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Journal of Science

On behalf of the Editorial board I thank all those who sent very encouraging complimentary messages on the publication of Volume 1. The past year had been a period of turmoil in Sri Lanka, and hence the publication of Volume 2 had been delayed beyond expectations, besides the two numbers of this volume had to be combined.

In this volume, as in the previous volume, six out of the eight papers deal with subjects directly concerned with regional problems.

The paper by K. Chitravadivelu reports observations on the growth and breeding seasons of three fish species, which are in very great demand in this part of Sri Lanka. Fertilizer nitrogen forms the subject of papers by Arulvathane P. Arudchandran and K. Theivendirarajah, and by A. M. T. Saverimuttu and S. Kandiah. Biological nitrogen fixation and nitrification in the alkaline soils of Jaffna are the subjects of investigation. The information should benefit the agriculturists of this area in designing sound cultural practices.

G. F. Rajendram with Francis R. Devarajah and Anita Selvadurai present two papers on the important rice pest - *Nilaparvata lugens* and its predator in Sri Lanka. N. Selvarajah has presented the results of her studies on the effect of food particle size, temperature and relative humidity on development of yet another grain pest. R. V. S. Sundaresan's paper deals with the chemical control of a virus disease in tobacco.

S. Kandiah and S. Kokulathasan present very encouraging results of their studies on chemical stimulation of sap ('toddy') flow in palmyrah palm, that could possibly increase yield by two to three fold.

The paucity of contributions from scientists outside the Jaffna University may be partly attributed to the unsettled conditions in the past, especially in most of our Universities. It is expected once conditions return to normalcy such contributions would increase.

CHIEF EDITOR

March 12, 1989

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OBSERVATIONS ON THE BIOLOGY OF THREE SIGANIDS
SIGANUS LINEATUS*, *SIGANUS JAVUS* AND *SIGANUS CANALICULATUS
FROM WATERS AROUND JAFFNA

K. CHITRAVADIVELU

(Department of Zoology, University of Jaffna, Sri Lanka.)

Vingnanam — Journal of Science 2: 1—13 (1987)

ABSTRACT *Siganus lineatus* (Valenciennes), *Siganus javus* (Linnaeus) and *Siganus canaliculatus* (Park) are three of the five species of Siganids recorded along the coastal areas and brackish water bodies in the northern part of Sri Lanka. These species are chosen as candidates for mariculture and investigations on their culture methods are under way in many countries. Commercial culture of these species in Sri Lanka is likely to be profitable because of consumer demand.

Two hundred and forty specimens of *S. lineatus*, 363 specimens of *S. javus* and 448 specimens of *S. canaliculatus* ranging in standard length from 21 mm to 306 mm were used in this investigation. Morphometrics, length-weight relationship, changes in coefficient of condition (K) and fecundity have been investigated. Statistical analysis of morphometric characters did not reveal sexual dimorphism in these species.

The calculated length-weight relationships, of $w = 0.00002857 \times 13.2444^3$ in *S. lineatus*, $w = 0.00000026 \times 13.0000^3$ in *S. javus* and $w = 0.018570 \times 13.1300^3$ in *S. canaliculatus* reflect an almost isometric growth. The decrease of K value beyond standard lengths of 165 mm, 145 mm and 125 mm in *S. lineatus*, *S. javus* and *S. canaliculatus* respectively is assumed to indicate the onset of sexual maturity at these lengths.

On the basis of the observations on length-weight relationship it is recommended to have existing fishing methods suitably modified to catch *S. lineatus*, *S. javus* and *S. canaliculatus* above 175 mm, 135 mm and 145 mm standard lengths respectively.

The marked decline in condition factor during September — October in *S. lineatus* suggests this as the main spawning period. In *S. javus* and *S. canaliculatus* June is a likely spawning month; however the data is less convincing for these species. The mean fecundity of *S. lineatus*, *S. javus*, and *S. canaliculatus* have been assessed as 2.99×10^3 , 2.44×10^4 and 4.88×10^3 respectively.

Introduction

The Siganids, commonly referred to as the 'rabbit fishes', are found in the tropical areas of the Indian and Pacific Oceans (Marshall, 1964; Lam, 1974; Woodland & Allen, 1977; Carcasson, 1977). These are an economically important group of food fishes found inhabiting the coastal areas and brackish water bodies in Sri Lanka (Munro, 1955). The flesh of the fish is meaty and considered to be tasty. The existing consumer demand and market potential are therefore fairly high. Siganids have recently attracted the attention of mariculturists because of their suitability for culturing and are currently the subject of a number of mariculture studies (Woodland & Allen, 1977). Their culture has been shown to be feasible in Israel, Guam, Singapore, the Phillippines (Siganid Mariculture Group, 1972), Tanzania (Bwathondi, 1981) and Sri Lanka (Chitravadivelu & Arudpragasam, 1982).

Description and nomenclature

Rabbit fish, the common name of Siganids, comes from their rounded head and rabbit like mouth. There are 2 spines in the pelvic fins, 7 in the anal fins and 13 in the single, continuous, spiny dorsal fin. Siganids are able to inflict very painful wounds with these strong spines when handled carelessly and these wounds cause distress with pain for hours afterwards and are slow in healing.

Five species of Siganids — *S. lineatus* (Valenciennes), *S. javus* (Linnaeus), *S. canaliculatus* (Park) *S. stellatus* (Forsk.) and *S. virgatus* (Valenciennes) have been recorded along the northern coasts of Sri Lanka and in the Thondaimannar and Jaffna lagoons. The first three species are widely distributed while the last two are rare and caught only occasionally. Neither Mendis (1954) nor Munro (1955) has reported *S. lineatus* from Sri Lankan waters.

S. Lineatus commonly referred to as the golden line spine foot is light grey, darkish above, with about 12 parallel longitudinal yellow lines as wide as interspaces and broken below into spots. The caudal fin is slaty grey with a large brown spot slightly larger than the eye-ball, just anterior to the caudal peduncle, changing bright yellow on death.

S. javus or streaky spine foot is brownish above and lighter below with many pale grey round spots on the head and back, forming longitudinal wavy lines on the belly. There are no streaks on the head and the spots are smaller than interspaces.

S. canaliculatus or pearl spotted spine foot is olive brown with numerous white spots which are smaller than the interspaces. These spots disappear shortly after death. This species in particular is claimed by the rural population to increase lactation when fed to breast feeding mothers.

Lam (1974) has reviewed the available information on Siganids and their biology with particular reference to their mariculture potential. Some basic ecological information on *S. lineatus* and *S. canaliculatus* have been reported by Drew.¹ Indrasena and Wijeyaratne (1984) have investigated the biology of juvenile rabbit fishes *S. javus* and *S. oramin* from Negombo lagoon and Puttalam lagoon in Sri Lanka. Basic information on the biology of Siganids from Sri Lankan waters, except the above mentioned studies, is lacking. A programme of investigation was started by the author in February 1981, with a view to collecting detailed information on the biology of the local species of Siganids. Food and feeding of *S. lineatus*, *S. javus*, *S. canaliculatus* have been reported by Chitravadivelu & Sivapalan (1982, 1983, 1984). The present paper deals with some observations on other aspects of the biology of *S. lineatus*, *S. javus* and *S. canaliculatus*.

Materials and Methods

Bimonthly samples were obtained from twelve locations using traps (Chitravadivelu & Arudpragasam, 1983), cast nets, set nets, torch and Sirahu valai (Sachithanathan & Thevathasan, 1970). Collections were obtained from the northern coastal areas extending from Thalayaddy to Punakari, Jaffna lagoon (79° 53' E to 80° 38' E longitude and 9° 26' N to 9° 46' N latitude) and Thondaimannar lagoon (80° 7' E to 80° 28' E longitude and 9° 34' N to 9° 49' N latitude) (Fig. 1). The Jaffna lagoon has an area of approximately 413 sq km and the depth does not exceed 4.0 m (Sachithanathan & Perera, 1970). The Thondaimannar lagoon is also a brackish water body which during the rainy season covers an area of about 78 sq km with an average depth of 1.5 m (Atputhanathan & Chitravadivelu, 1968).

In all, 1051 specimens, comprising 240 *S. lineatus*, 363 *S. javus* and 448 *S. canaliculatus* were examined. The entire collection was immediately preserved in 4% formalin and brought to the laboratory for detailed analysis. The total, standard (from the tip of the snout to the end of the caudal peduncle), head, predorsal and snout lengths and body depths were measured to the nearest mm for each specimen. These lengths are defined by Hubbs and Lagler (1949) and Lowe - Mc Connel (1971). The fish was weighed to the nearest mg and the body cavity cut open. The sex and gonad condition were determined. The ovaries of ripe females were preserved in Gilson's fluid for fecundity studies. Fecundity of all females in maturity stage of IV and V (Nikolsky, 1976) was determined by the method of sub-sampling by weight (Sarojini, 1957, Nikolsky, 1976, Bagnel & Braum, 1971).

1. Drew, A. W. (1971) Preliminary report on Klsebuul and Mayas, two fishes of Palau Islands. Unpublished report, dated January 1971, 1-20.

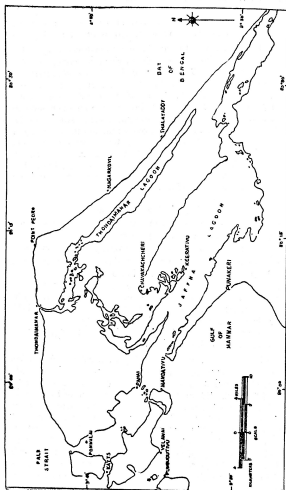


Fig.1 Map of northern part of Sri Lanka showing locations of collecting stations.

The data on length and weight of (i) male (ii) female and (iii) sexually undifferentiated specimens were analysed for each species by calculating regressions for each of the three groups by the method of least squares. The data were then analysed further by the method of covariance (Duncan, 1965).

Results & Discussion

Morphometrics

The members of the Siganidae have been notoriously difficult to identify to the species level because of their morphological uniformity (Woodland & Randall, 1979). Some important morphometrics have therefore been worked out to facilitate comparison with other species. The morphometric measurements also aim at comparing the body shape in the three species between males and females with a view to elucidating any sexual dimorphism.

Regression of the various body measurements on standard length calculated without regard to date of capture, maturity or sex for three species are given in Table 1. The regression of the various body measurements (y) on standard length (x) calculated for the males and females separately are given in Table 2. The regression coefficient did not show any significant difference when the morphometric characters of the males were compared with the corresponding characters of the females by the method of analysis of covariance at 95% level of confidence (Duncan, 1965).

Table: 1 Regression of various body measurements (y) on standard length (x) for all specimens of the three species of Siganids

Species	n	Body measurements	Regression equations
<i>S. lineatus</i>	240	Snout length	$y = 0.1362x - 1.86990$
		Pre-dorsal length	$y = 0.34362x - 0.25249$
		Head length	$y = 0.24171x + 0.31832$
		Body depth	$y = 0.46845x + 0.02247$
<i>S. javus</i>	363	Snout length	$y = 0.11250x - 0.14121$
		Pre-dorsal length	$y = 0.3758833x - 0.11024$
		Head length	$y = 0.219925x + 0.4812$
		Body depth	$y = 0.47166x + 0.2401$
<i>S. canaliculatus</i>	448	Snout length	$y = 0.0901168x + 0.0262560$
		Pre-dorsal length	$y = 0.260637x + 0.394698$
		Head length	$y = 0.1766744x + 0.7908955$
		Body depth	$y = 0.36711939x + 0.0192265$

Table 2 Regression equations of body measurements (y) of males and females on standard length (x) of the three species of Siganids.

Species	n	O O +	Body measurements	Regression equations	
				Males	Females
<i>S. lineatus</i>	23	14	Snout length	$y=0.11643x+1.67547$	$y=0.12908x-0.32315$
			Pre-dorsal length	$y=0.33783x+4.70284$	$y=0.34981x+2.92444$
			Head length	$y=0.23040x+5.66175$	$y=0.22762x+5.85414$
			Body depth	$y=0.45423x+2.07508$	$y=0.47514x+0.97974$
<i>S. javus</i>	31	14	Snout length	$y=0.149127x-4.6968$	$y=0.09766x+0.008310$
			Pre-dorsal length	$y=0.312685x+0.1053$	$y=0.30022x+0.330868$
			Head length	$y=0.250092x+0.04019$	$y=0.21318x+0.578587$
			Body depth	$y=0.43383x+0.19870$	$y=0.42869x-0.32834$
<i>S. canaliculatus</i>	19	28	Snout length	$y=0.100938x-0.1116$	$y=0.39727+0.81698$
			Pre-dorsal length	$y=0.2324062x+0.7325$	$y=0.144117x+1.667224$
			Head length	$y=0.189135x+0.74162$	$y=0.132113x+1.76706$
			Body depth	$y=0.3750515x-0.27046$	$y=0.142614x+3.47178$

Though Helfman² claimed that male Siganids especially of *S. lineatus* and *S. canaliculatus* have a slightly more elongated body than the female, the present morphometric studies did not reveal statistically significant differences between sexes in the three species. However, in *S. canaliculatus*, the possibility of sexual differences cannot be completely ruled out (Table 2), though Lam (1974) ruled out sexual dimorphism in *S. canaliculatus* confirming the observations of Manacop (1973).

Length-weight relationship

The ratio of the length to the weight of fish is known to be a useful index of the condition of fish (Nikolsky, 1976; De Silva, 1980). The equations obtained by analysing the data on length and weight are shown in Table 3. The results of analysis of the data by the method of covariance showed that the regression coefficients of the three groups did not differ significantly from one another. The regression equations of length weight data of the three groups of each species pooled together are given in Table 4.

Table 3: Linear relationship of log. weight (y) and log. standard length (x) of the three species of Siganids.

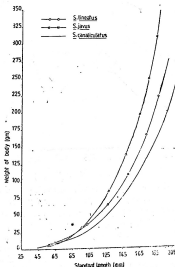
Linear relationship of log. length			
	<i>S. lineatus</i>	<i>S. javus</i>	<i>S. canaliculatus</i>
Male	$y=2.9276x-4.3194$	$y=2.9258x-4.3980$	$y=2.9083x-1.5072$
Female	$y=2.9053x-4.2649$	$y=2.6157x-3.6980$	$y=3.0623x-1.6545$
Sexually undifferentiated	$y=3.0812x-4.6496$	$y=2.7148x-4.0240$	$y=2.8671x-1.5393$

² Helfman, F.S. (1968) Preliminary observations on the Teuthiid (=Siganid) fishery in Palau. Unpublished report dated June, 1968.

