BIOECOLOGICAL STUDIES OF SOYBEAN GIRDLER, *Obereopsis* (= *Oberea*) *brevis* Swed. (Col., Lamiidae) AND ITS CONTROL

A Thesis
Submitted to the
Bidhan Chandra Krishi Viswavidyalaya
for the award of the Degree of Doctor of Philosophy
in
Agricultural Entomology

BY

PRADIP KUMAR PAL

Department of Agricultural Entomology
Faculty of Agriculture
Bidhan Chandra Krishi Viswavidyalaya

1 9 8 3

From: Prof. N.Dutt,
Emeritus Scientist, ICAR

Department of Agril. Entomology,
Faculty of Agriculture,
Bidhan Chandra Krishi Viswavidyalaya,
Kalyani, Nadia.

C_E_R_T_I_F_I_C_A_T_E

This is to certify that the work recorded in the thesis entitled " BIOECOLOGICAL STUDIES OF SOYBEAN GIRDLER, *Obereopsis* (=*Oberea*) *brevis* Swed.(Col., Lamiidae) AND ITS CONTROL " submitted by Shri Pradip kumar Pal, for the award of the Degree of Doctor of Philosophy in Agricultural Entomology of the Bidhan Chandra Krishi Viswavidyalaya, is the faithful and bonafide research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

(N. Dutt.)

Dated:
The 25th Jan., 1983.

A C K N O W L E D G E M E N T

With a profound and immarcescible sense, I redound to express my heartfelt thanks to Prof. N. Dutt, Ph.D.,(Cal.) formerly Vice-Chancellor, B.C.K.V., and presently Emeritus Scientist, I.C.A.R., Deptt. of Agril.Entomology, B.C.K.V., who as my Guide and Teacher imparted with his invaluable tutelage, benevolent suggestions, innovative ideas and constructive criticism during the course of this investigation and above all for his sustained inspiration at times of failure and depression. His painstaking thoroughness at the time of preparation of the manuscript left me dumbfounded.

I am highly indebted to Prof. T.K.Bose, Dean, Faculty of Agriculture, and Dr. S.K.Ghosh, Reader and Head,Deptt. of Agril.Entomology, for their unreserved co-operation and extension of the necessary facilities to carry out the research work.

Dr. N.C.Debnath, Reader and presently Head, Deptt. of Agril.Chem. & Soil Science; and Dr. N.R.Das, the then Directors of Research, deserve a special mention for the help rendered by them in the form of providing the requisite crop growing facilities at Gayeshpur Farm. I am much beholden to them.

I am also dumbstrucked by the needful advice intermingled with affections and love showered by the honourable Teachers of my Department whenever I was confronted with adversities in executing a particularly well-contemplated research operation.

It would be niggardly of me if I do not re-affirm my respect to and faith on them at this juncture, by placing their names in record with high esteem and reverence.

It is well-nigh impossible for me to express in words the extent of gratefulness for the services rendered by my friends *inter alia* Sri R.Saha, Shri A.Mukhopadhyay, Sri B.Bandyopadhyay, Sri S.Behera, Sri M.Saha, Sri A.Das, S.K.Ahmed, Sri S.Karmakar, Sri P.Das, Dr.S.K.Samanta, Dr.P.Bhattacharya, and Dr.S.K.Mitra. In fact they were ever-ready to give the cue and kept me gay. And this dissertation will always act as a mnemonical aid to remember them or, otherwise, *vice-versa*.

Sri Shyamal Chakraborty, a Research Scholar in the Deptt. of Plant Pathology, laboured into the odd hours to check and recheck the final manuscript with great speed and finesse. I hope, to express my deepest sense of gratitude for his services shall not be considered redundant.

The typist Sri Shyamal Banik performed his job well and left an indelible impression of his skill and adroitness on my mind. I must appreciate his tireless effort.

Dated:
The 25th Jan., 1983.

Pradip Kumar Pal
(Pradip Kumar Pal.)

CONTENTS

***

LIST OF TABLES

****

LIST OF TEXT FIGURES

Text Figure No.

Text Figure No.

LIST OF FIGURES

Figure No.

Figure No.

CHAPTER-I

INTRODUCTION

Soybean (Glycine max (L.) Merr.,Fam.,Leguminoseae) was formerly classified as an oilseed because of its oil-yielding quality. Now a days, however, soybean is utilized both for oil as well as an important source of protein. The increasing use of soybean as a source of protein is generating great deal of interest because of its nutritive value for human beings. From the compositional point of view soybean should logically be called protein seed rather than oil seed. The average approximate composition of soybean is 40 per cent protein,21 per cent oil,34 per cent carbohydrate and 5 per cent ash (Kawamura,1967). In a developing country like India where supply of protein in diet is inadequate, soybean meal may be considered as very useful particularly in rural areas where protein deficiency in diet is rather very large. The importance of soybean has now been fully recognised in our National Planning as a source of oil and of protein. The acreage under soybean in India during 1968 was about 300 hectares which has gone up to 6 lakh hectares in 1980-81 (Bhatnagar, 1982). It is expected that the area under soybean in the country may even cross the limit of 1 million hectares by the end of Sixth Five Year Plan. The average yield of soybean in India is about 6-7 quintals per hectare. Most of the soybean growing areas are in Madhya Pradesh and to a lesser extent in Uttar Pradesh. In other States of the country soybean is grown in limited areas inspite of its importance. In West Bengal, some experiments were conducted earlier under the Economic Botanist of the State. According to final estimate of Kharif soybean, (Agricultural Situation in India, ed. Faqir Chand, 1981) the acreage in West Bengal during 1980-81 was

0.5 thousand hectares. Turnipseed and Kogan (1976) stated that very little attention was given to soybean entomology prior to 1960. Recently, Indian Council of Agricultural Research, New Delhi has taken keen interest in the development of the crop and has approved an All India Co-ordinated Soybean Research Project with Research Stations all over the country with an unit under the Bidhan Chandra Krishi Viswavidyalaya, West Bengal since 1967-68. Inspite of establishment of the unit in the State about a decade and half back, soybean cultivation in the State has not yet made any recognisable impact on the farming community. In view of the recent introduction of the crop in the farming system in the State, very little or no work has been possible in West Bengal on soybean entomology. Neither there is any provision for technical personnel in entomology in the West Bengal unit of the All India Co-ordinated Soybean Research Project sponsored by I.C.A.R. Chatterjee and Roquib (1977) while compiling the results of work done under the auspices of the BCKV unit of the All India Co-ordinated Research Project during the period of 1967-68 to 1975-76 referred to caterpillars, cutworms, whiteflies, aphids and stem borers from West Bengal as pests of soybean but not soybean girdler. Neither Sachan and Gangwar (1980) reported occurrence of soybean girdler from Khasi hills of Meghalaya State in North East India. The girdler has recently been found to be potentially serious pest of Kharif grown soybean crop in West Bengal.

The present investigation has, therefore, been taken up to throw some light on the ecological background of the behaviour of the pest relating to its incidence and control.

CHAPTER-II

REVIEW OF LITERATURE

Turnipseed and Kogan (1976) in a recent world review on soybean entomology observed that little attention was given to entomological aspects of soybean cultivation prior to 1960. According to these authors, there was no indepth study of insect fauna with few exceptions. However, available literatures on soybean pests, with particular reference to soybean girdler, Oberea brevis Swed., renamed as Obereopsis brevis Swed.,(Bhattacharjee, 1981 and private communication from Breuning, 1982) have been reviewed under suitable headings.Breuning in a recent personal communication dated 15.1.82 informs as below:

" Ce n'est pas moi qui aie decrit l'Oberea brevis mais Gahan en 1895 dans les Ann. Mus.civ.Genova, xxxiv,1895 P.98 et je ne mentionne pas nonplus cette espèce dans ma revision du genre Oberea mais weulement dans celle du genre Obereopsis, car je considère cette espèce comme appartenant au genre Obereopsis. Je ne possède malheureusement pas de double de cette publication qui a paru dans les Ind. For.Rec.(5 new series) IX 1955, P.115.Je n'ai rien publié sur les larves de ces espèces puisque en Europe on n'en Connait pas."

Survey of soybean pests in India and other parts of world

In a survey carried out by American Soybean Association in 1974, it has been stated that United States of America grow approximately 57 per cent, People's Republic of China 21 per cent and Brazil more than 11 per cent out of world's total soybean area of 37.5

million hectares. Obviously, cultivation of soybean from the point of view of acreage in India is rather insignificant in comparison to other soybean growing countries of the world. Accordingly, no comprehensive research on soybean entomology was undertaken in India eventhough observation on soybean pests dates back as early as in 1915. Dutt (1915) observed Nupserha sp. as soybean stem borer from Bihar. Later on Gangrade (1974) reported Nupserha bicolor from Madhya Pradesh in addition to the girdler Oberea brevis. Nupserha bicolor was also reported as a pest of soybean (Srivastava, 1964; Jotwani, 1980). Bhardwaj and Bhalla (1977), however, reported Nupserha nitidior var. atripennis Breun. as pest of soybean from Himachal Pradesh. These authors have also observed 30 different insect species as pests of soybean from Himachal Pradesh. Rawat et al. (1969) reported from Madhya Pradesh more than 24 species of soybean pests, number of which increased later on to 85 according to Gangrade (1975). Bhattacharya and Rathore (1980) while compiling reports on insect problems of soybean in India observed that the crop is subject to infestation by a large number of pests ranging from 60-100. Sachan and Gangwar(1980) while surveying the insect pests of soybean from Khasi hills of Meghalaya State in North East India reported 24 species of insect pests. Bhattacharjee (1981) has recently listed a number of soybean pests, some of which are rather serious. He has included Obereopsis (= Oberea) brevis Swed. among the serious pests of soybean.

The survey of insect pests of soybean from different soybean growing tracts of India shows that the soybean girdler

O.brevis has been observed from Southern, Northern and Central India (Ayyar, 1963; Singh and Singh, 1966; Gangrade et al. 1971; Gangrade, 1974; Bhattacharya and Rathore, 1980) but not from Eastern India including Khasi hills in Meghalaya (Sachan and Gangwar, 1980) and West Bengal.

In United States surveys of soybean insects from different States have been reported for Ohio (Balduf, 1923), Illinois (Myers, 1940), Minnesota (Kretzschmar, 1948), Missouri (Blickenstaff and Huggans, 1962) and Arkansas (Tugwell et al.,1973). Soybean insects for Argentina have been reported by Rizzo (1972) and Corseuil et al. (1974). Ferreira (1970) has reported soybean pests from Brazil. Cheu (1944) reported soybean pests from China, Clausen (1931), Kurosawa and Matsumoto (1961) and Kobayashi et al.(1972) from Japan; Pacheco (1970) from Mexico; Van Dinther (1956) from Surinam; Robertson (1969) from Tanzania and Guagliumi (1966) from Venezuela. The pests as reported by the aforesaid authors include species which may be root feeders, cutworms, Lepidopterous, Coleopterous and Dipterous borers, defoliators, sucking, bud and blossom feeding species as well as species infesting pods and soybean seed.

It, however, appears that the soybean girdler, O.brevis , larvae of which are stem borers occurs particularly in India. Soybean girdler, O.brevis has also been reported to infest other leguminous plants like garden bean and cowpea, niger, urid , moong and other pulses as well as groundnut and wild jute (Fletcher, 1917 & 1919; Singh and Singh, 1966; Kapoor et al., 1971; Bhattacharyya and Rathore, 1980; Singh et al.,1978; Odak and Thakur,1978).

Breuning (1955) placed the species Oberea under the genus Obereopsis and named it as Obereopsis brevis. While reviewing the world's species under the genus Oberea , the species Oberea brevis was not included by him (Breuning, 1960-62) under the genus. Further Dr. Breuning (1982) in a personal communication informs that he considered the species brevis belongs to the genus Obereopsis. It is only recently Bhattacharjee (1981) referred the soybean girdler as Obereopsis (=Oberea) brevis. Present author has accordingly adopted the name Obereopsis (=Oberea)brevis in place of Oberea brevis.

Life history

Singh and Singh (1966) reported some aspects of bionomics and control of O.brevis as a pest of bean and cowpea. According to these authors a female is capable of laying 7-13 eggs, incubation period of eggs being 4-5 days. It seems that there was a confusion as to the period of larval life with a longer life during the winter season as against a shorter one during the summer months. They have, however, reported the larval character in a very generalised way without referring to any distinctive specific morphological characteristics. The pupal period has been reported by these authors as about a month under laboratory condition but according to them the period may be shorter under the field condition.

Gangrade et al.(1971) observed the incubation period of eggs as 3-4 days, larval period as 34-47 days and pupal period from 8-11 days. But the period under these different immature stages according to this author may, however, vary (Gangrade, 1975). Pupal period as reported by Gangrade et al.(1971) and Gangrade (1975) contradicts the period reported by Singh and Singh (1966). Singh (1980) reported the fecundity of O.brevis as 8-72 eggs per female and the incubation period of egg as ranging from 3-5 days. According to Bhattacharya and Rathore (1980) incubation period ranges from 3-8 days, larval period from 40-60 days.

Dutt (1961) reported the life history and bionomics of an allied Lamiid girdler species, Nupserha bicolor postbrunnea attacking olitorius jute. He (1956a, 1956b) has also reported the characteristic features of immature stages of the girdler and also ascertained the factors, responsible for determining the susceptible sites for girdling and consequent damage.

Hatchett et al. (1973) and Hatchett et al.(1975) reported the occurrence and life history of a Lamiid borer, Dectes texanus on soybean from South Eastern Missouri in USA.

Pre-ovipositional operation
and laying of egg

Cutting of girdles on stem, petiole and central leaf-let stalk of soybean plants as a pre-ovipositional operation by O.brevis have been reported by various authors (Singh and Singh, 1966; Rawat et al., 1969; Kapoor et al.,1971; Gangrade et al.1971; Saxena, 1972; Gangrade, 1975; Singh,1980; Bhattacharya and Rathore, 1980). Gangrade et al.(1971), however, reported the highest frequency of girdling on petiole and almost equal frequency on stem and central leaf-let stalk. The cutting of slit in between the two girdles and the mechanism involved in it so that the genital capsule of the ovipositing female can be pushed through it for egg laying has neither been observed nor reported correctly by any author till Dutt (1956a) reported details of girdling and cutting of slit in case of the Lamiid beetle, Nupserha bicolor postbrunnea.

Singh and Singh (1966) reported cutting of two girdles and three small punctures in a transverse line just above the lower girdle while Gangrade et al.(1971) stated that the female drills 1-3 holes just above the lower girdle. None of these authors, however, elucidated how an odd number of holes i.e.,one or three holes can be cut by paired mandibles.

Relationship between the intergirdle length, diameter and moisture content and its importance in the light of egg development has not been considered by any author in case of O.brevis.

Time taken for cutting girdles by O.brevis has not been reported by any author. Dutt (1956a) reported the time taken for cutting of girdles and slit on jute stem by N.b.postbrunnea. He has also indicated that girdles are cut to reduce moisture content in the intergirdle length to make development of egg congenial (Dutt, 1961).

Larval characteristics

Duffy (1953) while describing the larval and pupal characteristics of Cerambycid beetles has also not covered the larval characteristics of soybean girdler, *O.brevis* probably because of the absence of the species in European countries (Breuning, 1982 in a personal communication). Larval characteristics of *O.brevis* thus remain yet to fully described.

Progression factor and correlation of larval length and width

Singh and Singh (1966) have indicated five larval instars of *O.brevis* . Ruggles (1915) while working on the life history of another species of *Oberea* namely *O.tripunctata* Swed. measured the body length and head length of different larval instars which according to him, are five in number. But none of these authors has established any relationship between increase in width of the head capsule and larval instars as has been propounded in Dyar's Law (Dyar, 1890). Progression factor of 1.4 as propounded in Dyar's Law in case of Lepidopterous larvae has also been found to be applicable in cases of non-Lepidopterous insects like banana pseudostem weevil, *Odoiporus longicollis* (Dutt and Maity, 1972).

None of the earlier authors working on *O.brevis* or other soybean borers have reported progression factor in relation to different instars. High correlation values between the length and width of larvae of different instars have been reported by Dutt and Maity (1972) in case of the weevil, *O.longicollis*.

Morphology of different larval instars

No critical observation has been made on the number of instars as well as the distinctive features of these instars by any previous worker even though Duffy (1953) described the distinctive features of a large number of larvae of various Cerambycid. Dutt (1956b) has described the distinctive features of immature stages of jute stem girdler, N.b.postbrunnea.

Larval diapause

Singh and Singh (1966) referred the larval diapause as overwintering while Gangrade et al.(1971) called it as larval hibernation. Later on Gangrade in 1975 reported the dormancy as diapause which according to him continues for about 241-322 days till rains of the next year activated them. According to Singh (1980), most of the first generation and nearly all the second generation larvae of O.brevis overwinter and oversummer in 18-25 mm long pieces of stem cut by the pest and plugged at both the terminals. None of these aforesaid authors, however, ascertained the factors responsible for termination of larval dormancy or diapause of O.brevis.

Dutt (1956b), however, observed that diapause type of dormancy in case of jute stem girdler, N.b.postbrunnea could be terminated by exposure to 30°C and high level of relative humidity from 80 per cent and above under the laboratory condition and under about more than ten inches rainfall during the summer months i.e., from April to July. The aforesaid author also observed that under unfavourable laboratory condition diapause type of larval dormancy of N.b.postbrunnea continues for several years without its termination, till death.

Nature of damage

Review of literatures on the nature of damage by O.brevis indicated some confusion. Ayyar (1963) has reported the larva of this species is a typical stem borer and is responsible for the death of the entire soybean plant. Later on, Singh and Singh (1966) have also reported that a single larva was capable of destroying the whole plant. Gangrade et al.(1971), however, contradicted such larval damage and reported that the feeding of borer larva is seldom responsible for death of the whole plant. Rawat et al.(1969), Gangrade et al. (1971)and Kapoor et al.(1971) observed that the damage is mainly due to the cutting of girdles either on the stem, petiole or on the central leaf-let stalk. Saxena (1972) reported that the grub bore into the stem and infested shoots wither and dry. Srivastava et al.(1976) reported that the larvae of O.brevis mine the stem. Singh (1980) and Bhattacharya and Rathore (1980), however, are in agreement with the authors who reported that the damage is done mainly due to girdling.

Percentage of damage by the pest has also been variously reported by different authors (Rawat et al., 1969; Kapoor et al., 1971; Srivastava *et al.*, 1972; Gangrade and Singh, 1975; Singh *et al.*, 1979; Singh, 1980; Bhattacharya and Rathore, 1980) as ranging from 13.4 per cent to 52.33 per cent in different regions.

Factors determining selection of site for cutting girdles or for damage

No worker has reported as to why girdles are cut by *O.brevis* at a particular region of the stem, petiole or central leaf-let stalk. Dutt (1956a), however, ascertained the factors responsible for selection of site for girdling or for damage on jute stem by *N.b.postbrunnea*. He observed that the maximum girdling or damage is done to that portion of the stem where the ratio of the mandibular length to the depth of the stem tissue from epidermis down to the periphery of the pith tissue (extra-medullary tissue) ranges from 1:0.80 to 1:0.99. He also reported that the girdling or damage gradually decreases in those regions of stem where the depth of extra-medullary tissue increases or decreases these ratios.

Incidence and damage

Pest incidence of *O.brevis* has been reported by several authors. Rawat *et al.* (1969) reported that *O.brevis* infested 25 per cent soybean plants in Madhya Pradesh as against 1.0 - 29.4 per cent infestation in the same State as reported by Kapoor *et al.* (1971). Gangrade and Singh (1975) observed that on an average 13.4 per cent, 34.2 per cent and 21.2 per cent soybean plants were infested by

O.brevis in 1969, 1973 and 1974, respectively, in the State of Madhya Pradesh. Srivastava et al.(1972) reported that the damage by O.brevis ranged from 13.7 - 42.2 per cent in Uttar Pradesh.

Gangrade and Singh (1976) observed that early infestation caused 75 per cent of mortality of plant population while late infestation failed to do so. According to Singh (1980) infestation by O.brevis increased from 13.4 per cent in 1969 to 43.8 per cent in 1976 in Jabalpur, Madhya Pradesh. Bhattacharya and Rathore (1980) also considered O.brevis as a serious pest of soybean in Madhya Pradesh causing about 30 per cent damage to soybean plants.

Gangrade (1975) reported that sowing of Bragg variety of soybean on June 1 initiated heavier infestation of 32.8 per cent on an average than that of sowings of June 16, July 1,16 and 31 which gave 8.2 per cent, 2.5 per cent, 3.0 per cent and 4.5 per cent infestation respectively on average. Singh and Gangrade (1977) concluded that pre-monsoon sowing should be avoided in order to minimize the degree of infestation by O.brevis.

Varietal susceptibility

Very little informations are available regarding the susceptibility of soybean varieties to the infestation by O.brevis . Singh et al. (1979) observed 28.85 per cent to 52.33 per cent infestation in a field trial with 27 soybean varieties in Jabalpur and recorded no significant differences in the infestation rate among the varieties tested. According to Bhattacharjee (1981), varieties PK 271, PK 317, Alankar and DS-74-24-2 are fairly tolerant to most of the insect damage.

Chemical control

Various authors have worked on the chemical control of O.brevis and found insecticidal application to be effective in reducing incidence of the pest. Singh and Singh (1966) recommended a single application of 0.03 per cent Diazinon or 0.1 per cent Malathion for control of the pest. Rawat et al. (1969) found application of a mixture of 0.02 per cent Endrin and 0.03 per cent Rogor or 0.08 per cent Endosulfan at 2 weeks interval to be effective.

Srivastava (1973) found application of a mixture of 0.03 per cent Rogor and 0.03 per cent Diazinon were effective for control while Gangrade (1975) found 0.05 to 0.07 per cent Endosulfan 35 EC to be effective. Srivastava and Singh (1976) found 0.02 per cent Diazinon as effective for control.

Singh et al.(1978) tested the ovicidal effect of 11 insecticides on the eggs of O.brevis and observed that 0.03 per cent Dimethoate gave 87.5 per cent mortality of eggs and larvae that emerged subsequently; Chloropyriphos at 0.04 per cent gave 75 per cent and 92.5 per cent mortality of eggs and larvae respectively. Endosulfan at 0.07 per cent concentration gave 70 per cent and 92.5 per cent eggs and larval mortality respectively. Bhattacharya and Rathore (1980) recommended spraying of 0.05 per cent Endosulfan 35 EC, 0.03 per cent Dimethoate 30 EC and 0.03 per cent Methyl demeton 25 EC for reducing the infestation of O. brevis. Bhattacharjee (1981) reported application of Phorate or Curbofuran in furrows @ 1.5 kg a.i./ha at the time of sowing and spraying the crop 2 or 3 times with 0.07 per cent Endosulfan at 15 days interval starting from one week old crop as extremely useful.

CHAPTER-III

MATERIALS AND METHODS

Plant materials:

Eight varieties of soybean were taken as plant materials. The varieties were :

UPSM - 19

Ankur

BC-1

Soymax

Improved Pelican

Alankar

Kalitur

Bragg

These were collected from Pulses and Oil Seeds Research Station, Berhampore, West Bengal.

Fertilizers:

Nitrogenous fertilizers in the form of urea, phosphatic fertilizer in the form of single super phosphate and potassic fertilizer in the form of muriate of potash were applied as basal dressing.

Insecticidal materials:

Different insecticidal materials used during the course of investigation have been given in a tabular form below (Table 1).

METHODS

Adults of *O. brevis* were reared on soybean plants in the

Table 1 : Insecticides used during the course of present investigation

Sl. No.	Common name	Chemical name	Trade name	Name of the manufacturer	Form in which supplied
1.	Dichlorovos	0,0-Dimethyl 0-2,2-di chlorovinyl phosphate	Nuvan	Ciba Geigy of India Ltd.	liquid, 100 EC
2.	Phosphamidon	0,0-Dimethyl 0-(2-chloro-2-N,N-diethylcarbamoyl-1-methylvinyl)phosphate	Dimecron	Ciba Geigy of India Ltd.,	liquid, 100 EC
3.	Dimethoate	0,0-Dimethyl S-(N-methyl carbamoylmethyl)ditho phosphate	Rogor	Rallis India Ltd.	liquid, 30 EC
4.	Malathion	0,0-Dimethyl S-1,2-di carboethoxyethyl dithio phosphate	Cythion	Cynamid India Ltd.	liquid, 50 EC
5.	Methyl parathion	0,0-Dimethyl 0-4-nitro phenyl thiophosphate	Metacid	Bayer India Ltd.	liquid, 50 EC

laboratory for observations on different stages in the life cycle of the pest including behaviour of the adults, their feeding habits, mating, pre-ovipositional operations of cutting girdles and slits and oviposition.

Measurements on body length and body width of fifty adults of each of males and females were taken to find out the significant difference, if any, in length and width of two sexes. Measurements on the body length and body width of twenty larvae of each instar reared separately under the laboratory condition as well as on the width of the head capsule shed at the end of each instar were recorded in connection with studies of correlation between larval length and width of different instars and Progression factor.

Partial regression and multiple correlation on the variables namely larval length, larval width and the width of the head capsule were calculated to test the reliability in case of individual larva. The equation was :

$$Y = b_0 + b_1x_1 + b_2x_2$$

where, Y = calculated value of the width of the head capsule in mm,

x_1 = larval length in mm, x_2 = larval width in mm,

b_0 = regression constant, and b_1 and b_2 = coefficients of partial regression

Values of b_0 , b_1 and b_2 were calculated by the method of least squares. The regression equations obtained separately in case of larvae with four instars and in the larvae having five larval instars were as follows:

(i) $Y = 0.1344 - 0.01494\ x_1 + 0.5824\ x_2$ ....(in larvae with four instars)

(ii) $Y = 0.2456 - 0.02846\ x_1 + 0.5899\ x_2$ ....(in larvae with five instars)

For the purpose of assigning single individuals to their respective instars, relationship between instars and the mean width of the head capsules of larvae was ascertained by use of the regression equation as below:

$$\log y = a + bx$$

where, y = width of head capsule in mm, a = constant,

b = logarithm of growth ratio, and

x = number of instar

Values of a and b were found out by the method of least squares. The equations were accordingly:

(i) $\log y = -0.5046 + 0.1469\ x$ ....in larvae with four instars

(ii) $\log y = -0.5262 + 0.1178\ x$ ....in larvae with five instars

In connection with the investigation on the factors responsible for elimination of larval diapause, clyndrical glass jars with tight fitting glass stoppers were converted into small relative humidity chambers (Fig.1) using different concentrations

Explanation of Figure

Figure : 1 : Glass jars converted into small relative humidity chambers

FIG. 1

of sulphuric acid (H_2SO_4) for maintaining different levels of relative humidity per cent. Proportions of sulphuric acid and water used for maintaining different levels of relative humidity were in accordance to the procedure recommended by Stokes and Robinson (1949).

Four replicated laboratory test with diapausing larvae in small specimen tubes with top end open was set up in these different relative humidity chambers which were kept in a BOD incubator wherein a constant temperature of 30 $\pm$ 1°C was maintained.

Intergirdle length of stem, petiole and central leaf-let stalk and the diameter across the slits cut for oviposition were measured from 250 girdles samples of each stem, petiole and central leaf-let stalk. Each of these girdled stem, petiole and central leaf-let stalk was subsequently splitted to find out whether eggs were laid in the girdled pieces or not.

Tangential sections of stem, petiole and central leaf-let stalk were cut at the level of girdles to ascertain the nature of cutting of girdles by the mandibles of the females. Longitudinal sections were also cut at the region of girdling to ascertain the nature of tissue damage caused by mandibular insertions. Permanent preparations of these sections were made for subsequent observations. Transverse sections of the stem, petiole and central leaf-let stalk under different diameter classes were also cut at the level of the slit or close to it and permanent preparations made and measurement on the depth of tissue from epidermis down to periphery of the pith tissue (extra-medullary tissue) were recorded under the microscope.

Measurements on the width of the two lateral punctures and the central pit of the slits were taken under microscope from sections previously cut and permanent preparations made. Measurements of the loss of stem length of different soybean varieties due to girdling were also recorded from the field.

Genitalia of the adult females and their mandibles were dissected out from mature female adults and permanent preparations were made. Measurements on the length of the mandibles and the width of genital capsule at its base were taken under the microscope.

To assess the extent and intensity of incidence of each of eight soybean varieties to the pest, a four replicated randomised field trial was carried out for three consecutive years from 1979 to 1981. Fertilizers were applied as basal dressing and seeds were sown in lines with a spacing of 50 cm between lines and 5 cm between plants. Sowing was done on 15th, 14th and 16th June of 1979,1980 and 1981 respectively.

Extent and intensity of incidence i.e., girdling on stem, petiole or on central leaf-let stalk were recorded from the same 4 x 1 square meter area demarcated previously, immediately after germination. For ascertaining the extent of incidence the number of plants infested out of the total plants in the demarcated area in each of the treatment was periodically determined at regular interval. For ascertaining the intensity of incidence the number of incidence per plant and the site of incidence on each plant i.e., on stem, petiole or central leaf-let stalk were recorded periodically at regular interval. Observations on incidence were recorded at 15 days interval starting from one month after sowing. During each observation, girdled stem, petiole or the central leaf-let stalk were tagged immediately, so as to avoid their inclusion subsequently.

For the purpose of evaluating statistical significance, if any, between the treatments i.e., between extent of incidence in the eight different varieties, analysis of variance was done after necessary angular transformation of data. One was added before angular transformation to all per cent figures in case of zero data recorded in treatment. In case of observation on the intensity of incidence on central leaf-let stalk, petiole or stem where the number of incidence was involved, root transformation was done using the formula as below.

$$y = \sqrt{P + 0.5}$$

where,

y = transformed variate,

P = original variate (number).

CHAPTER-IV

RESULTS AND DISCUSSION

SECTION I

MORPHOLOGY AND BIOECOLOGY OF IMMATURE STAGES

Breuning (1955) while reviewing the genus *Obereopsis* placed the soybean girdler *Oberea brevis* Swed. (Col., Lamiidae) under the genus *Obereopsis* and renamed it as *Obereopsis brevis* Swed. Breuning (1952) in his revision of the subfamily Saperdini under the family Cerambycidae (Coleoptera) has given the distinctive features of the genus *Obereopsis* as follows:

"*Obereopsis* Kolbe.

Flügeldecken Sehr langgestreckt, zumindest dreimal so lang wie der kopf und der Halsschild Zusammengenommen; Halsschild fast stets zummindest so lang wie breit.

Fühler niemals sehr fein.

Fühler mehr oder weniger dünn, selten dick dann aber nicht merklich kürzer als der körper.

Diese Glieder nicht dicker als die folgenden und unterseits nicht dichter gefranst als die folgenden.

Erstes Fühlerglied ohne eine solche längskante, oder selten mit einer solchen, dann aber der körper sehr langgestreckt.

Halsschild niemals sehr dicht abstehend behaart.

Drittes Fühlerglied höchstens ein wenig länger als das vierte.
Flügeldecken ohne solche längslinien.
Erstes Fühlerglied nicht länger als das dritte oder die Fühler dick.

Erstes Fühlerglied ohne Narbe.

Alle Klauen in beiden Geschlechtern gelappt oder geteilt.

Ohne die Kombination dieser Merkmale.

Halsschild ohne einen solchen.

Flügeldecken ohne eine solche Schulterkante selten ist eine Humeralkante leicht angedeutet, diese beginnt aber dann merklich hinter der Schulterbeule.

Hinterschenkel den Hinterrand des zweiten Abdominalsegmentes merklich überrangend; Flügeldecken haüfig nur mäßig lang

Hinterschienen weniger als zweieinhalbmal so lang wie die Hintertarsen, oder selten so lang; dann aber der Halsschild meist ohne Andeutung von Beulen oder die Hinterschenkel das zweite Abdominalsegment nicht überragend.

Hinterschienen weniger als dreimal so lang wie die Hintertarsen, selten doch so lang, dann aber die Flügeldecken praeapikal ziemlich stark verbreitert oder die Fühlerhöcker einander genähert.

Die Abdominalsegments sind niemals ungewohnlich verlängert, das Abdomen überragt niemals mit zwei Segmenten das apikale Ende der Flügeldecken".

The pest O.brevis remains active during the summer months and enter into dormant phase during winter. Morphology and ecology of immature stages of the pest were mostly carried out during its active phase except in case of experiments with diapause larvae.

