BIOLOGY, POPULATION DYNAMICS AND SOME ASPECTS OF MANAGEMENT OF CASTOR WHITE FLY (Trialeurodes ricini Misra) ON GAUCH-1 CASTOR HYBRID

A Thesis
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OF
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IN
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BY
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ANAND CAMPUS, ANAND
JANUARY, 1990
Heavenly Blessings From:
My Guruji,
SANTRAM TEMPLE
NADIAD

Dedicated to
My beloved Parents
Smt. Ichchaben N. Patel
Late Shri Narashibhai C. Patel
Investigations were carried out on biology, population dynamics, screening and control aspects of *Trialeurodes ricini* Misra on GAUCH-I at Sardarkrushinagar during 1986 to 1989.

The egg of *T. ricini* was sub-elliptical in shape, smooth, shiny and pale yellow in colour which measured 0.218 ± 0.029 and 0.093 ± 0.013 mm in length and breadth, respectively.

White fly preferred to lay eggs on top leaf of a plant and maximum egg laying observed was 345.1 ± 183.5 eggs/sq.cm of leaf during peak periods of white fly infestation. In captive conditions, female of *T. ricini* on an average laid 95.80 ± 20.33, 83.28 ± 28.64 and 38.76 ± 10.06 eggs during March, June and January at an average temperature of 26.29 ± 9.65, 34.97 ± 6.74 and 15.90 ± 9.47°C coupled with 31.8, 47.46 and 51.66 per cent relative humidity, respectively.
Incubation periods were recorded as 5.64 ± 1.07, 5.25 ± 0.99 and 7.13 ± 1.41 days at an average temperature of 25.5 ± 8.68, 34.43 ± 6.26 and 16.04 ± 9.43°C in March, June, 1988 and January, 1989, respectively, while, per cent hatching of eggs was observed as 84.61, 82.75 and 70.59, respectively.

Nymph was elliptical, whitish to deep yellow in colour in different instars. The eyes on anterior and vasiform orifice on posterior were prominent in all the instars. The first instar was only moving immature stage which on settlement remained attached throughout the life. It measured 0.281 ± 0.022 mm and 0.143 ± 0.022 mm in length and breadth, respectively. The second instar with degenerated antennae and legs had no marginal setae but thin white waxy fibers were present. In length and breadth it measured 0.435 ± 0.028 mm and 0.255 ± 0.034 mm, respectively. The waxy filaments were fairly luminous in third instar nymph. It measured 0.546 ± 0.024 mm and 0.373 ± 0.026 mm in length and breadth, respectively. The total nymphal duration during March, June and January at an average temperature of 26.7 ± 8.55, 34.92 ± 6.48 and 16.04 ± 9.43°C with 46.5, 50.6 and 52.7 per cent relative humidity, respectively was in order 8.82 ± 1.06, 6.62 ± 0.83 and 13.48 ± 1.18 days.

Freshly formed pupa was thin, flat, yellow, elliptical in shape with waxy filaments on margin of the body. The pupa with filaments measured 1.038 ± 0.087 and 0.798 ± 0.066 mm in length and breadth, respectively. Average pupal period observed as 7.20 ± 0.82 and 6.62 ± 0.83 days in March and June, 1988 at 25.81 ± 10.08 and 33.57 ± 5.70°C with 24.22 and 53.72 per cent relative humidity, respectively, while in January, 1989 at 18.24 ± 10.27°C and 38.17 per cent relative humidity it lasted for 8.83 ± 1.07 days.

The adult was small, slender with a pair of dark red eyes, five segmented filiform antennae and yellow body. The wings were coated with waxy powder.
The female was larger than male. It measured as $1.000 \pm 0.046$ mm and $0.292 \pm 0.034$ mm in length and breadth, while the male was $0.919 \pm 0.049$ mm in length, $0.260 \pm 0.035$ mm, in breadth.

The sex ratio (male:female) was worked out to be 1:2.03 in natural population, whereas, it was observed as 1:2.48 in laboratory reared adults.

Pre-oviposition, oviposition and post-oviposition periods in March, 1988 were recorded as $1.45 \pm 0.51$, $4.5 \pm 1.19$ and $1.25 \pm 0.55$ days at $26.29 \pm 9.65^\circ C$ with 31.8 per cent relative humidity while during June they were of $1.44 \pm 0.51$, $4.2 \pm 0.87$ and $1.28 \pm 0.62$ days, respectively at $34.97 \pm 6.74^\circ C$ and 47.46 per cent relative humidity. At $15.90 \pm 9.47^\circ C$ coupled with 51.66 per cent relative humidity these periods were observed as $1.88\pm 0.78$, $5.48 \pm 1.33$ and $2.28 \pm 1.06$ days, respectively. During the said weather conditions for March, June and January the longevity of female and male was recorded as $7.25 \pm 1.41$ and $5.45 \pm 1.19$, $6.92 \pm 1.47$ and $5.12 \pm 1.05$ and $9.64 \pm 0.86$ and $8.40 \pm 0.87$ days, respectively. It was noticed that female lived for longer period than male. The total life span from egg to the death of adult was of $27.11 \pm 3.79$ and $36.75 \pm 5.14$, $24.27 \pm 3.09$ and $33.00 \pm 4.85$, $36.71 \pm 3.40$ and $50.78 \pm 8.78$ days, respectively during March-April, June-July, 1988 and December, 1988-February, 1989 when average temperature was $27.90 \pm 9.94$, $33.07 \pm 6.16$ and $18.02 \pm 9.39^\circ C$ and $33.48$, $56.51$ and $48.02$ per cent relative humidity respectively. In general all the stage of *T. ricini* prolonged at lower temperatures.

Biology of *T. ricini* at various temperatures and relative humidity during crop season was studied for the first time on green stemmed triple bloom, GAUCH-1 castor hybrid. These findings would be helpful in future to the workers for detailed studies on bio-ecology.

Both nymphs and adults sucked the cell sap from lower surface of the leaves as a result of which the plant lost its vigour and finally the seed
yield was affected. In case of severe infestation sooty molds also developed due to honey like secretion and the whole castor plant became dark.

Studies on population dynamics of *T. ricini* revealed that the crop remained free from white fly attack during August. However, Immature stages were observed in the 2nd fortnight of September. Severe peak levels were observed during November-December and March-April of which the latter peak being more severe and recorded maximum white fly population (471, 516, 97 and 4.43 and 506, 476, 97 and 3.30, adults, eggs, nymphs and pupal index, during 1987 and 1988, respectively). This study has been made for the first time in the major castor growing belt of the State. It would provide guidelines to workers for future ecological studies as well as castor growing farmers for adopting timely control measures.

In correlation studies with weather parameters it was found that positive maximum and negative average and minimum temperature and relative humidity regulated the population of *T. ricini*. Average temperature coupled with dry conditions favoured the pest build up whereas, fall in maximum temperature below 32°C prevented the multiplication of pest and was minimum at 26°C.

Out of 292 germplasms screened 55, 56, 75, 30 and 70 cultures were categorised into completely free, less susceptible, moderately susceptible, susceptible and highly susceptible groups, respectively. In six cultures only pupal development was observed. While considering the total adults and pupal population, 17 cultures from less susceptible group were separated. Low population of pupae in susceptible and highly susceptible cultures indicated that although they harboured adults, they either hampered egg laying or retarded the development of immature stages. The cultures with no bloom and some with single bloom can be used in future breeding programme, while the rest need further confirmation. Varieties/cultures having 18.58 adults and 2.67 pupal index
can be used as checks in breeding programmes. Present findings would be a new source of information for workers engaged in breeding resistant/tolerant varieties against whitefly.

While evaluating efficacy of different conventional and synthetic pyrethroids it was found that monocrotophos 0.04% and dimethoate 0.03% registered as highly effective against nymphal, pupal and adult stages of *T. ricini*, whereas, methyl-o-demeton, 0.025%, methyl parathion 0.05% and thiometon 0.025% had moderately control. Among synthetic pyrethroids cypermethrin 0.005% remained very effective followed by fenvalerate 0.01%, decamethrin 0.0028% and fluvalinate 0.0075%. In comparing different formulations of fenvalerate, LVC had negligible effect, while dust failed to control the pest.

It was further observed that LVC formulation of fenvalerate had phytotoxic effect on leaves and young capsules of castor plants. Small plants occasionally dried. This is the first report as far as the phytotoxicity on hybrid castor is concerned which will be useful in future to the scientists working on evaluation of different insecticides.

Looking to the seed yields monocrotophos 0.04% had the maximum yield followed by dimethoate 0.03%. Among synthetic pyrethroids cypermethrin 0.005% and fenvalerate 0.01% gave higher yield as compared to rest of the treatments. Maximum ICBR was recorded in dimethoate 0.03% (1:13.32), followed by monocrotophos 0.04%(1:8.88) and methyl-o-demeton 0.025% (1:7.76). Among synthetic pyrethroids maximum ICBR was obtained in fenvalerate 0.01% (1:15.52) followed by cypermethrin 0.005% (1:15.02), fluvalinate 0.0075% (1:6.62) and decamethrin 0.0028% (1:3.81). There is no published information on the use of synthetic pyrethroids and comparison of different formulations of fenvalerate against *T. ricini* on castor. Hence, the present findings on synthetic pyrethroids is a new contribution in this particular field.
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CERTIFICATE

This is to certify that the Thesis entitled "BIOLOGY, POPULATION DYNAMICS AND SOME ASPECTS OF MANAGEMENT OF CASTOR WHITE FLY, Trialeurodes ricini Misra ON GAUCH-1 CASTOR HYBRID" submitted by Mr. Suresh N Patel in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Agricultural Entomology of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place:Sardarkrushinagar.
Date: January,1990.

( H. N. Vyas )
Major Advisor
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CASTOR, Ricinus communis Linnaeus, is an important industrial oilseed crop in the World. It is cultivated in about 30 different countries on commercial scale. Among these Brazil, India, China, U.S.S.R., Thailand and Philippines are the most important countries as they account for 88 per cent of the World production (Fatteh, U.G., 1986). Because of its deep root system, drought tolerance and quick growth, it finds a place of prestige in the cropping system of dryland agriculture in semi-arid zones of India. India being the largest producer of castor in Asia and second in the World, grows about 26 per cent of World's total acreages of castor and contributes about 36 per cent of total output (Chidda Singh, 1984). Following Brazil, India occupies the next best position in the World's castor market earning foreign exchange by exporting major part of its total produce and thus plays an important role in the agricultural economy of our country.

Major castor producing States in India are Gujarat, Andhra Pradesh, Karnataka and Orissa. Among these, Gujarat State is the largest producer in the country contributing more than 54 per cent of country's total production (Table 1.). Mehsana, Banaskantha, Ahmedabad, Kutch, Gandhinagar and Sabarkantha are the major castor producing districts of Gujarat State. According to Fatteh, (1986) Gujarat shared more than 65 per cent of the total production of India during 1982-83, which indicated the remarkable contribution of the State.

Castor seed contain 50 to 60 per cent oil which is used as domestic, medicine and lubricant purposes. Castor oil differs from other vegetable oils as it does not freeze in the most adverse temperatures ( -12 to -18°C ) which makes it superb lubricating material particularly motors and aviation motors working under extreme conditions. It is used for the production of
Table 1. Statewise estimates of area and production of castor seed 1986-87.

<table>
<thead>
<tr>
<th>States</th>
<th>Area (Hectare)</th>
<th>Production (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>2,70,300</td>
<td>53,100</td>
</tr>
<tr>
<td>Assam</td>
<td>2,128</td>
<td>908</td>
</tr>
<tr>
<td>Bihar</td>
<td>1,628</td>
<td>1,833</td>
</tr>
<tr>
<td>Gujarat</td>
<td>2,08,800</td>
<td>1,29,300</td>
</tr>
<tr>
<td>Karnataka</td>
<td>28,100</td>
<td>23,000</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>2,303</td>
<td>674</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>4,900</td>
<td>1,800</td>
</tr>
<tr>
<td>Orissa</td>
<td>34,811</td>
<td>18,545</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>5,625</td>
<td>827</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>20,951</td>
<td>6,621</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>248</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total All India</strong></td>
<td><strong>5,79,794</strong></td>
<td><strong>2,36,728</strong></td>
</tr>
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brake oils and high quality lubricants. In natural form it is non-drying, but upon dehydration it becomes fast drying, demanded for production of synthetic resin-based drying oils used for coatings.

Hydrogenated castor oil is used in polishes, ointments, waxes, printing inks, cosmetics, perfumery, tanning industry, hair dressings, soaps, disinfectants, production of plastics and as an insulator in radio technology.

The oil cake is a valuable manure commonly used in nurseries and fields. It is also rich in protein and carbohydrates, makes a valuable ingredient for mix food. High protein content of the cake permits its use as a binding substance in the production of plywood, matches and construction (Chidda Singh, 1984 and Moshkin, 1988).

Such an important cash crop is found to be attacked by several insect and non-insect pests during different stages of growth. Vevai (1973) has listed fourteen pests attacking castor crop in India, while Patel et al., (1970) have recorded seven pests infesting castor crop in Gujarat, as detailed below:

1. Castor capsule borer \(Dichocrocis\) punctiferalis G.
2. Castor jassids \(Empoasca\) flavescens Fb.
3. Castor leaf eating caterpillars \(Ariadue\) meriona Cr., \(Laphygma\) exigua Hb, \(Prodenia\) litura F.
4. Castor semilooper \(Achoea\) janata L.
5. Castor whitefly \(Trialeurodes\) ricini M.
6. Castor mites \(Eutetranychus\) orientalis K., \(Tetranychus\) telarius L.
7. Hairy caterpillar \(Amsacta\) moorei B, \(Euproctis\) limbata B., \(Euproctis\) subnotata W.
Out of these some are endemic and serious pests in one or the other castor growing regions of the country. The degree of attack of various pests varies in different states of India. White flies and jassids are generally found throughout the year, whereas, the rest are the seasonal pests. The loss was found 20 per cent seed yield due to insect pests of castor (Anonymous, 1987). Among all these pests castor white fly, *Trialeurodes ricini* Misra is the serious sap sucking insect pest of castor adversely affecting its production. Both the nymph and adults suck the cell sap from the tender leaves remaining on lower side of the leaf, resulting in drying of leaves in case of heavy infestation.

North Gujarat is the major castor producing zone of the State, where castor is generally grown as rainfed but it is also taken with irrigation wherever farmers are having irrigation facilities. Since last five years the crop is heavily attacked by white fly both in the hybrid seed production as well as commercial crops resulting in low yields. Detailed information regarding the bionomics, population dynamics, susceptibility and control measures on hybrid castor is not available in this major castor producing zone. Keeping all these aspects in view, it was planned to carry out investigation on following aspects of *T. ricini* at Gujarat Agricultural University, Sardarkrushinagar during 1986-89.

1. Biology
2. Population dynamics
3. Screening of castor germ plasm against *T. ricini*.

The results obtained on the above aspects during the years 1986-89 form the subject matter of the thesis.
Castor white fly, *Trialeurodes ricini* Misra is a serious pest of *Ricinus communis* L. in North Gujarat and other States of India. From the available literature, it is found that very limited work has been done on this pest. However, efforts have been made to review the published literature on *Trialeurodes* sp. and presented hereafter in the following headings.

2.1. Distribution:

Maskew (1917) reported *Aleurodes* sp. on various host plants in Belgium, Mississippi, California, Britain, Japan, Texas and Ohio. Reinking (1921) found *Trialeurodes* in Siam, while *A. vaporariorum* Westwood and *A. abutilonea* were observed in great number of Kentucky (Garman and Jewel, 1923). The green house white fly, *Trialeurodes vaporariorum* Westwood had been observed in Hawaii (Sherman et al., 1954), South England (Hussey and Gurney, 1957), Bulgaria (Khristova, 1974), Czechoslovakia (Laska, 1975), India (Paul and David, 1975), Sweedan (Stenmark, 1976), Italy (del Bene, 1979) and Saudi Arebia (Treiti, 1986). Similarly *Trialeurodes abutilonea* Hald had been reported from S.E. California (Dickson et al., 1954) and Arizona (Butler, 1976). While *Trialeurodes ericae* had been reported from Netherlands (Bink-Moenen, 1976). Kulkarni and Ramananmurthy (1959) reported castor white fly *Trialeurodes ricini* Misra from India in Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu, whereas, David et al., (1973) noted *Trialeurodes rara* Singh in Tamil Nadu. Similarly Vevai, (1973) had reported *T. ricini* in Andhra Pradesh, Bihar, Gujarat, Tamil Nadu, Maharashtra and Punjab attacking moderately as a sporadic pest while in Haryana, Kerala and Mysore as minor pest. According to Weiss (1983), white flies occurred on large number of plants but the damage was confined to specific district or season. He further noted that *T. ricini* Misra had become a serious pest in Asia and Middle East.
2.2. **Host:**

Reinking (1921) noted *Trialeurodes* on castor oil plant, *Ricinus communis* in Siam. Similarly, Kulkarni and Ramanamurthy (1959) recorded *T. ricini* and David et al., (1973) noted *T. rara* on castor in India.

2.3. **Nature of damage:**

Trehan (1957) observed that the nymphs of *T. ricini* sucked the cell sap from under surface of the leaves. Kulkarni and Ramanamurthy (1959) reported that the female adult of *T. ricini* laid eggs in cluster on under surface of leaf. Further they informed that *T. ricini* and *T. rara* had been recorded in such large numbers in Cambodia that plants were black with sooty mold fungus growing on the secreted honeydew and the under surfaces of the leaves were almost completely covered with nymphs. Similarly, both the nymphs and adults of *T. ricini* remained in large number on under surface of the leaves and sucked the sap causing yellowing and drying up of leaves of castor. (Radha, 1972). Vevai (1973) observed that the nymphs of *T. ricini* fed on juice and secreted sticky honeydew which attracted ants.

2.4. **Life history:**

Chauhan (1974) studied bionomics of *T. ricini* in laboratory on castor hybrid-3, where he observed that the eggs were laid in circles on lower surface of the leaf. The measurements of eggs on an average were 0.20 and 0.08 mm in length and breadth, respectively. The incubation periods of eggs were of 5.04 and 5.8 days when reared in laboratory at 27.8° - 31.0° C and 22.0° - 26.1° C temperatures, respectively with maximum 96 per cent hatching at latter temperature range. He further noted that there were three larval instars, the average length and breadth of first, second and third instar being 0.25 and 0.11 mm, 0.37 and 0.21 mm, 0.50 and 0.30 mm, respectively. The total larval duration at laboratory temperatures, 28.9° - 31.7° C was of 6.88 days while, 9.85 days when the temperature ranged from 22.2° - 25.6° C. The larvae
pupated at the same place on the leaf and developed waxy margin around the pupal body. The average length and breadth of pupa measured 0.64 and 0.40 mm, respectively excluding white waxy filaments. The pupal periods recorded were 7.07 and 8.44 days at 28.9°- 31.1°C and 22.2° - 25.0°C, respectively. When adult male white fly measured from head to the tip of the abdomen it was recorded 0.945 mm while the female measured 0.988 mm. The fore wings of female averaged lengthwise 0.94 mm while that of male was 0.73 mm. Sex ratio of female to male was worked out and found 1: 0.045 under field condition. The average pre-oviposition, oviposition and post-oviposition, periods of female white fly were 1.27, 4.9 and 0.72 days, respectively and the average number of eggs laid by a single female was 93.2 at temperature range from 27.8° to 29.4°C. The average duration of adults was of 7.19 and 8.25 days in the months of September-October and January, respectively. The average life span of castor white fly from egg to the death of adult was 26.20 and 32.66 days at temperature range from 29.5° - 31.1°C and 22.2°C in the months of October - November and December - January, respectively. While studying the egg laying pattern of several white fly sp. Paulson and Beardsley (1985) observed that the egg pedicel of *Bemisia tabaci* and *T. vaporatorum* was inserted nonstomatally, directly into host plant tissues.

2.5. **Seasonal incidence:**

Bodenstein (1952) observed that the Aleyrodid could be multiplied rapidly despite cold and damp weather and infest wild and cultivated plants. Avidove (1957) found that peak populations of white fly occurred at high temperature however, rainfall/high atmospheric humidity was essential for population build up. David and Radha (1964) noted that *T. ricini* at Coimbatore was prevalent throughout the year but in a severe form during the months of March to June and light during November to January. According to the
study made on the influence of weather factors on the population of castor Aleyrodid, *T. rara* indicated that the Aleyrodid population was practically very low or absent during the period from November to the first fortnight of February and thereafter increased gradually. The peak infestation occurred during September-October followed by a decline in population. Increase in total number of eggs, larvae, pupae and adults of castor Aleyrodid was significant with increase in maximum temperature and exhibited a negative relationship with humidity and rainfall and non-significant positive relationship with minimum temperature. The findings further indicated that the fall in maximum temperature below 32°C resulted in low population of the various stages of the Aleyrodid and a temperature above 32°C favoured increased activity of the insect (David et al., 1973). A survey carried out on castor hybrid-3 by Chauhan (1974) indicated that the white fly persisted throughout the year and it was high in the months from January to May. Murugasen (1977) showed that maximum temperature was important in predicting white fly population. According to Lal (1981) the white fly *Bemisia tabaci* population was quite abundant throughout the year, however, June, July, August and October were the months of maximum population abundance in cassava, *Manihot esculenta* Crantz. He further stated that relative humidity coupled with rainfall played a major role and influenced white fly population rather than maximum temperature under Trivendrum conditions. In general extreme high temperature and both high and low relative humidities play an important role in regulating the populations of *B. tabaci* (Vatten and Allen, 1983, Abrahm, 1986).