Table 4: Linear relationships of log. weight and log. standard length and parabolic equations for pooled data.

Species	Equation from pooled data Linear relationship of log. weight and log. standard length.	Parabolic equation
<i>S. lineatus</i>	$\log w = 3.0464 \log l - 4.5791$	$w = 0.00002657 x^{3.0505}$
<i>S. javus</i>	$\log w = 3.0505 \log l - 5.5813$	$w = 0.00000026 x^{3.0550}$
<i>S. canaliculatus</i>	$\log w = 3.1209 \log l - 1.7311$	$w = 0.018570 x^{3.1209}$

The parabolic equations with exponents very close to 3 indicate an almost isometric growth in *S. lineatus*, *S. javus* and *S. canaliculatus* in the early growth period. The length-weight parabola is shown in Fig. 2. The parabola shows (i) an initial section where the increase in weight with increase in length is not appreciable (ii) a second section where the gain in weight with length is somewhat conspicuous (iii) followed by a section where the increase in weight compared to increase in length is very marked. The beginning of the third section indicates the length of the fish which gains rapidly in weight (Sarojini, 1957). It would therefore be more economical to have the existing methods of fishing suitably modified to catch only large sized *S. lineatus*, *S. javus* and *S. canaliculatus* of lengths above 175 mm, 155 mm, and 145 mm, respectively.

Fig. 2 Length - Weight relationship of *S. lineatus*, *S. javus* and *S. canaliculatus*

Condition factor

The mean coefficient of condition was obtained for each length group using the equation

$$K = \frac{W}{L^3} \times 100 \text{ (Le Cren, 1951)}$$

where K = coefficient of condition, W = weight in grams and L = length in centimetres. Condition factor has often been used to define seasonal changes in the condition of fishes in relation to the age and sex of fish (Tesch, 1971 and Nikolsky, 1976). The trend of variations in the K -values were almost similar in both males and females in the three species under investigation. The mean coefficient of condition, without regard to sex, was plotted against the mid-points of length groups for each species (Fig. 3).

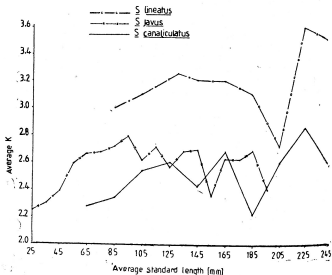


Fig. 3 Average K (coefficient of condition) values at different lengths of *S. lineatus*, *S. javus* *S. canaliculatus*

The mean coefficient of condition for each month was also plotted against the mid-points of length groups (Fig. 4). The first point of marked inflexion on the curve showing diminution of K with increasing length is a good indication of the length at which sexual maturity is attained (Sarojini, 1957). In *S. lineatus*, a gradual decrease of K occurs from 125 mm, becoming conspicuous from 165 mm, followed by a sudden drop at 185 mm (Fig. 3)

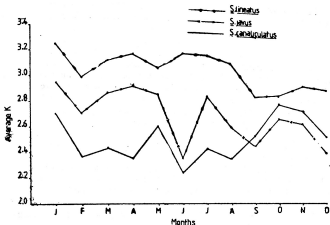


Fig. 4 Monthly variation of K (coefficient of condition) values of *S. lineatus*, *S. javus* and *S. canaliculatus*. Marked decrease in K indicates commencement of spawning

There is a steady increase in K up to 85 mm in *S. javus*, after which the fall in K occurs at 145 mm reaching the minimum in the 155 mm length group (Fig. 3). In *S. canaliculatus* the drop in K occurs at 125 mm (Fig. 3). The decrease of K value after length of 165 mm in *S. lineatus*, 145 mm in *S. javus* and 125 mm *S. canaliculatus* is indicative of the onset of attainment of sexual maturity at these lengths.

Of the females in stages IV and V (Nikolsky, 1976), 88.8% of *S. lineatus*, 84.2% of *S. javus* and 81.8% of *S. canaliculatus* were above 160 mm, 140 mm and 120 mm standard lengths respectively. These are consistent with the lengths of attainment of sexual maturity indicated by K-values.

Helfman² reported that *S. lineatus* matured at 140 mm standard length. Drew¹ claimed that the minimum size of ripe females was about 220 mm standard length. However, the present investigation indicates the attainment of sexual maturity beyond 165 mm in *S. lineatus*. Manacop (1937) has reported that *S. canaliculatus* males matured at 110 mm to 140 mm while the females matured at about 130 mm to 219 mm. Helfman² has similarly recorded a standard length of 130 mm and longer. The results of the present investigation indicating the attainment of sexual maturity at 165 mm in *S. lineatus* and 125 mm in *S. canaliculatus*, compares favourably with lengths reported by Manacop (1937) and Helfman².

² Helfman, F.S. (1968) Preliminary observations on the Teuthiid «Siganid» fishery in Palau. Unpublished report dated June, 1968.

Monthly fluctuations in the mean coefficient of condition are useful indications of the commencement of the spawning season. The mean coefficient of condition plotted against the respective months shows a marked decrease during September to October in *S. lineatus* (Fig. 4). This suggests that September to October is the main spawning period. It does not however rule out the possibility of *S. lineatus* being a multispawner with the majority spawning during September to October and some in February. The fact that specimens of 24 mm — 37 mm size range were found in very large numbers in the drag net collections along with prawns during November — December (Chitravadivelu & Arudpragasam, 1983) supports the present finding that the main period of spawning of *S. lineatus* is September to October.

In *S. canaliculatus* the data is less convincing as regards the period of spawning since the mean coefficient of condition plotted against the months shows a decreasing trend during January-February and May-June (Fig. 4). Majority of the specimens collected during mid-June were fully matured. June appears to be the main spawning month, though the spawning may cover the period May to July, generally. Lam (1974) in his report on *S. canaliculatus* from Palu Island has suggested two periods of spawning — one from February to June and the other from July to September.

In the case of *S. javus* the data is less definite; monthly fluctuations are more frequent. The main spawning period appears to be the month of June (Fig. 4), but periods around February and September too cannot be ruled out.

Fecundity

Fecundity is the number of ripening eggs in the female prior to the next spawning period (Bagenal & Braum, 1971). Tables 5 and 6 give the fecundity and its relationship to weight respectively of the different species. It may be observed that the fecundity of *S. lineatus* is higher than those of *S. javus* and *S. canaliculatus*. Knowledge of the fecundity of these species is meagre. Lam (1974) has estimated the fecundity of *S. canaliculatus* as 3.00×10^5 — 5.00×10^5 . The present figures for *S. canaliculatus* compares favourably with those reported by Lam (1974).

Table 5. Fecundity of the different species of Siganids.

Fecundity	<i>S. lineatus</i>	<i>S. javus</i>	<i>S. canaliculatus</i>
Range	1.53×10^6 — 6.1×10^6	6.78×10^5 — 4.46×10^6	1.09×10^5 — 2.66×10^6
S.D	1.56×10^6	1.46×10^6	5.85×10^5
Mean	2.99×10^6	2.44×10^6	4.88×10^5

Table 6. Relationship of fecundity to weight in the three species of Siganids

Species	Regression of fecundity on weight
<i>S. lineatus</i>	$F = 1.0162 \times 10^4 \quad w = 2.331 \times 10^3$
<i>S. javus</i>	$F = 5.9237 \times 10^3 \quad w = 1.269 \times 10^3$
<i>S. canaliculatus</i>	$F = 2.0244 \times 10^3 \quad w = 2.018 \times 10^3$

Size range

Marshall (1964) has reported *S. lineatus* of a maximum length of 381 mm. but failed to mention whether the length is total length or standard length. Drew has recorded a female *S. lineatus* of a maximum size of standard length 276 mm with a weight of 866 g and depth 133 mm. The largest *S. lineatus* encountered in the present investigation is also a female of standard length of 300 mm of 734.4 g with a depth of 142 mm. In the case of *S. javus* the largest specimen is a male of a standard length of 306 mm of 645.5 g with a depth of 128 mm. The largest specimen of *S. canaliculatus* recorded is 251 mm standard length and weight 483.1 g and this too is a female.

Acknowledgement

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EFFECT OF SOILS FROM TEN LOCATIONS IN JAFFNA ON THE NODULATION OF *CROTOLARIA JUNCEA* (SUNN HEMP)

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ABSTRACT: *Crotalaria juncea* L. (Sunn hemp) is a legume traditionally grown in Jaffna on paddy lands and garden soils for its green manurial value and symbiotic nitrogen fixing ability in its root nodules. Since there is no report on the nodulation of sunn hemp ten different agricultural locations were selected and the effect of soil characteristics on the pattern of nodulation and dry matter production of *C. juncea* were tested. Significant differences were observed in the dry matter production and nodulation.

Seed inoculation improved nodulation in all soils, but only some showed significant differences. Physical and chemical characteristics of the soils did not show any direct relationship with the pattern of nodulation.

Introduction

Crotalaria juncea L. (Sunn hemp) is a nodulating herbaceous annual of the family Leguminosae, capable of fixing atmospheric nitrogen symbiotically. According to Senewiratne and Appadurai (1966) varietal differences in this plant are based on the time of flowering. Flowering period starts 80 days after sowing in the early variety, 100 days in medium variety and 120 days in late variety. Sunn hemp is a rapid vigorous grower, which can achieve a height of over 1.2 m in 60 days and 1.8 m in 90 days when grown under favourable conditions.

C. juncea has been traditionally grown in Jaffna on paddy lands, following the maha rice crop during February and March. It is also grown in tobacco land and other vegetable gardens as a source of green manure. Howard and Howard (1910) reported that manuring tobacco with sunn hemp leads to early crop yield, compared to the addition of heavy doses of farm yard manure.

The green manurial value of the *C. juncea* is due to the symbiotic association in roots of bacteria of the genus *Rhizobium*. Nodules are formed on roots due to the association and atmospheric nitrogen is fixed in these nodules. The exact contribution of fixed nitrogen to the soils under local conditions is not known.

Since no systematic studies have been carried out regarding the nature and pattern of nodulation in this crop under local conditions, an investigation was undertaken using the early variety of *C. juncea* normally grown in Jaffna. Experiments were performed to find out the effect of some Jaffna soil types on the growth, dry matter production and nodulation. The effect of inoculation with pure strains of *Rhizobium* on nodulation and growth of the plant was also investigated.

Materials and Methods

Soil samples were collected from 10 different agricultural locations consisting of paddy soils and market garden soils. The soil representing each location was collected from several points (10 points covering 2 hectare-), at a depth of 30 cm, and composited. The locations are Atchuvely (A), Navaly (N), Kaithady (K₁), Kerathevu (K₂), Maruthanamadam (M), Vaddukoddai (V), Kankesanthurai (K₃), Chankanai (C₁), Kokuvil (K₄) and Chavakachcheri (C₂). The location of these places in Jaffna peninsula are indicated in Fig 1.

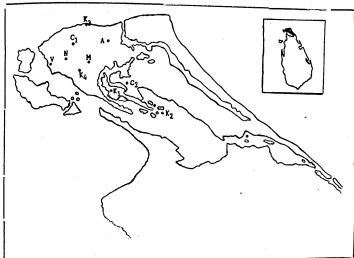


Fig. 1. The location of the places in Jaffna peninsula where the ten soil samples were collected.

Seeds were sown in polythene bags (30 cm depth and 12 cm diameter) containing the different soil samples. Five seeds were sown in each bag and thinned to 3 per bag by the end of the first week of germination. The experimental layout was in a completely randomized design with 10 replicates. Plants were watered adequately during the experimental period. The height of the shoot was measured at weekly intervals. The dry weight of shoots and fresh weight of nodules were taken on the 4th and 6th week after germination. Bags were slit open and the root systems carefully washed avoiding nodule detachment. The dry weight was determined after oven drying at 80° C.

Inoculation experiment.

Seeds of *C. juncea* were inoculated with *Rhizobium* species isolated from nodules collected from plants grown in the different soil types and then sown in the 10 soil samples. Aqueous suspension of the inoculum was prepared at a concentration of 1.3×10^7 cells/ml and the seeds were soaked in this inoculum for $\frac{1}{2}$ h and air dried before planting. The dry weight of shoots and fresh weight of nodules were taken 4 weeks after germination.

The following soil parameters were also measured.

pH. This was measured with a pH meter (Phillips PW 9416).

Organic carbon content. The organic carbon content of the soils was estimated by the method of Walker as described by Sivasubramaniam and Jayman (1979).

Total nitrogen (as%). Micro-Kjeldhal method was used to estimate the total nitrogen content of the soil samples.

Infiltration rate. Five gram dry soil samples were taken in funnels and 10 ml distilled water was added into each of the funnels and allowed to filter for the same time. The volume of water that infiltrated through the sample was measured. The infiltration rate (volume of water collected/time) was calculated for each soil sample.

Porosity. Fifty milliliters of oven dried soil samples were taken into measuring cylinders and 50 ml of distilled water added into each cylinder and allowed to equilibrate. After 3 h, volumes of the water level were recorded, the bulk density and real density were determined and the porosity calculated (Brady, 1974).

Field capacity of soil. Predetermined weight of soil samples were taken in small plastic trays, saturated with water and weighed. The samples were then dried in the oven at 80°C for 24 h and the dry weights determined and field capacity calculated (Williams, 1987).

Results and Discussion

C. juncea, like other well nodulated legumes, is generally considered to be capable of obtaining most of the nitrogen it requires from the atmosphere. Since this is an annual plant, nodules tend to disintegrate during flowering time and fruit set, presumably because of the utilization of carbohydrate reserves of the plants. Therefore, active nodule function is limited to a short period. Nodulation starts 1 wk after seed germination and functions actively till the 6th week. After the 6th week, nodules seem to

disintegrate and detach from the roots of the plant. Therefore, records were made during the 4th and the 6th week following germination — the active period of nodulation of this plant.

Fig. 2 shows the variation in growth in terms of height of *C. juncea* in the different soil samples. With the exception of C_2 , all others showed an increase in growth, after the 4th week of germination. Nodules started their function actively during the 3rd and the 4th week. Probably due to the efficient symbiosis, soluble nitrogenous substances were transferred to the shoot and the plants showed vigorous growth. In the case of C_2 a significant improvement in growth was observed after the 5th week of germination, indicating this to be the period of active nitrogen transfer.

