 has been released in India. It was essential to test the stability of resistance under diffeent agronomic conditions. This was done by conducting several field experiments.

(a) Incidence of BND in Robut, TMV-2 and M-13 cultivars in different seasons:

This trial was conducted over 4 rainy and 2 postrainy seasons. Robut 33-1 was compared with TMV-2 and M-13 by growing them on 100 sq.m. plots replicated 3 or 4 times. The row spacing was 75 cm and the plant spacing 15 cm. The numbers of thrips present were recorded weekly by counting them on the 3 youngest leaves of 10 randomly selected plants of each plot. The two species of thrips, F. schultzei, and S. dorsalis were counted separately. The incidence of BND was recorded at weekly interval by counting the number of BND affected plants.

Table 86 shows the incidence of BND in three common cultivars, Robut 33-1; TMV-2 and M-13 grown in 4 rainy and 2 postrainy seasons. Robut 33-1 had lower BND incidence than TMV-2 cultivar even under the high disease pressures in seasons 1979 and 1980. The largest difference was in 1981 rainy season trial when BND incidence was only 3.5% in Robut 33-1 compared to 60% in TMV-2. Though Robut 33-1 had.

25% more plants per plot than the other two cultivars, this was not the only reason for low incidence of BND in this cultivar. Because in the other plots on which Robut 33-1 plant stand was reduced by one-half, the disease incidence remained low.

Table 86. Incidence of BND in Robut 33-1, TMV-2 and M-13 cultivars in different seasons

Cultivar	Rainy season				Postrainy season	
	1978	1970	1980	1981	1978-79	1979-80
TMV-2	71.0	100.0	92.6	59.4	82.2	35.0
Robut 33-1	38.6	50.2	35.3	3.5	50.6	21.6
M-13	55.4	58.1	40.8	7.9	72.2	30.0
SE ±	(1.5)	(0.9)	(2.8)	(2.0)	(3.5)	(0.8)
CV %	(5.4)	(2.6)	(9.5)	(13.5)	(10.6)	(4.3)

* Figures in parentheses are arcsine transformed values.

(b) Incidence of BND in some commonly grown groundnut cultivars:

In this trial 28 cultivars that are commonly grown in India were compared with Robut 33-1 in randomized block design with 4 replications. Individual plots were of 4 rows of 4 m length with 75 cm row and 15 cm plant spacings. The observations on thrips infestation and BND incidence were recorded as described above.

Among the 28 commonly grown and/or promising cultivars, Robut 33-1 had the lowest incidence (8.4%) of BND are to S 206 the highest (86.1%) (Table 87). Among these cultivars, virginia types had lower BND incidence than spanish types but within virginia no clear differences occurred between bunch and runner growth habits.

Table 87. Incidence of BND in 28 commonly grown groundnut cultivars

Cultivars	BND incidence (%)	Growth habit
Robut 33-1	8.4 (16.3)	VB
RAU 5	12.9 (19.8)	VB
RAU 31-3	15.3 (22.8)	VB
BG 1	15.7 (22.9)	VB
T-28	19.9 (26.2)	VR
Chandra	20.8 (27.1)	VR
UF 70-103	20.8 (26.7)	VR
Kadiri 71-1	25.1 (28.5)	VR
Karad 4-11	25.4 (30.2)	VR
Punjab 1	27.1 (30.9)	VR
BG-2	29.0 (30.4)	-
S 230	32.9 (34.8)	VR
M 145	37.7 (37.0)	VB
MH 1	39.3 (38.0)	SB
M 197	43.2 (39.3)	-
Kopergaon 3	43.2 (39.3)	SB
C 501	44.7 (42.3)	VB
J 11	45.6 (42.3)	SB
Pol-2	49.0 (44.5)	SB
Kisan	53.9 (49.3)	SB
GAUG-10	57.9 (53.9)	VR
M-13	59.2 (55.7)	VR
Spanish	68.2 (61.0)	SB
GAUG-1	68.5 (61.1)	SB
OG 71-3	70.9 (58.0)	SB
DH 8	75.6 (61.0)	SB
S-206	86.1 (76.6)	SB
Mean	(40.1)	
SE ±	(9.69)	
CV %	(41.8)	

SB = Spanish Bunch; VB = Virginia Bunch;
VR = Virginia Runner

Figure in parentheses are arcsine transformed values.

(c) Effect of row and plant spacing on BND incidence in Robut 33-1

In this trial conducted in the 1981 rainy season in a pesticide-free Alfisol fields the incidence of BND in the Robut 33-1 crop was compared with TMV-2 and M-13, grown at high (0.3 million plants per ha) or low (0.08 million plants per ha) plant density. The high density was obtained by sowing crops at 30 cm row and 10 cm plant spacing, and the low density by sowing crops at 75 cm row and 15 cm. plant spacing. The net plot size was 80 sq m and there were 4 replications. The observations on thrips and BND were recorded as given before.

It is clearly seen from the Table 57 that the BND incidence was lowest in Robut 33-1 at both the densities. It is also interesting that Robut 33-1 showed the increase of 1.2% when the plant was reduced by 3.5 fold. TMV-2 on the other hand showed an increase of 37% under similar plant density changes.

In another trial in 1981 rainy season in which two plant spacings of 10 or 20 cm were tried with row spacing of 30 cm, Robut 33-1 had very low incidence of BND at 30 x 10 cm (1.5%) or 30 x 20 cm (4.5%) spacing. TMV-2 on the other hand had 22.6% BND at 30 x 10 cm spacing and 36.1% at 30 x 20 cm spacing (Table 56).

(d) BND incidence in Robut 33-1 under sole and intercrop situation

In the fourth trial the BND incidence in Robut 33-1 crop was compared with TMV-2 under sole or intercrop situations, and at two plant spacings. Three rows of groundnut were followed by one row of

pearl millet (hybrid BK 560). The row spacing was 30 cm and the plant spacing was either 20 or 10 cm depending up on the specific treatment. The plot size was 450 sq m. The three replication blocks were separated from each other by about 30 m of groundnut crop. The observations on thrips were recorded on five 1 m row sub-plots, one each at the 4 corners and the fifth at the center of each plot. The BND incidence was recorded in the entire plot on the 50th and the 100th day after emergence (DAE).

Robut 33-1 performed equally well under sole and intercrop situations (Table 88). The incidence of BND remained low in sole (1.5% and 4.5%) as well as intercropped (1.6% and 4.1%) situations. TMV-2, on the other hand, showed large differences between sole and intercropped .

Table 88. Incidence of bud necrosis disease in Robut 33-1 and TMV-2 crops grown at two plant spacings and as sole or intercrops

Cultivar	Spacing (cm)/ plant	Cropping	Plant population per plot	BND incidence %
TMV 2	10	Sole	2373	22.6 (28.0)
Robut 33-1	10	Sole	2547	1.5 (7.0)
TMV 2	10	Inter	1940	12.8 (20.9)
Robut 33-1	10	Inter	2040	1.6 (7.3)
TMV 2	20	Sole	1414	36.1 (35.7)
Robut 33-1	20	Sole	1380	4.5 (12.1)
TMV 2	20	Inter	1078	32.5 (34.7)
Robut 33-1	20	Inter	1178	4.1 (11.5)
SE				± (3.77)
CV %				(11.43)

Figures in parentheses are arcsine transformed values.

(e) Effect of neighbouring cultivars on BND incidence in Robut 33-1:

In a separate trial stability of Robut 33-1 was tested in relation to the neighbouring cultivars of varying susceptibility to thrips and BND. The experiment was conducted as per serially balanced design with 4 cultivars arranged in different combinations. The four cultivars were:

(1) Robut 33-1 - moderately resistant to BND but susceptible to thrips
(2) TMV-2 - susceptible to BND and thrips
(3) NC Ac 2214 - resistant to thrips but susceptible to BND
(4) NC Ac 1705 - resistant to BND and thrips

Each cultivar was exposed to 9 different combinations of neighbouring cultivars. All 36 plots of 4 rows x 4 m each were arranged in a linear fashion and were surrounded on all sides by 4 m guard row of TMV-2. Weekly row-wise observations on thrips were recorded and BND incidence was recorded on the 50th and 100th days after emergence.

As seen from the Table 89 the BND incidence in Robut 33-1 ranged between 23 and 33% when this cultivar was placed between two cultivars of different susceptibility to thrips. The BND incidence ranged from 22% to 33% in different plots. The highest (33%) being in plot flanked by plots of TMV-2 on either side. The lowest (22.6%) was when neighbouring cultivars were NC Ac 1705 and TMV-2.

In 1982-83 trial also, the similar results were obtained (Table 90).

Table 89: Effect of neighbouring genotypes on the incidence of BND in Robut 33-1 Postrainy 1981-82

Genotype	BND (%) in Robut 33-1	BND (%) incidence in neighbouring cultivars			
		1	BND	2	BND
Robut 33-1	33.0	TMV-2	66.6	TMV-2	67.1
Robut 33-1	24.8	TMV-2	62.7	NC Ac 2214	43.0
Robut 33-1	27.0	NC Ac 1705	26.8	NC Ac 1705	33.3
Robut 33-1	29.1	NC Ac 2214	31.7	NC Ac 2214	25.5
Robut 33-1	32.7	NC Ac 1705	40.7	NC Ac 2214	33.7
Robut 33-1	26.7	NC Ac 2214	33.7	NC Ac 1705	50.7
Robut 33-1	28.6	TMV-2	68.0	NC Ac 1705	48.1
Robut 33-1	22.6	NC Ac 1705	48.1	TMV-2	55.3
Robut 33-1	31.3	NC Ac 2214	49.1	TMV-2	65.6

Table 90: Effect of neighbouring genotypes on the incidence of BND in Robut 33-1, postrainy 1982-83 trial

Genotype	BND (%) in Robut 33-1	BND (%) incidence in neighbouring cultivars			
		Cultivar	BND	Cultivar	BND
Robut 33-1	23	TMV-2	30	TMV-2	41
Robut 33-1	15	TMV-2	38	NC Ac 2243	16
Robut 33-1	20	NC Ac 1705	20	NC Ac 1705	16
Robut 33-1	13	NC Ac 2243	15	NC Ac 2243	21
Robut 33-1	12	NC Ac 1705	16	NC Ac 2243	17
Robut 33-1	15	NC Ac 2243	17	NC Ac 1705	27
Robut 33-1	13	TMV-2	40	NC Ac 1705	25
Robut 33-1	9	NC Ac 1705	25	TMV-2	38
Robut 33-1	15	NC Ac 2243	20	TMV-2	43

(f) Performance of Robut 33-1 against BND in farmers' fields:(Table 91)

This trial was conducted in farmers' fields in an area having a history of high BND incidence. The trial was carried out in collaboration with the scientists and staff of Andhra Pradesh Agricultural University and the State Agriculture Department. The experimental plots were located in two fields in Akbarnagar village of the Nizamabad district of Andhra Pradesh, about 200 km north of ICRISAT. Robut 33-1 and TMV-2 were sown in paired plots of 200 sq m each and a total of 7 replications were formed. All the operations from sowing to harvest were carried out by the farmer. The seed was supplied by ICRISAT. The BND-affected plants were recorded on the 50th and the 100th DAE in 5 one sq m quadrats, one each at the four corners and the fifth in the center of each plot.

Robut 33-1 had only 4% BND incidence as compared to 33% in TMV-2. Robut 33-1 yielded more than TMV-2. According to this farmer, he has resorted to sowing in the month of January in place of December because of low incidence of BND in the January sown crop. But with a variety like Robut 33-1 available, which is good yielder, bold seeded, and resistant to BND, he can take up December sowings for better yields.

Table 91: Incidence of BND in Robut 33-1 and TMV-2 cultivars in farmers' field

Cultivar	BND incidence (%)*
Robut 33-1	4 (11)
TMV 2	33 (35)
SE ±	(1.3)
CV %	(14.8)

* Mean of 7 replications.

Figures in parentheses are arcsine transformation.

Conclusions: Robut 33-1 has a moderate level of field resistance to bud necrosis disease. The resistance appears to be stable across seasons, and under different agronomic practices such as plant density, sowing dates, and intercropping.

7.5.11. Basis of resistance of Robut 33-1 to bud necrosis disease:

a) Susceptibility to TSWV: Two trials were conducted to compare the susceptibility of Robut 33-1, TMV-2 (Spanish Bunch) and Gangapuri (Valencia) cultivars to TSWV. Twenty-days-old seedlings of test cultivars were inoculated with known dilutions of extract prepared from the infective young leaves of TMV-2 showing good BND symptoms. The extracts were prepared and the inoculations were made as per the procedure described by Ghanekar et al. (1979). The test seedlings were grown in 5" diameter pots outside the glasshouse and were sprayed

frequently with insecticides. They were brought into the glasshouse prior to their inoculation with TSWV inoculum, and thereafter maintained in the glasshouse for symptom development. The temperatures in the glasshouse during these trials ranged between 25 C and 30 C. It can be seen from Table 92 that Robut 33-1 was just as susceptible to TSWV as were the other two cultivars (Table 92).

Table 92: Transmission of TSWV to Robut 33-1, TMV-2 or Gangapuri cultivars by mechanical sap inoculation.

Dilution	First test		Second test	
	Robut 33-1	TMV-2	Robut 33-1	Gangapuri
$10^{-0.5}$	19/30 (63.3)	20/31 (65)	25/25 (100)	25/25 (100)
$10^{0-1.0}$			20/25 (80)	18/25 (72)
$10^{-0.15}$	10/29 (34.5)	8/29 (28)	20/25 (80)	18/25 (72)
$10^{-2.0}$			5/25 (20)	8/25 (32)

The figures in parenthese are percentages.

(b) Inoculation to and acquisition of TSWV from Robut 33-1 and TMV-2 cultivars by vector thrips:

In this trial infective thrips (F. schultzei) were employed to compare the susceptibility of Robut 33-1 and TMV-2 to TSWV. The procedures for raising disease-free colonies of thrips and handling them during (24 hour) acquisition and inoculation (72 hour) access periods, were similar to those described by Amin (1980), Amin et al. (1981). Black gram, Vigna mungo L. cv UPU-2, seedlings were used as susceptible controls. As a follow-up of this trial, the rates of acquisition of TSWV from Robut 33-1 and TMV-2 cultivars by thrips were

compared. The one-day old larvae were exposed to infected leaves of Robut 33-1 or TMV-2 and after an acquisition period of 24 hours they were transferred to and maintained on healthy leaflets of TMV-2 until they became adults. The infective adults, 1 per test seedling, were used in transmission tests which were carried out in the glasshouse at temperatures ranging from 30 C to 35 C as described above.

As seen from the results (Table 93), the thrips were capable of acquiring TSWV from Robut 33-1 and TMV-2 with equal efficiency. Similarly both cultivars were equally susceptible to TSWV when fed upon by infective thrips.

Table 93 : Rates of TSWV transmission to and acquisition from cvs Robut 33-1 and TMV-2 by Frankliniella schultzei.

Cultivar	Transmission		Acquisition	
	No. of plants tested/ infected	Percent transmission	No. of plants tested/ infected	Percent transmission
TMV-2	79/15	19.1 (25.5)	45/25	55.0 (47.7)
Robut 33-1	62/15	24.7 (28.9)	66/35	53.0 (46.5)
Black gram (UPU-2)	28/17	61.1 (56.6)	32/17	54.8 (47.9)
SE +		(6.37)		(6.68)
CV %		(42.20)		(34.54)

The figures in parentheses are arcsine transformed values

(c) Effect of nearby susceptible cultivar on BND incidence in Robut 33-1:

In this trial the effect of nearby susceptible peanut variety (TMV 2) on thrips infestation and BND incidence in Robut 33-1 was investigated by intercropping Robut 33-1 with TMV-2 in row proportions ranging from 1:1 to 10:1. The sole Robut 33-1 and TMV-2 crops served as controls. The individual plot size was 81 sq.m., the row and plant spacings were 60 and 10 cm respectively, and there were four replications. Each plot was surrounded by 1 m guard rows of TMV-2. Observations on thrips infestation and BND incidence were record as given before.

It can be seen from the Table 94 that BND incidence was about similar in Robut 33-1 when intercropped with susceptible TMV-2 in different row proportions.

Table 94: Effect of nearby susceptible cultivar (TMV-2) on BND incidence in Robut 33-1

Cultivar row ratio		No.of plants/plot		BND incidence (%)	
Robut 33-1	TMV-2	Robut 33-1	TMV-2	Robut 33-1	TMV-2
1	1	184	167	15	44
2	1	239	106	16	47
3	1	258	80	19	44
5	1	290	53	15	45
10	1	318	26	15	52
11	0	343	-	15	-
0	11	-	338	-	46
SE±		2.5	4.0	1.9	3.8
CV %		1.6	5.5	21.2	14.3

(d) Survival and fecundity of Frankliniella schultzei on Robut 33-1 and TMV-2:

Survival and fecundity of F. schultzei on these two cultivars were studied in laboratory trials. Thrips were reared on detached young leaves at 28 C day (12 hours 700 Lux) and 21 C night temperatures in a Percival incubator. The data on survival and fecundity were recorded for 40 females.