(i) <u>Egg and incubation period</u>

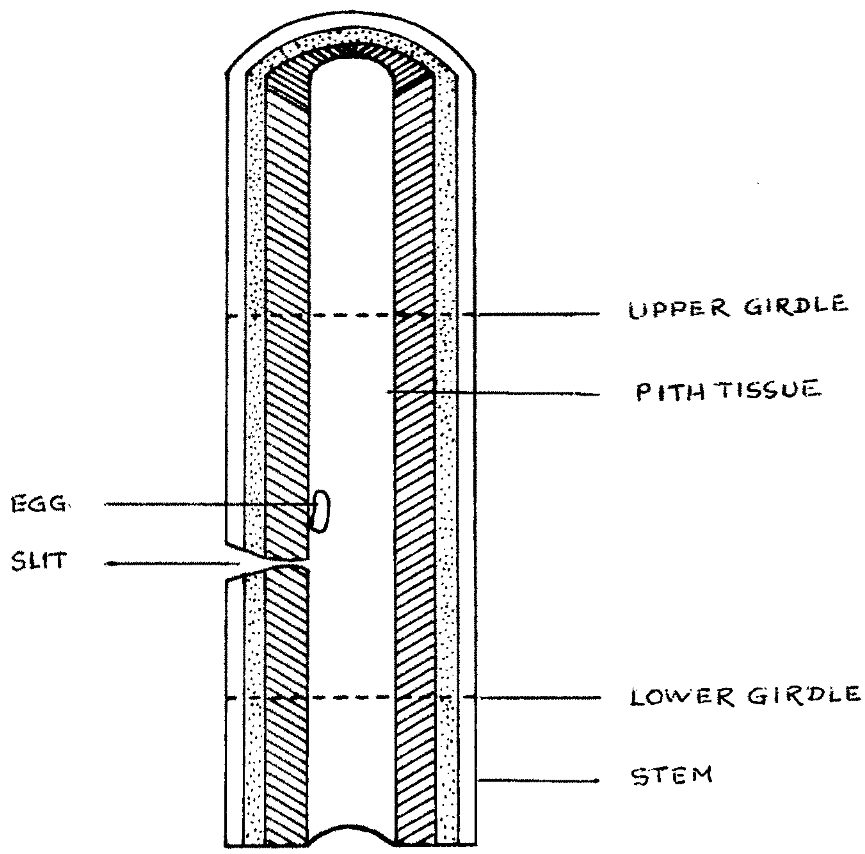
Eggs are deposited singly on the periphery of pith tissue just above the inner end of the tunnel of the slit cut either on the central leaf-let stalk, petiole or stem (Text Fig. 1.1). Eggs are light yellowish or creamy in colour and more or less cylindrical (Fig. 1.1 a) in shape with rounded ends with a slight curvature in the middle. Each egg measures 1.69 $\pm$ 0.02 mm in length on average, the range being 1.27 to 1.95 mm and 0.46 $\pm$ 0.008 mm in width on average, the range being 0.30 to 0.57 mm.

Incubation period of eggs ranges from 3 to 4 days under the room temperature range of 29.0 - 30.1°C (Table 1.1).

Table 1.1: Incubation period of egg

Total number of observation (eggs)	Incubation period of egg under the room temperature of 29°C - 30.1°C			
	3 days		4 days	
	No.	%	No.	%
73	26	35.62	47	64.38

It may be seen from Table 1.1 that the frequency of incubation period is, however, higher with 64.38 per cent with the incubation period of 4 days. The present observation agrees with that of Gangrade *et al.*(1971) but differs slightly with those of Singh & Singh (1966) and Singh (1980) who reported the incubation



TEXT FIG. 1.1 OVIPOSITION SITE

period as ranging from 4-5 days and 3-5 days respectively.

(ii) Larva

On hatching, the borer larva moves downward below the level of the lower girdle and starts feeding on the inner pith tissue (Fig. 1.2). The borer on hatching from eggs laid either in the central leaf-let stalk or in petiole enters the main stem through the junction of the central leaf-let stalk, petiole and the stem making passage through the woody xylem tissue. In no other stage during the larval life, these larvae re-enter the petiole nor cause any damage to the woody xylem tissue except (~~at the time of cutting emergence hole prior to their entering into the pupal phase and~~) at the time of making diapausing case as mentioned in Section IV.

Singh and Singh (1966) reported four moultings or five larval instars in case of the girdler, *O. brevis*. Hatchett *et al.* (1973) and Hatchett *et al.* (1975) while working on another Lamiid soybean beetle, *Dectes texanus* in Missouri, USA reported variation in the number of larval instars. According to Hatchett *et al.* (1973), there were four larval instars in case of *D. texanus* while Hatchett *et al.* (1975) reported six larval instars. In 40 per cent cases the number of larval instars has been observed to be four while in 60 per cent cases the number of larval instars has been found to be five. The period under each instar is also variable. Because of the variation in the number of larval instars, the larval period has

Explanation of Figure

Figure 1.1 : Photograph showing immature stages

a) egg

b) larva

c) pupa

Figure 1.2 : Larval tunnel

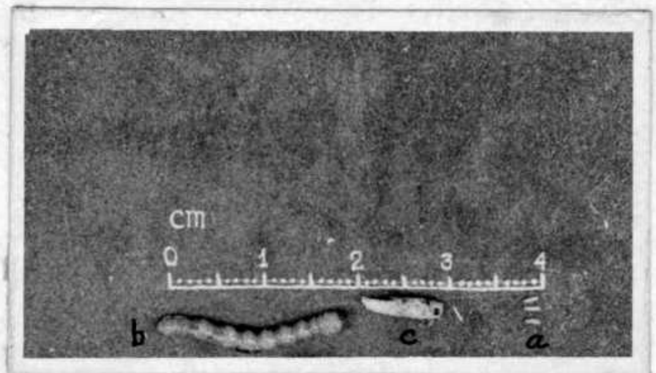


FIG. 1.1

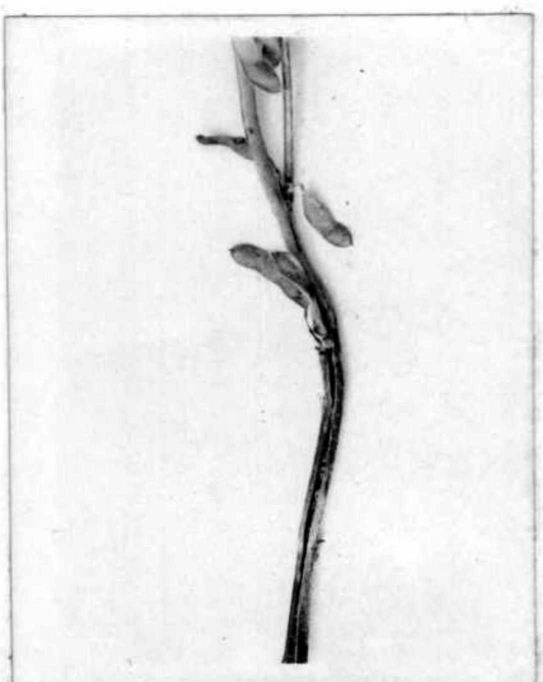


FIG. 1.2

also been found to vary from an average larval period of 29.6 days in case of larvae with four instars to 34.4 days on average in larvae with five instars under the temperature range of 28-31°C during summer months (Tables 1.2 & 1.3). Even though larval period in case of larvae with five instars is more than that of larvae with four instars, it is interesting to mention here that average larval period as well as its range is higher during the third and fourth instar stage in larvae with four instars than that of larvae with five instars. The larva at the advent of winter i.e., at the time of harvest of soybean crop enters into diapause type of dormancy thereby extending the larval period till it encounters a favourable condition with the onset of monsoon in the following summer. Under unfavourable condition the period may extend further beyond. The matter has been discussed in Section IV. The aforesaid two Tables (1.2 & 1.3) also show the mean larval period, larval length and width at the end of each instar prior to shedding of head capsule.

Mean larval growth in length and width of larvae with four instars has been graphically represented in Text Fig.1.2, a & b respectively. It may be seen from the Text Fig. that there is a gradual increase in larval length till the third instar stage in case of larvae with four instars after which there is a decrease in larval length. In case of larval width there is not such decrease in width during the fourth larval instar and slight increase in width has been observed during the fourth instar stage.

Table 1.2: Larval period, larval length & width of *O. brevis* with four instars (Mean of 8 observations).

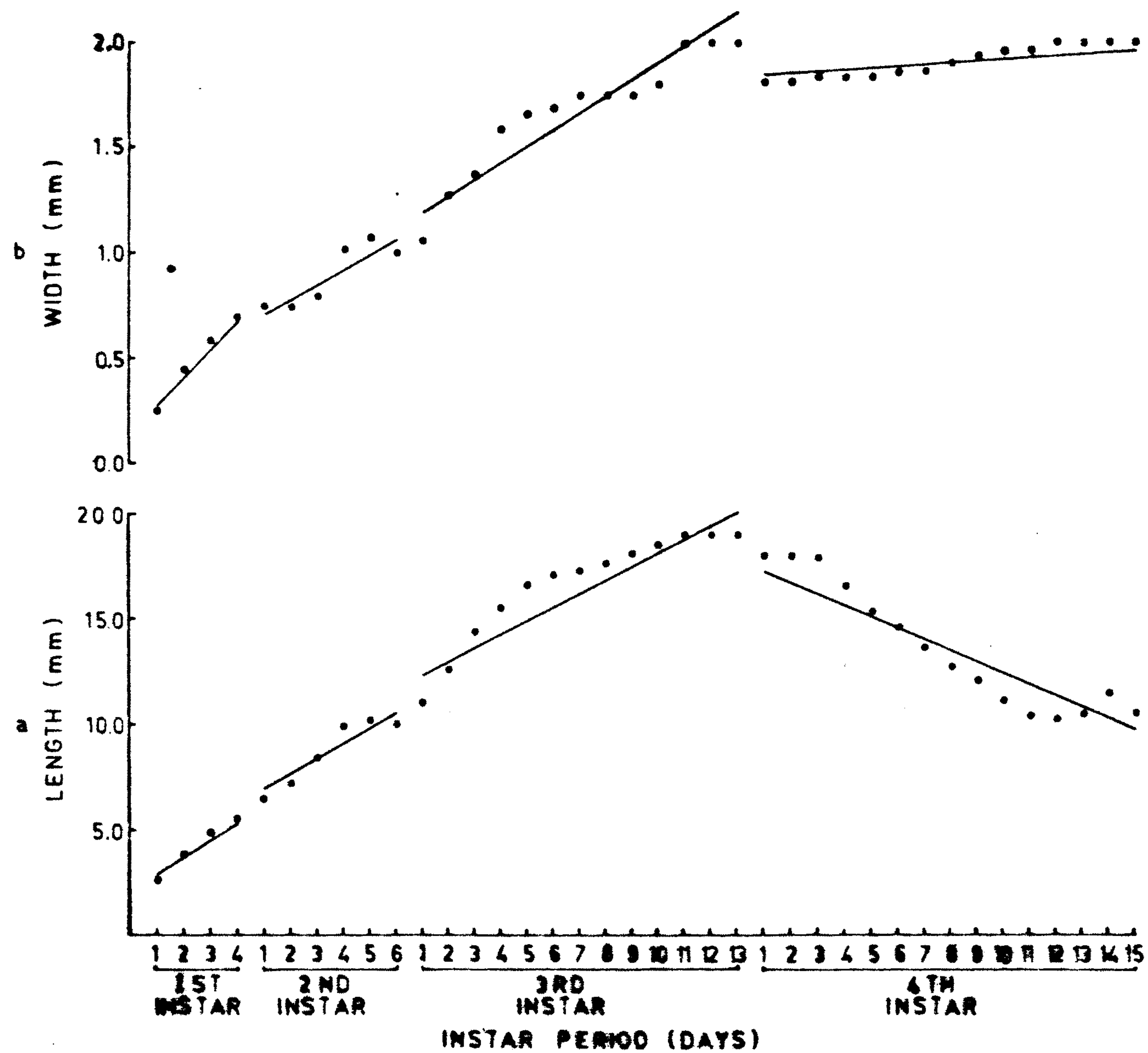
Instar	Mean larval period(days) ± S.E.	Mean larval length(mm)at the end of instar ± S.E.	Mean larval width(mm)at the end of instar ± S.E.	Temperature °C	
				Maximum	Minimum
1st	3.7 ± 0.1 (3 - 4)	5.37 ± 0.12 (5.00 - 6.00)	0.65 ± 0.04 (0.50 - 0.75)	30.0	28.5
2nd	4.5 ± 0.2 (4 - 6)	10.06 ± 0.11 (9.50 -10.50)	1.06 ± 0.04 (1.00- 1.25)	30.0	29.0
3rd	9.8 ± 0.5 (8 -13)	17.93 ± 0.40 (16.50 -20.00)	1.78 ± 0.03 (1.75 -2.00)	30.5	29.0
4th	11.6 ± 0.6 (9.- 15)	10.12 ± 0.30 (9.00 -11.50)	2.03 ± 0.03 (2.00 -2.25)	30.5	28.0

Range in parenthesis

Table 1.3: Larval period, larval length & width of O.brevis with five instar (mean of 12 observations)

Instar	Mean larval period(days) ± S.E.	Mean larval length(mm)at the end of instar ± S.E.	Mean larval width(mm)at the end of instar ± S.E.	Temperature °C	
				Maximum	Minimum
1st	3.7 ± 0.2 (3 - 5)	4.33 ± 0.06 (4.00 - 4.50)	0.44 ± 0.03 (0.25 - 0.50)	30.0	28.5
2nd	4.5 ± 0.1 (4 - 6)	8.25 ± 0.19 (7.00 - 9.00)	0.88 ± 0.03 (0.75 - 1.00)	30.0	29.0
3rd	5.7 ± 0.5 (4 - 9)	14.08 ± 0.58 (10.50 -16.00)	1.52 ± 0.05 (1.25 - 1.75)	30.5	29.0
4th	8.5 ± 0.3 (6 -10)	17.75 ± 0.44 (14.00 -19.00)	1.87 ± 0.03 (1.50 - 2.00)	30.5	29.0
5th	12.0 ± 0.5 (8 - 14)	9.08 ± 0.30 (8.00- 10.50)	1.93 ± 0.04 (1.75 - 2.25)	31.0	28.0

Range in parenthesis



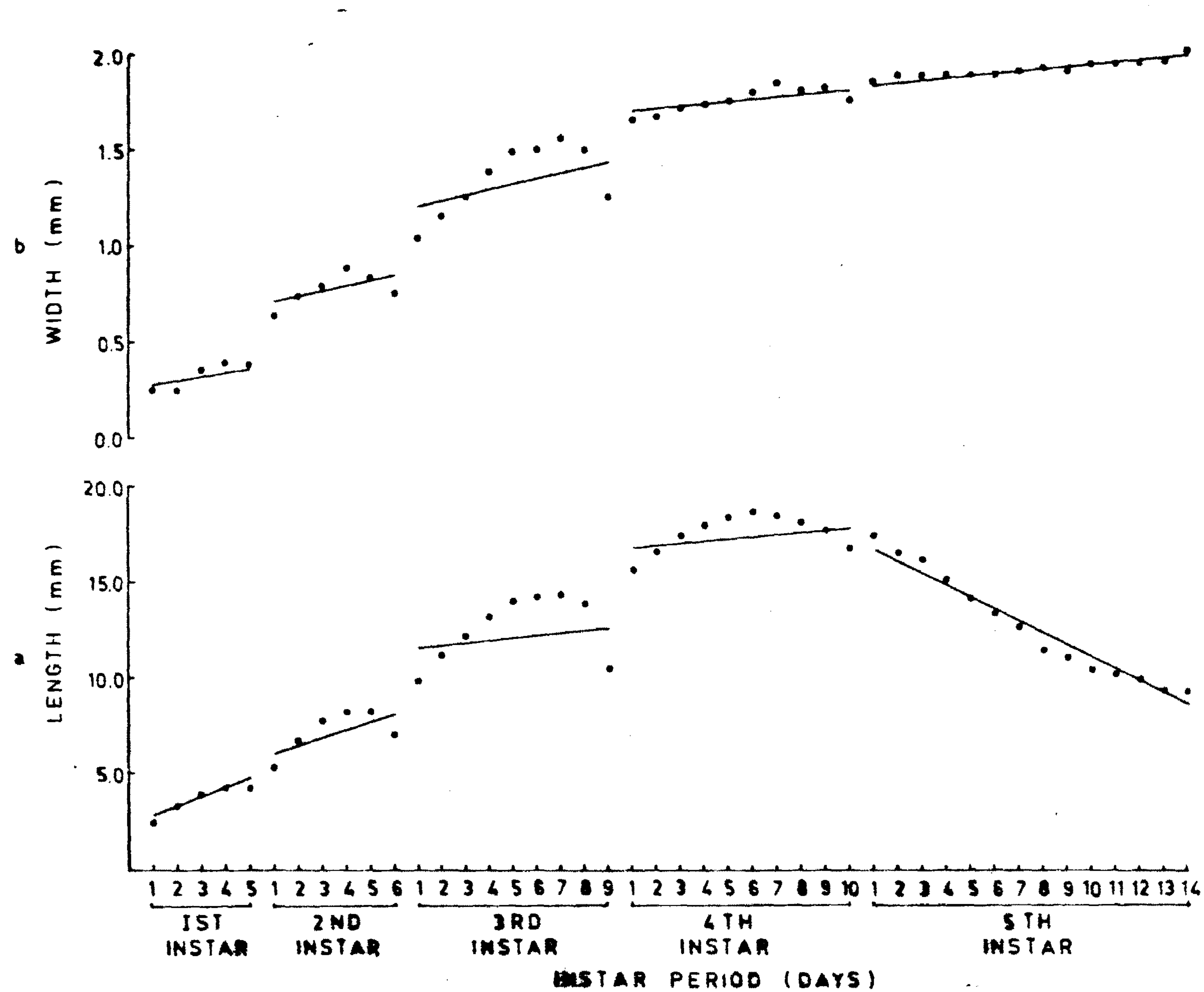
TEXT FIG. 1.2 INSTARWISE GROWTH (LENGTH, a; WIDTH, b) OF LARVAE WITH FOUR INSTARS

Similarly, in case of larvae with five instars a decrease in length during the fifth instar has been observed (Text Fig. 1.3,a) while a gradual increase in width in all the different larval instars has been recorded (Text Fig.1.3,b) as in case of larvae with four larval instars. It thus appears that maximum larval length is attained during the last but one instar stage i.e., during the third instar stage in case of larvae with four instars and during the fourth instar stage in case of larvae with five instars. In general it may be said that larval length and width in case of larvae with four instars are slightly more than that of larvae with five instars.

In between the two instars the old skin ruptures around the junction of the head and thorax. The exuviae works out at the caudal end while the head capsule is thrown out at the anterior end.

Larva (Fig. 1.1,b) subcylindrical in form, being slightly flattened laterally. Body soft, fleshy and light yellow in colour. Head elongated with its sides almost parallel. Antenna very short, two segmented. Second segment bears a hyaline lobe and few very minute lobe lets (Figs. 1.3 and 1.4).

Prothorax largest among the thoracic segments, almost equal to meso- and metathoracic segments together. Posterior third of pronotum asperate except a small area at the mid posterior region. Two raised lateral lines run obliquely from near the mid posterior towards the anterolateral margin of pronotum. A faint median furrow



TEXT FIG. 1.3 INSTARWISE GROWTH (LENGTH, a; WIDTH, b) OF LARVAE WITH FIVE INSTARS

Explanation of Figure

Figure 1.3 : Larval antenna x 240

Figure 1.4 : Larval antenna x 120

FIG. 1.3

FIG. 1.4

runs along the mid-dorsal line from the posterior third to the anterior end (Fig.1.5). Mesothoracic spiracle shifted to prothoracic segment and is largest in size (Fig. 1.6) Mesothoracic spiracle rudimentary. Thoracic legs absent.

Abdomen ten segmented. First to seven abdominal segments large, fleshy, each bears dorsal and ventral protuberances or ampullae, helping movement of the apodous larvae. Dorsal ampulla of the first abdominal segment bears a faint semicircular furrow. Lateral sides of first dorsal ampulla extend to the lateral furrows delimiting the dorsal ampulla. On either side of the base of the semicircular furrow, surface texture is spiculate. Spiculate area anterior to the base of the semicircular furrow divided into two groups by a median furrow. Three setae on either side of the ampulla posterolaterally (Fig. 1.7). Nature of the semicircular furrow and the spiculate area of dorsal ampullae of second to seventh segments have been shown in Figs. 1.8 to 1.13. Second dorsal ampulla more or less similar to the first except the median furrow which is indistinct. Third and fourth ampullae slightly less spiculate than the second while the sixth ampulla is more spiculate than the first to fifth ones. Seventh ampulla slightly less spiculate than the sixth. Pleural tubercles are prominent, each bears two setae (Fig.1.14). Ninth segment longer than others. Tenth segment comprises lobes around the anus. Anus is trilobate (Fig.1.15).

Explanation of Figure

Figure 1.5 : Median furrow along the mid-dorsal line of larval pronotum × 25

Figure 1.6 : Mesothoracic spiracle shifted to prothoracic segment × 25

Figure 1.7 : Ampulla (1st) showing the semicircular furrow & spicules × 50

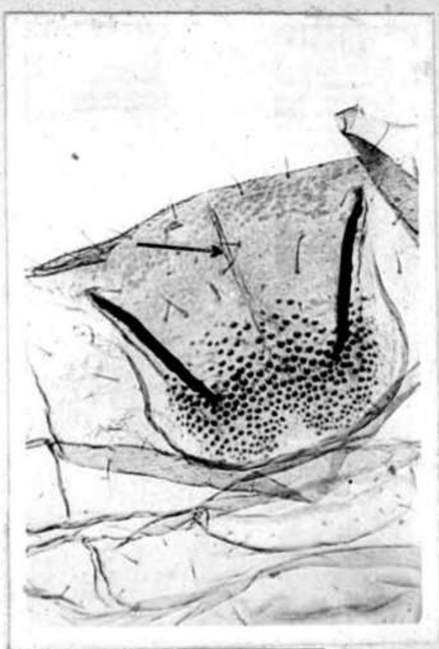


FIG. 1.5

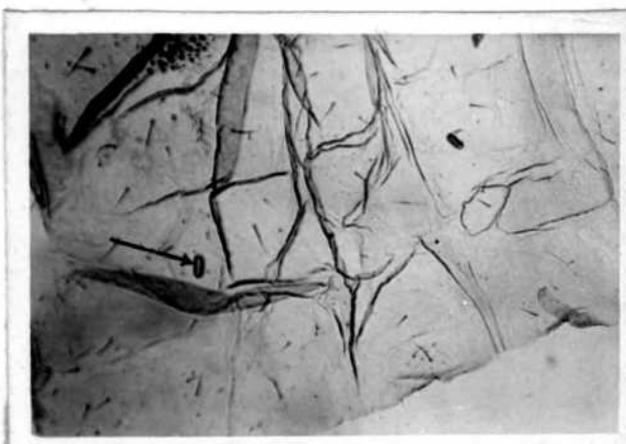


FIG. 1.6

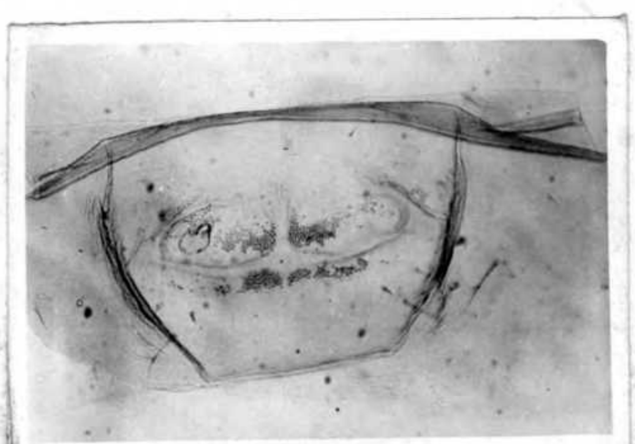


FIG. 1.7

Explanation of Figure

Figure 1.8 : Ampulla (2nd) showing the semicircular furrow & spicules × 50

Figure 1.9 : Ampulla (3rd) showing the semicircular furrow & spicules × 50

Figure 1.10: Ampulla (4th) showing the semicircular furrow & spicules × 50

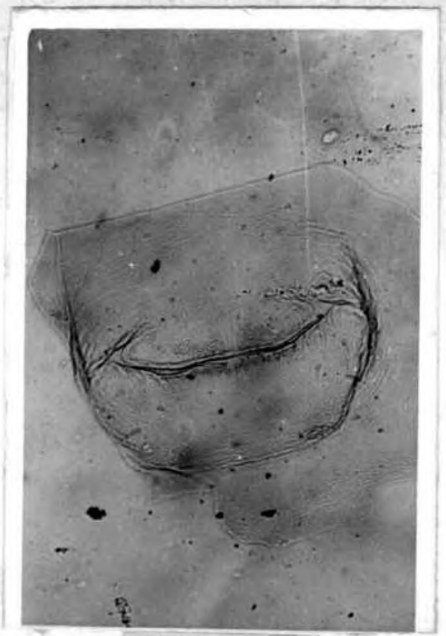


FIG. 1.8

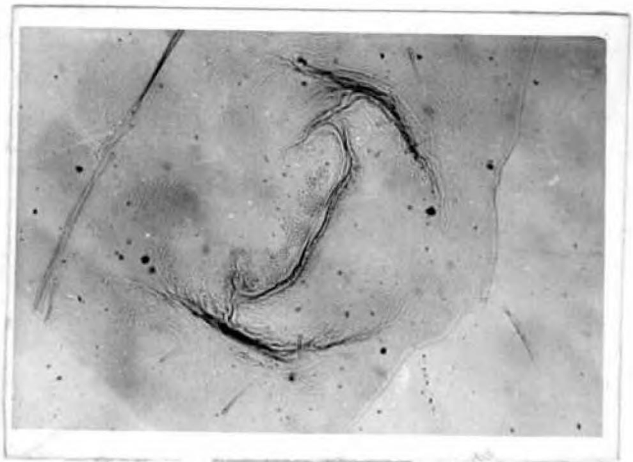


FIG. 1.9

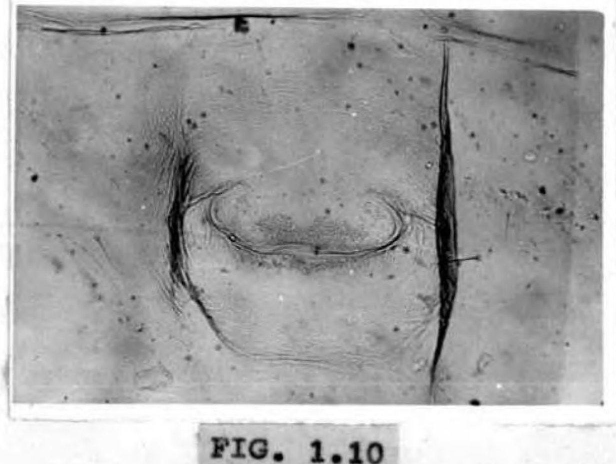


FIG. 1.10

Explanation of Figure

Figure 1.11 : Ampulla (5th) showing the semicircular furrow & spicules × 50

Figure 1.12 : Ampulla (6th) showing the semicircular furrow & spicules × 50

Figure 1.13 : Ampulla (7th) showing the semicircular furrow & spicules × 50

FIG. 1.11

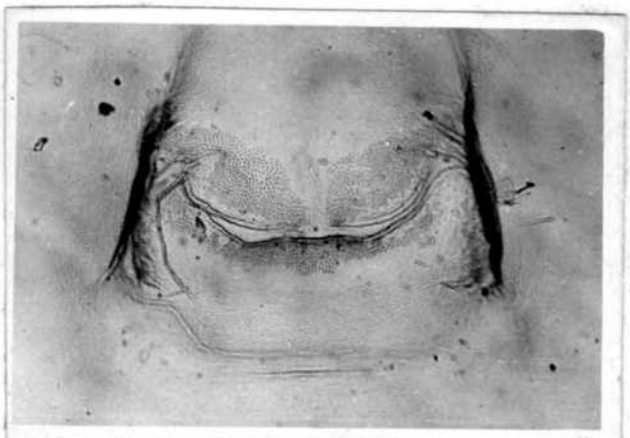


FIG. 1.12

FIG. 1.13

Explanation of Figure

Figure 1.14 : Pleural tubercle with setae × 50

Figure 1.15 : Anal lobes × 50

FIG. 1.14

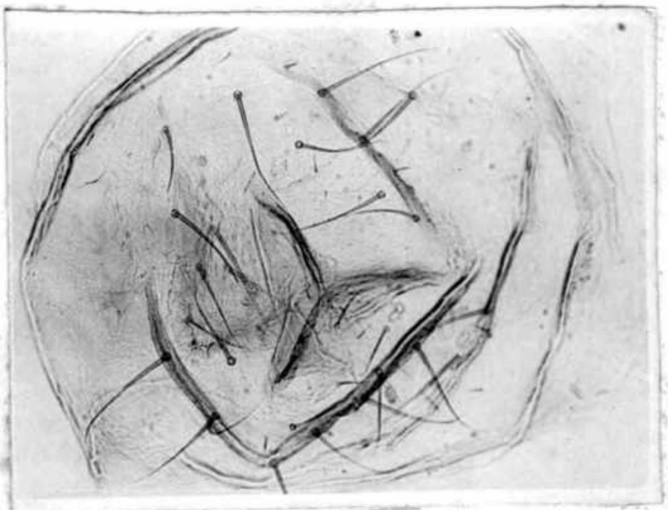


FIG. 1.15

(iii) Pupa

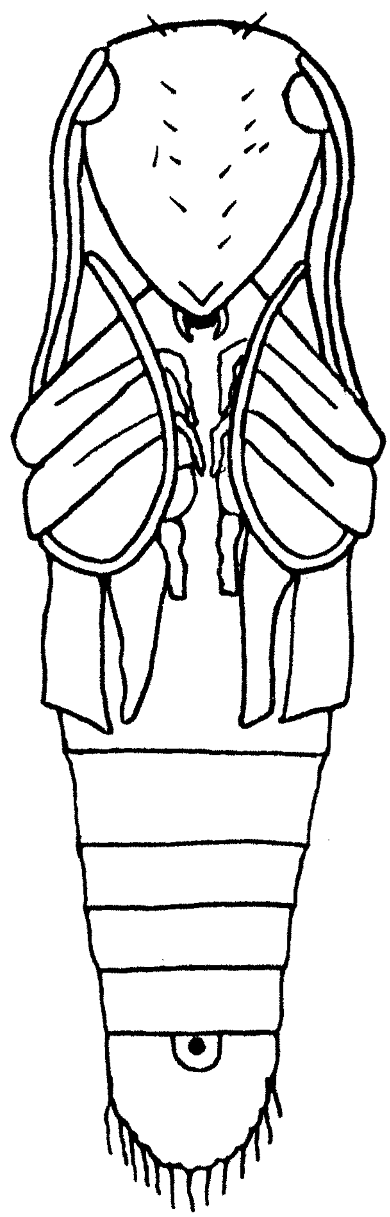
Pupation takes place inside the stem. Before entering into the pupal stage the prepupal larva plugs the two ends of the chamber with frass of wood. Pupa (Fig 1.1,c) more or less resembles the adult both in size and shape. The pupa obtained from four instar Larvae is slightly bigger in size than those obtained from five instar larvae is slightly longer than those obtained from four instar larvae under similar laboratory condition (Table 1.4). It may, however, be mentioned here that the ranges of pupal length, pupal width and pupal period obtained from five instar larvae are more than those pupae obtained from four instar larvae.

Table 1.4 : Pupal size and pupal period of pupae obtained from four and five instar larvae

Instar	Mean pupal length(mm) ± S.E.	Mean pupal width(mm) ± S.E.	Mean pupal period(days) ± S.E.	Temperature°C	
				Maximum	Minimum
4-instar larvae (Mean of 8 obs.)	9.81±0.20 (9.00-10.50)	2.03±0.03 (2.00-2.25)	7.75±0.24 (7-9)	31.0	28.0
5-instar larvae (Mean of 12 obs.)	8.83±0.22 (8.00-10.00)	1.96±0.04 (1.75-2.25)	8.83±0.40 (7-11)	31.0	28.0

Range in parenthesis

The pupa is exarate, pale yellowish in colour. The antennae extend beyond the mid-femora (Text Fig. 1.4). Eyes convex. Abdominal



TEXT FIG. 1.4 PUPA

targites have groups of short spines. Ninth abdominal segment bears setae. A few days always elapse in the pupal chamber before the adult emergence. Such resting period is necessary for hardening of wings and body cuticle.

