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Papers

Assessment of yield loss due to insect pests at different growth stages of groundnut in Pantnagar, Uttar Pradesh, India

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Abstract Field experiments were conducted during the 1988 and 1989 rainy seasons to assess yield loss at different growth stages in groundnut (peanut) due to insect pests. The crop was infested by thrips at the vegetative stage; by thrips, jassids and *Spilosoma obliqua* Walker at flowering; by thrips, *S. obliqua* and *Spodoptera litura* Fabricius at pegging, and by *S. litura* and *S. obliqua* at both podding and pod maturity. The greatest yield loss caused by insect pests at any crop stage was 31.4% in 1988 and 23% in 1989. Damage occurring during the bloom and vegetative stages resulted in maximum yield loss. Thus, crop protection measures at the vegetative and bloom stages are most effective in minimizing the yield loss due to insect pests in groundnut.

Keywords Thrips; *Spilosoma obliqua*; *Spodoptera litura*; groundnut; yield loss; *Arachis hypogaea*

Introduction

Groundnut (peanut; *Arachis hypogaea* L.) is one of the most important oilseed crops in India. It is grown on 7.5×10^6 ha in the rainy season and on 1.5×10^6 ha during the postrainy season. India produces 7.5×10^6 t of shells yearly (FAO, 1988). The yields, however, are low, averaging 800 kg ha^{-1} compared with 2500 kg ha^{-1} in developed countries. The major constraints to growing groundnuts in India are insect pests, diseases and drought (Gibbons, 1980).

In 1968, the only major pests of groundnut were an aphid (*Aphis craccivora* Koch), a leafminer (*Aproaerema modicella* Deventer), red hairy caterpillars (*Amsacta* spp.) and termites (*Odontotermes* sp. and *Microtermes* sp.) (Rai, 1976); however, the situation has now changed considerably. Insects such as white grubs (*Holotrichia* spp.), tobacco caterpillar (*Spodoptera litura* Fabricius), gram pod borer (*Helicoverpa armigera* Hübner), jassid (*Empoasca* spp.), thrips (*Scirtothrips dorsalis* Hood and *Frankliniella schultzei* Trybom) and leaf folder (*Anarsia ephippias* Meyrick), which were not previously considered to be important pests, are now recognized as such (Amin and Mohammad, 1980; Reddy, 1988; Wightman and Amin, 1988).

Several conflicting reports are available on the groundnut crop losses attributable to major insect pests in India. Losses caused by various insect pests were reported to be 40–70% in Gujarat, 5–10% in Maharashtra, 15% in Andhra Pradesh, 42% in Tamil Nadu, 35% in Orissa, 22% in Karnataka, 49% in Punjab, 20% in Uttar Pradesh and 50% in Rajasthan (Amin, 1983). Recently Reddy (1988) reported a total of 17% yield losses from damage caused by major field insect pests. Every year, India imports edible oil valued at US\$40 × 10^6. If losses due to groundnut insects pests were controlled, India could save 15% of expenditure on oil imports per year.

The studies described in this paper were carried out to investigate the incidence of insect pests at different stages of crop growth and to assess associated yield loss at each stage.

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Materials and methods

Field trials were conducted in the 1988 and 1989 rainy seasons at the Crop Research Centre (CRC), G.B. Pant University of Agriculture and Technology, Pantnagar, Uttar Pradesh, India (29 degrees N, 79.3 degrees E and 243.84 m above sea level).

Seeds of variety TMV-2 (Spanish bunch) treated with thiram (3 g kg^{-1} seed) were hand-sown in furrows on 1 July. Each plot was of 12.0 m^2 with a 30-cm row spacing and 15-cm plant spacing. Guard rows of 1 m width of the same variety were sown on all sides of a plot. Standard agronomic practices were followed. Experiments were laid out in a randomized block design. There were six treatments (*Figure 1*) and each treatment was replicated three times. The crop was protected from insect pests at various physiological stages. Insects were excluded by foliar application of a mixture of demeton-S-methyl (Metasystox 25 EC) and endosulfan (Thiodan 35 EC) at the start of each crop growth stage and repeated every 10 days. Pesticide drift was minimized by holding a polyethylene screen (6 m