It is seen from Table 95 that survival as well as fecundity did not differ on these two cultivars.

Table 95: Survival and fecundity of Frankliniella schultzei on Robut 33-1 and TMV-2 1/

Cultivar	Mean survival (days)	Mean Fecundity per female thrips
TMV-2	10.1	23.8
Robut 33-1	11.4	24.7
SE +	1.04	2.15
CV %	27.41	25.09

1/ 5 female thrips + 1 male were released on to a leaflet placed in a small glass vial. Each treatment was replicated 8 times. The experiment was carried out at 28 C day (12 hours) and 21 C night temperatures and illumination of 700 Lux was provided during day with the help of 6 fluorescent tubes.

(e). Incidence of F. schultzei on Robut 33-1 and TMV-2 cultivars with modified growth habit:

This trial was conducted to determine the effect of growth habits of Robut 33-1 (spreading bunch) and TMV-2 (upright bunch) on thrips infestation and associated BND incidence. There were 4 treatments: (a) Robut 33-1 grown normally, (b) Robut 33-1 with branches tied upright, (c) TMV-2 grown normally, and (d) TMV-2 with branches pinned down. Plot size was 12 sq.m. and there were four replications. Guard rows of 1 m width of TMV-2 surrounded each plot. Thrips were counted on 20 randomly selected plants in each plot and BND incidence on the 50th and 100th days after sowing.

Results (Table 96) showed that BND incidence was similar in cultivars TMV-2 and Robut 33-1 irrespective of changes in growth habit.

Table 96 : Effect of changes in growth habit of Robut 33-1 from spreading to upright and of TMV-2 from upright to spreading on the thrips infestation and BND incidence*

Cultivar	Growth habit	Thrips/20 plants		BND incidence (%)	
		Adults	Nymphs		
TMV-2	Erect	2.3 (1.5)	4.0 (2.0)	42.0	(40.3)
	Spreading	3.3 (1.8)	7.3 (2.6)	41.1	(39.9)
Robut 33-1	Spreading	1.7 (1.0)	2.0 (1.1)	14.7	(22.5)
	Erect	1.0 (0.8)	0.7 (0.5)	14.6	(22.3)
SE ±		(0.44)	(0.41)		(1.53)
CV %		(59.57)	(46.24)		(8.46)

The figures in parentheses are square root transformed values for thrips and arcsine transformed values for BND.

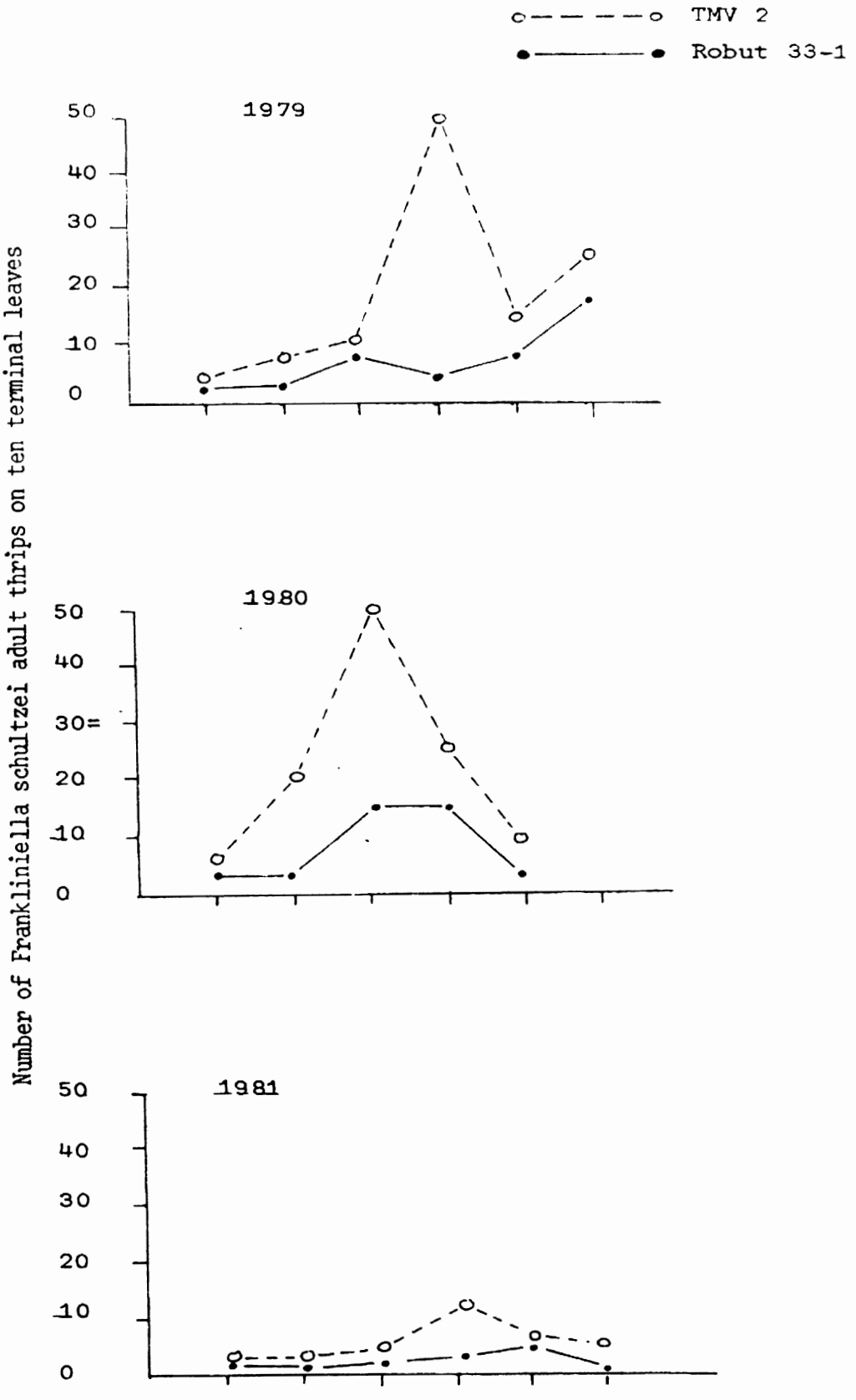
(f) Incidence of F schultzei on Robut 33-1 and TMV-2 crops under field conditions.

The incidence of F. schultzei on Robut 33-1 and TMV-2 plants was recorded in different seasons. The leafbud and the terminal leaf were carefully opened and the adult and nymph thrips were counted. Preliminary investigations had shown that leaf bud and the terminal leaf contain approximately 90% of the total thrips on that branch. For recording the number of thrips on plants a total of 10 plants were selected from each plot of 100 sq.m. or less, and for larger plots 5 one m row sub plots, one each at the 4 corners and the 5th at the center of a plot were used. The number of thrips was recorded once every week.

It can be seen from Fig. 65 that number of thrips on Robut 33-1 was lower than on TMV-2 crop, resulting in lower incidence of BND in Robut 33-1 than in TMV-2 crop. However further investigations are required to find the basis of this low infestation of thrips on Robut 33-1 crop.

Conclusions: Factors contributing to low incidence of BND in Robut 33-1 are not precisely known. The resistance is moderate and passive as infected Robut 33-1 plants produced all the common symptoms of BND. Resistance appears to be stable and is probably associated with low field infestation of F. schultzei. The reasons for the low thrips infestation are not known. However, it is possible that Robut 33-1 is less preferred than TMV-2 during initial alighting phase. Robut 33-1 has dark green foliage compared to yellowish green of TMV-2. Whether this colour difference of foliage is responsible for differences in alighting of thrips is being investigated.

Fig.65 Number of F. schultzei adult thrips on Robut 33-1 and TMV 2 cultivars



PART II

8. OTHER VIRUS/MYCOPLASMA DISEASES OF GROUNDNUT

8.1. Yellow spot:

Peanut yellow spot disease (PYSD) is widely distributed in India. It was reported for the first time in 1978 on groundnut (ICRISAT Annual Report, 1978-79). The causal pathogen was identified as a virus (Peanut yellow spot virus - PYSV) which resembled tomato spotted wilt virus (TSWV) in morphology and in having the similar thermal inactivation point (45 - 50 C). In the preliminary tests PYSV was reported to be transmitted by Scirtothrips dorsalis but not by Frankliniella schultzei or Caliothrips indicus (ICRISAT Annual Report, 1978-79). Further studies were conducted on transmission of PYSV by S. dorsalis.

Materials and Methods

Virus: PYSV was obtained from infected groundnut plants from the field and was maintained in peanut, cv. TMV 2 in a glasshouse at 25 - 30 c by periodic inoculations with infective S. dorsalis. Since PYSV produces distinct chlorotic lesions on cowpea (cv. C-152), virus cultures were periodically checked for contamination by TSWV causing bud necrosis disease of peanut.

Vector: Four species of thrips, S. dorsalis, F. shultzei, C. indicus, and T. tabaci were tested for their ability to transmit PYSV. T. tabaci was collected on onion (Allium cepa) plants in the field and were reared on the same host in the glasshouse because it did not infest groundnut plants and also survived poorly on them. The other three species of thrips were reared on detached leaflets of groundnut cv. TMV 2 in a Percival incubator at 28 c day time and 21 C night time temperatures. Light intensity of 700 lux was provided during the day time.

Adult thrips were collected from apparently healthy plants in the field and five adults were transferred on to the individual detached groundnut leaflet with at least one male in each of the five adults. The leaflet was then enclosed in a cork-stoppered glass vial (3 cm L, 1 cm D). After 1 day, surviving thrips were transferred to a new set of healthy leaflets. Transfers were discontinued after 10 days because the majority of adults oviposited within this period. The eggs laid on detached leaflets hatched in 6-8 days. The larvae were collected and were transferred to healthy leaflets. Each colony was numbered, maintained separately and ascertained for freedom from PYSV by exposing them to healthy groundnut leaflets maintained in vials for 21 days in the presence of a small moist filter paper. For maintaining F. schultzei, anthers from peanut flowers were provided which were found to be essential for longer survival and greater fecundity.

Transmission Tests:

One day-old larvae were given various acquisition access feeding periods on peanut leaflets showing faint chlorotic lesions. Transmission tests were similar to those described by Amin *et al.* (1981) with the exception that detached leaflets were employed. Exposed leaflets were maintained in glass vials for symptom development at the temperature and light conditions described above. Although PYSD symptoms appeared in 1-2 weeks the leaflets were maintained for a period of 3 weeks.

The presence of PYSV in leaflets was confirmed by infectivity assays on cowpea, *Vigna unguiculata* L. Walp. (cv. C-152) according to the procedure earlier described (see 4.3.5. page).

For detecting the minimum acquisition access period 500 one day-old larvae were starved for 1 hr. They were then exposed to infected leaflets for 5, 10, 15, and 30 minutes, 1, 2, 3, and 6 hours and then transferred to healthy leaflets. Individual adults that emerged were transferred to healthy leaflets, and were maintained for their entire life span.

In the second experiment to study the persistance of PYSV in *S. dorsalis* after various acquisition access periods, both larvae and subsequently the adult thrips were transferred serially to individual leaflets with 1 day inoculation access period at each transfer.

In the third experiment 250 adult thrips were fed on PYSV infected leaflets for 1 day followed by 15 days of inoculation access period. The leaflets were maintained for an additional 20 days to observe symptoms.

Latent Period: The latent period was estimated from the data obtained from the second experiment in which thrips were allowed various acquisition access periods. The mean latent period LP 50 was estimated by the procedure described by Sylvester (1958) after accounting for the duration of non-feeding prepupal and pupal stages of 4-6 days in individual thrips. Soon after the emergence of adults they transmit the virus.(fig.66)

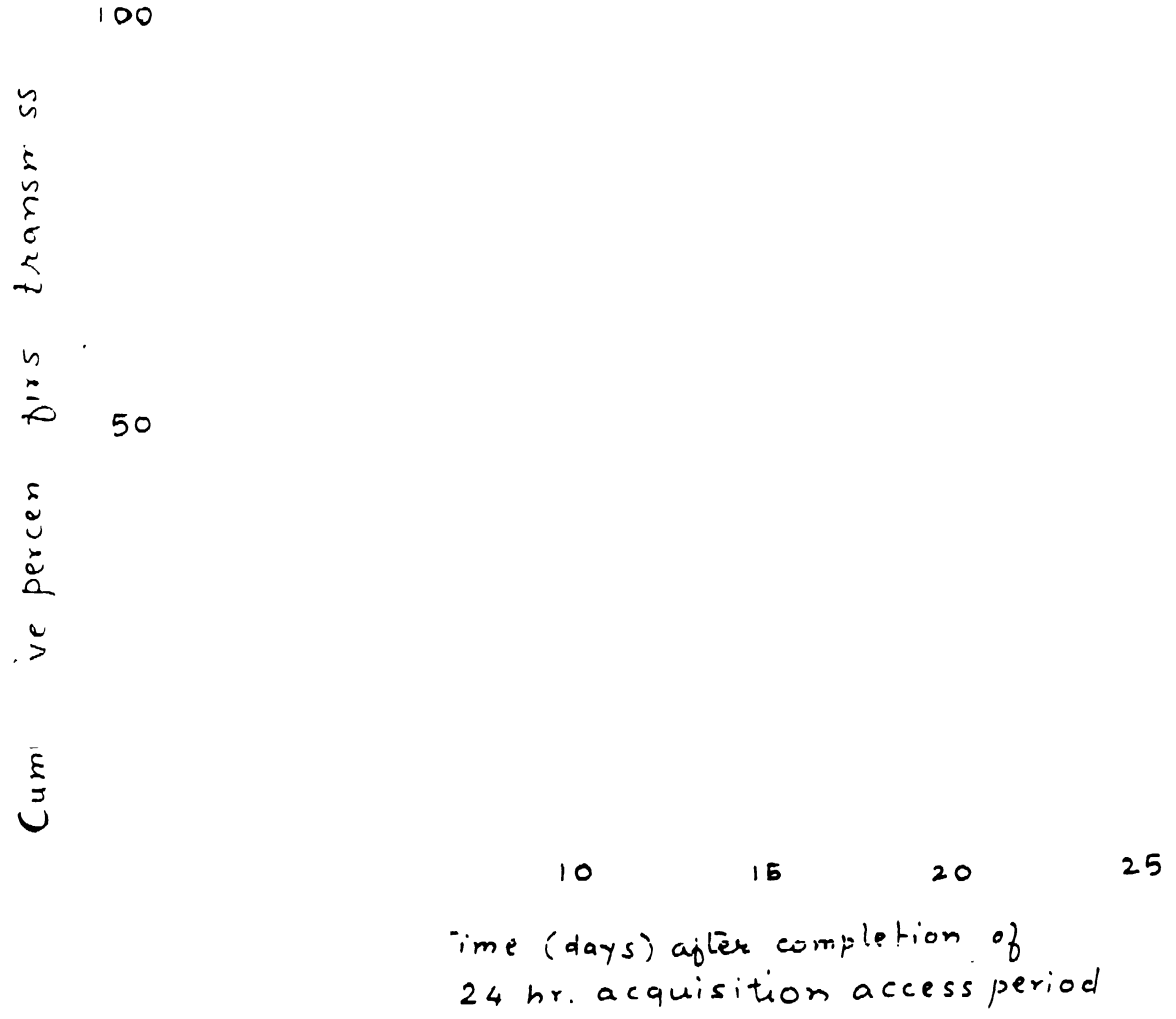
Inoculation Access Period: Over 400 one-day-old larvae were fed on PYSV infected leaflets for 1 day and then transferred to healthy leaflets. The adults that were obtained from the larvae were allowed various inoculation access periods to test leaflets. Symptoms were recorded after about 20 days.

RESULTS

Symptoms

Symptoms caused by PYSV on peanut detached leaflets were identical to those on plants and were produced after about 10-12 days on both. The initial symptom appeared 10-12 days after inoculation as small, approximately 1 mm diameter circular chlorotic lesions. The lesions gradually expanded to 3-4 mm diameter and became bright yellow. Frequently, adjacent lesions coalesced covering a large area of the leaflet. Ultimately the lesions became necrotic. Systemic infection was not observed in peanut plants.

Fig.66. Cumulative percentage of S. dorsalis transmitting yellow spot virus to groundnut leaflets for the first time. The temperature during the experiment was 28°C (12 hour light phase) and 21°C (12 hour dark phase)



Transmission

Of the four species of thrips tested, only S. dorsalis transmitted PYSV (Table 97).

Acquisition Access Period

The minimum acquisition access period was found to be 5 min. More thrips became infective with longer acquisition access periods (Table 98). PYSV persisted for longer intervals with higher acquisition periods (Table 100). None of the 250 adult thrips could acquire the virus.

Latent Period (Fig. 67)

The minimum latent period was 2 days. However, a small proportion of larvae also transmitted the virus. The duration of mean latent period changed with the duration of acquisition access period. It was 6.2 days with 30 minutes acquisition access and 3.4 days with 24 hr acquisition access period (Table 99).

