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Title FIELD EXPERIMENTATION FOR ASSESSMENT OF YIELD LOSS
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ALL INDIA WORKSHOP ON CROP LOSSES DUE TO INSECT PESTS
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FIELD EXPERIMENTATION FOR ASSESSMENT OF YIELD LOSS ASSOCIATED WITH INSECT PESTS OF GROUNDNUTS

P.W. AMIN*

SUMMARY

Damage from insect pests results in heavy losses to groundnut crops in India. However, precise estimates of yield loss are not available. One of the reasons for this lack of information is the non-availability of accurate experimental techniques. While knowledge of pests abundance and distribution is required to select the most suitable site for experimentation, only the use of appropriate experimental design and methods of measuring pest damage severity will give realistic estimates of yield loss. A methodology for planning and conducting yield loss assessment experiments and measuring the severity of damage caused by the major pests of groundnuts is given.

INTRODUCTION

Unreliable rainfall, diseases and pests are considered responsible for the low yields of groundnut in India (Gibbons, 1980). Insect pests cause severe damage to groundnut but precise estimates of yield loss are not available. This lack of quantitative data makes it difficult to judge the effectiveness of various plant protection schemes implemented by the State Agriculture

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Departments, and may jeopardise the development of new schemes. One reason for the lack of precise information on yield loss has been the inadequacy of experimental and pest damage assessment techniques used in the estimation of pest-caused losses in groundnuts. The present paper describes the methodology for conducting field experiments aimed at assessing the yield loss from individual insect pests and pest complexes infesting groundnut crops.

1. PLANNING AND CONDUCTING EXPERIMENTS

a) Duration of experiments: In agriculture no season can be regarded as 'typical' and variations between seasons are large. For example, crop loss estimation trials on thrips have shown that under certain conditions of soil and climate, thrips may damage the crop to such an extent as to reduce yields. Under other conditions of soil and climate the crop may grow out of the stunted condition resulting from thrips damage and suffer no permanent injury (Bass and Arant, 1973). Therefore, assessments based on year's experiments may be unrealistic and experiments on crop loss assessment should be carried out for at least three years.

b) Number of locations: It is difficult to determine the number of locations needed for pest control trials. Groundnut cultivation zones in India have been developed based mainly on soil type and climate. However, pest abundance and distribution varies considerably within a given climatic zone. For example, in Gujarat, jassid is an important pest in the Saurashtra region (Patel and Vora, 1981) while white grubs and termites are important in the sandy soils of Sabarkantha, Kaira, Mehsana, and Amreli districts. After considering pest populations and distribution, at least three to five locations should be chosen in each zone.

c) Selection of site: The sites for field experiments should be representative of farmers' condition of that region.

d) Plot size: For entomological trials the plots should be large enough to allow free movement of insects. However, they should not be so large as to be affected by variations in soil fertility or become too difficult to manage. An optimum size of plots has not been calculated for groundnuts. However, at ICRISAT a plot size of 10 rows each 9 meter long with 30 cm distance between rows and 10 cm distance between plants was found adequate. The optimum plot size for wheat and barley has been calculated as 2.4 m x 6 m, for potatoes 1.8 m x 6 m and for rice, 3.6 m x 9 m (Le Clerg, 1971).

e) Guard rows: Insect behaviour is affected by the pattern of the green crop and bare soil and therefore it is not desirable to leave gaps in between plots (Lewis, 1973). As far as possible, the gaps should be minimum. Guard rows, 1m wide of the same variety should be planted on all sides of a plot. Such guard rows reduce the effect of individual treatments on the neighbouring plots and also reduce the effect of pesticide drift (Jenkyn et al., 1979). Pesticide drift can also be reduced by holding partitions between plots at the time of spray application. Statistically, the co-efficient of variation is considerably reduced in trials with guard rows as compared to those without guard rows (Jenkyn _et al._, 1979). Guard rows also help to reduce the effect of soil treatment between plots (Verma and Pant, 1979).

f) _Replications_: A minimum of 4 and an optimum of 5 or 6 replications are adequate (Le Clerg. 1971). However, for pests such as termites or white grubs which are not distributed randomly or uniformly, more replications are desirable.

