Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop

BY

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CERTIFICATE-I

This is to certify that thesis entitled "**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop** " submitted for the degree of Master of Science in the subject of Entomology to the Chaudhary Charan Singh Haryana Agricultural University, Hisar is a bonafide research work carried out by **Mr. Yashdev Singh**, Admn. No. 2012A23M under my supervision and no part of the thesis has been submitted for any other degree.

All the assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE-II

This is to certify that the thesis entitled "**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop** " submitted by **Mr. Yashdev Singh,** Admn. No. 2012A23M to Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfilment of the requirement for the degree of Master of Science in the subject of Entomology has been approved by the Student's Advisory Committee after an oral examination on the same.

MAJOR ADVISOR **EXTERNAL EXAMINER**

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CHAPTER-I

INTRODUCTION

The Castor (*Ricinus communis* L.) is an important non-edible oilseed crop of dry lands, which is becoming popular as a commercial oilseed crop owing to its high export potential and industrial uses. The castor belongs to the Family: Euphorbiaceae and its local name is *arindi.* The castor is consider native to tropical Africa and grown particularly in arid and semi-arid regions. Castor is cultivated in 30 different countries on commercial scale. The major castor growing countries are India, China, Brazil, Africa, USA, and many Asian countries (Watt, 1892) of which India, China and Brazil accounting for 90 per cent of world production. India, ranks first among the major castor producing countries in the world with 68 per cent of area and 76 per cent of world castor production (Anonymous, 2008).

In India, total area under castor crop for year 2012-2013 is about 13.17 lakh ha with production about 21.77 lakh tones and average yield is about 1653 kg/ha. Castor is being grown in all the states, mainly in Gujarat and Andhra Pradesh where 61 and 21 per cent of the total area under the crop, respectively. In Haryana, particular in south west region, farmers are growing castor as an alternative crop of mustard due to availability of limited irrigation water and losses caused by orobanche (a parasitic weed) of mustard.

The oil contents of the castor seeds varied from 35-58 per cent in different varieties, the average being about 47 per cent that is rich in triglycerides mainly, ricinolein. Owing to its laxative property it is also used in medicines. Castor oil and its derivatives have long been used as a lubricant and have wide spread industrial use in diverse sectors like pharmaceutical, textiles, paper chemical, plastics, greases, hydraulic and break fluids, fabrication of artificial leather, paint, varnishes, linoleum, plasticizer, soap cosmetics and even in electronic and telecommunication industries. Castor cake is used in agriculture as organic manure due to its high nitrogen content. Castor cake contains 4.5 per cent nitrogen. The castor plant stalks can be used as thatching material or fuel and also used wrapping paper. Moreover, castor has been considered as most preferred host for eri silk worm (Sengupta and Singh, 1974) and the oil cake has vermicidal properties and being used as manure.

Among many factors responsible for lower yield, attack of insect pests is major one, which affected the quantity and quality of the castor. In India, castor is attacked by sixty one different species of insects (Rai, 1976). The most important pests are castor semilooper (*Achaea janata* L.), castor shoot and capsule borer (*Dichocrocis punctiferalis* Guen.), hairy caterpillar (*Euproctis fraternal* Moore), tabacco caterpillar (*Spodoptera litura* Fab.), castor jassids (*Empoasca flavescencee* Fab.), whitefly (*Trialeurodes ricini* N.), gram pod borer (*Helicoverpa armigera* Hub.), leaf minor (*Liriomyza trifolii* Burgess) (Vora *et al*., 1984).

Among which castor semilooper (*Achaea janata)* (Noctuidae: Lepidoptera) is one of the major defoliator of castor in India, as well as in Haryana. It is the key pest of castor in the rainfed castor belts of India and particular in southern Haryana and is also known to occur regularly throughout the country wherever the crop is being grown. Castor semilooper is a polyphagous pest which infesting more than 80 plant species including 54 species, most of them from India which are mainly belonging to field crops (Basappa, 1995). Gaikwad and Bilapate (1992) reported the yield reduction of castor crop due to semilooper attack is about 20 per cent. It feeds on tender capsules and causes yield loss ranging from 5 to 90 per cent depending upon larval density and crop stage (Prabhaker and Prasad, 2005).