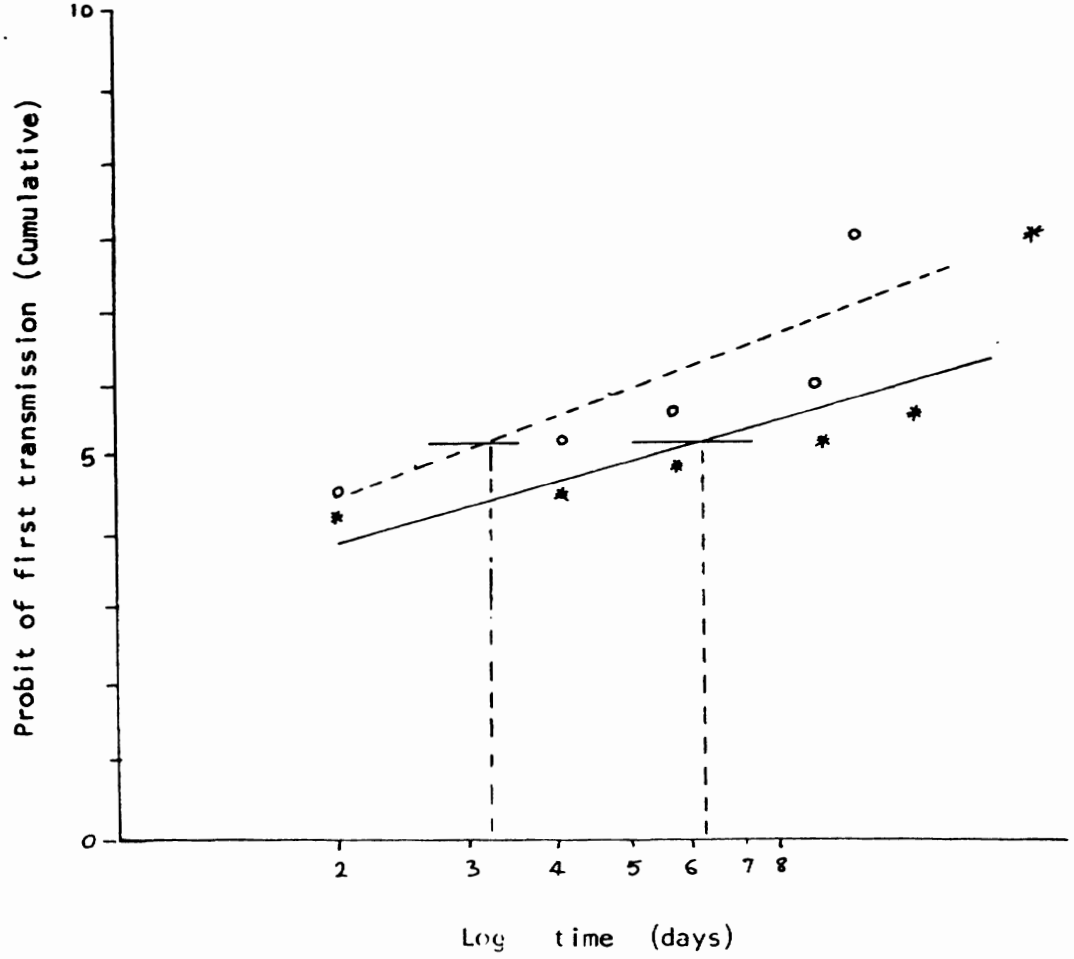
Inoculation Access Period

Five min. exposure was adequate to transmit PYSV. However, longer inoculation access periods resulted in increased rates of transmission (Table 101).

None of the 250 adult thrips exposed acquired PYSV.

Retention of PYSV in thrips S. dorsalis (Table 102)

Fig.67: Latent period lines for a trial involving different acquisition access periods and transmission of yellow spot virus by S. dorsalis at 28°C and 21°C day and night 12 hourly cycles from groundnut to groundnut. Inoculation access was 24 hrs.



x ½ hour acquisition access

o 24 hour acquisition access

DISCUSSION

The present findings confirm that PYSV is transmitted by S. dorsalis and not by F. schultzei or C. indicus. In addition T. tabaci was also found to be a non-vector of PYSV.

PYSV is transmitted very efficiently by S. dorsalis. The minimum acquisition access period of 5 minutes, the latent period of 2 days and the inoculation access period of 5 minutes reported for PYSV transmission by S. dorsalis are the lowest for any thrips-borne viruses. The PYSV is retained through larval and pupal moults of S. dorsalis. PYSV appears to be transmitted in a circulative manner. Such indications are based upon: (1) short latent period, (2) negative relationship of latent period with acquisition access period, (3) higher rates of transmission with longer single or with shorter repeated acquisition access periods, and (4) erratic patterns of transmission by individual insects particularly with short acquisition periods. However, long retention of PYSV up to 20 days by a few individual thrips that were exposed to PYSV for only 30 minutes is difficult to explain except by assuming that some thrips are capable of imbibing large quantity of virus sufficient to transmit to several plants during serial transfers. A possibility of PYSV being introduced into the leaflets and re-acquired from them during 24 hr serial transfers by the adult thrips is ruled out because the adults are unable to acquire the virus. However, this can happen during larval stages.

The vector relationship of PYSV with S. dorsalis indicated circulative mode of transmission. However, the investigation on the assessment of titre of PYSV in individual thrips at different period after acquisition access to PYSD infected leaves should be conducted to obtain direct evidence as to whether or not the virus is transmitted in a circulative manner.

If PYSV is proved to be distinct from TSWV, then this will be the second virus belonging to the TSWV group. Transmission of virus other than the TSWV group has already been reported with the known thrips vectors, T. tabaci and/or F. occidentalis (Kaiser et al., 1982).

Table 97: Ability of various thrips species to transmit peanut yellow spot virus (1)

Thrips species	No.of leaflets		Percentage of transmission
	Exposed	Infected	
Scirtothrips dorsalis*	445	142	28.2
Frankliniella schultzei**	100	0	0.0
Thrips tabaci**	110	0	0.0
Caliothrips indicus**	53	0	0.0

(1) Acquisition and inoculation access feeding 24 hrs each.
* Tests with single thrips

** Tests with 5 thrips

Table 98: Effect of acquisition access period on the transmission of peanut yellow spot virus by Scirtothrips dorsalis

Acquisition access period (Minutes)	Number of leaflets infected / Number of leaflets exposed	% transmission
5	2/25	8
10	1/26	4
15	6/35	17
30	16/50	32
60	7/34	21
120	6/24	25
180	6/20	30

Over 500 one day-old larvae were exposed to PYSV infected leaflets and then transferred to healthy leaflets. Single adult thrips were given inoculation access of 7 days. The tests were carried out at 12 hour cycles of 28 C (day time) and 21 C (night time) temperature.

Table 99: Effect of acquisition access period on the latent period of peanut yellow spot virus in Scirtothrips dorsalis

Acquisition access period	Latent period (days) Minimum	LP 50
30 m	5	6.2
3 h	3	5.5
6 h	4	3.8
24 h	2	3.4

Table 100: Effect of various acquisition access periods on serial transmission of peanut yellow spot virus by S. dorsalis

Acquisition access period	No.of infective insects	No.of leaflets inoculated	% transmission infected	
30 m	9	105	37	35
2 hr	5	52	25	48
3 hr	8	73	32	44
6 hr	6	65	34	52
24 hr	6	33	21	64

Over 200 one day old larvae were given various acquisition access periods and then serial transferred at 24 hr interval.

Table 101: Transmission of peanut yellow spot virus by Scirtothrips dorsalis in various inoculation access periods

Inoculation access period	No. of leaflets		% transmission
	Tested	Infected	
5 m	42	5	12
10 m	47	5	11
15 m	32	8	25
30 m	35	15	43
1 h	32	18	56
3 h	45	27	60

Over 400 one day-old larvae were exposed to PYSV infected leaflets for 24 hr. and then maintained on healthy leaflets. Soon after adults emerged they were allowed different inoculation access periods employing 1 adult thrips for each leaflet.

Table 10. Retention of yellow spot virus by individual Scirtothrips dorsalis given variable acquisition access and then serially transferred at approximately 24 hour intervals to healthy groundnut leaflets until death

Acq. access period	Results of transmission, days after acquisition access																									Total
	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	24	25	26	27	
0.5 hours	-	-	-	-	x	x	x	x	x	-	-	-	+	-	-	+	-	-	-	-	-	d				1/16
	-	-	x	x	x	x	x	x	x	-	+	-	M													1/5
	-	-	-	-	x	x	x	x	x	-	+	-	-	-	-	-	-	-	-	-	d					1/15
	-	-	-	+	x	x	x	x	-	-	d															1/6
	-	-	-	-	-	+	x	x	x	+	+	+	+	+	d											6/11
	-	-	x	x	x	x	x	x	x	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	d	13/17
	-	-	-	+	x	x	x	x	x	x	+	+	+	+	-	+	-	+	-	d						7/13
Total	0	0	0	2	0	1	0	0	0	1	5	3	3	3	1	3	1	2	1	1	1	1	1	1		30/72
2 hours	-	-	-	-	x	x	x	+	+	+	+	+	+	M												6/10
	-	-	+	x	x	x	x	x	+	-	d															2/5
	-	-	x	x	x	x	x	x	+	-	-	-	-	M												1/7
	-	-	+	x	x	x	x	x	-	+	+	+	+	+	+	-	+	+	+	-	d					10/15
	-	-	+	x	x	x	x	x	+	+	+	+	-	d												5/8
Total	0	0	3	0	0	0	0	1	4	3	3	3	2	1	1	0	1	1	1	0						24/45
3 hours	-	-	-	-	x	x	x	+	+	M																2/6
	-	-	-	-	x	x	x	x	+	+	+	+	+	+	+	+	+	-	-	d						9/15
	-	-	+	x	x	x	x	x	-	+	-	+	+	+	M											5/9
	-	-	-	x	x	x	x	x	+	+	+	+	+	+	d											6/9
	-	-	-	x	x	x	x	x	x	x	+	+	+	d												3/6
	-	-	-	-	+	x	x	x	x	x	x	+	d													2/6
	-	+	-	x	x	x	x	x	-	-	-	+	-	-	-	-	-	d								2/12
Total	0	1	1	0	1	0	0	1	3	3	3	6	4	3	1	1	1	0	0	0						29/63
6 hours	-	-	-	x	x	x	x	x	+	+	+	-	d													3/7
	-	-	-	x	x	x	x	+	+	+	-	-	-	M												3/9
	-	-	-	x	x	x	x	x	+	+	+	+	+	+	d											6/9
	-	-	-	+	x	x	x	+	+	+	+	+	+	+	M											8/11
	-	-	-	x	x	x	x	x	+	-	+	+	+	+	+	-	-	-	+	+	+	+	d			10/16
	-	-	-	x	x	x	x	+	-	-	-	-	-	+	-	-	d									2/12
Total	0	0	0	1	0	0	0	3	5	4	4	3	3	4	1	0	0	0	1	1	1	1	-			32/64
24 hours	-	-	x	x	x	x	+	M																		1/3
	-	+	x	x	x	x	x	+	+	+	+	+	M													6/7
	-	+	M																							1/2
	-	+	x	x	x	x	x	+	+	+	+	M														5/6
	-	x	x	x	x	x	x	+	+	+	-	+	+	+	-	-	d									6/10
	-	-	x	x	x	x	x	+	M																	1/3
	-	-	x	x	x	+	M																			1/3
Total	0	3	0	0	0	1	1	4	3	3	2	2	1	1	0	0										21/34
Grand Total	0	4	4	3	1	2	1	9	15	14	17	17	13	13	4	4	3	3	3	2	2	2	1			137/278

- = No transmission; + = Transmission; M = Missing; d = Dead; x = Prepupal and pupal stages.

8.2. Clump Disease

Effect of different fungicides, nematicides and insecticides on the incidence of clump disease

A patch of land which was marked during 1977 at Talod research farm of Gujarat Agricultural University having severe infection of clumped plants was selected for this experiment. A replicated trial was conducted in 1978 rainy season using a randomized block design. The treatments and clump incidence are given in Table 102.

The above results showed that there was much lower infection in carbofuran, nemagon, brassicol and temik treated plants. Aerial insects were not involved in transmission of this disease as the plants in control plots were covered with 1 x 1 meter fine wire mesh cages in all the four replications developed disease symptoms.

Bavistin was not effective; the Bavistin-treated plants developed infection as much as in control plots.

Patchy distribution of diseased plants suggests very slow moving soil-borne vector. The progress of infection in the field also clearly points out to the monocyclic spread as seen from the Table 102.

Table 102: Infection of clump disease in the field

Date of sowing	Date of emergence	No.of plants infected - days after sowing			Total
			15	25	35
		184/2250 (8.22) 1/	75/2250 (3.33)	0/2250 (0.00)	259/2250

1/ The figures in parentheses are percent disease infection

Table 102: Effect of fungicides, nematicides and insecticides on the incidence of clump disease.

Treatment	Rate of application	Method of application	Mode of action	No. of plants per plot	No. of clump affected plants
Nemagon	0.4% @ 5 ltrs/sq.m	Drenching in seed furrow	Nematicide	187	1
Carbofuran 3G	1 Kg ai/ha	As granules in a furrow (with wire mesh screen cage)	Nematicide Insecticide	200	2
Bavistin	0.25% spray	Spray immediately after germination	Systemic fungicide	199	48
Temik 10G	1 Kg ai/ha	As granules in furrow	Nematicide Insecticide	190	9
Brassicol	15 Kg ai/ha	Drenching in a furrow	Fungicide	198	11
Control		(with wire mesh screen cage)		183	70
SE ±				NS	15.3
CV %					67.5

The pattern of the disease spread in the field indicates a vector which once it infests the plant, does not move to other plants and therefore after initial infection there is no secondary spread of the disease. Another possibility is that plants develop resistance to virus or to the vector rapidly with age.

Discussion: Patchy distribution of the infected plants in the field and slow spread of the disease indicate a soil-borne vector. High degree of control of the disease by nematicides and fungicides is yet another indication of the involvement of either nematodes or fungi in causing the infection.

If the control of this disease by carbofuran proves successful, then it will also solve other serious pest problem i.e. white grub as both clum disease and white grub pests one problems in sandy soils. Carbofuran @ 1-1.15 kg ai/ha has been shown to be effective against white grubs.

8.3. Chlorotic leaf spot virus disease (CLSV):

The disease was observed in some fields in Karnataka. The symptoms consisted of chlorotic spots and patches and puckering and thickening of the leaves. The plants were infested by aphids. This disease has been shown to be graft transmissible.

The diseased plants were brought from the field and established in pots. Aphid transmission of this disease was attempted both in stylet-borne and circulative manner by using 5-10 adult apterae per plant. The results are shown in the Table 10.

Table 10: Transmission of chlorotic leaf spot by Aphis craccivora

Mode of transmission	No.of plants tested	No.of plants infected
1. Stylet-borne*	37	0
2. Circulative**	20	0

* Acquisition access period 15 seconds, and inoculation access period of 1 minute

** Acquisition access period 3 days, inoculation access period 8 days.

The results indicated that CLSV was not transmitted by Aphis craccivora. However, more desirable procedure would be to use Aphis craccivora from the field in which the disease was spotted. It is well known that the efficiency of virus transmission by aphids varies with the biotypes present.

Aphids that were collected from the field did not survive the journey.

Another possibility is the involvement of white flies or jassids as vectors. White fly population was high in the field where the diseased plants were found.

3.4. Peanut Mottle Virus: Peanut mottle virus was easily transmitted by Aphis craccivora in a stylet-borne manner as shown in the Table 105.

Table 105 : Peanut mottle virus transmitted by Aphis craccivora

No.of Tests	Pre-acquisition starving	Acquisition feeding	Inoculation feeding	Transmission Test	Control
2	1/2 hour	10-15 seconds	1 hr	9/23*	0/15*

Numerator is number of plants infected, denominator is number of plants tested.

Peanut mottle disease was marked by faint mottling and interveinal depressions on young leaves.

3.5. Witches' broom: Also known as phyllody, witches' broom disease is not economically important in India. However, it was interesting to find out its etiology. A simple test was done. Four pots containing 7 plants affected by witches broom disease were selected. Three pots has two infected plants each, one had only one plant. One each in three pots were kept as control while other three plants in these pots and one additional pot were treated with tetracycline, 200 ppm once every three days. Foliage of plants was dipped in

Tetracycline solution for 2 minutes. Control plants were dipped in water. A total of 10 dippings were given. The results are shown in the following Table 106.