g) _Plant stand_: For any yield trial, the plant stands in different plots should be comparable. In addition to the effect on total yield, the plant stand can also affect the insect infestation. In our trials at ICRISAT Center, we observed more thrips, jassids and leafminers per plant and higher leaf injury in plots with low plant populations than in plots with high plant populations. At ICRISAT we follow two methods to ensure good plant stands in experimental plots: (1) we sow more than one seed per hill, or (2) we use a high seeding rate, followed by thinning, to obtain the optimum plant population. A third method using partially germinated seeds can also be useful particularly for gap-filling. Before sowing, we conduct germination tests in the laboratory to assess the viability of seeds. Other factors that reduce the plant stand are soil-borne fungi and insects. _Fusarium_ spp., _Rhizoctonia_ spp. and _Aspergillus_ spp. can cause heavy mortality. Seed treatment with Thiram @ 3.0 g/kg of seeds is useful. For the control of soil insects such as ants, termites or millipedes that can reduce plant stand soil treatment with chlordane or heptachlor is required.

h) <u>Pest control</u>: In yield loss assessment trials it is essential to obtain good control of insect pests. Otherwise, estimates of yield loss will not be accurate. In several trials conducted under the All India Co-ordinated Research Project on Oilseeds from 1977-82, the reduction in insect numbers ranged from 30-80% with an average of 60% in protected plots as compared to non-protected plots.

Occasionally one may need to consider the effect of one group of insects only, and avoid interference from other pests. For example, when the effect of foliar pests is investigated all plots should receive a uniform treatment of non-systemic soil insecticides to control soil pests.

i) <u>Disease control</u>: Many fungal diseases such as leafspot and rust interfere with observations on insect injury and also affect yields. All entomological trial plots must be protected from fungal diseases. Care should be taken to choose a fungicide that has no adverse effect on insects. Chlorothalonil is a good general purpose contact fungicide that controls both rust and leafspot diseases. A mixture of dithane M-45 and Benlate is a useful alternative.

j) <u>Harvesting</u>: Prior to harvest, the plants in at least 0.3 m border on all sides of the plot should be discarded to avoid border effects. When the effects of pests such as termites are under investigation, special care should be taken to harvest all the pods in each plot since termites can damage pegs which results in pods being left in the ground at lifting.

2. FIELD LAYOUTS

The layout of an experiment depends upon its objective. Two types of yield loss experiment are conducted, to investigate (1) total yield loss from a pest or pest complex, and (2) to partition the yield loss between various pests.

a) Total yield loss assessment: Paird plots in which one plot is protected from all pests with appropriate pesticides and the other not protected are commonly used. Usually 5-6 replications are arranged as given by Le Clerg (1971) (Figure 1).

Paired plots are compared by 't' test with a formula:

$$t = \frac{Xp - Xnp}{Sd}$$

where Xp = mean yield of treated plots

Xnp = mean yield of non-treated plots

Sd = standard error of the difference between the two mean yields.

b) Multiple treatment experiments: These are aimed at partitioning yield loss among various insect pests in relation to growth stages of groundnut and such trials are conducted after the total yield loss from pest complex has been experimentally estimated. Multiple treatment experiments are done by: (1) choosing appropriate insecticides that will most effectively minimize the pest damage, e.g. dimethoate to control thrips and leafminer, or carbaryl to control tobacco caterpillar, (2) assigning successive treatments by which one or more growth stages remain non-protected while protecting the others (Fig. 3), (3) having fully protected and non-protected plots for comparison, (4) monitoring pests and their damage in all plots and (5) analysing the results statistically.

At ICRISAT we have used the design given in Figure 2 and a schedule of protection as in Figure 3. Thus, the yield difference between the treatments T1 and T8 reflects the yield loss during vegetative stage from thrips. Similarly, yield difference between T1 and T2 reflects loss at R1 stage, from thrips; T2 and T3 at R2 from thrips; T3 and T4 at R3 from thrips; T4 and T5 at R4 from thrips; T8 and T5 as total loss from thrips; T5 and T6 at R5 from leafminer; T6 and T7 at R6 and R7 from leafminer and tobacco caterpillar; T5 and T7 as total loss from leaf miner and tobacco caterpillar and T8 and T7 as total loss from all insects. It is difficult to partition the loss caused by two simultaneously infesting pests such as leafminer and tobacco caterpillar unless selective insecticides are available which control only one pest without affecting the other.

3. MEASUREMENT OF PEST DAMAGE SEVERITY AND SAMPLING

PROCEDURE

Assessment of crop loss always depends upon the realistic measurement of pest damage and the establishment of its relationship with yield. Methods to measure pest damage should be simple and reliable. For example, thrips can be counted by washing them from the plants foliage with alcohol and counting them under a microscope (Lewis, 1973). This method is precise and accurate but is not suitable for rapid estimates. Counting thrips-damaged leaflets is a simple and reliable method.