2.6. Susceptibility:

David and Radha (1964) studied incidence of the castor white fly, *T. ricini* in different castor varieties at Coimbatore and reported that the varieties having double or triple blooms were found to be more susceptible to the attack by the insect than the varieties having single bloom, and no
bloom varieties were highly resistant. They further informed that the pH of the plant sap did not seem to exercise any influence on the incidence of insect in those varieties as there was no significant difference of pH between highly susceptible and highly resistant varieties. Later on David and Paul (1973) reported that no bloom green stemmed types and single bloom rose stemmed types were free from attack of *T. rara* whereas, rose stemmed types with double and triple bloom and single bloom green stemmed types were susceptible to attack of the insect. Further they stated that in general the total free amino acid contents in the resistant types were found to be lower than that in susceptible types, the latter containing higher concentrations of essential amino acids such as arginine, threonine, methionine and isoleucine besides three non essential amino acids viz., cystine, aspartic acid and alanine. Among the essential amino acids, it appeared that threonine might have a greater role in the preference of castor varieties to white fly infestation. Studies made for intraspecific diversity on different host plants viz., *Aristolochia labiosa*, *Dolichos lablab*, *Phyllanthus acidus* and *Ricinus communis* with glabrous leaves, *Gossypium hirsutum* with partially hairy leaves and *Bauhinia* sp. with hairy leaves, revealed that *T. rara* showed remarkable variation in number of papillae on sub-margin and sub dorsum as also in length of dorsal setae and size of pupal cases. The ability of the species to develop on particular types of leaves, leading to the development of considerable plasticity appeared to be a direct reaction to the damage of their immediate environment (David and Ananthakrishnan, 1976). While screening germ plasm of castor the following entries Co-1 and EC-103745 were found complete resistant while entries SA-2, D-3, JGG, JRR, JI-53, 1379, 215768, 5912-A, EC-80852 and EC-97708 M found tolerant to white fly (Anonymous, 1988).
2.7. **Control measure:**

Various workers had studied control aspects of *Trialeurodes* and come out with effective and economic recommendations on different crops. *Trialeurodes ricini* on castor could be controlled by 0.05% malathion (Kulkarni et al., 1959) 0.06% trithion, 0.1% formothion and 0.06% carbaphenothion (David and Radha, 1964; Radha, 1972). Vevai (1973) reported that spraying with 300-500 ml of dimethoate 30% in 400 l water, methyl demeton 25% 300 ml, thimeton 25% 500 ml or malathion 50% 750 ml gave good control of castor white fly. Patel et al., (1973) recommended 0.03% dimethoate @ 1100 l/h for effective and economic control of white fly on castor hybrid-3, similarly Chauhan (1974) advocated 0.03% carbaphenothion, 0.03% parathion and 0.03% formothion for the same pest on said crop. Considering the overall effectiveness monocrotophos, dimethoate and quinalphos each at 0.05% were suggested for controlling white fly on castor (Patel et al., 1986). Looking to the yield and economic return, two sprays of 0.05% methyl parathion (NICBR 1: 8.18) followed by 0.05% ethion (NICBR 1:5.47) at 15 days' interval were recommended for the control of *T. ricini* on castor.

Further to minimise air pollution and pesticidal hazards, neem oil @ 5 ml/l water (NICBR 1:5.07) had also been advocated to the farmers of North Gujarat (Anonymous, 1988). Much work had been done on control aspects of greenhouse white fly, *T. vaporariorum* and good number of insecticides belonging to various groups had been evaluated for its effective control on various crops. Sharaf (1978) observed that none of the insecticides under laboratory test gave complete mortality of any stage of *T. vaporariorum*, but pirimiphos-methyl was the most effective followed by malathion and dimethoate and methyl parathion. The compounds performed poorly against all stages suggested that the strain of *T. vaporariorum* used was resistant to dimethoate and cross resistant to other compounds. According
to Oetting et al., (1980) the pyrethroids were most effective in controlling *T. vaporariorum* on ornamental plants viz., *Fuchsia triphylla*, *Hypoestes phyllostachya* and poinsettia, *Euphorbia pulcherrima*, fenpropethrin, fenvalerate, cis-permethrin, permethrin and cis-cypermethrin being the best. Similarly decamethrin and cypermethrin on tomato, while 0.025% permethrin, 0.02% cypermethrin, 0.05% decis, fenpropanate, fenvalerate, cis-permethrin, permethrin and FMC 45497 on ornamental plants and 0.01% fenvalerate, 0.00875% permethrin, or 0.05% methomyl on tomato were very effective against *T. vaporariorum* (Giustina et al., 1978; Morner et al., 1980; Oetting et al., 1980 and Brun, 1981). Johnson et al. (1982) informed that chemical insecticides did not control Aleyrodids on cotton owing to long incubation period and protective waxy covering of larvae and pupae. They further suggested avoiding use of pyrethroids application against cotton pests. It was noticed while comparing efficacy of synthetic pyrethroid, juvenile hormone analog and organophosphetic compounds against *T. vaporariorum* that fluvalinate was the most effective toxicant through its broad activity on white fly life stages. Kenoprene controlled second and third larval instars but has moderate effect on eggs, first instar and pupae, whereas, methomil remained effective against first instar larvae and adults (Roditakis, 1984). While calculating per cent effectiveness of different insecticides against *T. vaporariorum*, it was observed that permethrin, fenvalerate and amitraz at 0.1 - 0.2 % each reduced white fly population by 89-99%, whereas, organophosphorus compounds, pirimiphos-methyl and profenfos reduced population only 40.6 and 26.6% respectively (Tkachuk et al., 1986). Labanowski et al., (1985) carried out several experiments to know long term protection of *T. vaporariorum* with 30 different compounds in green house and found that single spray of all compounds except phosmet and amitraz gave initial good control of adult white flies. The long term
effectiveness was good with alphamethrin (10%), cypermethrin (25%) with two sprays long term protection was obtained with methamidophos, fluvalinate, amitraz and permethrin while when three sprays applied at weekly intervals, the best long term effect was obtained with alphamethrin, cypermethrin, methamidophos, oxamyl and a mixture of propoxur and methoxychlor.

2.8. **Phytotoxicity:**

Oetting et al., (1980) reported minor phytotoxicity of fenvalerate, permethrin and oxamyl on some varieties of poinsettia when repeated applications were made to control \textit{T. vaporariorum}. 

The materials and methods used for various investigations on different aspects of \textit{T. ricini} are described below.

3.1.1. Laboratory culture:

Initial culture of castor white fly, \textit{T. ricini} was raised by collecting large number of leaves during peak periods of the season. The leaves having large number of pupae were collected from the infested plants with their long petioles from the Castor Research Project, Gujarat Agricultural University, Sardarkrushinagar and brought to the laboratory. The petioles were kept in beakers filled with water and then the leaves with beaker were transferred into insect rearing cage having 30 x 30 x 30 cm dimensions. Everyday the beaker was filled in with water to maintain turgidity of the leaves. Castor plants of variety GAUCH-1 were also raised in small earthen pots of 9 x 9 cm in diameter. Adults emerging from pupae in early hours were less active, such flies were collected with the help of aspirator and transferred to potted castor plant having 3 to 5 leaves. Potted plant was then covered with punctured polythene bag to prevent the escape of released flies and to keep the plant free from other pests. Such pots were placed in shade for egg laying. The sets so prepared were used for various studies.

3.1.2. Biology:

Studies on biology of castor white fly, \textit{T. ricini} were carried out in the laboratory of Department of Entomology, College of Agriculture, Gujarat Agricultural University, Sardarkrushinagar, at varying temperatures and average relative humidity during the months of March, June, 1988, and January, 1989. Methodology adopted for various stages for biology is described hereafter.
3.1.2.1. Ovipositional site and pattern:

Studies were made separately to know the pattern and preference of site for egg laying in caged condition in laboratory as well as under field conditions. In the laboratory about ten flies were released per potted plant having 3 to 5 leaves and such five plants were maintained by covering polythene bags. The plants were observed after three days of the release of flies under stereoscopic microscope and the ovipositional pattern and site were noted. In the field, castor plants were critically observed periodically during crop season. The leaves of lower, middle and top sections of the plants were brought to the laboratory and observed under microscope for eggs. It was noticed that maximum adults were found on top or newly emerged leaves of castor plants. Therefore, maximum number of eggs laid on those leaves were observed. To know total number of eggs laid/sq.cm area of the leaf, 20 leaves were brought to the laboratory at different peak periods of infestation. Three spots each of 1 sq.cm were randomly marked on a leaf and observed under stereoscopic microscope. Total number of eggs/sq.cm were counted and recorded.

3.1.2.2. Egg:

Every morning the plants were changed and freshly laid eggs on the leaves of potted plants were marked by drawing a circle around individual or groups of eggs under stereoscopic microscope. The potted plants were then maintained protecting them by covering with punctured polythene bags. The marked eggs were examined daily for their shape, size and colour under microscope. For the study of incubation period and hatching percentage of eggs, counted number of freshly laid eggs were marked and observed daily till the nymphs developed from them. The data were recorded and minimum, maximum and average incubation periods with standard deviation were worked out.
Per cent eggs hatched was worked out by calculating number of eggs hatched out of total number of eggs observed.

3.1.2.3. Nymph:

To determine the nymphal instar, freshly hatched nymphs, the only mobile immature stage, before they settled at suitable place were transferred to the leaves of potted plants with the help of wet fine camel hair brush. They were kept undisturbed for about one hour and then the settled nymphs were marked individually by drawing circle around them. The plants were protected and observed daily in the morning under stereoscopic microscope. The change of nymphal stage was confirmed by the presence of exuviae on moulting. The duration of nymphal stage was studied at varying temperatures and average relative humidity in the months of March, 1988, June, 1988, and January, 1989, and duration of individual nymphal instars and total nymphal period were worked out. The shape, size and colour of each instar was also studied.

3.1.2.4. Pupa:

The last nymphal instar on moulting formed pupa. Newly formed pupae were marked and studied for their shape, size and colour. The pupal period was recorded from the last moulting of third instar and the day of emergence of adult from pupa. The pupal period was studied during different periods of the crop season at varying temperatures and average relative humidity. In all 25, 37 and 35 pupae were studied for the purpose during March, 1988; June, 1988 and January, 1989, respectively and minimum, maximum and average pupal periods were worked out and recorded.

3.1.2.5. Adult:

The adults emerged from pupae were inactive for sometime. They were collected by aspirator and anaestheticated with chloroform then were observed under stereoscopic microscope to study their shape, size, colour and sex differences.
Measurements of length and breadth of eggs, different nymphal instars, pupae and adults, (separately for male and female) were taken under microscope with the help of ocular micrometer. Minimum, maximum and average length and breadth were worked out.

3.1.2.5.1. Sex ratio:

To work out the sex ratio, laboratory reared adults, as well as adults from the castor fields were collected with the help of aspirator during different periods of the crop season. In all 24 collections were made during 8 months from field at an interval of about 10 days and brought to the laboratory. The adults were anestheticated with chloroform and observed under stereoscopic microscope. Similarly the laboratory reared adults of March, 1988, June, 1988 and January, 1989 were also observed. The sexes were differentiated on presence or absence of ovipositor. Total counts for male and female were separately made and the sex ratio was worked out.

3.1.2.5.2. Pre-oviposition, oviposition and post-oviposition periods:

To determine pre-oviposition, oviposition and post-oviposition periods of female at varying temperatures and relative humidity, newly emerged adults from the pupae were paired and confined to small 3 to 5 leaf potted plant and covered with polythene bag. Such 20, 25 and 25 sets were prepared, maintained and studied during March, 1988; June, 1988 and January, 1989, respectively. The plant was critically observed daily in the morning for egg laying. Pre-oviposition, oviposition and post-oviposition periods were noticed and recorded accordingly.

3.1.2.5.3. Fecundity:

While studying the oviposition periods of females at varying temperatures and relative humidity the leaves of potted plants were observed under microscope and the total number of eggs laid by each female were counted and recorded till its death.
3.1.2.5.4. **Longevity:**

To determine the longevity of adults, pairs maintained for studying oviposition periods were kept under observation. The duration in days between emergence of adults from pupae till their death were recorded separately for male and female at varying temperatures and relative humidity during different periods of the season.

3.1.2.6. **Total life span:**

To determine the total life span of *T. ricini* a study was made during March-April, 1988, June-July, 1988 and December, 1988 to February, 1989 at varying temperatures and relative humidity. The adults were released on 5 to 7 leaf potted plants and maintained for three days. The eggs laid by females were counted under stereoscopic microscope and observed daily after 10 days for adults' emergence. Total number of adults emerged were noted and observed till their death. The dead fly was observed under microscope for sex determination. The duration in days between freshly laid egg and death of an adult was considered as the total life span of white fly. The total life span of male and female were individually worked out.

3.1.3. **Nature of damage:**

The castor plants of hybrid variety GAUCH-1 in the field, infested by the white fly were critically observed to study the nature of damage.

3.1.4. **Population dynamics:**

In order to study the population dynamics of *T. ricini*, a general crop raised during the season on farms of Sardarkrushinagar was selected. The plot selected was kept unsprayed. Observations were recorded for two years i.e. 1986-87 and 1987-88 during crop growth. To determine the pest population, total number of adult white flies on top or newly emerged leaves were counted, whereas, for eggs 3 spots each of 1 sq.cm were marked on top leaf of a plant and counts were made in laboratory under microscope.
Three leaves, each from upper, middle and lower sections of a plant were observed and total number of nymphs/sq.cm from 3 spots each of sq.cm/leaf were counted. Similarly for pupae, pupal index was recorded on each top, middle and lower leaf of a castor plant. Observations for adults and pupal index were made on 100 randomly selected plants while for eggs and nymphs counts were taken on 10 plants at weekly interval as per meteorological standard weeks starting from August and continued upto May during both the years. Mean number of adults/10 plants, eggs/sq.cm, nymphs/sq.cm and pupal index per leaf/plant were worked out separately.

It is well known that weather plays an important role on population of natural fauna. With a view to know the effect of weather parameters, viz., maximum, minimum, average temperature, morning, evening and average relative humidity and rainfall on population of T. ricini, multiple correlation coefficient was worked out. Weekly meteorological data recorded by the office of Dry Farming Research Station, Gujarat Agricultural University, Sardarkrushinagar for the periods 1986 to 1988 were used for the purpose.

3.1.5. Screening:

Screening of germ plasm to find out any resistant/tolerant material against castor white fly was carried out for two years. Two hundred and ninety two germ plasm material obtained from the Castor Research Project, Gujarat Agricultural University, Sardarkrushinagar were screened. For screening five plants of each culture were planted in a line at 60 x 90 cm spacing keeping GAUCH-1 variety as check at every 10 lines. Three plants from five were selected randomly for recording observations. Total number of white flies were recorded on newly emerged leaf/plant while pupal index was noted from three, top, middle and lower leaves/plant. To determine pupal index the following criteria were used.
<table>
<thead>
<tr>
<th>Index</th>
<th>Condition**</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No pupae</td>
</tr>
<tr>
<td>1</td>
<td>1 to 50 pupae</td>
</tr>
<tr>
<td>2</td>
<td>51 to 100 pupae</td>
</tr>
<tr>
<td>3</td>
<td>101 to 200 pupae</td>
</tr>
<tr>
<td>4</td>
<td>200 to 500 pupae</td>
</tr>
<tr>
<td>5</td>
<td>More than 500 pupae and honey secretion with black fungus.</td>
</tr>
</tbody>
</table>

Total number of adults recorded on 3 leaves/3 plants and pupal index recorded on 9 leaves/3 plants were then calculated per leaf/plant and presented in tabular form. The screened germ plasm was classified as free, less susceptible, moderately susceptible and susceptible categories by using the following criterion.

<table>
<thead>
<tr>
<th>Population range (adult white flies)</th>
<th>Category**</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>Free</td>
</tr>
<tr>
<td>0.01 to 5.00</td>
<td>Less susceptible</td>
</tr>
<tr>
<td>5.01 to 10.00</td>
<td>Moderately susceptible</td>
</tr>
<tr>
<td>above 10</td>
<td>Susceptible</td>
</tr>
</tbody>
</table>

** The method followed was approved in XXXII Annual Kharif Oilseeds Workshop, 1987, held at Rajendra Agril.Uni., Patna, Bihar.
In the present studies pupal index have been considered while screening germ plasm material, further the plants having 15 or more adults/leaf/plant were categorised as highly susceptible.

3.1.6. **Bio-efficacy of in-secticides:**

With a view to evaluate the bio-efficacy of various conventional and synthetic pyrethroid insecticides against castor white fly, separate field trials for both the groups were conducted for two years during 1987 and 1988, at Regional Research Station, and College Agronomy farms Gujarat Agricultural University, Sardarkrushinagar. The materials and methods followed are as follows.

Details of the experiments for both the sets for both the years.

<table>
<thead>
<tr>
<th>Type of Soil</th>
<th>Loamy sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Design</td>
<td>Randomised Block Design</td>
</tr>
<tr>
<td>No. of Replications</td>
<td>Four</td>
</tr>
<tr>
<td>No. of Treatments</td>
<td>Eight</td>
</tr>
<tr>
<td>Plot Size</td>
<td></td>
</tr>
<tr>
<td>Gross</td>
<td>3.6 x 7.2 m (4x12 plants)</td>
</tr>
<tr>
<td>Net</td>
<td>1.8 x 6.0 m (2x10 plants)</td>
</tr>
<tr>
<td>Spacing</td>
<td>90 x 60 cm</td>
</tr>
<tr>
<td>Method of sowing</td>
<td>Dibbling</td>
</tr>
<tr>
<td>Fertilizer application</td>
<td></td>
</tr>
<tr>
<td>Basal dose</td>
<td>75 N:50 P</td>
</tr>
<tr>
<td>Top dressing</td>
<td>37.5 N:50 P</td>
</tr>
<tr>
<td>Date of Spraying</td>
<td></td>
</tr>
<tr>
<td>1st spraying</td>
<td>1987 1st November</td>
</tr>
<tr>
<td>2nd spraying</td>
<td>1987 16th November</td>
</tr>
<tr>
<td>3rd spraying*</td>
<td>1987 1st December</td>
</tr>
<tr>
<td>3rd spraying</td>
<td>1988 25th October</td>
</tr>
<tr>
<td>3rd spraying</td>
<td>1988 9th November</td>
</tr>
<tr>
<td>3rd spraying</td>
<td>1988 24th November</td>
</tr>
</tbody>
</table>
Harvesting  
Second week of December and onwards

The following insecticides were evaluated along with control against
*T. ricini.*

<table>
<thead>
<tr>
<th>Name of insecticide</th>
<th>Concentration</th>
<th>Formulation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experiment 1.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Monocrotophos</td>
<td>0.04</td>
<td>Nuvacron 40EC</td>
<td>Hindustan Ciba Geigy (India) Ltd., Bombay.</td>
</tr>
<tr>
<td>2. Methyl-o-demeton</td>
<td>0.025</td>
<td>Metasystox 25EC</td>
<td>Bayer (India) Ltd., Bombay.</td>
</tr>
<tr>
<td>3. Methyl parathion</td>
<td>0.05</td>
<td>Metacid 50EC</td>
<td>Bayer (India) Ltd., Bombay.</td>
</tr>
<tr>
<td>4. Dimethoate</td>
<td>0.03</td>
<td>Rogor 30EC</td>
<td>Rallis (India) Ltd., Bombay.</td>
</tr>
<tr>
<td>5. Ethion</td>
<td>0.05</td>
<td>Tate thion 50EC</td>
<td>Rallis (India) Ltd., Bombay.</td>
</tr>
<tr>
<td>6. Thiometon</td>
<td>0.025</td>
<td>Ekatin 25EC</td>
<td>Sandoz (India) Ltd., Bombay.</td>
</tr>
<tr>
<td>7. Fenvalerate</td>
<td>0.01</td>
<td>Fenval 20EC</td>
<td>Searle (India) Ltd., Bombay.</td>
</tr>
</tbody>
</table>

| **Experiment 2.**   |               |             |        |
| 1. Fenvalerate      | 0.01          | Fenval 20EC | Searle (India) Ltd., Bombay. |
| 2. Fenvalerate      | LVC           | Fenval 200 LVC | Searle (India) Ltd., Bombay. |
| 3. Fenvalerate      | 0.4           | Fenval 0.4% dust | Searle (India) Ltd., Bombay. |
| 4. Cypermethrin     | 0.005         | Ripcord 10EC | NOCIL, Bombay. |
| 5. Decamethrin      | 0.0028        | Decis 2.8EC  | Hoechst (India) Ltd., Bombay. |
| 6. Fluvalinate      | 0.0075        | Mavrik 25EC  | Sandoz (India) Ltd., Bombay. |
| 7. Monocrotophos    | 0.04          | Nuvacron 40EC | Hindustan Ciba Geigy (India) Ltd., Bombay. |
The crop was sown by dibbling on respective farms as per layout in randomised block design and uniform plant stand was maintained by filling up the gaps. All the agronomic operations were done as and when required as per the standard recommendations.