SECTION II

ECOLOGICAL BACKGROUND OF ADULT BEHAVIOUR AND DAMAGE

Bhattacharjee (1981) referred to the soybean girdler as *Obereopsis* (=*Oberea*)*brevis* Swed. as one of the serious pests of soybean. Earlier workers (Singh and Singh, 1966; Rawat *et al.* ,1969; Kapoor *et al.*,1971 Gangrade *et al.*, 1971; Srivastava *et al.*,1972; Gangrade, 1974 & 1975; Srivastava and Singh, 1976; Singh and Gangrade, 1977; Singh *et al.*, 1978; Singh, 1980; Bhattacharya and Rathore, 1980) referred to this species as *Oberea brevis*. During the investigation by the present author, the name *Obereopsis brevis* Swed. has been used for soybean girdler in place of *Oberea brevis* Swed. as revised by Breuning (1955) and also referred by Bhattacharjee (1981).

Even though the soybean girdler, *O.brevis* has been reported from Southern, Northern and Central India by various workers namely, Ayyar, 1963; Singh and Singh, 1966; Gangrade et al.,1971; Gangrade, 1974; Bhattacharya and Rathore, 1980; and Bhattacharjee, 1981 but occurrence of the pest from Eastern India including Khasi hills of Meghalaya (Sachan and Gangwar, 1980) and West Bengal was not reported. Balduf (1923), Myers (1940), Kretzschmar (1948), Blickenstaff and Huggans (1962), and Tugwell *et al.*(1973) reported soybean insects from different regions of United States where approximately 57 per cent of world's total soybean area is under the crop. Neither of the aforesaid authors, however, reported the occurrence of *O.brevis* from any part of U.S.A. Neither, the pest was reported from Argentina

(Rizso, 1972; Corseuil *et al*.,1974) nor from Brazil (Ferreira, 1970), China (Cheu, 1944), Japan (Clausen, 1931; Kurosawa and Matsumoto, 1961; Kobayashi *et al*. ,1972), Mexico (Pacheco, 1970), Surinam (Van Dinther, 1956), Tanzania (Robertson, 1969) and Venezuela (Guagliumi, 1966) which are the important soybean growing countries of the world. The soybean pests as reported by all these aforesaid authors include various types of pest species other than the soybean girdler, *O.brevis*.

It appears that the soybean girdler, *O.brevis* occurs particularly in India. Soybean (*Glycine max* (L.)Merr.,Fam.Leguminoseae) is mainly grown in the Indian States of Madhya Pradesh and to a lesser extent in Uttar Pradesh. In other States of the country including West Bengal soybean is grown in a limited area inspite of its importance as an important source of protein and oil. The soybean girdler, *O.brevis* has also been reported to infest other leguminous plants like garden bean, cowpea, niger, urid, moong, other pulses, groundnut as well as wild jute (Fletcher, 1917 & 1919; Singh and Singh, 1966; Kapoor *et al*.,1971; Bhattacharya and Rathore, 1980; Singh *et al*. 1978; Odak and Thakur, 1978).

(i) Adult and adult feeding

Adult males tend to be slightly smaller than the adult females as shown in Fig.2.1. Length and width of adult males and females as in Table 2.1 a,b show an overlapping pattern with a clear indication of a considerable number of males being smaller than females, out of 50 males and 50 females selected at random.

Table 2.1 : Frequency distribution of male and female in different length and width groups

a) Distribution in length groups

Length group (mm)	Frequency (No.)	
	Male	Female
7.0 - 7.5	6	-
>7.5 - 8.0	8	-
>8.0 - 8.5	8	-
>8.5 - 9.0	17	4
>9.0 - 9.5	9	17
>9.5 -10.0	2	21
>10.0 -10.5	-	8
Mean	8.67±0.1	9.80±0.06
Range	(7.0-10.0)	(9.0-10.5)

b) Distribution in width groups

Width group (mm)	Frequency (No.)	
	Male	Female
1.0 - 1.5	11	-
>1.5 - 1.75	23	6
>1.75- 2.0	15	31
>2.0 - 2.25	1	13
Mean	1.78 ±0.02	2.03±0.02
Range	(1.5 -2.25)	(1.75-2.25)

Adults are scanty feeders and feed in a very characteristic fashion either on ridges of the stem and petiole or on the mid ribs and veins from the under surface of the trifoliate leaf. While feeding on the stem they generally select the apical region and scrape it moving upward, making thereby small vertical streaks on apical region of stem. Feeding on petiole is usually done on the ridge on either side of the petiolar groove. While feeding on the leaves they eat upon the mid ribs and veins from the under surface and as a result open spaces along the eaten up mid ribs and veins are left on leaf on which the pest has previously fed. These characteristic feeding symptoms (Fig.2.2) on soybean leaves help in identification of pest under the field condition. Pre-ovipositional period usually ranges from 5-8 days and mating occurs 1-3 days prior to the end of the pre-ovipositional period. Under the laboratory condition it has been observed that a single female can lay about 43 eggs after cutting of girdles and slits either on the stem, petiole or on central leaflet stalk as pre-ovipositional operations.

(ii) <u>Ovipositional operation</u>

Ovipositional process of <u>O.brevis</u> can be divided into two distinct phases namely (a) pre-ovipositional operation on central leaf-let stalk, petiole and stem and (b) oviposition.

(a) Pre-ovipositional operation on central leaf-let stalk, petiole and stem:

Pre-ovipositional operation is done by the mandibles of the females. No earlier workers (Singh and Singh, 1966; Gangrade <u>et al.</u>

Explanation of Figure

Figure 2.1 : Adults : Male & Female

Figure 2.2 : Characteristic feeding symptoms by the adult on veins and mid ribs of trifoliate soybean leaf

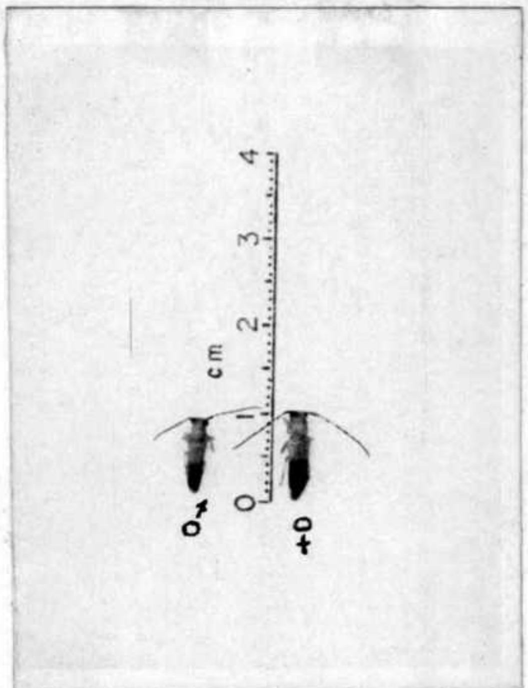


FIG. 2.1

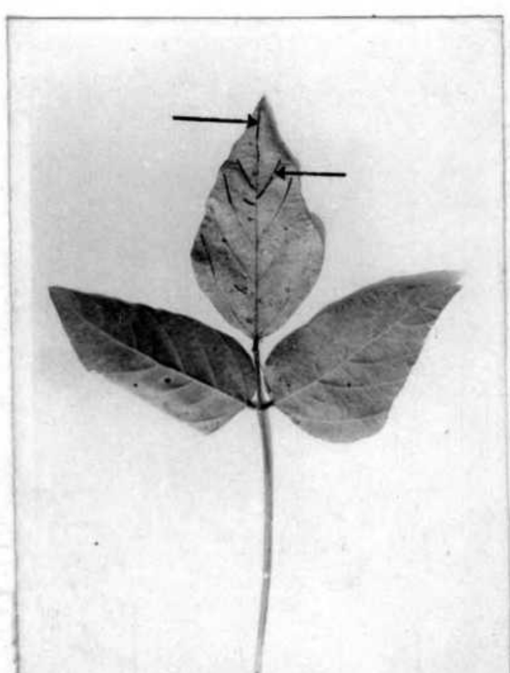


FIG. 2.2

1971; Bhattacharya and Rathore, 1980) have accurately observed the pre-ovipositional mandibular operation of O.brevis. Singh and Singh (1966) reported cutting of two girdles and three small punctures on a transverse line just above the lower girdle while Gangrade et al.(1971) stated that female drills one to three holes just above the lower girdle. Dutt (1915) who reported Nupserha sp. as a soybean stem borer observed cutting of two girdles on the stem and puncturing it above the lower girdle as pre-ovipositional operation. None of these aforesaid workers elucidated as to how an odd number of punctures can be cut by the paired mandibles nor made any reference to the wider central puncture. These authors neither provided any explanation for making the central puncture wider than the two lateral ones.

Present author has observed that after selecting the site for egg laying, the female with its head facing downward cuts the lower girdle first around the stem by mandibular insertions and then makes a complete turn with its head facing upward and cuts the upper girdle. After cutting of the upper girdle, the female turns its head again downward to cut the slit in between the two girdles at any point nearer the lower girdle. The average time taken for cutting the lower girdle, upper girdle and the slit on stem, petiole and central leaf-let stalk is shown in Table 2.2 below.

Table 2.2 : Time taken for ovipositional operation on central leaf-let stalk, petiole and stem (mean of 4 observations)

Site of operation	Average time (min. - sec.) for			
	cutting of lower girdle	cutting of upper girdle	cutting of slit	Ovipo-sition
Central leaf-let stalk	3-20	3-30	1-40	2-18
Petiole	4-56	5-11	1-39	2-32
Stem	4-54	5-31	1-26	2-23

It may be seen from the Table above that the time taken for gisdling on central leaf-let stalk is comparatively less possibly because of its thinness in comparison to stem and petiole. The time taken for cutting the slit on stem, petiole and central leaf-let stalk is more or less similar. The girdles irrespective of their cutting on central leaf-let stalk, petiole or stem consist of indentation holes as shown in Figs. 2.3, 2.4 and 2.5. As a result of mandibular insertions, different tissues from the epidermis down to the periphery of pith tissue are damaged along the path of the insertion (Figs. 2.6, 2.7 and 2.8). The slit irrespective of its cutting either on the stem, petiole or on central leaf-let stalk consists of a central pit bordered by two lateral punctures (Figs. 2.9, 2.10 and 2.11). The central pit and the two lateral punctures are made by two successive identations cut on the same horizontal level as illustrated in Text Fig. 2.1a, b. It is obvious that during second insertion of mandibles, one is placed in one corner

Explanation of Figure

Figure 2.3 : Indentation holes on central leaf-let stalk × 25

Figure 2.4 : Indentation holes on petiole × 25

Figure 2.5 : Indentation holes on stem × 25

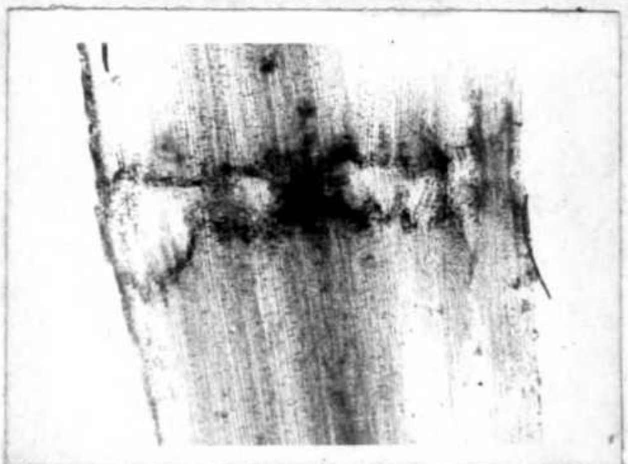


FIG. 2.3

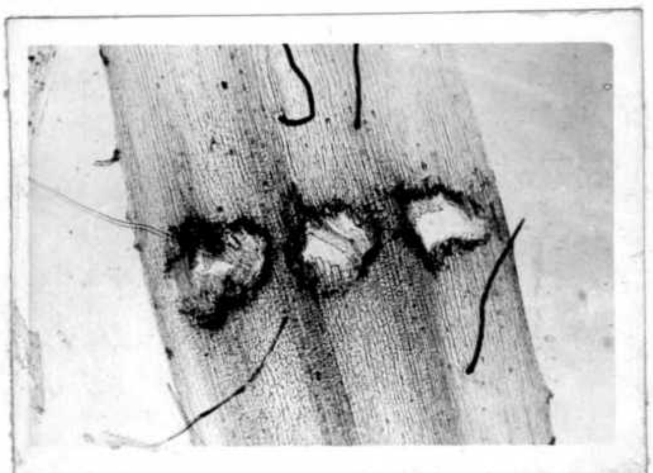


FIG. 2.4

FIG. 2.5

Explanation of Figure

Figure 2.6 : Nature of tissue damage in central leaf-let stalk × 50

Figure 2.7 : Nature of tissue damage in petiole × 25

Figure 2.8 : Nature of tissue damage in stem × 25

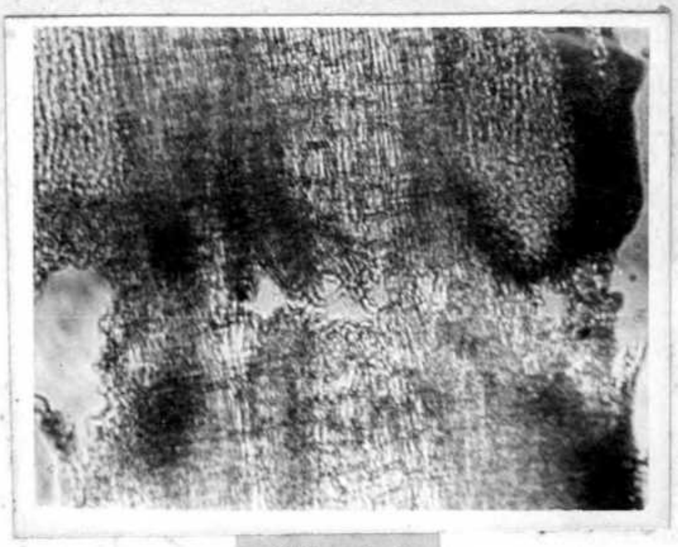


FIG. 2.6

FIG. 2.7

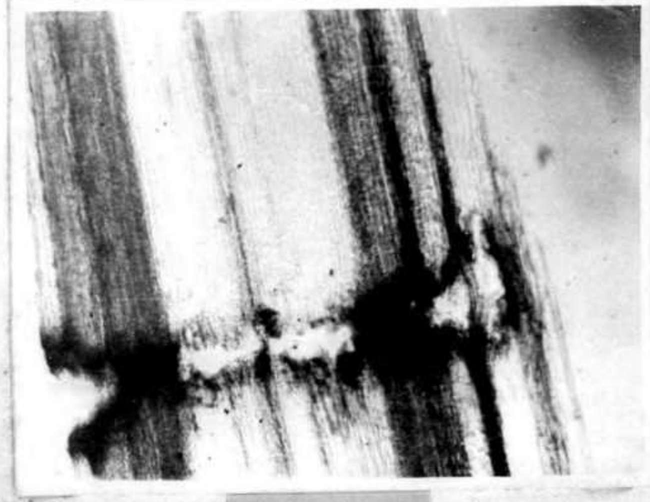


FIG. 2.8

Explanation of Figure

Figure 2.9 : The central pit and the two lateral punctures of the oviposition slit in central leaf-let stalk × 50

Figure 2.10 : The central pit and the two lateral punctures of the oviposition slit in petiole × 50

Figure 2.11 : The central pit and the two lateral punctures of the oviposition slit in stem × 50

FIG. 2.9

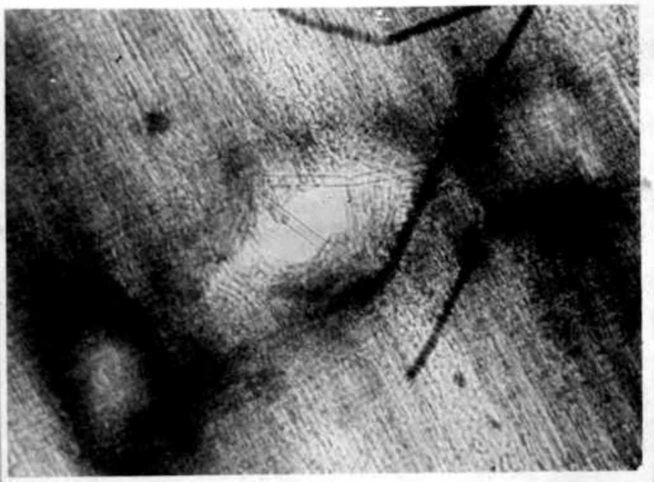


FIG. 2.10

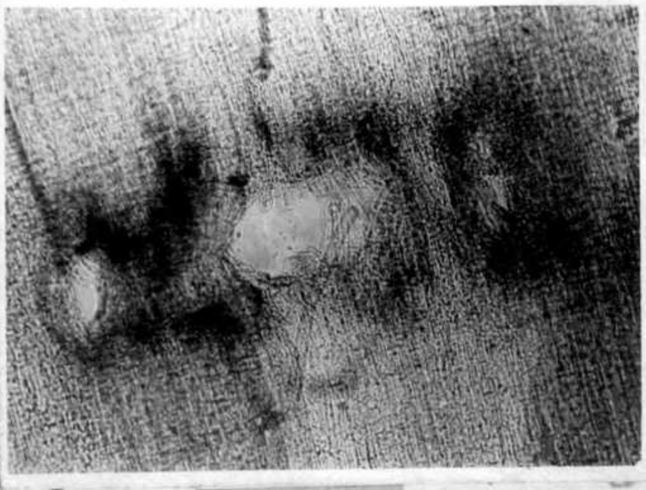
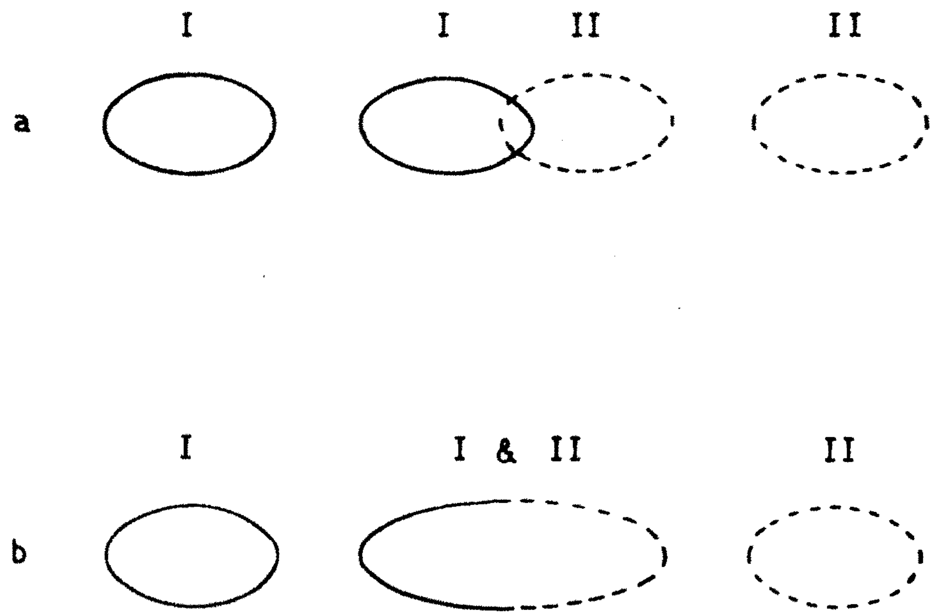


FIG. 2.11



TEXT FIG. 2.1 DIAGRAMMATIC REPRESENTATION SHOWING FORMATION OF OVIPOSITION SLIT BY TWO SUCCESSIVE INDENTATIONS OF MANDIBLES: a, FIRST (I, I) AND SECOND (II, II) INSERTIONS; b, LATERAL PUNCTURES (I, II) AND THE CENTRAL PIT (I & II) of one of the punctures already made by the previous indentation. The two inner insertions or indentations coalesce so as to make a central wider pit than the lateral punctures. The central pit and the lateral punctures penetrate down to the pith tissue. That the central pit is the resultant of two mandibular insertions is also supported by the fact that the width of the central pit is more or less equal to the widths of two lateral punctures taken together. The central pit is also wide enough to allow entry of the genital capsule through it for oviposition and not through the lateral punctures (Table 2.3). Dutt (1956a) reported a similar

Table 2.3: Width of central pit and lateral punctures of the slit cut on central leaf-let stalk, petiole and stem and the genital capsule of the female

Site of slit	Width in mm (average of 15-22)			
	Slit			Genital capsule
	Central pit	Left lateral puncture	Right lateral puncture	
Central leaf-let stalk	0.4242±0.008	0.2052±0.005	0.2081±0.004	-
Petiole	0.4276±0.014	0.2118±0.008	0.2087±0.005	-
Stem	0.4265±0.016	0.2078±0.006	0.2011±0.007	-
Genital capsule	-	-	-	0.40±0.009

method of cutting a central pit and two lateral punctures by two ~~lateral punctures by two~~ successive mandibular insertions by N.b.postbrunnea infesting olitorius jute.

(b) Oviposition:

After the slit has been cut, the female turns its head upward again and places the tip of the abdomen against the pit of slit for oviposition. The cylindrical genital capsule (Fig. 2.12) is pushed through the pit and the egg is laid in the periphery of pith tissue just above the end of the passage. It is also evident from Table 2.3 that the lateral punctures are too narrow for the entry of the genital capsule while the central pit is wide enough for its entry and is used as a passage for laying of egg inside the stem, petiole or central leaf-let stalk.

(iii) Girdling and damage

Feeding of the adults on mid ribs and veins of leaf-lets from the under surface or scraping on petioles or stems have no visible adverse effect on the growth of host soybean plants. Feeding of the borer larva on the inner pith tissue of stem has little or negligible adverse effect on the host plant which can grow with the borer inside. This observation is in agreement with that of Gangrade et al. (1971) but contradicts observations of Ayyar (1963) and Singh & Singh (1966) who reported that the whole plant may be killed by a single borer larva. Damage, it is obvious, is done by the ovipositing female at the time of girdling as a pre-ovipositional operation. Since a single female can lay about 43 eggs under the laboratory condition, it is apparent that a single female can cause damage to as many plants as the number of eggs a single female can lay which is likely to be more than 43 under field condition.

When girdling is done on the central leaf-let stalk, central leaf-let withers and dies (Fig.2.13); when girdles are cut on the petiole the trifoliate leaf with its three leaf-lets withers and dies from above the level of the lower girdle (Fig.2.14). Cutting of girdles on the stem (Fig. 2.15) results in loss of considerable portion of stem length ranging from 4.0 - 29.5 cm (Table 2.4) including a number of leaves. It is thus apparent that damage to soybean crop by O.brevis is due to cutting of girdles on the stem. Feeding by the adults or by the larva or girdling on the petiole or on central leaf-let stalk has little or no appreciable adverse effect on growth of the affected soybean plant.

It may be seen from Table 2.4 that loss of stem length ranging from >5 cm to 15 cm due to girdling on that portion of the stem where the diameter falls within the range of >2.2 mm to 3.1 mm, is more frequent. Frequency distribution of stem length lost under different length classes has been shown in Text Fig.2.2. Similarly Text Fig. 2.3 shows the frequency distribution of stem diameter classes where girdles are cut in eight soybean varieties. Unlike other pests of the crop O.brevis is responsible for direct loss of considerable portion of stem length which bear the fruits. Such equivalent decrease in the stem length can only be caused by other pests of the crop only at a very high level of incidence. Since the pest is capable of causing considerable loss of stem length even at a low level of incidence, it is rational to consider it as one of the major pests of soybean.

Explanation of Figure

Figure 2.12 : Genital capsule x 25

Figure 2.13 : Girdling on central leaf-let stalk showing the dying central leaf-let above the level of lower girdle

a) upper girdle
b) lower girdle
c) slit

Figure 2.14 : Girdling on petiole showing death of the trifoliate leaf above the level of lower girdle

a) upper girdle
b) lower girdle
c) slit

Figure 2.15 : Girdling on stem showing death of the stem above the level of lower girdle

a) upper girdle
b) lower girdle
c) slit

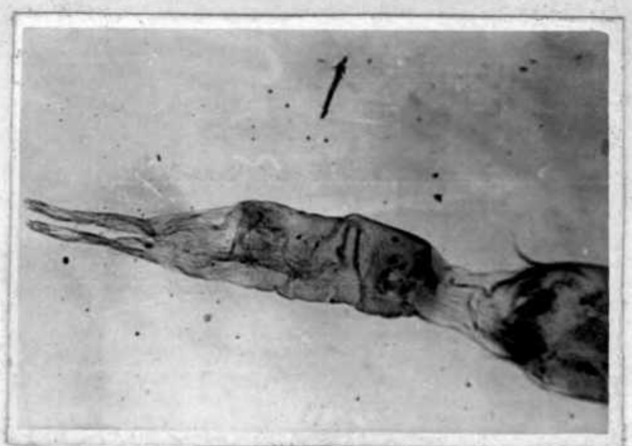


FIG. 2.12

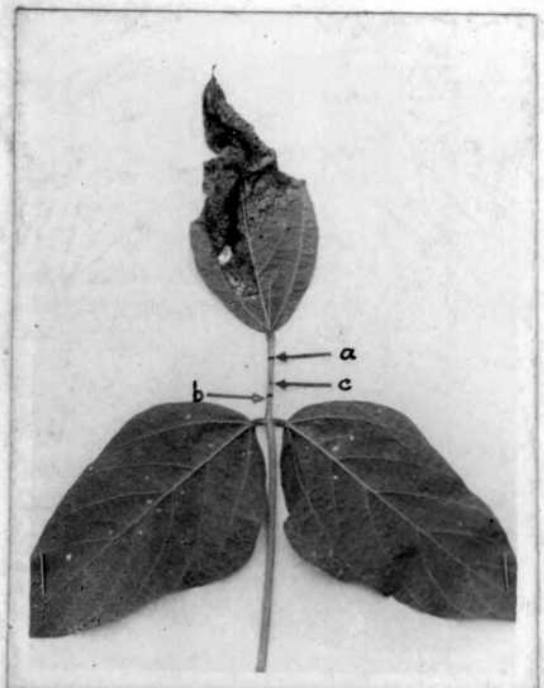


FIG. 2.13

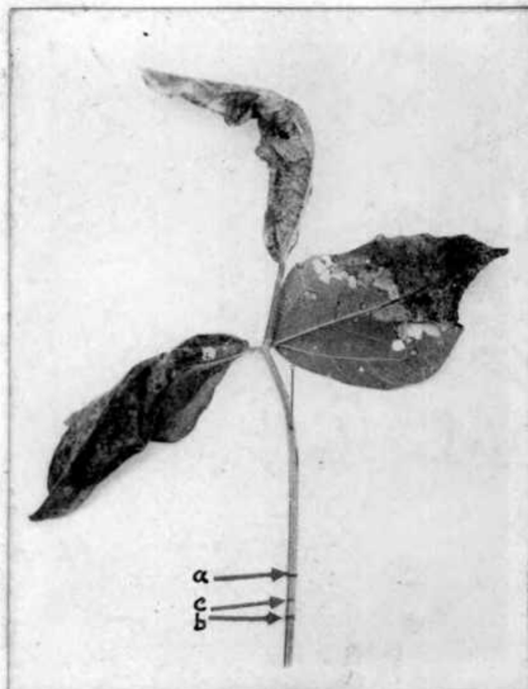


FIG. 2.14

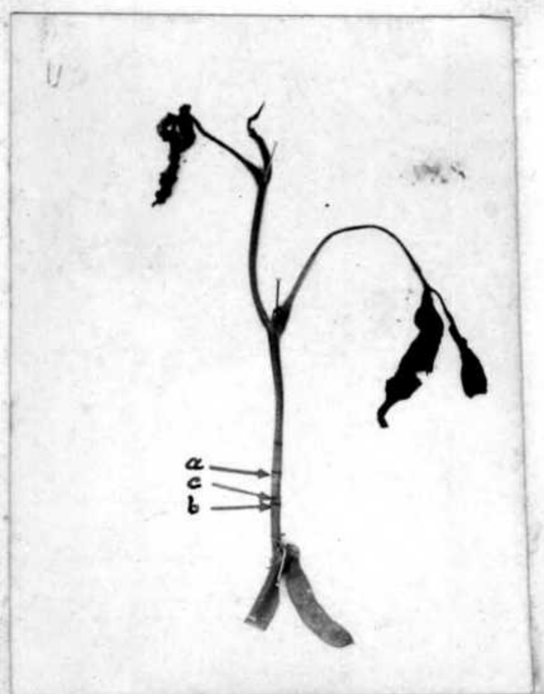
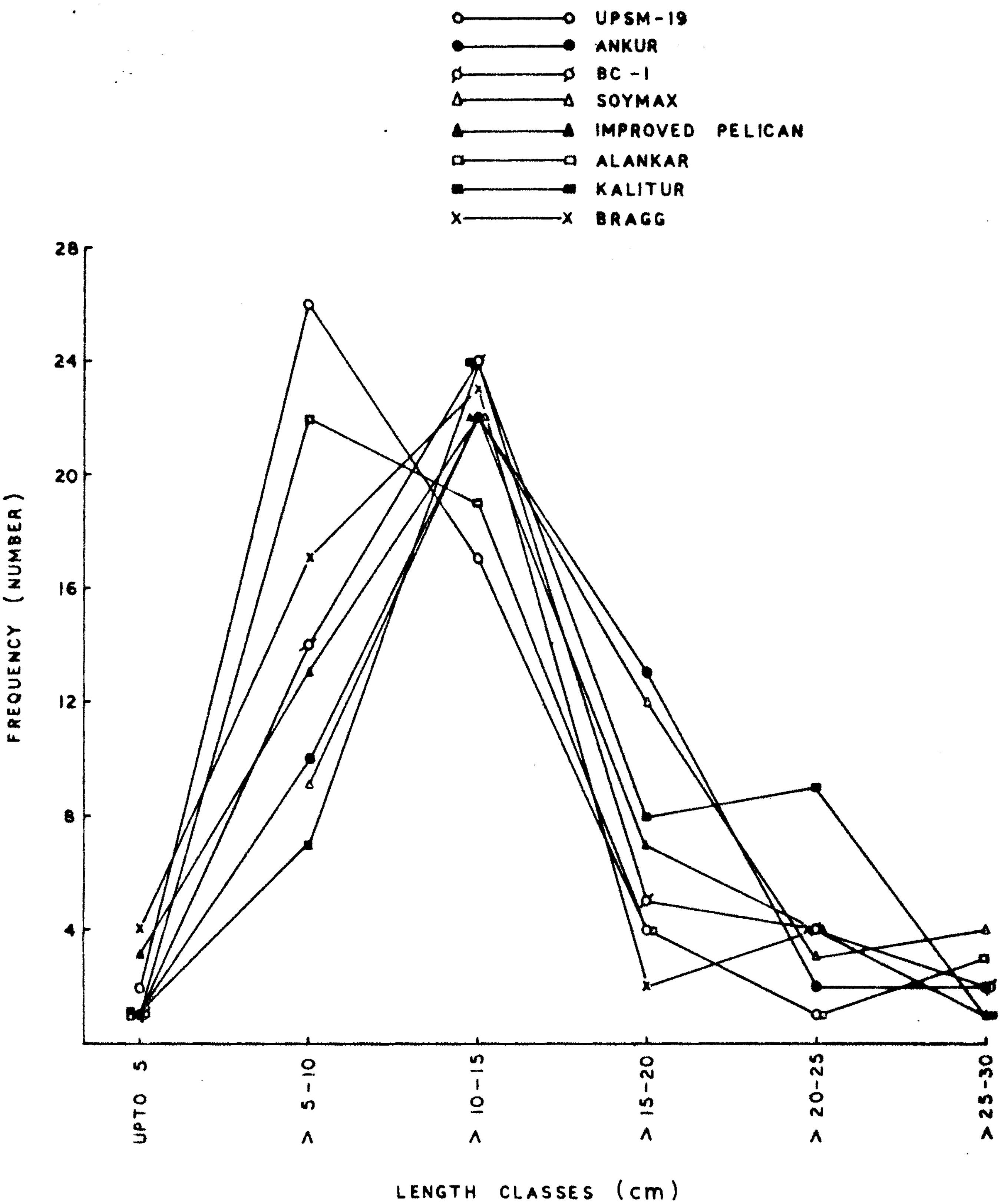
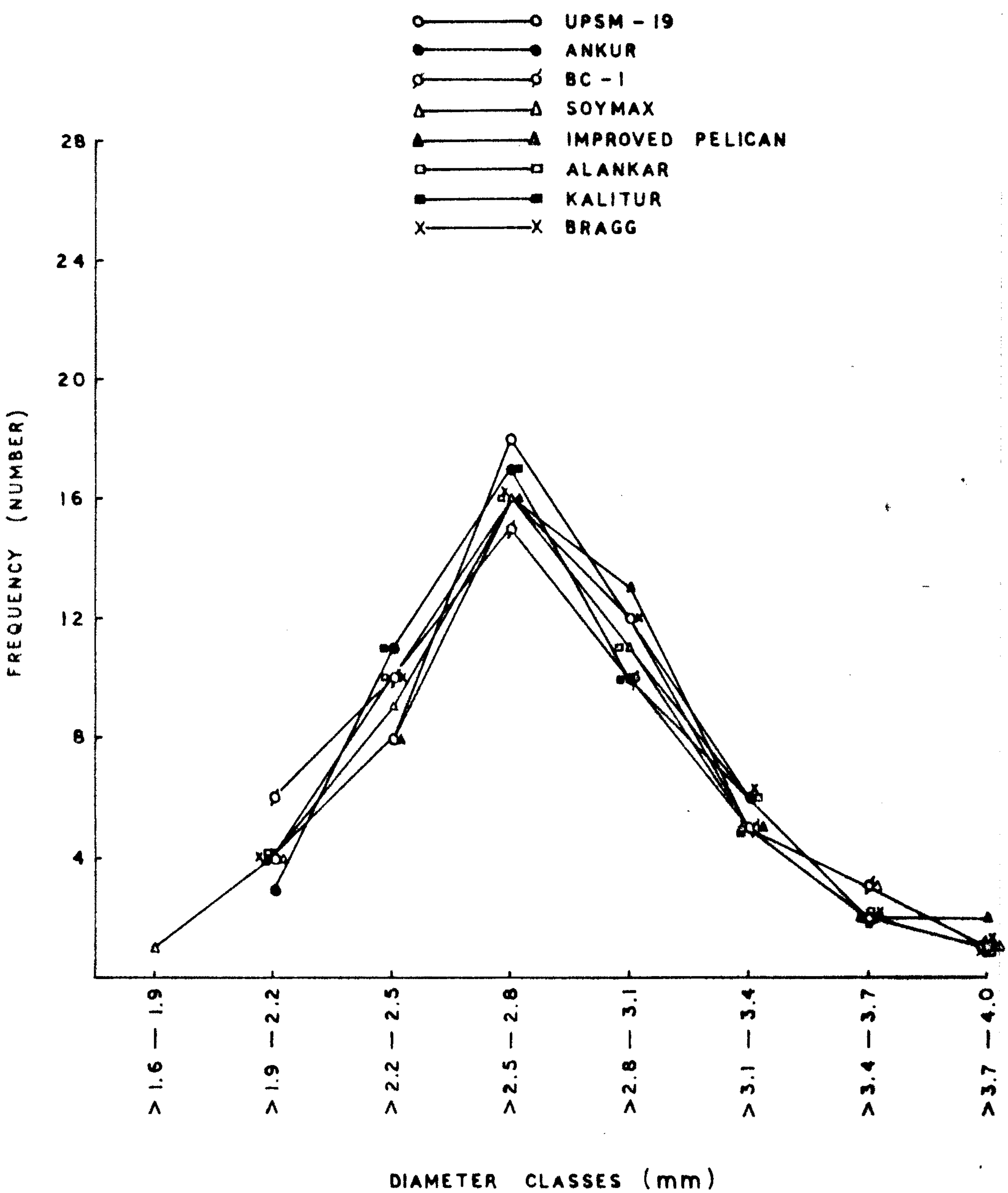


