A NOTE ON THE RELATION BETWEEN THE INTERNAL STEM STRUCTURE OF CERTAIN VARIETIES OF GRAM (*CICER ARIETINUM* L.) AND THEIR RESISTANCE TO CUTWORM ATTACK

By B. P. Pal, M.Sc., Ph.D. (Cantab.), F.L.S.

Second Economic Botanist, Imperial Institute of Agricultural Research, Pusa

Received June 17, 1936

1. Introduction

A yield trial of two varieties of gram (*Cicer arietinum* L.), namely, Pusa Types 17 and 41, laid down in the Botanical Section in 1933-34, was vitiated because of a differential attack by the cutworm. The parallel strip form of lay-out had been adopted, and it was notable that whereas Type 17 was severely damaged in all the seven replications, Type 41 was attacked in a noticeably lesser degree. The reasons for this unequal attack were investigated, and the results obtained form the subject of the present paper. Not only was the amount of damage done, *i.e.*, number of branches cut per plant, greater in the case of the first-named variety, but a considerably larger number of plants was attacked. A count was taken of the number of plants injured, and the results are presented in Table I.

The name "cutworm" is commonly applied to the larvæ or caterpillars of several species of Noctuid moths which are more or less similar in appearance and habits. They generally feed, at night, on the tender and succulent shoots of low-growing vegetation, cutting the plants at the soil level. A single larva may cut off as many as 50 plants in a single night.

The most common species in Northern India are *Agrotis ypsilon* Rott., *A. flammatra* Schiff., *A. nigrum* Linn., *Euxoa spinifera* Hb., and *E. segetum* Schiff. Their larvæ feed on a wide range of plants including gram, peas, beans, tobacco, tomatoes, potatoes, sweet potatoes, cabbage, cauliflower, lucerne, etc.

TABLE I

Showing the Numbers of Plants of Types 17 and 41 Damaged by Cutworms, in the Yield Trial Plots

Plot No.	Variety	Number of plants attacked in each plot	Number of plants attacked, expressed as a percentage of the total number of plants in each plot
	Type		
1	17	107	68
2	41	66	41
3	41	74	43
4	17	110	67
5	17	96	58
6	41	62	38
7	41	85	52
8	17	154	95
9	17	129	83
10	41	101	61
11	41	73	45
12	17	111	67
13	17	127	77
14	41	68	42

Average percentage damage due to cutworm in Type 17 = 73·4
Average percentage damage due to cutworm in Type 41 = 46·0

2. *Material*

The eighty-four Pusa types of gram (Shaw and Khan, 1931) which were growing in the same field were examined for cutworm attack and classified into the following three classes : (A) Very slightly attacked ; (B) moderately attacked ; (C) severely attacked. As the plots of each variety were not replicated and the classification based on eye-judgment, this grouping must be considered to be rough, and perhaps somewhat arbitrary.

Four types were selected from each group, as being typical of the damage sustained, for detailed study. These types were :—

Group	A	B	C
Types ..	3, 26, 38, 79	9, 36, 41, 58	17, 46, 52, 82

In the following crop-year (1934–35), the grouping was checked and it was found necessary, in a few cases, to transfer types previously placed in the B group to the A or C groups, or *vice versa*. In no instance, however, did it become necessary to transfer a variety from the A group to the C group or *vice versa*. Of the twelve types selected for detailed study, the only change made was in the case of Type 9, which was transferred from the moderately attacked or B group to the severely attacked or C group.

3. Experimental Procedure and Results

Two possible reasons for the selective attack by the cutworm suggested themselves: (1) The comparative resistance of certain varieties might be associated with the physiology of the plant, particularly the possession of certain substances in the tissues of the plant, which rendered them attractive or unattractive to the insect or its larva. Some examples of such cases are given by Davidson and Henson (1929), Martin (1928), etc. (2) The resistance might be, mainly, merely physical, not due to any discrimination on the part of the insect, but to the toughness of the stems of certain varieties, which rendered them difficult or impossible to cut.

The first-mentioned possibility was tested indirectly by hand-picking the caterpillars at intervals and counting the number collected from plots of each variety. The results of two typical counts are given in the Table on the next page.