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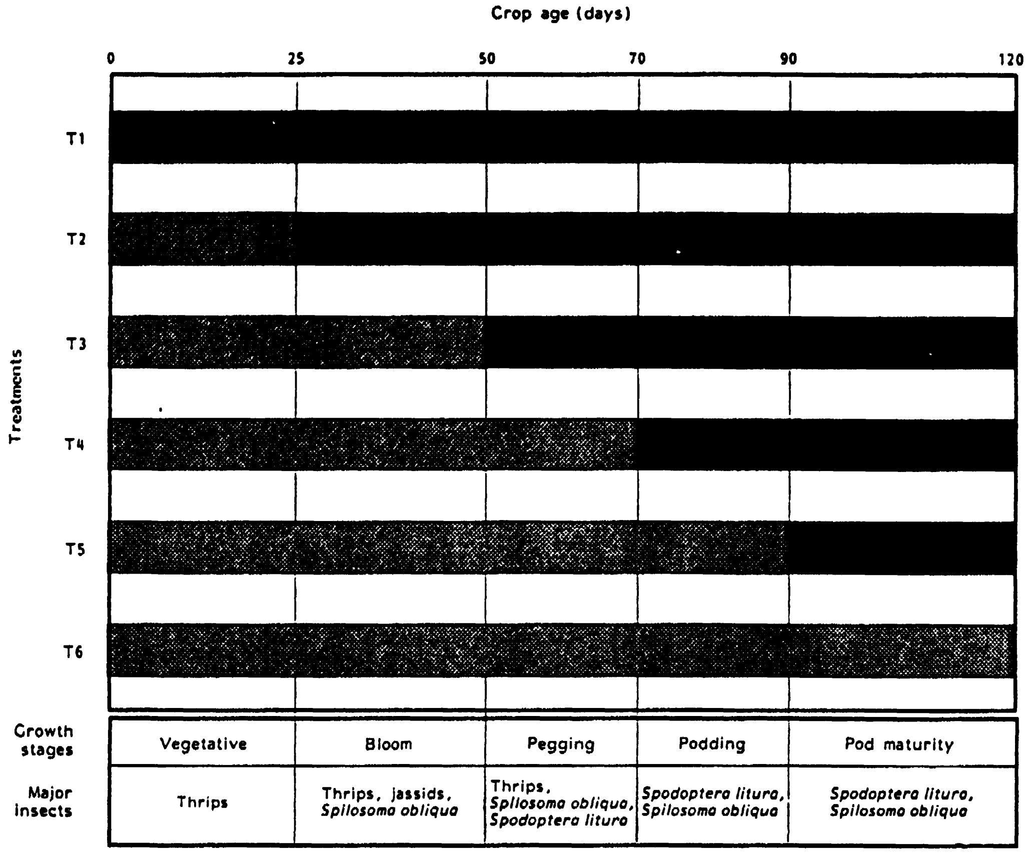

Figure 1. Protection of groundnut against major insect pests during various physiological growth stages of the crop: ■, protected; ▒, unprotected

long and 1 m wide) between plots during spraying. Carbendazim (Bavistin 50 WP) was sprayed at 125 g a.i. ha^{-1} at 60, 75 and 90 days after crop emergence to control leaf spots.

Insects were counted at weekly intervals; however, data are reported in the Tables when the peak infestations occurred at different growth stages of the crop. Five plants were selected randomly from the centre of each plot and the number of thrips were counted from the terminal bud, jassids from the first three terminal leaves and defoliators (*S. obliqua*, *S. litura* and *A. ephippias*) on all foliage. During the day, most of the *Spodoptera* larvae were hidden at the soil surface in leaf litters close to the stem. The percentage leaf defoliation (caused by defoliators) was recorded visually on a 0–100% scale. The number of plants showing thrips-borne bud necrosis disease (BND) caused by tomato spotted wilt virus (TSWV) (Ghanekar *et al.*, 1979; Amin *et al.*, 1981) was recorded in each plot at different growth stages of the crop. Harvesting took place 120 days after crop emergence, leaving the border rows. Pods were dried and weighed.