FIG. 2.15



TEXT FIG. 2.2 FREQUENCY DISTRIBUTION OF STEM LENGTH LOST UNDER DIFFERENT LENGTH CLASSES



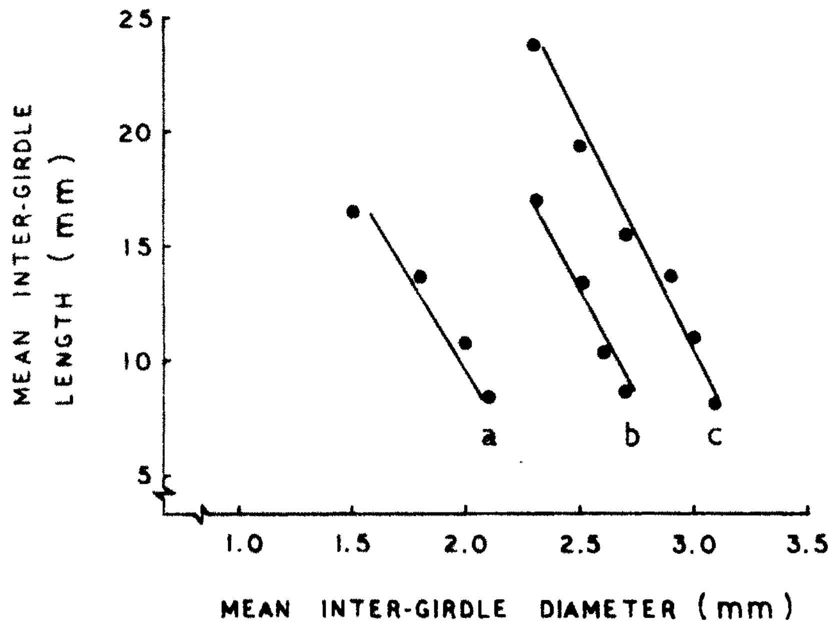
TEXT FIG. 2.3 FREQUENCY DISTRIBUTION OF STEM DIAMETER CLASSES WHERE GIRDLES ARE CUT IN EIGHT SOYBEAN VARIETIES

Table 2.4: Frequency distribution(number)of stem length lost due to girdling in different diameter classes

Length class (cm) / Diameter class (mm)	Stem length lost from above the lower girdle in cm								
	upto 5	>5-10	>10-15	>15-20	>20-25	>25-30	>30-35	Total	Per cent
>1.6-1.9	-	-	-	-	-	-	-	-	-
>1.9-2.2	1	14	11	4	4	-	-	34	8.50
>2.2-2.5	2	26	24	13	8	4	-	77	19.25
>2.5-2.8	1	39	66	17	5	3	-	131	32.75
>2.8-3.1	3	23	40	12	7	4	-	89	22.25
>3.1-3.4	5	10	16	7	3	2	-	43	10.75
>3.4-3.7	1	3	11	1	1	-	-	17	4.25
>3.7-4.0	-	3	5	1	-	-	-	9	2.25
>4.0-4.3	-	-	-	-	-	-	-	-	-
Total	13	118	173	55	28	13	-		
Per cent	3.25	29.50	43.25	13.75	7.00	3.25	-		

(iv) <u>Relationship between intergirdle length of stem, petiole or central leaf-let stalk and diameter & moisture content</u>

Intergirdle length of stem, petiole and central leaf-let stalk and their diameter were recorded from 100 observations from each of girdled stem, petiole and central leaf-let stalk. It may be seen from Text Fig. 2.4 and Table 2.5 that intergirdle length increases with decrease in diameter of stem, petiole or central leaf-let stalk. Frequency distribution in per cent within different



TEXT FIG. 2.4 INCREASE IN INTER-GIRDLE LENGTH WITH DECREASE IN INTER-GIRDLE DIAMETER IN CENTRAL LEAF-LET STALK (a); PETIOLE (b) AND STEM (c) intergirdle length groups of stem, petiole and central leaf-let stalk have been presented in Table 2.6. It may be seen from the Table that frequency distribution of girdling in all cases of stem, petiole or central leaf-let stalk is maximum where the intergirdle langth ranges from > 6.0 to 15.0 mm.

Table 2.5: Relationship between different intergirdle lengths(mm) with intergirdle diameters(mm) of central leaf-let stalk, petiole and stem (mean of 100 observations)

Central leaf-let stalk		Petiole		Stem	
Mean Inter-girdle length (mm)	Mean Inter-girdle diameter (mm)	Mean Inter-girdle length (mm)	Mean Inter-girdle diameter (mm)	Mean Inter-girdle length (mm)	Mean Inter-girdle diameter (mm)
8.4	2.1	8.2	2.7	8.1	3.1
10.7	2.0	10.4	2.6	11.0	3.0
13.7	1.8	13.4	2.5	13.6	2.9
16.5	1.5	17.0	2.3	15.5	2.7
				19.3	2.5
				23.6	2.3

Moisture content of intergirdle portion as shown in Table 2.7 under six length x diameter groups of stem, four length x diameter groups of each petiole and central leaf-let stalk was determined 48 hrs., 72 hrs. and 96 hrs. after artificially cutting girdles by needle on stem, petiole and central leaf-let stalk. Moisture

Table 2.6 : Frequency distribution(%) of different intergirdle lengths(mm) of central leaf-let stalk, petiole and stem

Central Leaf-let stalk		Petiole		Stem	
Intergirdle length groups (mm)	Frequency (%)	Intergirdle length groups (mm)	Frequency (%)	Intergirdle length groups (mm)	Frequency (%)
>6.0- 9.0	21.0	>6.0- 9.0	29.0	>6.0- 9.0	16.0
>9.0-12.0	50.0	>9.0-12.0	37.0	>9.0-12.0	26.0
>12.0-15.0	23.0	>12.0-15.0	25.0	>12.0-15.0	32.0
>15.0-18.0	6.0	>15.0-18.0	9.0	>15.0-18.0	14.0
>18.0-21.0	-	>18.0-21.0	-	>18.0-21.0	8.0
>21.0-24.0	-	>21.0-24.0	-	>21.0-24.0	4.0

contents of similar length x diameter groups were also determined from ungirdled stem, petiole and central leaf-let stalk. A gradual decrease in moisture content from the ungirdled to girdled pieces of stem, petiole and central leaf-let stalk has been shown in Table 2.7.

It may be seen from the Table that at the end of 96 hrs. after girdling the moisture content in different groups of inter-girdle portion comes down to the extent ranging from 62.04 per cent to 65.88 per cent in case of stem, from 67.51 per cent to 68.43 per cent in case of petiole and 63.08 per cent to 64.11 per cent in case of central leaf-let stalk from the original. Since the girdled petiolar piece may have 71.95 per cent moisture content at the end of 72 hours and since incubation period may also be 72 hours (range being 3-4 days) and since the original moisture content in central leaf-let stalk was to the maximum extent of 70.67 per cent, it is possible that reduction in moisture content in the intergirdle portion may not

Table 2.7: Decrease in moisture content in artificially girdled stem, petiole and central leaf-let stalk (mean of 4 observations)

Intergirdle length x diameter groups (mm)	Moisture Content (%)			
	Ungirdled (normal)	Girdled after hours		
		48	72	96
<u>Stem</u>				
i) 8.1x3.1	72.15	69.59	67.46	65.43
ii)11.0x3.0	74.81	68.59	66.88	65.88
iii)13.6x2.9	74.05	69.98	67.22	65.24
iv)15.5x2.7	73.65	69.05	66.22	63.96
v)19.3x2.5	72.19	71.53	67.22	62.04
vi)23.6x2.3	74.33	68.46	66.94	64.14
<u>Petiole</u>				
i) 8.2x2.7	74.42	73.00	70.14	68.43
ii)10.4x2.6	74.42	73.60	71.81	67.51
iii)13.4x2.5	73.90	73.03	69.83	67.98
iv)17.0x2.3	74.87	73.04	71.95	68.34
<u>Central leaf-let stalk</u>				
i) 8.4x2.1	70.04	68.58	65.42	63.08
ii)10.7x2.0	70.26	67.49	66.35	64.11
iii)13.7x1.8	69.17	68.87	65.58	63.23
iv)16.5x1.5	70.67	69.11	66.09	63.25

be a direct physiological necessity for egg development unless the stem, petiole or central leaf-let stalk are very succulent. It is possible that girdling may have indirect effect on the development of egg. To ascertain the effect of girdling on development of egg, a field trial was carried out wherein freshly laid eggs were transferred from the stems of Kalitur variety of soybean to the stems of same variety of similar diameter @ one egg per plant. By means of a scalpel, a longitudinal slit was cut on a fresh stem without any girdling and one egg was placed in the periphery of pith tissue of the plant. To prevent loss of moisture the slit was properly tied by polythene strip. The effect of transfer to an ungirdled stem on egg development was recorded and the result presented in Table 2.8 which shows that 72.0 per cent eggs failed to develop after transfer.

Table 2.8 : Effect of transfer of eggs to ungirdled stem of Kalitur variety of soybean

Eggs transferred (no.)	Eggs developed		Eggs failed to develop	
	(no.)	(%)	(no.)	(%)
50	14	28.0	36	72.0

It has been observed that in several cases callus tissue developed in the region of the cut slit to heal up the wound and in the process crushed the egg inside. Under the field condition healing of wounds at the level of the two girdles are also met with. In such plants neither the eggs develop nor there is death of apical portion of stem above the girdle. On the basis of present observations, it may be concluded that girdles are cut to reduce the moisture content in the intergirdle length which may be a physiological necessity for egg development in cases of more succulent plants and prevention of callus tissue formation at the level of the slit to avoid crushing of eggs.

(v) Relationship between diameter of stem, petiole or central leaf-let stalk and girdling & oviposition

For the purpose of finding out the relationship, if any, between diameter of the stem, petiole, central leaf-let stalk, girdling and oviposition, randomly selected girdled samples of 250 girdled stem, 250 girdled petiole and 250 girdled central leaf-let stalk were taken and their diamoter measured at the level of the slit. Observations were also recorded to find out as to whether girdling and cutting of slit were accompained by egg laying or not. It has been observed that selection of site for girdling is limited to that portion of the stem where the diameter falls within the range of >1.9 mm to 4.0 mm in case of stem; >1.4 mm to 4.0 mm in case of petiole and 1.0 mm to 3.0 mm in case of central leaf-let stalk as shown in Table 2.9 a,b,c.

It may be seen from the Table 2.9 a,b,c that girdling either on the stem, petiole or on the central leaf-let stalk is not done beyond a limited range. Maximum oviposition in case of stem is done where the diameter lies between >2.5 mm to 3.1 mm. Maximum oviposition in case of petiole takes place where the diameter range is from >2.2 mm to 2.8 mm; the diameter range is

Table 2.9 a,b,c: Relationship between girdling,oviposition and diameter of stem,petiole and central leaf-let stalk

a. Stem

Diameter class(mm)	Frequency of girdling			
	With Oviposition		Without oviposition	
	No.	%	No.	%
>1.6-1.9	-	NIL	-	NIL
>1.9-2.2	19	7.6	-	NIL
>2.2-2.5	48	19.2	-	NIL
>2.5-2.8	85	34.0	-	NIL
>2.8-3.1	55	22.0	-	NIL
>3.1-3.4	27	10.8	-	NIL
>3.4-3.7	14	5.6	-	NIL
>3.7-4.0	-	NIL	2	0.8
Total	248	99.2	2	0.8

b. Petiole

Diameter Class(mm)	Frequency of girdling			
	With Oviposition		Without Oviposition	
	No.	%	No.	%
>1.4-1.7	-	NIL	1	0.4
>1.7-1.9	7	2.8	-	NIL
>1.9-2.2	24	9.6	-	NIL
>2.2-2.5	81	32.4	-	NIL
>2.5-2.8	76	30.4	-	NIL
>2.8-3.1	37	14.8	-	NIL
>3.1-3.4	16	6.4	-	NIL
>3.4-3.6	6	2.4	-	NIL
>3.6-4.0	-	NIL	2	0.8
Total	247	98.8	3	1.2

c. Central leaf-let stalk

Diameter class(mm)	Frequency of girdling			
	With Oviposition		Without Oviposition	
	No.	%	No.	%
1.0-1.4	-	NIL	3	1.2
>1.4-1.6	11	4.4	-	NIL
>1.6-1.9	33	13.2	-	NIL
>1.9-2.2	87	34.8	-	NIL
>2.2-2.5	73	29.2	-	NIL
>2.5-2.8	35	14.0	-	NIL
>2.8-3.0	8	3.2	-	NIL
3.1	-	NIL	-	NIL
Total	247	98.8	3	1.2

from > 1.9 mm to 2.5 mm for maximum oviposition in case of central leaf-let stalk. In case of stem no oviposition was observed in 0.8 per cent case of girdling and cutting of slit. In petiole, 98.8 per cent girdling and cutting of slits were accompained by laying of eggs and in 1.2 per cent cases there was no oviposition inspite of girdling and cutting of slit. In central leaf-let stalk, 98.8 per cent girdling was followed by oviposition and in 1.2 per cent cases girdles and slits are cut but no egg was laid as in case of petiole. In central leaf-let stalk no oviposition was done where the diameter range was from 1.0 mm to 1.4 mm inspite of girdling and beyond the diameter of 3.0 mm. No egg was laid in petiole inspite of cutting girdles and slits with diameter > 1.4 mm to 1.7 mm and between

> 3.6 mm to 4.0 mm. In case of stem, no egg was laid with diameter > 3.7 mm to 4.0 mm inspite of cutting girdles and slits and where the diameter range was between > 1.6 mm to 1.9 mm. It is thus evident that a relationship exists between the diameter of stem, petiole and central leaf-let stalk, girdling and cutting of slits and oviposition with an error on the part of the egg laying female ranging from 0.8 - 1.2 per cent. The matter has been further examined in Section V.

(vi) Relative preference for girdling by the ovipositing female on stem, petiole and central leaf-let stalk of different soybean varieties

It has been mentioned before that adult females of *O.brevis* girdle the different regions of soybean plants namely stem, petiole and central leaf-let stalk at two levels and cut slit in between the two girdles but nearer to the lower one as a pre-ovipositional operation. Frequency distribution of girdling on stem, petiole and central leaf-let stalk of eight different soybean varieties namely UPSM-19, Ankur, BC-1, Soymax, Improved Pelican, Alankar, Kalitur and Bragg has been shown in Table 2.10.

Table 2.10 clearly shows that in all the varieties of soybean the highest frequency of girdling has been observed on central leaf-let stalk followed by that on petiole and stem. Present observation on frequency distribution of girdling in different regions of soybean is in contradiction to that of Gangrade *et al.*(1971) who reported highest girdling frequency on petiole and almost equal girdling frequency on stem and central leaf-let stalk.

Table 2.10 : Frequency distribution of preference for girdling at different sites of soybean varieties (1979 and 1980)

Name of the variety	No.of observations (girdling)	Site of girdling					
		Central leaf-let stalk		Petiole		Stem	
		No.	%	No.	%	No.	%
UPSM-19	424	306	72.17	94	22.17	24	5.66
Ankur	982	603	61.41	277	28.21	102	10.38
BC-1	682	355	52.05	173	25.37	154	22.58
Soymax	1081	499	46.16	317	29.32	265	24.52
Improved Pelican	1382	688	49.78	445	32.20	249	18.02
Alankar	906	543	59.93	252	27.82	111	12.25
Kalitur	1022	458	44.81	293	28.67	271	26.52
Bragg	631	396	62.76	199	31.54	36	5.70
Total	7110	3848	54.12	2050	28.83	1212	17.05

SECTION III

BIOMETRICAL ANALYSIS
OF LARVAL GROWTH

Daily observations on larval length and width were recorded from twenty larvae reared separately. These were obtained from eggs, laid by *O.brevis* in the laboratory. Besides, observations on the width of the shed larval head capsule along with its length and width at the end of each instar by each of these larvae were recorded. Variation in the number of larval instars has been observed and 40 per cent of the larvae i.e., eight out of twenty larvae passed through four instars before pupation as against 60 per cent of the larvae passed through five larval instars before entering into the pupal phase. Such variation in the number of instars in case of the Lamiid beetle has also been observed by Hatchett *et al*., 1973 and Hatchett *et al*., 1975.

Biometrical analysis of larval growth characteristics in the light of variation in the number of instars has been done.

(i) Correlation between larval length, larval width and width of head capsule

Correlation studies on larval length, larval width and width of head capsule were carried out separately with larvae having four or five instars.

(a) Larvae with four instars:

Data on the larval length, larval width prior to shedding of head capsule as well as the width of the head capsule in different instars have been shown in Table 3.1. Multiple correlation coefficient has been calculated and found to be 0.985 for larvae having four instars. High value of the multiple correlation clearly indicates that the regression was a good fit. It may be seen from the above Table that the larval length decreases considerably during the last or fourth instar in comparison to the length of the third instar larvae as against increase in larval width in comparison to the earlier ones.

(b) Larvae with five instars:

Similar biometrical analysis of larval growth in respect of larvae having five larval instars was carried out and the multiple correlation coefficient was calculated, the value of which was found to be 0.977 (Table 3.2). As in case of larvae having four instars, high value of correlation coefficient with five instars also indicates that the regression was a good fit. It may be mentioned here that there was increase in larval length during the fourth instar stage as against decrease in length observed in case of larvae with four instars. The larval length, however, decreased during the fifth instar stage with a tendency of increase in larval width. It may be concluded that the decrease in the larval length occurs during the prepupal instar irrespective of variation in the number of instars.

(ii) Progression factor in respect of width of head capsule of larvae of different instars

(a) Larvae with four instars:

Width of the head capsules of larvae with four larval

Table 3.1: Correlation between larval length, width and width of the head capsule of four different instars

Instar	Sl.No. of larvae	Larval length prior to shedding of head capsule (mm)	Larval width prior to shedding of head capsule (mm)	Observed width of larval head capsule (mm)	Calculated value of the width of the head capsule (mm)	Coefficient of multiple correlation
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1st	1	5.5	0.75	0.429	0.489	
	2	5.0	0.5	0.429	0.351	
	3	6.0	0.75	0.429	0.481	
	4	5.0	0.5	0.429	0.351	
	5	5.5	0.75	0.436	0.489	
	6	5.5	0.75	0.429	0.489	
	7	5.5	0.75	0.429	0.489	
	8	5.0	0.5	0.436	0.351	
						0.985
2nd	1	10.5	1.25	0.651	0.705	
	2	10.0	1.0	0.614	0.567	
	3	10.0	1.0	0.614	0.567	
	4	9.5	1.0	0.606	0.574	
	5	10.0	1.0	0.621	0.567	
	6	10.0	1.0	0.621	0.567	
	7	10.5	1.25	0.651	0.705	
	8	10.0	1.0	0.606	0.567	

Contd.

Table 3.1 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
3rd	1	17.0	1.75	0.880	0.899	
	2	18.0	1.75	0.888	0.885	
	3	18.0	1.75	0.888	0.885	
	4	16.5	1.75	0.865	0.907	
	5	20.0	2.0	0.932	1.000	
	6	18.0	1.75	0.888	0.885	
	7	19.0	1.75	0.920	0.870	
	8	17.0	1.75	0.873	0.899	
						0.985
4th	1	10.5	2.0	1.213	1.142	
	2	9.5	2.0	1.139	1.157	
	3	10.5	2.0	1.169	1.142	
	4	9.0	2.0	1.154	1.165	
	5	11.5	2.25	1.243	1.273	
	6	10.5	2.0	1.213	1.142	
	7	10.5	2.0	1.176	1.142	
	8	9.0	2.0	1.139	1.165	

Table 3.2: Correlation between larval length, width and width of the head capsule of five different instars

Instars	Sl.No. of larvae	Larval length prior to shedding of head capsule (mm)	Larval width prior to shedding of head capsule (mm)	Observed width of larval head capsule (mm)	Calculated value of the width of the head capsule (mm)	Coefficient of multiple correlation
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1st	1	4.0	0.25	0.37	0.279	
	2	4.25	0.5	0.377	0.419	
	3	4.5	0.5	0.384	0.412	
	4	4.5	0.5	0.392	0.412	
	5	4.5	0.5	0.384	0.412	
	6	4.5	0.5	0.414	0.412	0.977
	7	4.0	0.25	0.37	0.279	
	8	4.5	0.5	0.384	0.412	
	9	4.0	0.25	0.377	0.279	
	10	4.25	0.5	0.377	0.419	
	11	4.5	0.5	0.384	0.412	
	22	4.5	0.5	0.384	0.412	

Contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
2nd	1	8.0	0.75	0.503	0.460	
	2	8.5	1.0	0.532	0.593	
	3	9.0	1.0	0.547	0.579	
	4	7.0	0.75	0.503	0.489	
	5	9.0	1.0	0.540	0.579	
	6	9.0	1.0	0.540	0.579	
	7	7.5	0.75	0.510	0.474	
	8	8.0	0.75	0.510	0.460	
	9	7.5	0.75	0.503	0.474	
	10	9.0	1.0	0.547	0.579	
	11	8.0	0.75	0.510	0.460	
	12	8.5	1.0	0.518	0.593	
						0.977
3rd	1	14.5	1.5	0.666	0.718	
	2	14.5	1.5	0.666	0.718	
	3	16.0	1.75	0.732	0.822	
	4	10.5	1.25	0.643	0.684	
	5	16.0	1.75	0.710	0.822	
	6	16.0	1.75	0.725	0.822	
	7	12.0	1.25	0.651	0.641	
	8	14.5	1.5	0.673	0.718	
	9	14.5	1.5	0.680	0.718	
	10	16.0	1.75	0.725	0.822	
	11	14.0	1.5	0.673	0.732	
	12	10.5	1.25	0.651	0.684	

Contd.

(1)	(2)	(3)	(4)	(5)	(6)	(7)
4th	1	17.0	1.75	0.880	0.794	
	2	19.5	2.0	0.925	0.870	
	3	19.0	2.0	0.917	0.885	
	4	17.0	1.75	0.873	0.794	
	5	18.0	1.75	0.895	0.766	
	6	18.5	2.0	0.888	0.899	
	7	17.0	1.75	0.873	0.794	
	8	19.0	2.0	0.917	0.885	
	9	19.0	2.0	0.925	0.885	
	10	18.5	2.0	0.902	0.899	
	11	16.5	1.75	0.858	0.808	
	12	14.0	1.5	0.673	0.732	
						0.977
5th	1	8.0	1.75	1.110	1.050	
	2	10.5	2.25	1.198	1.274	
	3	10.0	2.0	1.194	1.141	
	4	8.0	2.0	1.124	1.198	
	5	9.0	2.0	1.132	1.169	
	6	9.5	2.0	1.139	1.155	
	7	8.0	1.75	1.124	1.050	
	8	10.0	2.0	1.191	1.141	
	9	10.5	2.0	1.213	1.126	
	10	9.5	2.0	1.132	1.155	
	11	8.0	1.75	1.124	1.050	
	12	8.0	1.75	1.102	1.050	

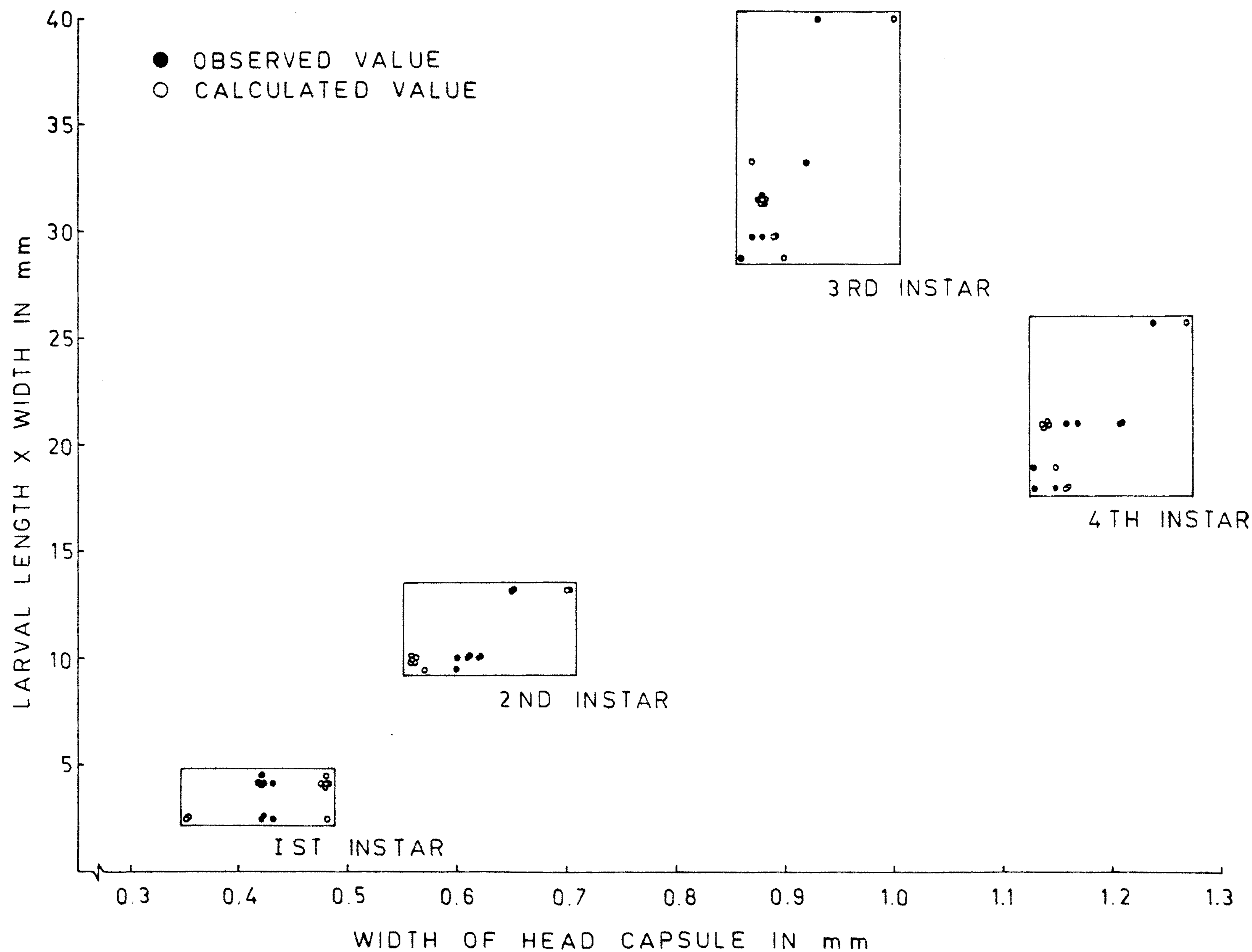
instars were observed individually. Observed mean width of the head capsules of the larvae of successive instars along with standard error of the mean and calculated values of the width of the head capsules along with progression factor were calculated. Relative larval growth of different instars and the calculated and observed values of head capsules have been plotted in Text Fig.3.1.

Table 3.3 shows mean observed and calculated values of the width of head capsules of different instars as well as the progression factor which in this case has been found to be 1.40. The full agreement of this data with Dyar's law as was propounded by him in case of Lepidopterous larvae by a factor of 1.4, has been illustrated by the regression line (Text Fig. 3.2).

(b) Larvae with five instars:

Similar observation and subsequent statistical analysis was carried out. Relative larval growth of five different instars and the observed and calculated values of head capsules have been illustrated in Text Fig. 3.3. Observed and calculated values on mean width of head capsules of five larval instars as well as the progression factor have also been ascertained and the data presented in Table 3.4.