Table 106: Remission of witches' broom symptoms by tetracycline

No.of plants	Treatment	Symptoms before treatment	Symptoms after treatment
4	Tetracycline	Yellowing, axillary shoot proliferation, negative geotrophism of pegs, few flowers	Green normal foliage, normal flowering, pegs positively geotrophic.
3	Water	"	Yellow foliage, axillary shoot proliferation, pegs few and negatively geotrophic

The remission of the symptoms occurred in about 20 days (after 7 treatments with tetracycline). Recovery of plants after tetracycline treatment indicates that mycoplasma may be involved in the etiology of the disease. Species of leafhoppers of the genus Orosius are the main suspects a as species of this genus, Orosius argentatus, is the vector of witches' broom in South East Asia.

PART 3

LIST OF CULTIVARS AND BREEDING LINES SCREENED FOR FIELD RESISTANCE TO BUD NECROSIS DISEASE

SOURCE OF DATA FOR: KHARIF 1978

DATE OF DATA COLLECTION: KHARIF 1978

DESCRIPTION OF THE EXPERIMENT:

SCREENING FOR RESISTANCE TO BUD NECROSIS DISEASE

GERMPLASM LINES (EB)

	IDENTITY	BND incidence (%)
1	NC 56	54
2	NC 44	58
3	TMV-2	62
4	NC 2723	63
5	NC 448	70
6	NC 1337	71
7	NC 2753	72
8	NC 471	73
9	NC 399	76
10	NC 765	76
11	NC 353	76
12	NC 354	78
13	NC 528	78
14	NC 51	78
15	NC 710	79
16	NC 400	79
17	NC 495	80
18	NC 778	81
19	NC 766	84
20	NCA 1303	85
21	NC 414	86
22	NC 723	87
23	NC 2661	87
24	NC 2689	88
25	NC 2666	88
26	NC 2884	89
27	NC 775	89
28	NCA 2888	90
29	NC 2828	90
30	NCA 2879	92
31	NC 470	92
32	NC 510	92
33	NC 50	93
34	NC 714	96
35	NC 2798	96
36	NC 2748	96
37	NC 545	96
38	NCA 1270	99
39	NC 474	99
40	NC 1308	100

41	NC 339	100
42	NC 2696	100
43	NC 548	100
44	NC 751	100
45	NC 2663	100
46	NC 2751	100
47	NC 405	100
48	NC 513	100
49	NC 472	100
50	NC 768	100
51	NC 2654	100
52	NC 2612	100
53	NC 2741	100
54	NCA 2882	100
55	NC 776	100
56	NC 2664	100
57	NC 394	100
58	NC 481	100
59	NC 411	100
60	NC 2681	100
61	NC 771	100
62	NC 494	100
63	NC 527	100
64	NC 2742	100
65	NC 2885	100
66	NC 2700	100
67	NC 2739	100
68	NC 2818	100
69	NC 503	100
70	NC 2236	100
71	NC 515	100
72	NCA 1259	100
73	NC 2744	100
74	NC 2795	100
75	NC 2651	100
76	NC 406	100
77	NC 489	100
78	NC 2653	100
79	NC 2717	100
80	NC 404	100

GRAND MEAN	90.3
S.E. OF MEAN	19.3
S.E.%	37.5

SOURCE OF DATA FOR: KHARIF 1978

DATE OF DATA COLLECTION: KHARIF 1978

DESCRIPTION OF THE EXPERIMENT: SCREENING FOR RESISTANCE TO BUD NECROSIS DISEASE

GERMPLASM LINES (RUNNER)

	GERMPLASM	BND incidence(%)
1	NC 17123	12
2	NC 9925	13
3	NC 2242	16
4	NC 17287	17
5	NC 546	17
6	NC 2243	17
7	NC 15923	18
8	NC 1105	19
9	NC 1460	19
10	NCA 2232	19
11	NC 1113	20
12	NC 9975	21
13	NC 2242	22
14	NC 1068	23
15	NC 2542	23
16	NC 2465	23
17	NC 2821	23
18	NC 17273	24
19	NC 344	24
20	NCA 17273	24
21	NC 15926	24
22	NC 343	25
23	NC 9975	25
24	NC 749	25
25	NC 2913	25
26	NC 17279	26
27	NC 15729	26
28	NC 2831	27
29	NC 17312	27
30	NC 1045	27
31	NC 1162	28
32	NC 10067	29
33	NC 2773	29
34	NC 2724	29
35	NC 17326	29
36	NC 17288	29
37	NC 7220	31
38	NC 1233	31
39	NC 497	31
40	NC 17268	32

41	NCA 7481	32
42	NC 46	32
43	NC 2214	33
44	NCA 61521	34
45	NCA 333	34
46	NC 307	36
47	NC 2240	36
48	NCA 7302	36
49	NC 601	37
50	NC 853	37
51	NC 1205	37
52	NC 15905	38
53	NC 17271	38
54	NC 9975	38
55	NC 825	38
56	NC 853	38
57	NCA 507	38
58	NC 9979	38
59	NC 2945	38
60	NC 2189	40
61	NC 306	40
62	NC 826	40
63	NCA 7302	41
64	NC 2214	41
65	NC 298	42
66	NC 576	43
67	NC 595	44
68	M-13	46
69	NC 10213	46
70	NC 1268	47
71	NC 8284	47
72	NC 2771	51
73	NC 1223	56
74	NC 682	57
75	NC 758	58
76	NC 2890	59
77	NC 9987	60
78	NC 944	69

GRAND MEAN	33.2
S.E. OF MEAN	9.7
S.E.%	54.4

SOURCE OF DATA FOR: KHARIF 1978

DATE OF DATA COLLECTION: KHARIF 1978

DESCRIPTION OF THE EXPERIMENT:

SCREENING FOR RESISTANCE BUDNECROSIS DISEASE

GERMPLASM SCREENING (SB)

	GERMPLASM	BND incidence (%)
1	NCA 2761	12
2	NC 2935	18
3	NCA 2467	18
4	NCA 2461	19
5	NCA 1491	24
6	NC 17142	24
7	NCA 2462	25
8	NC 2938	25
9	NCA 2277	26
10	NCA 2747	26
11	NC 29	27
12	NCA 17530	27
13	NCA 2575	27
14	NCA 2944	27
15	NCA 1824	27
16	NCA 2460	28
17	NC 17587	28
18	NCA 1648	29
19	NCA 2729	29
20	NCA 10033	29
21	NC 2802	30
22	NCA 2690	31
23	NC 23	31
24	NC 17113	32
25	NC 17127	32
26	NCA 2479	32
27	NCA 2808	33
28	NCA 2747	34
29	NCA 2469	35
30	NCA 816	35
31	NC 2815	35
32	ROBUT 33-1	35
33	NCA 2730	35
34	KRAPTO-10	36
35	NCA 17858	37
36	NCA 2278	37
37	NC 17090	38
38	NCA 2279	38
39	NCA 2470	39
40	NC 2416	40

41	NC 17147	41
42	NC 2477	41
43	NC 2377	41
44	NC 17896	41
45	NCA 17501	41
46	NCA 822	42
47	NC 2676	42
48	NC 2471	42
49	NCA 814	43
50	NCA 2858	43
51	NC 17780	43
52	FLO-392	44
53	NC 2817	47
54	NCA 17812	47
55	NC 2893	47
56	NCA 2738	47
57	NC 15986	48
58	NCA 1651	48
59	NC 2737	51
60	NCA 17782	52
61	NCA 2876	53
62	NCA 2758	53
63	NCA 17401	54
64	NC 2560	55
65	NCA 2316	56
66	NCA 2740	57
67	NCA 2859	60
68	NC 2673	60
69	NC 17745	61
70	NC 17129	61
71	NCA 1451	61
72	NC 2732	64
73	NC 17093	66
74	NC 2433	74
75	NC 2904	75
76	NC 17094	81
77	NCA 773	84
78	NC 17075	87
79	NC 17091	96
80	NCA 2891	100

GRAND MEAN	42.86
S.E. OF MEAN	16.11
S.E.%	75.27

SOURCE OF DATA: RABI 1978-79

DATE OF DATA COLLECTION: RABI 1978-79

DESCRIPTION OF THE EXPERIMENT:

SCREENING OF GROUNDNUT GERMPLASM FOR RESISTANCE TO BUD NECROSIS DISEASE

ERECT BUNCH CULTIVARS

S.No.	Identity	BND Incidence (%)
1.	Imp. Spanish	18
2.	NC Ac 841	19
3.	EC 27446	20
4.	U-2-1-16	21
5.	Uganda	21
6.	An 7299	22
7.	An 8068.	24
8.	U-2-1-14	25
9.	EC 76451	25
10.	U-2-1-30	25
11.	Exotic 2	25
12.	EC 243374	26
13.	Local 3	26
14.	An 811	27
15.	An 3533	27
16.	An 3524	28
17.	EC 259627	28
18.	C.No. 2274	28
19.	Spancross	29
20.	C.No. 691-11-4	29
21.	U-4-47-10	29
22.	An 7070	29
23.	IG 4	29
24.	K 7	30
25.	Akit-24	30
26.	G 64-403	30
27.	An 1	30
28.	Ovarii 29	30
29.	Exotic 3-5	31
30.	C. No. 887	31
31.	U 2-1-19	31
32.	MGS 9	31
33.	C. No. 40-93	31
34.	3190/Russia	31
35.	# 14-4	31
36.	Taedak	31
37.	IG 10	32
38.	An 7223	32
39.	U-2-1-25	32
40.	C. No. 742	32
41.	NC Ac 17089	33
42.	MG 4	33
43.	NC Ac 1337	33
44.	ICG 1360	33
45.	R 13-1	33
46.	U-2-1-15	33
47.	USA 93	33
48.	EC 386607	33
49.	An 7673	33

50.	U4-4-10	34
51.	NC Ac 2650	34
52.	C. No. 225	34
53.	C.No. 677	34
54.	EC 38604	34
55.	JH 141	35
56.	# 2196	35
57.	Exotic 6	35
58.	G 64838	35
59.	EC 2069833	35
60.	Var 27	35
61.	NC Ac 394	35
62.	Ah 0653	35
63.	U-1-7-2	35
64.	GO 171-B	35
65.	# 26-5-2	35
66.	C. No. 1812	35
67.	U-2-1-10	35
68.	Fed Spanish	35
69.	EC 21090	36
70.	NC Ac 2695	36
71.	NC Ac 2861	36
72.	# 3527	36
73.	Valencia type	36
74.	EC 24422	36
75.	A 14	36
76.	U1-1-23	36
77.	NC Ac 17115	36
78.	U4-1-23	36
79.	C.No. 924	36
80.	C. No. 3270	36
81.	E 22	36
82.	# 21-1-3	36
83.	U-2-1-1	36
84.	NG 387	37
85.	NG 387	37
86.	SEI 71	37
87.	U4-7-20	37
88.	NC 2698	37
89.	U-2-17-5	37
90.	C. No. 720-1	37
91.	SEA Spanish	38
92.	Sunbelt	38
93.	Erect Peanut	38
94.	PI 10	38
95.	C. No. 23-S-11	39
96.	C. No. 24-S-11	39
97.	Ah 7322	39
98.	Ah 1320	39
99.	C. No. 171	39
100.	Exotic 5-3	39
101.	Ah 2184	40
102.	U-2-12-1	40
103.	U-1-12-2	40
104.	C.No. 640	40

105.	U-4-4-8	40
106.	Floriglant	40
107.	JH 313	40
108.	Faizpur	40
109.	C.No.292	40
110.	U-2-1-7	40
111.	Mankoi	40
112.	JH 113	40
113.	Strain No. 5	41
114.	U-4-4-33	41
115.	JH 171	41
116.	A# 3278	41
117.	AH 7340	41
118.	AH 7340	41
119.	EC 106972	41
120.	U-2-12-4	42
121.	# 2-2	42
122.	JG 70	42
123.	C.No. 923	42
124.	EC 21107	42
125.	B 353	42
126.	EC 37484	42
127.	EC 206	42
128.	GO 353	42
129.	AH 6909	43
130.	IC AC 618	43
131.	Vinimk 1057	43
132.	AH 7128	43
133.	EC 37430	43
134.	IC AC 2734	43
135.	Arunflesh 2	43
136.	C.No. 99-5	43
137.	EC 206965	43
138.	U-1-4-24	43
139.	U-4-1-24	43
140.	Lifespan 1134	44
141.	JG 51-2	44
142.	V-2-1-6	44
143.	GO 173	44
144.	EC 99671	44
145.	AH 7364	44
146.	V-1-12-3	44
147.	IC AC 764	44
148.	IC AC 697	44
149.	PS 6	44
150.	U-1-7-24	44
151.	IC AC 780	45
152.	C. No. 32-3-4	45
153.	C.No. 27-3-1	45
154.	No. 91776	45
155.	AH 7171	45
156.	AH 7044	45
157.	AH 7299	45
158.	C.No. 27-4-2	45
159.	Acholiwrite	45

160.	Ah 59	45
161.	Ah 3490	45
162.	EC 76447	46
163.	EC 24402	46
164.	TMV 2	46
165.	ICG 1365	46
166.	Ah 6738	46
167.	NC Ac 2672	46
168.	NC Ac 600	46
169.	NC Ac 2702	46
170.	Balarampur	46
171.	Sir-Do-Bizpur	46
172.	Saifani Bizapur	46
173.	NG 51-44	46
174.	U-4-7-12	47
175.	U-2-12-2	47
176.	Ah 7336	47
177.	Ah 7336	47
178.	Ah 8312	47
179.	B 17-5	47
180.	C.No. 3272	47
181.	U-4-7-9	47
182.	NG 387-6	47
183.	U-2-1-22	47
184.	Sakariaivar 31	47
185.	C.No. 3277	47
186.	Ah 39	48
187.	Talod 68-4	48
188.	Ah 58	49
189.	Ah 3527	49
190.	Ah 3527	49
191.	NC Ac 527	49
192.	NC Ac 495	50
193.	NC Ac 2388	50
194.	KG 3	50
195.	EC 37483	50
196.	Ah 7382	50
197.	Roxo (21878)	50
198.	U-2-1-5	51
199.	NC Ac 2723	51
200.	U-4-7-17	51
201.	Parchurue	51
202.	C.No. 3270	51
203.	EC 19126	51
204.	U-4-3-25	51
205.	Ah 1104-1	51
206.	B 20-3-3	52
207.	Ah 4340	52
208.	U-2-1-4	52
209.	C.No. 654-2	52
210.	AK 9511	53
211.	Ah 7343	53
212.	U-4-4-25	53
213.	C.No. 29-1-2	53
214.	Pirco 431	53

215.	NC Ac 414	54
216.	U-2-1-9	54
217.	Ah 3276	54
218.	C.No. 729	54
219.	NC Ac 504	54
220.	R-7-43-10	54
221.	G 64-477	54
222.	Kanki No. 17	54
223.	U-4-7-3	54
224.	NC Ac 2927	55
225.	J 11	55
226.	Ah 4218	55
227.	Ah 60	55
228.	NC Ac 763	55
229.	Ah 4218	55
230.	Ah 4148	55
231.	Ah 7086	56
232.	U-2-1-24	56
233.	Ah 812	56
234.	C.No. 1841	56
235.	GU 171-A	56
236.	Ah 36	57
237.	NC Ac 889	57
238.	Betani 9	57
239.	K 71	58
240.	U-4-17-20	58
241.	Ah 41	58
242.	Tainan No.	58
243.	NC Ac 1253	58
244.	Ah 3528	58
245.	Ah 7150	59
246.	NC Ac 2794	59
247.	Ah 3277	59
248.	NG 53	59
249.	NC Ac 545	60
250.	U-4-4-1	60
251.	U-4-1-1	60
252.	Ah 7120	61
253.	KG 61-99	61
254.	NC 513	62
255.	NC Ac 2940	62
256.	NC Ac 429	62
257.	U-4-4-8	62
258.	J 206	62
259.	Ah 7319	62
260.	Sukatai	62
261.	U-2-24-3	63
262.	U-1-1-1	65
263.	C.No. 26-S-1	69
264.	NC Ac 2718	69
265.	NC Ac 892	70
266.	NC Ac 2870	71
267.	NC Ac 174	76
268.	NC Ac 994	85
269.	NC Ac 2953	90

SOURCE OF DATA: RABI 1978-79

DATE OF DATA COLLECTION: RABI 1978-79

DESCRIPTION OF THE EXPERIMENT:

SCREENING OF GROUNDNUT GERMPLASM FOR RESISTANCE TO BUD NECROSIS DISEASE

SPREADING BUNCH CULTIVAR

S.No.	Identity	BND Incidence (%)
	EC 16622	12
	An 7224	15
	EC 76445	16
	EC 76445	16
	NC Ac 1741	17
	Spanish No.9	20
	NC Ac 302	21
	NC Ac 2828	21
	EC 76450	22
	An 6607	22
	Punjab 501	23
	EC 76444	23
	An 699	24
	An 477	24
	EC 95325	24
	US 11	24
	TG 7	24
	A-40-A-X-3-B	24
	An 6615	25
	NC Ac 611	26
	EC 21138-1	26
	An 4424	26
	NC Ac 1859	27
	G 1023	27
	NC Ac 2815	27
	NC Ac 2154	27
	An 1718	27
	An 7066	28
	ICG 1850	28
	Shin-tan-Gin	29
	An 2108	29
	NC Ac 843	29
	An 424	30
	An 7188	30
	NC Ac 1044	30
	EC 7404	30
	P-2	31
	NC Ac 17530	31
	NC Ac 2188	31
	NC Ac 7	31
	EC 20963	31
	U-1-2-1	31
	An 7423	32
	EC 76443	32
	NC Ac 2749	32
	NC Ac 311	32
	NC Ac 479	32
	NC Ac 17401	32
	NC Ac 407	