Before yield loss experiments are conducted it is necessary to standardize the methods used to measure the damage caused by insect pests. The following methods are suggested for groundnut pests:

Termites: Termites cause three types of damage to groundnuts, (1) they kill the plants by tunnelling into roots or stems, (2) they penetrate the pods by boring into them and feed on the kernels, and (3) they scarify the pods. *Odontotermes obesus* Rambur causes the first two types of damage while termites belonging to the genus *Odontotermes* cause pod scarification. The following observations give a measure of termite damage.

(1) Percentage of plants killed,

(2) Percentage of pods bored,

(3) Percentage of pods scarified,

(4) Injury rating of scarified pods on 1-9 scale where 1 is no scarification and 9 is total scarification of the

pod.

The distribution of termites in a field is often not uniform or random, therefore, measurements should be taken at several locations in a plot or the entire plot should be treated as a sampling unit.

White grub: *Holotrichia spp.* The larvae feed on the roots of groundnut and kill the plant. The number of seedlings per plot killed by white grub attack is an adequate measure of damage.

The selection of experimental plots for white grub control experiments is a difficult task. This is because of the extremely patchy distribution of this insect in the field. The maximum damage to the crop occurs near to the host plants of adult beetles. It is, therefore, necessary to use a higher number of replications of plots, and arrange them at several locations in a field.

White grubs are pests mainly in sandy or loamy soils where some crop mortality also results from fungal diseases such as collar rot pathogen, *Aspergillus niger*. Fungicidal seed treatment with thiram is essential and it is also necessary to keep a record of fungus-killed plants. Because of the extremely uneven distribution of white grubs, the whole plot should be treated as a sampling unit.

Thrips: Three species of thrips commonly infest groundnuts. *Scirtothrips dorsalis* adults and nymphs feed on young leaves resulting in the formation of brownish green patches on the upper leaf surface and dark necrotic patches on the lower leaf surface, heavy damage results in leaf curl. Feeding by *Frankliniella schultzei* results in white scars on the upper surface of young foliage and under heavy infestation the leaves become deformed. Feeding by *Caliothrips indicus* results in spots or 'stippling' on the upper surface of the older leaves, and when infested by several thrips the excessive feeding results in drying of foliage. Two types of observation are essential to assess damage caused by thrips: (1) the number of leaflets showing thrips injury, and (2) the severity of damage recorded on a 1-9 scale where 1 is no damage and 9 is heavy damage indicated by curling of leaves in the case of *S. dorsalis*, malformation of leaflets in the case of *F. schultzei* and drying of foliage in the case of *C. indicus*.

Thrips are normally randomly distributed in the field. Five sampling units each of 1 meter row arranged diagonally in a plot have been routinely used at ICRISAT for recording thrips injury.

Jassid: The jassid, *Empoasca kerri*, induces yellowing of foliage. The yellowing begins at the tip and spreads to other parts of leaflet. Most jassids inhabit the younger foliage. At ICRISAT we record two types of observations: (1) the percentage of yellowed foliage, and (2) the number of jassid nymphs on three terminal leaves. The observations are recorded from five, 1 meter row units arranged diagonally in a plot.

Aphid: Aphis craccivora is a sporadic pest of groundnuts and large populations build up in low rainfall years. When the plants begin to produce flowers and pegs aphids infest these and thus remain hidden in the crop canopy, therefore, the canopy should be opened for counting aphids. The distribution of aphids is not random or uniform, so the size of sampling unit needs to be increased. Five each 1 meter square sub-plots arranged diagonally in a plot are adequate for the sampling of aphids. At ICRISAT we record two types of observations: (1) the number of plants infested with aphids, and (2) the size of individual aphid colony as small (1-25 aphids), medium (26-100) and large (> 100).

Leafminer: Larvae of Aproaerema modicella mine the leaves and feed inside the mines. After 5-6 days they come out from the mines, draw the leaves together and feed and pupate in the webbed leaves. The area of mined leaves dry and when several mines occur in a leaflet, the entire leaflet dries. The leafminer pest is randomly distributed in a field and five 1-meter row plots arranged diagonally form the sampling unit. We routinely record percentage of dried foliage.