The castor semilooper population have been reported to fluctuation on castor crop. During the crop season this pest mainly occur during August and September and thereafter, there is decrease in the pest population and pest infestation. Meteorological factors *viz*. maximum and minimum temperatures, relative humidity and rainfall are most important environmental factors which affect the pest and gives us idea of the environmental factors that regulates cyclic occurrence of the pest.

The biology of this pest has been studied by many workers (Khan, 1946; Khan and Rao, 1948; Byale and Bilapate, 1990; Bhadauria*, et al.*, 2002). Similarly, the seasonal abundance had been studied by Somasekhar *et al.* (1993), Prabhaker and Prasad (2005) and Mohan *et al.* (2010). But no such work has been done in Haryana, so far on its biology and seasonal abundance.

Castor semilooper moth is pale reddish brown, which laid eggs singly mostly on the top second leaf which hatch out within 2 to 5 days. The larval period ranges from 11 to 15 days. The pupal period lasts for 10 to 14 days. The first instar larvae nibble only the outer tissues of the leaf, second instar damages the leaves by making holes and the third and later instars devour the green foliage completely leaving veins. During capsule formation stage they also found to feed on capsules. In the case of very severe attack, whole field of castor are completely defoliated and sometimes even the stems are attacked and destroyed (Lakshminarayana, 2003). Gaikwad and Bilapate (1992) recorded 36.4 per cent reduction in castor leaves, 26.4 per cent branches per plant, 21.4 per cent capsules per bunch and 19.6 per cent loss in seed yield in unprotected plots over protected plots from insecticides.

A number of insecticides namely, parathion and carbaryl (Vittal and Saroja, 1968) phosvel and quinalphos (Deshmukh *et al.,* 1981) decamethrin (Dalaya *et al.*, 1983) fenvalerate (Basappa and Lingappa 2004) and spinosad (Narayanamma *et al.,* 2010) were found to control effectively the semilooper infesting castor. But very scanty information is available on insect pests of castor and their management in Haryana State.

There is great need to initiate work on bionomics of castor semilooper and its chemical control. Keeping in view the severity of damage, it was felt desirable to evaluate some new insecticides against this pest. The present studies were therefore, proposed to find out the bionomics of castor semilooper and its chemical control in castor with following objectives in view:

1. To study the biology and seasonal abundance of castor semilooper infesting castor crop.
2. To study the bio-efficacy of different insecticides against castor semilooper.

CHAPTER-II

REVIEW OF LITERATURE

Castor is severely attacked by different lepidopteron insect-pests *viz.,*castor semilooper (*Achaea janata* L.), castor shoot and capsule borer (*Dichocrocis punctiferalis* Guen.), hairy caterpillar (*Euproctis fraternal* Moore), tabacco caterpillar (*Spodoptera litura* Fab.) in which the castor semilooper, *A. janata* is a major defoliator in Haryana. In order to plan the pest control strategies it is necessary to study the bionomics and population dynamics of pest to avoid the crop loss and elevate the production. Work done by different workers on various aspects of "**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop**" is reviewed as following heading:

2.1. Seasonal abundance and incidence of castor semilooper

The incidence of *A. janata* on castor crop was reported for the first time by Subramania in 1921. He found that in Karnataka, A. *janata* appeared during June - July and continued up to the end of September. Similarly in Andhra Pradesh, Khan (1946) observed that *A. janata* occurred in middle of May on perennial crop of castor. The pest outbreak was common in August, September, and October, in castor growing areas. The larvae feed on the leaves and most of the damage was caused by the second and third generation of *A. janata* in August and September, though the fourth and fifth generation were injurious in October and November. He observed four to five eggs per leaf in the months of July and August and concluded that the activity of *A. janata* decreased from November onwards on castor crop. Srivastava and Pande (1966) conducted experiment to record the seasonal history of *A. janata* in Rajasthan, they observed that seasonal history of this pest varied greatly from different parts of the Rajasthan state. In the Bikaner- Barmer region this pest was active from July-September and completed three generation in a year and hibernates from October to June. While in the Ajmer-Bharatpur, region this pest was active from July to November and completed five generations in the year and the hibernation took place from November to June. Similarly, this pest was active from July to November and hibernated during winter months in the Sirohi – Kota region of the Rajasthan state.