3.1.6.1. Insecticidal application:

Insecticidal spray solutions were prepared sufficiently for four plots in a stock container. This quantity was fixed by spraying four control plots with known quantity of water. Thus the total quantity required for each plot was calculated. All the sprayings of emulsion concentrate formulations were made by hand operated "Knapsack" sprayer using duromist nozzle. While the dust and LVC formulations were applied with hand rotary duster and battery operated Hally sprayer, respectively. The sprayable solution was used @ 800 l/ha while the dust and LVC were used @ 25 kg and 1 l/ha, respectively. Insecticidal applications were made at an interval of 15 days after the first spraying which was done at initiation of population build up of white fly. In all three sprayings were made in conventional insecticidal experiment, while only two in synthetic pyrethroids experiment. Drift of insecticides from plot to plot was prevented by fixing cloth screen between the plots.

3.1.6.2. Observations:

Five plants from the net plot were selected at random on which newly emerged or top leaf was observed for adults' count, while, 3 leaves were selected/plant from lower, middle and upper sectors for nymphal and pupal counts. On each leaf 3 spots each of sq.cm were marked at random and counts of nymphs were made from that area whereas, the pupal counts were made per leaf under stereoscopic microscope. All the nymphs and pupe were pricked by a sharp pointed needle and those stages from which fluid oozed out were considered as living. Initial observations were recorded before
the first spraying in both the sets of experiments, while, subsequent observations for conventional insecticides were recorded at 24, 48, 72 and 96 hours, 1 week and 2 weeks; 24 hours, 1 week and 2 weeks and 1 week and 2 weeks for adults, nymphs and pupae respectively. Observations in the experiment of synthetic pyrethroids were recorded at 24 hours, 1 week and 2 weeks for nymphs and adults whereas, for pupae they were recorded at 1 week and 2 weeks' interval after spraying. In all cases the observations taken at 2 weeks after spraying were considered as initial for the next spraying. Finally average population of nymphs were worked out as nymphs/sq.cm/leaf, while pupae and adults as No. per leaf, respectively. The data were subjected to $\sqrt{X + 0.5}$ transformation for analysis. Individual analysis for each experiment and pooled analysis of both the experiments of two years were carried out with the help of computer. After presenting the transformed means the figures were retransformed to give actual means. For discussion the results of pooled analysis 24 hrs, 1 week and 2 weeks and 1 week and 2 weeks after spraying for nymph and adults and pupae respectively were considered. Therefore, data of pooled results for the said time interval only are presented in tabular form.

3.1.6.3. Phytotoxicity:

During evaluating efficacy of insecticides against *T. ricini*, the plots sprayed with different insecticides were critically observed for their toxicity if any on castor plants.

3.1.6.4. Yield:

To determine the effect of insecticidal treatment on castor seed yield, the spikes with capsules as and when matured were harvested and collected from net plot. In all four to five harvestings were made during the season. The material collected were dried, threshed and the weight of castor seed was recorded plotwise. The data were statistically analysed by computer.

3.1.6.5. Economics of the insecticides:
for recommending any insecticide for the control of particular pest in a crop for large scale adoption by farming community. It indicates the efficacy and superiority of an insecticide for the pest. The Cost Benefit Ratio was worked out on the basis of pooled seed yield for both the years and presented in respective table.
IV RESULTS AND DISCUSSION


The results of the investigations on various aspects of *T. ricini* carried out in the laboratory as well as in the field are presented and discussed in this chapter.

4.1.1. Biology:

4.1.1.1. Ovipositional site and pattern:

The female white fly, *T. ricini* in caged plants laid eggs in circular fashion or in clusters in the interveinal areas on lower surface of leaves under laboratory conditions. The clusters or batches of eggs were scattered on the lower surface of the leaf. As the caged plants were of three to five leaves there was no preference of top leaf for egg laying. Therefore, the eggs were found on all the leaves of a plant. In the field condition, the white flies were found congregating in hundreds of number on a top leaf or newly emerged leaf of a plant, therefore, they laid eggs covering the entire lower surface of the leaf. In rare cases the eggs were observed on upper surface of the leaf. However, it was noticed that when pest population was very high and the plant density too low during the season, or in off-season the flies were found laying eggs on upper surface of the leaves. In such conditions the pupae also developed on upper surface of the leaves. In no cases the eggs were observed on lower or middle lower leaves of a plant. To determine maximum number of eggs in sq.cm area of a leaf during peak period of infestation i.e. October-November and March-April, twenty top leaves were plucked off from the plants of castor and brought to the laboratory. Total number of eggs/sq.cm were counted under microscope from three different randomly selected sq.cm areas on a leaf. The data are presented in Table 2.
Adults of *T. ricini* Misra congregated on top leaf of a castor plant.

Eggs of *T. ricini* Misra on top leaf.
It can be seen from the data presented in Table 2 that there was heavy egg laying on Lop leaves. Almost entire lower surface of the leaf was covered by eggs. The data indicated that in all there were 20,707 eggs/60 sq.cm area of 20 leaves. The number of eggs laid per sq.cm ranged from 46 to 736 with an average of 345.1 + 183.5 eggs/sq.cm. Published information is not available particularly for this aspect and hence the present finding could not be discussed. However, Lloyd (1922) reported that the eggs of T. vaporariorum were laid in circle on tomato but on hairy surface they were scattered in groups. This is in agreement with present finding for pattern of egg laying.

4.1.1.2. Egg:

The egg of castor white fly, T. ricini was sub-elliptical, smooth, shiny and pale yellow in colour when freshly laid. The egg was broadly rounded at the base and tapering apically. Each egg was attached to the leaf surface by a short stalk called peduncle inserted into leaf tissue. Paulson and Beardsley (1985) had made observations on different species of white flies on egg pedicel insertion into host plants. According to them the egg pedicel of Orchnoplatus mammaeferus, Aleurotrixus floccosus, Aleurodicus dispersus was inserted into host plant stomata, while of Bemisia tabaci and T. vaporariorum was inserted nonstomatally directly into host plant tissues. The present findings confirm with their observations made on Trialeurodes. Gradually the egg turned to dirty white in colour and lost shine before hatching. In freshly laid egg a yellow mass or spot was visible through chorion and was found moving anterior to posterior end resting almost in the centre. A day before hatching the egg became opaque, however, a pair of red eye spots on the anterior portion was conspicuous through transparent chorion. Present findings regarding shape and colour are according to the results reported by Chauhan (1974), however, he failed to observe a pair of red eyes before hatching.
Eggs of *T. ricini* Misra (45 x) (3.5 x)
Table 2. Total number of eggs of *Trialeurodes ricini* Misra per sq.cm leaf area during peak periods of crop season

<table>
<thead>
<tr>
<th>Period of observation</th>
<th>No. of leaf</th>
<th>Number of eggs/sq.cm</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>October</td>
<td>1</td>
<td>194</td>
<td>215</td>
</tr>
<tr>
<td>October</td>
<td>2</td>
<td>736</td>
<td>253</td>
</tr>
<tr>
<td>October</td>
<td>3</td>
<td>518</td>
<td>538</td>
</tr>
<tr>
<td>October</td>
<td>4</td>
<td>87</td>
<td>407</td>
</tr>
<tr>
<td>November</td>
<td>5</td>
<td>536</td>
<td>418</td>
</tr>
<tr>
<td>November</td>
<td>6</td>
<td>125</td>
<td>95</td>
</tr>
<tr>
<td>November</td>
<td>7</td>
<td>46</td>
<td>84</td>
</tr>
<tr>
<td>November</td>
<td>8</td>
<td>557</td>
<td>467</td>
</tr>
<tr>
<td>November</td>
<td>9</td>
<td>576</td>
<td>618</td>
</tr>
<tr>
<td>November</td>
<td>10</td>
<td>531</td>
<td>494</td>
</tr>
<tr>
<td>March</td>
<td>11</td>
<td>459</td>
<td>358</td>
</tr>
<tr>
<td>March</td>
<td>12</td>
<td>626</td>
<td>451</td>
</tr>
<tr>
<td>March</td>
<td>13</td>
<td>485</td>
<td>250</td>
</tr>
<tr>
<td>March</td>
<td>14</td>
<td>480</td>
<td>389</td>
</tr>
<tr>
<td>March</td>
<td>15</td>
<td>278</td>
<td>178</td>
</tr>
<tr>
<td>April</td>
<td>16</td>
<td>125</td>
<td>85</td>
</tr>
<tr>
<td>April</td>
<td>17</td>
<td>115</td>
<td>250</td>
</tr>
<tr>
<td>April</td>
<td>18</td>
<td>423</td>
<td>389</td>
</tr>
<tr>
<td>April</td>
<td>19</td>
<td>167</td>
<td>195</td>
</tr>
<tr>
<td>April</td>
<td>20</td>
<td>257</td>
<td>225</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Sd +</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>46</td>
<td>736</td>
<td>345.1</td>
<td>183.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20,707</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Measurements of different stages of *Trialeurodes ricini* Misra

<table>
<thead>
<tr>
<th>Stage</th>
<th>No. Observed</th>
<th>Length in mm</th>
<th>Breadth in mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Egg</td>
<td>50</td>
<td>0.168</td>
<td>0.236</td>
</tr>
<tr>
<td>Nymph</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I Instar</td>
<td>50</td>
<td>0.236</td>
<td>0.304</td>
</tr>
<tr>
<td>II Instar</td>
<td>50</td>
<td>0.405</td>
<td>0.472</td>
</tr>
<tr>
<td>III Instar</td>
<td>50</td>
<td>0.506</td>
<td>0.574</td>
</tr>
<tr>
<td>Pupae</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without filament</td>
<td>50</td>
<td>0.608</td>
<td>0.709</td>
</tr>
<tr>
<td>With filament</td>
<td>50</td>
<td>0.95</td>
<td>1.18</td>
</tr>
<tr>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40</td>
<td>0.844</td>
<td>0.979</td>
</tr>
<tr>
<td>Female</td>
<td>40</td>
<td>0.912</td>
<td>1.047</td>
</tr>
</tbody>
</table>
Freshly laid 50 eggs measured 0.168 to 0.236 mm with an average of 0.218 ± 0.029 in length and 0.07 to 0.101 mm with an average of 0.093 ± 0.013 mm in breadth (Table 3 and Appendix 1). There was no variation in the length of pedicel of different eggs and it measured 0.03 mm. The measurements of eggs recorded by Chauhan (1974) varied from 0.19 to 0.2 mm with an average of 0.20 mm and 0.08 to 0.09 mm with an average of 0.08 mm in length and breadth respectively, while the pedicel measured on an average 0.09 mm. The present measurements are slightly greater which may be due to host variation and other ecological factors.

4.1.1.2.1. Incubation period:

The incubation period of eggs of *T. ricini* was studied at varying temperatures during the months of March, 1988; June, 1988 and January, 1989. The data are presented in Table 4 and Appendices 2, 3 and 4.

Looking at the data presented in Table 4 and Appendices 2, 3 and 4, it is found that the incubation period of eggs of *T. ricini* varied considerably in different parts of the season. The incubation period varied from 4 to 7 days with an average of 5.64 ± 1.07 days during March, 1988 at varying temperatures of 13.7 to 35.7°C with an average of 25.5 ± 8.68°C and 41.92 per cent relative humidity. At temperature range from 27.4 to 45.7°C with an average of 34.43 ± 6.26°C and 51.43 per cent average relative humidity in the month of June, 1988, the incubation period varied from 4 to 7 days with an average of 5.25 ± 0.99 days, while, it was of on an average 7.13 ± 1.41 days ranging from 5 to 10 days during January, 1989 at temperatures varying from 4.1 to 27.6°C with an average of 16.04 ± 9.43°C and average relative humidity of 52.70 per cent. The incubation period was more at lower temperatures as compared to higher temperatures which is in confirmation
Table 4. Details of time period of various stages of *Trialeurodes ricini* Misra on castor during different periods

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Ave+sd</td>
</tr>
<tr>
<td>Egg period in days</td>
<td></td>
<td>4</td>
<td>7</td>
<td>5.64 ± 1.07</td>
</tr>
<tr>
<td>Nymphal period in days</td>
<td></td>
<td>2</td>
<td>4</td>
<td>3.05 ± 0.68</td>
</tr>
<tr>
<td>I Instar</td>
<td></td>
<td>2</td>
<td>4</td>
<td>2.84 ± 0.55</td>
</tr>
<tr>
<td>II Instar</td>
<td></td>
<td>2</td>
<td>4</td>
<td>2.89 ± 0.50</td>
</tr>
<tr>
<td>III Instar</td>
<td></td>
<td>6</td>
<td>10</td>
<td>8.82 ± 1.06</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>6</td>
<td>8</td>
<td>7.20 ± 0.82</td>
</tr>
<tr>
<td>Pupal period in days</td>
<td></td>
<td>1</td>
<td>2</td>
<td>1.45 ± 0.51</td>
</tr>
<tr>
<td>Pre-oviposition</td>
<td></td>
<td>3</td>
<td>6</td>
<td>4.50 ± 1.19</td>
</tr>
<tr>
<td>Oviposition</td>
<td></td>
<td>0</td>
<td>2</td>
<td>1.25 ± 0.55</td>
</tr>
<tr>
<td>Post-oviposition</td>
<td></td>
<td>4</td>
<td>10</td>
<td>7.20 ± 2.25</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>4</td>
<td>7</td>
<td>5.45 ± 1.19</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td>5</td>
<td>9</td>
<td>7.25 ± 1.41</td>
</tr>
</tbody>
</table>
to Lloyd (1922), where he observed prolonged incubation period of eggs of *T. vaporariorum* in cold weather. This finding does not tally with the reports of Chauhan (1974) where, he had observed 5.04 and 5.8 days of incubation period during months of October and December, respectively. As per observations made by Khidir et al., (1962), incubation period of eggs of *T. vaporariorum* was of 5.1 days at temperatures 29 to 33°C and 100% relative humidity. The variations in incubation period observed may be due to difference in host plants, species involved, and other ecological parameters.

4.1.1.2.2. Per cent hatching:

Hatching percentage of the eggs of *T. ricini* was worked out during March, 1988; June, 1988 and January, 1989. The results are presented in Table 5. Perusal of the data revealed that the percentage of hatching varied during different months under study. During March, 1988 at varying temperatures 13.7 to 35.7°C with an average of 25.5 ± 8.68°C and 41.92 per cent average relative humidity, percentage hatching was 84.61. It was also observed that per cent eggs hatched after 4th, 5th, 6th and 7th day were 13.85, 23.69, 26.15 and 20.92, respectively. Observations made at 27.4 to 45.7°C with an average of 34.43 ± 6.26°C temperature and 51.43 per cent average relative humidity during June, 1988 revealed that on 4th, 5th, 6th and 7th day 23.14, 25.49, 24.71 and 9.41 per cent eggs hatched, respectively, the total being 82.75 per cent. Only 70.59 per cent egg hatching was observed in the month of January, 1989 at 4.1 to 27.6°C with an average of 16.04 ± 9.43°C temperature and average relative humidity of 52.70% where, 6.27, 21.57, 18.82, 10.20, 8.24 and 5.49 per cent eggs hatched on 5th, 6th, 7th, 8th, 9th and 10th day, respectively. It was also noticed that at higher temperatures more than 75 per cent of the eggs hatched within three days, while, at lower temperature only about 66 per cent of the eggs hatched within that period. This indicated that the hatchability of eggs was less at lower temperatures.
Table 5. Hatching percentage of eggs of *Trialeurodes ricini* Misra at varying temperatures and relative humidity.

<table>
<thead>
<tr>
<th>Period of study</th>
<th>Temperature °C</th>
<th>Ave.% No. of egg observed</th>
<th>Percentage of eggs hatched on day after laying</th>
<th>Total % hatched</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st to 12th, March 1988</td>
<td>13.7 to 35.7</td>
<td>41.92 to 325</td>
<td>13.85 to 26.15 to 20.92</td>
<td>84.61</td>
</tr>
<tr>
<td>10th to 24th, June 1988</td>
<td>27.4 to 45.7</td>
<td>51.43 to 255</td>
<td>23.14 to 24.71 to 9.41</td>
<td>82.75</td>
</tr>
<tr>
<td>4th to 20th, January 1989</td>
<td>4.1 to 27.6</td>
<td>52.70 to 255</td>
<td>6.27 to 21.57 to 18.82 to 10.20 to 8.24 to 5.49</td>
<td>70.59</td>
</tr>
</tbody>
</table>
Since no detailed information was available on per cent hatching of eggs the finding could not be compared. However, Chauhan (1974), had reported 94.6 per cent and 96 per cent hatching during October and December, 1973, respectively. The variation in observations found may be due to different ecological conditions prevailing in the region.

4.1.1.3. Nymph:

The nymphs of *T. ricini* were reared under laboratory conditions to study different instars.

The nymph was elliptical in shape varying with whitish yellow to deep yellow in colour in various instars. The newly hatched nymph was the only immature mobile stage before settling at suitable place on lower surface of a leaf after which it remained attached throughout its life. Wriggling movement was only observed at the time of moulting. The size, shape and colour of the nymph changed with its gradual development. There were no conspicuous differences in the general appearance among different nymphal instars except the size, shape and colour. The eyes on anterior and vasiform orifice on posterior were prominent in all the instars. There were three nymphal instars and the exuviae could be seen near body of the latter instar if not disturbed. The same number of nymphal instars were observed in *T. vaporariorum* (Louise, 1948), *T. ricini* (Chauhan, 1974) and *T. lubia* (Khidir et al., 1972) which are in close agreement with the present finding.

4.1.1.3.1. First instar nymph:

Freshly emerged nymph started moving after about five to ten minutes. It moved for about 3 to 4 cm within 30 minutes to 1 hour and settled on finding a suitable place. It was flat, elliptical in shape, yellowish white in colour and had six legs. Two long curved pointed spines on meso and meta thoracic legs were well defined. Two dark red eye spots were observed prominently on anterior
part of the body, several well defined setae were found arising from the lateral margin of the nymphal body. Cephalic and caudal setae were distinct and well developed vasiform orifice near posterior end was clear and well marked. Seven abdominal segments could easily be counted. Similar observations were reported by Chauhan (1974) which confirm the present findings.

Measurements of 50 nymphs (Table 3 and Appendix 5) revealed that the length of the first instar varied from 0.236 to 0.304 mm with an average of $0.281 \pm 0.022$ mm, while the breadth varied from 0.101 to 0.168 mm with an average of $0.149 \pm 0.022$ mm. The present findings on length and breadth of 1st instar nymph are almost similar to those of Chauhan (1974).

4.1.1.3.2. Second instar nymph:

The freshly moulted second instar nymph resembled the first instar but slightly larger in size, deep yellow in colour and stationary. It had conspicuous two dark red eye spots on the head and the legs and antennae were degenerated. The integument was transparent through which internal body parts could be seen clearly. Well defined caudal setae were present but marginal setae could not be observed. The margin of the body in latter stage was covered evenly with very thin white waxy fibres. Vasiform orifice was clearly seen. The exuviae of the preceeding instar sometimes did not easily detach from the posterior end of the body of freshly moulted nymph, the nymph exhibited wriggling movement and lifting the hind portion till the exuviae got completely removed. The present observations more or less tally with that of Chauhan (1974).

Looking to the Table 3 and Appendix 6 for the measurements, it is clear that the length of the second instar nymphs ranged from 0.405 to 0.472 mm, with an average of $0.435 \pm 0.028$ mm, while in breadth it ranged from 0.202 to 0.304 mm with an average of $0.255 \pm 0.034$ mm. According to Chauhan (1974) the measurements were 0.34 to 0.38 mm with an average of 0.37 mm and 0.19 to 0.22 mm with an average of 0.21 mm of length and breadth,
respectively. The variation in measurements may be due to difference in the variety of the host plant.

4.1.1.3.3. Third instar nymph:

The third instar nymph was similar to second instar, but was larger in size and dark yellow in colour. A pair of dark red coloured eye spots on anterior end and caudal setae at the abdominal end were more prominent. The marginal setae were not observed but the waxy fillaments were faintly luminous. The vasiform orifice on posterior region was clearly seen. In some of the nymphs a small drop of white transparent sticky material (honey dew) ejected from vasiform orifice was found adhering on the posterior end of the body. The newly moulted nymph completely detached the exuviae by wriggling and lifting posterior portion of the body. It can be seen from the Table 3 and Appendix 7 that the length of third instar varied from 0.506 to 0.574 mm with an average of 0.546 ± 0.024 mm, while the breadth was of on an average 0.373 ± 0.026 mm having range from 0.337 to 0.405 mm. The present findings differ from that of Chauhan (1974), where he measured the length on an average 0.5 mm which varied from 0.41 to 0.56 mm, while the breadth ranged from 0.27 to 0.32 mm with an average of 0.31 mm. This variation may be due to the food variation on account of different varieties on which they were reared and other ecological factors regulating the growth.