The percentage yield loss during different physiological growth stages of the crop was calculated as follows: percentage yield loss = $[(Y_1 - Y_2)/Y_1] \times 100$, where Y_1 is the yield in completely protected plots and Y_2 is the yield in untreated plots. Differences in yield between treatments T_1 and T_2, T_2 and T_3, T_3 and T_4, T_4 and T_5, and T_5 and T_6 represent the yield loss during the vegetative, bloom, pegging, podding and pod maturity stages, respectively.

The data were subjected to a statistical analysis. The original data on insect numbers were transformed to log $(x+1)$, and percentages of leaf defoliation and BND plants to angular transformation to achieve normality of the data. An analysis of variance (ANOVA) procedure was used to determine the difference between the treatments at different growth stages of the crop. Least significant difference at the 5% significance levels was used to compare treatment means. Correlation coefficients (r) between pod yield and insect density, thrips-borne BND, and leaf defoliation (by defoliators) at different stages of crop growth were computed.

Results and discussion

The percentage yield reduction due to insect pests is shown in *Tables 1* and *2*. During the 1988 rainy season, the greatest pod yield (2431 kg ha^{-1}) was recorded in the fully protected crop (T_1) where insect density was low throughout the crop growth period; the lowest pod yield (1667 kg ha^{-1}) was recorded in the unprotected crop (T_6). Leaf defoliation varied significantly (ANOVA, $p < 0.05$)

Table 1 Insect pest incidence and loss in pod yield in groundnut protected with insecticides at different stages of crop growth (rainy season, 1988)

	Major insect pests per five plants during different crop growth stages										
	Vegetative (0–25 days)	Bloom (26–50 days)		Pegging (51–70 days)		Podding (71–90 days)		Pod maturity (91–110 days)	Leaf defoliation[b] (%)	Pod yield (kg ha^{-1})	Yield loss (%)
Treatment[a]	Thrips	Thrips	*S. obliqua*	*S. obliqua*	*S. litura*	*S. obliqua*	*S. litura*	*S. obliqua*			
T_1	2.7 (0.5)[c]	1.7 (0.3)[c]	3.3 (0.6)[c]	1.7 (0.4)[c]	1.7 (0.4)[c]	16.0 (1.2)[c]	11.7 (1.1)[c]	7.0 (0.9)[c]	40.0 (39.8)[d]	2431	—
T_2	33.3 (1.5)	2.0 (0.4)	4.3 (0.7)	1.3 (0.4)	2.7 (0.6)	14.0 (1.2)	9.7 (1.0)	8.3 (1.0)	43.3 (41.7)	2326	4.3
T_3	37.3 (1.6)	2.3 (0.5)	5.3 (0.8)	1.7 (0.4)	3.7 (0.6)	15.3 (1.2)	9.3 (1.0)	7.0 (0.9)	46.7 (43.7)	2014	17.2
T_4	34.3 (1.5)	23.7 (1.4)	11.3 (1.1)	2.3 (0.5)	2.7 (0.6)	19.7 (1.3)	8.7 (1.0)	8.0 (0.9)	46.7 (43.7)	1933	20.5
T_5	36.7 (1.6)	15.7 (1.2)	7.3 (0.9)	2.7 (0.6)	4.7 (0.8)	16.0 (1.2)	12.3 (1.1)	6.3 (0.9)	56.7 (49.4)	1794	26.2
T_6	34.7 (1.5)	29.7 (1.4)	7.7 (0.9)	2.3 (0.5)	3.7 (0.7)	13.0 (1.1)	13.7 (1.2)	21.3 (1.3)	73.3 (59.7)	1667	31.4
s.e. (±)	(0.07)	(0.15)	(0.08)	(0.10)	(0.07)	(0.05)	(0.06)	(0.04)	(1.97)	134.9	

[a] T_1, complete crop protection; T_2, crop exposed to insect pests until vegetative stage; T_3, crop exposed to insect pests until bloom; T_4, crop exposed until pegging; T_5, crop exposed until podding; T_6, no protection; [b] 100 days after crop emergence; [c,d] numbers in parentheses are log $(x+1)$ and angular transformation, respectively