The figures just presented do not reveal any clear association between severity of attack and the number of cutworm larvæ found, and discountenance the possibility that any selection, in repect of varieties, was exercised by the moths (*i.e.*, in selecting places for laying eggs) or by the larvæ. Such selective action, if found, would indeed have been surprising on the part of a pest which attacks so many widely different plants. Attempts to associate resistance with place of collection of the variety, maturity, size of leaves and leaflets also proved unsuccessful. This line of investigation was therefore not persevered with and attention was concentrated on investigating the second possibility (*vide supra*).

A large number of sections were cut. As it was found difficult to obtain good microtomic sections, freehand sections were cut. For this purpose

Group	Variety	No. of caterpillars	
		Collected on 2—1—34	Collected on 6—1—35
A ..	3	23	0
	26	14	6
	38	24	11
	79	15	11
B ..	9*	13	2
	36	21	7
	41	13	4
	58	11	10
C ..	17	19	6
	46	23	11
	52	24	10
	82	15	5

* This variety was later transferred to Group C.

six plants of each of the twelve varieties were selected, care being taken that they were as typical as possible of the condition of growth of the whole culture. A small portion of the stem was then snipped off at a point about half an inch above soil level, *i.e.*, at the point at which the caterpillars usually cut the plants, and fixed in formalin-alcohol. This was done fifty-four days after sowing, at a time when cutworm incidence was at its maximum. The pieces of stem were then sectioned and stained with safranin and light green.

A study of the sections revealed the interesting fact that the internal stem-structure was probably the factor responsible for the differential preference shown by the cutworm. In the case of the severely attacked group, the stem diameter was comparatively small and the secondary wood weakly developed. In the case of the very slightly attacked group, on the other

hand, the stem diameter was large and the secondary wood very well-developed. The moderately attacked group was intermediate between these two groups in respect of stem diameter and resembled the very slightly attacked group in respect of development of woody tissues.

The internal structure of the stem, associated with the three groups, is illustrated in Plates XXIII, XXIV and XXV. The sections shown are of the 1933–34 material. Average measurements of the stem diameter for the same material are given in Table II.

TABLE II

Average Stem Diameters (mm.) of the Three Groups of Gram Grown at Pusa in 1933–34

Group A		Group B		Group C	
Variety	Average diameter	Variety	Average diameter	Variety	Average diameter
Type		Type		Type	
3	2·45	9*	1·58	17	1·58
26	2·76	36	2·20	46	1·58
38	2·82	41	1·83	52	1·46
79	2·79	58	1·92	82	1·52

* Later transferred to Group C.

It will be observed that both in its internal anatomy (Plate XXIV, Fig. 5) and in its average stem-diameter, Type 9 agrees with the members of Group C rather than with those of the group in which it was originally placed. As stated in Section 2, Type 9 was transferred to the C group on the basis of observations on the crop grown in 1934–35 : this is in agreement with the results now presented, and the placing of Type 9 in Group B was obviously a case of incorrect diagnosis.

To verify the above results, sections of the same types grown at Pusa in 1934–35, were also cut. The internal stem-structure of these was found to be, in a relative sense, very similar to that described above. Type 9 was again found to resemble the varieties in Group C in regard to extent of development of the wood, but in stem-diameter it was more like the varieties

in Group B. Average stem-diameters for the 1934–35 material are giv n in Table III.

TABLE III

Average Stem Diameters (mm.) of the Three Groups of Gram Grown at Pusa in 1934–35

Group A		Group B		Group C	
Variety	Average diameter	Variety	Average diameter	Variety	Average diameter
Type		Type		Type	
3	3·44	9	2·38	17	1·94
26	2·65	36	2·52	46	2·05
38	2·73	41	2·24	52	1·75
79	3·16	58	2·25	82	1·92

In view of the fact that a rather small number of plants of each variety was studied (it was found impracticable to cut sections of large populations), no attempt was made to calculate standard errors and to determine the significance of the differences between the means presented in Tables II and III. Emphasis should therefore be placed on the trends and not on the absolute values.

The data which have been presented suggest that the severity of cutworm attack is directly associated with the internal structure and thickness of the stem, the caterpillars causing most damage to those varieties which typically possess slender, soft-wooded stems and hence offer less resistance to the insect's jaws. Such a conclusion is supported by observations which were made on varieties with thick, hard-wooded stems (*e.g.*, Type 79). Here the stem was sometimes seen to be partially gnawed near the base of the plant. Apparently the cutworm failed in its attempt to cut the stem near the base, and proceeded to the softer top portion and cut it off. Indeed in the very slightly attacked group, almost the whole of the damage was confined to weakly developed plants or to the extreme tips of the normally developed plants.