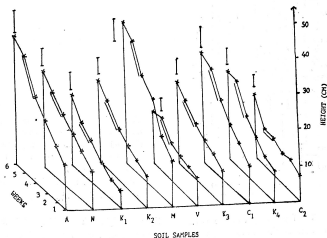


Fig. 2. Growth in height of *Crotalaria juncea* in ten different soil samples (A to C_2) during the first 6 weeks following germination (Growth between the 4th and 5th week is shown by the double lines Bar = s.)

In A, K_2 , M, V, C_1 and K_4 active growth ceased after the 5th week and growth was less during the 6th week (Fig. 2). In these soil samples nodule activity ceased after the 5th week which coincides with the 50% flowering stage of the plants. In the remaining samples, it continued into the following week and 50% flowering occurred at this time. These results agree with the findings of Sprent and Bradford (1977). They reported that the yield of *Vicia faba* varies widely between locations in Britain.

Fig. 3 shows the growth in the 4th and the 6th week after germination in terms of dry matter content of plants. The difference due to soil is significant. The maximum difference in dry matter production between plants growing in the soils tested was 69.60% and 65.49% in the 4th and the 6th week respectively. Comparison between the fresh weight of nodules and the dry matter content of the plants is clearly indicated in Fig. 3. The dry matter content of plants and fresh weight of nodules are significantly correlated ($r = 0.386$, $p = 0.05$).

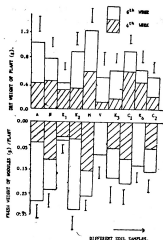


Fig. 3 Comparison of dry matter production (above) and nodule mass (below) of *Crotonia juncea*, grown in soil samples collected from ten locations (A - C₂).

Values denote mean of 30 plants.
Bar = L.S.D. at 5% level.

The fresh weight of the nodules in K₂ was higher than in M, while the contribution of nitrogen to the dry matter production of the plants was less than in M. Therefore, probably, most of the nodules formed in M sample effectively fixed atmospheric nitrogen and transferred it to the shoots of the plants, while most of the nodules formed in K₂ sample were comparatively ineffective in nitrogen fixation. This aspect is in contrast to the findings of Summerfield *et al.* (1977) who reported that the nodular mass was directly proportional to the rate of nitrogen fixation and the dry matter production of the plants. In V, very little dry matter was produced up to 4 weeks, followed by a significant increase in the dry matter production. This may be due to nodulation occurring 4 weeks after germination. Although the pattern of nodulation of K₄ resembled that of V, the dry matter production differed significantly.

The differences in growth and nodulation may be conditioned by edaphic factors or by the higher efficiency of certain strains of *Rhizobium*. This was proved by Mytton and Livesey (1983). They reported variation in effectiveness of local *Rhizobium* between different locations. In order to investigate whether the efficiency of the strains is the limiting factor for nodulation, a seed inoculation experiment was carried out. The results are presented in Table 1.

Table 1. Effect of inoculation of seeds of *Crotalaria juncea* with strains of local Rhizobia, on dry weight of plant and fresh weight of nodules, 4 weeks after germination.

Soil Samples		Mean dry weight of plant $\pm s$ (g)		Mean fresh weight of nodules $\pm s$ (g)	
		Inoculated	Uninoculated	Inoculated	Uninoculated
Atchuvely	A	$0.728 \pm 0.014^*$	0.460 ± 0.020	0.051 ± 0.002	0.038 ± 0.004
Navaly	N	0.691 ± 0.113	0.490 ± 0.100	0.122 ± 0.010	0.107 ± 0.006
Kaithady	K ₁	0.443 ± 0.020	0.342 ± 0.110	0.031 ± 0.003	0.014 ± 0.004
Kerathivu	K ₂	$0.791 \pm 0.020^*$	0.370 ± 0.007	$0.222 \pm 0.005^*$	0.015 ± 0.001
Maruthanamadam	M	0.839 ± 0.271	0.658 ± 0.163	$0.256 \pm 0.004^*$	0.147 ± 0.002
Vaddukoddai	V	0.230 ± 0.007	0.150 ± 0.040	$0.013 \pm 0.005^*$	0
Kankesanthurai	K ₃	0.310 ± 0.090	0.200 ± 0.005	0.051 ± 0.007	0.041 ± 0.004
Chankanai	C ₁	$0.937 \pm 0.038^*$	0.625 ± 0.024	0.114 ± 0.011	0.091 ± 0.006
Kokuvil	K ₄	0.709 ± 0.007	0.475 ± 0.161	$0.213 \pm 0.007^*$	0
Chavakachcheri	C ₂	0.637 ± 0.112	0.725 ± 0.225	$0.097 \pm 0.001^*$	0.041 ± 0.001

(* Difference significant at 5% level; n=30)

The dry matter content of the plant improved in all the soil samples following seed inoculation. In V and K₄, initially there was no nodule formation until the 4th week, but when the seeds were inoculated with *Rhizobium*, a significant increase in the fresh weight of nodular mass was obtained. The results of these experiments indicated that there were only a few efficient strains in the soils, so that inoculation by these strains improved the dry matter production. Therefore, if the seeds are inoculated with efficient strains and planted, then the dry matter production and nitrogen fixation can be improved in all agricultural locations in Jaffna.

Soil factors may also affect the pattern of nodulation. In order to find out whether these factors affect nodulation, determinations were made on a few chemical and physical characteristics of the soils (Table 2).

Table 2. Some physical and chemical characteristics of the soil tested as reflected in pH, organic carbon, total nitrogen, porosity, infiltration rate and field capacity.

Soil location		pH	% organic carbon	Total nitrogen (%)	Porosity	Infiltration rate (ml/min)	Field Capacity (%)
Atchuvely	A	7.2	0.8835	0.182	21.95	0.35	19.23
Navaly	N	7.0	0.5349	0.098	25.00	1.28	18.60
Kaithady	K ₁	7.1	0.921	0.175	21.95	0.03	19.57
Kerathivu	K ₂	7.3	0.4602	0.105	28.20	4.00	15.1
Maruthanamadam	M	7.4	0.2162	0.140	26.58	0.53	16.90
Vaddukoddai	V	8.0	0.5041	0.108	23.45	15.20	16.06
Kankesanthurai	K ₃	7.6	1.1570	0.231	33.33	0.45	28.00
Chankanai	C ₁	7.4	0.9084	0.175	31.57	0.19	20.06
Kokuvil	K ₄	7.8	0.7839	0.119	20.48	0.70	17.26
Chavakachcheri	C ₂	7.8	0.0369	0.098	23.45	0.15	17.33

Initial nodulation may have been affected by the higher pH values of 8.0 and 7.8 in V and K₄ respectively. However, other factors may have improved the nodulation of C₂ sample which also had a pH 7.8. Although the organic carbon content was higher in K₃, it did not contribute much to the initial dry matter production of sunn hemp. M had less organic carbon content than most others, but the initial growth of sunn hemp in M was higher than in other soils. Therefore, organic carbon content did not produce any direct effect on nodulation. K₁ and C₁ had the same percentage of nitrogen content, but the dry matter production differed significantly at $P=0.05$. Therefore no relationship could be established based on this character.

Field capacity and porosity were almost the same for many types of soils, but the infiltration rate was very much higher in the V sample. This may be one of the reasons for the failure in dry matter production and nodulation in this soil sample, due perhaps to the plants experiencing low soil moisture during their growth period.

Most of the factors did not show any clear relationship or trends with nodulation. However, significant differences in nodulation and dry matter production of *C. juncea* were observed among the different soil samples. Therefore a complex interaction of these factors or any of the other untested factors may contribute to the growth differences at different locations. This was supported by the work done by Sorwli and Mytton (1986) who reported that nodule dry matter and total plant dry matter were positively correlated, but that the relationship was not statistically significant, so that factors other than the amount of existing nodule tissue are important determinants of nitrogen fixation in field beans. Therefore, the important conclusions drawn from the data presented here are:

(1) There was a significant difference in growth (height and dry matter production) and nodulation of *C. juncea* among the different soil samples though no relationship was obtained with the soil characteristics tested.

(2) Seed inoculation with *Rhizobium* improved dry matter production and nodular mass of this plant.

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NITRIFICATION STUDIES IN A GARDEN SOIL IN NORTH SRI LANKA

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Vingnanam - Journal of Science 2: 22-28

ABSTRACT: Nitrification of urea (a fertilizer extensively used by Jaffna farmers) was investigated under laboratory conditions using soil samples collected from a chilli garden in Thirunelvely, Jaffna, Sri Lanka.

Soil in polythene bags kept at 35% moisture content was treated with urea, at a rate equivalent to 5 cwt acre⁻¹, which was the dosage currently being used for chilli cultivation. Samples, removed at 2 to 4-day intervals, were analysed for ammonium-nitrogen (NH₄-N) and nitrate-nitrogen (NO₃-N).

Nitrate-nitrogen was found to increase from negligible amounts on day 1 until day 22, after which a constant level was reached. Ammonium-nitrogen increased rapidly up to day 9 followed by a decrease which was rapid initially but gradual thereafter. The net result of these changes after 35 days led to the recovery of only 56% of the applied nitrogen, of which 45% was NH₄-N and 11% NO₃-N. The balance was lost mostly as gaseous ammonia. This was confirmed in a second experiment where the ammonia gas was trapped using filter papers soaked in dilute H₂SO₄ in a modified set-up. Evolution of ammonia from urea-treated soil was very rapid during the first 2 weeks and ceased after 3 weeks.

Introduction

Urea is widely used by farmers in Sri Lanka as a source of mineral nitrogen. Urea is hydrolysed in the soil by microbial urease enzyme and forms ammonium carbonate, an unstable compound, which decomposes easily to release gaseous ammonia (Volk 1959). A part of the released ammonia is lost to the atmosphere while the rest is absorbed in the soil by mechanisms such as soil cation exchange. The ammonia which is retained in the soil is gradually converted to nitrate ions by microbial action. The rate of nitrification has been found to be dependent on various soil fertility factors, such as microbial population, organic matter content and soil pH. In addition, temperature, moisture content and aeration of the soil also determine the rate of nitrification (Black 1968).

In cultivated soils the major loss of applied N is due to leaching of soluble nitrate ions and by volatilization of gaseous NH₃. Volk (1959) reported a 17-59% loss of NH₃-N from pelleted urea applied to acidic soils in U. S. A.

Thus a study to determine the partitioning of the applied N into these two forms under local conditions was necessary. These results could be helpful in regulating fertilization and irrigation practices to enhance more efficient use of N by plants and to lessen wastage.

Materials and Methods

Two sets of experiments were carried out: the first to determine the partitioning of ammonium-nitrogen and nitrate-nitrogen and the second to determine the amount of loss of gaseous ammonia-nitrogen.

The soil used in both experiments was collected from a chilli garden in Thirunelvely, Jaffna, Sri Lanka. The soil was a loam belonging to the Calcic Red-Yellow Latosolic soil group and had a pH of 8. Studies on the soil from the same area have shown that it has a nitrogen content of 0.017% and an organic carbon content of 0.56% in the 0–10 cm layer (N. Saverimuttu, Unpublished). The soil was collected from a depth of 0–10 cm at 10 random points under the crop canopy. The soil was mixed well, passed through a 1 cm sieve to remove stones and large organic debris and air-dried for 24 h. Samples of the air-dried soil, each weighing 500 g, were used in the experiments. In both experiments the treatments consisted of the addition of 1.535 g urea fertilizer to the soil sample. This dosage was based on the amount of urea that was currently being used by local farmers, 5 cwt acre⁻¹ season⁻¹. This was nearly 40% less than the amount recommended by the Department of Agriculture (450 kg acre⁻¹ chilli mixture [13-11-6]). The controls were untreated. Both the treatment and the control, in each experiment, were duplicate. The moisture content of all the soil samples was brought up to 35% (w/w) by adding suitable amounts of distilled water. Each of these was then transferred to a polythene bag.

Experiment 1

The open ends of the polythene bags containing the soil samples were tied and the bags incubated at room temperature, ranging from 27–30° C, in the laboratory. At 2–4 day intervals, the soil in each bag was thoroughly mixed and sub-samples of 5 g each were removed. Soil extracts were prepared by shaking each sub-sample with 25 ml of 2N KCl solution for 1 h on a flask shaker. The extracts were decanted and centrifuged. Ten ml aliquots of the supernatant were distilled with NaOH using Devarda's alloy, and the distillate collected into a flask containing standard boric acid. The excess boric acid was titrated with standard HCl solution.

Experiment 2

The polythene bags containing the soil samples were kept open-ended inside desiccators. A glass tripod placed inside each desiccator held filter papers (Whatman No. 1, 9 cm diameter) moistened with 5 ml of 0.05 N H_2SO_4 , above the soil. The filter papers were replaced at 1-2 day intervals. The filter papers removed from the desiccators were torn and shaken with 25 ml distilled water and the resultant solution was titrated against standard borax solution to determine the amount of ammonia-nitrogen ($\text{NH}_3\text{-N}$) trapped.

Results

The changes in the concentrations of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ in the soil samples in Experiment 1 are shown in Fig. 1. In the treated soil there was a rapid increase in $\text{NH}_4\text{-N}$ up to day 9. This was followed by a decrease, which was rapid for the first 3 days and gradual thereafter. The concentration of $\text{NH}_4\text{-N}$ became almost constant after day 36. There was no appreciable change in $\text{NH}_4\text{-N}$ in the control soil samples.

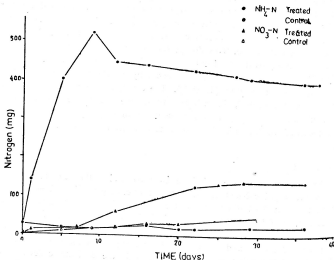


Fig. 1 Changes in amounts (mg) of ammonium-nitrogen ($\text{NH}_4\text{-N}$) and nitrate-nitrogen ($\text{NO}_3\text{-N}$) in 500 g soil treated with urea fertilizer and in untreated soil plotted against incubation time (days). ($n=2$).

The $\text{NO}_3\text{-N}$ concentration was negligible initially in both the treated and control samples. This was followed by a gradual increase in both cases. While the increase in the control soil continued to be gradual till day 29, that in the treated soil was relatively rapid after day 7. The concentration in the latter also reached a constant value after day 29. The final concentration of $\text{NO}_3\text{-N}$ in the treated soil was more than 2.5 times that in the control.

At the end of the experiment the ratio of $\text{NH}_4\text{-N}:\text{NO}_3\text{-N}$ in the treated soil was approximately 4:1.

The results obtained in Experiment 2 are shown in Fig. 2, as cumulative loss of gaseous $\text{NH}_3\text{-N}$. Loss of gaseous NH_3 occurred in the treated soil till day 19. There was no measurable loss of gaseous ammonia thereafter. No loss of gaseous ammonia was recorded from the control soil samples.