4.1.1.3.4. Duration of nympha! instars:

To determine the duration of nymphal instars the newly hatched nymphs were transferred to potted plants and marked after their settlement. They were observed everyday under microscope to confirm moulting. The duration of each instar was worked out and presented in Table 4 and Appendix 8.

Perusal of results presented in Table 4 and Appendix 8 indicated that there was effect of temperature on nymphal duration. At temperature range from 16.8 to 37.1 °C with an average of 26.7 ± 8.55 °C and average relative humidity
of 46.50 per cent the nymphal duration of the first, second and third instars varied from 2 to 4 days each, with an average of 3.05 ± 0.68, 2.84 ± 0.55 and 2.89 ± 0.50 days, respectively. The duration of all three nymphal instars varied from 2 to 3 days with an average of 2.24 ± 0.43, 2.27 ± 0.45 and 2.19 ± 0.40 days for the first, second and third instar, respectively at varying temperatures of 27.4 to 45.7°C with an average 34.92 ± 6.48°C and 50.6 per cent average relative humidity. During January, 1989 at temperature range from 4.1 to 27.6°C with an average of 16.04 ± 9.43°C and average relative humidity 52.70 per cent, the first, second and third instar nymphs varied from 3 to 5, 3 to 5 and 4 to 6 days with an average of 4.06 ± 0.75, 4.22 ± 0.74 and 5.20 ± 0.72 days, respectively. The total nymphal period under study during different months i.e. March, 1988; June, 1988 and January, 1989 ranged from 6 to 10, 6 to 9 and 11 to 16 days with an average of 8.82 ± 1.06, 6.69 ± 0.75 and 13.48 ± 1.18 days, respectively.

Chauhan (1974) found that the average durations of I, II and III instars were of 2.3, 2.22 and 2.18 days in October, while in December, they were of 3.31, 3.18 and 3.66 days, respectively. The total nymphal period being 6.88 and 9.85 days at temperature range from 28.9 to 31.7°C and 22.2 to 25.6°C during October and December, respectively. The nymphal period of T. vaporariorum on tomato according to reports of Hussey et. al., (1957), was on an average of 9.3, 7.8 and 7.7 days at 70°F, 75°F and 80°F respectively, while the duration of three nymphal instars of T. lubia on cotton lasted for an average 2.5, 2.2 and 2.7 days, respectively at 29.33°C and 100 per cent relative humidity (Khidir et. al., 1962). The present studies are comparable with the findings of above workers in the case that the nymphal duration depends on temperature and relative humidity. At lower temperature the nymphal period is prolonged. The variation in nymphal periods may be due to the host, species and ecological factors.
Pupae of *T. ricini* Misra

Single pupa of *T. ricini* Misra (30x) (4x)
4.1.1.4. **Pupa:**

Freshly formed pupa was thin, flat, yellow elliptical in shape with slight development of waxy filaments from the margin of the pupal body. On gradual development of pupa the colour changed to deep yellow and the filaments increased in length. They tended to curve towards ventral side. The waxy filaments found attached closely to each other and were brittle in nature. Well developed eye spots, vasiform orifice and other internal developing organs could be seen under microscope through transparent integument.

Measurements of 50 pupae with filaments (Table 3 and Appendix 9) varied from 0.95 to 1.18 mm and 0.74 to 0.91 mm with an average of 1.038 ± 0.087 and 0.798 ± 0.066 mm in length and breadth, respectively. Whereas, the length of pupae without filaments (Appendix 10) varied from 0.608 to 0.709 with an average of 0.645 ± 0.036 mm, while, in breadth 0.371 to 0.439 mm with an average of 0.407 ± 0.023 mm. According to Chauhan (1974) the average length of pupa was 0.74 mm and breadth 0.61 mm with filaments and 0.64 mm and 0.40 mm in length and breadth, respectively without filaments. The variation observed in measurements may be due to different host plants and ecological factors of the region.

4.1.1.4.1. **Pupal period:**

To determine pupal period, the freshly formed pupae were marked and observed till adults' emergence. The data obtained are presented in Table 4 and Appendix 11.

It is evident from the results (Table 4 and Appendix 11) that the pupal period varied from 6 to 8 days with an average of 7.20 ± 0.82 days at varying temperatures of 13.5 to 36.9°C with an average of 25.81 ± 10.08°C and average 24.22 per cent relative humidity in the month of March, 1988. At temperature
Adult of *T. ricini* Misra.
ranging from 27.4 to 40.0°C with an average of 33.57 ± 5.7°C and average 53.72 per cent relative humidity the pupal stage ranged from 6 to 7 days with an average of 6.62 ± 0.83 days in June, 1988 while it was of 7 to 11 days with an average of 8.83 ± 1.07 days at varying temperatures of 5.2 to 30°C with an average of 18.24 ± 10.27°C and 38.17 per cent average relative humidity during January, 1989.

The pupal stage of *T. vaporariorum* lasted for 6 days at 70 and 75°F while, it was of 5.5 days at 80°F (Hussey et al., 1957), whereas, the average pupal period was of 8.2 days at 29 to 33°C and 100 per cent relative humidity for *T. lubia* on cotton (Khidir and Khidir, 1962). According to Chauhan (1974), the pupal stages of *T. ricini* were of 7.07 and 8.44 days at 28.9 to 31.1°C and 22.2 and 25.0°C respectively. The variation in pupal stage observed may be attributed to different host plants, species of white fly and ecological factors prevailing in the area.

**4.1.1.5. Adult:**

The adult white fly emerged from pupa by splitting along with mid dorsal line of the pupal case. The adult was small and slender with head, thorax and abdomen yellow in colour. On head, a pair of compound eyes was prominent with dark red to brown in colour. A pair of antennae was filiform, five segmented and yellowish white in colour. In freshly emerged adult wings were yellow in colour and folded. The wings got contorted to their normal size after sometime and the fly showed movement. The wings were coated with white waxy powder, on removal they became transparent. They were held roof-like on abdomen while resting. The wings of pro-thorax were larger than wings of meso thorax. All pairs of legs were equal in size. The tibia had one spur at the end, while, the tarsi were two segmented with spur at the end of second segment. The female was larger in size than male. The
Male of *T. ricini* Misra.

Female of *T. ricini* Misra.
abdomen of female was broad and spindle shaped, while, in male it was narrow and tapering posteriorly which ended in a pair of claspers and basal plates. The adeagus was present between the claspers. Some of the morphological characters were also studied by Chauhan (1974) which were in agreement with the present studies.

Measurements of 40 males and 40 females (Table 3 and Appendix 12 and 13) revealed that the females were larger than males. Females varied from 0.912 to 1.047 mm in length with an average of 1.000 ± 0.046 mm while in breadth they varied from 0.236 to 0.337 mm with an average of 0.292 ± 0.034 mm. The males on an average were of 0.919 ± 0.049 mm in length and 0.260 ± 0.035 mm breadth which ranged from 0.844 to 0.979 and 0.202 to 0.304 in length and breadth, respectively. According to Chauhan (1974), the males on an average measured 0.945 mm while the females 0.988 mm. Present results are almost in agreement to his measurements, however, the variation in size observed may be due to host differentiation and other ecological factors.

4.1.1.5.1. Sex ratio:

To determine the sex ratio of white flies, they were collected from field during different months at an interval of about ten days. In all 24 collections were made from field and brought to the laboratory for examination under microscope to separate males and females. Similarly laboratory reared cultures were also examined and the results obtained are summarised in Table 6.

The population of female was higher than the male in all collections either from field or laboratory indicating the dominance of female over male. The ratio of male:female was 1:1.48 in August, 87 which gradually changed to 1:2.11 in October, 87. During colder months, it was 1:1.84 and 1:1.85
Table 6. Sex ratio of *Trialeurodes ricini* Misra

<table>
<thead>
<tr>
<th>Months</th>
<th>Total No. of adults observed</th>
<th>Male</th>
<th>Female</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Field Collection</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August,'87</td>
<td>62</td>
<td>25</td>
<td>37</td>
<td>1:1.48</td>
</tr>
<tr>
<td>September,'87</td>
<td>85</td>
<td>30</td>
<td>55</td>
<td>1:1.83</td>
</tr>
<tr>
<td>October,'87</td>
<td>227</td>
<td>73</td>
<td>154</td>
<td>1:2.11</td>
</tr>
<tr>
<td>November,'87</td>
<td>118</td>
<td>39</td>
<td>79</td>
<td>1:2.03</td>
</tr>
<tr>
<td>January,'88</td>
<td>71</td>
<td>25</td>
<td>46</td>
<td>1:1.84</td>
</tr>
<tr>
<td>February,'88</td>
<td>134</td>
<td>47</td>
<td>87</td>
<td>1:1.85</td>
</tr>
<tr>
<td>March,'88</td>
<td>190</td>
<td>56</td>
<td>134</td>
<td>1:2.39</td>
</tr>
<tr>
<td>April,'88</td>
<td>131</td>
<td>41</td>
<td>90</td>
<td>1:2.19</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>1018</td>
<td>336</td>
<td>682</td>
<td>1:2.03</td>
</tr>
<tr>
<td><strong>Laboratory reared</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March,'88</td>
<td>86</td>
<td>27</td>
<td>59</td>
<td>1:2.19</td>
</tr>
<tr>
<td>June,'88</td>
<td>78</td>
<td>19</td>
<td>59</td>
<td>1:3.11</td>
</tr>
<tr>
<td>January,'89</td>
<td>55</td>
<td>17</td>
<td>38</td>
<td>1:2.24</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>219</td>
<td>63</td>
<td>156</td>
<td>1:2.48</td>
</tr>
</tbody>
</table>
while in hot periods of March and April, 1987, the ratio was 1:2.39 and 1:2.19, respectively. During the crop season, 1018 adults were collected of which 682 were females while, 336 male. The overall ratio worked out for male:female was 1:2.03. The sex ratio worked out for laboratory reared cultures were of 1:2.19, 1:3.11 and 1:2.24 during the months of March, 1988, June, 1988 and January, 1989 respectively. Overall ratio worked out for male:female for laboratory reared culture was 1:2.48. According to Chauhan (1974) the sex ratio of *T. ricini* was 1:2.22. The present findings are in close agreement with the work of Chauhan. The slight variation during different periods may be due to ecological factors.

4.1.1.5.2. Pre-oviposition, oviposition and post-oviposition periods:

Pre-oviposition, oviposition and post-oviposition periods of a female of *T. ricini* were studied at different varying temperatures and relative humidity during the months of March and June, 1988 and January, 1989. The results obtained are summarised in Table 7 and Appendix 14, 15 and 16.

Perusal of data indicated that at temperature range of 13.5 to 37°C with an average of 26.29 ± 9.65°C and 31.8 per cent average relative humidity during March, 1988, pre-oviposition, oviposition and post-oviposition periods of 20 females were of 1 to 2, 3 to 6 and 0 to 2 days with an average of 1.45 ± 0.51, 4.5 ± 1.19 and 1.25 ± 0.55 days respectively. Similarly during June, 1988 pre-oviposition, oviposition and post-oviposition periods of 25 females were of 1 to 2, 3 to 5 and 0 to 2 days, the average being 1.44 ± 0.51, 4.2 ± 0.87 and 1.28 ± 0.62 days, respectively, at varying temperatures of 27.4 to 45.7°C with an average of 34.97 ± 6.74°C and 47.46 per cent average relative humidity, while during January, 1989 at varying temperatures 4.1 to 27.0°C with an average of 15.90 ± 9.47°C and 51.66 per cent relative humidity, the pre-oviposition, oviposition and post-oviposition periods of 25 females
Table 7.  
Fecundity, pre-oviposition, oviposition and post-oviposition periods of *Trialeurodes ricini* Misra

<table>
<thead>
<tr>
<th>Period of study</th>
<th>Temperature range with Ave.$\pm$ sd$^\circ$C</th>
<th>No.of female Min.</th>
<th>No.of eggs laid Min.</th>
<th>Ave.$\pm$sd</th>
<th>Pre-oviposition period days Min.</th>
<th>Max.</th>
<th>Ave.$\pm$sd</th>
<th>Oviposition period (days) Min.</th>
<th>Max.</th>
<th>Ave.$\pm$sd</th>
<th>Post-oviposition period (Days) Min.</th>
<th>Max.</th>
<th>Ave.$\pm$sd</th>
</tr>
</thead>
<tbody>
<tr>
<td>12th to 24th</td>
<td>13.5 to 37.1</td>
<td>20 55 135</td>
<td>95.80 1 2</td>
<td>1.45</td>
<td>3 6 4.5</td>
<td>0</td>
<td>2</td>
<td>1.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March, 1988</td>
<td>26.29 $\pm$ 9.65</td>
<td></td>
<td>+20.33 +0.51</td>
<td>+1.19</td>
<td>+0.55</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Av.R.H.31.8%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8th to 20th</td>
<td>27.4 to 45.7</td>
<td>25 50 142</td>
<td>83.28 1 2</td>
<td>1.44</td>
<td>3 5 4.2</td>
<td>0</td>
<td>2</td>
<td>1.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June, 1988</td>
<td>34.97 $\pm$ 6.74</td>
<td></td>
<td>+28.64 +0.51</td>
<td>+0.87</td>
<td>+0.62</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(Av.R.H.47.46%)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>4th to 19th</td>
<td>4.1 to 27.6</td>
<td>25 21 55</td>
<td>38.76 1 3</td>
<td>1.88</td>
<td>4 8 5.48</td>
<td>1</td>
<td>4</td>
<td>2.28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>January, 1989</td>
<td>15.90 $\pm$ 9.47</td>
<td></td>
<td>+10.06 +0.78</td>
<td>+1.33</td>
<td>+1.06</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(Av.R.H.51.66%)</td>
<td></td>
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<td></td>
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</tbody>
</table>
ranged from 1 to 3, 4 to 8 and 1 to 4 days with an average of 1.88 ± 0.78, 5.48 ± 1.33 and 2.28 ± 1.06 days, respectively. Studies made by Chauhan (1974) on 17 females revealed that the average pre-oviposition, oviposition and post-oviposition periods of T. ricini were of 1.27, 4.9 and 0.72 days, respectively at temperatures ranging from 27.8 to 29.4 °C and 64 per cent relative humidity during October, 1973. The present findings do not tally with his findings which may be due to variation in ecological factors.

4.1.1.5.3. Fecundity:

While studying the oviposition periods of T. ricini the eggs laid by females were counted everyday which are summarised in Table 7 and Appendices 14, 15 and 16.

According to the results (Table 7 and Appendices 14, 15 and 16), it was clear that the egg laying capacity of the female varied considerably during different months of the crop season. During March the egg laying capacity of 20 females varied from 55 to 135 eggs with an average of 95.80 ± 20.33 egg at varying temperatures 13.5 to 37.1 °C with an average of 26.29 ± 9.65 °C and average 31.8 per cent relative humidity. At temperature range from 27.4 to 45.7 °C with an average of 34.97 ± 6.74 °C and 47.46 per cent average relative humidity, the egg laying capacity of 25 females varied from 50 to 142 eggs with an average of 83.28 ± 28.64 eggs during June, whereas, in January, the egg laying capacity of 25 females ranged from 21 to 55 eggs with an average of 38.76 ± 10.06 eggs at an average relative humidity of 51.66 per cent and varying temperatures of 4.10 to 27.6 °C with an average of 15.90 ± 9.47 °C. The egg laying capacity of T. ricini noted by Chauhan (1974), was on an average of 93.2 eggs per female during October, 1973 at varying temperatures of 27.8 to 29.4 °C and 64 per cent relative humidity, while the fecundity of T. vaporariorum on an average was 130 eggs per female
Lloyd 1922), whereas, at 60°, 75° and 80°F the eggs laid by a single female were about 3 to 5, 2 to 9 and 7 to 14 per day, respectively (Hussey et al., 1957), while, the female of *T. lubia* on an average laid 100 eggs on under surface of cotton leaves (Khidir et al., 1962).

As per the reports made by earlier workers there is a considerable variation in the egg laying capacity of female white flies. This may be attributed to difference in host plants, species of white flies, and the climatic conditions of the region.

4.1.1.5.4. **Longevity:**

At the time of making studies on ovipositional periods of *T. ricini* the observations on longevity of male and female were recorded separately and the results obtained are presented in Table 4 and Appendices 14, 15 and 16.

It is evident from the data that the longevity of adults of *T. ricini* varied considerably during different periods under study. During March, it could be seen that the longevity was of 5 to 9 days with an average of 7.25 ± 1.41 days for female, while it was 4 to 7 days with an average of 5.45 ± 1.19 days for male at temperatures ranging from 13.5 to 37.1°C with an average of 26.29 ± 9.65°C and average relative humidity of 31.8 per cent. At varying temperatures of 27.4 to 45.7°C with an average of 34.97 ± 6.74°C and average 47.46 per cent relative humidity, the longevity varied from 5 to 9 days with an average of 6.92 ± 1.47 days and 4 to 7 days with an average of 5.12 ± 1.05 days for female and male, respectively during June, while in January, at temperatures ranging from 4.1 to 27.6°C with an average of 15.90 ± 9.47°C and average 51.66 per cent relative humidity the longevity of female and male varied from 8 to 11 days and 7 to 10 days with an average of 9.64 ± 0.86 and 8.40 ± 0.87 days, respectively.
Chauhan (1974) observed that the average duration of adult stage of \textit{T. ricini} at temperatures ranging from 28.3 to 30.6°C and 63 per cent relative humidity was of 7.19 days in October while, it was of 8.25 days in month of January at varying temperature of 21.1 to 23.3°C and 51 per cent relative humidity. The female of \textit{T. vaporariorum} lived for 12 to 51, 15 to 57 and 12 to 33 days at 60°F, 75°F and 80°F, respectively (Hussey et al., 1957), while the longevity of male and female of \textit{T. lubia} on an average were of 8.2 and 13 days respectively at 29 to 33°C and 100 per cent relative humidity (Khidir et al., 1962).

All the above earlier workers had reported that the longevity of female was higher than the male and had effect of temperature and relative humidity on adult period. The present findings confirm the observations made by the earlier workers. Some variation in longevity may be attributed to host plants, species and other climatic factors of the particular region.

4.1.1.6. Total life period:

To determine total life span of \textit{T. ricini} observations from eggs to the death of the adults were recorded during various periods under study. The results are summarised and exhibited in Table 8.

Perusal of the data of Table 8 revealed that there was an impact of weather parameters viz., the temperature and relative humidity on total life span of \textit{T. ricini}. The life cycle was prolonged at lower temperatures. The life span of male and female on an average were of 27.11 ± 3.79 and 36.75 ± 5.14 days which varied from 20 to 32 and 25 to 44 days, respectively during March–April at varying temperatures of 14.0 to 43.2°C with an average of 27.90 ± 9.94°C and 33.48 per cent relative humidity. In June–July, 1988 at varying temperatures of 25.4 to 45.7°C with an average of 33.07 ± 6.1°C and average relative humidity of 56.51 per cent the total life span cycle
<table>
<thead>
<tr>
<th>Period of study</th>
<th>Temperature °C</th>
<th>Ave. R.H. %</th>
<th>No. of eggs observed</th>
<th>No. of adults emerged</th>
<th>Total life span in days (from egg to adults death)</th>
</tr>
</thead>
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<td></td>
<td>Min.</td>
<td>Max.</td>
<td>Average + sd</td>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td>4th March to 17th April, '88</td>
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<td>43.2</td>
<td>27.90 ± 9.94</td>
<td>33.48</td>
<td>175</td>
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<td>32 females 25 44 36.75 ± 5.14</td>
</tr>
<tr>
<td>1st June to 11th July, '88</td>
<td>25.4</td>
<td>45.7</td>
<td>33.07 ± 6.16</td>
<td>56.51</td>
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<td>25 females 25 41 33.00 ± 4.85</td>
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<tr>
<td>20th December to 21st Feb, '89</td>
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<td>33.5</td>
<td>18.02 ± 9.39</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>18 females 37 63 50.78 ± 8.78</td>
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</table>

Table 8. Total life span of Trialeurodes ricini Misra
of male and female were on an average 24.27 ± 3.09 days and 33.00 ± 4.85 days which ranged from 22 to 30 days and 25 to 41 days respectively. During colder period i.e. December 1988 to February 1989 the life span of males and females varied from 30 to 47 days and 37 to 63 days with an average of 36.71 ± 3.40 days and 50.78 ± 8.78 days, respectively at an average temperature of 18.02 ± 9.39°C which ranged from 4.1 to 33.5°C and average relative humidity of 48.02 per cent. The life span of adults of *T. ricini* reported by Chauhan (1974), varied from 23 to 29 days with an average of 26.26 days when the temperatures ranged from 29.5 to 31.1°C whereas, it varied from 28 to 35 days during December-January, when temperatures ranged from 22.2 to 24.7°C. The reports on life span had been made by different workers on various species of *Trialeurodes*. For development from egg to the adult, *T. abutilonea* required 47.5 and 20.3 days at temperatures 65°F and 95°F, respectively (Butler, 1967), while the most rapid development from egg to adult was of 21 to 24 days at 22 to 27°C and 79 to 87 per cent relative humidity (Treiti, 1986). The present findings are in agreement with the results reported in the above workers that the temperature and relative humidity play a major role in the development and life span of white fly. The variation in life span observed may be due to host variation, species involved and other ecological factors prevailed in the region.