Tobacco caterpillar, Spodoptera litura, and hairy caterpillars, Amsacta spp. Caterpillars of both these insects feed on the foliage and growing tips, and under severe infestation only the bare stem is left. The percentage of defoliation is a good index of damage severity. Additional observations can be recorded on the number of larvae/2 meter rows arranged diagonally at 5 places in a plot.

The yield of groundnuts, as in any other crop, is the end result of several interacting factors such as variety, soil type and fertility, plant density, time of planting, temperature and rainfall in addition to pests and diseases. It is difficult to obtain absolute values of losses, but, useful results can be obtained from properly designed and well conducted field experiments.

REFERENCES

1. Bass, M.H. and Arant, F.S. 1973. Insect Pests. In 'Peanut culture and uses'. Stone Printing Company Roanoke, Virginia, USA. Pages 383-428.

2. Boote, K.J. 1982. Growth stages of peanut (*Arachis hypogaea* L.). Peanut Science, 9:35-39.

3. Gibbons, R.W. 1980. The ICRISAT Groundnut Program. ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). Proceedings of the International Workshop on Groundnuts, 13-17 October, 1980, Patancheru, A.P., India.

4. Jenkyn, J.F., Brainbridge, A., Dyke, G.V. and Todd, A.D. 1979. An investigation into inter-plot interactions, in experiments with mildew on barley, using balanced designs. Annals of Applied Biology 92: 11-28.

5. Le Clerg, E.L. 1971. Field experiments for assessment of crop losses. *In* FAO Manual on the evaluation and prevention of losses by pests, diseases and weeds. Ed: L. Chiarappa. Alden Press, Oxford, Great Britain.

6. Lewis, T. 1973. Thrips: their biology, ecology and economic importance. Academic Press, London and New York. Pages 349.

7. Patel, B.R. and Vora, V.J. 1981. Efficacy of different insecticides for the control of groundnut jassid, *Empoasca kerri Pruthi*. Pesticides 15: 33-34.

8. Verma, S. and Pant, N.C. 1979. Movement of pharate in soil and its residues & residual toxicity. Indian Journal of Entomology 41: 110-116.

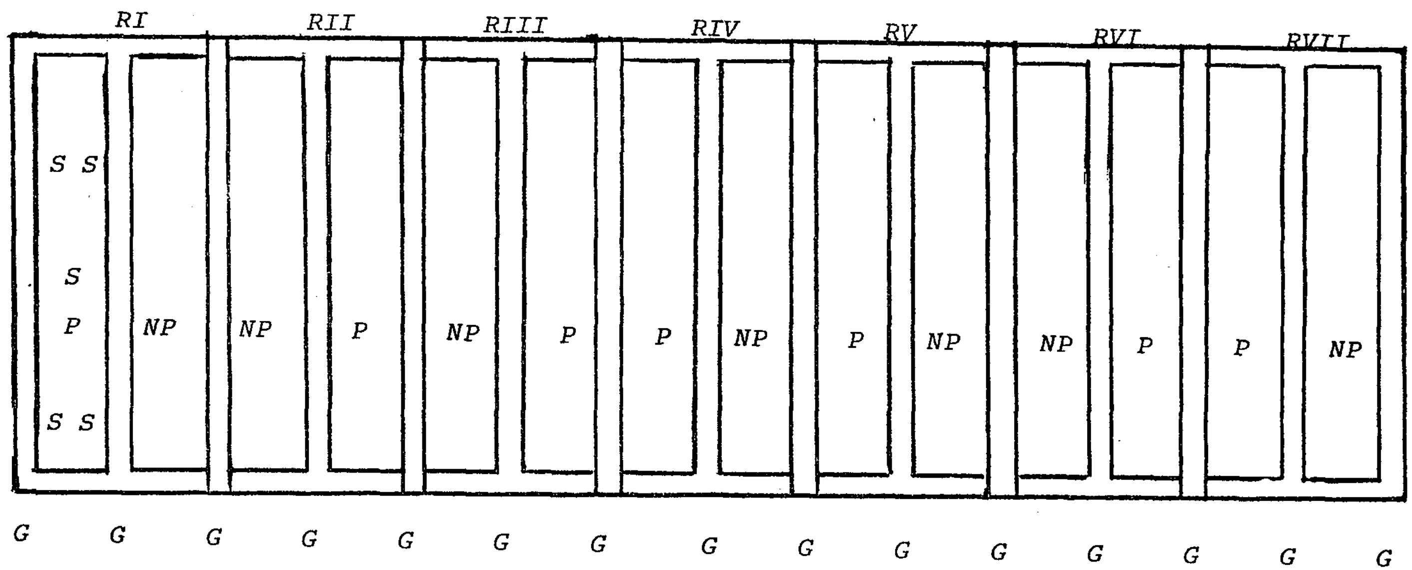

Figure I: Layout of randomized complete block strip trial in paired plot treatment experiment (P = protected, NP = non-protected, G = guard rows, RI to RVII = Replication blocks, S = sampling place.)