50.	NC Ac 1085	32
51.	EC 21018	33
52.	RS 218	33
53.	US 39	33
54.	NC Ac 16567	33
55.	NC Ac 11	33
56.	Ah 6606	33
57.	NC Ac 2846	33
58.	Ah 7312	33
59.	Ah 7301	33
60.	Ah 699	34
61.	NC Ac 2750	34
62.	NC Ac 17860	34
63.	Fla-392-12-8-2	34
64.	Ah 7334	34
65.	EC 20972	35
66.	NC Ac 322	35
67.	NC Ac 17870	35
68.	NC Ac 17528	35
69.	NC Ac 1336	36
70.	C.No. 1090	36
71.	NC Ac 770	36
72.	NC Ac 770	36
73.	NC Ac 958	36
74.	NC Ac 10452-A	36
75.	EC 20966	36
76.	An 7500	36
77.	Robut 33-1	36
78.	NC Ac 2820	36
79.	NC Ac 2679	36
80.	NC Ac 1301	37
81.	NC Ac 17884	37
82.	GU 266	37
83.	Bombay 48-36	37
84.	US 13-6	37
85.	NC Ac 17760	37
86.	NC Ac 2172	38
87.	An 7187	38
88.	Ah 7045	38
89.	NC Ac 2575	38
90.	NC Ac 1561 (Van)	38
91.	Arboval local	39
92.	Ah 54	39
93.	Tallman	39
94.	Culture No.43-56	39
95.	Ah 7142	39
96.	UCS 2032 = No.1852	39
97.	An 6429	39
98.	NC Ac 1066	39
99.	NC Ac 2199	39
100.	NC 70446	39
101.	NC Ac 2277	39
102.	NC 20952	40
103.	Penc-33-27	40
104.	C-50	40

105. An 7211
106. RG 61-22
107. NC Ac 1740
108. NC Ac 1861
109. US-12-A
110. NC Ac 10033
111. ICG 33-RS-114
112. An 8395
113. NC Ac 2167
114. NC Ac 477 (Tan)
115. NC Ac 10452-A P1/1
116. NC Ac 602
117. Koperplaon
118. NC Ac 1628
119. Pent GS 24
120. NC Ac 2144
121. NC Ac 1276
122. NC Ac 2709
123. C-67
124. FDCED 14
125. NC Ac 505
126. NC Ac 2569
127. NC Ac 1824
128. An 685
129. NC Ac 876
130. NC Ac 930
131. NC Ac 389
132. C-501
133. ICG 3876-A01
134. An 7704
135. C-148
136. An 6604
137. NC Ac 420
138. NC Ac 17587
139. NC Ac 2690
140. NC Ac 449
141. An 23
142. # 61-101
143. NC Ac 10
144. An 7252
145. NC Ac 23
146. NT 375
147. NC Ac 464
148. NC Ac 2935
149. Arab Str 10
150. NC 75135
151. Skotish 5
152. NC NC 1040
153. NC NC 17128
154. NC NC 2182
155. n 7373
156. NC NC 2440
157. -2575
158. NC 5715
159. C NC 1672

160.	IARI 52	46
161.	NC Ac 570	46
162.	NC Ac 300	47
163.	NC Ac 2944	47
164.	NC Ac 29	47
165.	EC 20974	47
166.	NC Ac 2722	47
167.	NC Ac	47
168.	NC Ac 2203	47
169.	ICG 5628	47
170.	Nadiad No.5	47
171.	NC Ac 729	47
172.	NC Ac 17278	47
173.	NC Ac 17895	47
174.	NC Ac 2155	48
175.	NC Ac 2855	48
176.	NC Ac 2169	48
177.	NC Ac 153 (Samaru)	48
178.	NC Ac 699	48
179.	NC Ac 2719	48
180.	NC Ac 603	48
181.	NC Ac 739	48
182.	NC Ac 2556	48
183.	NC Ac 2861	48
184.	P-501/19	48
185.	NC Ac 609	49
186.	NC Ac 1546	49
187.	EC 1682	49
188.	NC Ac 2608	49
189.	NC Ac 2467	49
190.	NC Ac 575	49
191.	NC Ac 1703	49
192.	NC Ac 1033	49
193.	ICG 49-RS 142	49
194.	An 7257	49
195.	An 7215	49
196.	NC Ac 2372	49
197.	NC Ac 1312	50
198.	NC Ac 2761	50
199.	C-346	50
200.	MF 46-5-143	50
201.	NC Ac 315	51
202.	EC 21062	51
203.	NC Ac 965	51
204.	NC Ac 773	51
205.	NC Ac 50	51
206.	NC Ac 2891	51
207.	NC Ac 2676	52
208.	NC Ac 2197	52
209.	NC Ac 17111	52
210.	NC Ac 1031	52
211.	An 7306	52
212.	ICG 71-Erect	52
213.	An 6610	52

214.	NC Ac 2142	52
215.	NC Ac 732	53
216.	Nukui Bomb 95	53
217.	NC Ac 547	53
218.	NC Ac 17559	53
219.	NC Ac 2093	53
220.	NC Ac 2772	53
221.	MG 1-11	53
222.	NC Ac 579	54
223.	ICG 1529 Var 125	54
224.	US 16-B	54
225.	NC Ac 1133	54
226.	A-3	54
227.	MG 11	54
228.	An 6719	54
229.	US 13-A	54
230.	NC Ac 17859	55
231.	NC Ac 816	55
232.	NC Ac 1279	56
233.	NC Ac 1333	56
234.	A. monticola	56
235.	NC Ac 1306	57
236.	NC Ac 2813	57
237.	An 7567	57
238.	An 7567	57
239.	NC Ac 2682	57
240.	An 3262	58
241.	* 27-1	59
242.	NC Ac 1092	59
243.	NC Ac 2552	59
244.	NC Ac 17159	59
245.	An 7293	60
246.	NC Ac 2449	60
247.	NC Ac 1305	60
248.	NC Ac 834	60
249.	NC Ac 2803	60
250.	NC Ac 1086	60
251.	NC Ac 17159	60
252.	NC Ac 1043	61
253.	NC Ac 17282	61
254.	NC Ac 712	61
255.	NC Ac 746	62
256.	NC Ac 573	63
257.	NC Ac 17501	63
258.	NC Ac 2765	63
259.	ICG 1132	63
260.	NC Ac 1122	64
261.	NC Ac 835	64
262.	NC Ac 2409	64
263.	NC Ac 2765	65
264.	NC Ac 2115	65
265.	NC Ac 2133	66
266.	NC Ac 755	67
267.	NC Ac 990	67
268.	NC Ac 722	68

269.	ICG 95-TG-8	68
270.	Ah 7411	68
271.	NC AC 2553	68
272.	NC AC 413	68
273.	NC AC 589	69
274.	NC AC 318	69
275.	NC AC 17845	69
276.	NC AC 606	70
277.	NC AC 581	71
278.	NC AC 2752	72
279.	NC 6120	74
280.	NC AC 895	74
281.	NC AC 2747	74
282.	NC AC 2876	77
283	NC AC 819	86

DATE OF DATA COLLECTION: RABI 1978-79

DESCRIPTION OF THE EXPERIMENT:

SCREENING OF GERMPLASM FOR RESISTANCE TO BUD NECROSIS DISEASE

RUNNER CULTIVARS

S.No.	Cultivar	BND Incidence (%)
1.	C 120	5
2.	EC 100280	9
3.	C 99	11
4.	NC Ac 343	12
5.	An 7445	13
6.	C 123	14
7.	C 127	14
8.	Cackle early	14
9.	C 108	15
10.	NCA 16045	16
11.	RG 102	16
12.	C 162	16
13.	EC 112029	16
14.	NC Ac 897	18
15.	C 152	18
16.	An 7140	19
17.	An 7140	19
18.	C 966	19
19.	C 174	20
20.	An 7024	20
21.	EC 2063	20
22.	C 118	20
23.	An 7787	21
24.	C-12-P-34	21
25.	C 151	21
26.	An 6478	22
27.	C 150	22
28.	EC 20923	22
29.	NC Ac 17090	22
30.	C 154	23
31.	C 12-P-7	23
32.	Makalai 1-4	23
33.	C 117	24
34.	C 1025	24
35.	C 147	24
36.	C 113	24
37.	EC 20965	25
38.	C 122	25
39.	# 576-12	26
40.	Morlosa 2	26
41.	EC 20954	26
42.	Un 26	26
43.	EC 1690	27
44.	# 59-9	27
45.	EC 20949	27
46.	# 2953	27
47.	NC Ac 33	27
48.	C-12-P-31	28
49.	# 576.6	28

50.	NC Ac 2125 (Tan)	28
51.	Ah 14	29
52.	C 857	29
53.	C 132	29
54.	Local Dargi	29
55.	NC Ac 17395	30
56.	Ah 7137	30
57.	# 1022	30
58.	# 3095	30
59.	Ah 7055	30
60.	F 13	30
61.	Ah 7005	30
62.	NC Ac 2853	30
63.	NC Ac 17273	30
64.	EC 21095	31
65.	NC Ac 6755	31
66.	EC 16671	31
67.	G-22-31	31
68.	TiE-tan 453	31
69.	EC 76444	32
70.	EC 37482	33
71.	NC Ac 10277	33
72.	EC 20927	33
73.	= 605	34
74.	NC Ac 46	35
75.	Ah 7010	35
76.	EC 38603	35
77.	Ah 7240	35
78.	EC 1703	35
79.	EC 16668	36
80.	NC Ac 17348	36
81.	NC Ac 2416	36
82.	Durgapur 1	36
83.	# 2142-1	36
84.	Danacoali	37
85.	NC Ac 17340	37
86.	F-16	37
87.	EC 39545	37
88.	EC 21025	38
89.	RG 395-RR-1	38
90.	NC Ac 1174	39
91.	NC Ac 17332	39
92.	J-15	39
93.	NC Ac 832	39
94.	Ah 6967	40
95.	= 593-11	40
96.	Ah 7550	40
97.	JH 353	40
98.	EC 21060	41
99.	C 124	41
100.	EC 141	41
101.	NC Ac 1750	41
102.	EC 34279	42
103.	G-3-SAUR	42
104.	Ah 7003	43

105.	An 7376	43
106.	NC Ac 2777	44
107.	NC Ac 908	44
108.	EC 106971	45
109.	NC Ac 690	45
110.	An 7369	45
111.	NC Ac 308	45
112.	NC Ac 342	46
113.	An 7577	46
114.	NC Ac 15923	47
115.	C-12-P-28	47
116.	An 7236	47
117.	NC Ac 1268	47
118.	EC 11590	47
119.	NC Ac 1223	47
120.	Krap strain 6-1	48
121.	NC Ac 15926	48
122.	EC 25188	18
123.	EC 21034	50
124.	Durgapur 4	50
125.	NC Ac 1351	50
126.	Jh 351	50
127.	NC Ac 1113	50
128.	An 7053	31
129.	EC 20951	51
130.	Punjab local	51
131.	An 7110	51
132.	NC Ac 2821	52
133.	M 13	52
134.	NC Ac 7302	52
135.	NC Ac 326	53
136.	US 74	53
137.	NC Ac 2897	55
138.	NC Ac 2542	55
139.	EC 36892	56
140.	ICG 2613	57
141.	NC Ac 2243	60
142.	NC Ac 17368	60
143.	Durgapur 2	62
144.	NC Ac 17139	64
145.	NC Ac 2644	75
146.	An 7013	78
147.	NC Ac 2214	92

SOURCE OF DATA FOR: RABI 78-79

DATE OF DATA COLLECTION: RABI 78-79

DESCRIPTION OF THE EXPERIMENT:

GERMPLASM SCREENING (RUNNER)

	IDENTITY	BND incidence(%)
1	NCAC 2883	14
2	JENKINTURBU	19
3	C-18	19
4	C-145-12-P-7	20
5	C-3	21
6	Flo Runner	22
7	AH-7665	23
8	AH-6481	24
9	C-14	24
10	C-145-12-P-14	25
11	C-15	27
12	AH-7114	27
13	S-23	27
14	C-2	28
15	C-100	28
16	C-9	28
17	BOCHALA	29
18	AH-6949	29
19	AH-18	29
20	C-29	30
21	C-145-12-P-15	30
22	# 1022	30
23	AH-675	30
24	AH-7008	31
25	16-D	31
26	AH-3839	32
27	C-145-12-P-2	32
28	C-11	32
29	AH-7639	33
30	PUNJAB-649	33
31	NCAC 1045	33
32	302/19	33
33	HG-7	34
34	AC-145-12-20	34
35	PB-71/17	34
36	AH-2105	35
37	PUNJAB-1-10-1	35
38	EARLY-RUNNER	35
39	A-24-11	35
40	AH-664	35

41	AH-6913	35
42	C-5	36
43	OSMANABAD	36
44	AH-16	36
45	AH-731	36
46	61-C	37
47	P-36/2	38
48	EC-20975	38
49	C-105	38
50	PANDUCHERI-8	38
51	P-8 (BIG JAPAN)	39
52	x-7-3-7-17B 106	39
53	AH-7188	39
54	C-145-12-9	39
55	AH-7143	40
56	C-149	40
57	PRODUCLET	40
58	PUNJAB-1	41
59	C-145-12-31	41
60	C-107	41
61	AH-6950	41
62	# 429	41
63	AH-11	41
64	AH-692	41
65	AH-4354	41
66	BAGALCOT	41
67	C.NO.857	42
68	AH-7134	42
69	x-7-2-4-3-22-B	42
70	C-106	43
71	# 71-17	43
72	GO-268	43
73	AH-6606	43
74	AH-7241	44
75	S-61	44
76	AH-6917	44
77	AH-6918	44
78	A-RESTORIO	44
79	C-178	44
80	C-1	44
81	PUNJAB BOLE	45
82	E-RUNNER	45
83	AH-3262	45
84	SP-PEANUT	46
85	x-7-2-4-11-B	46
86	C-163	47
87	AH-31	47
88	RS-10	47
89	NIZAM BOLD	47
90	GO-005	47
91	# 69-94	47
92	# 913-1	47
93	C-145-12-33	48
94	AH-25	49
95	M-13	49

96	TOPANTOE	49
97	MOUL-240-30	49
98	C-145-12-22	50
99	PUNJAB-648	50
100	MENIR-040-30	50
101	P-23	50
102	S-7-2-2	50
103	# 575/2	50
104	AH-6	51
105	AH-6924	51
106	AH-7373	51
107	AH-554	51
108	# 39-7	52
109	AH-7512	52
110	x-43-x-x-4-B	53
111	AH-8	53
112	SET-11-CPE	53
113	US-74	53
114	AH-7419	54
115	AH-6928	55
116	LOCAL SPREEING	55
117	S-8	55
118	# 2719	55
119	PAUL-GS-21	56
120	# 5202	56
121	AH-263	57
122	ICG 1567	57
123	LOCAL BALLARY	57
124	R-B-4	58
125	AH-7339	58
126	# 2578	59
127	NCAC 2771	60
128	AH-16904	61
129	GUABIL NO.5203	62
130	AH-6908	64
131	AH-7003	65
132	B-12	65
133	AH-7114	65
134	AH-5	65
135	AK-8-11	67
136	NCAC 2913	70
137	AH-6624	71
138	NCAC	73

SOURCE OF DATA FOR: RABI 79-80

DATE OF DATA COLLECTION: RABI 79-80

DESCRIPTION OF THE EXPERIMENT:

GERMPLASM LINES SCREENING FOR BND

GERMPLASM LINES (SB)

****

	GERMPLASM	BND Incidence (%)
1	AH 54	0.0
2	NCAC 17780	1.1
3	NC 2772	1.3
4	NC 1086	3.0
5	NCAC 2891	3.0
6	AH 11	3.6
7	AH 1054	4.2
8	NCAC 2575	4.4
9	NCAC 841	5.4
10	NCAC 2470	6.1
11	NCAC 2460	6.8
12	NCAC 1044	6.9
13	NCAC 2477	6.9
14	NC 2462	7.0
15	ROBUT 33-1	8.8
16	NCAC 2172	9.5
17	NC 814	10.3
18	NCAC 1628	10.5
19	NC 17401	11.1
20	NC 17129	11.7
21	NC 876	11.7
22	NC 17142	12.5
23	NCAC 773	12.6
	GRAND MEAN	6.92
	S.E. OF MEAN	3.17
	C.D. AT 5%	9.04
	S.E.%	79.35