Pande *et al.*(1967) reported that over wintered pupae of *A. janata* of earlier season gave rise to adults at the beginning of June in next season and the pest passed through five overlapping generation in a year. Serious damage was caused to the fruits of guava near Delhi in 1967 by large number of adults of the fruit piercing moth, *A. janata* up to 14 moth per fruit were observed and contrary to their usual, they feed throughout the day, even in bright light (Bhattacherjee, 1969). In Dharwad, Jairamaiah *et al. (*1975) noticed that the large number of larvae of *A. janata* were observed to feed on *Bauhinia purpurea* and other plant during

August to September. Hua (1981) stated that there were six to seven generations of *A. janata* in a year with no apparent over wintering in China. According to Tahiliani (1985) in Saurashtra of Gujarat state, *A. janata* remained active during September to November. However, it appeared in endemic form during middle of October.

Islam and Narsin (1986), studied the seasonal incidence of *A. janata* on Castor in Bangladesh. Where the population was low during winter and serious damage occurred in August to September. In Manipur during 1975-1977, Ram and Pathak (1987), observed that *A. janata* was found to be active from June to August on castor. Mote *et al.* (1991) observed during the survey in September, 1988 at Sangola and Taklimiya in Maharastra there was a heavy attack of 3 to 4 moths per pomegranate fruit. A heavy attack of this moth was observed on citrus fruit at Rahuri during August to October. A castor variety VI-9 was sown during 1985-86 and 1986- 1987, at College of Agriculture, Parbhani, in which Gaikwad and Bilapate (1991) recorded four regular and overlapping generations of *A. janata on* castor and also found that the duration of two generation was 4-7 days more as compared to previous two generation due to monsoon rain during that period and pest remain active from July to September. Somasekhar *et al.* (1993) reported that the pest was active from the 2nd fortnight of July until the end of November with maximum of 4.1 and 3.3 larvae per plant during September 1988 and 1989, respectively on castor. Vyas (1996) *reported* that 13 species of insect pests including *A. janata* were recorded on *Ziziphus mauritiana* causing considerable damage. Ranjeet *et al.* (1997) observed an outbreak of *A. janata at Madhuri* on *Tararindus indica* with an average of 400 to 650 larvae per tree over an area of about 100 hectares in April to May.

Dadmal and Pawar (2000) observed the larval stage of *A. janata* on *Trewia nudiflora* at Akola (Maharastra) during July to August 1999. Basappa and Lingapa (2001a) observed a direct correlation between larval number of *A. janata* and defoliation, yield attributes and oil content in castor. Plant mortality increased with increasing number of late larvae at 30 days after sowing. The damage on spikes and capsule caused higher yield losses compared to damage on leaves at later crop growth stages. Rishi *et al.* (2004) observed at Hisar that the activity of *A. janata* start from July to November. The maximum number of this pest was observed in the month of September and October with per cent abundance of 10.88 and 8.60 per plant, respectively and the per cent abundance become 0.89 and 0 in the month of November and December, respectively. In Andhra Pradesh, Prabhaker and Prasad (2005) recorded the incidence of *A. janata* on castor during *Kharif* seasons of 2001 to 2003. They observed 26, 8, and 11 larvae per plant on 29th September 2001, 18th September 2002, and 18 august 2003, respectively.