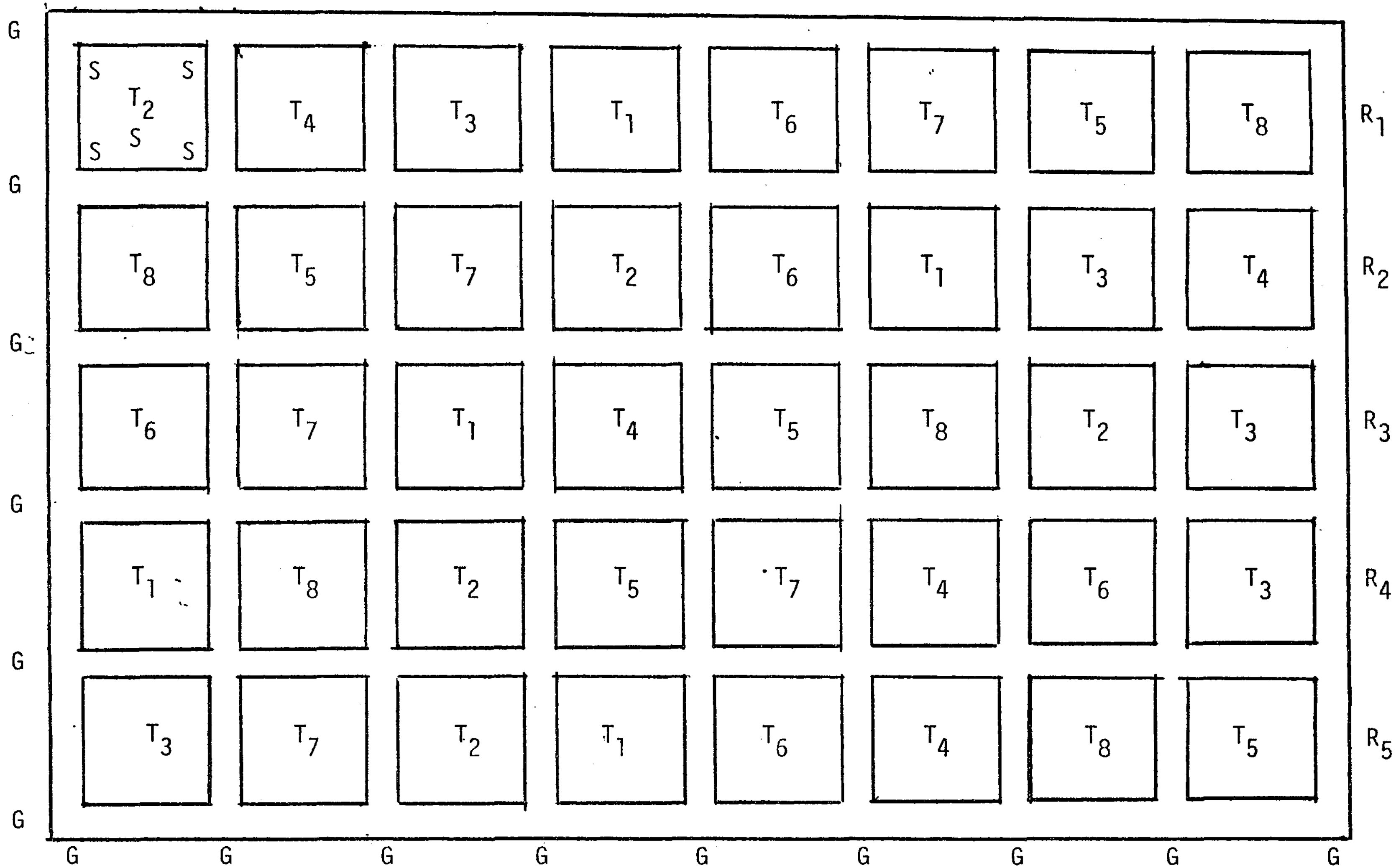

Figure 2: Layout of randomized block trial for partitioning of yield loss among different pests (T_1 to T_8 = treatments, R_1 to R_5 = replication blocks, G = guard rows, S = sampling place).