Table 2. Insect pest incidence and loss in pod yield in groundnut protected with insecticides at different stages of crop growth (rainy season, 1989)

	Major insect pests per five plants during different crop growth stages														
	Vegetative (0–25 days)		Bloom (26–50 days)				Pegging (51–70 days)				Podding (71–90 days)		Leaf defoliation[b] (%)	Pod yield (kg ha^{-1})	Yield loss (%)
Treatment[a]	Thrips	BND[e] (%)	Thrips	Jassids	*S. obliqua*	BND (%)	Thrips	*S. litura*	*A. ephippias*	BND (%)	*S. litura*	*A. ephippias*			
T_1	6.0 (0.7)[c]	4.2	7.0 (0.8)[c]	0.0 (0.0)[c]	2.0 (0.5)[c]	11.7 (19.9)[c]	1.7 (0.4)[c]	3.3 (0.6)[c]	4.3 (0.7)[c]	53.5 (47.0)[d]	3.3 (0.6)[c]	2.7 (0.6)[c]	11.7 (19.9)[d]	767.0	—
T_2	17.7 (1.2)	5.0	9.7 (0.9)	0.7 (0.2)	4.0 (0.7)	16.8 (24.1)	2.7 (0.5)	2.0 (0.5)	3.7 (0.7)	57.3 (49.2)	3.7 (0.7)	2.0 (0.5)	10.0 (18.1)	690.3	10.0
T_3	22.3 (1.4)	4.3	51.7 (1.7)	13.7 (1.2)	6.3 (0.8)	28.2 (32.1)	5.0 (0.8)	2.7 (0.6)	4.3 (0.7)	70.1 (56.9)	1.2 (0.4)	3.3 (0.6)	11.7 (19.9)	590.3	23.0
T_4	24.7 (1.4)	4.1	72.7 (1.9)	14.0 (1.2)	7.3 (0.9)	19.8 (26.4)	3.3 (0.6)	3.3 (0.6)	6.0 (0.8)	58.5 (49.9)	4.7 (0.7)	2.3 (0.4)	18.3 (25.3)	662.5	13.6
T_5	24.0 (1.3)	3.6	66.3 (1.8)	10.7 (1.1)	7.0 (0.9)	21.3 (27.4)	4.0 (0.7)	4.0 (0.7)	6.3 (0.9)	62.6 (52.3)	2.0 (0.5)	2.7 (0.5)	21.7 (27.5)	667.7	13.0
T_6	28.0 (1.4)	4.5	64.3 (1.8)	12.3 (1.1)	8.0 (1.0)	18.7 (25.5)	5.0 (0.8)	4.7 (0.7)	5.0 (0.8)	68.5 (55.9)	3.7 (0.7)	5.0 (0.7)	30.0 (33.0)	656.9	14.3
s.e.(±)	(0.18)	0.57	(0.13)	(0.07)	(0.09)	(1.26)	(0.11)	(0.07)	(0.06)	(1.52)	(0.15)	(0.14)	(2.10)	62.69	

[a–d] As in *Table 1*; [e] BND, bud necrosis disease

among different treatments. The greatest leaf defoliation (73.3%) was recorded in the unprotected crop (T_6) followed by 56.7% in treatment T_5 where the crop was exposed to defoliators until podding. Correlation coefficients indicated that thrips at the bloom stage and leaf defoliation at pod maturity significantly and negatively correlated with pod yield (*Table 3*). The yield loss caused by insect pests in the T_6 treatment was estimated to be 31.4%. Yield loss at different growth stages was 4.3% at the vegetative stage, 12.9% at bloom, 3.3% at pegging, 5.7% at podding and 5.2% at the pod maturity stages of crop growth (*Table 1*).

During the 1989 rainy season, the greatest yield loss was 23% in treatment T_3, where the crop was exposed to insects feeding until bloom; the yield reduction was 14.3% in the unprotected treatment (T_6). The insect pests associated with the crop were thrips at the vegetative stage; thrips, jassids and *S. obliqua* at the bloom stage; thrips, *S. litura* and *A. ephippias* at pegging, and *S. litura* and *A. ephippias* at the podding stages of crop growth. Bud necrosis disease appeared early in the season during the vegetative stage and significant differences among the treatments (ANOVA, $p < 0.05$) were observed at bloom and pegging stages. At pegging, BND incidence reached 70.1% in treatment T_3 where the crop was exposed to thrips until the bloom stage.