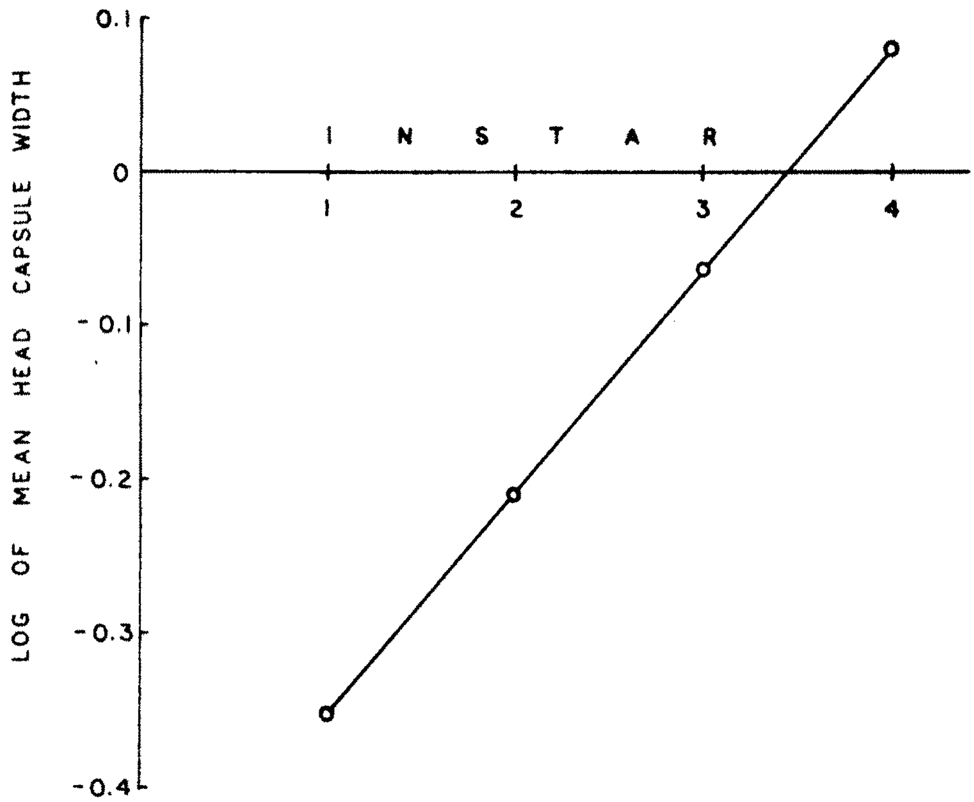
It may be seen from the Table that in case of larvae with five instars the progression factor has been observed to be 1.31 which is slightly less than the factor propounded by Dyar (1890) and has been illustrated by the regression line (Text Fig.3.4).



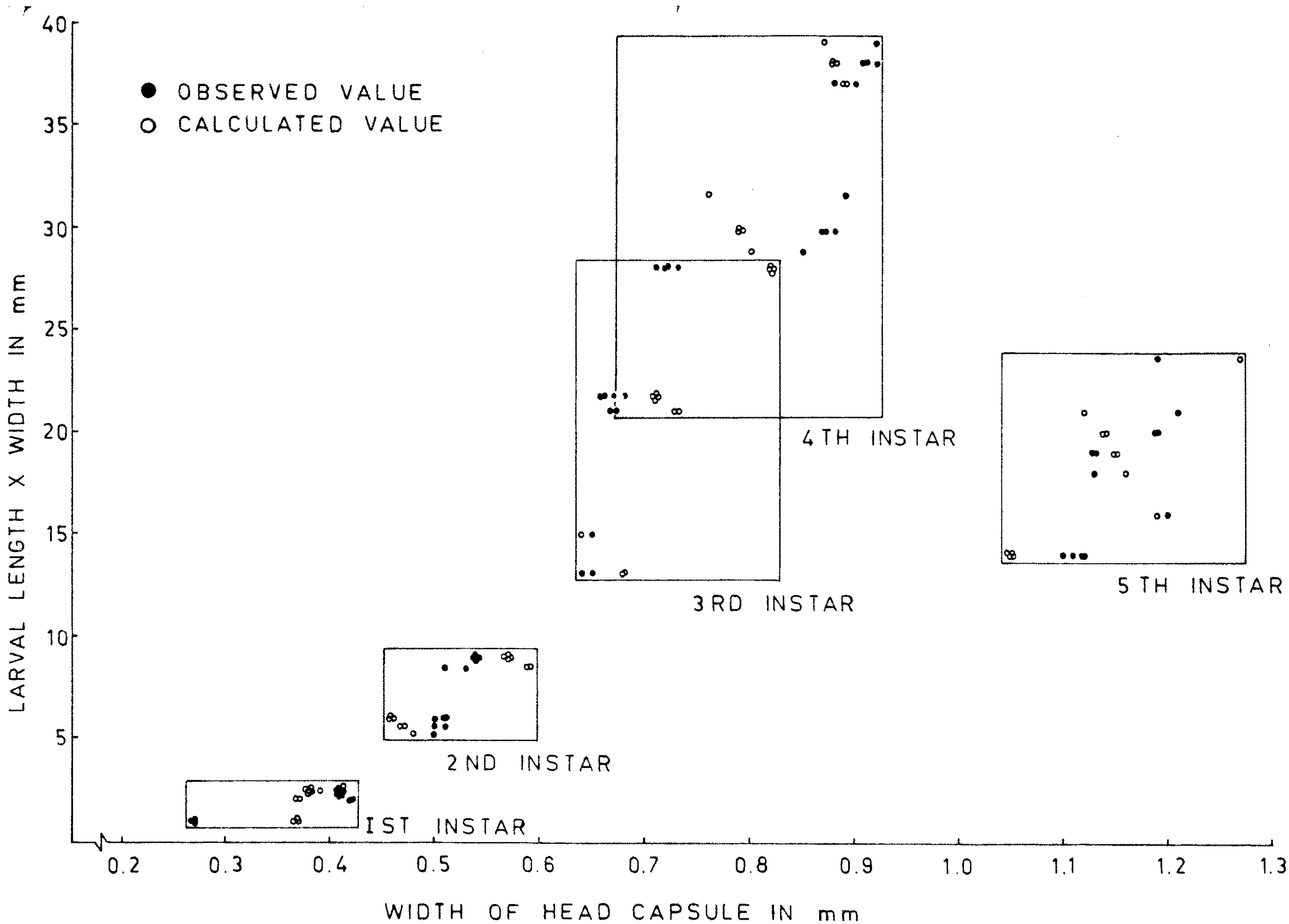
TEXT FIG. 3.1 OBSERVED AND CALCULATED VALUES OF THE WIDTH OF LARVAL HEAD CAPSULES IN LARVAE WITH FOUR INSTARS

Table 3.3 : Observed and calculated values of head capsule of larvae with four instars along with progression factor (mean of 8 observations)

	Mean width of head capsule(mm) ± S.E. during 1st instar	Mean width of head capsule(mm) ± S.E. during 2nd instar	Mean width of head capsule(mm) ± S.E. during 3rd instar	Mean width of head capsule(mm) ± S.E. during 4th instar	Progression factor
Observed	0.431 ± 0.001	0.623 ± 0.006	0.892 ± 0.008	1.181 ± 0.013	
Calculated	0.439	0.615	0.863	1.210	1.40
Difference	-0.008	0.008	0.029	-0.029	



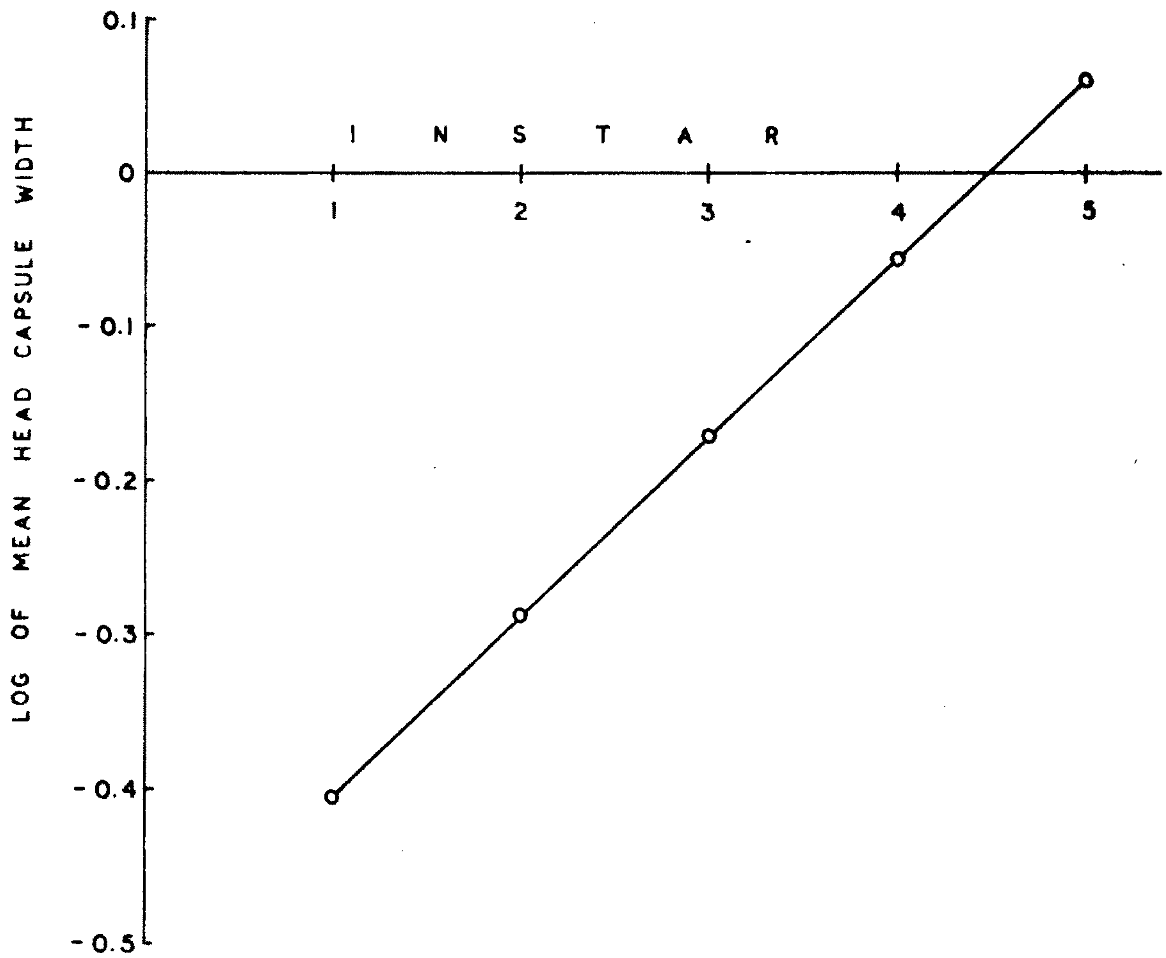
TEXT FIG. 3.2 REGRESSION GRAPH OF INSTAR ON MEAN HEAD CAPSULE WIDTH IN LARVAE WITH FOUR INSTARS



TEXT FIG. 3.3 OBSERVED AND CALCULATED VALUES OF THE WIDTH OF LARVAL HEAD CAPSULES IN LARVAE WITH FIVE INSTARS

Table 3.4 : Observed and calculated values of head capsule of larvae with five instars along with progression factor (mean of 12 observations)

	Mean width of head capsule(mm) ± S.E. during 1st instar	Mean width of head capsule(mm) ± S.E. during 2nd instar	Mean width of head capsule(mm) ± S.E. during 3rd instar	Mean width of head capsule(mm) ± S.E. during 4th instar	Mean width of head capsule(mm) ± S.E. during 5th instar	Progression factor
Observed	0.383 ± 0.003	0.522 ± 0.005	0.683 ± 0.009	0.877 ± 0.02	1.149 ± 0.011	
Calculated	0.391	0.512	0.672	0.881	1.156	1.31
Difference	-0.008	0.01	0.011	-0.004	-0.007	



TEXT FIG. 3.4 REGRESSION GRAPH OF INSTAR ON MEAN HEAD CAPSULE WIDTH IN LARVAE WITH FIVE INSTARS

That the Dyar's Law in respect of progression factor is also applicable in non-Lepidopterous insects besides O.brevis has also been reported by Dutt and Maity (1972) in case of Odoiporus longicollis under the Coleopeterous family of Curculionidae. No previous workers working on the soybean girdler, O.brevis have reported neither on multiple correlation on larval length, larval width and width of the head capsule nor on the applicability of Dyar's Law in respect of progression factor of 1.4.

SECTION IV

LARVAL BEHAVIOUR UNDER DIFFERENT ECOLOGICAL CONDITION AND DIAPAUSE

Larva remains active in soybean raised during the Kharif season. It feeds upon the inner pith tissue in stem as has been mentioned earlier. When the plants attain maturity towards the later part of Kharif season or at the advent of winter, the larva gradually moves towards the basal part of the plant, at times entering into the root portion which remains under the soil. The movement of the borer larva from the upper part of the stem down to the root zone is possibly for search of higher moisture content in plant tissues which at that time i.e., at the advent of winter or at plant maturity, is higher in the basal part of the plant and at the root zone. The larva enters into the diapause type of dormancy at the advent of winter with the maturation of soybean crop. Larval diapause thus affects the final autumn generation. On the eve of diapause, the larva cuts the stem above and below its body length, plugs its two ends with frass of wood and encases itself in the small piece of stem so cut and plugged. The cutting of stem results in dropping of the encased larva on the surface of the soil. Fig. 4.1 shows a small piece of stem, cut by the diapausing larva on the eve of its dropping on the surface soil. Fig.4.2 shows the stem casing, split open, with the diapausing larva inside along with the frass of wood used for plugging the two ends of the casing. It has also been seen in some cases that diapause may occur inside the root and in such cases the root represents the casing of the diapausing larva. That the larvae of O.brevis enter into the diapause

Explanation of Figure

Figure 4.1 : Piece of stem cut by the diapausing larva on the eve of its dropping on surface soil

Figure 4.2 : Stem casing, split open, showing the diapausing larva inside along with frass of wood used for plugging the two ends of the casing

FIG. 4.1

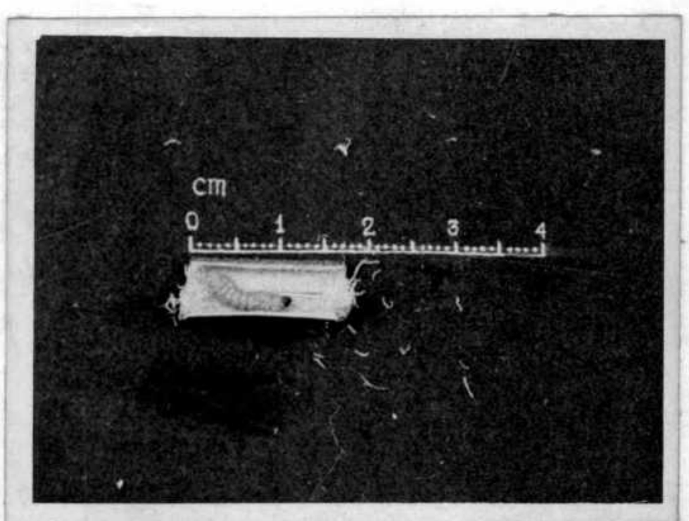


FIG. 4.2

phase has been reported earlier by several workers (Singh and Singh, 1966; Gangrade et.al.,1971; Gangrade, 1975; Singh,1980) but no critical investigation was undertaken by any of them to ascertain the factors responsible for elimination of diapause and subsequent emergence of adults. Gangrade (1975) observed that soybean crop raised on 1st June is more susceptible to the incidence of the pest than those raised later. Since incidence is dependent on adult emergence and the aforesaid author did not ascertain the factors responsible for termination of diapause and adult emergence, Gangrade's (1975) observation may not hold good for years with delayed emergence of adults due to late operation of factors responsible for termination of diapause.

(i) Effect of temperature & relative humidity on the elimination of diapause

Of the various factors tested under the laboratory condition for elimination of diapause, exposure to temperature namely, 31°C - 34°C during summer months and high relative humidit per cent were found necessary for termination of the dormant diapause phase. Investigation was carried out with two months old dormant diapause larvae which were exposed to different levels of relative humidity per cent at the room temperature and the data presented in Table 4.1.

It may be seen from the Table that an exposure of the larvae to 100 per cent relative humidity at maximum temperature ranging from 31°C - 34°C under the room condition could eliminate

Table 4.1 : Effect of temperature & relative

Treatment (relative humidity per cent)	Number of dormant larvae per treatment	Time(month) of onset of diapause	Date when put under treatment	% dead (a)										or
				Jan.		Feb.		Mar.		Apr.		May		Jun.
				a	b	a	b	a	b	a	b	a	b	a
10	9	Nov.,80	1.1.81	–	–	–	–	–	–	11.11	–	–	–	55.56
20	9	do	do	–	–	–	–	–	–	22.22	–	11.11	–	11.11
30	9	do	do	–	–	–	–	–	–	11.11	–	22.22	–	22.22
40	9	do	do	–	–	–	–	–	–	–	–	11.11	–	11.11
50	9	do	do	–	–	–	–	11.11	–	–	–	11.11	–	11.11
60	9	do	do	–	–	–	–	–	–	–	–	–	–	–
70	9	do	do	–	–	–	–	–	–	–	–	–	–	–
80	9	do	do	–	–	–	–	–	–	–	–	–	–	–
90	9	do	do	–	–	–	–	–	–	–	–	–	–	–
100	9	do	do	–	–	–	–	–	–	–	–	11.11	88.89	–
	Temperature °C		Max.	22.5		26.75		28.0		30.5		31.0		34.0
			Min.	19.0		19.0		22.5		24.5		26.5		27.5

umidity on elimination of diapause

released	from		diapause (b)								Per cent
	Jul.		Aug.		Sep.		Oct.		Total		dormant
b	a	b	a	b	a	b	a	b	a	b	till 28.10.81
-	-	-	33.33	-	-	-	-	-	100.00	-	-
-	22.22	-	33.34	-	-	-	-	-	100.00	-	-
-	22.22	-	22.23	-	-	-	-	-	100.00	-	-
-	11.11	-	22.22	-	44.45	-	-	-	100.00	-	-
-	-	-	11.11	-	22.22	-	22.23	-	88.89	-	11.11
-	11.11	-	11.11	-	33.34	-	11.11	-	66.67	-	33.33
-		-	11.11	-	22.22	-	33.34	-	66.67	-	33.33
-	-	-	33.33	-	-	-	-	-	33.33	-	66.67
33.33	-	-	-	-	-	-	-	-	-	33.33	66.67
-	-	-	-	-	-	-	-	-	11.11	88.89	-
	34.0		32.0		32.5		31.0				
	27.5		27.0		27.5		29.0				

diapause of 88.89 per cent larvae with 11.11 per cent dead. In case of larvae exposed to 90 per cent relative humidity, diapause was terminated in 33.33 per cent cases with adult emergence and rest 66.67 per cent larvae remained in dormant phase till 28.10.81. In case of larvae exposed upto 40 per cent relative humidity, all the larvae died. A similar laboratory experiment was carried out during 1982 with two months old diapause larvae keeping the level of relative humidity per cent as in the previous year but the different relative humidity chambers were exposed to a constant temperature of 30.0 ± 1°C in a BOD incubator. It may be seen from the Table 4.2 that release from diapause took place in larvae which were exposed to 100 per cent relative humidity by first fortnight of May, 1982. Larvae exposed to low level of relative humidity died whereas other larvae in higher level of relative humidity continued to remain in dormant phase. These two experiments clearly suggest that mere presence of suitable temperature and moisture is not enough for termination of diapause. But a certain period of time namely, the winter months immediately following initiation of diapause need to be elapsed before its termination under favourable condition. Obviously, diapause development takes place during the intervening period, and the dormancy is of diapause type. Dutt (1956b) also reported termination of larval diapause of *N.b.postbrunnea* by exposing them to 30°C and high percentage of relative humidity.

(ii) Soil moisture and its effect on diapause larvae

One laboratory experiment was set up to find out the

Table 4.2: Effect of temperature & relative humidity on elimination of di...

Treatment (relative humidity per cent)	Number of dormant larvae per treatment	Time(month) of onset of diapause	Date when put under treatment	% dead (a)								or r...
				Jan.		Feb.		Mar.		Apr.		May
				a	b	a	b	a	b	a	b	a
10	4	Nov.,81	6.1.82	–	–	75.00	–	25.00	–	–	–	–
20	4	do	do	–	–	–	–	–	–	50.00	–	50.00
30	4	do	do	–	–	–	–	–	–	–	–	–
40	4	do	do	–	–	–	–	–	–	–	–	–
50	4	do	do	–	–	–	–	–	–	–	–	–
60	4	do	do	–	–	–	–	–	–	–	–	–
70	4	do	do	–	–	–	–	–	–	–	–	–
80	4	do	do	–	–	–	–	–	–	–	–	–
90	4	do	do	–	–	–	–	–	–	–	–	–
100	4	do	do	–	–	–	–	–	–	–	–	–

pause at a constant temperature of 30.0 ± 1°C

leased from diapause (b)													Per cent dormant till
	Jun.		Jul.		Aug.		Sep.		Oct.		Total		
b	a	b	a	b	a	b	a	b	a	b	a	b	19.10.82
–	–	–	–	–	–	–	–	–	–	–	100.00	–	–
–	–	–	–	–	–	–	–	–	–	–	100.00	–	–
–	75.00	–	25.00	–	–	–	–	–	–	–	100.00	–	–
–	50.00	–	25.00	–	25.00	–	–	–	–	–	100.00	–	–
–	50.00	–	25.00	–	–	–	–	–	–	–	75.00	–	25.00
–	50.00	–	25.00	–	–	–	–	–	–	–	75.00	–	25.00
–	25.00	–	–	–	25.00	–	–	–	–	–	50.00	–	50.00
–	25.00	–	–	–	–	–	–	–	–	–	25.00	–	75.00
–	–	–	–	50.00	–	–	–	–	–	–	–	50.00	50.00
100.00	–	–	–	–	–	–	–	–	–	–	–	100.00	–

effect of continued exposure of diapause larvae in soil having different percentages of moisture under the room temperature. For this purpose diapause larvae encased in soybean stem were put under soil in glass jars with known different percentages of moisture. Each jar was covered with paper soaked in paraffin and sealed with paraffin wax to prevent escape of soil moisture. Fortnightly observations on the larvae were recorded after taking them out from the sealed jars which resulted in gradual decrease of soil moisture. It may be seen from Table 4.3 that in soil, moisture content of which decreased to 3.11 - 3.02 per cent at the end, the diapause larvae died 1-1½ months after setting up of the experiment. In treatments where the moisture decreased to 4.02 per cent at the end, the diapausing larvae survived for a longer period but died after a period of 5 to 6 months. In jars where the soil moisture ranged from 6.17 to 15.91 per cent at the end, 100 per cent adult emergence occured after expiry of winter months. The soil moisture to the extent of initial 9.32 per cent decreasing upto a level of 6.17 per cent during the course of 5½ months, helped adult emergence during the summer month of June. Adult emergence occurred earlier during the month of May when the larvae were exposed to soil having soil moisture ranging from 15.33 - 31.29 per cent decreasing after 5 months to a level of ranging from 10.60 - 18.11 per cent. In soil where the moisture content decreased from the original moisture content but remained at a level of 16.40 per cent and 18.11 per cent, adult emergence in 66.67 per cent cases occurred while in 33.33 per cent cases diapause larvae died as a result of fungal infection of

Table 4.3: Effect of different percentages of soil moisutre on elimination of larval diapause

Treatment % soil moisture on the date of start of experiment	Number of larvae exposed per treatment	% Soil moisture (in parenthesis) on dates of larval death (a) or adult emergence (b)													
		19.1.80		3.2.80		3.5.80		19.5.80		3.6.80		18.6.80		Total	
19.12.79		a	b	a	b	a	b	a	b	a	b	a	b	a	b
3.21	3	1 (3.11)	–	2 (3.02)	–	–	–	–	–	–	–	–	–	3	–
6.30	3	–	–	–	–	–	–	1 (4.12)	–	–	–	2 (4.02)	–	3	–
9.32	3	–	–	–	–	–	–	–	–	–	3 (6.17)	–	–	–	3
12.59	3	–	–	–	–	–	–	–	–	–	3 (9.81)	–	–	–	3
15.33	3	–	–	–	–	–	–	–	2 (10.60)	–	1 (10.55)	–	–	–	3
15.51	3	–	–	–	–	–	–	–	–	–	3 (12.05)	–	–	–	3
22.70	3	–	–	–	–	–	–	–	3 (15.91)	–	–	–	–	–	3
24.38	3	–	–	–	–	1 (16.47)	–	–	2 (16.40)	–	–	–	–	1	2
31.29	3	–	–	–	–	1 (18.55)	–	–	2 (18.11)	–	–	–	–	1	2

Temperature °C		Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
	Max.	21.0	22.5	26.75	28.0	30.5	31.0	34.0
	Min.	17.0	19.0	19.0	22.5	24.5	26.5	27.5

the diapause casing of soybean stem as well as of the dormant larvae, possibly due to over - hydration.

(iii) Effect of placement of diapause larva at different depths of soil under the field condition

The diapause larvae which remain in the root zone remain under the soil till emergence. Ploughing of soybean field after harvest often buries the diapause larvae encased in soybean stem at different depths of soil. To ascertain if the depth of soil at which a larva is buried has any effect on the diapausing larva and their emergence, an experiment was set up under the field condition keeping the diapausing larvae within the diapause stem casings at depths of 0,2,4 and 6 inches which are within the depth range turned over during ploughing. Baked earthen pots (9" diam. x 7½" height) with their bottom open were buried in the soil upto the rim and diapausing larvae were placed in different depths inside the pots. Wire net cages were fixed around the rim of each buried pot (Fig.4.3) so as to prevent escape of the adults when emerged.

It may be seen from Table 4.4 that chances of survival of the diapausing larvae which remain on soil surface are comparatively less than those placed at lower depths. They either suffer predation or die probably due to desiccation. It has been observed that emergence of adults at a depth of 4 and 6 inches started from third week of May when the amount of prior rainfall was 8.16 inches (207.26 mm) (Table 4.5).

Explanation of Figure

Figure 4.3 : Wire net cages fixed around the rim of bur-ied pots in field

FIG. 4.3

Table 4.4 : Effect of placement of diapausing larvae in stem casings at different depths of soil on emergence

Soil depth (inches)	Number of larvae	Time (month)of onset of diapause	Date of placement under soil	Number of larvae dead (a) adults emerged (b) during																	
				Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul.		Aug.		Total	
				a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
0	8	Nov.,81	1.1.82	-	-	-	-	3	-	2	-	-	-	3	-	-	-	-	-	8	-
2	8	do	do	-	-	-	-	-	-	1	-	1	-	3	1	-	2	-	-	5	3
4	8	do	do	-	-	-	-	-	-	-	-	-	1	-	6	-	1	-	-	-	8
6	8	do	do	-	-	-	-	-	-	-	-	1	-	2	3	-	1	-	1	3	5

Table 4.5: Temperature, rainfall and adult emergence under the field condition

Year	Month	Temperature°C		Number of rainy days	Amount of rainfall (inches)	Time of adult emergence
		Max.	Min.			
1982	January	30.5	9.0	-	-	-
	February	32.0	12.0	4	1.42 (36.06 mm)	-
	March	39.0	15.5	5	3.22 (81.78 mm)	-
	April	42.0	19.0	7	2.44 (61.97 mm)	-
	May	44.0	21.0	3	1.08 (27.43 mm)	3rd week
	June	40.0	22.0	13	3.78 (96.01 mm)	2nd, 3rd & 4th week
	July	42.5	25.5	11	4.05 (102.87 mm)	4th week
	August	35.0	24.0	13	5.21 (132.33 mm)	1st week

On the basis of laboratory and field observations it may be concluded that the elimination of diapause depends upon the amount and frequency of rainfall during the summer months so as to maintain the soil moisture at higher level. No adult emergence would occur during winter months following initiation of diapause inspite of presence of suitable temperature & moisture.

Incidence of the pest can thus be foreseen as frequent and sufficient rainfall in summer will influence early emergence of the pest while late rainfall will be associated with late incidence. Dutt (1956b) has also reported a similar phenomenon in case of Jute stem girdler. The present observations clearly indicate that the incidence of the pest does not depend on the date of raising the crop as reported by Gangrade (1975) and is independent of it as the time of adult emergence under the field condition and subsequent incidence depend on the amount of rainfall during summer months.

SECTION V

FACTORS DETERMINING SELECTION OF SITE ON STEM, PETIOLE AND CENTRAL LEAF-LET STALK FOR GIRDLING, OVIPOSITION OR DAMAGE

It has been mentioned in Section II that girdles on stem, petiole and central leaf-let stalk are not cut at any and every point on the stem, petiole or central leaf-let stalk. Such girdles, cut as a pre-ovipositional operation have been found to remain limited within certain diameter range of each of stem, petiole and central leaf-let stalk. In case of stem, cutting of girdles are limited to the diameter ranging from > 1.9 mm to 4.0 mm with an error of 0.8 per cent i.e., girdles are cut but without oviposition. In case of petiole such girdles are cut where the petiolar diameter ranges from > 1.4 mm to 4.0 mm with an error of 1.2 per cent i.e., without egg laying. In case of central leaf-let stalk, girdles are cut where the diameter ranges from 1.0 mm to 3.0 mm but with an error per cent of 1.2 i.e., without oviposition.

Since damage is done as a result of cutting girdles followed by oviposition, it is apparent that there are certain factors which determine laying of eggs within a certain diameter range of stem, petiole or central leaf-let stalk.

The explanation for cutting girdles and laying of eggs at a particular portion of stem, petiole or central leaf-let stalk which fall within a certain diameter range can be found in the relationship that exists between the length of the mandibles of the females, the depth of the tissue from epidermis down to the periphery of pith tissue (called hereafter as extra-medullary tissue) of stem, petiole or central leaf-let stalk and girdling & oviposition.

For the purpose of determining the relationship between the diameter, depth of extra-medullary tissue of central leaf-let stalk, petiole or stem, mandibular length of female and susceptibility to girdling or damage, observations as detailed below were recorded and data presented in Tables 5.1, 5.2, 5.3.

Measurements of the extra-medullary tissue were taken under the microscope from slides prepared from transverse sections cut from each of stem, petiole and central leaf-let stalk, falling under different diameter classes wherein cutting of girdles and slits was done. Length of the cutting faces of the mandibles of females was similarly recorded under the microscope after dissecting them out and subsequent preparation of slides.

Length of the cutting face of the mandibles of females was found to be 0.666 ± 0.005 mm. Maximum girdling to the extent of 34.8 per cent and 29.2 per cent was observed in central leaf-let stalk where the diameter ranged from > 1.9 mm to 2.2 mm and > 2.2 mm to 2.5 mm respectively. The ratios of the mandibular length to the thickness of extra-medullary tissue of these two diameter classes of central leaf-let stalk were found to be 1:0.84 and 1:0.88 respectively (Table 5.1).