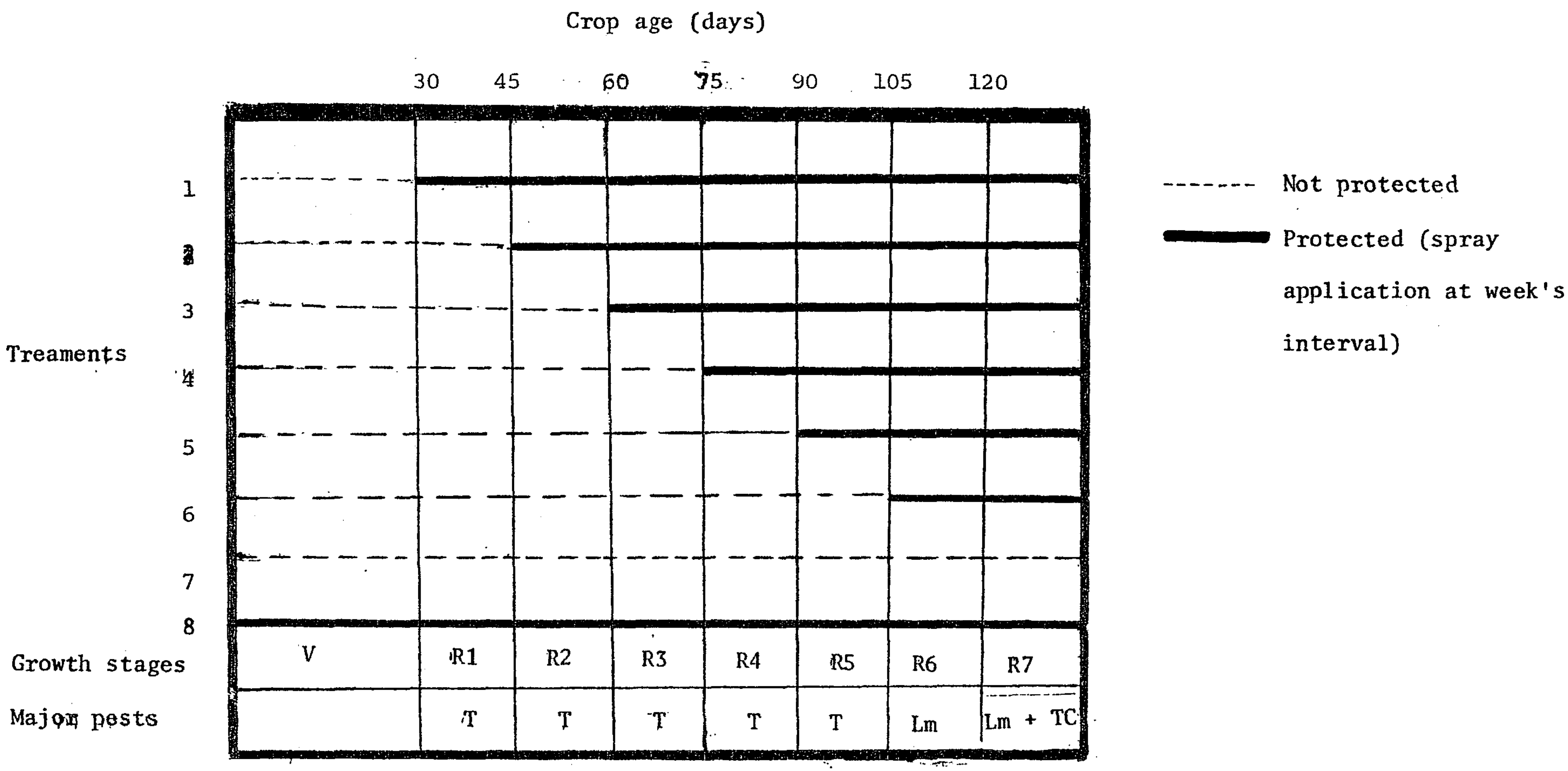

Figure 3. Partitioning of yield loss among different pests of ground in postrainy (rabi) season at ICRISAT.

Growth stages (Boote, 1982) : V=vegetative, R1=bloome, R2=pegging, R3=podding, R4=full pod, R5=seed formation, R6=full seed, R7=maturity.

Major pests : T=thrips, Lm=leafminer, TC=tobacco caterpillar.