4.1.2. **Nature of damage:**

The nymphs and adults of *T. ricini* were found sucking cell sap from under surface of the leaves of castor in the field. During severe infestation the leaves were almost entirely covered with nymphs and pupae. Due to continuous sucking of the sap the leaves lost turgidity, became pale yellow, turned to brown in colour and dried. The affected plants lost their vigour and had comparatively stunted growth which finally affected the yield. On
Entire leaf covered with nymphs and pupae of *T. ricini* Misra.
Honey dew secretion of *T. ricini* Misra on a leaf

Glistening white (honey dew) in sunlight and drying of leaf
account of honey dew secreted by later instars of the pest on leaves and later on development of black sooty mold on the secretion, the heavily infested plants looked shining black and leaves glistened in sun rays. The infested fields could easily be recognised from distance. On such plants black ants in large numbers were found moving. Similar observations were also made by Trehan (1957), Richard (1960), Radha (1972) and Vevai (1973). Kulkarni and Ramananurthy (1959) had reported that *T. ricini* and *T. rara* were in large numbers by which the plant became blackish with sooty mold fungus growing on secreted honey dew. They also observed that the under surfaces of leaves were almost completely covered with nymphs. Present observations are in agreement with earlier workers.

4.1.3. **Population dynamics of castor white fly, *T. ricini* on castor:**

Studies on population dynamics of castor white fly *T. ricini* were made during the years 1986-87 and 1987-88 on GAUCH-1 hybrid castor cultivated at Sardarkrushinagar. Observations were recorded as per standard meteorological weeks from August to May for adults and pupae on 100 plants, while for eggs and nymphs from 10 plants. The population of eggs, nymphs and pupae were worked out as eggs or nymph/sq.cm/leaf and pupal index/leaf per plant while adults as number of adults/10 plants and presented in Table 9 and 10 and Fig.1 and 2 for 1986-87 and 1987-88, respectively.

It is clear from the results that population levels of white fly observed during various months differed significantly. The white fly was active throughout the crop season. The population of aleyrodid on castor crop was practically absent during the first fortnight of August, 1986 and commenced from the third week of August and gradually increased. The population of eggs, nymphs and pupae could not be noticed till second and third week of August and last week of September, respectively. The population of immature stages gradually built up with increase in adults. The peak infestation occurred in November where all the stages being maximum indicating heavy infestation of the pest, the population of the pest slowly declined being negligible in the first fortnight of January, 1987. The average nymphs

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<th>Std. week</th>
<th>Date</th>
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<th>Av. No. of eggs/10 plant sq.cm.</th>
<th>Av. No. of nymphs/leaf</th>
<th>Av. pupal index/leaf</th>
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67.5 mm rainfall was only observed in 32nd week.
and pupal index were minimum 4 and 0.17 in the last week of December, 1986 and third week of January, 1987, respectively. The second peak infestation of the pest in castor was again observed during March, 1987 being more severe than the first peak level, where the population of all the stages remained at maximum in which the adults, eggs, nymphs and pupal index were found to be 471, 516, 97 and 4.23, respectively. This population afterwards declined gradually in succeeding months.

During 1987-88 the trend of population fluctuation was more or less similar to that of 1986-87 (Table 10 and Fig.2). The crop remained completely free from white fly attack up to the third week of August, 1987. The adults appeared thereafter, whereas, the nymphs and pupae were only observed during the last week of August and after the first fortnight of September, respectively. The population of white fly gradually built up and attained the peak level during the first fortnight of December 1987, with adults, eggs, nymphs and pupae being 388, 305, 57 and 2.77, respectively. Thereafter it declined to minimum in the last week of January, 1988, where only 27, 37, 24 and 0.57 adults, eggs, nymphs and pupae were observed respectively. The second peak level of the pest population on the crop appeared in the last and first week of March-April, 1988; the adults and eggs were maximum being 506 and 434, respectively, whereas, nymphal and pupal populations were maximum during the second fortnight of April, 1988. The population of all stages again started declining in May, 1988.

According to David and Radha (1964), _T. ricini_ was prevalent throughout the year at Coimbatore but in a severe form during the months of March to June and light during November to January. Similarly the population of _T. rara_ was practically very low or absent during the period from November to first fortnight of February and thereafter increased gradually and the peak infestation occurred during September-October (David et. al., 1973). A survey carried out by Chauhan (1974) on castor hybrid-3 indicated that the population

<table>
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<th>Std. week</th>
<th>Date</th>
<th>Av. No. of adults/10 plant</th>
<th>Av. No. of eggs/sq.cm.</th>
<th>Av. No. of nymphs/leaf</th>
<th>Av. No. of pupal index/leaf</th>
<th>Temperature °C</th>
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of *T. ricini* persisted throughout the year and was high during January to May.

The present findings on seasonal incidence of *T. ricini* were in agreement with the reports made by David and Radha (1964), while it differed with the observations on *T. rara*, where, the peak infestation was noticed during September-October (David et al., 1973). Whereas, the rest of the reports were more or less in close agreement with the present findings. The variation in population fluctuation and peak infestation periods observed may be attributed to the species of white fly, the host and weather parameters prevailing in the particular region.

4.1.4. **Correlation studies between castor white fly infestation and weather parameters:**

In nature the population of organisms are never truly stable. The rise and fall of population density depends on weather conditions. To know the effect of various weather parameters on the population fluctuations of castor white fly, investigations were carried out for two years and the data on correlation among them are presented in Table 11.

The results of 1986-87 (Table 11) revealed that the increase in adult population of *T. ricini* was positively and significantly correlated with maximum temperature and non-significantly with minimum and average temperature. There was non-significant negative correlation with minimum temperature and non-significant positive correlation with maximum and average temperature with the population of immature stages of white fly. In case of relative humidity, it was negatively correlated with all the stages of *T. ricini*. There was a negative correlation of rainfall with the population of white fly.

Perusal of the data (1987-88) revealed that the maximum temperature exhibited non-significant positive correlation, while the minimum and average temperature showed non-significant negative correlation with the population levels of all the stages of the castor white fly. The correlation between relative
humidity and the population of white fly in all the cases except morning relative humidity for nymphs were significantly negative; similarly the rainfall also showed non-significant negative correlation.

From the pooled results of both the years, it can be seen that the maximum temperature showed non-significant positive correlation with the population of all the stages of *T. ricini*, whereas, non-significant negative correlation was observed with minimum temperature. Except for nymphal stage, the average temperature registered was non-significant positive correlation. In the case of relative humidity, evening and average relative humidities expressed significant negative correlation with all the stages of white fly, while morning relative humidity showed significant negative correlation with only adult stage. Rainfall had non-significant negative correlation with the population.

The present findings on correlation of weather parameters with population of *T. ricini* indicated that different weather factors had influence on the pest population and its fluctuations throughout the season. Maximum temperature had positive correlation, while minimum and average temperature had negative correlation. The relative humidity had played an important role for the built up of population as it had significant negative correlation with all the stages, whereas, the rainfall also had negative correlation. It can be thus said that positive maximum and negative average and minimum temperatures and relative humidity regulated the population of *T. ricini*. Average temperature with dry conditions favoured the pest to build up the population, while fall in maximum temperature below 32°C prevented the pest to build up its population and was minimum at 26°C.

The findings were in close confirmity with the reports of David et al., (1973), where they observed that the population of eggs, larvae, pupae and adults of castor aleyrodid was significant with increase in maximum
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**1987-88**

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**Pooled (1986-87 & 1987-88)**

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\[df = (n-k-2)\]

Table \( r \) value at 0.05\% = 0.325

0.01\% = 0.418
temperature and exhibited a negative relationship with humidity and rainfall. Moreover, they further stated that the maximum temperature below 32°C resulted in low population of various stages of aleyrodid which is also confirmed by the present findings. According to Lal (1981) relative humidity coupled with rainfall played a major role and influenced B. tabaci population rather than maximum temperature under Trivendrum conditions, whereas, Lal said (1982), the increase in B. tabaci population was positively and significantly correlated with increase in maximum temperature, while, relative humidity, minimum temperature and rainfall had no significant correlation with the population of nymphs and adults. In general high temperature, and both high and low relative humidity and rainfall play an important role in regulating the populations of Aleyrodids (Avidove, 1957; Murugesan, 1977; Vetten and Allen, 1983 and Abrahim, 1986). Although, earlier workers have worked on different species of white flies, their findings confirm the present findings.

4.1.5. Screening of castor varieties/cultures against T. ricini

With a view to study the comparative susceptibility of various castor lines against castor white fly, T. ricini, 292 varieties/germplasms were screened during 1987 and 1988 at the Castor Research Station, Gujarat Agricultural University, Sardarkrushinagar, the green stemmed cultures with no bloom, single bloom, double bloom and triple bloom were 5, 35, 71 and 71 while red stemmed were 14, 11, 35 and 10 cultures with no bloom, single bloom, double bloom and triple bloom respectively, whereas, there were 6, 15 and 19 cultures with single, double and triple bloom, respectively for mahogany stemmed plants. The population of adults and pupae observed in these cultures is summarised and presented in Table 12.

Perusal of data of two years indicate that there was a good source of resistance against white fly in castor. Out of 292 cultures 55 remained
**Relative performance of castor white fly *T. ricini* Misra against different varieties/cultivars of castor**

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<td>0.00</td>
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<td>MDT</td>
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<td>1.11</td>
<td>3.33</td>
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<td>294</td>
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<td>M1</td>
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<td>14.00</td>
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<td>2.20</td>
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**Legend:**

- **G** = Green stem
- **M** = Mahogany stem
- **DT** = Dwarf
- **O** = No bloom
- **2** = Double bloom
- **R** = Red stem
- **MDT** = Medium dwarf
- **NT** = Normal type
- **1** = Single bloom
- **3** = Triple bloom
completely free from white fly attack. These cultures have been presented in Table 13. During screening it was also marked that, eventhough the plants were completely free from adults, the pupae could be observed on the leaves of some of these lines viz., EC-80852, 4401, 894, 453, 1077-1 and 215768. The cultures which were found completely free from white fly attack were with no bloom, some with single bloom and a few had double bloom except the red stemmed cultures. None of the triple bloomed cultures was free from white fly attack. Similarly the material on which only pupae could be noticed were all of single bloom type. This indicated that the pest did not prefer no bloom or single bloomed plants for prolonged shelter. The material screened need further investigations under pot trials with artificial release of white fly before reaching final conclusion for using material in breeding programme. However, only no bloom and a few cultures with single bloom could be used without hesitation. Majority of double bloomed and all triple bloomed types were susceptible to white fly, however, the degree of susceptibility varied considerably among these cultures.

The next group of cultures was "Less susceptible" (Table 14) on which the adults recorded varied from 0.19 to 5 per leaf per plant. This group included 56 different varieties/cultures.

The criterion used for categorising various germ plasm into different groups was as per the procedure laid out and approved by the XXXII Annual Kharif Oilseeds Workshop 1987. Some of the earlier workers have used the presence of adult numbers only to study susceptibility of castor to white flies. However, during present study it was observed that the cultures showing reduction in adults had high incidence of pupae. It is, therefore, necessary to group different cultures for their susceptibility based on incidence of adults as well as pupae. The pupal index among 56 varieties/cultivars (Table 12) varied from 0.11 to 2.06 per leaf. Considering the adult and pupal population
Table 13. Varieties/cultures completely free from white fly attack

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Variety/culture</th>
<th>Sr. No.</th>
<th>Variety/culture</th>
<th>Sr. No.</th>
<th>Variety/culture</th>
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<td>28.</td>
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<td>48.</td>
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<td>9.</td>
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<td>Muthner</td>
<td>51.</td>
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<td>32.</td>
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Table 14. Varieties/cultures less susceptible to white fly attack (0.01 to 5 adults/leaf)

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<td>4-36-16</td>
<td>22.</td>
<td>VH-70 1/3</td>
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<tr>
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<td>37502-2</td>
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<td>EC-97706</td>
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<td>VH-74 1/6</td>
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<td>VH-62.2/4</td>
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simultaneously for susceptibility towards white fly, out of 56 less susceptible cultures, 17 cultures could be traced out on the basis of adults and pupal population. After critical observations, the cultivars with more than 1.53 pupal index/leaf separated from the above "less susceptible group were 719-1, JI-62, VH-23-1-A, VH-51, JH-101, VH-68 1/5, VH-70 1/3, EC-103744, 142, SPS-50-2, SPS-16-8, SPS-45-2, 37502, 961, VH-61 2/4, TMV-5 and 14808. These cultures now should not be placed in "less susceptible" group. The varieties/cultures presented in Table 15 had white fly population ranging from 5.09 to 10 adults/leaf therefore, they were categorised into "moderately susceptible" cultures. However, in this category the pupal index varied from 0.92 to 2.31/leaf. In all 23 cultures had pupal index below 1.5/leaf. This indicated that, though, the plants had favoured the flies for shelter, egg laying or development of immature stages might have retarded due to various physiological and chemical factors of the plants. The material having below 1.5 pupal index were, SA-1, 4589-A, 80853, NPH-2, K-6, 14811, Baker-147, Dwarf mutant, SPS-27-4, VI-12, 37500, 833, SPS-65-9, 21844-B-1, 80852, VH-72 2/2, 144, 1069, 1092, 1141, 4409-A, 4414-2 and 14815-5-2.

Susceptible cultures were screened out following the adults ranging from 10.01 to 15 per leaf. In that group as per Table 16, 30 cultivars were recognised where only 3 viz., HC-3, 4708 and RC-8 had 1.22, 1.00 and 1.06 pupal index per leaf, respectively while the rest were with 1.59 and above, the highest being 2.56 pupal index/leaf.

The plants having more than 15 adults per leaf were considered as "highly susceptible" and in this category 70 cultures were grouped (Table 17). The pupal index varied from 1.19 to 3.37, where, only six cultures viz., JM-3, E-13-31, 14811-13, HC-8, VH-28-1 and SPS-62-10 had 1.46 or lower pupal index/leaf. This indicated that, though the plants had attracted large
Table 15. Varieties/cultures, moderately susceptible to white fly attack (5.01 to 10 adults/leaf)

<table>
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<th>Sr. No.</th>
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<th>Variety/culture</th>
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<td>5. T-3</td>
<td>30. Dwarf mutant</td>
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<td>6. K-6</td>
<td>31. IC-25353 small</td>
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<td>7. 14811</td>
<td>32. VH-64</td>
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Table 16. Varieties/cultures susceptible to white fly attack (10.01 to 15 adults/leaf)

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</tbody>
</table>
number of adults, the development of immature stages was hampered on account of various plant factors. Looking to the adult and pupal population among these cultures, 11 were the most susceptible which included 4948-3, 39963, VI-15-2, EC-97709-G, JMD, SPS-54-2, HC-2, JH-109, JGY, 21859 and 39-54-A-1, lines, out of which II-C-2, JGY, 39-54-A-1, 21859, SPS-54-2 and JH-109 having 50.67 and 3.81, 45.84 and 2.67, 22.79 and 3.01, 42.67 and 2.67, 20.34 and 3.01 and 18.58 and 3.37 adults and pupal index per leaf, respectively. These could be used satisfactorily in future for white fly screening programme as checks being the most susceptible cultures.

David and Radha (1964) while investigating on seasonal occurrence, varietal incidence, natural enemies and control of *T. ricini* observed that the varieties having double or triple bloom were more susceptible to the attack by this insect than the varieties having single bloom, whereas, no bloom varieties were highly resistant. While screening ten types of castor to the infestation of *T. rara* it was seen that no bloom green stemmed type and single bloom rose stemmed types were free from attack, whereas, rose stemmed types with double and triple bloom and single bloom green stemmed type were susceptible to the attack of the pest (David and Radha, 1973). In general they observed that the total free amino acid contents in resistant types was found to be lower than that of susceptible types. They further stated that among the essential amino acids, it appeared that threonine might have a greater role in preference of castor varieties by white fly.

The present finding was in agreement with the above workers, where, double and triple bloom cultures were susceptible to *T. ricini* in which some of the triple bloomed cultures remained highly susceptible. However, it differed in the case where even some of the single bloomed green stemmed and double bloomed mahogany stemmed types were completely free from white fly attack. This need further confirmation.
Table 17. Varieties/cultures highly susceptible to white fly attack (More than 15 adults/leaf.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Variety/culture</th>
<th>Sr. No.</th>
<th>Variety/culture</th>
<th>Sr. No.</th>
<th>Variety/culture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>JM-3</td>
<td>26.</td>
<td>SPS-62-8</td>
<td>51.</td>
<td>VH-69 2/2</td>
</tr>
<tr>
<td>2.</td>
<td>JM-6</td>
<td>27.</td>
<td>SPS-77-9</td>
<td>52.</td>
<td>VH-48-2</td>
</tr>
<tr>
<td>3.</td>
<td>1-32</td>
<td>28.</td>
<td>SPS-12-5</td>
<td>53.</td>
<td>HC-2</td>
</tr>
<tr>
<td>4.</td>
<td>E-13-31</td>
<td>29.</td>
<td>SPS-31-2</td>
<td>54.</td>
<td>1205</td>
</tr>
<tr>
<td>5.</td>
<td>TMV-2</td>
<td>30.</td>
<td>SPS-43-9</td>
<td>55.</td>
<td>JH-22</td>
</tr>
<tr>
<td>6.</td>
<td>L-6-7</td>
<td>31.</td>
<td>955</td>
<td>56.</td>
<td>Ji-1</td>
</tr>
<tr>
<td>7.</td>
<td>L-54-4</td>
<td>32.</td>
<td>SPS-38-3</td>
<td>57.</td>
<td>SPS-57-7</td>
</tr>
<tr>
<td>8.</td>
<td>4947-3</td>
<td>33.</td>
<td>SPS-55-4</td>
<td>58.</td>
<td>SPS-59-10</td>
</tr>
<tr>
<td>9.</td>
<td>4948-3</td>
<td>34.</td>
<td>SPS-55-1-D</td>
<td>59.</td>
<td>SKI-3</td>
</tr>
<tr>
<td>10.</td>
<td>14811-13</td>
<td>35.</td>
<td>SPS-54-2</td>
<td>60.</td>
<td>VH-70 1/2</td>
</tr>
<tr>
<td>11.</td>
<td>39963</td>
<td>36.</td>
<td>SPS-42-9</td>
<td>61.</td>
<td>VH-72 1/2</td>
</tr>
<tr>
<td>12.</td>
<td>Local</td>
<td>37.</td>
<td>SPS-38-8</td>
<td>62.</td>
<td>VH-72 2/5</td>
</tr>
<tr>
<td>14.</td>
<td>VI-15-2</td>
<td>39.</td>
<td>OTC-30-9</td>
<td>64.</td>
<td>JGY</td>
</tr>
<tr>
<td>15.</td>
<td>VH-36-1</td>
<td>40.</td>
<td>OTC-30-7</td>
<td>65.</td>
<td>RC-830</td>
</tr>
<tr>
<td>16.</td>
<td>VH-54 2/2 B G</td>
<td>41.</td>
<td>OTC-30-19</td>
<td>66.</td>
<td>JCH-2</td>
</tr>
<tr>
<td>17.</td>
<td>37503-1</td>
<td>42.</td>
<td>OTC-28-1</td>
<td>67.</td>
<td>SHB-18</td>
</tr>
<tr>
<td>18.</td>
<td>VH-70 2/3 D</td>
<td>43.</td>
<td>Ji-69</td>
<td>68.</td>
<td>1179-2</td>
</tr>
<tr>
<td>19.</td>
<td>VH-73 2/2</td>
<td>44.</td>
<td>HC-8</td>
<td>69.</td>
<td>21859</td>
</tr>
<tr>
<td>20.</td>
<td>VH-75-2/8 B</td>
<td>45.</td>
<td>VH-28-1</td>
<td>70.</td>
<td>39-54-A-1</td>
</tr>
<tr>
<td>21.</td>
<td>EC-97709-G</td>
<td>46.</td>
<td>S2-48-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22.</td>
<td>RUS-4</td>
<td>47.</td>
<td>VI-18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.</td>
<td>JMD</td>
<td>48.</td>
<td>2-73-11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24.</td>
<td>Short mutant</td>
<td>49.</td>
<td>SPS-62-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>CH-1</td>
<td>50.</td>
<td>SPS-74-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.1.6. Control measures:

To evaluate effective and economic control measures against *T. ricini* two experiments, one with conventional insecticides along with fenvalerate and the other with synthetic pyrethroids vs monocrotophos were conducted at Castor Research Station and College Agronomy Farm, Gujarat Agricultural University, Sardarkrushinagar, during 1987 and 1988.