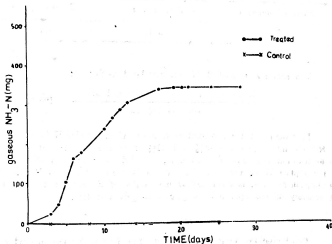


Fig. 2. Cumulative changes in amounts (mg) of gaseous ammonia-nitrogen ($\text{NH}_3\text{-N}$) evolved from 500g of soil treated with urea fertilizer and from untreated soil plotted against incubation time (days). ($n=2$).

The amounts of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ measured at the end of Experiment 1 and the cumulative amount of $\text{NH}_3\text{-N}$ evolved in Experiment 2 are given in Tables 1 and 2.

Table 1. Amounts (mg) of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ measured in 500 g soil samples at the end of Experiment 1 (day 29).

Form of nitrogen	Treated soil	Control soil
$\text{NH}_4\text{-N}$	396	28
$\text{NO}_3\text{-N}$	135	49

Table 2. Cumulative amounts (mg) of $\text{NH}_3\text{-N}$ evolved from 500 g soil samples till the end of Experiment 2 (day 19).
(nd — not detectable)

Form of nitrogen	Treated soil	Control soil
$\text{NH}_3\text{-N}$	344	nd

The recovery of applied N was calculated as follows:

$$\frac{\text{N in treated soil} - \text{N in control soil}}{\text{Total N applied}} \times 100 \%$$

In Experiment 1 the percentage recovery of the applied N in the forms of $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ was 45% and 11% respectively. The net result of the nitrification reactions, after 36 days, thus led to the recovery of only 56% of the applied N in the soil. The balance is presumed lost as NH_3 gas to the atmosphere. This is confirmed by the results of Experiment 2, where the net recovery of the applied N as gaseous $\text{NH}_3\text{-N}$ was 43%.

Discussion

Two limitations occur in this study. The first is that the method used to extract $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ from the soil was different from that used for extracting $\text{NH}_3\text{-N}$ from filter papers. Thus care should be taken while interpreting the results. The second limitation is that the experiments were carried out only under laboratory conditions. No measurements were made under field conditions of high temperature and low soil moisture levels. Furthermore, functional plant roots, an important component of this reaction system under field conditions, were not considered in this study.

The graph indicating the change in $\text{NH}_4\text{-N}$ and $\text{NO}_3\text{-N}$ in Experiment 1 is comparable with that obtained by Sandanam *et al.* (1978) for a poor tea soil in the hill country wet zone of Sri Lanka. As in the case of the poor tea soil, there was rapid increase in $\text{NO}_3\text{-N}$ after day 7. The recovery of $\text{NO}_3\text{-N}$ in Experiment 1 was 11%, which is comparable to the 8–9% reported for the poor tea soil. These similarities, in spite of the extreme divergence in soil type and pH (8 vs 4), therefore, suggest a low rate of nitrification in the dry zone soil used in this study.

Krishnapillai & Pethiyagoda (1980) reported faster nitrification of urea in sand culture when CaCO_3 was incorporated. However, it is known that the activity of nitrifiers is inhibited by the combination of high NH_3 concentrations and high pH, which are likely to occur in calcareous soils treated with urea (Black, 1968). On the other hand, efficient nitrification of NH_3 could decrease the pH. The initial pH of the soil used in this study was 8 and there would have been an increase in pH during ammonification of urea. This may be a likely cause of the low rate of nitrification found in this study.

The loss of gaseous ammonia was high in this soil as NH_4^+ ions are unstable under alkaline conditions. The high Ca content of the soil would also have contributed towards the high amount of volatilization (Black, 1968).

Even though 56% of the applied N was recovered in this study, all of this nitrogen will not be available under field conditions. Part of the nitrate may be lost through leaching. Thus irrigation after the third week, when NO_3^- ion, concentration in the soil is at its maximum, should be controlled to reduce losses through leaching. In this respect, the predominance of $\text{NH}_4\text{-N}$ over $\text{NO}_3\text{-N}$ is likely to minimise leaching losses of the fertilizers and, under conditions of adequate carbohydrate supply, ensures efficient absorption of the applied N. But if carbohydrate supply is restricted, $\text{NH}_4\text{-N}$ nutrition can be detrimental, e.g., following severe shoot pruning or leaf disease (Krishnapillai & Pethiyagoda, 1979).

However, a more important path of loss of nitrogen from urea fertilizer seemed to be by volatilization, amounting to 43%. Since the soil is calcareous, it would not be possible to lower the pH for purposes of cultivation. Increasing the soil fertility by the addition of organic matter will promote the rate of nitrification and this will reduce the loss of ammonia by reducing the concentration of ammonium ions and also promote absorption of NH_4^+ ions in the soil by increasing soil humus. In addition, organic matter amendments will raise the C:N ratio, which will result in the immobilization of part of the applied nitrogen in the soil microbial population. Although such immobilized nitrogen will not be available to the plants immediately, losses will be reduced.

Deeper placement of the urea fertilizer in the soil by tillage instead of surface application will also help in reducing loss by volatilization. Placement of urea in the deeper 'reduced horizon' of rice soils also helps maintain it in the better absorbed NH_4^+ form (Vivekanandan, personal communication).

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STUDIES ON THE PREDATORY EFFECTIVENESS OF
CYRTORHINUS LIVIDIPENNIS (HEMIPTERA: MIRIDAE) ON
NILAPARVATA LUGENS (HOMOPTERA: DELPHACIDAE)

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ABSTRACT The predatory capabilities of *Cyrtorhinus lividipennis* Reuter on *Nilaparvata lugens* (Stål) were studied. *C. lividipennis* adult male consumed an average of 2.07 eggs, 0.24 to 0.11 nymph and 0.16 male adult prey and the adult female 3.3 eggs, 0.21 to 0.08 nymph and 0.17 adult male prey per day. Nymphs consumed 1.07 to 3.05 eggs, and 0.38 to 0.05 nymph per day. Nymphs did not attack adult prey. The present study confirms that *C. lividipennis* is not as effective against *N. lugens* as against *Nephotettix virescens* (Distant); it is a more effective predator of eggs and nymphs than of adult *N. lugens*; it is less effective at low densities of *N. lugens*.

Introduction

Cyrtorhinus lividipennis Reuter is a predator of *Nilaparvata lugens* (Stål), a major pest of rice in South-east Asian countries since the introduction of high yielding rice varieties (Smith, 1972; Nickel, 1973). It was reported from the East Indies in 1884, but its predatory habit was not discovered until 1920 (Usinger, 1939). Though belonging to a predominantly phytophagous subfamily Orthotylinae of the great plant feeding family Miridae, it has somehow shifted to an almost exclusively predatory life. It feeds on planthoppers and leafhoppers on rice (Chiu, 1979; Yamatsu *et al.* 1981; Liquido & Nishida, 1985) and *Peregrinus maidis* (Ashmead) on corn (Usinger, 1939; Hinckley, 1963). It is also reported to feed on *Sporobolus* grass. In Sri Lanka, *C. lividipennis* has been reported from several districts (Otake *et al.*, 1976; Rajendram, 1982; 1984.) Studies on the biology of *C. lividipennis* from Sri Lanka were carried out by Rajendram and Devarajah (1986).

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Materials and Methods

Mass cultures of *C. lividipennis* were maintained in the laboratory according to the methods reported by Rajendram & Devarajah (1986).

In experiments on egg predation, a rice stem bearing *N. lugens* eggs was dissected, with 20 eggs exposed on the dissected stem, and placed on a moist filter paper strip, 5×2 cm. in a glass vial (7.5×2.5 cm). The vials were arranged on a plastic tray. Male and female adult *C. lividipennis*, as well as different instar nymphs, were introduced singly and the mouth of the vial plugged with cotton. The vials were observed daily and the number of shrunk eggs noted. The adult or nymph was transferred to a vial with 20 fresh eggs every other day, by means of an aspirator.

In experiments on predation of *N. lugens* nymphs, four *N. lugens* nymphs of a particular instar were introduced into a test tube (15×1.5 cm) containing a 2 week old rice seedling of variety Bg 90—2, held in position by moist cotton. Male and female adults, as well as different instar nymphs of *C. lividipennis*, were introduced singly. The test tube was plugged with cotton and observations made daily under a dissecting microscope. Dead *N. lugens* nymphs were removed and live nymphs introduced daily to maintain a total of four host nymphs in the test tube. The experimental cultures were transferred to a test tube with a fresh plant every third day.

In experiments on predation of adults, four male *N. lugens* adults were introduced into the test tube and the rest of the procedure followed as in the previous experiment.

When two values were compared, t-test was employed to determine significance. When more than two values were compared, analysis of variance was employed. Significant contrasts were determined by means of studentized range q test.

Results and Discussion

C. lividipennis male adults consumed an average of 2.07 *N. lugens* eggs per day and the female adult 3.3 eggs (Table 1). The average number of *N. lugens* nymphs of different instars consumed by male *C. lividipennis* adult is given in Table 2 and by the female predator adult in Table 3. The daily consumption of male adult ranged from 0.24 first instar to 0.11 fifth instar prey nymph. The corresponding values for the female predator adult are 0.21 first instar and 0.08 fifth instar prey nymph. The number of *N. lugens* male adults consumed by the predator adults, male and female, are given in Table 4. The male predator consumed an average of 0.16 male prey adult and the female 0.17 male prey adult per day.

Table 1. Number of *N. lugens* eggs consumed by *C. lividipennis* adults

Sex of adult predator	Number of adult predator	Average prey eggs consumed (Mean $\pm$ SD)	Average predator longevity	Average eggs consumed per predator per day	t-value
Male	30	21.00 $\pm$ 7.39	8.31 $\pm$ 3.30	2.07 $\pm$ 1.9	
Female	30	23.57 $\pm$ 9.31	8.60 $\pm$ 3.60	3.30 $\pm$ 1.8	0.53 _a

a Not significant at 5% level.

Table 2. Number of *N. lugens* nymphs consumed by *C. lividipennis* male adults

Nymphal stage of prey	Number of adult predators	Average prey nymphs consumed (Mean $\pm$ SD)	Average predator longevity (Mean $\pm$ SD)	Average nymphs consumed per predator per day
First instar	25	1.52 $\pm$ 0.73	6.48 $\pm$ 2.05	0.24 $\pm$ 0.04 _{abc}
Second instar	25	1.04 $\pm$ 0.09	6.52 $\pm$ 2.10	0.16 $\pm$ 0.05
Third instar	25	0.72 $\pm$ 0.32	7.60 $\pm$ 2.04	0.09 $\pm$ 0.03 _a
Fourth instar	25	0.82 $\pm$ 0.34	7.10 $\pm$ 2.39	0.11 $\pm$ 0.02 _b
Fifth instar	25	0.84 $\pm$ 0.36	7.20 $\pm$ 2.48	0.11 $\pm$ 0.03 _c

F = 71.23 : significant at 2% level.

Data followed by same letters are significant (Studentized q range).

Table 3. Number of *N. lugens* nymphs consumed by *C. lividipennis* female adults

Nymphal stage of prey	Number of adult predators	Average prey nymphs consumed (Mean $\pm$ SD)	Average predator longevity (Mean $\pm$ SD)	Average nymphs consumed per predator per day
First instar	25	1.41 $\pm$ 0.40	6.61 $\pm$ 2.11	0.21 $\pm$ 0.03 _{ab}
Second instar	25	1.51 $\pm$ 0.40	7.01 $\pm$ 2.62	0.21 $\pm$ 0.05 _{cd}
Third instar	25	1.01 $\pm$ 0.31	8.40 $\pm$ 2.08	0.12 $\pm$ 0.04
Fourth instar	25	0.71 $\pm$ 0.20	9.00 $\pm$ 2.36	0.10 $\pm$ 0.03 _{ac}
Fifth instar	25	0.60 $\pm$ 0.18	6.88 $\pm$ 2.56	0.08 $\pm$ 0.02 _d

F = 23.29; significant at 2% level.

Data followed by same letters are significant (Studentized q range).

Table 4. Number of *N. lugens* adults (male) consumed by *C. lividipennis* adults (male and female)

Sex of adult predator	Number of adult predators	Average prey adults consumed (Mean $\pm$ SD)	Average predator longevity (Mean $\pm$ SD)	Average adults consumed per predator per day	t-value
Male	30	1.60 $\pm$ 1.19	10.13 $\pm$ 6.24	0.16 $\pm$.09	
Female	30	1.60 $\pm$ 0.50	9.40 $\pm$ 2.91	0.17 $\pm$ 0.5	0.13*

* Not significant at 5% level.

All four instars of *C. lividipennis* nymphs preyed on the eggs of *N. lugens* quite readily (Table 5). But the first instar nymphs were not seen attacking any *N. lugens* nymphs. In fact, when placed in a test tube with host nymphs, they died before moulting. Similarly second instar *C. lividipennis* nymphs survived only on first instar prey nymphs, the third instar only on first and second instar prey nymphs and the fourth instar on first, second and third instar prey nymphs. Hence results on predation by *C. lividipennis* could be scored only on the above mentioned set up. The results of this experiment are given in Table 6.

Table 5. Number of *N. lugens* eggs consumed by *C. lividipennis* nymphs

Nymphal stage of pre-larva	Number of predator nymphs	Average eggs consumed (Mean $\pm$ SD)	Average predator longevity (Mean $\pm$ SD)	Average eggs consumed per predator per day
First instar	30	2.18 $\pm$ 0.70	2.03 $\pm$ 0.40	1.07 $\pm$ 0.29 ^{abc}
Second instar	30	6.03 $\pm$ 1.46	2.50 $\pm$ 1.10	2.41 $\pm$ 0.33*
Third instar	30	7.53 $\pm$ 2.57	2.55 $\pm$ 0.70	2.94 $\pm$ 0.59 ^b
Fourth instar	30	8.83 $\pm$ 2.57	2.89 $\pm$ 0.90	3.05 $\pm$ 0.86 ^c

F = 11.87; significant at 5% level.

Data followed by same letters are significant (Studentized q range).