Madhuri *et al.* (2006) observed that the peak incidence of *A. janata* was during the first week of December correlation studies revealed that the *A. janata* population was negatively and significantly correlated with minimum temperature, positively and significantly correlated with morning relative humidity. The correlation coefficient revealed that morning relative humidity showed positive effect whereas, evening relative humidity, maximum temperature and rainfall showed direct negative effect. Magar (2006) reported that the highest population of *A. janata* to the extent of 1.6 larvae per quadrat was recorded on soyabean in 34th meteorological week when the maximum temperature, minimum temperature, before noon relative humidity, after noon relative humidity, rainfall and number of rainy days were 29.04º C, 22.14 ºC, 89.57 per cent, 84.71 per cent, 7.2 mm and 3 days, respectively. The path analysis studied revealed that increase in rainfall associated with less number of rainy days increase the population of *A. janata* on soya bean during *Kharif* season 2005. However, *A. janata* passed only one generation.

Rathod *et al.* (2009) at Parbhani (Maharashtra) recorded the first incidence of *A. janata* was reported on castor on 33rd meteorological weeks (6.80 larvae per quadrat) with its peak level (13.4 larvae per quadrat) in 38th meteorological weeks. At maximum level of pest population the prevailing weather factors viz. maximum and minimum temperature, before noon and after noon relative humidity, rainfall and number of rainy days were 31.7º C, 22.2 º C, 85.9 and 88.7 per cent, 47.6 mm and 1 days, respectively. The correlation coefficient revealed that before noon relative humidity showed positive effect whereas, afternoon relative humidity showed direct negative effect. Mohan *et al.*(2010) studied the pest scenario of castor at various phenological stages from July to November in the farmer's field at Shikaripur, Honnali and Channagiri talukas, they observed that *A. janata* was found from first fortnight of July to second fortnight of November. The peak incidence was during the first fortnight of August to second fortnight of September, with maximum 15.1 larvae per plant on the second fortnight of September and subsequent decline of larval population up to November.

2.2. Biology of castor semilooper

2.2.1. Per-oviposition period

Khan (1946) stated that the pre-oviposition period of *A. janata* was varied from 6-21 days in June and July and lasts for about 21 days in September and October. Cherian and Basheer (1947), recorded the pre-oviposition period varied from 22-30 days in Coimbatore. Smee (1962) observed that the pre-oviposition period of *A. janata* was 4-10 days. Karmawati and Tobing (1988) reported the pre-oviposition period was 2.5 days in Indonesia. According to Gaikwad and Bilapate, (1993) the pre-oviposition period of *A. janata* was about 2 days on castor, 5 days on pomegranate, 7 days on dudhi and 5 days on rose. Basappa and Lingappa (2001b) studied at Dharwad and reported that the pre-oviposition period varied from 3-4 days on castor.

2.2.2. Oviposition period

According to Srivastava and Pande (1966), the female usually takes 1 to 3 weeks for oviposition. In colder season longer period is required for laying of eggs but in the field condition they observed that the oviposition period varied from 2 to 7 days. Pande *et al.* (1967) reported that the oviposition period of *A. janata* was 2-11 days on castor leaves. Bilapate (1985) reported oviposition period was 7 days on castor leaves. According to Gaikwad and Bilapate, (1993) the oviposition period of *A. janata* was about 8.02 days on castor,7.12 days on pomegranate, 7.19 days on dudhi and 6.68 on rose. At Dharwad, Basappa and Lingappa (2001b) reported the oviposition period varied from 8-12 days on castor.

2.2.3. Fecundity

Subramania (1921) stated that the eggs were deposited singly on the lower surface of castor leaves at night, one female lay about 400 eggs. Similarly, Grunwald (1930) observed that the female of *A. janata* lay about 400 eggs on the lower surface of castor leaves. According to Cherian and Basheer (1946), a single female lay about 318 eggs with a maximum of 648 eggs. Smee (1962) reported that when female fed with a mixture of honey and water, laid about 600 eggs in five days on castor leaves. According to Srivastava and Pande (1966), the number of eggs laid per female varied from 90 to 300 and they also concluded that 65 per cent of eggs were laid on the lower surface of leaves, 30 per cent on the upper surface of leaves and 5 per cent eggs may be laid on the other parts of plants.