Leaf defoliation was greatest (30%) in the unprotected crop (T_6) and least (10%) in treatment T_2. Yield losses

Table 3. Correlation coefficients between pod yield and insect pest density, thrips-borne bud necrosis disease (BND), and leaf defoliation at different stages of crop growth (1988–1989 rainy seasons)

Rainy season	Pest damage	Correlation coefficients (r) Vegetative stage	Bloom stage	Pegging stage	Podding stage	Pod maturity stage
1988	Thrips	−0.69	−0.83*			
	S. obliqua		−0.70	−0.81	0.04	−0.55
	S. litura			−0.80	0.39	
	Leaf defoliation					−0.86*
1989	Thrips	−0.78	−0.65	−0.88*		
	BND	0.04	−0.96**	−0.87*		
	Jassids		−0.81			
	S. obliqua		−0.74			
	S. litura			0.00	0.45	
	A. ephippias			−0.16	−0.30	
	Leaf defoliation					−0.19

*, ** Significant at $p = 0.05$ and $p = 0.01$, respectively

were 10% at the vegetative stage and 13% at the bloom stage. No yield loss was recorded at other stages of crop growth (except during pod maturity where yield loss was 1.3%) (*Table 2*). Thrips at the pegging and BND both at the bloom and pegging stages were significantly and negatively associated with pod yield (*Table 3*). Thus, most difference in yield in various periods of exposure to insect pests could be attributed to the appearance of thrips-borne BND early in the season; crops appear to be more vulnerable to thrips attack during the vegetative and bloom stages, which leads to more BND and a low rate of pod setting.

At the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) farm, Patancheru, where groundnut plants were infected with BND when they were 60–75 days old, an average of 50% yield loss occurred (P. W. Amin and K. N. Singh, unpublished data). The application of an insecticide (systemic) to a groundnut crop infested by the thrips *F. schultzei* can increase the incidence of TSWV (BND) (Wightman and Amin, 1988), for reasons that have not yet been elucidated. The pest status of thrips in groundnut remains controversial the world over, except when they act as vectors of viral diseases (Feakin, 1973; Smith and Barfield, 1982). In India, BND occurred in epidemic form in 1979 and has become a serious constraint to groundnut production in Andhra Pradesh, Karnataka, Maharashtra, Gujarat, Uttar Pradesh, and Haryana, where it caused up to 90% yield loss (Amin, 1983, 1987).

There is no doubt that thrips are responsible for yield reductions in groundnut. Ananthakrishnan (1973) described thrips as a menace to groundnut production. Severe injury to groundnut by thrips has been reported by Amin (1983). Yield losses of 4[illegible]% by thrips (Thimmaiah and Panchabhavi, 1973) and 40% by both thrips and jassids have been reported (Saboo and Puri, 1978). At the National Research Centre for Groundnuts, Junagadh, Gujarat, a 20–23% yield loss due to insect pests was observed in Spanish varieties of groundnut (NRCG, 1987). Ayyanna *et al.* (1982) found that feeding by *S. litura* caused a marked reduction of pod yields by 1200 kg ha^{-1}. Studies conducted at the ICRISAT farm indicated that in the rainy season, 50% defoliation by *S. litura* at flowering and 30% at the pegging and podding stages did not reduce the yield significantly (ICRISAT, 1987). Pachori *et al.* (1980) found reductions of up to 43% of foliage and 27% of pod yield caused by *S. obliqua*, which has been reported as the major pest of groundnut, together with other defoliators such as *S. litura* and *A. ephippias* (Islam *et al.*, 1983).

Knowledge of the most critical stage of plant growth at which most losses attributable to insect pests occur would be of great importance in reducing such losses by the timely application of insecticides. From the two seasons' data it is apparent that the groundnut crops suffered maximum yield loss due to thrips during the vegetative stage and due to thrips, jassids and *S. obliqua* during the bloom stage. At podding and afterwards, the crop defoliators are of significance and are responsible for minor reductions in yield.