Table 5.1 : Mandibular length of female and its ratio to the diameter and depth of extra-medullary tissue of the central leaf-let stalk in relation to oviposition

Leaf-let stalk diameter classes (mm)	Mean depth of extra - medullary tissue(mm) ± S.E.	Mean mandibular length (mm) ± S.E.	Ratio of mandibular length to :		% distribution of oviposition/ girdling within leaf-let stalk diam. classes
			Leaf-let stalk diameter class	Depth of extra-medullary tissue	
1.0 - 1.4	0.334 ± 0.007	0.666±0.005	1:1.50-1:2.10	1:0.50	Nil
>1.4 - 1.6	0.413 ± 0.01		1:2.25-1:2.40	1:0.62	4.4
>1.6 - 1.9	0.512 ± 0.01		1:2.55-1:2.85	1:0.76	13.2
>1.9 - 2.2	0.563 ± 0.01		1:3.00-1:3.30	1:0.84	34.8
>2.2 - 2.5	0.592 ± 0.008		1:3.45-1:3.75	1:0.88	29.2
>2.5 - 2.8	0.621 ± 0.01		1:3.90-1:4.20	1:0.93	14.0
>2.8 - 3.0	0.766 ± 0.01		1:4.35-1:4.50	1:1.15	3.2
3.1	0.835 ± 0.005		1:4.65	1:1.25	Nil

Table 5.2 : Mandibular length of female and its ratio to the diameter and depth of extra-medullary tissue of the petiole in relation to oviposition

Petiole diameter classes (mm)	Mean depth of extra medullary tissue (mm) ± S.E.	Mean mandibular length (mm) ± S.E.	Ratio of mandibular length to :		% distribution of oviposition/ girdling within petioler diam. classes
			Petiole diameter class	Depth of extra-medullary tissue	
>1.4 - 1.7	0.381 ± 0.008	0.666±0.005	1:2.25-1:2.55	1:0.57	Nil
>1.7 - 1.9	0.421 ± 0.008		1:2.70-1:2.85	1:0.63	2.8
>1.9 - 2.2	0.480 ± 0.008		1:3.00-1:3.30	1:0.72	9.6
>2.2 - 2.5	0.592 ± 0.01		1:3.45-1:3.75	1:0.88	32.4
>2.5 - 2.8	0.642 ± 0.01		1:3.90-1:4.20	1:0.96	30.4
>2.8 - 3.1	0.674 ± 0.01		1:4.35-1:4.65	1:1.01	14.8
>3.1 - 3.4	0.742 ± 0.02		1:4.80-1:5.10	1:1.11	6.4
>3.4 - 3.6	0.802 ± 0.01		1:5.25-1:5.40	1:1.20	2.4
>3.6 - 4.0	0.896 ± 0.02		1:5.55-1:6.00	1:1.34	Nil

Table 5.3 : Mandibular length of female and its ratio to the diameter and depth of extra-medullary tissue of the stem in relation to oviposition

Stem diameter classes (mm)	Mean depth of extra - medullary tissue(mm) ± S.E.	Mean mandibular length (mm) ± S.E.	Ratio of mandibular length to :		% distribution of oviposition/ girdling within stem diameter classes
			Stem diameter class	Depth of extra - medullary tissue	
>1.6 - 1.9	0.400 ± 0.01	0.666 ± 0.005	1:2.55-1:2.85	1:0.60	Nil
>1.9 - 2.2	0.460 ± 0.01		1:3.00-1:3.30	1:0.69	7.6
>2.2 - 2.5	0.528 ± 0.006		1:3.45-1:3.75	1:0.79	19.2
>2.5 - 2.8	0.599 ± 0.008		1:3.90-1:4.20	1:0.89	34.0
>2.8 - 3.1	0.626 ± 0.01		1:4.35-1:4.65	1:0.93	22.0
>3.1 - 3.4	0.698 ± 0.009		1:4.80-1:5.10	1:1.04	10.8
>3.4 - 3.7	0.743 ± 0.009		1:5.25-1:5.55	1:1.11	5.6
>3.7 - 4.0	0.828 ± 0.01		1:5.70-1:6.00	1:1.24	Nil

In case of petiole, maximum girdling to the extent of 32.4 per cent and 30.4 per cent were observed where the petiolar diameter fell in the diameter classes of $>$ 2.2 mm to 2.5 mm and $>$ 2.5 mm to 2.8 mm. The ratios of the mandibular length to the depth of extra-medullary tissue of these two classes were found to be 1:0.88 and 1:0.96 respectively (Table 5.2).

Similarly, oviposition/girdling or damage to the extent of 34.0 per cent and 22.0 per cent were observed in stem where the diameter fell within the diameter classes of $>$ 2.5 mm to 2.8 mm and $>$ 2.8 mm to 3.1 mm respectively. The ratios of the mandibular length to the depth of extra-medullary tissue of these two classes were 1:0.89 and 1:0.93 respectively (Table 5.3).

It is also evident from Table 5.1 to 5.3 that maximum girdling is done where the ratio of mandibular length to the depth of the extra-medullary tissue irrespective of whether the site of cutting girdles in central leaf-let stalk, petiole or stem ranges from 1:0.76 to 1:0.96. About 10 to 15 per cent girdling is observed where the mandibular length is almost equal to the depth of the extra-medullary tissue with ratios ranging from 1:1.01 to 1:1.04. Cutting of girdles further decreases where the ratio of mandibular length to the depth of extra-medullary tissue ranges from 1:1.11 to 1:1.20 while no girdling is done where the depth of extra-medullary tissue further increases with ratio of mandibular length to the depth of extra-medullary tissue as 1:1.24 or more. It may be seen from these tables that where the ratio of the mandibular length to the diameter of central leaf-let stalk diameter classes of $>$ 1.6 mm to 2.8 mm ranges from 1:2.55 to 1:4.20 with ratio of mandibular length to the depth of extra-medullary tissue as 1:0.76 to 1:0.93, a total girdling of 91.2 per cent occurred.

In case of petiole, the ratio of mandibular length to the diameter of petiolar diameter classes of $>$2.2 mm to 3.1 mm ranges from 1:3.45 to 1:4.65 having the ratio of mandibular length to the depth of extra-medullary tissue as 1:0.88 to 1:1.01 with a total girdling of 77.6 per cent.

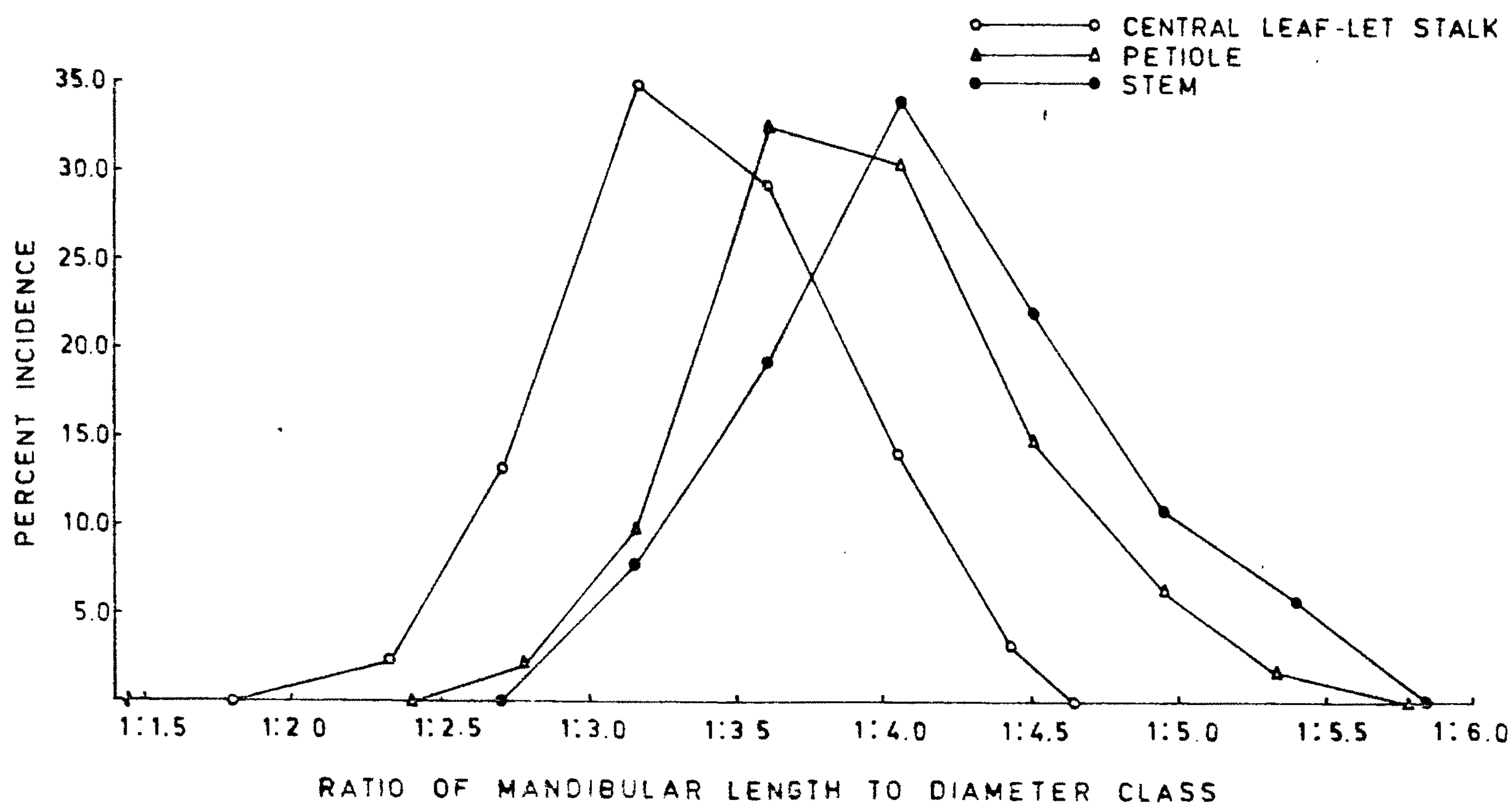
In case of stem, the ratio of mandibular length to the diameter of stem diameter classes of $>$ 2.2 mm to 3.4 mm ranges from 1:3.45 to 1:5.10 having the ratio of mandibular length to the depth of extra-medullary tissue as 1:0.79 to 1:1.04 with a total oviposition/ girdling of 86.0 per cent.

It is interesting to mention here that the ratio of mandibular length of the ovipositing female to the diameter of central leaf-let stalk, petiole and stem ranges from 1:2.55 to 1:5.10 with 77.6 per cent to 91.2 per cent girdlings. The ratio of mandibular length to the aforesaid diameter classes is wider as against the range of ratio between the mandibular length and extra-medullary tissue of the aforesaid diameter classes namely 1:0.76 to 1:1.04 for the same percentage of girdling showing thereby that maximum girdling or damage is done where the depth of extra-medullary tissue is slightly less or almost equal to the length of the mandible irrespective of diameter of central leaf-let stalk, petiole or stem as shown in Text Fig. 5.1 and 5.2.

In thinner portion of central leaf-let stalk, petiole and stem with diameter ranging from 1.0 mm - 1.4 mm, $>$ 1.4 mm to 1.7 mm and $>$ 1.6 mm to 1.9 mm respectively, ratios of the mandibular length to the depth of extra-medullary tissue were found to be 1:0.50, 1:0.57 and 1:0.60 respectively. In these cases mandibles are too long and the slit cut by the mandibles and the passage made for the genitalia would lead the genital capsule and the oviposition to a wrong place for deposition of eggs. Hence, such portions of central leaf-let stalk, petiole and stem are rejected.

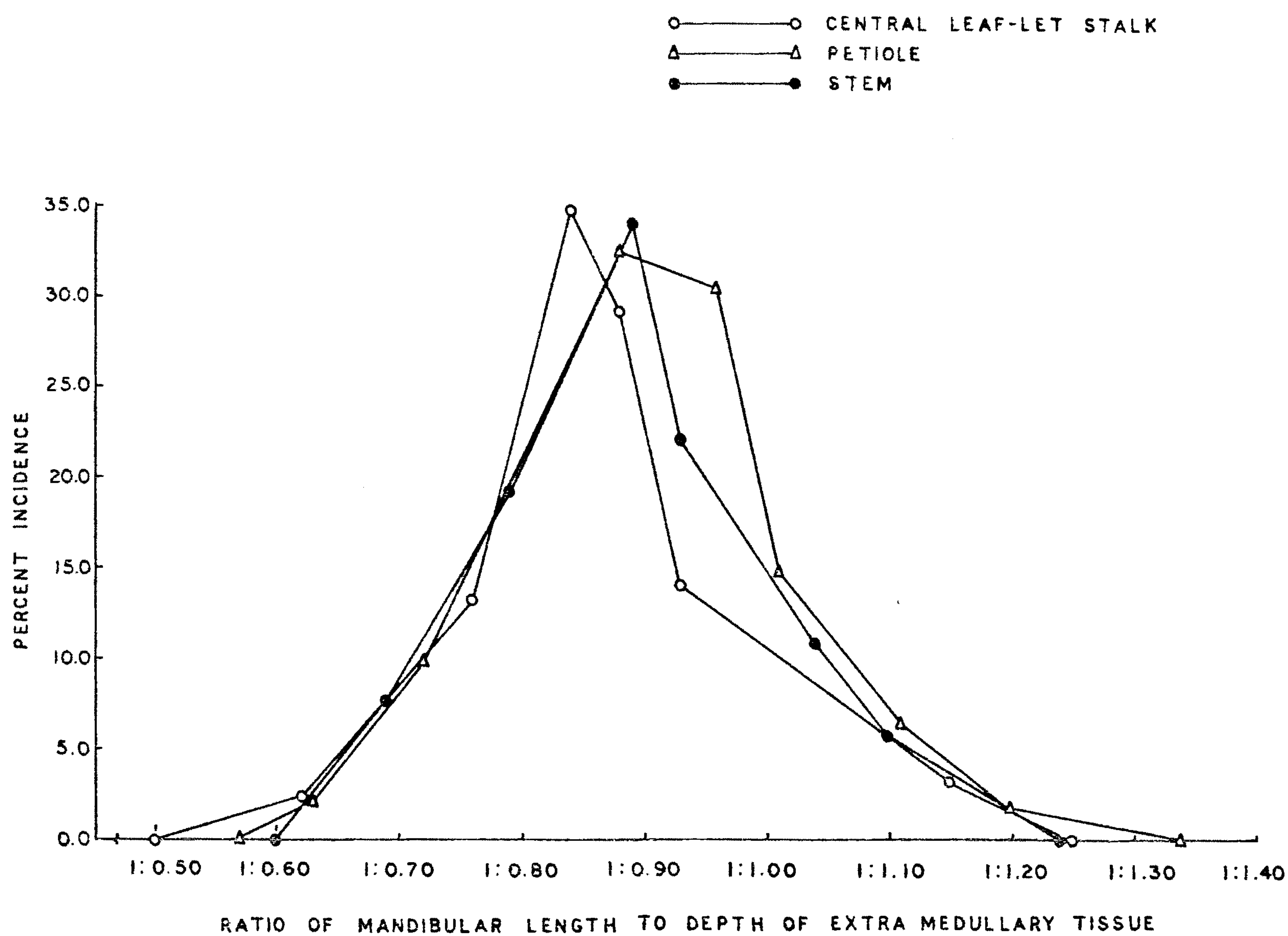
Thicker portions of central leaf-let stalk, petiole and stem where the ratio of mandibular length to the depth of extra-medullary tissue is more in the ratio, are rejected because the mandibles fall short to make a slit or passage for the genital capsule for egg deposition on the periphery of pith tissue. Such slit or passage with shorter depth is unsuitable for oviposition in the right place which account for absence of egg laying in central leaf-let stalk, petiole and stem with diameter $>$ 3.0 mm, $>$ 3.6 mm and $>$ 3.7 mm respectively.

The degree of cutting girdles decreases gradually in those portions of the central leaf-let stalk, petiole and stem where the thickness of the extra-medullary tissue increases or



TEXT FIG. 5.1 RATIO OF MANDIBULAR LENGTH TO THE DIAMETER CLASSES OF CENTRAL LEAF-LET STALK, PETIOLE AND STEM

N.B: RATIO OF EACH POINT IS THE MEAN OF DIAMETER RANGE (VIDE TABLES 5.1, 5.2 AND 5.3)



TEXT FIG. 5.2 RATIO OF MANDIBULAR LENGTH TO THE DEPTH OF EXTRA-MEDULLARY TISSUE OF CENTRAL LEAF-LET STALK, PETIOLE AND STEM decreases ratios mentioned earlier. The region of the central leaf-let stalk, petiole and stem where the ratio of the mandibular length of the female to the depth of extra-medullary tissue ranges from 1:0.62 to 1:1.15; 1:0.63 to 1:1.20 and 1:0.69 to 1:1.11 respectively represent, therefore, the susceptible site for girdling, oviposition and damage. No previous worker working on soybean girdler, O.brevis has established such relationship which determines the site on stem, petiole or central leaf-let stalk susceptible for damage. Dutt (1956a), however, reported a similar relationship between the mandibular length of female and depth of extra-medullary tissue in case of Lamiid beetle N.b.postbrunnea infesting olitorius jute.

SECTION VI

EXTENT AND INTENSITY OF INCIDENCE ON SOYBEAN VARIETIES

Extent of incidence on soybean varieties and their susceptibility

For ascertaining the susceptibility of common soybean varieties namely UPSM-19, Ankur, BC-1, Soymax, Improved Pelican, Alankar, Kalitur, and Bragg grown under West Bengal condition to the incidence of *O.brevis* either on stem, petiole or on central leaf-let stalk, a four replicated field trial was carried out during the years 1979, 1980 and 1981 as mentioned under Materials and Methods (Chapter III).

Observations on the extent and intensity of incidence on the aforesaid varieties were recorded at fortnightly interval till harvest starting one month after sowing i.e., from mid July till last week of October from four 1 m^2(1 m x 1 m) areas from each plot of 28 m^2 (7 m x 4 m), taking pre-ovipositional operation of girdling on stem , petiole and central leaf-let stalk as the index of incidence in different varieties. Percentage of incidence was calculated for ascertaining its extent and transformed subsequently to angular values for analysis of variance and the result on the extent of incidence on eight different soybean varieties has been presented in Tables 6.1, 6.2 and 6.3 for 1979, 1980 and 1981 respectively. It may be seen from these Tables that the differences on the extent of incidence of the pest on these varieties were non-significant when the crop was about one month old. Differences were, to

Table 6.1: Extent of incidence (transformed/angular values) on different soybean varieties (1979)

Variety	Dates of observation							
	15.7.79	30.7.79	14.8.79	29.8.79	13.9.79	28.9.79	13.10.79	28.10.79
UPSM-19	8.23 (2.15)	13.29 (5.33)	14.71 (6.48)	17.88 (9.94)	15.48 (7.77)	6.82 (1.51)	*	*
Ankur	11.40 (3.93)	7.31 (1.79)	16.16 (7.84)	29.51 (24.38)	24.71 (17.88)	22.42 (14.65)	11.10 (4.00)	5.74 (1.00)
BC-1	10.98 (3.83)	10.58 (3.38)	18.45 (10.17)	22.31 (14.51)	16.62 (8.47)	13.58 (5.82)	6.77 (1.49)	5.74 (1.00)
Soymax	9.82 (2.95)	9.60 (2.90)	16.87 (8.59)	22.67 (15.15)	19.14 (10.91)	15.04 (7.02)	12.65 (4.81)	7.80 (1.90)
Improved Pelican	12.39 (4.71)	18.15 (9.88)	20.30 (12.12)	29.57 (24.46)	27.47 (21.78)	17.16 (8.83)	14.31 (6.11)	5.74 (1.00)
Alankar	10.31 (3.20)	9.10 (2.84)	15.05 (6.82)	23.13 (15.95)	21.97 (14.08)	14.40 (6.23)	7.92 (1.99)	5.74 (1.00)
Kalitur	11.44 (4.01)	8.33 (2.73)	14.32 (6.17)	22.51 (14.84)	19.46 (11.39)	17.23 (8.84)	15.82 (7.54)	10.01 (3.03)
Bragg	9.08 (2.40)	9.95 (3.04)	16.15 (8.02)	25.66 (18.88)	14.76 (6.67)	12.75 (5.22)	5.74 (1.00)	5.74 (1.00)
	Non-Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±		1.40	1.15	1.87	1.99	1.33	1.04	0.33
C.D.at 5% level		4.10	3.37	5.48	5.83	3.90	3.08	0.97

Original mean values in parenthesis, * Harvested.

Table 6.2: Extent of incidence (transformed to angular values) on different soybean varieties (1980)

Variety	Dates of observation							
	14.7.80	29.7.80	13.8.80	28.8.80	12.9.80	27.9.80	12.10.80	27.10.80
UPSM-19	5.70 (1.03)	11.76 (4.23)	11.49 (4.57)	17.46 (9.21)	16.76 (8.34)	6.87 (1.48)	*	*
Ankur	9.41 (2.88)	9.11 (2.79)	13.57 (6.35)	30.58 (25.91)	27.75 (21.75)	15.19 (6.87)	8.61 (2.33)	5.74 (1.00)
BC-1	8.84 (2.43)	7.95 (1.99)	9.05 (2.68)	23.01 (15.34)	19.94 (11.85)	14.33 (6.20)	6.94 (1.51)	5.74 (1.00)
Soymax	9.92 (3.06)	11.71 (4.20)	13.23 (5.59)	26.21 (19.63)	23.67 (16.28)	18.69 (10.30)	10.98 (3.69)	7.36 (1.68)
Improved Pelican	9.90 (2.97)	18.56 (10.28)	21.46 (13.70)	30.72 (26.14)	23.76 (16.32)	17.67 (9.75)	10.36 (3.27)	5.74 (1.00)
Alankar	10.00 (3.45)	11.98 (4.81)	13.48 (5.88)	29.02 (23.56)	21.98 (14.02)	17.04 (8.64)	7.06 (1.58)	5.74 (1.00)
Kalitur	9.73 (2.94)	10.37 (3.64)	10.25 (3.35)	24.55 (17.49)	25.97 (19.64)	19.42 (11.25)	11.76 (4.39)	9.16 (2.59)
Bragg	8.55 (2.38)	12.72 (4.99)	15.32 (7.32)	26.30 (19.81)	21.79 (14.00)	13.87 (5.80)	5.74 (1.00)	5.74 (1.00)
	Non-sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±		1.86	2.07	1.46	1.27	1.16	0.71	0.40
C.D.at 5% level		5.45	5.07	4.28	3.72	3.40	2.10	1.18

Original mean values in parenthesis, * Harvested.

Table 6.3: Extent of incidence (transformed to angular values) on different soybean varieties (1981)

Variety	Dates of observation							
	16.7.81	31.7.81	15.8.81	30.8.81	14.9.81	29.9.81	14.10.81	29.10.81
UPSM-19	8.18 (2.22)	12.96 (5.18)	13.42 (5.53)	17.70 (9.34)	19.57 (11.26)	9.67 (2.84)	*	*
Ankur	10.70 (3.56)	10.73 (3.50)	19.33 (10.99)	26.90 (20.66)	25.22 (18.21)	14.80 (6.67)	9.66 (2.85)	5.74 (1.00)
BC-1	8.91 (2.54)	11.36 (3.95)	17.28 (8.83)	28.01 (22.10)	20.75 (12.70)	9.35 (2.77)	7.24 (1.66)	5.74 (1.00)
Soymax	10.74 (3.49)	11.14 (3.82)	19.52 (11.19)	27.06 (20.78)	24.16 (16.83)	18.23 (9.97)	10.74 (3.49)	7.35 (1.72)
Improved Pelican	12.30 (5.38)	13.65 (5.71)	25.66 (19.06)	32.41 (28.93)	30.56 (25.85)	20.93 (12.81)	12.20 (4.47)	5.74 (1.00)
Alankar	11.71 (4.27)	13.77 (5.68)	23.08 (15.50)	28.86 (23.09)	29.62 (24.49)	17.75 (9.49)	8.49 (2.26)	5.74 (1.00)
Kalitur	12.93 (5.11)	14.26 (6.20)	19.77 (11.54)	23.22 (15.75)	26.19 (19.65)	23.13 (15.48)	14.19 (6.02)	9.50 (2.76)
Bragg	9.06 (2.63)	10.81 (3.60)	18.40 (9.99)	23.40 (16.06)	16.22 (7.95)	15.08 (6.83)	5.74 (1.00)	5.74 (1.00)
	Non-sig.	Non-sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±			0.80	1.43	1.13	1.05	0.51	0.46
C.D.at 5% level			2.34	4.19	3.31	3.07	1.51	1.36

Original mean values in parenthesis, * Harvested.

however, significant from one and half month old crop onward as may be seen from Tables 6.1 and 6.2. In case of 1981 season (Table 6.3), however, the incidence became significant from two month old crop onward. It may, however, be seen from these Tables that the soybean variety UPSM-19 showed lesser incidence on girdling and was significantly superior to the other soybean varieties tested.

Intensity of incidence on stems, petioles and central leaf-let stalks of different varieties

In connection with the relative preference of the pest to girdling on different sites of each of the soybean varieties namely stem, petiole and central leaf-let stalk, it has been mentioned (Section II) that higher frequency of girdling is observed on central leaf-let stalk followed by that on petiole and stem. But the differences in the intensity of girdling on different sites of each of the varieties during different periods has, however, not been mentioned earlier. Intensity of incidences either on stem, petiole or central leaf-let stalk in terms of number, from the same fixed sample area of four 1 m^2 (1 m x 1 m) per plot of 28 m^2 (7 m x 4 m) was recorded. Root transformation of number of girdlings or the intensity of incidences was done before analysis of variance.

Intensity of incidence on

(i) Central leaf-let stalk:

Intensity of girdling on central leaf-let stalk of the eight different soybean varieties during 1979, 1980 and 1981 was evaluated and the data have been presented in Tables 6.4, 6.5 and 6.6.

It may be seen from these Tables that the variety Improved Pelican showed the highest level of girdling on central leaf-let stalk during the year from 1979 to 1981. UPSM-19, closely followed either by the variety Bragg or BC-1, showed lowest level on intensity of incidence during the same period.

(ii) Petiole :

Girdling intensity or damage on petiole of the eight different varieties during different periods of 1979, 1980 and 1981 have been presented in Tables 6.7, 6.8 and 6.9.

It may be seen from these Tables that the intensity of incidence of girdling on petiole was highest on the variety Improved Pelican during the years from 1979 to 1981 while it was lowest on the variety UPSM-19 during the same period followed either by the variety Bragg or BC-1.

(iii) Stem :

Intensity of incidence on stem to girdling or damage on eight different varieties during 1979, 1980 and 1981 was ascertained and the data have been presented in Tables 6.10, 6.11 and 6.12.

It may be seen from these Tables that the intensity of incidence on stem of the variety UPSM-19 is least amongst the

Table 6.4: Intensity of incidence (root transformed values) on central leaf-let stalk of different soybean varieties(1979)

Variety	Dates of observations							
	15.7.79	30.7.79	14.8.79.	29.8.79	13.9.79	28.9.79	13.10.79	28.10.79
UPSM-19	1.26 (1.75)	2.18 (4.75)	2.92 (8.75)	3.44 (12.75)	2.81 (8.25)	1.29 (1.75)	*	*
Ankur	1.49 (2.25)	1.39 (2.00)	2.25 (5.25)	4.84 (23.75)	5.16 (27.50)	4.14 (17.50)	1.35 (2.00)	0.71 (0.50)
BC-1	1.64 (3.00)	2.05 (4.25)	2.33 (5.75)	3.42 (12.00)	3.76 (14.50)	2.22 (5.50)	0.84 (0.75)	0.71 (0.50)
Soymax	1.56 (2.50)	1.95 (4.00)	3.07 (9.50)	4.24 (18.25)	3.26 (10.75)	3.04 (9.50)	1.64 (2.75)	1.06 (1.25)
Improved Pelican	1.82 (3.50)	2.45 (6.00)	3.12 (10.00)	5.12 (26.50)	5.31 (29.50)	3.26 (10.75)	1.79 (3.25)	0.71 (0.50)
Alankar	1.64 (2.75)	1.91 (4.00)	2.28 (5.25)	4.13 (18.25)	4.92 (24.25)	3.20 (10.25)	1.06 (1.25)	0.71 (0.50)
Kalitur	1.70 (3.00)	2.01 (4.25)	2.13 (4.75)	3.34 (11.50)	3.75 (14.25)	3.49 (14.75)	2.01 (4.25)	1.31 (1.75)
Bragg	1.27 (1.75)	1.80 (3.50)	2.57 (7.00)	4.04 (16.75)	2.36 (5.75)	1.85 (3.75)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Non-sig.	Non-sig.	Non-sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±					0.33	0.30	0.18	0.05
C.D.at 5% level					0.96	0.87	0.53	0.14

Original mean values in parenthesis, * Harvested.

Table 6.5: Intensity of incidence (root transformed values) on central leaf-let stalk of different soybean varieties (1980)

Variety	Dates of observations							
	14.7.80	29.7.80	13.8.80	28.8.80	12.9.80	27.9.80	12.10.80	27.10.80
UPSM-19	1.47 (2.25)	2.29 (5.25)	2.43 (7.00)	3.78 (15.00)	3.15 (10.25)	1.06 (1.25)	*	*
Ankur	1.70 (3.00)	1.73 (3.25)	1.88 (3.75)	5.97 (36.75)	4.78 (23.00)	1.71 (3.00)	1.06 (1.25)	0.71 (0.50)
BC-1	1.77 (3.25)	1.59 (2.75)	1.61 (3.25)	4.41 (20.00)	3.25 (11.00)	2.32 (5.50)	0.84 (0.75)	0.71 (0.50)
Soymax	1.98 (4.00)	2.25 (5.50)	2.29 (5.75)	5.07 (28.00)	4.26 (18.75)	2.27 (5.50)	1.47 (2.25)	0.97 (1.00)
Improved Pelican	2.03 (4.25)	3.09 (9.75)	3.44 (12.25)	5.97 (36.25)	4.51 (20.50)	1.51 (2.50)	0.71 (0.50)	0.71 (0.50)
Alankar	2.07 (4.75)	2.39 (6.25)	2.22 (5.25)	6.01 (36.75)	3.87 (15.00)	2.00 (4.25)	0.93 (1.00)	0.71 (0.50)
Kalitur	1.69 (3.25)	1.65 (3.25)	1.85 (3.75)	3.97 (16.00)	4.75 (23.25)	2.51 (6.75)	1.70 (3.00)	1.06 (1.25)
Bragg	1.41 (2.25)	2.04 (4.25)	2.61 (7.00)	5.22 (28.00)	4.17 (18.75)	1.63 (2.25)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Sig.	Non-sig.	Sig.	Non-sig.	Sig.	Sig.	Non-sig.
S.Em ±		0.30		0.52		0.28	0.15	
C.Dt.at 5% level		0.87		1.52		0.82	0.44	

Original mean values in parenthesis, * Harvested.

Table 6.6 : Intensity of incidence(root transformed values)on central leaf-let stalk of different soybean varieties(1981)

Variety	Dates of observations							
	16.7.81	31.7.81	15.8.81	30.8.81	14.9.81	29.9.81	14.10.81	29.10.81
UPSM-19	0.84 (0.75)	1.57 (2.75)	1.71 (3.00)	2.24 (5.25)	2.40 (5.75)	1.10 (1.25)	*	*
Ankur	1.47 (2.25)	1.63 (2.75)	2.67 (7.25)	4.12 (17.50)	4.39 (19.75)	1.81 (3.50)	1.40 (2.00)	0.71 (0.50)
BC-1	1.09 (1.25)	2.09 (4.50)	2.39 (6.00)	4.14 (17.50)	2.73 (8.00)	1.18 (1.50)	0.97 (1.00)	0.71 (0.50)
Soymax	1.49 (2.25)	1.81 (3.50)	3.29 (11.50)	4.05 (17.75)	3.61 (13.25)	1.95 (4.00)	1.73 (3.00)	0.84 (0.75)
Improved Pelican	1.73 (3.25)	2.11 (4.75)	4.32 (18.75)	6.17 (38.75)	4.73 (22.75)	2.48 (6.25)	0.84 (0.75)	0.71 (0.50)
Alankar	1.61 (2.75)	2.03 (4.25)	3.64 (13.50)	4.30 (19.00)	4.69 (22.50)	2.11 (4.75)	1.18 (1.50)	0.71 (0.50)
Kalitur	1.81 (3.50)	2.55 (6.50)	3.20 (10.25)	3.15 (10.25)	3.57 (13.75)	3.31 (11.00)	1.49 (2.25)	0.97 (1.00)
Bragg	1.18 (1.50)	1.73 (3.25)	2.85 (8.25)	4.29 (19.00)	2.47 (6.50)	1.91 (3.75)	0.71 (0.50)	0.71 (0.50)
	Sig.	Non-sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Non-sig.
S.Em ±	0.19		0.19	0.33	0.36	0.15	0.10	
C.D.at 5% level	0.55		0.55	0.96	1.05	0.43	0.29	

Original mean values in parenthesis, * Harvested.