SOURCE OF DATA FOR: RABI 79-80

DATE OF DATA COLLECTION: RABI 79-80

DESCRIPTION OF THE EXPERIMENT:

SCREENING OF GERMPLASM FOR RESISTANCE TO BUD NECROSIS DISEASE

GERMPLASM LINES (EB)

****

	GERMPLASM	BND Incidence (%)
1	NCAC 489	8.0
2	NCAC 44	9.5
3	# 2196	11.5
4	U2-1-30	11.8
5	NCAC 1337	12.2
6	NCAC 2700	12.7
7	IMPROVED SPANTS	12.8
8	NCAC 548	13.2
9	TMV-2	13.2
10	NCAC 1303	14.7
11	NCAC 1308	15.2
12	NCAC 2661	15.4
13	#3527	15.6
14	NCAC 2798	16.0
15	NCAC 2723	16 0
16	NCAC 406	16 5
17	NG 387	16.7
18	NCAC 2696	18.4
19	NCAC 2744	19.2
20	NCAC 489	21.3
	GRAND MEAN	14.58
	S.E. OF MEAN	3.58
	C.D. AT 5%	10.26
	S.E%	42.59

SOURCE OF DATA FOR: RABI 79-80

DATE OF DATA COLLECTION: RABI 79-80

DESCRIPTION OF THE EXPERIMENT:

SCREENING OF GERMPLASM FOR RESISTANCE TO BUD NECROSIS DISEASE

GERMPLASM LINES (EB)

****

	GERMPLASM	BND Incidence (%)
1	NCAC 489	8.0
2	NCAC 44	9.5
3	# 2196	11.5
4	U2-1-30	11.8
5	NCAC 1337	12.2
6	NCAC 2700	12.7
7	IMPROVED SPANTS	12.8
8	NCAC 548	13.2
9	TMV-2	13.2
10	NCAC 1303	14.7
11	NCAC 1308	15.2
12	NCAC 2661	15.4
13	#3527	15.6
14	NCAC 2798	16.0
15	NCAC 2723	16 0
16	NCAC 406	16 5
17	NG 387	16.7
18	NCAC 2696	18.4
19	NCAC 2744	19.2
20	NCAC 489	21.3
	GRAND MEAN	14.58
	S.E. OF MEAN	3.58
	C.D. AT 5%	10.26
	S.E%	42.59

SOURCE OF DATA FOR: RABI 79-80

DATE OF DATA COLLECTION: RABI 79-80

SCREENING OF GERMPLASM FOR RESISTANCE TO BUD NECROSIS DISEASE

GERMPLASM LINES (RUNNER)

****

	GERMPLASM	BND Incidence (%)
1	M-13	10.0
2	NCAC 2232	0.8
3	NCAC 9979	0.9
4	NC 159[illegible]	1.0
5	NC 11[illegible]	1.1
6	AH 744	1.4
7	NCAC 100[illegible]	2.1
8	FLO RUNNER	2.3
9	AC-145-12-2[illegible]	2.3
10	NC 546	2.3
11	NC 2242	2.4
12	C-108	2.4
13	NC 595	2.5
14	C-120	4.0
15	NCAC 9975	5.7

GRAND MEAN	2.11
S.E. OF MEAN	± 1.14
S.E.%	94.07

SOURCE OF DATA FOR: KHARIF 1980

DATE OF DATA COLLECTION: KHARIF 1980

SCREENING OF GERMPLASM AGAINST BUDNECROSIS DISEASE

(21 LINES, 1980 RAINY SEASON)

	IDENTITY	BND Incidence(%)
1	NCAC 2242	41.2
2	C-145-12-P7	45.2
3	C-14	58.7
4	NCAC 2462	61.7
5	ROBUT 33-1	62.8
6	NCAC 2232	63.9
7	NCAC 2477	65.7
8	M-13	67.0
9	NCAC 1308	72.5
10	NCAC 548	72.8
11	NCAC 9975	74.8
12	NCAC 44	75.7
13	NCAC 17780	77.1
14	NCAC 17587	78.0
15	NCAC 2770	82.9
16	TMV-2	83.3
17	NCAC 2666	85.9
18	NCAC 448	87.4
19	NCAC 406	90.8
20	NCAC 1337	90.8
21	NG 387	94.4
	GRAND MEAN	73.72
	S.E. $\pm$	6.28
	CV%	14.70

SOURCE OF DATA FOR KHARIF 1981
DATE OF DATA COLLECTION KHARIF 1981

	IDENTITY	BND incidence(%)
1	NCAC 2232	11.1
2	NCAC 2243	14.0
3	NCAC 2230	5.9
4	NCAC 2242	3.5
5	NCAC 2243T	3.8
6	NCAC 2214	22.2
7	NCAC 2240	3.6
8	NCAC 2144	3.0
9	NCAC 1705	3.4
10	NCAC 489	28.4
11	NCAC 2666	38.2
12	NCAC 343	3.0
13	NCAC 2142	3.9
14	NCAC 1337	28.1
15	NCAC 2661	22.0
16	NCAC 2700	34.7
17	M-127-74	20.5
18	NCAC 406	27.6
19	NCAC 2888	24.1
20	NCAC 2203	8.9
21	NCAC 17888	6.0
22	U2-47-5	24.5
23	M-13	6.3
24	NCAC 2744	21.0
25	NCAC 2462	5.6
26	NCAC 2277	1.2
27	NCAC 17288	7.2
28	NCAC 1308	17.4
29	AH 7215	6.0
30	RMP-40	9.3
31	NCAC 9975	7.6
32	ROBUT 33-1	6.8
33	NCAC 1132	8.9
34	NCAC 1044	7.5
35	NCAC 2199	19.0
36	NCAC 10223	21.6
37	NCAC 20986	4.6
38	TMV-2	18.3
39	NCAC 2575	6.7
40	AH 54	9.6
41	FESR-108	7.0
	Mean	13.0
	S.E.	3.9
	CV%	51.6

SOURCE OF DATA FOR: KHARIF 1981

DATE OF DATA COLLECTION: KHARIF 1981

DESCRIPTION OF THE EXPERIMENT:

SCREENING FOR BUDNECROSIS DISEASE RESISTANCE

36 LINES

	IDENTITY	BND incidence (%)
1	MK-374	10.9
2	NCAC 2575	21.6
3	NCAC 2232	26.0
4	NCAC 2575	26.6
5	M-13	27.8
6	RS-14	29.1
7	ROBUT 33-1	30.4
8	K-71-1	31.0
9	16541	33.3
10	16949	34.9
11	VAR-34-11-11-3	35.4
12	17373	35.5
13	17843	40.6
14	17890	41.8
15	A-24-11	46.0
16	NCAC 17621	46.7
17	NCAC 17538	47.6
18	NCAC 16911	47.8
19	F-13	49.1
20	NCAC 16442	50.0
21	AH 7829	67.5
22	U4-7-7	67.7
23	AH 7777	68.4
24	ARGENTINE	71.9
25	45-29	76.5
26	NCAC 16453	78.1
27	No.53	78.7
28	10054	79.0
29	EC-109276	81.6
30	TMV-2	82.0
31	16077	82.4
32	NCAC 10088	84.1
33	NCAC 945	84.3
34	NCAC 1337	86.6
35	POL-2	87.6
36	J-11	91.6
	Mean	55.04
	SE	± 4.74
	CV%	17.23

Table 65: Screening of germplasm for BND resistance (1981 rainy season)

S.No.	Identity	% BND incidence
1	NC Ac 2277	1.1
2	NC Ac 343	3.0
3	NC Ac 2214	3.0
4	NC Ac 1705	3.4
5	NC Ac 2242	3.5
6	NC Ac 2240	3.6
7	NC Ac 2243 T	3.8
8	NC Ac 2142	3.9
9	NC 20986	4.6
10	NC Ac 2462	5.6
11	NC Ac 2230	6.0
12	Ah 7215	6.0
13	NC Ac 17888	6.1
14	M-13	6.4
15	Robut 33-1	6.8
16	NC Ac 2575	6.9
17	FESR No.108	7.0
18	NC Ac 17288	7.2
19	NC Ac 1044	7.5
20	NC Ac 9975	7.7
21	NC Ac 1122	8.9
22	NC Ac 2203	8.9
23	RMP 40	9.3
24	Ah 54	9.6
25	NC Ac 2232	11.1
26	NC Ac 2243 (B)	14.0
27	NC Ac 1308	17.3
28	TMV-2	18.2
29	NC Ac 2199	18.9
30	M-127-74	20.5
31	NC Ac 10223	21.5
32	NC Ac 2661	22.0
33	NC Ac 2214	22.2
34	NC 2888	24.0
35	U2-47-5	24.5
36	NC Ac 406	27.6
37	NC Ac 1337	28.1
38	NC 489	28.4
39	NC Ac 2700	34.6
40	NC 2666	38.2
SE ±		6.03
CV %		48.26

SOURCE OF DATA FOR KHARIF 1982

DATE OF DATA COLLECTION: KHARIF 1982

DESCRIPTION OF THE EXPERIMENT:

SCREENING AGAINST BUD NECROSIS DISEASE

PATHOLOGY MATERIAL

S.NO.	TREAT	BND Incidence (%)
1	F2 P107[4][A]	13.10
2	F2 P4 [1]	13.62
3	F2 P4[1]	14.36
4	F282[1]	21.72
5	F2 P14[1]	21.73
6	F2 P52[2]TAN	24.44
7	ROBUT	27.34
8	ICG6022	28.01
9	SM5*PI 259747	28.53
10	ICG6323	29.68
11	ICG6322	30.18
12	F2 P43 [1]	30.99
13	T-64	31.82
14	ICG7899	33.79
15	F2 P3 [1]	34.19
16	F2 P34[1]	34.50
17	F2 P107[4][B]	34.72
18	ICG7892	35.95
19	ICG3580	36.73
20	F2 P52[2]PURPLE	37.02
21	F2 P135 B-7	38.37
22	F2 P135 B1-[7]	39.43
23	F2 P 85-1	40.43
24	F2 P85 [1]	40.80
25	ICG7900	41.29
26	F2 P128	42.05
27	ICG7886	42.16
28	F2 P61P1	42.79
29	F2 P122[P1]	43.85
30	ICG1246	45.12
31	ICG1697	45.31
32	F2P2 30[P1]	46.64
33	ICG7887	46.68
34	F2 P152 [2]	46.76
35	CGS4007[PSREDDY]	46.99
36	F2 P92[1]	47.87
37	F2 P2-1	48.03
38	ICG7890	48.17
39	F2 P122 [1]	49.39
40	ICG4580	49.70
41	F2 P175[1]	49.89
42	F2 P92 B-4	50.01

43	ICG391	50.23
44	ICG4790	50.25
45	EC-21127	50.60
46	ICG4746	50.75
47	F2 P145 P-1	51.04
48	ICG7894	51.28
49	F2 P77-P1	51.57
50	ICG7898	51.89
51	ICG7882	52.45
52	ICG7893	52.94
53	CGS4018(PSREDD)	52.96
54	EC-2103	53.40
55	ICG7889	54.10
56	ICG2716	54.11
57	ICG1712	54.50
58	ICG1710	54.87
59	ICG7881	56.74
60	ICG6330	56.89
61	ICG4747	57.02
62	ICG1703	57.52
63	NCAC1301	57.53
64	F2 P1[1]	57.73
65	F2 P92-1	57.96
66	F2 P21	59.15
67	ICG7895	61.02
68	ICG7897	61.11
69	AH-6742	61.12
70	ICG6280	61.75
71	F2 P132[1]	62.00
72	ICG7013	63.58
73	F2 P61 [B]	64.24
74	ICG7885	64.25
75	ICG7896	64.62
76	F2 P61 [B]	65.12
77	ICG1704	65.28
78	F2 P162	65.49
79	F2 P21[1]	65.98
80	ICG7884	66.19
81	AH-6511	66.92
82	ICG7888	67.64
83	TMV-2	67.92
84	SAM.COLL#.88	68.14
85	AH-7129	68.55
86	ICG6340	70.12
87	680/73	70.59
88	NCAC17149	71.41
89	ICG1707	71.72
90	EC.38604	72.31
91	VAR-OG-66-2	73.60
92	VAR-OG-75-B	80.31
	GRAND MEAN	49.92
	S.E. OF MEAN	6.49
	C.D. AT 5%	17.98
	S.E.%	22.50

****

SOURCE OF DATA FOR :

DATE OF DATA COLLECTION:

DESCRIPTION OF THE EXPERIMENT

GERMPLASM SCREENING AGAINST JASSID &BND

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SUMMARY REPORT OF THE VARIABLES CONSIDERED :----------

IN THIS REPORT RANKINGS OF VARIABLE BND% ARE USED FOR THE R

S.NO.	TREAT	BND%
1	NCAC1741	7.21
2	C-108	10.36
3	NCAC841	14.31
4	G.NARROWLEAF	14.56
5	NCAC1086	15.53
6	NCAC29	16.58
7	NCAC7481	17.05
8	NCAC2203	17.26
9	NCAC17488	17.87
10	ROBUT	18.99
11	AH-54	19.77
12	NCAC1113	20.95
13	C-145-12-P17	21.51
14	NCAC343	21.82
15	NCAC16940	22.00
16	EC75445	22.42
17	NCAC2243T	22.82
18	NCAC17587	22.89
19	NCAC2243B	23.18
20	NCAC2277	23.69
21	NCAC843	24.85
22	MK-374	26.00
23	FLDP INTER	26.54
24	NCAC2772	27.04
25	NCAC17129	27.28
26	C-5	27.94
27	RMP40	28.20
28	NCAC545	28.55
29	FESR385	28.55
30	FESR108	28.67
31	NCAC23	29.00
32	KG61-22	29.11
33	NCAC1705	29.11
34	EC36982	30.05
35	NCAC2575	30.78
36	NCAC2142	31.41
37	M-13	32.37

40	[illegible]	[illegible]
41	NCAC2242	34.38
42	NCAC7404	36.00
43	NCAC9925	36.24
44	NCAC2462	36.35
45	NCAC17530	36.55
	NCAC2144	36.78
	NCAC505	36.84
	NCAC1750	36.91
	NCAC2477	37.27
	NCAC2240T	37.51
	AH7215	37.99
52	P3672	38.45
53	NCAC2944	39.33
54	NCAC2172	39.42
55	NCAC595	39.62
56	AH7653	40.06
57	NCAC22320	40.83
58	PC-20986	41.10
59	NCAC2154	41.15
60	NCAC17142	41.25
61	C-14	43.12
62	AH7445	43.18
63	NCAC17784	43.72
64	NCAC2897	46.56
65	PC1642	47.01
66	NCAC2480	47.13
67	NCAC1308	48.49
68	NCAC2240B	48.89
69	NCAC10033	49.94
70	NCAC2690	50.37
71	NCAC44	51.26
72	NCAC1457	53.38
73	NCAC2751	53.61
74	FESR-37	53.94
75	NCAC2230	54.84
76	NCAC785	55.18
77	C-00.42-3-4	56.07
78	NCAC1122	57.00
79	NCAC697	57.95
80	NCAC2771	61.32
81	NCAC548	63.85
82	PG387	65.14
83	GO.171-A	66.04
84	NCAC2891	67.43
85	SC27445	68.92
86	NCAC2666	71.92
87	NCAC2700	72.16
88	PCG412	72.37
89	C-00.723	72.99
90	SPAJ CROSS	73.11
91	NCAC2798	75.18
92	NCAC2679	75.60
93	NCAC2199	75.93
94	NCAC1337	76.00
95	NCAC2169	77.11
96	AH550	77.97
97	TMV-2	78.45
98	KANKINO.17	81.32
99	NCAC2744	81.49

100	J-11	81.72
101	U.2-1-14	81.78
102	#2-7	82.60
103	NCAC489	83.06
104	INP.SPANISH	[illegible]
105	#3527	84.70
106	VIMIMIK-2	88.33
107	NCAC2196	88.51
108	NCAC2723	89.03
109	C-123	90.36
110	K-4	90.79
111	NCAC17011	93.91

GRAND MEAN	46.64
S.E. OF MEAN	8.34
C.D. AT 5%	23.12
S.E.%	30.98
MIN	7.21
MAX	93.91
F.VALUE	7.57
REP MSS	3174.81
TREAT MSS	1581.82
ERROR MSS	208.83
ERROR DF	220

SIGNIFICANCE

Source of Data : Kharif 1982

Date of Data Collection : Kahrif 1982

Description of Experiment : Screening of Germplasm for resistance to bud necrosis disease.