4.1.6.1. Efficacy of conventional insecticides along with fenvalerate against *T. ricini*:

Six conventional insecticides viz., monocrotophos 0.04%, methyl-o-demeton 0.025%, methyl parathion 0.05%, dimethoate 0.03%, ethion 0.05% and thiometon 0.025% were evaluated along with fenvalerate 0.01% and control (water spray) against various stages of *T. ricini*. The pooled data obtained for 24 hrs, 1 week and 2 week are presented in Tables 18, 19 and 20 and discussed hereafter.

4.1.6.1.1. Nymphs:

Looking to the pooled results (Table 18) of nymphs of castor white fly before first spraying, the population was uniformly distributed over the experimental area. The effect of insecticides remained non-significant at 24 hrs after first spraying. At 1 week after spraying monocrotophos 0.04% was the most effective where, only 0.09 nymphs/sq.cm area were observed. The next in order of effectiveness was dimethoate 0.03% followed by methyl-o-demeton 0.025% which were at par with monocrotophos 0.04%. Fenvalerate 0.01% recorded maximum nymphal population (10.12 nymphs/sq.cm) and proved as the least effective and was at par with ethion 0.05% and control. The pooled results at 2 weeks remained non-significant.

All the treatments remained significantly superior to control at all the time intervals after second spraying. At 24 hrs and 1 week after spraying,
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatments</th>
<th>Initial observation</th>
<th>First spraying</th>
<th>Second spraying</th>
<th>Third spraying</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>24 hrs. 1 week 2 week</td>
<td>No. of nymphs/cm² of leaf</td>
<td>No. of nymphs/cm² of leaf</td>
<td>No. of nymphs/cm² of leaf</td>
</tr>
<tr>
<td>1.</td>
<td>Monocrotophos</td>
<td>4.050*</td>
<td>(15.90)**</td>
<td>0.04%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.059 (8.86)</td>
<td>0.771 (0.09)</td>
<td>1.145 (0.81)</td>
<td>0.723 (0.02)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.145</td>
<td>(0.81)</td>
<td>(0.02)</td>
<td>(0.00)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.04%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Methyl-o-demeton</td>
<td>4.086</td>
<td>(16.20)**</td>
<td>0.025%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.428 (11.25)</td>
<td>1.832 (2.86)</td>
<td>1.915 (3.17)</td>
<td>1.450 (1.60)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.915</td>
<td>(3.17)</td>
<td>(1.60)</td>
<td>(0.65)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.025%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Methyl parathion</td>
<td>4.219</td>
<td>(17.30)**</td>
<td>0.05%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.408 (11.11)</td>
<td>2.168 (4.19)</td>
<td>2.178 (4.24)</td>
<td>1.794 (2.72)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.178</td>
<td>(4.24)</td>
<td>(2.72)</td>
<td>(1.50)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Dimethoate</td>
<td>4.077</td>
<td>(16.12)**</td>
<td>0.03%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.063 (8.88)</td>
<td>0.858 (0.236)</td>
<td>1.987 (3.45)</td>
<td>0.738 (0.04)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.987</td>
<td>(3.45)</td>
<td>(0.04)</td>
<td>(0.00)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.03%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Ethion</td>
<td>4.018</td>
<td>(15.64)**</td>
<td>0.05%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.589 (12.36)</td>
<td>3.030 (6.88)</td>
<td>3.240 (10.00)</td>
<td>2.823 (7.47)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.240</td>
<td>(10.00)</td>
<td>(7.47)</td>
<td>(5.64)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Thiometon</td>
<td>3.963</td>
<td>(15.21)**</td>
<td>0.025%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.397 (11.04)</td>
<td>2.727 (6.94)</td>
<td>3.046 (8.78)</td>
<td>2.569 (6.10)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.046</td>
<td>(8.78)</td>
<td>(6.10)</td>
<td>(2.99)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.025%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Fenvalerate</td>
<td>4.076</td>
<td>(16.11)**</td>
<td>0.01%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.512 (11.83)</td>
<td>3.259 (10.12)</td>
<td>3.480 (11.61)</td>
<td>3.127 (9.28)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.259</td>
<td>(10.12)</td>
<td>(9.28)</td>
<td>(7.86)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.01%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Control</td>
<td>4.020</td>
<td>(15.66)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.006 (15.55)</td>
<td>4.044 (15.85)</td>
<td>4.146 (16.69)</td>
<td>4.202 (17.16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.146</td>
<td>(16.69)</td>
<td>(17.16)</td>
<td>(16.69)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.202</td>
<td>(17.16)</td>
<td>(16.69)</td>
<td>(17.73)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.302</td>
<td>(18.02)</td>
<td>(18.69)</td>
<td>(19.29)</td>
</tr>
</tbody>
</table>

**SEm±**
- Year: 0.036
- Treatment: 0.114
- Year x treat: 0.102
- C.D. 5%
  - Treatment: NS
  - Year x treat: NS

**C.V.%**
- 5.029

* √X + 0.5 transformed values.
** Retransformed values.
although monocrotophos 0.04% had the least nymphal population (0.02 and 0.00 respectively) it was at par with dimethoate 0.03% and remained significantly superior to the rest of the insecticides. The toxicity of remaining insecticides was in the order methyl-o-demeton 0.025%> methyl parathion 0.05% > thiometon 0.025% > ethion 0.05% > fenvalerate 0.01% where, all of them remained significantly superior to one another. The same trend remained equally true at 2 weeks after spraying.

After 3rd application, all the insecticides at 24 hrs, 1 week and 2 weeks remained significantly superior to control. The results of 24 hrs after spraying indicated that monocrotophos 0.04% proved very effective in reducing the nymphal population where, only 0.18 nymphs/sq.cm of leaf were found, while fenvalerate 0.01% showed 7.46 nymphs/sq.cm and remained as the least effective treatment. In effectiveness dimethoate 0.03% was as good as monocrotophos 0.04% which was followed by methyl-o-demeton 0.025% and methyl parathion 0.05%. Thiometon 0.025% exhibited moderate effect and was superior to ethion 0.05% and fenvalerate 0.01%. Dimethoate 0.03% at 1 week and 2 weeks after spraying had 0.02 and 0.21 nymphs/sq.cm of leaf, respectively and was statistically at par with monocrotophos 0.04%. There was no significant difference between methyl-o-demeton 0.025% and methyl parathion 0.05% and were significantly superior to thiometon 0.025%. It was followed by ethion 0.05% and fenvalerate 0.01% which differed significantly with each other. Fenvalerate 0.01% had 6.81 and 8.10 nymphs/sq.cm at 1 week and 2 weeks after spraying, respectively and found as less effective in controlling the nymphal population of white fly.

4.1.6.1.2. Pupae:

It is evident from the results presented in Table 19 that all the treatments remained non-significant after first spraying. It had proved that the insecticides failed to control pupae within 15 days of first spraying. After
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatments</th>
<th>Initial Observation</th>
<th>First spraying No. of pupae/leaf</th>
<th>Second spraying No. of pupae/leaf</th>
<th>Third spraying No. of pupae/leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 week 2 week</td>
<td>1 week 2 week</td>
<td>1 week 2 week</td>
</tr>
<tr>
<td>1.</td>
<td>Monocrotophos</td>
<td>7.056* (49.29)**</td>
<td>5.135 (25.89) 4.693 (21.52)</td>
<td>2.402 (5.27) 2.813 (7.41)</td>
<td>0.932 (0.37) 1.595 (2.04)</td>
</tr>
<tr>
<td></td>
<td>0.04%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Methyl-o-demeton</td>
<td>7.010 (48.64)**</td>
<td>5.841 (33.62) 5.160 (26.13)</td>
<td>4.203 (17.17) 3.871 (14.48)</td>
<td>2.780 (7.23) 2.828 (7.50)</td>
</tr>
<tr>
<td></td>
<td>0.025%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Methyl parathion</td>
<td>7.189 (51.18)**</td>
<td>5.649 (31.41) 5.363 (28.26)</td>
<td>4.036 (15.79) 5.191 (26.44)</td>
<td>3.091 (9.05) 3.318 (10.51)</td>
</tr>
<tr>
<td></td>
<td>0.05%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Dimethoate</td>
<td>7.066 (49.43)**</td>
<td>5.381 (28.46) 5.018 (24.68)</td>
<td>2.491 (5.71) 2.807 (7.38)</td>
<td>1.141 (0.80) 1.699 (2.39)</td>
</tr>
<tr>
<td></td>
<td>0.03%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Ethion</td>
<td>7.027 (48.88)**</td>
<td>6.578 (42.77) 5.989 (35.37)</td>
<td>4.975 (24.25) 4.780 (22.35)</td>
<td>3.870 (14.48) 3.976 (15.31)</td>
</tr>
<tr>
<td></td>
<td>0.05%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Thiometon</td>
<td>7.021 (48.79)**</td>
<td>5.994 (35.43) 5.418 (28.85)</td>
<td>4.374 (18.63) 4.717 (18.61)</td>
<td>3.439 (11.33) 3.479 (10.70)</td>
</tr>
<tr>
<td></td>
<td>0.025%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Fenvalerate</td>
<td>7.171 (50.92)**</td>
<td>5.879 (34.06) 5.781 (32.92)</td>
<td>4.643 (21.06) 4.772 (22.27)</td>
<td>3.759 (13.63) 3.839 (14.24)</td>
</tr>
<tr>
<td></td>
<td>0.01%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Control</td>
<td>6.727 (44.75)**</td>
<td>5.887 (34.16) 6.878 (46.81)</td>
<td>7.081 (49.64) 7.172 (50.94)</td>
<td>7.416 (54.50) 7.578 (56.93)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEm ±</td>
<td>Year</td>
<td>0.064 0.200 0.073</td>
<td>0.075 0.193 0.070 0.076</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment</td>
<td>0.130 0.383 0.394</td>
<td>0.443 0.410 0.394 0.447</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year x treat</td>
<td>0.182 0.566 0.208</td>
<td>0.213 0.545 0.199 0.215</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.D.5%</td>
<td>Treatment</td>
<td>NS NS NS</td>
<td>1.483 NS 1.317 1.494</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year x treat</td>
<td>NS NS NS</td>
<td>0.608 NS 0.569 0.614</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* √X + 0.5 transformed values.
** Retransformed values.
second spraying all the treatments remained significantly superior to control at 1 week. Among different insecticides monocrotophos 0.04% was effective and recorded only 5.21 pupae/leaf. There was no significant difference between monocrotophos 0.04% and dimethoate 0.03% and remained significantly superior to rest of the treatments. Ethion 0.05% remained as less effective treatment with 24.25 pupae/leaf.

All the insecticidal treatments exhibited significantly superior control at 1 week and 2 weeks after third spraying. Monocrotophos 0.04% and dimethoate 0.03% recorded 0.37 and 0.80 pupae/leaf, respectively, after 1 week of spraying and remained at par. The next best insecticides were methyl-o-demeton 0.025% and methyl parathion 0.05% which remained significantly superior to thiometon 0.025%, fenvalerate 0.01% and ethion 0.05%, respectively. Looking to the results of 2 weeks after spraying, monocrotophos 0.04% and dimethoate 0.03% being at par again showed their effectiveness and proved significantly superior to rest of the treatments. The order of toxicity against pupae for remaining insecticides was as follows, methyl-o-demeton 0.025% > methyl parathion 0.05% > thiometon 0.025% > fenvalerate 0.01% > ethion 0.05%, respectively.

4.1.6.1.3. Adults:

Looking to the pooled results (Table 20) of conventional insecticides along with fenvalerate against the adults of *T. ricini* before first spraying, the population was uniformly distributed over the experimental area. All insecticides remained significantly superior to control at 24 hrs, 1 week and 2 weeks after the first spraying.

At 24 hrs of spraying dimethoate 0.03% had the least adult population (1.88 per leaf), however, it was at par with monocrotophos 0.04%, methyl-o-demeton 0.025%, methyl parathion 0.05% and thiometon 0.025%. Pooled results of 1 week and 2 weeks after the first spraying indicated that monocrotophos 0.04% with 0.19 and 1.14 adults/leaf, respectively proved very effective.
in controlling adults. Ethion 0.05% having 3.08 and 4.87 adults/leaf proved less effective. According to the toxicity against adult white fly, the insecticides were in order as dimethoate 0.03% > monocrotophos 0.04% > methyl-o-demeton 0.025% > methyl parathion 0.05% > thiometon 0.025% > ethion 0.05% > fenvalerate 0.01%.

A close perusal of data presented in Table 20 revealed that all the insecticides registered significantly superior results in white fly control at 24 hrs, 1 week and 2 weeks after second spraying. Except at 1 week after spraying, treatment dimethoate 0.03% remained most effective in controlling adults having only 0.36 and 1.38 adults/leaf, respectively. However, it was at par with monocrotophos 0.04%, methyl-o-demeton 0.025% and methyl parathion 0.05% which in turn remained significantly superior to the next effective group of thiometon 0.025%, ethion 0.05% and fenvalerate 0.01%, respectively. Almost similar trend of insecticides in efficacy was observed at 1 and 2 weeks after spraying. Fenvalerate 0.01% when compared with conventional insecticides exhibited poor efficacy in controlling adults, where, maximum 4.19 and 5.68 adults/leaf were observed at one and two weeks after second spraying.

After third spraying all the insecticides at 24 hrs, 1 week and 2 weeks showed significantly superior results over control. Monocrotophos 0.04%, dimethoate 0.03%, methyl-o-demeton 0.025% and methyl parathion 0.05% were at par in their efficacy and remained significantly superior to thiometon 0.025%, ethion 0.05% and fenvalerate 0.01% which were equally effective in controlling adults at 24 hrs of spraying. At 1 week after third spraying dimethoate 0.03%, monocrotophos 0.04%, methyl-o-demeton 0.025% and methyl parathion 0.05% recorded significantly superior results as compared to thiometon 0.025% which in turn was superior to fenvalerate 0.01% and ethion 0.05%. Almost similar trend was also observed during 2 weeks after spraying. Dimethoate with 0.77
adults/leaf registered as the most effective, while ethion 0.05% with 5.45 adults/leaf proved less effective among conventional insecticides. Fenvalerate 0.01% when compared with organophosphorous insecticides, was found poor in controlling white fly adults.

4.1.6.2. Efficacy of synthetic pyrethroids along with monocrotophos against T. ricini:

With a view to know the effectiveness of various formulations of fenvalerate and other widely used synthetic pyrethroids, fenvalerate 0.01%, fenvalerate 2% LVC, fenvalerate 0.4% dust, decamethrin 0.0028%, cypermethrin 0.005% and fluvalinate 0.0075% were evaluated with standard treatment monocrotophos 0.04% and control for two years during 1987 and 1988 against various stages of T. ricini. The pooled results of two years are presented in Table 21, 22 and 23.

4.1.6.2.1. Nymphs:

Perusal of the results (Table 21) indicated that the population of nymphs was uniformly distributed over the experimental unit. All insecticidal treatments remained significantly superior to control at 24 hrs, 1 week and 2 weeks after first spraying. Monocrotophos 0.04% was the most effective treatment against nymphs and showed significantly superior results as compared to other insecticides tested. While comparing synthetic pyrethroids, cypermethrin 0.005%, decamethrin 0.0028% and fenvalerate 0.01% were equally effective at all the intervals after first spraying and remained significantly superior to fenvalerate LVC, fluvalinate 0.0075% and fenvalerate dust. However, fenvalerate dust proved poor in controlling nymphs as the treated plots had more nymphal population per leaf at all the time intervals.

Similarly after second spraying it was noticed that the order of effectiveness was mostly alike during both the years. Looking to the pooled results (Table 21) it is evident that all the treatments remained significantly superior
to control. Monocrotophos 0.04% showed most effective treatment and significantly superior to all synthetic pyrethroids at all the time intervals. At 24 hrs, 1 week and 2 weeks after second spraying fenvalerate 0.01%, cypermethrin 0.005%, decamethrin 0.0028% and fluvalinate 0.0075% were equal in toxicity and significantly superior to fenvalerate LVC as well as dust formulation. Again fenvalerate dust proved less toxic to nymphs as maximum population of nymphs was observed in this treatment.

4.1.6.2.2. Pupae:

The data presented in Table 22 indicated that conventional insecticide monocrotophos 0.04%, with minimum population registered as highly toxic to white fly pupae at 1 week and two weeks after both sprayings. Among synthetic pyrethroids, cypermethrin 0.005%, fenvalerate 0.01%, decamethrin 0.0028% and fluvalinate 0.0075% were more or less equal in toxicity, however, cypermethrin 0.005% proved next best to monocrotophos 0.04%. Fenvalerate dust and fluvalinate 0.0075% were at par in their effect in controlling white fly pupae.

4.1.6.2.3. Adults:

According to the pooled results of Table 23, the initial observation of adults before spraying was non-significant, indicating that the population of adult white fly was uniformly distributed in an experimental area. Monocrotophos 0.04% proved to be very effective in controlling adults and it had only 1.36 and 0.14 adults/leaf at 24 hrs and 1 week after first spraying. Next to monocrotophos 0.04% was cypermethrin 0.005% which had 2.92 and 2.18 adults/leaf at 24 hrs and 1 week after first application. Though it had minimum population among synthetic pyrethroids, it was at par with fenvalerate 0.01%, decamethrin 0.0028% and fluvalinate 0.0075%. Fenvalerate dust with maximum population (5.81 and 5.40 adults/leaf) registered as least effective treatment.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatments</th>
<th>Initial Observation</th>
<th>First spraying No. of Pupae/leaf after</th>
<th>Second spraying No. of pupae/leaf after</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fenvalerate 0.01%</td>
<td>7.321</td>
<td>(53.09) ** 6.065 (36.28)</td>
<td>4.693 (21.52) 5.011 (24.61)</td>
</tr>
<tr>
<td></td>
<td>Fenvalerate LVC</td>
<td>7.033</td>
<td>(48.35) 6.365</td>
<td>6.789 (44.51) 6.401 (44.20)</td>
</tr>
<tr>
<td>3.</td>
<td>Fenvalerate 0.4% dust</td>
<td>7.482</td>
<td>(55.48) 7.033</td>
<td>7.278 (52.47) 6.912 (52.72)</td>
</tr>
<tr>
<td></td>
<td>Cypermethrin 0.005%</td>
<td>6.989</td>
<td>(48.96) 5.585</td>
<td>5.826 (33.44) 4.341 (18.34)</td>
</tr>
<tr>
<td>4.</td>
<td>Decamethrin 0.0028%</td>
<td>7.328</td>
<td>(53.20) 6.210</td>
<td>6.513 (41.92) 5.252 (27.08)</td>
</tr>
<tr>
<td>5.</td>
<td>Fluvalinate 0.0075%</td>
<td>7.509</td>
<td>(55.89) 6.408</td>
<td>6.596 (43.04) 5.422 (28.90)</td>
</tr>
<tr>
<td>6.</td>
<td>Monocrotrophos 0.04%</td>
<td>7.269</td>
<td>(52.34) 4.724</td>
<td>4.832 (22.85) 2.227 (4.46)</td>
</tr>
<tr>
<td>7.</td>
<td>Control</td>
<td>7.365</td>
<td>(53.74) 7.528</td>
<td>7.938 (62.51) 8.086 (64.88)</td>
</tr>
<tr>
<td>SEM</td>
<td>Year</td>
<td>0.065</td>
<td>0.046</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>Treatment</td>
<td>0.208</td>
<td>0.221</td>
<td>0.265</td>
</tr>
<tr>
<td></td>
<td>Year x treat</td>
<td>0.185</td>
<td>0.129</td>
<td>0.112</td>
</tr>
<tr>
<td></td>
<td>C.D.5%</td>
<td>Treatment</td>
<td>NS</td>
<td>0.740</td>
</tr>
<tr>
<td></td>
<td>Year</td>
<td>0.527</td>
<td>0.369</td>
<td>0.887</td>
</tr>
</tbody>
</table>
|         | C.V.%               | 5.065               | 4.138                                 | 3.456                                 | 4.402 | 4.609

* √(X + 0.5) transformed values.
** Retransformed values.
The results of 2 weeks after 1st spraying were non-significant indicating no difference among various treatments as far as the efficacy was concerned.

Looking to the results of 24 hrs after second spraying it was clear that monocrotophos 0.04% with 0.06 adults/leaf showed significantly superior results as compared to other treatments. Among synthetic pyrethroids, though cypermethrin 0.005% had the lowest white fly population (2.5 adults/leaf), remained at par with decamethrin 0.0028%, fenvalerate 0.01% and fluvalinate 0.0075%. Fenvalerate LVC and its dust formulation observed to be less effective treatments and were at par with fluvalinate 0.0075%.