Table 6.7 : Intensity of incidence(root transformed values)on Petiole of different soybean varieties (1979)

Variety	Dates of observations							
	15.7.79	30.7.79	14.8.79	29.8.79	13.9.79	28.9.79	13.10.79	28.10.79
UPSM-19	0.97 (1.00)	1.80 (3.25)	1.35 (2.00)	1.37 (2.00)	2.34 (5.50)	0.84 (0.75)	*	*
Ankur	1.06 (1.25)	0.97 (1.00)	1.49 (2.25)	3.18 (10.25)	2.42 (6.00)	2.37 (6.00)	1.35 (2.00)	0.71 (0.50)
BC-1	1.27 (1.75)	1.38 (2.00)	1.73 (4.00)	1.85 (3.50)	1.76 (3.50)	1.61 (2.75)	0.84 (0.75)	0.71 (0.50)
Soymax	1.41 (2.25)	1.22 (1.75)	2.03 (4.50)	3.30 (11.25)	2.41 (6.25)	2.39 (6.75)	1.56 (2.50)	0.84 (0.75)
Improved Pelican	1.73 (3.00)	2.17 (4.75)	2.08 (4.50)	3.49 (12.25)	3.52 (12.50)	2.23 (5.00)	1.80 (3.25)	0.71 (0.50)
Alankar	1.18 (2.00)	1.44 (2.25)	1.63 (3.00)	2.84 (8.25)	2.40 (6.00)	1.76 (3.50)	0.84 (0.75)	0.71 (0.50)
Kalitur	1.31 (1.75)	1.31 (1.75)	2.51 (6.50)	2.64 (7.00)	2.30 (5.50)	2.14 (4.50)	2.09 (5.25)	1.06 (1.25)
Bragg	1.09 (1.25)	1.73 (3.00)	1.80 (3.25)	1.99 (4.50)	0.97 (1.00)	1.38 (2.25)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Sig.	Non-sig.	Sig.	Sig.	Sig.	Sig.	Non-sig.
S.Em ±		0.14		0.26	0.22	0.25	0.18	
C.D.at 5% level		0.41		0.76	0.64	0.73	0.53	

Original mean values in parenthesis, * Harvested.

Table 6.8 : Intensity of incidence (root transformed values) on petiole of different soybean varieties (1980)

Variety	Dates of observations							
	14.7.80	29.7.80	13.8.80	28.8.80	12.9.80	27.9.80	12.10.80	27.10.80
UPSM-19	0.71 (0.50)	1.35 (2.00)	1.06 (1.00)	1.72 (4.00)	2.24 (5.50)	0.71 (0.50)	*	*
Ankur	0.84 (0.75)	0.97 (1.00)	1.74 (3.75)	4.41 (20.25)	3.83 (14.75)	1.87 (3.75)	1.27 (1.75)	0.71 (0.50)
BC-1	1.09 (1.25)	0.97 (1.00)	1.56 (2.50)	3.39 (11.50)	3.10 (9.75)	1.85 (3.50)	0.97 (1.00)	0.71 (0.50)
Soymax	1.27 (1.75)	1.36 (2.00)	1.76 (3.25)	4.35 (19.75)	3.49 (13.25)	2.23 (5.00)	1.72 (3.00)	1.27 (1.75)
Improved Pelican	1.41 (2.25)	2.84 (8.50)	3.15 (10.25)	4.97 (25.25)	4.03 (16.50)	2.54 (7.00)	1.27 (1.75)	0.71 (0.50)
Alankar	1.22 (1.75)	1.18 (1.50)	1.67 (3.00)	4.38 (20.00)	3.25 (10.75)	2.27 (5.25)	0.93 (1.00)	0.71 (0.50)
Kalitur	1.54 (2.50)	1.98 (4.25)	1.30 (2.25)	3.52 (13.25)	3.61 (13.25)	2.54 (6.75)	1.41 (2.25)	1.18 (1.50)
Bragg	1.31 (1.75)	1.92 (4.00)	1.80 (3.75)	3.95 (16.25)	2.98 (9.25)	2.00 (4.00)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±		0.25	0.26	0.37	0.34	0.21	0.17	0.10
C.D.at 5% level		0.73	0.76	1.08	0.99	0.61	0.50	0.29

Original mean values in parenthesis, * Harvested.

Table 6.9: Intensity of incidence (root transformed values) on petiole of different soybean varieties (1981)

Variety	Dates of observations							
	16.7.81	31.7.81	15.8.81	30.8.81	14.9.81	29.9.81	14.10.81	29.10.81
UPSM-19	0.84 (0.75)	0.97 (1.00)	1.21 (1.50)	1.10 (1.25)	1.29 (1.75)	0.84 (0.75)	*	
Ankur	1.06 (1.25)	0.97 (1.00)	1.89 (4.00)	2.53 (6.50)	2.79 (8.25)	1.36 (2.00)	1.06 (1.25)	0.71 (0.50)
BC-1	0.84 (0.75)	1.13 (1.50)	2.06 (4.25)	3.26 (10.75)	2.23 (5.50)	0.93 (1.00)	0.84 (0.75)	0.71 (0.50)
Soymax	1.06 (1.25)	1.35 (2.00)	2.48 (6.50)	3.01 (10.50)	2.47 (6.50)	2.03 (4.25)	1.18 (1.50)	1.06 (1.25)
Improved Pelican	1.82 (3.50)	1.86 (3.50)	3.83 (14.75)	4.07 (17.25)	3.90 (15.25)	2.17 (4.75)	1.27 (1.75)	0.71 (0.50)
Alankar	0.97 (1.00)	1.73 (3.00)	2.94 (8.75)	2.98 (9.00)	3.24 (11.00)	1.97 (4.00)	0.84 (0.75)	0.71 (0.50)
Kalitur	1.35 (2.00)	1.86 (3.50)	2.67 (7.25)	3.03 (9.50)	3.03 (9.50)	2.76 (7.75)	1.27 (1.75)	0.84 (0.75)
Bragg	0.71 (0.50)	1.18 (1.50)	2.01 (4.25)	2.83 (8.50)	2.10 (4.75)	1.96 (4.00)	0.71 (0.50)	0.71 (0.50)
	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Non-sig.
S.Em ±	0.18	0.17	0.20	0.26	0.31	0.17	0.12	
C.D. at 5% level	0.52	0.49	0.58	0.76	0.90	0.49	0.35	

Original mean values in parenthesis, * Harvested.

Table 6.10 : Intensity of incidence (root transformed values)on stem of different soybean varieties (1979)

Variety	Dates of observations							
	15.7.79	30.7.79	14.8.79	29.8.79	13.9.79	28.9.79	13.10.79	28.10.79
UPSM-19	0.71 (0.50)	1.15 (1.50)	1.18 (1.50)	1.22 (1.75)	0.71 (0.50)	0.71 (0.50)	*	*
Ankur	0.84 (0.75)	0.71 (0.50)	1.15 (1.50)	1.64 (3.00)	1.19 (1.75)	0.84 (0.75)	0.71 (0.50)	0.71 (0.50)
BC-1	1.06 (1.25)	1.18 (1.50)	2.23 (5.00)	2.40 (6.00)	1.56 (2.75)	0.97 (1.00)	0.71 (0.50)	0.71 (0.50)
Soymax	0.71 (0.50)	0.84 (0.75)	1.85 (4.25)	2.55 (8.00)	2.32 (5.50)	1.26 (1.75)	1.35 (2.00)	0.97 (1.00)
Improved Pelican	0.71 (0.50)	1.73 (3.00)	2.06 (4.50)	2.98 (9.25)	1.92 (4.00)	0.71 (0.50)	1.56 (2.50)	0.71 (0.50)
Alankar	0.71 (0.50)	1.09 (1.25)	1.49 (2.25)	1.69 (3.25)	1.61 (2.75)	0.84 (0.75)	0.84 (0.75)	0.71 (0.50)
Kalitur	0.84 (0.75)	1.13 (1.50)	2.15 (5.00)	3.09 (9.75)	2.20 (5.25)	1.40 (2.00)	1.84 (3.75)	1.47 (2.25)
Bragg	0.71 (0.50)	0.84 (0.75)	0.84 (0.75)	1.06 (1.25)	0.71 (0.50)	0.84 (0.75)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±		0.16	0.27	0.33	0.23	0.13	0.15	0.08
C.D. at 5% level		0.46	0.79	0.96	0.67	0.38	0.44	0.23

Original mean values in parenthesis, * Harvested.

Table 6.11: Intensity of incidence (root transformed values)on stem of different soybean varieties (1980)

Variety	Dates of observations							
	14.7.80	29.7.80	13.8.80	28.8.80	12.9.80	27.9.80	12.10.80	27.10.80
UPSM-19	0.71 (0.50)	0.71 (0.50)	0.71 (0.50)	1.18 (1.50)	1.10 (1.25)	0.71 (0.50)	*	*
Ankur	0.93 (1.00)	0.71 (0.50)	1.34 (2.25)	2.76 (8.00)	2.57 (6.75)	1.93 (3.75)	0.71 (0.50)	0.71 (0.50)
BC-1	0.97 (1.00)	0.97 (1.00)	0.71 (0.50)	3.57 (12.75)	2.62 (7.00)	1.74 (3.75)	0.71 (0.50)	0.71 (0.50)
Soymax	0.71 (0.50)	0.84 (0.75)	1.18 (1.50)	4.33 (19.25)	3.49 (12.25)	3.39 (11.75)	1.61 (2.75)	0.84 (0.75)
Improved Pelican	0.71 (0.50)	0.97 (1.00)	1.26 (1.75)	4.21 (18.25)	3.42 (11.75)	2.55 (7.50)	1.76 (3.25)	0.71 (0.50)
Alankar	0.71 (0.50)	0.84 (0.75)	0.93 (1.00)	3.29 (11.25)	2.05 (4.75)	1.82 (3.50)	0.71 (0.50)	0.71 (0.50)
Kalitur	0.97 (1.00)	0.84 (0.75)	0.97 (1.00)	3.90 (16.00)	3.23 (11.75)	2.96 (9.00)	1.70 (3.75)	1.06 (1.25)
Bragg	0.71 (0.50)	0.71 (0.50)	0.97 (1.00)	1.62 (2.75)	1.60 (2.75)	1.28 (2.00)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Non-sig.	Non-sig.	Sig.	Sig.	Sig.	Sig.	Non-sig.
S.Em ±				0.34	0.29	0.31	0.14	
C.D.at 5% level				0.99	0.85	0.90	0.41	

Original mean values in parenthesis, * Harvested.

Table 6.12: Intensity of incidence (root transformed values) on stem of different soybean varieties (1981)

Variety	Dates of observations							
	16.7.81	31.7.81	15.8.81	30.8.81	14.9.81	29.9.81	14.10.81	29.10.81
UPSM-19	0.71 (0.50)	0.71 (0.50)	1.00 (1.00)	1.21 (1.50)	0.84 (0.75)	0.71 (0.50)	*	*
Ankur	0.71 (0.50)	0.84 (0.75)	1.71 (3.00)	1.70 (3.00)	1.58 (2.50)	1.13 (1.50)	0.71 (0.50)	0.71 (0.50)
BC-1	1.06 (1.25)	0.84 (0.75)	1.29 (1.75)	2.36 (5.75)	1.49 (2.25)	1.27 (1.75)	0.71 (0.50)	0.71 (0.50)
Soymax	0.97 (1.00)	0.97 (1.00)	1.75 (3.75)	3.60 (13.25)	3.66 (14.00)	2.20 (5.00)	1.09 (1.25)	0.84 (0.75)
Improved Pelican	0.97 (1.00)	1.06 (1.25)	2.40 (5.75)	3.36 (12.25)	3.28 (11.00)	2.31 (5.50)	1.85 (3.50)	0.71 (0.50)
Alankar	0.97 (1.00)	0.71 (0.50)	2.44 (6.00)	2.34 (5.50)	2.88 (8.50)	1.83 (3.50)	0.71 (0.50)	0.71 (0.50)
Kalitur	0.97 (1.00)	0.97 (1.00)	3.36 (11.50)	3.42 (12.50)	4.14 (15.00)	3.58 (13.00)	2.18 (4.75)	1.56 (2.50)
Bragg	1.06 (1.25)	1.27 (1.75)	1.68 (3.00)	2.42 (6.00)	0.97 (1.00)	0.84 (0.75)	0.71 (0.50)	0.71 (0.50)
	Non-sig.	Non-sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±			0.20	0.25	0.24	0.21	0.08	0.07
C.D.at 5% level			0.58	0.73	0.70	0.61	0.23	0.20

Original values in parenthesis, * Harvested.

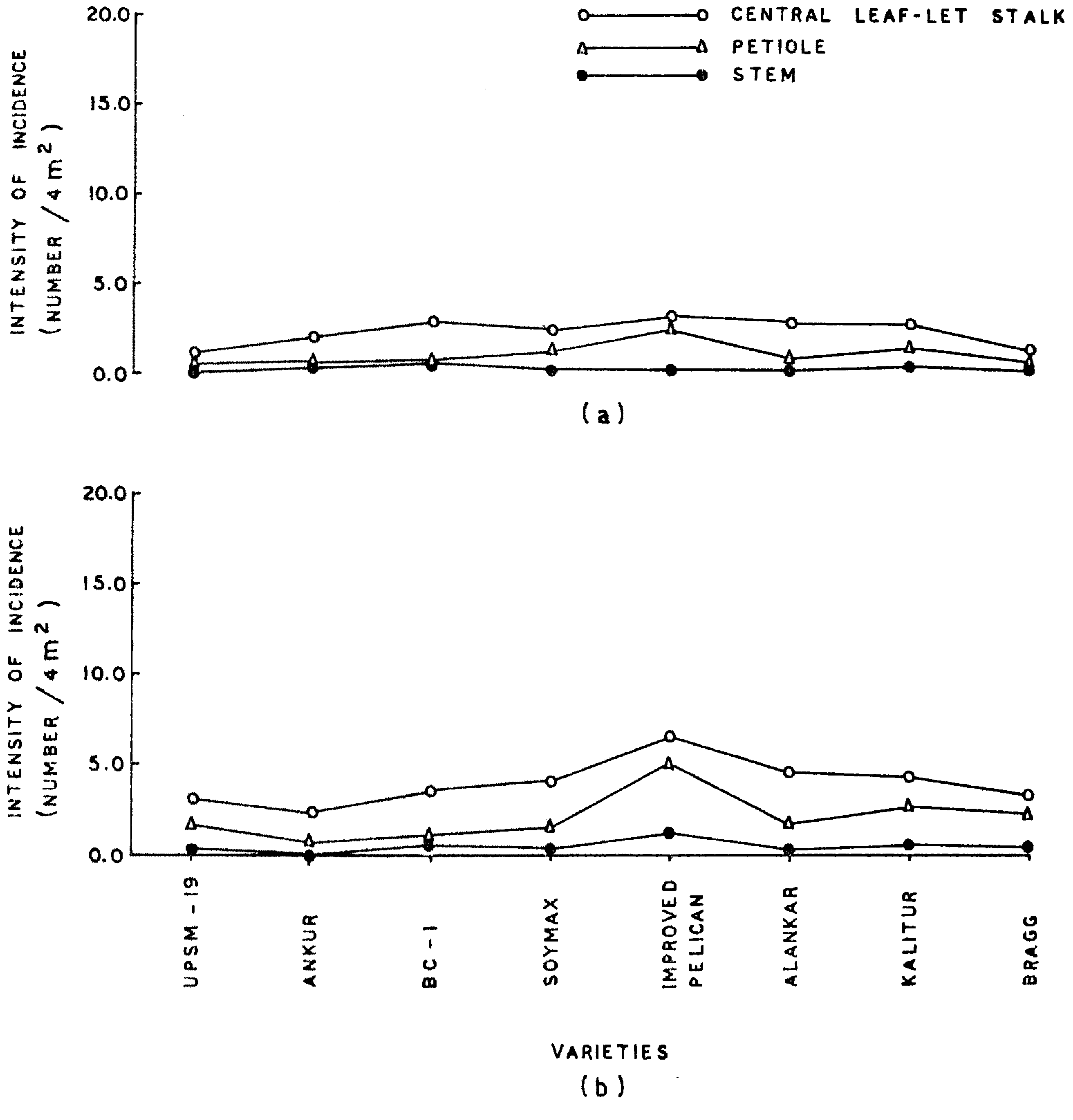
varieties tested in all the three years followed either by the variety Bragg or Ankur. The variety Kalitur showed highest level of intensity of girdling during years 1979 and 1981 while the variety Soymax showed slightly higher level of intensity of incidence than Kalitur during 1980.

Average intensity of girdling on central leaf-let stalk, petiole and stem for the three years from 1979 to 1981

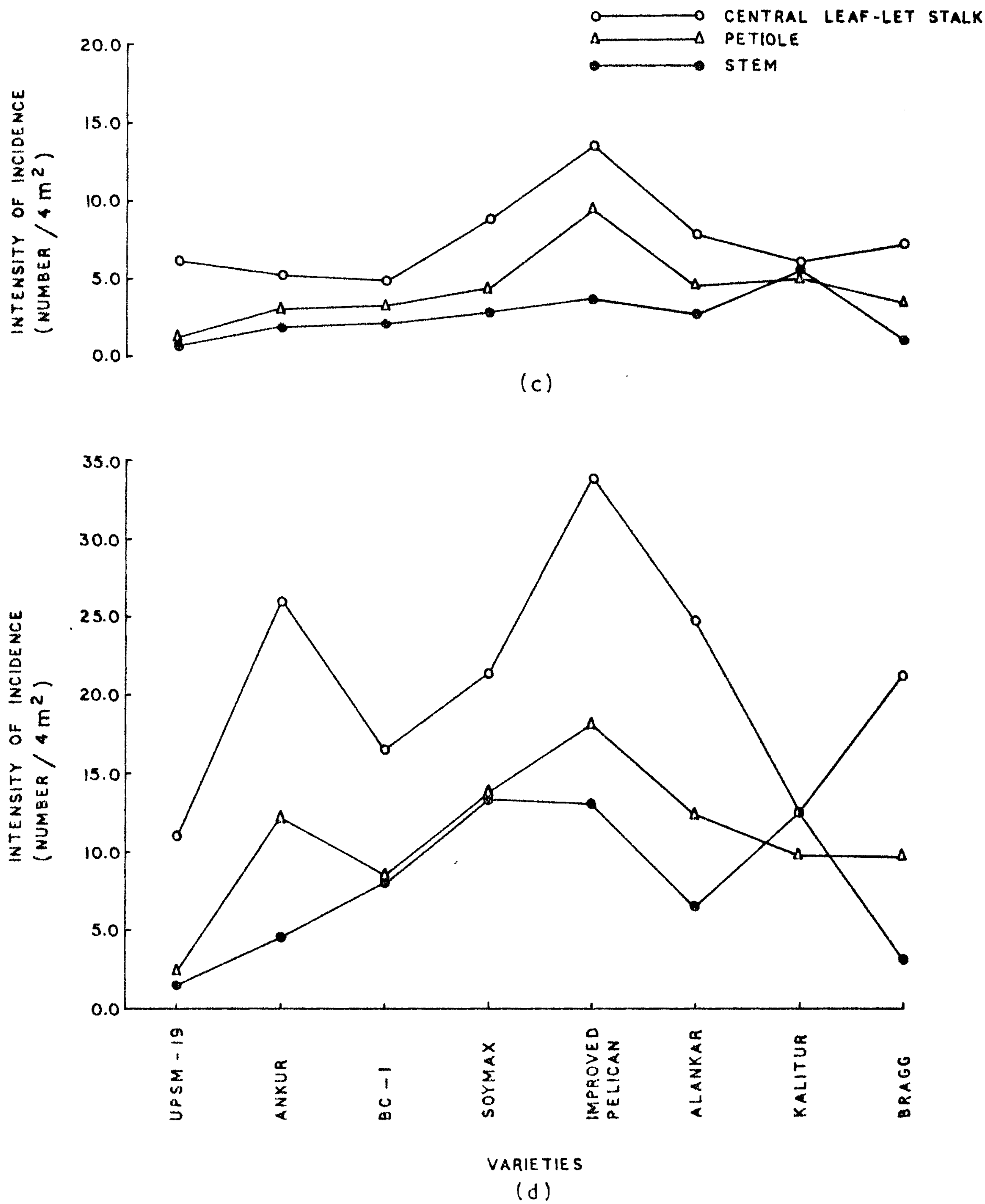
Average intensity of incidence on central leaf-let stalk, petiole and stem for three years from 1979 to 1981, at fortnightly intervals starting from 30 days old crop to 125 days old crop, has been graphically illustrated in Text Fig. 6.1,a-h.

It may be seen from these Text Figs. that UPSM-19 showed least level of intensity of girdling on central leaf-let stalk, petiole and stem on average for the aforesaid three years while Improved Pelican showed the highest level of intensity of incidence on central leaf-let stalk, as almost during the entire period of crop growth.

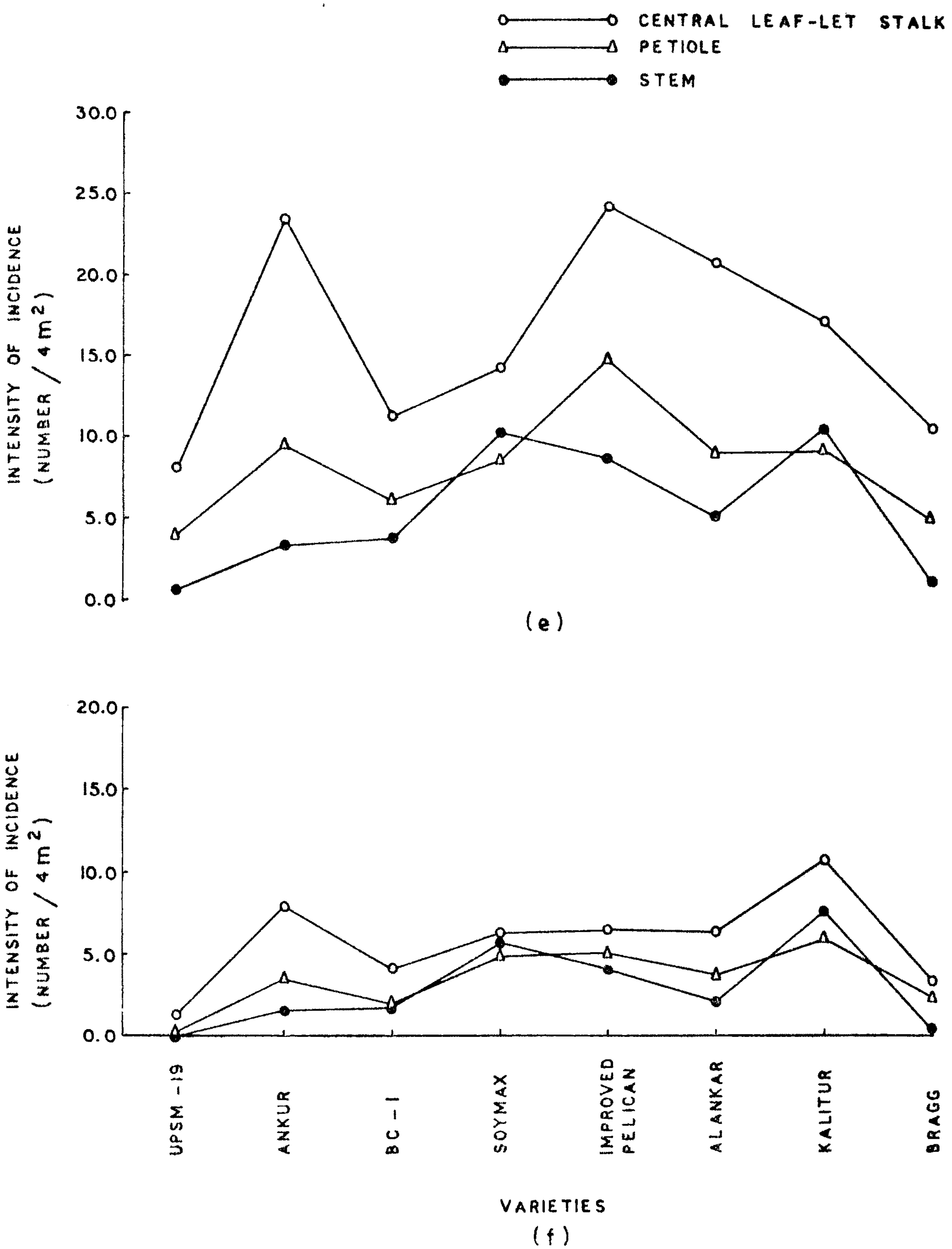
Since incidence on stem causes loss of considerable portion of stem length i.e., higher damage in comparison to that on petiole or central leaf-let stalk, the varieties with lower level of incidence on stem during different periods of growth may be considered as more tolerant to actual loss or damage by the pest. Taking the extent of incidence during different periods of 1979 to 1981 in terms of percentage of plant infested from a fixed sample area and taking the intensity of incidence in terms of number of



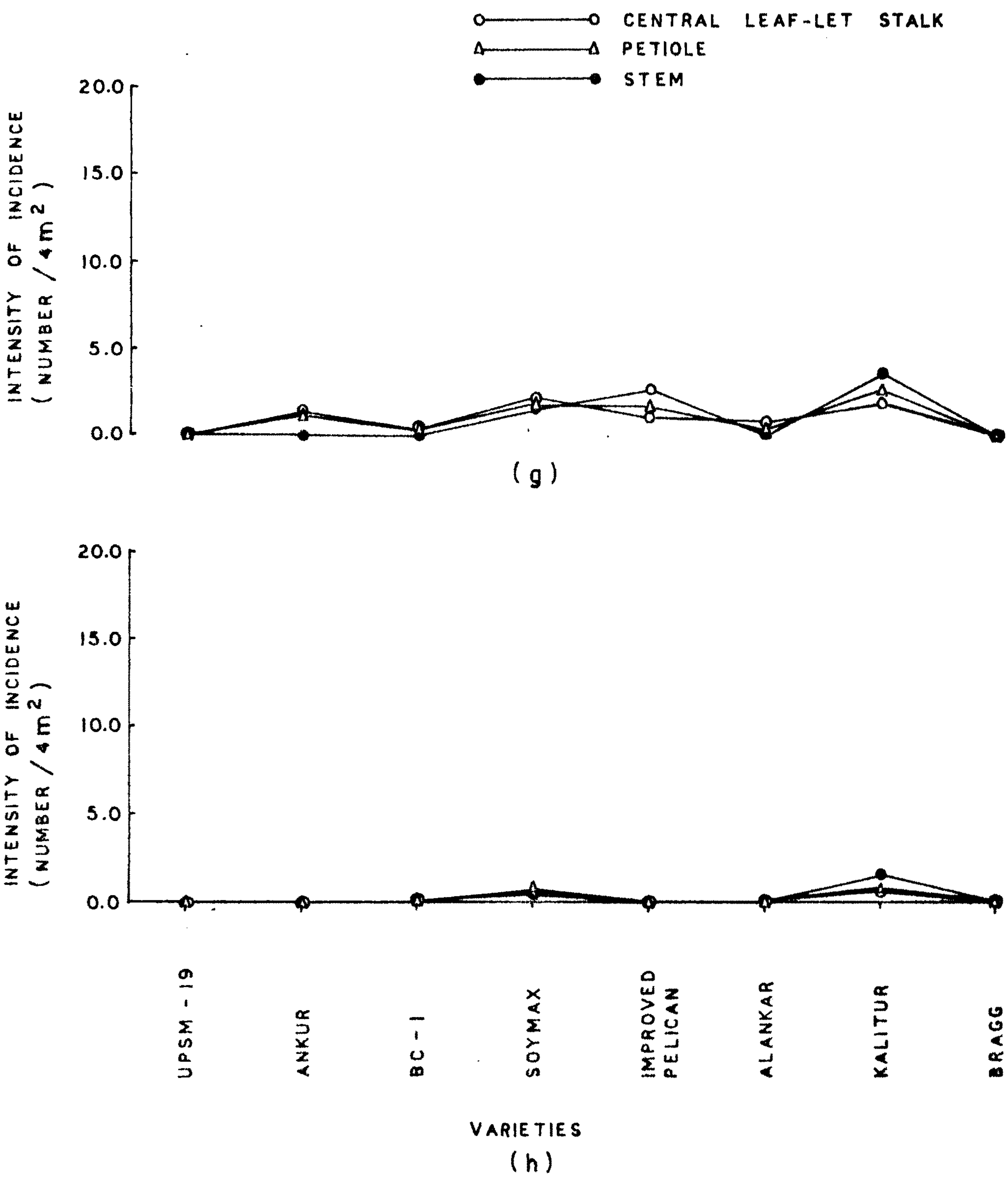
TEXT FIG. 6.1 INTENSITY OF INCIDENCE ON CENTRAL LEAF-LET STALK, PETIOLE AND STEM OF DIFFERENT SOYBEAN VARIETIES ON 30 DAYS OLD CROP, a; 45 DAYS OLD CROP, b



TEXT FIG. 6.1 INTENSITY OF INCIDENCE ON CENTRAL LEAF LET STALK, PETIOLE AND STEM OF DIFFERENT SOYBEAN VARIETIES ON 60 DAYS OLD CROP, c; 75 DAYS OLD CROP, d



TEXT FIG. 6.1 INTENSITY OF INCIDENCE ON CENTRAL LEAF-LET STALK, PETIOLE AND STEM OF DIFFERENT SOYBEAN VARIETIES ON 90 DAYS OLD CROP, e; 105 DAYS OLD CROP, f



TEXT FIG. 6.1 INTENSITY OF INCIDENCE ON CENTRAL LEAF-LET STALK, PETIOLE AND STEM OF DIFFERENT SOYBEAN VARIETIES ON 120 DAYS OLD CROP, g; 135 DAYS OLD CROP, h girdlings from the same fixed sample area as mentioned above, it is observed that variety UPSM-19 is more tolerant to the damage by the pest while Kalitur, Soymax and Improved Pelican were more susceptible to damage among the soybean varieties tested. Improved Pelican showed highest level of girdling on central leaf-let stalk and on petiole amongst the eight varieties tested. Bhattacharjee (1981) tested a number of soybean varieties for their tolerance to *O.brevis* . He reported the soybean variety, Alankar to be fairly tolerant to the incidence of the pest. The variety, Alankar, however, was found to be much less tolerant than UPSM-19, Bragg, BC-1 and Ankur to the incidence of *O.brevis*.

SECTION VII

C O N T R O L

Control of soybean girdler, *O. brevis* by application of insecticides, as is usually done in cases of considerable number of crop pests, is rather difficult since eggs are laid inside the stem; larva which is a borer remains in the central pith region of the stem whereas the adults remain underneath the leaf-lets feeding on the midribs and veins from the lower surfaces of leaf-lets. Obviously an integrated approach for control of the pest becomes necessary. The method proposed for control of the pest is an integration of physical & mechanical as well as chemical method based on observations made during the course of the present investigation, as detailed below.

(i) Physical & mechanical method

(a) Collection & destruction of girdled pieces of stem, petiole and central leaf-let stalk containing freshly laid eggs:

It has been stated earlier (Section II) that girdles are cut there on stem, petiole or on central leaf-let stalk as a pre-ovipositional operation prior to laying of egg. Such cutting of girdles results in dropping of the stem or the three leaf-lets or the central leaf-let above the level of the girdles cut either on stem, petiole or central leaf-let stalk respectively. Dropping and withering of stem, petiole with the three leaf-lets or the central leaf-let is clearly visible. Collection of freshly girdled stem, petiole or central leaf-let stalk from above the lower girdle containing the egg inside and their destruction is recommended for limiting the population of O.brevis. Freshly girdled stem, petiole and central leaf-let stalk containing the egg inside can be very easily recognised from the nature of fresh dropping and withering of leaves. Collection of freshly girdled stem, petiole and central leaf-let stalk has to be made before completion of the minimum period of incubation i.e., 3 days.

(b) Collection & destruction of stem casings containing the diapause larvae inside:

It has also been started earlier (Section IV) that prior to the onset of diapause type of larval dormancy, before harvest of the crop or at the advent of the winter, the larva cuts the stem above and below its body length and encases itself in the cut piece of stem with its two ends plugged with frasses of wood. Such cut pieces of stem casings containing the diapausing larvae drop down on the surface of the soil. If the small pieces of stem are found to be plugged with frasses of wood then it can be taken for granted that the casing contains the diapausing larva inside. Collection and subsequent destruction of the diapause casings along with the dormant larvae inside limit considerably the emergence of adult population in the following season.

(ii) Chemical method

For the purpose of evaluation of the effectiveness of five organophosphorus insecticides with low mammalian toxicity to limit the incidences of adult females of O.brevis i.e., girdling followed by oviposition, a four replicated randomised field experiment with control treatment was conducted in the year 1981. It has already been stated (Section II) that adult feeding has no or very little visible effect on the growth of the plant. Each of the five organophosphorus insecticides as mentioned in Chapter III was applied twice, 37 and 57 days after sowing having a concentration 0.03 per cent (a.i.). Control treatments were sprayed with water alone. The susceptible soybean variety Improved Pelican was used in the trial as host.

Observations on the extent and intensity of incidence i.e., girdling on stem, petiole or central leaf-let stalk of this variety were recorded at fortnightly interval till harvest, starting one month after sowing from the same fixed four 1 m^2(1 m x 1 m), demarcated earlier, from each plot of 28 m^2 (7 m x 4 m).