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References

Amin, P. W. (1983) Major field pests of groundnut in India and associated crop losses. *Indian J. Entomol.* (Special issue) **2**, 337–344

Amin, P. W. (1987) Insect pests of groundnut in India and their management. In: *Plant Protection in Field Crops* (Ed. by M. V. Rao and S. Sithanantham) pp. 219–233, Plant Protection Association of India, Rajendranagar, Hyderabad

Amin, P. W. and Mohammad, A. B. (1980) Groundnut pest research at ICRISAT. In: *Proc. Int. Workshop on Groundnuts, 13–17 October, 1980, Patancheru*. pp. 158–166, ICRISAT, Patancheru

Amin, P. W., Reddy, D. V. R., Ghanekar, A. M. and Reddy, M. S. (1981) Transmission of tomato spotted wilt virus, the causal agent of bud necrosis disease of peanut, by *Scirtothrips dorsalis* and *Frankliniella schultzei*. *Plant Dis.*, **65**, 663–665

Ananthakrishnan, T. N. (1973) *Thrips Biology and Control*. Macmillan, New Delhi, 120 pp

Ayyanna, T., Arjunarao, P., Subbaratnam, G. V., Krishnamurthy Rao, B. H. and Narayana, K. L. (1982) Chemical control of *Spodoptera litura* (Fabricius) on groundnut crop. *Pesticides* **16**, 19–20

FAO (1988) Groundnuts in shell. *FAO Production Year Book* **42**, 157

Feakin, S. D. (1973) Pest control in groundnuts. *PANS Manual No. 2*, p. 197, Centre for Overseas Pest Research, London

Ghanekar, A. M., Reddy, D. V. R., Iizuka N., Amin, P. W. and Gibbons, R. W. (1979) Bud necrosis of groundnut (*Arachis hypogaea*) in India caused by tomato spotted wilt virus. *Ann. Appl. Biol.* **93**, 173–179

Gibbons, R. W. (1980) The ICRISAT groundnut program. In: *Proc. Int. Workshop on Groundnuts, 13–17 October 1980, Patancheru*. pp. 12–16, ICRISAT, Patancheru

ICRISAT (1987) *International Crops Research Institute for the Semi-Arid Tropics, Annual Report 1986*, p. 231, ICRISAT, Patancheru, AP 50 2324, India

Islam, W., Ahmed, K. N., Nargis, A. and Islam, U. (1983) Occurrence, abundance and extent of damage caused by insect pests of groundnut (*Arachis hypogaea* L.). *Malays. Agric. J.* **54**, 18–24

NRCG (1987) *National Research Centre for Groundnut, Report for 1987*, p. 8, NRCG, Junagadh, Gujarat, India

Pachori, R., Rathore, V. S., Rawat, R. R., Jakhmola, S. S. and Khatri, A. K. (1980) Economic threshold of *Diacrisia obliqua* Wlk. on groundnut. *Indian J. Agric. Sci.* **50**, 69–72

Rai, B. K. (1976) *Pests of Oilseed Crops in India and Their Control*, ICAR (Indian Council of Agricultural Research), New Delhi, 121 pp

Reddy, P. S. (1988) Genetics, breeding and varieties. In: *Groundnut* (Ed. by P. S. Reddy) pp 200–317, ICAR (Indian Council of Agricultural Research), New Delhi

Sahoo, K. C. and Puri, S. N. (1978) Effect of insecticides on incidence of sucking pests and yield of groundnut, *Arachis hypogaea* Linn. *Indian J. Entomol.* **40**, 311–315

Smith, J. W. and Barfield, C. S. (1982) Management of preharvest insects. In: *Peanut Science and Technology* (Ed. by H. E. Patee and C. T. Y. Young) pp. 250–325, American Peanut Research and Education Society, Texas

Thimmaiah, G. and Panchabhavi, K. S. (1973) Insecticidal control of thrips (*Heliothrips indicus* Bagnall) on groundnut. *Mysore J. Agric. Sci.* 7, 334–335

Wightman, J. A. and Amin, P. W. (1988) Groundnut pests and their control in the semi-arid tropics. *Trop. Pest Mgmt* **34**, 218–226

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