Perusal of the data of 1 week and 2 weeks after second spraying indicated that the order of effectiveness of different treatments remained almost same, where, monocrotophos 0.04% was significantly superior to all the treatments. It had 0.08 and 0.68 adults/leaf after 1 week and 2 weeks of spraying, respectively. In case of synthetic pyrethroids, cypermethrin 0.005% proved as the best treatment showing minimum population i.e. 1.70 and 2.91 adults/leaf at 1 week and 2 weeks after spraying respectively. But there was no significant difference among cypermethrin 0.005%, fenvalerate 0.01%, decamethrin 0.0028% and fluvalinate 0.0075%. The LVC and dust formulations remained significantly superior to control and at par with fluvalinate 0.0075%. The dust formulation of fenvalerate had 6.05 and 7.53 adults/leaf at 1 week and 2 weeks after spraying.

Present findings of two years revealed that among conventional insecticides dimethoate 0.03% and monocrotophos 0.04% proved highly effective in reducing the pest population of *T. ricini* on castor hybrid variety GAUCH-1. Both of them were equally effective in controlling nymphs, pupae and adults of white fly. Other conventional insecticides except ethion 0.05% had intermediate effect on various stages of *T. ricini*. Ethion 0.05% proved less effective for
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatments</th>
<th>Initial observation</th>
<th>First spraying</th>
<th>No. of adults/leaf after 24 hrs.</th>
<th>No. of adults/leaf after 1 week</th>
<th>No. of adults/leaf after 2 weeks</th>
<th>Second spraying</th>
<th>No. of adults/leaf after 24 hrs.</th>
<th>No. of adults/leaf after 1 week</th>
<th>No. of adults/leaf after 2 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fenvalerate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.01%</td>
<td>2.560*</td>
<td>1.918</td>
<td>1.806</td>
<td>2.258</td>
<td>1.862</td>
<td>1.496</td>
<td>1.935</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(6.05)**</td>
<td>(3.18)</td>
<td>(2.76)</td>
<td>(4.60)</td>
<td>(2.97)</td>
<td>(1.74)</td>
<td>(3.24)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Fenvalerate</td>
<td>2.658</td>
<td>2.399</td>
<td>2.352</td>
<td>2.775</td>
<td>2.503</td>
<td>2.389</td>
<td>2.754</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LVC</td>
<td>(6.56)</td>
<td>(5.26)</td>
<td>(5.03)</td>
<td>(7.20)</td>
<td>(5.77)</td>
<td>(5.21)</td>
<td>(7.08)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Fenvalerate</td>
<td>2.685</td>
<td>2.511</td>
<td>2.430</td>
<td>2.819</td>
<td>2.648</td>
<td>2.559</td>
<td>2.833</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.4% Dust</td>
<td>(6.71)</td>
<td>(5.81)</td>
<td>(5.40)</td>
<td>(7.45)</td>
<td>(6.51)</td>
<td>(6.05)</td>
<td>(7.53)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Cypermethrin</td>
<td>2.519</td>
<td>1.849</td>
<td>1.638</td>
<td>2.179</td>
<td>1.731</td>
<td>1.482</td>
<td>1.847</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.005%</td>
<td>(5.85)</td>
<td>(2.92)</td>
<td>(2.18)</td>
<td>(4.25)</td>
<td>(2.50)</td>
<td>(1.70)</td>
<td>(2.91)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Decamethrin</td>
<td>2.506</td>
<td>2.064</td>
<td>1.853</td>
<td>2.191</td>
<td>1.845</td>
<td>1.599</td>
<td>2.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0028%</td>
<td>(5.78)</td>
<td>(3.76)</td>
<td>(2.93)</td>
<td>(4.30)</td>
<td>(2.90)</td>
<td>(2.06)</td>
<td>(3.51)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Fluvinate</td>
<td>2.810</td>
<td>2.377</td>
<td>2.213</td>
<td>2.645</td>
<td>2.260</td>
<td>2.034</td>
<td>2.331</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.0075%</td>
<td>(7.40)</td>
<td>(5.15)</td>
<td>(4.40)</td>
<td>(6.50)</td>
<td>(4.61)</td>
<td>(3.64)</td>
<td>(4.93)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Monocrotophos</td>
<td>2.739</td>
<td>1.363</td>
<td>0.800</td>
<td>1.500</td>
<td>0.747</td>
<td>0.760</td>
<td>1.086</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.04%</td>
<td>(7.00)</td>
<td>(1.36)</td>
<td>(0.14)</td>
<td>(1.75)</td>
<td>(0.06)</td>
<td>(0.08)</td>
<td>(0.68)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7.01)</td>
<td>(6.78)</td>
<td>(7.57)</td>
<td>(9.60)</td>
<td>(9.30)</td>
<td>(9.91)</td>
<td>(11.26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEM ±</td>
<td>Year</td>
<td>0.037</td>
<td>0.035</td>
<td>0.031</td>
<td>0.055</td>
<td>0.027</td>
<td>0.028</td>
<td>0.032</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment</td>
<td>0.071</td>
<td>0.141</td>
<td>0.188</td>
<td>0.113</td>
<td>0.197</td>
<td>0.174</td>
<td>0.175</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year x treat</td>
<td>0.104</td>
<td>0.098</td>
<td>0.088</td>
<td>0.156</td>
<td>0.076</td>
<td>0.080</td>
<td>0.090</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C.D. 5%</td>
<td>Treatment</td>
<td>NS</td>
<td>0.471</td>
<td>0.629</td>
<td>NS</td>
<td>0.659</td>
<td>0.581</td>
<td>0.587</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Year x treat</td>
<td>NS</td>
<td>0.280</td>
<td>0.252</td>
<td>NS</td>
<td>0.216</td>
<td>0.229</td>
<td>0.257</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* √X ± 0.5 transformed values.
** Retransformed values.
controlling the pest. Among synthetic pyrethroids cypermethrin 0.005% proved to be the most effective giving satisfactory control of *T. ricini*. It was followed by fenvalerate 0.01% and decamethrin 0.0028%, while fluvalinate 0.0075% had a little effect on *T. ricini*. The LVC formulation of fenvalerate had given a negligible control, while the dust formulation failed to control aleyrodid.

Several workers have evaluated different insecticides against *T. ricini* and came out with recommendations. *T. ricini* on castor could easily be controlled with 0.025% parathion (David and Radha, 1964) and parathion 0.03% (Chauhan, 1974). Patel et al. (1973) recommended dimethoate 0.03% for the control of white fly on castor hybrid-3, while Vevai (1973) advocated 300-500 ml of dimethoate 30%, 300 ml methyl demeton 25% and 500 ml thiometon 25% in 400 l of water for its good control, whereas methyl parathion dimethoate and quinalphos each at 0.05% were also found to be effective against castor white fly (Patel et al., 1986; Anonymous, 1988).

The present findings on conventional insecticides indicated that monocrotophos 0.04% and dimethoate 0.03% proved as excellent treatment for the control of *T. ricini*, whereas methyl parathion 0.05% and methyl-o-demeton 0.025% were intermediate in their effectiveness. These results are almost in confirmation with the results reported by earlier workers.

Synthetic pyrethroids had been widely evaluated by various workers on *Trialeurodes* sp. on different crops. Fenvalerate, permethrin, cypermethrin, fenpropathrin, biorismethrin, decamethrin and fluvalinate had been recommended for the control of *Trialeurodes* on various food crops and ornamental plants (Veire, et al., 1974; Mboob, 1975; Stenmark, 1976; Giustina, Dayton, 1978; and Oetting, Mohiuddin, 1980; Mother, Naser, 1980; Brun, 1981 and Tkachuk, 1986).

The present findings on synthetic pyrethroids particularly for cypermethrin, fenvalerate and decamethrin are in close agreement with the results reported by earlier workers.
As there was no literature available on evaluation of dust and LVC formulations of fenvalerate for the control of *T. ricini* the present findings could not be compared. The findings regarding evaluation of different insecticides against castor white fly revealed that monocrotophos 0.04% and dimethoate 0.03% proved to be superior treatments, whereas, in case of synthetic pyrethroids cypermethrin 0.005% followed by fenvalerate 0.01% and decamethrin 0.0028% exhibited effective control.

4.1.7. Phytotoxicity:

While evaluating the efficacy of different insecticides against *T. ricini* on castor variety GAUCH-1 it was observed that the LVC formulation of fenvalerate exhibited Phytotoxicity to castor plants. A day after spraying, the leaves developed chlorotic whitish patches along with the midrib and branched veins. Later on the patches increased and turned brown in colour along with the main veins and midrib. The leaves turned upward, formed cup shape and finally dried and dropped down from the plants. The toxicity was also observed on capsules in a spike. The spines looked as if burnt and the capsules turned black. Very small capsules dried, however, in developed capsules the seeds remained undamaged. The toxicity was severe in small plants causing occasionally drying of plants. Oettinger and Konishi (1980) had reported minor phytotoxicity of fenvalerate, permethrin and oxanyl on some varieties of poinsettia when repeated applications were made to control *T. vaporariorum*. The present finding confirms his observations on phytotoxicity of fenvalerate. The dust and EC formulations of fenvalerate observed to be non-toxic to plants.

4.1.8. Yield and economics:

4.1.8.1. Yield:

The seed yield obtained for various insecticidal treatments were summarised separately yearwise and pooled which are presented in Tables 24 and 25.
Table 24. Effect of conventional insecticides along with fenvalerate on the yield of castor hybrid variety GAUCH-1

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatments</th>
<th>1987 Yield Kg/plot</th>
<th>1988 Yield Kg/plot</th>
<th>Pooled Yield Kg/plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Monocrotophos 0.04%</td>
<td>2.090</td>
<td>2.505</td>
<td>2.297</td>
</tr>
<tr>
<td>2.</td>
<td>Methyl-o-demeton 0.025%</td>
<td>1.649</td>
<td>2.049</td>
<td>1.849</td>
</tr>
<tr>
<td>3.</td>
<td>Methyl parathion 0.05%</td>
<td>1.355</td>
<td>1.778</td>
<td>1.567</td>
</tr>
<tr>
<td>4.</td>
<td>Dimethoate 0.03%</td>
<td>1.991</td>
<td>2.189</td>
<td>2.090</td>
</tr>
<tr>
<td>5.</td>
<td>Ethion 0.05%</td>
<td>1.021</td>
<td>1.600</td>
<td>1.311</td>
</tr>
<tr>
<td>6.</td>
<td>Thiometon 0.025%</td>
<td>1.206</td>
<td>1.770</td>
<td>1.488</td>
</tr>
<tr>
<td>7.</td>
<td>Fenvalerate 0.01%</td>
<td>1.442</td>
<td>1.888</td>
<td>1.665</td>
</tr>
<tr>
<td>8.</td>
<td>Control</td>
<td>0.933</td>
<td>1.422</td>
<td>1.177</td>
</tr>
</tbody>
</table>

SEm±
C.D.5%
C.V.%

Year
Treatment
Year x treat
C.D.5%
Treatment
Year x treat
C.V.%
4.1.8.1.1. Effect of conventional insecticides along with fenvalerate on the yield:

From the results presented in Table 24, it can be seen that the plots treated with monocrotophos 0.04% registered the highest seed yield during both the years, and at par with dimethoate 0.03% during 1987, whereas, it remained significantly superior to dimethoate 0.03% in 1988 and in pooled analysis. The yield realised in monocrotophos 0.04% was 2.505 kg/plot followed by 2.189 and 2.049 kg in dimethoate 0.03% and methyl-o-demeton 0.025% treated plots, respectively. The results of these insecticides remained superior to fenvalerate 0.01%, which was intermediate in the yield. Ethion 0.05% recorded the lowest yield (1.6 kg/plot).

4.1.8.1.2. Effect of synthetic pyrethroids along with monocrotophos on the yield:

The yield results of the experiment with synthetic pyrethroids (Table 25) indicated that the organophosphorous compound monocrotophos 0.04% remained highly effective in yielding maximum castor seed yield/plot during both the years. With 2.255 kg/plot (pooled) yield, monocrotophos 0.04% remained significantly superior to all the synthetic pyrethroids. Among synthetic pyrethroids the maximum yield per plot was realised in the treatment cypermethrin 0.005% (1.804 kg/plot), however, it did not differ with fenvalerate 0.01% and decamethrin 0.0028%. The treatments fenvalerate dust and fenvalerate LVC with low yield 0.990 and 0.942 kg/plot, respectively remained at par with control which expressed no significant effect in increasing the yield. Fluvalinate 0.0075% with 1.274 kg/plot yield remained moderately effective in increasing the yield.

Present findings of two years for conventional insecticides proved that the yield of castor seed could be increased significantly by protecting the plots with monocrotophos 0.04% followed by dimethoate 0.03% and methyl-o-demeton 0.025%.
Table 25. Effect of synthetic pyrethroids along with monocrotophos on the yield of castor hybrid variety GAUCH-1

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Treatment</th>
<th>1987 Yield kg/plot</th>
<th>1988 Yield kg/plot</th>
<th>Pooled Yield kg/plot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fenvalerate 0.01%</td>
<td>1.526</td>
<td>1.949</td>
<td>1.737</td>
</tr>
<tr>
<td>2.</td>
<td>Fenvalerate LVC</td>
<td>0.834</td>
<td>1.051</td>
<td>0.942</td>
</tr>
<tr>
<td>3.</td>
<td>Fenvalerate 0.4% dust</td>
<td>0.961</td>
<td>1.019</td>
<td>0.990</td>
</tr>
<tr>
<td>4.</td>
<td>Cypermethrin 0.005%</td>
<td>1.580</td>
<td>2.028</td>
<td>1.804</td>
</tr>
<tr>
<td>5.</td>
<td>Decamethrin 0.0028%</td>
<td>1.201</td>
<td>1.832</td>
<td>1.517</td>
</tr>
<tr>
<td>6.</td>
<td>Fluvalinate 0.0075%</td>
<td>1.151</td>
<td>1.397</td>
<td>1.274</td>
</tr>
<tr>
<td>7.</td>
<td>Monocrotophos 0.04%</td>
<td>2.088</td>
<td>2.422</td>
<td>2.255</td>
</tr>
<tr>
<td>8.</td>
<td>Control</td>
<td>0.827</td>
<td>0.981</td>
<td>0.904</td>
</tr>
</tbody>
</table>

$SEm +
C.D.5% 
C.V.% 

Year $SEm +
Treatment $0.016
Year x treat $0.092
C.D.5% Treatment $0.307
Year x treat $0.133
C.V.% $6.518
While comparing the recently nowadays used synthetic pyrethroids against monocrotophos the results revealed that maximum yield was obtained, if castor plants were protected with cypermethrin 0.005%. However, the yield when compared with organophosphorous compounds, was even less than dimethoate and methyl-o-demeton. There was no significant difference among cypermethrin 0.005% fenvalerate 0.01% and decamethrin 0.0028%. Among different formulations of fenvalerate, LVC and dust recorded very low yields. It was remarkable to note in the present findings that among all the treatments including synthetic pyrethroids, monocrotophos 0.04% remained the most versatile treatment giving the best protection to the crop and ultimately registered maximum yield.

4.1.8.2. Economics:

Economics of applications of various insecticides was worked out along with the Incremental Cost Benefit Ratio (ICBR) as it is an important criterion for recommending any pesticide for wide scale adoption by farming community. The results would help extension worker or farmer to select the most appropriate chemical after considering gross income, net income over control and additional gain realised per every rupee spent. The ICBR was worked out on the basis of pooled seed yield of 1987 and 1988 for both experiments. The results obtained are presented in Tables 26 and 27.

The economics worked out for conventional insecticides (Table 26) showed that, though monocrotophos 0.04% had maximum yield, remained next to dimethoate 0.03% in respect of Economics. According to ICBR the chronological order followed by insecticides was dimethoate 0.03% (1:13.32), monocrotophos 0.04% (1:8.88), methyl-o-demeton 0.025% (1:7.76), fenvalerate 0.01% (1:5.46), methyl parathion 0.05% (1:3.81), thiometon 0.025% (1:2.86) and ethion 0.05% (1:0.75).
Table 26. Economics of various conventional insecticides along with fenvalerate against *Trialeurodes ricini* Misra attacking castor GAUCH-1

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Insecticide reqd. for 1 spray l/ha</th>
<th>Total Qnt. reqd. for 3 sprays l/ha</th>
<th>Cost of insecticide Rs/l</th>
<th>Total Cost of insecticide for 3 sprays Rs.</th>
<th>Labour charges for 3 sprays Rs.</th>
<th>Total cost of pl.prot. Rs.</th>
<th>Ave. yield of castor seed kg/ha</th>
<th>Gross income Rs/ha*</th>
<th>Gain over Control Rs/ha</th>
<th>Net income Rs/ha</th>
<th>ICBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monocrotofos 0.04%</td>
<td>0.8</td>
<td>2.4</td>
<td>230</td>
<td>552</td>
<td>78</td>
<td>630</td>
<td></td>
<td>2127</td>
<td>12762</td>
<td>6222</td>
<td>5592</td>
</tr>
<tr>
<td>Methyl-o-demeton 0.025%</td>
<td>0.8</td>
<td>2.4</td>
<td>145</td>
<td>348</td>
<td>78</td>
<td>426</td>
<td></td>
<td>1712</td>
<td>10272</td>
<td>3732</td>
<td>3306</td>
</tr>
<tr>
<td>Methyl parathion 0.05%</td>
<td>0.8</td>
<td>2.4</td>
<td>155</td>
<td>372</td>
<td>78</td>
<td>450</td>
<td></td>
<td>1451</td>
<td>8706</td>
<td>2166</td>
<td>1716</td>
</tr>
<tr>
<td>Dimethoate 0.03%</td>
<td>0.8</td>
<td>2.4</td>
<td>115</td>
<td>276</td>
<td>78</td>
<td>354</td>
<td></td>
<td>1935</td>
<td>11610</td>
<td>5070</td>
<td>4716</td>
</tr>
<tr>
<td>Ethon 0.05%</td>
<td>0.8</td>
<td>2.4</td>
<td>145</td>
<td>348</td>
<td>78</td>
<td>426</td>
<td></td>
<td>1214</td>
<td>7284</td>
<td>744</td>
<td>318</td>
</tr>
<tr>
<td>Thionetron 0.025%</td>
<td>0.8</td>
<td>2.4</td>
<td>154</td>
<td>370</td>
<td>78</td>
<td>448</td>
<td></td>
<td>1378</td>
<td>8268</td>
<td>1728</td>
<td>1280</td>
</tr>
<tr>
<td>Fenvalerate 0.01%</td>
<td>0.4</td>
<td>1.2</td>
<td>285</td>
<td>342</td>
<td>78</td>
<td>420</td>
<td></td>
<td>1542</td>
<td>9252</td>
<td>2712</td>
<td>2292</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>1090</td>
<td>6540</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* The cost of castor seed was Rs. 6/kg.
Looking to the results of second experiment (Table 27), among synthetic pyrethoids maximum ICR was obtained with fenvalerate 0.01% (1:15.52) followed by cypermethrin 0.005% (1:15.02), fluvalinate 0.0075% (1:6.62) and decamethrin 0.0028% (1:3.81).

Present findings proved that most of the insecticides gave higher return when sprayed against T. ricini on castor GAUCH-1. Among them dimethoate 0.03% and monocrotophos 0.04% remained the most effective and economic treatments.

In synthetic pyrethoids, fenvalerate 0.01% was found to be most economic followed by cypermethrin 0.005% and fluvalinate 0.0075%. LVC and dust formulations of fenvalerate were proved to be uneconomical. Two sprayings with monocrotophos 0.04% gave the highest (1:16.87) net return.

According to the yield and economic return, two sprayings of methyl parathion 0.05% (NICBR 1:8.16) followed by ethion 0.05% (NICBR 1:5.47) at 15 days' interval were recommended for the control of T. ricini on castor (Anonymous, 1988). The present findings completely differ from the above recommendations, where, methyl parathion 0.05% being poor earner and ethion 0.05% performed negatively.