(a) Extent of incidence:

Extent of incidence i.e., per cent of plant infested was calculated in per cent and transformed subsequently to angular values for analysis of variance and the data has been presented in Table 7.1.

It may be seen from Table 7.1 that the extent of incidence increased as compared to pretreatment level after the

1st spray which is probably due to light shower immediately after the 1st spray. A significant difference was observed between Dimecron treatment and control after 1st spray. The level of incidence decreased probably due to no shower after the 2nd spray. All the insecticidal treatments showed significantly lower level of incidence, incidence being lower in Dimecron treated plots. The trend was maintained till the termination of the trial.

(b) Intensity of incidence :

For evaluating of differences, if any, in between the treatments on intensity of incidence i.e., average number of girdlings per infested plant, analysis of variance was done after root transformation of the number of girdlings on stem, petiole and central leaflet stalk as observed at fortnightly interval and the data have been presented in Table 7.2.

It may be seen from the Table that no significant difference in between the insecticidal treatments and control was observed after 1st spray, which may be due to light shower immediately after spray. Significant differences on the intensity of incidence, however, were observed after 2nd spray between the treated and untreated control in all the observations except the last one. In Dimecron treatment, intensity of incidence was lowest.

(c) Index of incidence:

In order to evaluate the combined effect of extent and

Table 7.1: Effect of insecticidal application on the extent of incidence (transformed to angular values)

Treatment (% concentration(a.i.) of organo-phosphorus insecticides)	Pretreatment extent of incidence (Average) 31-7-81	Post treatment extent of incidence								
		Date of 1st spray	Rainfall if any after 1st spray (inches)	Date of 2nd spray	Rainfall if any after 2nd spray (inches)	% incidence on				
						15.8.81	30.8.81	14.9.81	29.9.81	14.10.81
0.03 Nuvan 100 EC	15.92 (7.86)	7-8-81	0.21	27-8-81	-	21.39 (13.39)	19.07 (10.60)	12.65 (4.89)	10.36 (3.30)	6.40 (1.28)
0.03 Dime-cron 100 EC						19.03 (9.81)	14.07 (5.97)	11.62 (4.12)	9.13 (2.56)	5.74 (1.00)
0.03 Rogor 30 EC						21.40 (13.47)	14.80 (6.64)	12.71 (4.86)	10.02 (3.06)	5.74 (1.00)
0.03 Mala-thion 50 EC						23.52 (16.09)	20.43 (12.32)	17.75 (9.42)	14.63 (6.42)	7.58 (1.85)
0.03 Methyl para-thion 50 EC						21.66 (13.72)	18.63 (10.47)	13.43 (5.58)	11.78 (4.20)	7.33 (1.71)
Control						24.12 (16.76)	25.10 (18.04)	24.52 (17.23)	17.92 (9.48)	14.79 (6.55)
						Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±						1.02	1.35	1.08	0.67	0.67
C.D.at 5% level						3.06	4.05	3.24	2.01	2.01

Original mean values in parenthesis

Table 7.2: Effect of insecticidal application on the intensity of incidence(root transformed values)

Treatment (% concentration(a.i.) of organophosphorus insecticides)	Pretreatment intensity of incidence (Average) 31-7-81	Post treatment intensity of incidence								
		Date of 1st spray	Rainfall if any after 1st spray (inches)	Date of 2nd spray	Rainfall if any after 2nd spray (inches)	No. of incidence per plant on				
						15.8.81	30.8.81	14.9.81	29.9.81	14.10.81
0.03 Nuvan 100 EC	1.12 (1.25)	7-8-81	0.21	27-8-81	-	1.22 (1.49)	1.07 (1.15)	1.04 (1.09)	1.03 (1.05)	0.84 (0.75)
0.03 Dimecron 100 EC						1.20 (1.47)	1.03 (1.06)	1.00 (1.00)	1.00 (1.00)	0.71 (0.50)
0.03 Rogor 30 EC						1.22 (1.51)	1.04 (1.08)	1.02 (1.04)	1.00 (1.00)	0.71 (0.50)
0.03 Malathion 50 EC						1.24 (1.55)	1.08 (1.18)	1.04 (1.09)	1.04 (1.08)	0.97 (1.00)
0.03 Methyl parathion 50 EC						1.26 (1.60)	1.09 (1.19)	1.05 (1.10)	1.04 (1.08)	0.97 (1.00)
Control						1.34 (1.80)	1.38 (1.91)	1.33 (1.77)	1.14 (1.29)	1.23 (1.53)
						Non-sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±							0.03	0.02	0.01	0.09
C.D. at 5% level							0.09	0.06	0.04	0.27

Original mean values in parenthesis

intensity of incidence, an incidence index was calculated as below:

$$\text{Index of incidence} = \frac{\text{Extent of incidence} \times \text{Intensity of incidence}}{100}$$

Indices of incidence under different insecticidal treatments as well as under control were calculated and subjected to analysis of variance. Angular transformed values of extent of incidence in per cent and root transformed values of intensity of incidence in number were pulled together. The data on the effect of insecticidal application on the index of incidence have been presented in Table 7.3.

It may be seen from the Table that Dimecron closely followed by Rogor is superior in reducing incidence of the pest in comparison to other insecticides.

Control of O.brevis by insecticides alone as is often recommended by various previous workers is rather difficult since the egg is laid inside the stem and the borer larva remains in the pith region of the stem while adults remain underneath the leaf-lets feeding on the midribs and veins and are scarcely visible. Singh and Singh (1966), Rawat et al.(1969), Srivastava (1973), Gangrade (1975), Srivastava and Singh (1976), Singh et al.(1978), Bhattacharya and Rathore (1980) and Bhattacharjee (1981) used various insecticides either alone or in combination. Rogor (Dimethoate) having a concentration of 0.03 per cent was observed to be effective against the pest by Singh et al.(1978). Srivastava (1973) found a

Table 7.3: Effect of insecticidal application on the index of incidence

Treatment (% concentration(a.i.) of organophosphorus insecticides)	Pretreatment index of incidence (Average) 31-7-81	Post treatment index of incidence								
		Date of 1st spray	Rainfall if any after 1st spray (inches)	Date of 2nd spray	Rainfall if any after 2nd spray (inches)	Index of incidence on				
						15.8.81	30.8.81	14.9.81	29.9.81	14.10.81
0.03 Nuvan 100 EC	0.18	7-8-81	0.21	27-8-81	-	0.26	0.20	0.13	0.11	0.06
0.03 Dimecron 100 EC						0.22	0.15	0.12	0.09	0.04
0.03 Rogor 30 EC						0.26	0.15	0.13	0.10	0.04
0.03 Malathion 50 EC						0.30	0.22	0.19	0.15	0.08
0.03 Methyl parathion 50 EC						0.27	0.21	0.14	0.12	0.08
Control						0.32	0.35	0.33	0.20	0.18
						Sig.	Sig.	Sig.	Sig.	Sig.
S.Em ±						0.01	0.01	0.01	0.007	0.01
C.D. at 5% level						0.03	0.03	0.03	0.02	0.03

mixture of Rogor with Diazinon to be effective against the pest. During the present investigation with five different organophosphorus compounds only with low mammalian toxicity Dimecron (Phosphamidon) was found to be superior to Rogor (Dimethoate). Malathion at concentration of 0.1 per cent was found to be effective against the pest by Singh and Singh (1966). Two applications of Malathion having a concentration of 0.03 per cent a.i. was found to be inferior to Dimacron and Rogor. Rawat et al.(1969) found a mixture of Endrin with either Rogor or Endosulfan to be effective against the pest. Gangrade (1975) found Endosulfan to be effective. Srivastava and Singh (1976) found Diazinon as effective for control. Singh et al.(1978) observed 0.07 per cent Endosulfan gave 70 per cent egg and larval mortality. Bhattacharya and Rathore (1980) also recommended spraying of 0.05 per cent Endosulfan for reducing infestation of O.brevis. Bhattacharjee (1981) found spraying of Endosulfan to be effective against the pest. Since soybean is mainly grown in Kharif season under West Bengal condition with high precipitation and since the insecticide Endosulfan and Endrin show a very high level of toxicity (Dutt and Bhattacharya, 1960; Dutt and Dass, 1971) to aquatic fauna including fishes, with the possibility of polluting bound water in ponds and canals causing fish mortality, these insecticides were not included in the present investigation.

The organophosphorus compounds choosen not only with low mammalian toxicity but they showed similar lower level of toxicity to bound water fishes (Guha, 1980). Dimecron which has been found to be superior in reducing incidence of the pest also shows a very low level of fish toxicity (Guha, 1980). Accordingly, two applications of Dimecron having concentration of 0.03 per cent a.i. on 37th and 57th days after sowing have been recommended along with collection & destruction of girdled pieces of stem, petiole and central leaf-let stalk containing the freshly laid eggs and also the stem casings containing the diapause larva inside, for control.

CHAPTER-V

SUMMARY AND CONCLUSION

1. Soybean girdler, Obereopsis (=Oberea) brevis Swed. (Col.,Lamiidae) has been reported by the present author for the first time from North Eastern India including West Bengal. The pest has turned out as one of the major pests of soybean (Glycine max.(L.) Merr., Fam., Leguminoseae) under West Bengal condition.

2. Incubation period of eggs has been found to vary from 3 to 4 days. In 35.62 per cent cases incubation has been found to be 3 days and in 64.38 per cent cases incubation period has been observed to be 4 days.

3. In 40 per cent cases the number of larval instars has been observed to be four while in 60 per cent cases the number of larval instars has been found to be five. Larval period has been found to vary from an average larval period of 29.6 days in case of larvae with four instars and 34.4 days on average in larvae with five instars. Larval length and width are slightly more in case of larvae with four instars than those larvae having five instars. The distinctive morphological features including ampullar characters have been described for the first time enabling identification of the larvae of O.brevis . The pupal length and width of larvae with four instars have been found to be slightly more than those obtained from five instars larvae. But the pupal period is less i.e., 7.75 days on average in case of pupae obtained from four

instar larvae while it is 8.83 days on average in pupae obtained from five instar larvae.

4. Ecological back-ground of the adult behaviour and damage has been investigated. Presence of the adults which are scarcely visible in the field can be ascertained from its characteristic feeding habits on mid ribs and veins from the under surface of trifoliate leaves leaving empty spaces at their site of feeding.

5. Unlike the other crop pests very little or no appreciable damage is done during the course of feeding either by the adult or by the larva. Damage is done at the time of girdling on stem during the pre-ovipositional operation.

6. Two girdles and a slit are cut either on the central leaf-let stalk, petiole or on the stem by the egg laying female as pre-ovipositional operation causing loss of the central leaf-let of the trifoliate leaf or of the trifoliate leaf or a considerable portion of the stem.

7. A considerable portion of stem length ranging from 4.0 to 29.5 cm along with leaves, flowers and fruits, if any, is lost when girdling is done on stem. Damage is thus really caused when girdling is done on stem.

8. Lower girdle is cut first followed by the upper girdle and the slit which is cut nearer the lower girdle. Time taken for cutting the upper and lower girdle on central leaf-let stalk is less than the time taken for cutting girdles on petiole and stem while the time taken for cutting the slit on central leaf-let stalk, petiole or stem is more or less equal, so also the ovipositional time.

9. The slit consists of a central pit bordered on either side by two lateral punctures. The central pit and two lateral punctures are made by two successive indentations. During the second insertion of mandibles one is placed in one corner of one of the punctures already made by the previous indentation. Two inner insertions coalesce so as to make a central wider pit than the lateral punctures. The central pit and the lateral punctures penetrate down to the pith tissue. That the central pit is the resultant of two mandibular insertions is supported by the fact that the width of the central pit is more or less equal to the widths of the two lateral punctures taken together. Central pit is made wider to allow entry of the genital capsule through it for oviposition on the periphery of pith tissue and not through the lateral punctures.

10. It has been observed that cutting of girdles is limited to that portion of the stem where diameter ranges from $>$ 1.9 mm to 4.0 mm. Maximum girdling is done to that portion of the stem where the diameter ranges from $>$ 2.2 mm to 3.4 mm.

11. A relationship exists between the intergirdle length of stem, petiole or central leaf-let stalk and diameter & moisture content. It has been observed that intergirdle length increases with decrease in diameter of stem, petiole or central leaf-let stalk. The girdles, cut for reduction of moisture content in the intergirdle portion, may not be a direct physiological necessity for egg development unless the stem, petiole or central leaf-let stalk are very succulent but for prevention of callus tissue formation at the level of the slit to avoid crushing of eggs.

12. A relationship between diameter of stem, petiole or central leaf-let stalk and girdling & oviposition has been found to exist. It has been observed that the selection of site for girdling is limited to that portion of stem where the diameter ranges from $>$ 1.9 mm to 4.0 mm; $>$1.4 mm to 4.0 mm in case of petiole and 1.0 mm to 3.0 mm in case of central leaf-let stalk.

13. In case of stem, girdling is accompained by oviposition in 99.2 per cent; in case of petiole, girdling is accompained by oviposition in 98.8 per cent; in case of central leaf-let stalk girdling is accompained by oviposition in 98.8 per cent cases.

14. Relative preference for girdling on stem, petiole or central leaf-let stalk of eight soybean varieties have been ascertained. It has been found that frequency distribution of girdling on

central leaf-let stalk occurs to the extent of 54.12 per cent cases; 28.83 per cent cases on petiole and 17.05 per cent cases on stem out of a total observations of 7110 covering eight different soybean varieties namely UPSM-19, Ankur, BC-1, Soymax, Improved Pelican, Alankar, Kalitur and Bragg.

15. Correlation studies between larval length, larval width and width of head capsule of larvae with four instars were made and a high value of correlation coefficient namely 0.985 was found. Similar biometrical analysis of larval growth in respect of larval length, larval width and width of head capsule of larvae having five instars was carried out and the multiple correlation coeffieient value of 0.977 was found.

16. Progression factor in respect of width of head capsule of larvae with four instars was determined and was found to be 1.40 whereas the progression factor in larvae with five instars was observed to be 1.31.

17. The larva enters into diapause type of dormancy at the advent of winter with the maturation of soybean crop. On the eve of entering into their diapause phase it cuts the stem above and below its body length and plugs its two ends with frass of wood and encases itself in small pieces of stem so cut and plugged. Such cut pieces of stem containing the diapause larva inside

ultimately drops at the surface of soil to skip over the unfavourable condition.

18. Of the various factors tested under laboratory condition for determination of diapause, exposure to a temperature ranging from 31.0°C - 34.0°C during summer months and high relative humidity per cent were found necessary for termination of diapause.

19. It was observed that the diapause type of dormancy is eliminated at higher level of relative humidity per cent and constant temperature of 30.0 ± 1°C whereas larvae exposed to low level of relative humidity died. A certain period of time namely, the winter months immediately following initiation of diapause need to be elapsed before its termination under favourable condition indicating thereby that the dormancy is of diapause type.

20. Laboratory experiment was carried out with diapause larvae exposed continuously in soil having different percentages of moisture under the room temperature. It has been observed that in cases where the soil moisture decreased to a range of 6.17 - 15.91 per cent from the original moisture till the end, 100 per cent adult emergence occurred after expiry of winter months. Where the soil moisture decreased below 6.17 per cent, the diapause larvae died. In soil with soil moisture above 15.91 per cent at the end, diapause was terminated in most cases while over-hydration of larvae occurred leading to fungal infection and death of diapausing larvae.

21. Emergence of diapausing larvae under the field condition was found to occur after a monsoon precipitation of at least 8.16 inches. No adult emergence was observed during the winter months. The diapause larvae exposed to the surface soil died while 100 per cent adult emergence occurred in cases of larvae exposed to a soil depth ranging from 2 to 6 inches. The peak adult emergence namely 100 per cent occurred in case of larvae exposed to a depth of 4 inch followed by emergence in other depths.

22. The explanation for the susceptibility to cutting girdles and oviposition at a particular portion of stem, petiole or central leaf-let stalk which falls within a certain diameter range has been found in the relationship that exists between the length of the mandibles of female, depth of extra-medullary tissue from epidermis down to periphery of pith tissue of stem, petiole or central leaf-let stalk and girdling & oviposition. It has been observed that the regions of the central leaf-let stalk, petiole and stem where the ratio of the mandibular length of the female to the depth of extra-medullary tissue ranges from 1:0.62 to 1:1.15, 1:0.63 to 1:1.20 and 1:0.69 to 1:1.11 respectively, represent the susceptible sites for girdling, oviposition and damage. The degree of cutting girdles decreases gradually in those portions of central leaf-let stalk, petiole and stem where the thickness of extra-medullary tissue increases or decreases these ratios.

23. Extent and intensity of incidence in eight different soybean varieties namely UPSM-19, Ankur, BC-1, Soymax, Improved Pelican, Alankar, Kalitur and Bragg were evaluated from a four replicated field trial carried out for three consecutive years from 1979 to 1981 and it was found that UPSM-19 was the most tolerant to the damage by the pest while Kalitur soymax and Improved Pelican were more susceptible to damage amongst the varieties tested. Improved Pelican,however, showed highest level of girdling on Central leaf-let stalk and on petiole amongst the eight varieties tested.

24. For control of the pest, an integrated approach was found necessary since the larva is a borer and the adults are scarcely visible in the field. Accordingly, collection & destruction of girdled pieces of stem, petiole and central leaf-let stalk containing the freshly laid eggs were found useful. Similarly,collection & destruction of soybean stem casings containing the diapause larva inside was helpful in reducing the adult emergence in the following year. Such small pieces of stem containing the diapausing larva can easily be recognised by their two ends plugged with frasses of wood.

25. Five organophosphorus insecticides namely Dichlorovos (Nuvan) Phosphamidon (Dimecron), Dimethoate(Rogor), Malathion (Cythion) and Methyl parathion (Metacid) with low mammalian and

fish toxicity were applied twice on 37th and 57th days after sowing, each having a concentration of 0.03 per cent a.i., for control of the pest in a replicated field trial. Extent and intensity of incidence vis-a-vis control treatment were evaluated. Indices of incidence were also evaluated by combining the extent and intensity of incidences after application of different insecticides. Dimecron (Phosphamidon) with low mammalian and fish toxicity was found superior to the rest of the other insecticides followed by Rogor (Dimethoate) and Cython (Malathion).

CHAPTER-VI

FUTURE SCOPE OF RESEARCH

Critical investigation on soybean girdler, *Obereopsis brevis* (Col., Lamiidae) has laid the foundation of investigation on soybean entomology in Eastern India particularly in West Bengal. Present work on the description of the larval characteristics particularly the ampullar characters making it possible to identify the species on larval characters alone would help future programme of work in locating alternative host plants based on the characters of the larva of *O. brevis* which is a borer.

Present work on larval diapause and the factors responsible for its elimination have similarly opened up scope of work on various aspects of diapause development and forecasting of incidence of the pest.

Evaluation of tolerance of different soybean germplasm to the pest species as well as the factors responsible for determining the site of damage in a particular portion of stem, petiole or central leaf-let stalk would stimulate future work on exploration of factors conferring tolerance / resistance in soybean germplasm which would ultimately help in evolving suitable tolerant type in connection with integrated control of the pest

CHAPTER-VII

BIBLIOGRAPHY

Anonymous (1981) Agricultural Situation in India. Faqeir Chand, ed. 36 (9): 728-730.

Ayyar, T.V.R. (1963) Hand book of economic entomology for South India (Revised ed.). Govt. press, Madras. pp 516.

Balduf, W.V. (1923) The insects of the soybean in Ohio. Ohio. Agric. Exp. Sta. Bull. 366 : 145-181.

Bhardwaj, S.P. and Bhalla, O.P. (1977) Record of insect pests of soybean in Himachal Pradesh. Indian J. Ent. 38 (3): 286-289.

Bhatnagar, P.S. (1982) Soybean in India-Retrospective and prospective. In project coordinator's report in 13th annual workshop of All India Coordinated Research Project on Soybean (I.C.A.R.) held at G.B. Pant University of Agriculture & Technology, Pantnagar (Nainital), May 17-19, 1982. pp 9-33.

Bhattacharjee, N.S. (1981) Soybean pests and their management. National seminar on strategies of pest management, December 21st - 23rd, 1981, IARI, New Delhi organised by Entomological Society of India. pp 62-63.

Bhattacharya, A.K. and Rathore, Y.S. (1980) Soybean insect problems in India. World Soybean Res. Conf.-II: Proc.; March 26-29, 1979; North Carolina State University, Raleigh, North Carolina, USA, Frederick T. Corbin, ed. pp 291-301.

Blickenstaff, C.C. and Huggans, J.L. (1962) Soybean insects and related arthropods in Missouri. Mo. Agric. Exp. Sta. Res. Bull. No. 803. pp 51.

Breuning, S. (1952) Revision einiger Gattungen aus der Gruppe der Saperdini Muls. (Col. Cerambycidae) Ent. Arb. Mus. Frey. 3: 113.

Breuning, S. (1955) Revision Du Genre Obreopsis Chvrl. (Insecta: Coleoptera: Cerambycidae: Lamiinae). Indian For. Rec. (New Series) 9 (3): 115.

Breuning, S. (1960-62) Revision systematique Des espèces du genre Oberea Mulsant du Globe (Coleoptera, Cerambycidae) Frustula Entomologica. Vol. 3, 4, 5, Nos. 4, 3, 4.

Breuning, S. (1982) A personal Communication.

Chatterjee, B.N. and Roquib, M.A. (1977) Soybean research 1967-1975. Bulletin No. 3: 42-44. BCKVV, W.B.

*Cheu,S.P.(1944) Insect menace - the cause of soybean failure in Kwangst(In Chinese). Kwangst Agric. 4 (3):7.

Clausen, C.P. (1931) Insects injurious to Agriculture in Japan. US Dept.Agric.Circ. 168. pp 115.

*Corseuil, E.,Cruz, F.Z.da and Meyer, L.M.C.(1974) Insetos nocivos a soja no Rio Grande do Sul. Univ.Fed.Rio Grande do Sul.Fac.Agric. Dep Fitotecnia, Setor Entomol.Porto Alegre, Brasil. pp 37.

Duffy, E.A.J.(1953) A monograph of the immature stages of British and imported timber beetles (Cerambycidae).London,Brit. Mus.(Nat.Hist.).pp 350.

Dutt, H.L.(1915) The soybean stem borer.Agric.J.Bihar-Oris. 3:52-56.

Dutt, N.(1956a) Mandibular length in _Nupserha bicolor_ Thoms.ssp. _postbrunnea_ Breun.(Col.,Lamiidae) as the factor in determining the site of oviposition in _Corchorus olitorius_. Bull.ent.Res. 47 :777-783.

Dutt, N.(1956b) Studies on _Nupserha bicolor_ Thoms.ssp._postbrunnea_ Breun.(Col., Lamiidae).IV.Preliminary observations on immature stages and elimination of larval diapause. Jute Bull.18 (10): 254-256.

Dutt, N. and Bhattacharjee,S.P.(1960) Toxicity of some insecticides to carp fingerlings.Proc.Zool.Soc.,Calcutta. 13 (1): 43-49.

Dutt, N.(1961) Studies on the bionomics of the jute stem girdler, _Nupserha bicolor postbrunnea_ Dutt (Col.,Lamiidae). Bull.ent.Res.51 : 765-779.

Dutt,N. and Dass,G.B.(1971) The bioassay technique for determining insecticidal pollution of water.Proc.1st All-Ind. Symp. on Progr.& Probl.Pesti.Resi.Anal.,Ludhiana. pp 261-265.

Dutt, N. and Maity, B.(1972) Bionomics of the banana pseudostem weevil,_Odoiporus longicollis_ Oliv.(Coleoptera: Curculionidae).Indian J.Ent.34 (1):20-30.

Dyar,H.G.(1890).The number of moults of Lepidopterous larvae. Psyche.5 : 420-422.

*Ferreira,E.(1970) Pragas da soja no Rio Grande do Sul.Simp.Brasileiro Soja, 1st 11 pp (Mimeogr.)

Fletcher, T.B.(1917) Rept.of Proc.of the sec.Entomol.Meeting-Pusa. pp 52.

Fletcher, T.B.(1919) Rept.Imp.Entomologists.Sci.Rept.Agric.Res. Inst.,Pusa, pp 84,116.

Gangrade, G.A. Kapoor, K.N. and Gujrati, J.P.(1971) Biology, behaviour and control of Oberea brevis Swed.(Col:Cerambycidae-Lamiinae) on soybeans in Madhya Pradesh, India. The Entomologist. 104 : 260-264.

Gangrade, G.A.(1974) Insects of soybean. Directorate of Research services. JNKVV, Jabalpur, Madhya Pradesh, India. pp 88.

Gangrade, G.A.(1975) Some aspects of soybean entomological work in Madhya Pradesh, India. Soybean production, protection and utilization; Proc.Conf. for scientists of Afr., MiE & S. Asia; October 14-17, 1974; Addis Ababa, Ethiopia. D.K.Whingham,ed. INTSOY Sr.No.6: 141-146.

Gangrade, G.A. and Singh, O.P.(1975) Soybean plant response to the attack of Oberea brevis Swed.(Col,Cerambycidae) Zeitschrift für Angewandte Entomologie.79 (3): 285-290.

Gangrade, G.A. and Singh, O.P. (1976) Assessment of losses to soybean by Oberea brevis Swed.(Col.,Cerambycidae).Zeitschrift für Angewandte Entomologie. 81 (1):26-30.

*Guagliumi, P.(1966) Insetti e aracnidi delle pianti comuni del Venezuela segnalati nel periodo 1938-1963.Relaz. Monograf. Agrarie Subtropicali Tropicali, Nuova Ser. Inst.Agron. Perl'Oltremare, Firenze, No.86:391.

Guha,R.S.(1980) Toxicity of insecticides to fishes with and without soil layer in the test aquaria.Ph.D.Thesis. pp 140

Hatchett, J.H.,Jackson,R.D. and Barry,R.M.(1973) Rearing a weed Cerambycid,Dectes texanus on an artificial medium with notes on biology.Ann.Ent.Soc.America.66(3): 519-522.

Hatchett, J.H.,Daugherty, D.M.,Robbins,J.C.,Barry,R.M. and Houser, E.C.(1975) Biology in Missouri of Dectes texanus, a new pest of soybean.Ann.Ent.Soc.America.68(2): 209-213.

Jotwani, M.G.(1980) Hand Book of Agriculture. P.L.Jaiswal,ed. ICAR, New Delhi. pp 1303.

Kapoor, K.N., Gangrade,G.A. and Gujrati,J.P.(1971) Note on the effect of infestation by Oberea brevis Swed. (Coleoptera: Lamiidae) on pods and yield of soybean (Glycine max (L.) Merr.) Indian J. agric.Sci.41 (3): 272-273.

Kawamura,S.(1967) Quantitative paper chromatography of sugars of the cotyledon, hull and hypocotyl of soybeans of selected varieties. Kagawa Univ.Fac.Tech.Bull.18 :117-131.

Kobayashi,T.,Hasegawa, T. and Kegasawa, K.(1972) Major insect pests of leguminous crops in Japan.Symp.Food Legumes, 109-25. Tokyo:Trop.Agric.Res.Ctr.

Kretzschmar, G.P.(1948) Soybean insects in Minnesota with special reference to sampling techniques. J.econ.Ent. 41: 586-591.

Kurosawa, T. and Matsumoto, S. (1961) On the pest insect fauna of soybean in newly cultivated field in mountanious area near Sapporo.Res.Bull.Hokkaido Nat.Agric.Exp. Sta.76 : 60-71.

*Myers, C.V. (1940) Insects inhabiting soybean fields.MS thesis. Univ.of Illinois, Urbana. pp 69.

Odak, S.C. and Thakur, B.S. (1978) Record of new alternate host plants of girdle beetle, Oberea brevis Swed. (Coleoptera: Lamiinae) in India.Indian J.Ent.40(4): 444-445.

*Pacheo,F.(1970) Plagas del valle del Yaqui.Cir.Cent.Invest.Agric. Noroeste Invest.Agric.No.53.,Inst.Nac.Invest.Agric., S.A.G.Mexico. pp 124.

Rawat, R.R.,Singh,Z. and Kapoor, K.N.(1969) Arthropod pests of soybean in Madhya Pradesh.Agric.Agro-Ind.J.2 (9-10): 11-13.

*Rizzo,H.F.(1972) Enemigos animales del cultivo de la soja.Rev.Inst. Bolsa Cereales No.2851:6.

Robertson, I.A.D.(1969) Insecticide control of insect pests of soybean [Glycine max (Linnaeus)] in eastern Tanzania. E.Afr. Agric.For.J.35 :181-184.

Ruggles,A.G.(1915) Life history of O.tripunctata Swed.J.eco.Ent. 8 (1): 79-85.

Sachan, T.N. and Gangwar, S.K.(1980) Insect pests of soybean in Khasi hills of Meghalaya and their control.Bull.Ent.21: 105-112.

Saxena, D.K.(1972) Arthropod pests of soybean in Madhya Pradesh and their control.Pesticides.6 (4):17-19.

Singh, D.P. and Singh, K.M.(1966) Certain aspects of bionomics and control of Oberea brevis S. - new pest of beans and cowpeas. Labdev.J.Sci.Tech. 4 (3):174-177.

Singh, O.P. and Gangrade,G.A.(1977) Note on girdle beetle infestation in relation to dates of planting of soybean.Indian J.agric.Sci.47 (8):425-426.

Singh, O.P.,Jakhmola,S.S. and Rawat,R.R. (1978) Ovicidal effect of some insecticides on the eggs of the girdle beetle, Oberea brevis Swed. (Coleoptera : Lamiidae) on soybean. Indian J.agric. Sci. 48 (11):669-671.

Singh,O.P.,Jakhmola,S.S. and Gangrade,G.A.(1978)Neue Wirtspflanzen des Ringelbocks, Oberea brevis Swed.(Col.,Cerambycidae, Lamiinae) in Indien. Anzeiger fur Schäldinskunde Pflanzenschutz, Umweltschutz. 51 (6):88-89.

Singh, O.P.,Mehta,S.K.,Sharma,S.M. and Gangrade,G.A.(1979) Response of new strains of soybean to girdle beetle, Oberea brevis Swed.(Coleoptera:Lamiidae). JNKVV Res.Jour. 10 (3):267-268.

Singh, O.P.(1980) Oberea brevis Swed.(Coleoptera: Lamiidae): A threat to soybean cultivation in Central India. World Soybean Res. Conf.-II:Abst.; March 26-29, 1979; North Carolina State University, Raleigh,North Carolina, USA. Fredrick T.Corbin, ed.pp 24.

Srivastava, A.S.,Srivastava,K.M.,Aswasthi, B.K.and Nigam, P.M.(1972) Damage of stem borer,Oberea brevis S.(Cerambycidae: Coleoptera) a new pest of soybean crop in Uttar Pradesh. Labdev J.Sci.Tech.10-B(1):53-54.

Srivastava, A.S.,Srivastava,K.M. and Singh,R.P.(1976) Incidence of and damage by Myllocerus maculosus Desbrochus, Melanagromyza phaseoli Tryon and Oberea brevis S. to different varieties of soybean Labdev J.Sci.Tech. 12 (3):119-120.

Srivastava,B.K.(1964) Pests of pulse crops.Entomology in India. N.C.Pant,ed. pp 87.

Srivastava,O.S.(1973) Effect of insecticidal treatment on the yield of Bragg variety of soybean.JNKVV Res.Jour.7(2): 96-97.

Srivastava,O.S. and Singh,M.P.(1976) Chemical control of girdle beetle and stemfly pests of soybean. Indian J.Ent. 36 (2):170-172.

Stokes, R.H. and Robinson,R.A.(1949) Standard solutions for humidity control at 25°C.Industr.Engng.Chem.41 :2013.

Tugwell, P.,Rouse,E.P. and Thompson,R.G.(1973) Insects in soybean and a weed host (*Desmodium sp.*). Arakansas Agric. Exp.Sta.Rep. Ser.214.pp 18.

Turnipseed, G.S. and Kogan, M. (1976) Soybean entomology.Ann.Review of Entomology.Ray F.Smith,Thomas E.Mittler and Carroll N.Smith,ed.21 :247-282.

Van Dinther, J.B.M.(1956) Soybean insects.Entomol.Ber Amsterdam.16: 104-109.

* Original not seen.