Pande (1967) observed that about 90-300 eggs were laid per female on the lower surface of castor leaves. Pande *et al.* (1967) found that the female of *A. janata* lays on an average of about 622 eggs on castor leaves. Karmawati and Tobing (1988) stated that the total number of progeny produced per female averaged 1305. According to Gaikwad and Bilapate (1993), the female of *A. janata* laid about 636 eggs on castor, 541.6 on pomegranate, 385.6 on dudhi (*Lagenaria siceraria*) and 389.4 eggs on rose. Vyas (1994) observed that the *A. janata* laid on an average of 600-650 eggs over a period of 4-5 days.Under laboratory condition Bhaduria *et al.* (2002) reported the female of *A. janata* lay about 535 eggs on castor and about 250 eggs on rose.

2.2.4. Incubation period

Various workers made observation on incubation period of castor semilooper, *A.janata*. Subramania (1921) reported that the incubation period of eggs of *A. janata* ranged from 2-4 days, while Grunwald (1930) and Gaikwad and Bilapate (1993) observed the incubation period of was 2-3 days; similarly Khan (1946) reported that the eggs of *A. janata* was laid singly on either surfaces of leaf and the incubation period varies from 2-3 days. Cherian and Basheer (1947), recorded the incubation period of 3 days in Coimbatore. Smee (1962) reported that the incubation period of *A. janata* was 3 days on castor leaves in laboratory while Srivastava and Pande (1966) recorded 2 to 4 days during monsoon months which was considerably increased as the winter advanced. Pande (1967) reported that the eggs are laid usually singly on the lower surface of castor leaves and hatched after 2-3 days. Pande *et al.* (1967) observed the incubation period of *A. janata* ranged from 3-5 days. According to Karmawati and Tobing (1988) the eggs hatches in 3 to 4 days in the laboratory in February-March month in Indonesia. Further Byale and Bilapate (1990) reported that the egg duration lasts about 2.02 days. According to Gaikwad and Bilapate (1993) the incubation period of *A. janata* is about 2 days. Basappa and Lingappa (2001b) reported the incubation period varied from 3-4 days on castor. Bhaduria *et al.* (2002) recorded the incubation period of *A. janata* on castor is about 2.05 and about 2.85 on rose.

2.2.5. Larval instars

Khan (1946) stated that there were four instars of *A. janata* on castor leaves. He observed the first, second, third and fourth larval instars lasts for 2, 2, 2, and 5-7 days, respectively. Srivastava and Pande (1966) reported the five larval instars of *A. janata* in Rajasthan. According to them, the first instar last for 1 to 2 days, second and third lasts for 1 to 3 days, fourth larval instar for 2 to 5 days and the fifth larval instar lasts for 2 to 5 days. Ramdev and Rao (1979) reported five instars of *A. janata* on castor leaves and stated that, fifth instar having maximum period of 5.45 days. According to Byale and Bilapate (1990), the larval instar duration were 1.54, 1.39, 1.60, 1.55 and 4.40 days for I, II, III, IV and V instar, respectively.

2.2.6. Larval period

Subramania (1921) reported that, the larval period of *A. janata* was 15-21 days, after which they descend to the ground for pupation in dry weeds and leaves underneath the plants. Khan (1946) recorded total larval period of *A. janata* on castor ranging from 12-13 days. Similarly Cherian and Basheer (1947), recorded the larval period varied from 9-15 days in Coimbatore. Smee (1962) observed the larval period of *A. janata* lasted for 11-17 days on castor leaves when reared under laboratory conditions. Srivastava and Pande (1966) reported the total larval period of *A. janata* lasts for about 10 to 16 days in monsoon months and 15-31 days in colder months. According to Pande *et al.* (1967), the larval period of *A. janata* on castor ranged from 9-23 days, the first instar larvae fed on the lower epidermis of the leaves, the second instar makes holes in the leaves and last three instars completely consumed the leaves. According to Pant and Anand (1975), it was 12-15 days, when reared on artificial diet (5 per cent castor leaf powder) and 8-12 days on castor leaves.