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.NO.	TREAT	BND%
1	C-135	4.46
2	C-102	7.43
3	C-145-12-P-16	14.76
4	GO.09	14.91
5	C-156	15.70
6	C-145-12-P-7	16.50
7	C-145-12-P[PL]	18.24
8	C-121	18.41
9	C-163	18.75
10	C-125	18.79
11	263076-S	19.15
12	69-9	19.67
13	C-18	19.93
14	C-108	20.44
15	T-S-4	20.49
16	ROHIT	20.87
17	C-155	20.92
18	C-15	21.26
19	AH-7067	22.24
20	KEDANGLE	22.47
21	EC-1741	23.01
22	C-158	23.01
23	AH-7330	23.14
24	NCAC2230	23.31
25	C-173	23.72
26	JH-62	24.38
27	GO-788	24.75
28	C-99	25.00
29	MARIA-8	25.20
30	MARLAB-1-2-3	25.56
31	C-100	25.76
32	C-180	25.95
33	R-81	26.11
34	VRR.755	26.11
35	AH.5-3-2	26.35
36	K-4-11-II[PL]	26.79
37	C-85	27.27
38	C-145-12-P-17	27.52
39	C-145-12-P-34	27.66
40	RS-7	28.49
41	C-87	28.60
42	EC-6118	28.60
43	C-103	28.69
44	VRR.711	28.71
45	C-175	28.91
46	C-179	29.04
47	C-148	29.43
48	EC-20927	29.63
49	MORILOSE-1	30.05
50	C-8120	30.07

51	EC21010	30.13
52	C-61	30.23
53	C-145-12-P-14	30.24
54	EC21016	30.39
55	M.ASIRIA	30.55
56	EC21015	30.79
57	C-147	30.99
58	C-151	31.02
59	GO.002	31.60
60	C-168	31.79
61	C-117	31.94
62	NCAC2123	32.53
63	K-5-H-1	32.60
64	EC20888	32.73
65	NCAC2561	32.78
66	K-3	33.04
67	C-177	33.30
68	75-83	33.45
69	C-114	33.47
70	C-107	33.99
71	AH-7009	34.41
72	AH-7049	34.61
73	EC-20930	34.70
74	S-61	35.31
75	EC-1703	35.33
76	VRR.793	36.09
77	AH-3	36.11
78	M-395	36.77
79	RB-4	37.09
80	RS-14	37.65
81	NO.230	37.79
82	C-124	37.82
83	P.ERECT416	38.15
84	S-42	38.23
85	NCAC2566	38.51
86	C-104	38.62
87	73-35	38.69
88	AH-7147	38.89
89	T-11-11	39.27
90	RS-1	39.30
91	C-79	39.36
92	EC-20925	39.37
93	C-176	39.64
94	PONDICHERRY-8	40.15
95	CULTIVARNO.966	40.45
96	EC.1699	41.00
97	BIG JAPAN	41.01
98	C-116[R1	41.16

99,	SP-1	41.67
100	F-7	41.74
101	EC-4078	41.77
102	EC-1539	41.96
103	ICG965	42.02
104	EC-20920	42.96
105	MONTR-240-30	43.17
106	H-13 ✓	43.39
107	C-80	43.78
108	C-116[PI.]	45.04
109	AH-7304	45.38
110	69-8	46.18
111	AH-7053	47.09
112	EC21995	47.17
113	AH7411	47.65
114	AH-4042	47.73
115	USA-20	47.82
116	GINAK	47.88
117	EC20968	48.02
118	AH-7142	48.61
119	NCAC819	49.26
120	NCAC2158	50.00
121	AH-1	50.00
122	C-45	50.37
123	S-44	51.50
124	EC20981	51.67
125	E.R	51.78
126	AH-7214	51.86
127	EC-16677	52.77
128	RUNNER-E5914	52.98
129	41-C	56.71
130	PI-139921	58.89
131	NCAC528	59.39
132	PI240546	63.61
133	P31/4A	64.03
134	PI240543	64.30
135	GA.171	64.75
136	321/2	65.38
137	PI-152870	65.85
138	PI-152813	66.41
139	PI-118474	67.61
140	AH-7301	68.89
141	PI-149266	70.33
142	PI-161308	70.36
143	PI-119075	70.70
144	PI-119204	71.12
145	RS-218	72.17
146	PI-313949	74.24
147	PI-161312	74.25
148	PI-118480	74.27
149	PI-118995	75.15
150	PI-117446	75.16
151	PI-149270	75.49
152	NCAC529	75.68
153	PI-155246	76.67

154	SR.X1	76.92
155	PI-118996	77.03
156	PI118989-38	77.33
157	PI-152130	77.33
158	PI-118989	77.57
159	PI-152138	78.03
160	PI-153159	78.55
161	EC.21137-1	79.23
162	PI-161315	79.26
163	586	79.49
164	PI-121521	79.59
165	F1-5	80.00
166	PI-268561	80.16
167	PI-161303	80.20
168	PI-118989-	80.32
169	PI-153169	80.71
170	PI-152119	80.82
171	AK.12-24-6	81.11
172	PI-149265	81.37
173	PI-152140	81.41
174	PI-118471	81.59
175	PI-119063	81.89
176	PI-119082	82.00
177	NG-268	82.08
178	PI-149643	82.22
179	NCAC666	82.39
180	PI-149267	83.33
181	AH-7506	83.88
182	P-765	83.89
183	3-5	84.41
184	P-2	84.57
185	PI-152125	84.83
186	PI-155243	84.85
187	C-1025	85.16
188	PI-117850	85.21
189	GA-163	85.35
190	PI-119081	86.04
191	AH.6279	86.34
192	13/46	86.43
193	BEFORE	86.76
194	PI-155050	86.90
195	RS-12	87.16
196	TMV-2	89.37
197	PF-161297	89.50
198	PI-152144	89.67
199	EC-1691	89.80
200	PI-262012	90.67
201	PI-155051	91.41
202	PI-152139	91.82
203	IART.687	92.31
204	PI-152135	92.42

205	PI-156668	92.52
206	B.3/8	92.82
207	56-6	92.98
208	PI-161303	93.94
209	AH-7893	94.41
210	PI-155112	94.84
211	GA-177	95.00
212	GA-145	95.43
213	PI-149641	100.00

GRAND MEA	52.15
S.E. OF M	8.79
C.D. AT	~~24.37~~
S.E.+	29.21

SOURCE OF DATA FOR RAB: 82-83

DATE OF DATA COLLECTION RABI 82-83

S.NO.	TREAT	BND Incidence(%)
1	NCAC1741	5
2	NCAC2232N	7
3	NCAC2232Q	9
4	NCAC841	9
5	NCAC2243T	9
6	NCAC546	10
7	C-5	10
8	AH-54	10
9	NCAC2575	10
10	EC-76445	10
11	NCAC2242	10
12	NCAC2460	11
13	NCAC2772	11
14	NCAC17888	11
15	NCAC2771	11
16	AH-7215	11
17	NCAC505	11
18	NCAC2230	12
19	NCAC17587	12
20	M-13	12
21	C-14	12
22	NCAC2891	12
23	ROBUT33-1	12
24	G NARROWLEAF	12
25	C-108	12
26	NCAC343	12
27	NCAC1705	13
28	NCAC2240T	13
29	EC20986	13
30	NCAC7481	13
31	FLO-RUNNER	13
32	NCAC2277	14
33	FESR-108	14
34	NCAC1113	14
35	AH-7445	14
36	NCAC1086	15
37	NCAC17784	15
38	NCAC7404	15
39	NCAC16940	15
40	NCAC843	15
41	NCAC2477	15
42	NCAC876	15
43	KG-61-22	15
44	NCAC7302	15
45	NCAC2154	15
46	NCAC2144	15
47	NCAC17530	16
48	P36/2	16
49	NCAC17142	16
50	NCAC2243B	16
51	NCAC2897	17
52	NCAC2944	17
53	NCAC2172	17

54	NCAC1122	
55	EC-36982	17
56	NCAC2142	17
57	NCAC2203	17
58	AH-7663	18
59	C-145-12-P17	18
60	MK-374	18
61	NCAC23	19
62	NCAC9925	19
63	EC-1682	20
64	NCAC29	20
65	NCAC2462	20
66	RMP-40	21
67	NCAC595	21
68	NCAC7236	21
69	NCAC17129	22
70	NCAC785	23
71	NCAC1308	23
72	NCAC1750	23
73	FESR-386	24
74	NCAC10033	24
75	NCAC2240B	24
76	NCAC2214	24
77	NCAC1457	26
78	NCAC17011	26
79	FESR-37	27
80	NCAC2690	29
81	U2-1-14	32
82	NCAC44	33
83	C-123	33
84	IMP.SPANISH	34
85	SPAN CROSS	34
86	NCAC2723	35
87	C NO.32-3-4	35
88	ICG412	36
89	NCAC548	36
90	NCAC697	38
91	#3527	39
92	NCAC2199	39
93	K-4	39
94	KANKI NO.17	39
95	J-11	40
96	EC-27446	40
97	NCAC2196	40
98	OG-171-A	41
99	NCAC2798	41
100	NCAC1337	41
101	C-729	42
102	NCAC2666	42
103	NCAC2761	43
104	NCAC489	44
105	#2-7	44
106	NG-387	45
107	NCAC2744	48
108	NCAC2700	48
109	AH-60	49
110	TMV-2	49
111	NCAC2679	50

GRAND MEAN 23.02

SE+

35.27

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF EXPERIMENT:

SCREENING OF BREEDING LINES FOR RESISTANCE TO BUD NECROSIS DISEASE

INRRL F6 (13) LINES

S.NO.	CULTIVAR	BND Incidence(%)	YIELD gr/PLOT.
1	(Manipentor x R.33-1) x NCAC 2232 F2-B1-B2-B1-B2	39	607
2	(Manfredi-68 x 343) F2-B1-B1-B1-B2	52	483
3	(Ah-6279 x 2232) F2-B1-B1-B1-B2	56	397
4	(Manfredi-68 x 343) F2-B1-B2-B1-B2 Tan	60	340
5	(NCAC-2719 x 2232) F2-B1-B1-B1-B2	61	337
6	(TG-1 x 343) F2-B1-B1-P1-B1 Tan	68	247
7	(AH-6279 x 2232) F2-B1-B1-B1-B2	69	153
8	ROBUT 33-1	69	278
9	(Manfredi-68 x 343) F2-B1-B2-B1-B1	71	287
10	(NC-17 x 343) F2-B1-B2-B1 TAn	72	343
11	(NC-17 x 343) F2-B1-B2-B2-B2-VB	73	238
12	(Manfredi-68 x 343) F2-B1-B2-B1-B2 Red	74	302
13	(NCAC-2719 x 2232) F2-B1-B1-B1-B2	77	235
14	(Faizpur 1-5 x 2232) F2-B1-B2-B1-B1	82	220
	GRAND MEAN	65.9	319.0
	S.E. OF MEAN	8.6	73.6
	S.E.%	22.7	39.9

SOURCE OF DATA FOR: *KHARIF1983*

DATE OF DATA COLLECTION: *KHARIF1983*

DESCRIPTION OF THE EXPERIMENT:

BREEDING MATERIAL INR F8

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SUMMARY REPORT OF THE VARIABLES CONSIDERED:

	IDENTITY	BND%	YIELD gr/PLOT	
1	(R 33-1 x 2214) F3-B1-B1-B2-B1-B2	52.12	556.67	
2	(R 33-1 x 2214) F3-B1-B1-B2-B2-B3	46.38	510.00	
3	(R 33-1 x 2214) F3-B1-B1-B3-B1-B3	42.60	416.67	
4	(R 33-1 x 2214) F3-B1-B1-B2-B2-B3	54.30	365.00	
5	(R 33-1 x 2214) F3-B1-B1-B2-B2-B3	61.17	336.67	
6	(R 33-1 x 2214) F3-B1-B1-B2-B2-B2	61.83	336.67	
7	(R 33-1 x 2214) F3-B1-B1-B2-B1-B2	57.35	311.67	
8	(R 33-1 x 2214) F3-B2-B1-B2-B2-B3	63.51	291.67	
9	(R 33-1 x 2214) F3-B1-B2-B1-B3-B3	69.19	278.33	
10	(R 33-1 x 2214) F3-B1-B1-B2-B2-B2	51.88	271.67	
11	(R 33-1 x 2214) F3-B1-B1-B1-B1-B1	64.35	255.00	
12	(R 33-1 x 2214) F3-B1-B1-B2-B4-B3	74.09	251.67	
13	(R 33-1 x 2214) F3-B1-B1-B2-B2-B2	30.11	250.00	
14	(R 33-1 x 2214) F3-B1-B1-B1-B1-B1	82.97	240.00	
15	(R 33-1 x 2214) F3-B1-B1-B2-B4-B3	61.74	208.33	
16	(R 33-1 x 2214) F4-B1-B2-B1-B3	78.68	160.00	*
17	(R 33-1 x 2214) F3-B1-B1-B2-B1-B3	64.24	145.00	
18	(R 33-1 x 2214) F3-B1-B1-B2-B1-B2	90.90	101.67	
19	(R 33-1 x 2214) F3-B1-B1-B2-B2-B2	68.11	95.00	
	GRAND MEAN	61.87	283.25	
	S.E. OF MEAN	9.66	85.53	
	C.D. AT 5%	27.71	245.28	
	S.E.%	27.05	52.30	

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF EXPERIMENT:

SCREENING OF BREEDING LINES FOR RESISTANCE TO BUD NECROSIS DISEASE

INRYT (44) LINES

S.NO.	CULTIVAR	BND incidence(%)	YIELD gr/PLOT
1	(TMV-4 x Robut 33-1) F2-B1-B1-B2-B3	35	260
2	NCAC 343	37	192
3	BNV(R-33-1 x 2214) F3-B1-B2-B1-B2-B3	38	188
4	(GANGAPURI x MK-374)(R.33-1 x 2214) F2-B1-B2-B1-B3	44	447
5	(2-22)(R.33-1 x 2214) F3-B1-B2-B2-B1-B3	49	403
6	(2-7) (R.33-1 x 2214) F2-B1-B1-B2-B1-B1-B3	51	410
7	(2-17)(R.33-1 x 2214) F2-B1-B1-B1-B2-B1-B3	51	303
8	(NCAC 2719 x 2232) F2-B1-B1-B1-B3	52	302
9	BNV(R.33-1 x 2214) F3-B1-B1-B2-B1-B3	54	295
10	(343 x 2232) F2-B1-B2-B2-B3	54	302
11	BNV(R.33-1 x 2214) F3-B1-B2-B2-B3-B3	56	227
12	(R.33-1 x 343) F2-B1-B1-B1-B2-B1-B3	57	425
13	(F334 A-B-14 X 2232) F2-B1-B3-B1-B3	59	340
14	BNV(R.33-1 x 2214) F2-B2-B1-B2-B2-B3	60	130
15	(28-206 x 2214) F2-B1-B2-B1-B3	62	193
16	BNV(R.33-1 x 2214) F3-B1-B1-B2-B1-B3	63	217
17	BNV(R.33-1 x 2214) F2-B2-B2-B1-B2-B3-B3	63	187
18	(Makulu Red x 2232) F2-B1-B3-B2-B3	64	348
19	(2-20)(R.33-1 x 2214) F3-B1-B2-B1-B1-B3	65	356
20	BNV(R.33-1 x 2214) F3-B1-B1-B3-B1-B3	67	150
21	x52-x-x-3-Bx(R.33-1 x 2214) F2-B1-B2-B1-B3	67	170
22	(R.33-1 x 2232) F2-B1-B3-B3-B3	67	205
23	Robut 33-1	68	278
24	(Manfredi 68 x NCAC 343) F2-B1-B2-B1-B3	72	283
25	BNV(R.33-1 x 2214) F3-B1-B1-B1-B1-B3	75	122
26	BNV(R.33-1 x 2214) F3-B1-B1-B3-B1-B3	81	153
27	(28-206 x NCAC 10247) F2-B1-B2-B1-B3	82	192
28	(MGS-9 x 2232) F2-B1-B3-B3-B3	83	123
29	(TMV-10 x 2232) F2-B1-B2-B3-B3	89	97
30	(SM-5 x 343) F2-B1-B2-B2-B3	96	102
31	(Colarado Manifredi x 2232) F2-B1-B1-B3-B1-B3	96	50
32	(R.33-1 x 2214) F2-B1-B1-B1-B2-B1-B3	97	18
33	(NCAC 343 x 2232) F2-B1-B2-B1-B3	97	107
34	(2-12)(R.33-1 x 2214) F2-P11-P50-B2-P14-B1-B3	98	20
35	(F-SB-7-2 x 2232) F2-B1-B2-B5-B3	99	50
36	(FSB-7-2 x 2232) F2-B1-B2-B3-B3	99	62
37	JL-24	99	7
38	(Dh-3-20 x 2214) F2-B1-B2-B1-B3	99	40

39	J-11	99	57
40	(G-201 x 2232) F2-B1-B3-B1-B3	99	8
41	(Colarado Manfredi x 343) F2-B1-B2-B1-B2	100	18
42	INRSL5-27-EB3	100	18
43	(FSB-7 x 2232) F2-B1-B2-B4-B3	100	10
44	(G-201 x 2232) F2-B1-B3-B2-B3	100	13
	GRAND MEAN	73.73	179
	S.E. OF MEAN	4.49	32
	S.E.%	17.58	31