Table 6. *N. lugens* nymphs consumed by *C. lividipennis* second, third and fourth instar nymphs

Nymphal stage of predator	Nymphal stage of prey	Number of predator nymphs	Average nymphs consumed (Mean±SD)	Average predator longevity (Mean±SD)	Average nymphs consumed per predator per day	t-value or F-value
Second instar	First instar	20	0.50±0.51	3.13±1.65	0.16±.09	
Third instar	First instar	20	0.51±0.51	2.38±1.33	0.21±.12	
	Second instar	20	0.50±0.40	1.6±1.57	0.25±.30	t=0.09
Fourth instar	First instar	20	1.11±0.55	1.45±0.86	0.38±0.22*	pV0.05
	Second instar	20	0.90±0.72	1.65±1.03	0.27±0.02	
	Third instar	20	0.40±0.20.1	1.80±1.08	0.05±0.01*	F=148.6 p>0.02

* In the third group, data followed by same letter are significant (Studentized q range)

The feeding rate of *C. lividipennis* reported here is in general agreement with the results obtained by Dyck & Orlido (1977). On predation of *N. lugens* adults by *C. lividipennis* adults at a predator-prey ratio of 1:4, they reported 35% mortality after two days, indicating a feeding rate of 0.17 *N. lugens* adult per day, the same rate manifested by the female adult predator in this experiment. They also reported consumption rates of 0.6 to 0.9 planthopper nymph during the first five days and 0.4 on the 6th day, at predator-prey ratios ranging from 1:1 to 1:4. However when very few *N. lugens* remained in the cage, the feeding rate dropped off markedly to 0.1 or less, comparable to results obtained here of 0.24 to 0.11 prey nymphs per day. They assume that the searching capacity of the predator is not adequate to maintain a high percentage kill when *N. lugens* density is comparatively low.

The predation rates obtained in these experiments are considerably lower than those reported by Reyes and Gabriel (1975) for *C. lividipennis* feeding on *Nephotettix virescens* (Distant) in the Philippines. The male and female *C. lividipennis* adults consumed respectively an average of 10.41 and 10.01 *N. virescens* eggs

per day, during 14 days of adult life, 4.69 and 4.75 host nymphs per day, during 10 days of adult life, and 2.45 and 2.25 *N. virescens* adults per day for 10 days of adult life. These workers also reported considerably higher predation rates by *C. lividipennis* nymphs at 7.45 eggs and 1.35 nymphs, of various instars, per day. Predator nymphs did not attack any *N. virescens* adult.

The differences manifested by *C. lividipennis* from the Philippines may be due to various factors. A different host, *N. virescens*, was used in the study. *N. virescens* is a smaller insect than *N. lugens*. And *C. lividipennis* is known to prefer *N. virescens* and to be a better predator of this species than of *N. lugens* (IRRI, 1973; 1974). The predator prey ratio was different with a considerably higher ratio of prey — 1:20 prey nymphs and 1:15 prey adults.

The present study does confirm that *C. lividipennis* has a strong preference for *N. virescens* as opposed to *N. lugens* and is a more effective predator of *N. virescens*. Also from our results, it is clear that *C. lividipennis* is a more effective predator of eggs and early instar nymphs of *N. lugens*. It is less effective against the adult population of *N. lugens*. *C. lividipennis* is not an effective predator of *N. lugens* at lower densities of the pest population. However *C. lividipennis* can be a successful biological control agent of planthopper and leafhopper complex of the rice crop in Sri Lanka, particularly since it is already present in the rice fields in several districts.

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OBSERVATIONS ON THE EARLY EMBRYONIC DEVELOPMENT OF *NILAPARVATA LUGENS* (STÅL) (HOMOPTERA: DELPHACIDAE)

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ABSTRACT The paper describes the embryonic development of the brown planthopper, *Nilaparvata lugens* (Stål) during the first three days. Whole mounts of eggs were stained with aceto-orcein. One day old egg has a large yolk mass. Protocephalon and protocorm regions are visible in the 2 day old embryo. Segmentation and appendages are visible in the 3 day old embryo. Measurements of various stages are given.

Introduction

The brown planthopper *Nilaparvata lugens* (Stål) is one of the most destructive pests of the rice crop in southeast Asia. In light infestation they reduce the general vigour of the crop and cause development of moulds. During outbreaks they cause "hopperburn"—a drying up of the plants in large patches (Kisimoto, 1960; Dyck & Thomas, 1979). The brown planthopper is also the vector of grassy stunt virus on the rice crop (Rivera *et al.*, 1966; Ling, 1967). In Sri Lanka, during the past two decades, *N. lugens* has been appearing in large numbers in several districts and especially in Amparai and Batticaloa districts on the east coast, where the pest has assumed serious status (Rajendram, 1982).

Studies on the biology of *N. lugens* in Sri Lanka was carried out recently by Rajendram & Daniel (1986) who reported an incubation period of 9.6 days when *N. lugens* was reared under laboratory conditions of temperature 25°–29.5°C and relative humidity 30–100%. A study on the embryonic development of *N. lugens* has been carried out in Japan (Nasu & Suenaga, 1956). The present study describes the early embryonic development of *N. lugens* from Sri Lanka.

Materials and Methods

N. lugens used in this experiment was collected from rice fields in Amparai district and reared in the laboratory in Jaffna on rice variety BG 94-1. The temperature in the laboratory registered a range of 25–32°C and relative humidity 30–100%. Eggs were obtained from pairs of adults maintained in test tubes 15 cm long and 1.5 cm diameter, into which a 10 day old BG 94-1 rice seedling had been introduced with a wad of moist cotton at the base. The mouth of the test

tube was plugged with cotton. After 6 h the adults were removed and the rice stem dissected after 1, 2 or 3 days. The eggs obtained were termed 1, 2 and 3 day old respectively. Morphological observations of the different stages were made under a stereo-microscope. The measurements were made with the help of an ocular micrometer and were averaged from 10 individuals.

The eggs were stained as follows. The eggs were transferred to a watch glass in Lo Bianco's fixative and allowed to remain overnight for a period of 24 h. The eggs were then washed in tap water until the stain disappeared. They were then dehydrated with a graded series of alcohol. During the dehydration (between 70-90% alcohol) the eggs were stained with aceto-orcein for 4 h. Some eggs were also mounted in paraffin and 12 μ m sections stained in Haematoxylin and Eosin.

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Results

One day old egg

The eggs are laid in single rows on leaf sheath tissues near the base of the plant or in ventral midribs of leaf blades. The anterior end is attached to the leaf sheath by a cementing material and its cap is flat (Fig. 1). The newly laid egg contains a large yolky mass. When newly laid, the eggs are whitish in colour and measure 750 ± 12 μ m long and 150 ± 7 μ m wide.

Two day old egg

Protocephalon and protocorm regions are visible in the 2 day old embryo (Fig. 2). The head develops subsequently in the anterior end of the egg. Length of the blastula is 540 ± 10 μ m and width 240 ± 5 μ m.

Three day old egg

The embryo at this stage manifests segmentation and appendages. The first three segments give rise to mandibles, maxillae and labrum. The thorax and its appendages develop from the adjoining three segments. Slight segmentation of the abdomen is also evident (Fig. 3). Three pairs of legs can be seen developing. The embryo measures 700 ± 15 μ m long and 120 ± 6 μ m wide. The hind femur measures 50 ± 4 μ m and the tibia 70 ± 5 μ m. Two red eye spots were visible through the chorion but disappeared during fixation.

Discussion

Studies of the germ band in eggs of several orders have indicated the presence of a differentiation centre, in the middle of the presumptive germ band, in a position corresponding to the future thorax of the embryo (Wigglesworth 1972). Such a differentiation centre, where visible differentiation of form begins in point

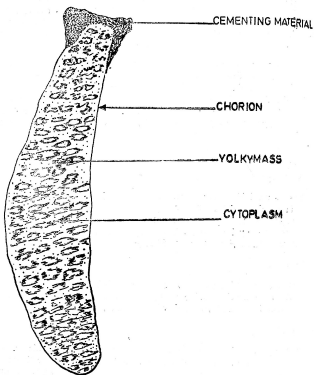
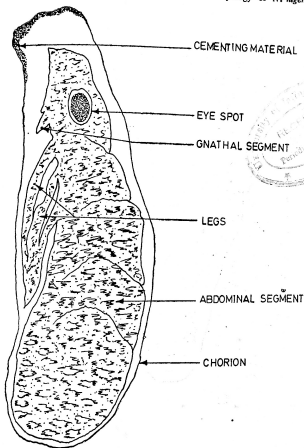


Fig 1. Whole mount of 1 day old egg of *N. lugens* 400x.



100µm

Fig. 2. Whole mount of 2 day old egg of *V. lugens* 400x.

of time, and at which later the degree of differentiation at any moment is greatest, has also been reported in the Hemipteran *Pyrrhocoris* sp. (Seidel, 1924). The findings of the present studies in *N. lugens* confirm previous reports. Organ systems appear first in the future thoracic region in the ventral side of the embryo and then extend to the lateral and dorsal sides.

Coloured eye spots in the embryo have also been reported in *Culex tarsalis* by Rosay (1959) who observed that eyes could be vaguely discerned as a yellowish spot turning to orange red in 31–34 h, as bright red in 34–44 h and finally, before hatching, at 61–68 h, as a dark centre with red edges, at 70° F. The eye spots of *N. lugens* were visible after 72 h, less than half way through embryogenesis.

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EFFECT OF COUMARIN ON TOBACCO NECROSIS VIRUS INFECTION IN *PHASEOLUS VULGARIS* C. V. PRINCE

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ABSTRACT: An investigation was undertaken to study the effects of coumarin on necrotic local lesion formation in *Phaseolus vulgaris* c.v. Prince infected with tobacco necrosis virus. When the plants were treated with coumarin, by incorporating the coumarin into the inoculum there was only a slight inhibition in lesion formation compared to the controls.

Maximum inhibitory effect of 50.2% was obtained when 1000 ppm of coumarin was administered to plants by vacuum infiltration immediately before inoculation. As the time interval between treatment and inoculation increased, the inhibitory effect of coumarin was found to decrease. Pre-inoculation treatment with coumarin was found to be more effective than post-inoculation treatment. It was further observed that there was no tendency for the infection in coumarin treated leaves to spread systemically.

When 100 ppm coumarin was administered to plants, by immersing the roots in coumarin solution, there was a marked inhibitory effect of 39.7% in lesion formation. In all the above experiments the diameter of the lesions and the virus content of the treated leaves was less than in the controls.

In vitro studies revealed that coumarin does not interfere with the infectivity of the virus to an appreciable extent. Therefore most of the loss in virus content is through an effect on the infection process and these observations are explained on the basis of a hypothesis explaining virus localisation in plants.

Introduction

Coumarin, a natural growth inhibitor present in plants, has been reported to inhibit tobacco mosaic virus replication in tobacco leaf discs even at a concentration of 100 ppm (Knypl and Gubanski, 1960). Mishra *et al.* (1968) have found that coumarin inhibited the infectivity of C. P. O. strain of T.M.V. to the extent of 57.5% when mixed with the inoculum at a concentration of 500 ppm. Pre- and post-inoculation sprays of *Chenopodium amaranticolor* (Linnaeus) leaves were found to be equally effective in inhibiting local lesion formation. The inhibition was maximum at 51% and 57.6% respectively when inoculations were made immediately before and after spraying. Inoculations done at greater time intervals of pre- and post-inoculation treatments resulted in a progressively reduced level of inhibition.

The investigations carried out so far have been confined to T.M.V. No attempts have been made to determine the virus content of the infected leaves and, more importantly, whether there was any tendency for the infection in coumarin treated leaves to become systemic. Thus the present investigation was undertaken with an equally common virus, tobacco necrosis virus, causing necrotic local lesions in *Phaseolus vulgaris* c v. Prince to gather more convincing information by employing some efficient methods of treatment of the plants with the coumarin solution. This is of considerable practical importance since, till now, very few chemicals with a capacity to inhibit virus infection in plants have been reported.

Materials and Methods

Modes of treatment of plants with coumarin

Incorporating into the inoculum. A solution of coumarin was mixed with the inoculum such that the final inoculum which was used to inoculate the plants contained the appropriate concentration of the virus and coumarin, viz. 500 ppm and 1000 ppm respectively.

Vacuum infiltration. The primary leaves of Prince bean plants were immersed in a solution of coumarin in a large beaker kept inside a desiccator which was connected to a vacuum pump. Vacuum infiltration was carried out for 40 min in each treatment by applying suction either before or after inoculation. The effect of different concentrations of coumarin on virus infection was studied by varying the time interval between treatment and inoculation.

Root dip treatment. The plants were maintained in black beakers such that their root systems were totally submerged in the solution 24 h prior to inoculation.

Controls were subjected to the appropriate treatment with distilled water. In all treatments, the change in lesion formation was calculated as a percentage of the difference between the control and test plants.

Source of virus and inoculation procedures

Virus. Rothamstead variety of tobacco necrosis virus was used in all the experiments.

Inoculation of plants. The inoculum was prepared at the time of the experiment by making suitable dilutions of the stock suspension with phosphate buffer. Five percent celite (w/v) was used as an abrasive in all inoculations and the inoculum was applied with a 1 in. brush, to the upper surface of the primary leaves of the test plants which were darkened for 24 h prior to the inoculation. After inoculation the leaves were rinsed with distilled water. A second set of plants that were left untreated served as the controls. Twelve replicates were used both for the test and the controls.

The plants were scored for lesions on the fourth day after inoculation and the diameter of the lesions measured under a dissecting microscope fitted with an ocular micrometer.

Local lesion assay. The virus content of the infected leaves was determined by a local lesion assay. Random samples of 1 g portions of the infected

leaves, after being deribbed, were thoroughly ground with a mortar and pestle and the extract filtered through a double layer of cheese cloth. The filtrate was made up to 25 ml with phosphate buffer. This suspension containing celite (5% w/v) was used as the inoculum to determine the virus content of the infected leaf, which was expressed as the mean number of lesions per leaf.

Determination of the tendency for localised infection to become systemic. Plants that were treated with 1000 ppm coumarin by vacuum infiltration were inoculated with the virus immediately afterwards and maintained in the growth room until the first pair of trifoliate leaves had fully expanded. These were harvested and the sap, extracted as in local lesion assay above, was used to inoculate Prince bean plants which were observed for symptoms on these primary leaves.

Invitro studies. In investigating the effect of coumarin on virus infectivity invitro, the virus suspension was incubated with a solution containing 1000 ppm coumarin for various lengths of time and the mixture used to inoculate Prince bean plants at periodic intervals and the appearance of local lesions studied.

Results

Effects of different modes of treatment with coumarin

Incorporating into the inoculum. The results of this experiment are outlined in Table 1. It was observed that at concentrations of both 500 ppm and 1000 ppm, coumarin inhibited local lesion formation only to a slight extent, viz. 4.0% and 5.3% respectively, compared to the controls. This was also reflected in the size of the lesions which were slightly smaller in coumarin treated leaves than in the controls.