Ramdev and Rao (1979) reported that the larval stages lasted for 13.55 days and the maximum food intake (85 per cent of total) was observed in the fifth instar. According to Karmawati and Tobing (1988) the larval period varied from 9-13 days in Indonesia. Byale and Bilapate (1990) reported that the larval duration lasts for about 12.38 days. Gaikwad and Bilapate (1993) observed that the larval period of *A. janata* was about 11.71 days. Vyas (1994) reported that the total larval period of *A. janata* was 15-19 days. While, Basappa and Lingappa (2001b) reported the larval period varied from12-17 days on castor at Dharwad. According to Bhaduria *et al.* (2002) the larval period ranged from 10.38 on castor and 21.31 on rose.

2.2.7. Pupal period

Subramania (1921) observed that the pupal stage lasted for 10 to 14 days. Khan (1946) reported the pupal period varied from 11 to 27 days. Cherian and Basheer (1947), recorded the pupal period varied from 10-12 days in Coimbatore. Smee (1962) observed 9-14 days pupal period on castor. Srivastava and Pande (1966) reported the total pupal period varies from 10 to 15 days and the duration however becomes more during colder months. The pupae of *A. janata* overwintered from November-December in the soil or among dead leaves and gave rise to adults at the beginning of June at Kanpur and the pupal period ranged from 7-26 days on castor (Pande *et al.*, 1967). The pupal stage of *A. janata* lasted for 5-8 days on both artificial diet (5 per cent castor leaf powder) and castor leaves. There was 60 per cent survival of adults when reared on artificial diet (Pant and Anand 1975). Ismail and Salim (1982) stated that the pupation took place in a loose coccon in the soil, between leaves spun together or in the bark cervices, the pupal stages lasted for 10 days. According to Karmawati and Tobing (1988), the pupal period was 8 to 10 days in the laboratory in February-March months.

Byale and Bilapate (1990), the pupual duration lasts for about 8.30 ± 1.12 days. Gaikwad and Bilapate, (1993) observed the pupal period of *A. janata* was about 8.93 days. According to Vyas (1994), the total pupal period of *A. janata* was 12-13 days. At Dharwad, Basappa and Lingappa (2001b) reported the pupal period varied from 9-11 days on castor. Bhaduria *et al.* (2002) studied that the pupal period of *A. janata* was about 9.80 on castor crop and about 14.55 on rose.

2.2.8. Adult emergence

Byale and Bilapate (1990) reported the per cent emergence ranged from 96.04 and while Bhaduria *et al.* (2002) reported the adult emergence 95.00 per cent adult emergence.

2.2.9. Sex ratio

Dani *et al.* (1980) prescribed the method to differentiate the male and female pupae on the basis of distance between the genital and anal aperture the distance between these two apertures is less in case of male and was more in case of female. Srivastava and Pande (1966), observed that the sex ratio of *A. janata* which was about 57:43 it was found that males slightly outnumbered than the female.

2.2.10. Adult longevity

Srivastava and Pande (1966) reported that the longevity of male and female varied from 12 to 13 and 20 to 21 days when kept singly and 9 to 10 and 14-15 days when kept in pairs and guava fruit provided as food and 3 to 4 and 6 to 7 days when kept in pairs and food was not given. Pande (1967) found that the female had higher longevity (3-15 days) as compared to males (8-10 days). Holihosusr, (1985) reported the adult longevity 14.5 days. According to Karmawati and Tobing (1988), the adult longevity varied from 22 to 32 days in the laboratory in month of February-March.

2.2.11. Life cycle

Khan (1946) reported that life cycle of *A. janata* on castor was 28 days from June, July and August and it was 47 from February to March on the same host. 30 days recorded by Ismail and Salim (1982). Karmawati and Tobing (1988) reported the life cycle varied from 22-27 days in Indonesia According to Gaikwad and Bilapate (1993), the life cycle of *A. janata* was about 24.48 days on castor and 40.38 days on rose. Vyas (1994) reported the life cycle ranged from 33-41 days. At Dharwad, Basappa and Lingappa (2001b) reported the total life cycle varied from 26-35 days on castor.