Looking to the results and net return dimethoate 0.03% and monocrotophos 0.04% @ 800 l/ha could be recommended for control of T. ricini on castor in North Gujarat. Although some of the synthetic pyrethroids were effective and economical their use should be avoided for the control of T. ricini in the present situation so as to minimise population flareup in near future.
Table 27. Economics of various synthetic pyrethroids along with monocrotophos against *Trialeurodes ricini* Misra attacking castor GAUCH-1.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Insecticide reqd. for 1 spray l or kg/ha</th>
<th>Total Qnt. reqd. for 2 sprays l or kg/ha</th>
<th>Cost of insecticides Rs/1 or Rs/25kg</th>
<th>Total cost of insecticides for 2 sprays Rs/ha</th>
<th>Labour charges for 2 applications Rs/ha</th>
<th>Total cost of pl.prot. Rs/ha</th>
<th>Ave. yield income of castor Rs/ha*</th>
<th>Gross Gain Rs/ha</th>
<th>Gain income Rs/ha</th>
<th>Net income Rs/ha</th>
<th>ICBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fenvalerate 0.01%</td>
<td>0.4</td>
<td>0.8</td>
<td>285</td>
<td>228</td>
<td>52</td>
<td>280</td>
<td>1608</td>
<td>9648</td>
<td>4626</td>
<td>4346</td>
<td>1:15.52</td>
</tr>
<tr>
<td>Fenvalerate 2% LVC</td>
<td>1.0</td>
<td>2.0</td>
<td>NA</td>
<td>NA</td>
<td>52</td>
<td>-</td>
<td>872</td>
<td>5232</td>
<td>210</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fenvalerate 0.4% dust</td>
<td>25.0</td>
<td>50.0</td>
<td>215</td>
<td>430</td>
<td>52</td>
<td>482</td>
<td>917</td>
<td>5502</td>
<td>480</td>
<td>-2.0</td>
<td>-</td>
</tr>
<tr>
<td>Cypermethrin 0.005%</td>
<td>0.4</td>
<td>0.8</td>
<td>325</td>
<td>260</td>
<td>52</td>
<td>312</td>
<td>1670</td>
<td>10020</td>
<td>4998</td>
<td>4686</td>
<td>1:15.02</td>
</tr>
<tr>
<td>Decamethrin 0.0028%</td>
<td>0.8</td>
<td>1.6</td>
<td>410</td>
<td>656</td>
<td>52</td>
<td>708</td>
<td>1405</td>
<td>8430</td>
<td>3408</td>
<td>2700</td>
<td>1:3.81</td>
</tr>
<tr>
<td>Fluvallinate 0.0075%</td>
<td>0.24</td>
<td>0.48</td>
<td>455</td>
<td>218</td>
<td>52</td>
<td>270</td>
<td>1180</td>
<td>7080</td>
<td>2058</td>
<td>1788</td>
<td>1:6.62</td>
</tr>
<tr>
<td>Monocrotophos 0.04%</td>
<td>0.8</td>
<td>1.6</td>
<td>230</td>
<td>368</td>
<td>52</td>
<td>420</td>
<td>2088</td>
<td>12528</td>
<td>7506</td>
<td>7.86</td>
<td>1:16.87</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>837</td>
<td>5022</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* The cost of castor seed was Rs. 6/kg.
SUMMARY AND CONCLUSIONS

Investigations on biology, population dynamics and control aspects along with screening of castor germplasms against \( T. \) ricini attacking GAUCH-1 castor hybrid were made at Gujarat Agricultural University, Sardarkrushinagar during 1986 to 1989. Summary and conclusions accrued from the investigations are given below.

5.1. Biology:

Study on biology of \( T. \) ricini was carried out at varying temperatures and relative humidity during different months i.e. March 1988, June 1988 and January 1989 of the crop season, respectively. Descriptions of different stages with their periods in brief have been narrated herewith.

5.1.1. Egg:

The egg of \( T. \) ricini was sub-ellipticle, smooth, shiny and pale yellow in colour when freshly laid. It was broadly rounded at the base and tapering anteriorly which remained attached with inserted pedicel into leaf tissues. A day before hatching a pair of red eye spots become conspicuous. Freshly laid egg measured on an average \( 0.218 \pm 0.029 \) and \( 0.093 \pm 0.013 \) mm in length and breadth, respectively.

5.1.1.1. Incubation period and per cent hatching:

During March, June and January at an average temperatures of \( 25.5 \pm 8.68, 34.43 \pm 6.26 \) and \( 16.04 \pm 9.43 \) °C with \( 41.92, 51.43 \) and \( 52.70 \) per cent relative humidities, respectively, the incubation periods recorded were \( 5.64 \pm 1.07, 5.25 \pm 0.99 \) and \( 7.13, \pm 1.41 \) days, respectively. At the same time and weather conditions per cent egg hatching observed were \( 84.61, 82.75 \) and \( 70.59 \), respectively. In general it was found that the incubation period was prolonged at lower temperatures, whereas, per cent hatching was comparatively more at higher temperatures.
5.1.1.2. Ovipositional site and pattern:

Female of *T. ricini* in captive conditions laid eggs in circular fashion or scattered in batches on all leaves of a plant. In field, as adults preferred to shelter on young leaf, maximum egg laying covering the entire lower surface of the leaf was observed. In no cases the eggs were observed on lower or middle lower leaves. The eggs laid were 345.1 ± 183.5 eggs/sq.cm area of a top leaf.

5.1.2. Nymph:

The nymph was elliptical in shape varying with whitish yellow to deep yellow in colour. There were three distinct nymphal instars. The first instar nymph was flat elliptical, yellowish white in colour with six legs. It had a pair of eyes, vasiform orifice and several well defined setae on the body. On an average it measured 0.281 ± 0.022 mm and 0.149 ± 0.022 mm in length and breadth, respectively.

The second instar resembled the first one, but was larger, deep yellow in colour and stationary. The legs and antennae were degenerated. It measured on an average 0.255 ± 0.034 mm in breadth, and 0.435 ± 0.028 mm in length.

In third instar nymph the eye spots and well defined setae were more prominent; however, marginal setae were not observed, but waxy filaments were conspicuous. On an average it measured 0.546 ± 0.024 and 0.373 ± 0.026 mm in length and breadth, respectively.

5.1.2.1. Duration of nymphal instars:

In March 1988 with 26.7 ± 8.55°C temperature and 46.50 per cent relative humidity, duration of the first, second and third instar was of 3.05±0.68, 2.84 ± 0.55 and 2.89 ± 0.50 days, respectively, while it was of 2.24 ± 0.43, 2.27 ± 0.45 and 2.19 ± 0.40 days, respectively during June, 1988 at an average temperature of 34.92 ± 6.48°C with 50.6 per cent average relative humidity.
In January, 1989 when temperature was 16.04 ± 9.43°C with 52.70 per cent relative humidity, the duration of the first, second and third instar was of 4.06 ± 0.75, 4.22 ± 0.74 and 5.20 ± 0.72 days, respectively. The total nymphal duration during above periods was recorded as 8.82 ± 1.06, 6.69 ± 0.75 and 13.48 ± 1.18 days, respectively. It was also observed that the nymphal duration of *T. ricini* had prolonged at lower temperatures.

5.1.3. **Pupa:**

Freshly formed pupa was thin, flat, yellow, elliptical with slightly developed waxy filaments from margin of the pupal body. Latter on the filaments increased in size, attached closely to each other and brittle in nature. Measurements of pupae with filaments were on an average 1.038 ± 0.087 mm and 0.798 ± 0.066 mm in length and breadth, respectively. It measured as 0.645 ± 0.036 mm in length and 0.407 ± 0.023 mm in breadth without filaments.

5.1.3.1. **Pupal period:**

Pupal period of *T. ricini* during March and June, 1988 lasted for 7.20 ± 0.82 and 6.62 ± 0.83 days, respectively, whereas, in January, 1989, it was recorded as 8.83 ± 1.07 days. The pupal period was prolonged during colder months as compared to hot periods.

5.1.4. **Adult:**

Adult of *T. ricini* was small and slender with yellowish body. The antennae were five segmented and filiform. The wings were yellow and folded when newly emerged which then contorted to their normal size. The wings were coated with white waxy powder and held roof like on abdomen when at rest. Spurs were found on tibia and 2nd segment of tarsi. The abdomen in female was broad and spindle shaped while in male it was narrow and tapering which ended in a pair of claspers and basal plates. Female measured on an average 1.000 ± 0.046 mm and 0.292 ± 0.034 mm in length and breadth,
respectively, while, in male the length and breadth was of 0.919 ± 0.049 mm and 0.260 ± 0.035 mm, respectively. This indicated that females were larger than males.

5.1.4.1. Sex ratio:

The sex ratio (male : female) was recorded as 1:2.03 for natural population, while, that of laboratory reared adults, it was observed as 1:2.48. This suggests that the population of female was more as compared to male of *T. ricini*.

5.1.4.2. Pre-oviposition, oviposition and post-oviposition periods:

During March, 1988 at 26.29 ± 9.65°C and 31.8 per cent relative humidity pre-oviposition, oviposition and post-oviposition periods were observed on an average as 1.45 ± 0.51, 4.5 ± 1.19 and 1.25 ± 0.55 days, respectively. In June, 1988, these periods were recorded as 1.44 ± 0.51, 4.2 ± 0.87 and 1.28 ± 0.62 days respectively when the temperature prevailed was 34.97 ± 6.74°C and relative humidity as 47.46 per cent. In January, 1989 when the average temperature was low these periods were slightly prolonged.

5.1.4.3. Fecundity:

The egg laying capacity of a female *T. ricini* varied considerably and on an average it was 38.76 to 95.80 eggs during March, 1988 to January, 1989. It was also found that the fecundity was reduced in cold months as compared to hot period of the crop season.

5.1.4.4. Longevity:

As other stages, the adult stage also varied significantly during different periods of the season. In March, 1988 when average temperature was 26.29 ± 9.65°C with 31.8 per cent average relative humidity the longevity was of 7.25 ± 1.41 and 5.45 ± 1.19 days for female and male respectively. Female and male lived for 6.92 ± 1.47 and 5.12 ± 1.05 days, respectively at
34.97 ± 6.74°C and 47.46 per cent relative humidity in June, 1988. During January, 1989 at 15.90 ± 9.47°C temperature with 51.66 per cent average relative humidity. The longevity of female and male was of 9.64 ± 0.86 and 8.40 ± 0.87 days, respectively. It was found that female lived longer than male irrespective of varying temperatures. However, the longevity of adults was prolonged at lower temperatures.

5.1.5. Total life span:

Total life span of T. ricini from egg to adult’s death varied according to variation in temperature. It was of 27.11 ± 3.71 and 36.75 ± 5.14 days for male and female respectively during March-April, 1988 at 27.90 ± 9.94°C and 33.48 per cent relative humidity. In June-July, 1988 at an average temperature of 33.07 ± 6.16°C and average relative humidity of 56.51 per cent the total life cycle of male and female averaged to 24.27 ± 3.09 and 33.00 ± 4.85 days, respectively. In cooler part of the season i.e. December 1988 to February 1989, the life span of male and female averaged as 36.71 ± 3.40 days and 50.78 ± 8.78 days respectively at an average temperature of 18.02 ± 9.39°C coupled with 48.02 per cent relative humidity. The temperature and relative humidity play a major role and have a direct impact on the development of T. ricini. The biology was studied for the first time on green stemmed triple bloom hybrid variety GAUCH-1 at varying temperatures and relative humidity. Since such information was earlier not available, it may form the base to conduct further detailed study on bio-ecology of the pest.

5.2. Nature of damage:

Nymphs and adults of T. ricini suck the cell sap from lower surface of the leaves of castor. Due to continuous sucking of cell sap the leaves loose turgidity, become pale yellow and subsequently turn to brown in colour and dry. Heavily infested plant looses its vigour and become stunted. On account
of sooty mold growth developed on honey dew secreted by the latter instars, the plants look shiny black. Due to heavy infestation of *T. ricini* seed yield also affected.

5.3. **Population dynamics:**

*T. ricini* was found active throughout the year, however, the population levels during various months differed significantly. Castor crop was found free from white fly attack up to the third week of August. Population of immature stages was found from first fortnight of September which built up with an increase in adult population and attained peak 368 and 388 adults, during 1st fortnight of November 1986 and December 1987, respectively. Afterwards it decreased and became negligible during January in both the years. Thereafter, with the rise in temperature again a second peak in white fly population during March was observed where, the population of adults, eggs, nymphs and pupal index was 471, 516, 97 and 4.23, respectively during 1987. The same trend of peak population also remained equally true during 1988. The population of white fly started declining from May onwards. This study was carried out for the first time in major castor producing zone. The information would help the research worker to plan for further detailed studies and to farmer for timely management of the pest for better harvest.

5.4. **Correlation studies between castor white fly infestation and weather parameters:**

The weather parameters play an important role in regulating white fly population in nature. Maximum temperature showed non-significant positive correlation with the population of all stages of *T. ricini*, whereas, non-significant negative correlation was observed with minimum temperature. Except the nymphal stage, average temperature had non-significant positive correlation. Evening and average relative humidity expressed significant negative correlation with all stages of white fly, while morning humidity showed significant negative
correlation with adult stage only. Rainfall had non-significant negative correlation with the population. Average temperature coupled with dry conditions favoured the pest build up. Fall in maximum temperature below 32°C retarded the growth and development of the pest and was minimum at 26°C.

5.5. **Screening of castor varieties/cultures against *T. ricini***

Out of 292 germplasms of castor screened, 55, 56, 75, 30 and 70 were categorised into completely free, less susceptible, moderately susceptible, susceptible and highly susceptible, respectively. In six cultures only pupae were observed. Considering the adult and pupal population of white fly, out of 56 'less susceptible' cultures (adults 0.01 to 5/leaf) 17 were having more than 1.53 pupal index and hence can not be put in "less susceptible" group. Moderately susceptible and susceptible germplasm groups had some lines with less than 1.5 pupal index/leaf which indicated that though the plants had favoured the flies for shelter, egg laying or development of immature stages might have retarded due to different physical and chemical characters of plants. In highly susceptible (more than 15 adults/leaf) group there were 11 cultures, which were most susceptible of which 6 had population ranging from 18.58 to 50.67 adults/leaf and pupal index 2.67 to 3.81/leaf, those could be used satisfactorily in future for white fly screening programme as checks. The resistant cultures need further confirmation under artificial release of the pest before finalizing for breeding programme, however, no bloom and a few cultures with single bloom can be used in breeding programme. An attempt had been made for the first time to screen the material using population of both pupae and adults for grouping the germplasms into various categories. Present findings would provide a source of information for the workers engaged in resistance breeding programme.

5.6. **Control measures:**

5.6.1. **Efficacy of conventional insecticides alongwith fenvalerate against *T. ricini***
Six conventional insecticides viz., monocrotophos 0.04%, methyl-o-demeton 0.025%, methyl parathion 0.05%, ethion 0.05%, dimethoate 0.03% and thiometon 0.025% were evaluated alongwith fenvalerate 0.01% for two years. Pooled results revealed that monocrotophos 0.04% proved to be highly effective in protecting nymphs, pupae and adults of *T. ricini* on castor hybrid GAUCH-1. The next best treatment was dimethoate 0.03%. Methyl-o-demeton 0.025%, methyl parathion 0.05% and thiometon 0.025% had moderate effect in controlling the white fly population.

5.6.2. Efficacy of synthetic pyrethroids alongwith monocrotophos against *T. ricini*.

Different formulations of fenvalerate viz., EC, LVC and Dust formulations and other widely used synthetic pyrethroids including cypermethrin 0.005%, decamethrin 0.0028% and fluvalinate 0.0075% were evaluated against *T. ricini* for two years. Pooled results indicated that monocrotophos 0.04% was registered as the best treatment in controlling the white fly population on castor. Among synthetic pyrethroids cypermethrin 0.005% was very effective in reducing pest population and was followed by fenvalerate 0.01% and decamethrin 0.0028%. Fluvalinate 0.0075% had intermediate effect. Among different formulations of fenvalerate, LVC proved poor while the dust failed to check the pest. Use of synthetic pyrethroids is considered as one of the reasons for outbreak of white flies in cotton. Since no information was available on use of synthetic pyrethroids on castor against white fly and its effect on population flare up, cypermethrin, decamethrin, fluvalinate and fenvalerate were first time tested against white fly on castor. Similarly there is no literature available on dust and LVC formulations of fenvalerate therefore, they were also tested for the first time against castor white fly. Hence, the results of the present findings would become a good source of information for conducting evaluation trials in future for recommending to the farmers.
5.7. **Phytotoxicity:**

While evaluating different insecticides against white fly on GAUCH-1, the plants sprayed with fenvalerate LVC showed toxic symptoms on leaves and capsules. Whitish yellow patches along with midrib and branched veins were developed, which turned to brown, whereas leaves became cup shaped and finally dried up. Small capsules turned black and dried whereas in developed capsules the seed remained undamaged. The toxicity was severe in small plants. This is the first record of phytotoxicity of fenvalerate LVC on castor which would provide guideline for workers to make detail study on various crops before going for recommendations to farming community.

5.8. **Yield and economics:**

5.8.1. **Yield:**

Looking to the effect of various insecticides on castor seed yield, the highest seed yield was recorded in monocrotophos 0.04% (2127 kg/ha) followed by dimethoate 0.03% (1935 kg/ha), methyl-o-demeton 0.025% (1712 kg/ha), fenvalerate 0.01% (1542 kg/ha), methyl parathion 0.05% (1451 kg/ha) and thiometon 0.05% (1378 kg/ha).

Among synthetic pyrethroids cypermethrin 0.005% recorded the highest yield (1670 kg/ha) followed by fenvalerate 0.01%, decamethrin 0.0028% and fluvalinate 0.0075%.

5.8.2. **Economics:**

Economics of conventional insecticides showed that although monocrotophos had the excellent control and maximum yield, it followed dimethoate 0.03% in regard of ICBR which had ICBR 1:13.32. The chronological order followed was monocrotophos 0.04% (1:8.88), methyl-o-demeton 0.025% (1:7.76), fenvalerate 0.01% (1:5.46), methyl parathion 0.05% (1:3.81), thiometon 0.025% (1:2.86) and ethion 0.05% (1:0.75).
Among synthetic pyrethroids the maximum ICBR was obtained with fenvalerate 0.01% (1:15.52) followed by cypermethrin 0.005% (1:15.02), fluvalinate 0.0075% (1:6.62) and decamethrin 0.0028% (1:3.81).

In view of efficacy and economics of the insecticides, it can be concluded that dimethoate 0.03% and monocrotophos 0.04% @ 800 l/ha can be recommended for the control of T. ricini in castor.
REFERENCES


* Original not seen.
### Appendix 1. Measurements of eggs of *Trialeurodes vicini* Misra

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<th>Sr. No.</th>
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Appendix 5.  Measurements of the first instar nymphs of *Trialeurodes ricini* Misra

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Minimum 0.236  0.101
Maximum 0.304  0.168
Average 0.281  0.149
Sd +0.022  0.022
Appendix 6. Measurements of the second instar nymphs of Trialeurodes ricini Misra

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Minimum 0.405 0.202
Maximum 0.472 0.304
Average 0.435 0.255
Sd + 0.028 0.034
**Appendix 7.**

**Measurements of the third instar nympha of *Trialeurodes ricini* Misra

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Minimum 0.506 0.337  
Maximum 0.574 0.405  
Average 0.546 0.373  
$Sd^+$ 0.024 0.026
Appendix 8. Duration of different nymphal instars of *Trialeurodes ricini* Misra at varying temperatures and relative humidity

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| Ave. | 3.05 | 2.84 | 2.89 | 8.82 | 2.24 | 2.27 | 2.19 | 6.69 | 4.06 | 4.22 | 5.20 | 13.48 |
| Sd± | 0.68 | 0.55 | 0.50 | 1.06 | 0.43 | 0.45 | 0.40 | 0.75 | 0.75 | 0.74 | 0.72 | 1.18 |

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### Appendix 9.

Measurements of pupae (with filaments) of *Treatleurodes ricini* Misra

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Minimum          0.95         0.74
Maximum          1.18         0.91
Average          1.038        0.798
$\sigma$           0.087        0.066
Appendix 10. Measurements of pupae (without filaments) of *Trialeurodes ricini* Misra

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<tr>
<th>Sr. No.</th>
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<th>Breadth in mm</th>
<th>Sr. No.</th>
<th>Length in mm</th>
<th>Breadth in mm</th>
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*Minimum* 0.608 0.371  
*Maximum* 0.709 0.439  
*Average* 0.645 0.407  
*Sd* ± 0.036 0.023
Appendix 11. Duration of pupal period of *Trialeurodes ricini* Misra at various temperatures and average relative humidity.

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Appendix 12. Measurements of male *Trialeurodes ricini* Misra

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Minimum: 0.844 0.202  
Maximum: 0.979 0.304  
Average: 0.919 0.260  
$Sd \pm$: 0.049 0.035

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Minimum: 0.912 0.236  
Maximum: 1.047 0.337  
Average: 1.000 0.292  
Sd: 0.046 0.034
Appendix 14. Pre-oviposition, oviposition and post-oviposition periods, fecundity and longevity of Trialeurodes vaporariorum Misra (March, 1988)*

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* Temperature range from 13.5 to 37.1°C with an average of 26.29 ± 9.67°C and 31.8 per cent average relative humidity.
### Appendix 15. Pre-oviposition, oviposition and post-oviposition periods, fecundity and longevity of *Trialeurodes* ricini Misra (June, 1988)*

<table>
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| Min.   | 0                     | 5                             | 4                     |
| Max.   | 2                     | 9                             | 7                     |
| Ave.   | 1.28                  | 6.92                          | 5.12                  |
| Sd.    | 0.62                  | 1.47                          | 1.05                  |

* Temperature ranged from 27.4 to 45.7°C with an average of 34.97 ± 6.74°C and 47.46 per cent average relative humidity.
### Appendix 16

**Pre-oviposition, oviposition and post-oviposition periods, fecundity and longevity of *Trialeurodes vaporariorum* Misra (January, 1989)**

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<th>Sr. No.</th>
<th>Adults emerged &amp; paired on (date)</th>
<th>Starting egg laying(Date)</th>
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<th>No. of eggs laid</th>
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Min. 1 8 7  
Max. 4 11 10  
Ave. 2.28 9.64 8.40  
Sd+ 1.06 0.86 0.87  

* Temperature ranged from 4.1 to 27.8°C with an average of 15.90 ± 9.41°C and 51.66 per cent average relative humidity.