Vacuum infiltration. The results (Table 2) reveal that 1000 ppm coumarin applied immediately before and after inoculation inhibited local lesion formation by 90.2% and 85.0% respectively compared to the controls. This tendency was strongly reflected in both the smaller virus content as well as in the smaller size of the lesions of the infected leaves compared with the controls. The tendency for inhibition in lesion formation became less apparent as the time interval between treatment and inoculation was increased. Pre-inoculation treatment with coumarin always had a slightly greater inhibitory effect on lesion formation than post-inoculation treatment.

Root dip treatment. Observations (Table 3) reveal that 25 ppm and 100 ppm coumarin inhibit the formation of lesions to the extent of 27.6% and 39.7% respectively, which was followed by a reduction in the lesion size as well as in the virus content of the infected leaves compared to the control plants.

Determination of the tendency for localized infection to become systemic. In this study it was observed that there was absolutely no tendency for localised infection in leaves treated with 1000 ppm coumarin, as well as in controls, to become systemic.

Invitro studies. In investigations on the effect of coumarin on virus infectivity invitro, the results reveal that coumarin does not have an appreciable effect on virus infectivity. With 1000 ppm a maximum loss in infectivity of 13.9% was observed after incubation for 24 h (Table 4).

Table 1. Effect of incorporating coumarin into the inoculum on virus infection

Treatment	500 ppm Coumarin	Control	1000 ppm Coumarin	Control
Mean number of lesions per leaf $\pm$ S.D.	259 $\pm$ 7	270 $\pm$ 9	267 $\pm$ 11	282 $\pm$ 9
Percentage inhibition in lesion formation	4.0		5.3	

Table 2. Effect of pre- and post-inoculation treatment with coumarin by vacuum infiltration on virus infection

Time interval between treatment and inoculation	Mean number of lesions per leaf $\pm$ SD				Percentage inhibition in lesion formation				Virus content of infected leaves			
	Coumarin		Control		500 ppm		1000 ppm		Coumarin		Control	
	500 ppm	1000 ppm	1	2					500 ppm	1000 ppm	1	2
1. 12 h pre-inoculation	189 $\pm$ 9	172 $\pm$ 7	268 $\pm$ 5	284 $\pm$ 11	29.3	39.5	108	94	159	169		
2. 6 h pre-inoculation	169 $\pm$ 7	101 $\pm$ 5	271 $\pm$ 7	296 $\pm$ 7	37.6	65.8	90	56	155	162		
3. 0 h Pre-inoculation	140 $\pm$ 5	28 $\pm$ 3	280 $\pm$ 7	289 $\pm$ 8	50.0	90.2	83	19	165	150		
4. 0 h post-inoculation	164 $\pm$ 5	45 $\pm$ 4	307 $\pm$ 10	302 $\pm$ 8	47.3	85.0	76	36	149	162		
5. 6 h post-inoculation	188 $\pm$ 10	61 $\pm$ 6	290 $\pm$ 6	281 $\pm$ 10	35.0	68.0	91	50	167	67		
6. 12 h post-inoculation	187 $\pm$ 7	108 $\pm$ 8	260 $\pm$ 4	270 $\pm$ 11	28.0	39.8	104	89	176	50		

Table 3. Effect of immersion of roots in coumarin on virus infection

Treatment	Mean number of lesions per leaf $\pm$ SD	Percentage inhibition in lesion formation	Virus content of infected leaves
Coumarin 25 ppm	194 $\pm$ 6	27.6	72
Control	268 $\pm$ 11	—	83
Coumarin 100 ppm	171 $\pm$ 7	39.7	66
Control	284 $\pm$ 12	—	84

Table 4. Loss in virus infectivity caused by coumarin in vitro

Treatment	1000 ppm Coumarin				Control		
	12 hrs.	18 hrs.	24 hrs.		12 hrs.	18 hrs.	24 hrs.
Period of incubation							
Mean number of lesions per leaf $\pm$ SD	254 $\pm$ 14	253 $\pm$ 12	240 $\pm$ 10		275 $\pm$ 15	287 $\pm$ 16	261 $\pm$ 12
Percentage inhibition in lesion formation	6.5	8.8	13.9		—	—	—

Discussion

The effect of coumarin on localized necrotic lesion formation in *P. vulgaris* c. v. Prince infected with T. N. V. was seen to be an inhibition of lesion formation, a reduction in lesion size and virus content of leaves subjected to all modes of treatment with coumarin. When coumarin was incorporated into the inoculum and administered to the plants by abrasion, the level of inhibition was rather low both with 500 ppm and 1000 ppm coumarin. The work of Mishra *et al.* (1968) with the CPO strain of TMV also revealed an inhibition in lesion formation when 500 ppm coumarin was incorporated into the inoculum.

Maximum inhibitory effect of coumarin was observed when plants were subjected to pre-inoculation treatment with coumarin by vacuum infiltration immediately before inoculation. This caused an inhibition of 90.2% in lesion formation. Vacuum infiltration would have provided a continuous influx of coumarin into the intercellular spaces of the leaf mesophyll tissue. This probably caused a marked reduction in the number of local lesions which is not only of academic interest, but is of considerable practical importance, perhaps serving as a clue in devising control measures for virus diseases in the future. Further, the appearance of symptoms in coumarin treated leaves was delayed by about 10h compared with the controls.

In experiments where the plants were treated by immersing the roots in coumarin for 24 h prior to inoculation, the level of inhibition, though less dramatic, was pronounced at 27.6% with 25 ppm coumarin and 39.7% with 100 ppm coumarin respectively.

Results from the series of experiments done with coumarin on virus infection reveal that there is an appreciable reduction in virus content of the infected leaves compared to the controls. However, studies on the loss in infectivity of the virus on incubating with the coumarin *in vitro* did not reveal any significant loss in infectivity. Hence most of the loss in virus content may be through an effect on the infection process. Evidence in support of this is that coumarin is considered to stimulate the synthesis of ethylene in quantities proportional to the amount of coumarin present in the tissue (Toimann-1972). Investigations made on the possible roles of ethylene on localisation of TMV infection in hyper-sensitively responding tobacco plants has revealed that, in resistant tissues, the infection stimulated synthesis of ethylene commenced before that in the non-resistant leaves and was in higher quantities (Pritchard and Ross 1975). They also observed that higher quantities of ethylene liberated are associated with reduced number of lesions accompanied by a lower virus content and vice versa. Thus this offers a rather satisfactory explanation for the noticeable reduction in the virus content of the infected leaves compared to the controls. It is probable that the endogenous concentration of coumarin in plants is not sufficient to elicit an inhibitory effect on virus infection in the field.

According to one of the hypotheses explaining necrotic local lesion formation in virus infections, a barrier of secondary wall is synthesized around the site of virus infection in resistant plants in advance of the virus spread and this prevents further expansion and proliferation of the lesions (Kimmins and Brown, 1973). They also showed that in *Phaseolus vulgaris* c.v. Pinto plants infected with TNV, the development of local lesions is correlated with the synthesis of two glycoproteins associated with the cell wall. Further Kimmins and Wuddah (1977), using the lignothioglycollic acid and phenolic aldehyde derivatives of lignin in Prince and Pinto bean plants infected with TNV, showed that the lignin content of leaves infected with TNV was higher than the lignin content in abraded leaves and healthy leaves had the least lignin content. The amount of lignin in infected leaves was found to be correlated with the size and number of necrotic local lesions.

Work by Sundaresan and Kimmins (1981) has shown that though coumarin stimulates cell wall synthesis in higher plants, it inhibits the synthesis of lignin by 58% and glycoproteins by 48% the two components of the cell wall which have been reported to be involved in local lesion formation. Thus, one could assume that the inhibition in lesion formation and reduction in the size of lesions in coumarin treated plants is probably a consequence of the reduced availability of the components associated with the synthesis of the barrier of secondary wall around the infection sites.

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THE EFFECT OF PARTICLE SIZE OF FOOD ON THE BIOLOGY OF TWO SPECIES OF *CRYPTOLESTES*

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ABSTRACT Experiments carried out at two humidities and three temperatures, on different particle sizes of wheat, show that development of *Cryptolestes ferrugineus* Stephens is quicker on coarser particles while that of *Cryptolestes turcicus* Grouvelle is quicker on finer particles. Increase of temperature was found to reduce the developmental period of both species, but at 32.5°C high mortality of *C. turcicus* occurred. Low humidity affects the development of *C. turcicus* more than that of *C. ferrugineus*; on whole grain larval mortality was 100% in *C. turcicus*, but 60% in *C. ferrugineus*.

Introduction

Cryptolestes ferrugineus Stephens and *Cryptolestes turcicus* Grouvelle are Coleopterans of the family Cucujidae. They are found on a variety of stored products but mainly on wheat and wheat products. Howe and Lefkovitch (1957) noticed the abundance of *C. ferrugineus* in warehouses, where wheat is stored, and the predominance of *C. turcicus* in flour mills and in flour.

Materials and Methods

Insect culture

The Insect culture used in the experiments was maintained as follows: One hundred adults were introduced into a 1 litre jam jar, two-thirds full of a mixture of wheat-feed, rolled-oats and yeast in the proportion of 9:9:1. The mouth of the jar was covered with black filter paper, to avoid the entry of mites, and sealed with paraffin wax. The jar was placed in a large trough containing a saturated solution of sodium chloride, to maintain a relative humidity of 75% over a range of temperature around 28°C (O'Brien 1949). Two sets of cultures of each species were kept at the same time, and the trough covered with a plastic tray. This was left in an incubator at a temperature of $28 \pm 1^\circ\text{C}$. A deep dish of solid potassium hydroxide was left among the jars so as to avoid accumulation of carbon dioxide, and the trough cover was opened every other day. The insects were subcultured in the same manner at intervals of 6 weeks.

Temperature and humidity

Experiments were carried out in an incubator at 3 different temperatures accurate to $\pm 0.5^{\circ}\text{C}$. The relative humidity was maintained constant at 60 or 80% in desiccators by means of potassium hydroxide solutions. In the desiccators were perforated perspex plates, on which the experimental tubes were stood in bundles held together by rubber bands.

Food

The food provided was wheat in three particle sizes:

1. Whole grain. This was hand picked. Any grain showing insect damage or break in the pericarp to the naked eye was rejected. (Most grain showed some damage under the microscope. Therefore it would have been difficult to find enough completely sound grains for experiments).
2. Some undamaged grain was passed through a coffee grinder adjusted to the coarser size, the resulting form being crushed grain.
3. Some undamaged grain was ground to flour completely.

The food was sterilized by subjecting it to 70°C for 4 h in closed kilner jars.

Equal volumes of crushed grain or flour, or five wheat grains were placed in each 5×1.25 cm specimen tubes. The food was standardised to the experimental conditions of temperature and humidity for at least 6 days before the eggs were introduced.

The desiccators were opened weekly for observation at the beginning of the experiments but daily observations were made a few days prior to the emergence of the adults.

The eggs for all the experiments were obtained as follows:

Fifty adults were removed from the culture with an aspirator and placed on whole wheat flour already passed through 2.4 mesh/mm (60 mesh to the inch) sieve, and were kept at 28°C and 75% R.H. On the following day at the same time as the insects were introduced, the flour was sieved using a similar sieve. Most of the eggs were retained by the sieve. Eggs were placed singly in experimental tubes containing food. Not more than one egg in fifteen was found to be non-viable.

The criterion used for comparing the effect of particle size of food was the developmental period of the larva. Preliminary experiments indicated at any particular environmental condition, the period of incubation of the egg and the duration of the other inactive stages such as the pre-pupa and the pupa remained fairly constant. Therefore instead of the period of development of the larva, the more convenient measure of the egg to adult or the pre-adult period was studied. Since the pupa becomes tanned before emergence, the date

of the adults emerging from the pupal skin can be noted to within 24 h. For those on whole grain, where some emerged as adults from within the grain, it was necessary to deduct the average pre-emergence period, found in those which pupated outside the grain, but within a cocoon, to determine the day of the final moult.

Results and Discussion

The effect of particle size of food on the egg to adult period of *C. ferrugineus* together with percentage mortality is given in Table 1.

Table 1. Egg to adult period (pre-adult development) in days and percentage mortality of *C. ferrugineus* on wheat in three forms

Temp. °C	R. H. %	Food	Number	Days (Mean $\pm$ S. E.)	Mortality %
32.5	80	Whole grain	11	25 $\pm$ 1.38	27
		Crushed grain	14	21 $\pm$ 1.49	7
		Flour	11	26 $\pm$ 1.45	27
	60	Whole grain	8	30 $\pm$ 1.77	47
		Crushed grain	12	29 $\pm$ 2.48	20
		Flour	12	30 $\pm$ 1.41	20
27.5	80	Whole grain	20	39 $\pm$ 2.56	33
		Crushed grain	28	34 $\pm$ 1.85	7
		Flour	26	36 $\pm$ 3.7	13
	60	Whole grain	11	44 $\pm$ 2.68	63
		Crushed grain	26	43 $\pm$ 3.45	13
		Flour	26	43 $\pm$ 3.05	13
22.5	80	Whole grain	14	69 $\pm$ 5.93	53
		Crushed grain	8	60 $\pm$ 2.52	20
		Flour	25	65 $\pm$ 4.04	17
	60	Whole grain	12	79 $\pm$ 3.84	60
		Crushed grain	23	73 $\pm$ 4.75	23
		Flour	24	78 $\pm$ 9.34	20

The corresponding data for *C. turcicus* are given in Table 2. The egg to adult periods of *C. ferrugineus* and *C. turcicus* on the three particle size of food at different temperature and humidity are given in Figures 1 and 2 respectively

Table 2. Egg to adult period (pre-adult development) in days and percentage mortality of *C. turcicus* on wheat in three forms

Temp. °C	R. H. %	Food	Number	Days (Mean $\pm$ S. E)	Mortality %
32.5	80	Whole grain	4	34 $\pm$ 5.68	73
		Crushed grain	9	58 $\pm$ 3.94	40
		Flour	5	34 $\pm$ 4.07	66
	60	Whole grain	—	—	100
		Crushed grain	2	39	87
		Flour	—	—	100
27.5	80	Whole grain	5	41 $\pm$ 2.45	83
		Crushed grain	21	33 $\pm$ 1.93	30
		Flour	20	34 $\pm$ 2.12	33
	60	Whole grain	—	—	100
		Crushed grain	19	49 $\pm$ 3.4	37
		Flour	19	41 $\pm$ 2.64	37
22.5	80	Whole grain	3	64 $\pm$ 2.08	90
		Crushed grain	7	60 $\pm$ 3.42	30
		Flour	22	54 $\pm$ 3.27	27
	60	Whole grain	—	—	100
		Crushed grain	4	75 $\pm$ 1.58	—
		Flour	23	68 $\pm$ 4.42	23

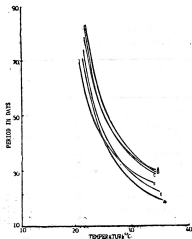


Fig. 1. The effect of particle size of food on the egg to adult period of *C. ferrugineus* at different temperatures and relative humidities

A. - 60% R. H.,	Whole grain	(1.76; 2.67; 3.79)*
B. - " "	Flour	(1.42; 2.67; 3.79)
C. - " "	Crushed grain	(2.46; 3.43; 4.73)
D. - 80% R. H.,	Crushed grain	(1.48; 1.68; 2.52)
E. - " "	Whole grain	(1.35; 2.66; 5.93)
F. - " "	Flour	(1.35; 2.66; 5.93)

* Values of S. E. in days at 32.5°C, 27.5°C & 22.5°C respectively

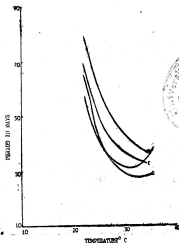


Fig. 2. The effect of particle size of food on the egg to adult period of *C. turcicus* at different temperatures and relative humidities

C. - 60% R. H., Crushed grain	(3.48; 3.40; 1.58)*
D. - " 80% Crushed grain	(3.93; 1.88; 3.26)
E. - " " , Whole grain	(5.67; 2.41; 3.41)
F. - " " , Flour	(5.67; 2.41; 3.26)

* Values of S, E. in days at 32.5°C, 27.5°C and 22.5°C respectively.