SOURCE OF DATA FOR: KHARIF 1983

DATE OF DATA COLLECTION; KHARIF 1983

DESCRIPTION OF THE EXPERIMENT:

SCREENING OF SOME GERMPLASM FOR YIELD POTENTIAL AND RESISTANCE TO BUD NECROSIS DISEASE

	IDENTITY	BND Incidence(%)	YIELD gr/PLOT
1	C-108	14	373
2	NCAC 17888	19	307
3	NCAC 7481	30	263
4	NCAC 343	31	322
5	EC-76445	32	407
6	ROBUT 33-1	40	218
7	NCAC 2460	41	332
8	EC-20986	43	172
9	NCAC 7302	43	260
10	AH-7215	44	73
11	NCAC 17784	44	218
12	NCAC 2772	47	387
13	M-13	47	175
14	PI-268876	49	183
15	NCAC 23	49	200
16	RMP-40	50	38
17	MK-374	51	115
18	PI-161297	60	508
19	AH-7663	60	68
20	NCAC 17288	62	253
21	RMP-12	63	50
22	NCAC 29	63	60
23	Flo Runner	64	318
24	EC-36982	67	223
25	ROBUT 33-1	68	278
26	AH-7777	69	260
27	NCAC 1113	69	160
28	NCAC 2944	76	98
29	NCAC 10033	77	27
30	NCAC 17530	82	162
31	NCAC 2723	85	220
32	NCAC 2761	85	332
33	NCAC 1308	88	153
34	C.No.32-3-4	89	110
35	EC-109276	90	178
36	Pircom-43	93	145
37	SPAN CROSS	94	117
	GRAND MEAN	58.8	209.9
	S.E. OF MEAN	7.5	52.6
	C.D. AT 5%	21.3	148.2
	CV %	22.3	43.3

SOURCE OF DATA FOR: KHARIF 1983

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF THE EXPERIMENT:

YIELD TRIAL (BREEDING ICGS LINES)=62 LINES

KHARIF 1983 RUS 5B

PLOT=4M*4 ROW

S.NO.	TREAT	BND Incidence(%)	YIELD gr/PLOT
1	ICG 37	24	210
2	ICG 50	37	350
3	ICG 38	38	341
4	ICG 32	39	206
5	ICG 19	41	366
6	ICG 44	44	228
7	ICG 46	45	340
8	ICG 1	46	281
9	ICG 47	46	268
10	ICG 17	46	131
11	ICG 56	46	265
12	ICG 4	47	348
13	ICG 40	47	180
14	ICG 55	48	331
15	ICG 31	48	261
16	ICG 41	50	306
17	ICG 5	50	188
18	ICG 22	51	223
19	ICG 61	51	265
20	ICG 29	51	126
21	ICG 36	51	341
22	ICG 34	52	293
23	ICG 52	52	323
24	ICG 16	53	275
25	ICG 35	53	333
26	ICG 6	54	303
27	ICG 48	54	213
28	ICG 18	54	288
29	ICG 26	55	228
30	ICG 54	56	105
31	ICG 21	57	115
32	ICG 45	57	186
33	ICG 24	59	288
34	ICG 11	59	286
35	ICG 49	59	343
36	ICG 27	60	153
37	ICG 30	60	241
38	ICG 12	61	281
39	ICG 51	63	168
40	ICG 20	63	296

41	ICG 23	64	195
42	ICG 57	64	253
43	ICG 25	65	176
44	ICG 58	66	246
45	ICG 33	66	401
46	ICG 13	67	228
47	ROBUT 33-1 (Check)	67	278
48	ICG 43	69	236
49	ICG 2	70	168
50	ICG 15	73	225
51	ICG 28	73	150
52	ICG 62	73	85
53	ICG 8	75	100
54	ICG 53	76	186
55	ICG 14	78	160
56	ICG 42	82	165
57	ICG 9	88	43
58	ICG 59	89	123
59	ICG 3	89	90
60	ICG 60	91	110
61	ICG 7	92	63
62	ICG 39	94	113
63	ICG 10	97	61
	GRAND MEAN	60.7	224.6
	S.E. OF MEAN	7.7	40.9
	C.D. AT 5%	21.3	113.5
	S.E.%	21.9	31.5

SOURCE OF DATA FOR: KHARIF 1983

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF THE EXPERIMENT:

PRELIMINARY SCREENING OF NEW GRAMPLASM LINES (63 LINES).

KHARIF 1983 RUS 6B&5A
PLOT=4M*4 ROW

	IDENTITY	BND Incidence (%)
1	NCAC 10223	19.0
2	C-12-P-10	22.1
3	APAU C-4	22.5
4	PI-153330	23.2
5	M-145	23.4
6	VRR 170	28.9
7	AH-7890	32.2
8	ROBUT 33-1	34.5
9	NCAC 2893	36.2
10	EC-20927	37.3
11	VRR-299	37.7
12	DWARF MUTANT	38.0
13	NCAC 1044	38.7
14	NCAC 2146	39.0
15	VRR-257	39.7
16	NCAC 17679	40.0
17	AH-6857	40.8
18	NCAC 15926	44.0
19	NCAC 2146	44.5
20	PI-149263	46.8
21	NCAC 17273	48.0
22	C-145-12-20	48.0
23	AH-11	48.4
24	VRR-265	48.5
25	NCAC 17902	48.9
26	SB-7	49.9
27	NCAC 505	52.2
28	VRR-298	55.5
29	AH-76446 (292)	55.7
30	NCAC 2831	56.4
31	VRR-301	56.9
32	VRR-282	58.4
33	VRR-263	59.0
34	VRR-228	59.4
35	VRR-294	59.4

36	NCAC 2747	60.0
37	NCAC 2125	60.5
38	NCAC 1132	61.5
39	VRR-195	64.5
40	VRR-296	65.3
41	VRR-219	66.5
42	PI-138870	66.8
43	PI-269062	67.3
44	M-13	71.2
45	AH-7294	71.2
46	NCAC 10067	71.6
47	PI-152133	72.0
48	VRR-316	73.3
49	NCAC 2169	74.5
50	NCAC 1303	78.6
51	PI-240579	80.2
52	PI-149266	84.8
53	607-4	84.9
54	PI-149268	86.1
55	PI-155243	89.3
56	CRINKLE LEAF	89.6
57	PI-261903	90.5
58	COMET	91.7
59	PI-153158	92.9
60	26-5-II	94.7
61	PI-118992-2	95.2
62	NCAC 474	96.2
63	NCAC 608	96.4
64	TMV-2	96.5
65	PI-262123	97.2
66	PI-152139	100.0

GRAND MEAN	60.42
S.E. OF MEAN	10.80
C.D.AT 5%	29.94
S.E.%	30.97

SOURCE OF DATA FOR: KHARIF 1983

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF THE EXPERIMENT:

ADVANCE SCREENING OF PROMISING GERMPLASM LINES

KHARIF 1983 RUS 6B-TERMITE INFESTED BLOCK

PLOT=4M*4ROWS

	IDENTITY	BND Incidence(%)
1	C-136	5.6
2	C-121	6.6
3	NC 2232(Q)	7.8
4	C-107	8.7
5	GUJARAT NARROW LEAF	9.0
6	NCAC 2240	9.5
7	NCAC 2243B	9.7
8	C-102	10.8
9	NCAC 1741	11.5
10	NCAC 2242	12.5
11	C-145-12-P-16	12.7
12	GO-09	14.1
13	C-108	14.3
14	NCAC 2243T	14.9
15	C-163	15.2
16	NCAC 2142	16.9
17	NCAC 1705	17.0
18	69/9	17.4
19	C-87	17.4
20	NCAC 841	17.8
21	C-151	18.5
22	F2-P3(1) (Path)	18.8
23	C-18	19.0
24	KHADIRI-2	19.6
25	NCAC 17888	20.2
26	C-156	20.2
27	NCAC 2575	20.5
28	F2-P4(1) (Path)	20.5
29	C-114	20.8
30	C-145-12-P7	21.0
31	AH 7663	21.1
32	NCAC 343	21.4
33	C-145-12-P-17	24.2
34	NCAC 2462	24.3
35	NCAC 2144	24.5
36	FESR-108	24.5
37	M-13	25.0
38	NCAC 2690	26.1

39	AH 7215	26.4
40	C-125	26.6
41	RMP-40	27.8
42	NCAC 7481	29.1
43	NCAC 1086	29.1
44	C-145-12-P-(PL)	29.5
45	EC-20888	30.2
46	T-64	31.3
47	NCAC 10033	33.3
48	FESR-386	34.6
49	NCAC 7587	34.7
50	R28-P2 (Cyto)	34.8
51	NCAC 1113	35.4
52	NCAC 29	36.3
53	PI-414332	36.7
54	AH-1	36.9
55	NCAC 2230	37.2
56	EC-1741	38.1
57	NCAC 2203	38.4
58	NCAC 2891	40.7
59	BIG JAPAN	41.0
60	EC-20986	41.7
61	EC-76445	42.9
62	AH-54	43.1
63	NCAC 2240	45.8
64	267076-S	46.8
65	NCAC 1112	51.2
66	ROBUT 33-1	60.5
67	TMV-2	82.7
68	NCAC 16940	86.6
69	NCAC 2723	95.0

GRAND MEAN	28.22
S.E. OF MEAN	6.97
C.D.AT 5%	19.32
S.E.%	42.80

SOURCE OF DATA FOR: KHARIF 1983

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF THE EXPERIMENT:

PRELIMANARY SCREENING OF GROUND GERMPLASM AGAINST INSECT PESTS AND BND

KHARIF 1983 RUS 6B&5A

PLOT=4M*1 ROW

	IDENTITY	BND incidence(%)
1	C-107	22.5
2	AH-7067	25.5
3	C-145-12-P-34	26.3
4	C-147	31.3
5	EC-20968	31.5
6	EC-6118	31.8
7	M-13	32.2
8	EC-21010	40.5
9	NCAC 1301	41.1
10	S-16	43.4
11	C-163	43.6
12	C-168	44.1
13	C-103	44.5
14	C-145-12-P-17	44.5
15	C-145-12-P-14	44.6
16	NCAC 2123	45.2
17	EC-20930	45.2
18	CULTURE #966	45.3
19	VRR-711	45.7
20	C-104	45.8
21	F-7	47.5
22	GO-788	48.3
23	MARLAB-1-2-3	49.2
24	AH-7053	49.3
25	AH-5-3-2	49.9
26	C-99	50.5
27	EC-1539	50.5
28	RS-7	51.8
29	C-61	52.0
30	C-79	52.1
31	C-85	52.5
32	C-179	53.3
33	C-124	53.4
34	GINAK	53.7
35	C-45	53.9

36	M-395	54.2
37	T-S-4	54.3
38	MONIR-240-30	54.5
39	EC-20981	54.7
40	C-8120	55.0
41	AH-7049	55.6
42	AH-7214	56.1
43	AH-7304	56.1
44	AH-7147	56.5
45	T-11-11	56.6
46	VRR-755	56.6
47	C-100	56.8
48	PONDACHERRY-8	56.8
49	MORILOZE-1	57.6
50	[illegible]	[illegible]
51	C-173	58.4
52	P-31/4A	58.6
53	C-176	58.9
54	R-3	58.9
55	C-116(PL)	59.2
56	EC-21015	59.3
57	ROBUT 33-1	60.0
58	AH-7330	60.1
59	RS-1	60.1
60	P.ERRECT-416	60.2
61	USA-20	60.2
62	EC-21127	60.4
63	AH-7214	60.5
64	#230	61.1
65	EC-20968	62.1
66	EC-16677	62.4
67	GO-002	62.4
68	RS-6	62.9
69	EC-20925	62.9
70	MARIA-B	63.6
71	BIG JAPAN	63.7
72	AH-3	63.8
73	PI-118995	63.9
74	C-148	64.1
75	RUNNER-E-5914	64.2
76	PI-161308	64.3
77	C-116(R)	64.6
78	RS-14	65.8
79	EC-1703	66.1
80	EC-20920	66.3
81	JH-62	67.1
82	68-B	67.6
83	R-81	68.0
84	VRR-793	68.2
85	NCAC 2561	68.9
86	C-180	69.3
87	EC-20927	69.5
88	C-175	69.6
89	NCAC 2158	69.9
90	C-125	70.5

91	EC-21995	70.9
92	PI-149270	71.1
93	AH-7411-T	71.3
94	PI-153139	72.1
95	AH-7301	72.4
96	AH-7411-B	72.4
97	41-C	73.0
98	VAR-OG-66-2	73.5
99	MWITUNDE ASIRIA	75.0
100	AH-7142	75.5
101	NCAC 2566	76.6
102	ER	76.8
103	RB-4	77.8
104	NCAC 2230	78.6
105	S-42	79.4
106	NCAC 819	79.9
107	PI-118989-3B	80.1
108	EC-1699	80.8
109	321/2	81.3
110	PI-119204	82.7
111	680/73	82.9
112	PI-313949	83.3
113	AH-6511	83.6
114	AH-6279	84.4
115	PI-149267	85.1
116	AH-7121	85.7
117	PI-268561	86.0
118	NCAC 17149	86.2
119	PI-161315	86.6
120	PI-162813	87.1
121	686	87.1
122	AH-1	87.6
123	NCAC 529	87.9
124	PI-139921	87.9
125	IARI-687	88.0
126	PI-149266	89.2
127	AH-6742	89.2
128	AH-7506	89.7
129	NCAC 528	89.8
130	RS-12	90.1
131	NCAC 666	90.3
132	3-5	90.5
133	PI-118471	90.5
134	PI-161887	90.5
135	PI-15668-3	90.7
136	P-2	90.8
137	PI-117850	91.0
138	SB-XI	91.0
139	PI-119063	91.8
140	PI-152135	92.1
141	PI-161297	92.4
142	PI-5	92.5
143	C-1025	92.7
144	PI-152144	92.9
145	PI-149641	93.0

146	PI-149643	93.4
147	GA-145	93.9
148	SAM Coll #88	94.1
149	PI-152119	94.1
150	PI-155246	94.5
151	PI-149265	94.5
152	VAR-OG-75-B	94.7
153	PI-118474	94.9
154	BEJORE	95.5
155	EC-2103	95.8
156	GA-163	96.0
157	EC-21137-1	96.0
158	PI-152130	96.2
159	PI-262012	96.4
160	PI-155050	96.5
161	PI-161312	96.6
162	PI-155243	96.9
163	PI-155051	97.0
164	PI-152125	97.1
165	EC-1691	97.1
166	PI-152140	97.9
167	GA-177	98.0
168	AK-12-24-64	98.0
169	13-46	98.0
170	PI-118989	98.0
171	PI-240543	98.0
172	PI-119081	98.1
173	PI-118480	98.1
174	56-6	98.1
175	PI-152138	98.1
176	PI-121521	98.1
177	EC-38604	98.1
178	AH-6742	98.3
179	NG-268	98.3
180	P-765	98.4
181	RS-218	98.4
182	AH-7983	100.0
183	PI-161303	100.0
184	PI-118995	100.0
185	PI-118989-3	100.0
186	PI-119075	100.0
187	PI-152139	100.0
188	TMV-2	100.0
189	PI-153169	100.0
190	B3/B	100.0

GRAND MEAN	73.42
S.E. OF MEAN	9.56
C.D. AT 5%	26.50
S.E.%	22.56

DATE OF DATA COLLECTION: KHARIF 1983

DESCRIPTION OF EXPERIMENT:

SCREENING OF BREEDING LINES FOR RESISTANCE TO BUD NECROSIS DISEASE

INRRL F8 (18) LINES

S.NO.	CULTIVAR	BND Incidence(%)	YIELD gr/PLOT
1	(Robut 33-1 x 2214) F3-B1-B1-B1-B1-B1	30	250
2	(Robut 33-1 x 2214) F3-B1-B1-B3-B1-B3	43	417
3	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B3	46	510
4	(Robut 33-1 x 2214) F3-B1-B2-B1-B3-B3	52	272
5	(Robut 33-1 x 2214) F3-B1-B1-B2-B1-B2	52	557
6	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B3	54	365
7	(Robut 33-1 x 2214) F3-B1-B2-B1-B3-B3	57	312
8	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B3	61	337
9	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B2	62	208
10	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B2	62	337
11	(Robut 33-1 x 2214) F3-B2-B1-B2-B2-B3	63	292
12	(Robut 33-1 x 2214) F3-B1-B1-B2-B1-B3	64	145
13	(Robut 33-1 x 2214) F3-B1-B1-B3-B2-B2	64	255
14	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B2	68	95
15	ROBUT 33-1	69	278
16	(Robut 33-1 x 2214) F3-B1-B1-B2-B2-B2	74	252
17	(Robut 33-1 x 2214) F4-B1-B2-B1-B3	78	160
18	(Robut 33-1 x 2214) F3-B1-B1-B2-B4-B3	83	240
19	(Robut 33-1 x 2214) F3-B1-B1-B2-B1-B2	91	102
	GRAND MEAN	61.8	283.2
	S.E. OF MEAN	9.6	85.5
	S.E.%	27.0	52.3