It should be emphasised, however, that stem diameter and the extent of development of woody tissues may be profoundly influenced by

nutritional and environmental factors. Under certain conditions, the stems of all or nearly all the varieties of gram become extremely woody, and the anatomical differences noted under a different set of conditions may be completely obliterated, and the relative positions of the varieties, in respect of the characters discussed, may even be interchanged. Thus, the same twelve varieties of gram grown under irrigation conditions at Karnal, in both the years, made much more vigorous growth than at Pusa. Sections cut from stems of plants of the same age (about eight weeks) as the Pusa lots, showed that the varieties were alike in possessing extensive development of secondary wood and large stem diameters. On the analogy of the results obtained at Pusa, it was to be expected that, by reason of their robust growth, the grams grown at Karnal would sustain very slight injury from cutworms. It is perhaps significant that such proved to be indeed the case.

As few cases of a simple, direct relation between the anatomical characters of a variety and liability to insect attack, such as has been described in this paper, appear to be known, it seems likely that further investigations of this nature, with other varieties of gram and with other crop plants, may yield data of both interest and value. The demonstration that such a relation exists, in the case of the gram varieties studied at Pusa, suggests as an obvious measure for the control of the cutworm pest, the selection of tough-stemmed varieties for cultivation in tracts known to be particularly prone to the pest.

I am indebted to Dr. F. J. F. Shaw, the Imperial Economic Botanist and Director, for the suggestion to take up this investigation. My thanks are also due to Dr. H. S. Pruthi, the Imperial Entomologist, for information relating to North Indian cutworms and their habits, and to Messrs. Hukam Singh, Pushkar Nath and Mohammad Umar, for assistance in the field and laboratory work.

The photomicrographs were kindly taken by Dr. M. Mitra in the Mycological Section, by permission of the Imperial Mycologist.

4. *Summary*

1. Much more severe cutworm damage was noticed in Pusa gram Type 17 than in Type 41. The two varieties were grown in paired plots in a yield trial conducted at Pusa in 1933–34. The reasons for this differential attack were investigated.

2. Caterpillar counts in all the 84 Pusa types of gram showed no obvious relation between severity of attack and the number of caterpillars found. This suggested that probably no preference in respect of varieties was exercised either by the moths or the larvæ but that some physical attribute of

the stem was responsible for the unequal damage in varieties. To test this possibility, cross-sections of the stems of very slightly attacked, moderately attacked and severely attacked varieties were studied.

3. It was found that very slightly attacked varieties were characterised by a large stem diameter and extensive development of woody tissues, whilst severely attacked varieties had a comparatively smaller stem-diameter and the secondary wood was weakly developed. Moderately attacked varieties were intermediate between the two groups in respect of stem-diameter, and like the very slightly attacked group in respect of extent of development of woody tissues.

REFERENCES

1. Davidson, J., and Henson, H., "The internal condition of the host plant in relation to insect attack, with special reference to the influence of pyridine," *Ann. Appl. Biol.*, 1929, **16**, 458–471.
2. Martin, H., *The Scientific Principles of Plant Protection*, London, 1932, 316 pp.
3. Shaw, F. J. F., and Khan, A. R., "Studies in Indian Pulses—II. Some varieties of Indian gram (*Cicer arietinum* Linn.)," *Mem. Dept. Agric. India*, 1931, **19**, 27–47.

EXPLANATION OF PLATES

PLATE XXIII

FIG. 1.—T.S. stem of gram Type 3. × 80.
FIG. 2.—T.S. stem of gram Type 26. × 80.
FIG. 3.—T.S. stem of gram Type 38. × 80.
FIG. 4.—T.S. stem of gram Type 79. × 80.

PLATE XXIV

FIG. 5.—T.S. stem of gram Type 9. × 80.
FIG. 6.—T.S. stem of gram Type 36. × 80.
FIG. 7.—T.S. stem of gram Type 41. × 80.
FIG. 8.—T.S. stem of gram Type 58. × 80.

PLATE XXV

FIG. 9.—T.S. stem of gram Type 17. × 80.
FIG. 10.—T.S. stem of gram Type 46. × 80.
FIG. 11.—T.S. stem of gram Type 52. × 80.
FIG. 12.—T.S. stem of gram Type 82. × 80.