At 60% R. H. mortality was high in A at all temperatures & at 32.5°C in B. Hence curves for these were not drawn.

It is clear that 32.5°C is nearer the optimum temperature for the development of *C. ferrugineus* than either 27.5°C or 22.5°C, and that within the experimental range, a rapid increase in development occurs with increase of temperature and humidity. On the other hand *C. turcicus* cannot develop on reasonably undamaged whole grain (i.e. with no insect damage or cracks visible to the naked eye) at low humidity, and 22.5°C is not a suitable temperature for the development of this species. Although the temperature most suitable for the development of *C. turcicus* is around 32.5°C, mortality percentage at this temperature was high.

Since whole grain is not always accessible to the larva for feeding, the crushed grain and flour was considered, in comparing the effect of particle size on the developmental period.

It can be seen from Table 2 that development of *C. turcicus* on crushed grain is most rapid at 32.5°C and 80% relative humidity, and on flour at 32.5°C and 27.5°C at 80% relative humidity although development is fairly rapid on crushed grain mortality was high at 32.5°C at 90% relative humidity. At 22.5°C at both humidities and at 27.5°C at 60% relative humidity, the period of development is shortest on flour, mortality being similar to or less than that in the previous conditions.

But in all the experiments the developmental period of *C. ferrugineus* is shorter on crushed grain than on whole grain or flour, (the difference being statistically significant $p=0.05$), except in two experiments which were at low humidities (Table 1.)

Therefore, of the two forms provided affording equal availability of the food for the insect, in most experiments, development of *C. ferrugineus* was significantly quicker on the coarser food namely crushed grain while the development of *C. turcicus* was more rapid on the finer food namely flour. The periods of development in all other experiments were not significantly different, only one combination showing marginal value.

It is seen therefore that the rate of development of the two species is affected by the particle size of the food, other conditions remaining constant.

With regard to temperature the high mortality of *C. turcicus* at 32.5°C shows that this is not a suitable temperature for its development.

Also affected by the temperature and humidity and to some extent by the food is the period that adult remains in the cocoon. This period between the emergence of the adult from the pupal skin and emergence from the cocoon is generally referred to as pre-emergence. This period appears to be of shortest duration at about the probable optimum physical conditions for development of the two species.

In comparing crushed grain and flour, the pre-emergence is generally of longer duration when the cocoon is made in flour for both species. Although there is no definite trend with regard to results on relative humidity, the pre-emergence period seems to be somewhat longer for both species at high relative humidity. But a marked variation appears with temperature (Selvarajah, 1961).

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This paper presents the early results of studies made with the objective of increasing sap flow from tapped inflorescence by chemical means. Even though sap flow from a tapped palmyrah spathe is not a phenomenon whose mechanism is clearly understood, the involvement of the cells of the phloem tissue is most likely (Kandiah¹, 1983). Ethylene Diamine Tetra-acetate (EDTA) is a chemical known to stimulate phloem translocation in a number of plants (King and Zeevaart, 1974; Pate *et al.*, 1974; Dickson, 1977; Fellows *et al.*, 1978; Tully and Hanson, 1979; Sjut *et al.*, 1980; Costello *et al.*, 1982; Robert and Z. evaart, 1983). Hence EDTA was tested in this study. The results were found to be very encouraging and warranted advanced communication.

Materials and Methods

Preliminary trials indicated that 20 millimolar aqueous solution of EDTA is the most suitable solution for applying on the cut surface of the tapped spathe in palmyrah. This was prepared by dissolving 0.744 g of the disodium salt of Ethylene Diamine Tetra Acetic acid in 100 ml of distilled water. The solution was applied by the tapper on the freshly cut surface of the inflorescence at each sap collecting occasion, in the morning and evening, using a cotton wool swap. Distilled water was similarly applied to the spathes of the control treatment. A randomly selected sample of 5 female palms per treatment was allocated to the EDTA and control treatments. Only one of the tapped inflorescence in each tree was treated. The volume of sap collected from the treated spathe was measured daily in the morning and evening using a 1 L measuring cylinder. Yield recordings were continued until the treated spathes ceased to yield sap.

Results and Discussion

Mean daily yield of sap from the treated spathe is plotted in Fig. 1. It is evident that EDTA treatment had increased volume of sap tapped. Though EDTA stimulation is evident from the first day of application, the effect becomes very pronounced two weeks after the beginning of tapping of the spathe. Daily yield increased more than 300% of the control as tapping progressed. Duration of tapping too increased in the EDTA treated spathe. Sap could be tapped from the control spathe for 7 weeks, while the EDTA treated spathes were tapped up to 13 weeks. The overall effect of these trends is 126% increase in sap yield from the EDTA treated spathe. From the point of view of tapping toddy in palmyrah, this virtually means a two to three fold increase in the harvest index of the palm, an impossible target to achieve in many other agricultural crops.

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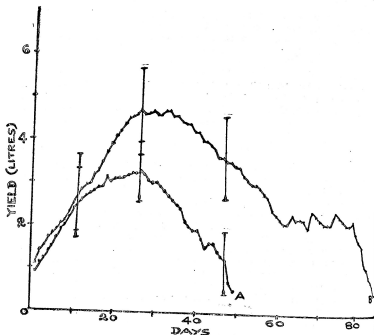


Fig. 1. Mean daily yield of sap from control (A) and EDTA - treated (B) spathes [Baral]

These results indicate that EDTA may provide a means of immediately increasing palmyrah toddy output in the Jaffna peninsula without additional labour or financial commitment. EDTA is a comparatively harmless agrochemical. Officially permissible level of this chemical in food is 25 parts per million. The dilution used in this study is unlikely to reach this concentration in the sap tapped daily. However, these and other aspects associated with widescale use of this chemical are being investigated.

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இவ்விதழ் கட்டுரைகளின் சுருக்கங்கள்

யாழ்ப்பாணத்தைச் சூழ்ந்துள்ள நீர் நிலைகளில் வரையும் *SIGANUS LINEATUS*, *SIGANUS JAVUS*, *SIGANUS CANALICULATUS* ஆகிய மூன்று சிகானிட்டுக்களில் (ஓரா, ஒட்டி மீன் இனங்களில்) மேற்கொண்ட அவதானங்கள்.

ஆசிரியர் :

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Vingnanam J. Sci. 2 : 1-13 (1987)

சுருக்கம் :

இலங்கையின் வடபிரதேசத்திலுள்ள கரையோரங்களிலும், உவர் நீர்த் தீவங்களிலும் இுத்த (*Siganus lineatus*) ஓரா, (*S. javus*) ஒட்டி, (*S. canaliculatus*) பாக் ஒட்டி ஆகிய மூன்று சிகானிட்டு இனங்கள் அறியப்பட்டுள்ளன. இம்மூன்று இனங்களும் உள் மீன்வளரிப்புக்குப் பயன்படக்கூடிய உறுப்பினர்களாகத் தெரிவுசெய்யப்பட்டு, இவற்றின் வளர்ப்பு முறைகள் தற்போது பலநாடுகளில் ஆராயப்பட்டு வருகின்றன. இவ்வினங்கள் பொறுத்தமட்டில் இயல்வினங்களின் வர்த்தகநீரிதரமான வளர்ப்பு ௨ இனாடகரமான மூன்று சிபாக வினங்களும், ஏனெனில் இம்மீன்கள் இவ்வினங்களில் அதிகளவுபட்ட வளர்ப்பு கொள்ளின்றன.

இவ்வாட்டிவளர்ப்பு ௨1 மி. மீ. திவம தீவத்திலிருந்து 306 மி. மீ. திவம தீவ வரைக்கான *S. lineatus*, *S. javus*, *S. canaliculatus*, ஆகிய இனாட்டி இனங்கள் ஒக் கொன்றிலும் முறையே 240, 363, 448 மீன்கள் ஆராயப்பட்டன. மேலும் புறவூழ் இயல்புகள், தீவத்திலுள்ள தொடர்புகள், குணகத்தின் (K) மாறுதல்கள், இனப்பெருத் தீவ திவம் ஆகியவையும் ஆராயப்பட்டன. புள்ளிவிபரவியல் ரீதியில் புறவூழ் இயல்புகள் ஆராயப்பட்டபோது பெறுமானங்கள், பாக் அடிப்படையிலுள்ள வேறுபட்ட உருவ வியல்புகளை இயல்வினங்கள் எடுத்தக்காட்டினன.

S. lineatus, *S. javus*, *S. canaliculatus*, ஆகியவற்றின் கணிக்கப்பட்ட தீவத்திலுத் தொடர்புகள் முறையே $W=0.7002657 \times L^{3.04248}$, $W=0.00000016 \times L^{3.0571}$, $W=0.014570 \times L^{3.1209}$ ஆகும். இம்மூன்று சமன்பாடுகளும் அவற்றித்திய சிகானிட்டு இனங்களில் சீரான உடல்வளர்ச்சி காணப்படுவதை எடுத்தக்காட்டுகின்றன. K பெறுமானத்தைப் பொறுத்தனையில் திவம் குறைவு இம்மூன்று இனங்களிலும் முறையே 165 மி. மீ., 145 மி. மீ., 125 மி. மீ. திவமதீவங்களக்கு அப்பால் வெளிக்காட்டப்படுகின்ற இம்மாதிரம் அக்குறிப்பிட்ட திவம தீவங்களில், அம்மீன்களின் சனைகள் முதிர்ச்சி திவம அடைகின்றன என்பதை காட்டுகின்றன.

தீவத் திவப்புத் தொடர்புகளின் அடிப்படையில் இம்மூன்று இனங்களும் முறையே 175 மி. மீ., 155 மி. மீ., 145 மி. மீ. திவம தீவங்களிலும் கூடிய தீவங்கள் உள்ள மீன்கள் மாதிரம் பிடிக்கக்கூடிய வகையில் மீன்பிடி முறைகள் மாற்றி அமைக்கப்பட ஆராய்வு வழங்கப்பட்டுள்ளது.

S. linearis இல் K பெறுமானத்தில் செப்டெம்பர் தொடக்கம் ஒக்டோபர் மாதங்களில் ஏற்படும் குறிப்பிடத்தக்க வீழ்ச்சி அக்காலப்பகுதிகளை இவ்வினத்தின் முக்கிய முட்டையிடும் காலமென மறைமுகமாகக் சுட்டிக்காட்டுகின்றன. *S. jaya* இடும் *S. conchyliatus* இதும் யூன்மாதமே அவையின் முட்டையிடும் காலப்பகுதி எனத் தோன்றுகிறது. எனினும் இவையுடன் சம்பந்தப்பட்ட தரவுகள் குறைந்தளவு கம்பிக்கை உள்ளவாகத் தோன்றுகின்றன. இம்முன்று சிகாவிட இனங்களின் சராசரி இனப்பெருக்குத் திறன் பெறுமானங்களாவன முறையே 2.99×10^8 , 2.44×10^6 , 4.88×10^5 ஆகும்.

CROTOLARIA JUNCEA (சணல்) இன் வேர்ச் சிறுகணுவாக்கலில் யாழ்ப்பாணத்தின் பத்து பகுதிகளிலிருந்து பெறப்பட்ட மண்ணின் விவரங்கள்.

ஆசிரியர்கள்:

அருள்வதனி பே. அருட்சந்திரன், க. தெம்பேந்திரராஜா

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Vingnanam J. Sci. 2 : 14—21 (1987)

சுருக்கம் :

Crotalaria juncea L. (சணல்) தாவரமானது யாழ்ப்பாணப் பகுதிகளின் நெல் வயல்களிலும், தோட்ட மண்களிலும் அதன் பசுணக்காகவும் ஒன்றிய வாழ்வு ஈட்டத்தினால் வேர்ச்சிறுகணுக்களின் நைதரசனைப் பறிக்கும் தன்மைக்காகவும் பாரம்பரியமாக பயிரிடப்படுகின்றது. இத்தாவரத்தின் வேர்ச்சிறுகணுவாக்கம் பற்றிய குறிப்புக்கள் இல்லாமையால் பத்து வேறுபட்ட விவசாயப் பகுதிகள் தெரிவுசெய்யப்பட்டு அவற்றின் மண்ணின் இயல்புகளையும் சணல் தாவரத்தின் வேர்ச்சிறு கணுவாக்கத் தன்மையும் உலர்நிலைவு தொகுப்பும் எவ்வாறு பாதிக்கப்படுகின்றது என பரிசோதிக்கப்பட்டது. கருத்திற்கொள்ளக்கூடிய வேறுபாடுகள் உலர்நிலைவு தொகுப்பிலும் வேர்ச்சிறு கணுக்களின் உற்பத்தியிலும் அவதானிக்கப்பட்டன.

வித்துக்களிற்கு நிகுமி புழுத்தப்பட்டபாது எல்லா மண் வகையிலும் வேர்ச்சிறுகணுவாக்கம் அதிகரிக்கப்பட்டது. ஆனால் சில மண் வகையிலேயே கருத்திற் கொள்ளக்கூடிய வேறுபாடுகள் அவதானிக்கப்பட்டன. மண்ணின் பெளதிக, இரசாயன இயல்புகள் எவ்விதமான நேரடித் தொடர்புகளையும் வேர்ச்சிறு கணுவாக்கத்தில் காட்டவில்லை.

வடக்கு இலங்கைத் தோட்ட மண் ஒன்றில் நைத்திரேற்றுக்க ஆய்வுகள்

ஆசிரியர்கள்:

அ. மா. த. சுவரிமுத்து, சா. +நந்தயா

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Vingnanam J. Sci. : 2 22—28 (1987)

சுருக்கம் :

யூரியா யாழ்ப்பாண விவசாயிகளினால் பரந்த அளவில் பயன்படுத்தப்படும் ஒரு உரமாகும். நிகுதெல்வேலிப் பகுதியில் உள்ள மிளகாய்த் தோட்டமொன்றிலிருந்து மண்மாதிரிகள் பெறப்பட்டு அவற்றில் யூரியாவின் நைத்திரேற்றுக்கம் ஆய்வுகூட நிபந்தனையில் ஆராயப்பட்டது.

பூரீயா சேர்க்கப்பட்ட, 35% ஈரப்பற்றுடைய மண் பொலித்தின் பைகளில் இடப் பட்டது அக்ளாவத்தில் மினகாய்ச் செய்கைக்கு பயன்படுத்தப்பட்டு வந்த ஏக்கருக்கு 5 அத்தர் என்ற வீதத்தில் பூரீயா மண்ணிற்குச் சேர்க்கப்பட்டது. 2—4 நாள் இடைவெளிகளில் மண் பாதிரிகள் பைளிலிருந்து பெறப்பட்டு இவற்றில் அமோனியம்—நைதரசன் ($\text{NH}_4\text{-N}$), நைத்திரேற்று—நைதரசன் ($\text{NO}_3\text{-N}$) என்பன அளவிடப்பட்டன.

நைத்ரேற்று—நைதரசன் ஆரம்பத்தில் புறக்கணிக்கத்தக்க அளவுகளிலிருந்து ஆறாகித்து 22-ம் நாளின்பின் மாறுத பெறுமானமொன்றை அடைந்தது. ஒன்பதாவது நாள் வரை விரைவாக அடிகரித்த $\text{NH}_4\text{-N}$ பின்பு குறைந்தது. இக்குறைவு ஆரம்பத்தில் விரைவாகிவந்து பின்பு படிப்படியானது. இம்மாற்றங்களின் காரணமாக 36 நாட்களின்மீது இடப்பட்ட நைதரசனில் 86% மட்டுமே மீளப்பெறப்பட்டது இதில் 45% அமோனியம்—நைதரசனாகவும், 11% நைத்திரேற்று—நைதரசனாகவும் இருந்தன. இடப்பட்ட நைதரசனின் மிகுதி பெரும்பாலும் வாயுநிலை அமோனியா (NH_3) ஆக இழக்கப்பட்டது. நிக் செய்ப்பட்ட உபகரண அமைப்பொன்று பயன்படுத்தப்பட்ட இரண்டாவது பரிசோதனையில் இது நிக்ரிக்கப்பட்டது. வாயுநிலை அமோனியாவானது ஐதரான H_2SO_4 இல் நிக் கப்பட்ட வடிதாள்களில் உறிஞ்சப்பட்டது. பூரீயா இடப்பட்ட மண்ணிலிருந்து அமோனியாவின் வெளியேற்றம் முதல் இரண்டு வாரங்களில் மிக விரைவாகவிருந்தது மூன்ற வாரங்களின்பின் இது மூற்றாக நின்றுவிட்டது.

*NILAPARVATA LUGENS*ன் (கபில நிறத்தத்தின்) மேலான *CYRTORHINUS LIVIDIPENNIS*ன் இரை கொளவும் ஆற்றல் பற்றிய படிப்பு

ஆதிவர்கள் :

G. F. இராஜேந்திரம், பிரான்சிசு R. தேவராஜா

(விஸயியியல் துறை, யாழ் பல்கலைக்கழகம்)

Vingnanam J. Sci. 2 : 29—35 (1987)

சுருக்கம் :

Nilaparvata lugens (Stål) இன்மேலான *Cyrtorhinus lividipennis* (Reuter)ன் இரைகொளவும் தன்மை ஆராயப்பட்டது. ஆண் *C. lividipennis* நானொன்றுக்கு ஈர பரிவாக 2.07 முட்டைகளையும், 0.24—0.1 அணக்குகளையும் 0.16 ஆண் திறைவுடிகளையும் உணவாக உண்ணத்தக்கும் அணக்குகள் நானொன்றுக்கு 1.07—3.05 முட்டைகளையும், 0.38—0.05 அணக்குகளையும் உணவாக்கும். அணக்குகள் திறைவுடிக் இரையை தாக்கி வதிகை. தற்போதைய ஆராய்வுகளின்படி *C. lividipennis* ஆனது *Nephotettig* க்கு எதிரானது போலானாம், *V. lugens* க்கு எதிரான விளைவை ஏற்படுத்துவதில்லை. இம் முட்டைகளுக்கும் அணக்குகளுக்கும் திறைவுடிக் *N. lugens* மிட கூடிய விளைவுகளும் இரையாகவியாகும். குறைந்த செறிவுள்ள *N. lugens* க்கு குறைவான விளைவுகளும்

*NILAPARVATA LUGENS*ன் (கபில நிறத்தத்தின்) முகைய விருத்தி பற்றிய அவதானிப்புகள்

ஆசிரியர்கள் :

G. F. இராஜேந்திரம், அளிற்றா செல்வத்துரை

(விவாயியல் துறை, யாழ் பல்கலைக்கழகம்)

Vingnanam J. Sci. 2 : 36—42 (1987)

சுருக்கம் :

இக்கட்டுரை *Nilaparvata lugens* (Stål) கபிலநிறத்தத்தின் முதல் நான்கு நாட்களில் நடைபெறும் முகையவிருத்தியை விபரிக்கின்றது. முட்டையின் முழுமையான பதிப்பு *autoorcein* இனால் சாயமிடப்பட்டது. 12 மணித்தியால முட்டையானது பெருமளவிலான கருவுண்டினைவைக்கொண்டது. இரண்டுநாள் வயதடைய முகையத்தில் முன்முகையப் பகுதியும், முன்கம்புப் பகுதியும் காணக்கூடியதாக இருக்கும். நான்கு நாள் முகையத்தில் துண்டாடலும், தூக்கங்களும் காணப்படக்கூடியதாக இருக்கும். வெவ்வேறு நிலைகளின் அளவீடுகள் தரப்பட்டுள்ளன.

PHASEOLUS VULGARIS குலவகை *PRINCE* இல் புகையிலை இறத்தல் வைரஸின் தொற்றலில் குமாரினின் விளைவுகள்

ஆசிரியர் :

இ. வி. ச. சுந்தரேசன்

(தாவரவியல் துறை, யாழ் பல்கலைக்கழகம்)

Vingnanam J. Sci. 2 : 43—49 (1987)

சுருக்கம் :

Tobacco necrosis virus இனால் *Phaseolus vulgaris*, குலவகை Prince இல் தோற்ற விகம்பமும் இறத்தலுக்கூடிய தோயல்பரப்பில் Coumarin இனால் ஏற்படும் விளைவுகளை விபரமாக அறிவதற்காக உற்போதைய ஆராய்ச்சி மேற்கொள்ளப்பட்டது. தாவரங்கள் பல்வேறு முறைகளினால் Coumarin பரிசீலித்த உட்படுத்தப்பட்டன. Coumarin ஆனது கிருமித் தொங்கலுடன் ஒன்று சேர்க்கப்பட்டு தாவரங்களுக்குப் பரிசீலிக்கப்பட்ட போது இத்தாவரங்களில் தோற்று விகம்பப்பட்ட தோயல்பரப்பு, கட்டுப்பாட்டுடன் ஒப்பீடுமீயோது சிறிதளவே நிரோதிகப்பட்டுக் காணப்பட்டது. கிருமி உட்புகுதலுக்கு சற்றே முன்னதாகவே 1000ppm Coumarin வெற்றிட உட்செலுத்தல் மூலம் தாவரங்களுக்கு அளிக்கப்பட்ட போது 90 வீதமே மிகக் கூடியளவு நிரோதிகப்பட்டிருப்பது அவதானிக்கப்பட்டது. பரிசீலிப்பிற்கும் கிருமி உட்புகுத்தலுக்கும் இடையான நேர இடைவேளைகளை அளிக்கவும் போது Coumarin இன் நிரோதிகமும் இயல்பு குறைவடைவது அவதானிக்கப்பட்டது. கிருமி உட்புகுதலிற்கு முன்னர் Coumarin உடன் பரிசீலித்ததும், கிருமி உட்புகுதலிற்குப் பின்னர் Coumarin உடன் பரிசீலித்ததிலும் கூடுதலான விளைவை ஏற்படுத்தியது மேலும் Coumarin உடன் பரிசீலிக்கப்பட்ட இலைகளில் தொகுதிகத்திய (Systemic) பரவுதலுக்கான போக்கு அவதானிக்கப்பட்டமீயின.

100ppm Coumarin கரைசலினால் வேர்த்தொகுதியை அழித்துவதன் மூலம் Coumarin ஆனது தாவரத்திற்கு அளிக்கப்பட்டபோது தோயல்பரப்பு உருவாகும் அளவு அவதானிக்கத் தக்க அளவு அதாவது 39.7 வீதத்தால் நிரோதிகப்பட்டது. மேற்குறிப்பி

பிட்ட எவ்வா பரிசோதனைகளிலும் கட்டுப்பாட்டுடன் ஒப்பிடும்போது, எவ்வா பரிசீலிப்புகளிலும் நோய் பரப்பின் விட்டமும் வைரசினாலும் குறைவாகவே காணப்பட்டது. Coumarin வைரசின் தொத்துத் தன்மையில் குறிப்பிடத்தக்களவு தலைபிடுவதில்லை என கவப்பற ஆய்வுகள் (invitro) வெளிப்படுத்தின. எனவே அதிகமாக வைரசினாலும் ஏற்படும் குறைவானது, கிருமீத் தொற்று செய்முறையில் ஏற்படும் விளைவினுலேயே ஏற்படுகிறது என்று கணிக்கப்படுவதுடன் இவ்வவதாளிப்புகள் தாவரங்களில் வைரசின் ஓரிடப்படுதல் தலை விளைக்க முன்வைக்கப்பட்ட கருது கோளொன்றின் அடிப்படையில் விளக்கப்படுகிறது.

CRYPTOLESTESன் இரு இனங்களின் உயிரியல் உணவுத் துணிக்கைப் பருமனின் விளைவு

ஆசிரியர் :

N. செல்வராஜா

(இலங்கையிலுமுறை, யாழ்ப்பகைக்கழகம்)

Vingnanam J. Sci. 2 : 50—57 (1987)

சுருக்கம் :

வெவ்வேறு பருமனுடைய துணிக்கைகளிலும் ஆன கோதுமையில் இரு ஈரப்பதன் நிலைகளிலும், மூன்று வெவ்வேறு நிலைகளிலும் மேற்கொள்ளப்பட்ட பரிசோதனைகளிலிருந்து வெளிக்கொட்டப் படுவதாவது பெரிய துணிக்கைகளில் *Cryptolestes ferrugineus* இன் விருத்தியும் நுண்ணிய துணிக்கைகளில் *C. turcicus* இன் விருத்தியும் அதிகமாகக் காணப்படுகின்றது என்பதாகும். வெவ்வேறான அதிகரிப்பானது இரு இனங்களினதும் விருத்திக் காலத் தினை குறைப்பதாக அறியப்பட்டுள்ளது. ஆனால் 32-50°C இல் *C. turcicus* இன் உயர் இறப்பு வீதம் நடைபெற்றுள்ளது. தாழ் ஈரப்பதமானது *C. ferrugineus* இன் விருத்தியிலும் பரிக்க *C. turcicus* இன் விருத்தியைப் பாதிக்கின்றது. முழு மணியில் குடம்பியின் இறப்பு வீதமானது *C. turcicus* இல் 100% ஆகவும், *C. ferrugineus* இல் கிட்டத்தட்ட 60% ஆகவும் காணப்பட்டது.

பனைமரம் சிவதலின்போது பூந்துணரிலிருந்து சாறு (கள்ளு) வடிதலை EDTAயினால் தூண்டல்

ஆசிரியர்கள் :

சோ. கந்தையா, சோ. கோகுலதாசன்

(தாவரவியல்துறை, யாழ்ப்பாணப் பல்கலைக்கழகம், இலங்கை)

Vingnanam J. Sci. 2 : 58—61 (1987)

சுருக்கம் :

பனைமரத்தின் (*Borassus flabellifer*) வெட்டப்பட்ட பூந்துணரிலிருந்து (பானை) கசியும் சாறு (கள்ளு) சேகரிக்கப்பட்டு பல்வேறு ஆசிய நாடுகளில் பல்வாயிரக் கணக்கான மக்களால் வர்த்தகரீதியாகப் பார்க்கப்படுகிறது. எதிலின் இரு அமின் டாக்சிற் மேற்று (EDTA) என்னும் இரசாயனத்தின் ஆற்றல், வெட்டப்பட்ட பூந்துணரிலிருந்து சாறு வடியும் வீதத்தை அதிகரிப்பதற்கு பரிசோதிக்கப்பட்டது. 20 பில்லி மோலார் நீர்க்கரைசல் பானையின் வெட்டப்பட்ட மேற் பகுதிக்கு காய்ச்சினும், மாய்ச்சினும் பூசப்பட்டு சோதிக்கப்பட்ட பெண்பனைகளில் பெறப்பட்ட கள்ளின் அளவு இரண்டு அல்லது மூன்று மடங்காக அதிகரித்தது. பானையின் அசைனகரியமான உயரத்தையும் சிவதலின்போது பனை ஏறும் தொழிற்பாட்டையும் கருத்திற் கொண்டு, பெறுபேறுகளின் விவசாய, பொருள்தாரக் கோட்பாடுகள் ஆராயப்பட்டுள்ளன.

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