2.3. Bio-efficacy of different insecticides against castor semilooper

Vevai and Talgeri (1948) stated that three to four spraying of 0.15 per cent DDT water suspension or dusting of 5 per cent DDT at 20 days interval would control the *A. janata*. Precha *et al.* (1962) found that sevin 0.02 to 0.05 per cent was effectively control this pest in Thailand. Field experiment on the control of *A. janata* were conducted at the Agriculture college and Research institute, Coimbatore during 1964 and 1965 by Chelliah and Gopalan (1967) revealed that parathion 0.05 per cent was the most effective to control this pest with mean larval reduction 83.63 per cent, followed by endrin which reduce 80.08 per cent larval reduction. Similarly, Vittal and Saroja (1968) found that the spray of parathion 0.025 per cent and carbaryl 0.1 per cent were the most efficient to control the *A. janata*. In Tamil Nadu, Regional Agriculture Research Station, Tindivanam, during 1968-71 the effectiveness of eleven insecticides in controlling *A. janata* on castor was evaluated under field-plot tests by Saroja *et al.* (1973) reported that the sprays of 0.05% fenitrothion, 0.05% parathion and 0.1% DDT gave the best control and resulted in the highest crop yield. Field plots tested at Jodhpur, on the effectiveness of sprays of various insecticides applied to for control of *A. janata* showed that carbaryl 0.25 per cent was most effective when plant height was 1.2 m (Kushwaha and Pal 1976).

An experiment was laid out by Kushwaha and Pal (1977) at Central Arid Zone Research Institute, Jodhpur to carried out the effectiveness of six insecticide and found that Dimethoate 0.05 per cent gave the best result followed by metacid, 0.05 per cent with mean larval reduction 94.32 and 92.50 per cent, respectively. Pal (1977) tested the efficacy of two organic chemical insecticides (carbaryl and dicrotophos) and two bacterial insecticides (dipel and cajrab) each in three doses against *A. janata*. The overall performance of both organic chemical insecticides was found superior to bacterial insecticidal formulation. Carbaryl was the most effective followed by dicrotophos, dipel while cajrab was the least effective among the insecticides.Rai and Jayaramaiah (1978) tested the efficacy of different insecticidal dusts containing 10% carbaryl, 5% malathion, 2% parathion, 5% trichlorphon and 10% HCH (BHC) against the *A. janata* at University of Agricultural Sciences, Bangalore, out of these, they found that carbaryl and parathion were the most effective insecticide, both were causing 89.75% mortality in 24 hours.A field trial to evaluate the efficacy of eight insecticides was conducted against *A. janata* by Deshmukh *et al.* (1981) during *Kharif* 1977 at Akola and proved that phosolone, phosvel and phenthoate were found more effective in reducing the larval population as compared to quinalphos. Ismail and Salim (1982) observed that permethrin and monocrotophos were effective and gave quick knock down of semilopper. Singh (1982) tested eight insecticides against larvae of *A. janata* under the laboratory, quinalphos at 0.05% was most effective, causing 85.5% mortality, followed by 0.05% fenitrothion, which caused 74.8% mortality.

Dalaya *et al.* (1983) tested the efficacy of synthetic insecticide against *A. janata* on castor in which they found that insecticides tested were proved to be effective in controlling *A. janata*. Decamethrin @ 10 gm as per ha was the most effective treatment and it was significantly superior to quinalphos @ 250 gm and untreated control. The other synthetic pyrethriods like lndothrin @ 60 gm, AC 222-705 @ 40 gm, permethrin @ 60 gm, fenvalrate @ 50 gm and cypermethrin @ 40 gm per ha were on par with decamethrin. The comparative toxicity of several pyrethroid and non-pyrethroid insecticides against larvae of *A. janata* was studied by Singh *et al.* (1983) in the laboratory. On the basis of the LC50, the synthetic pyrethroids cypermethrin, deltamethrin, permethrin and fenvalerate and phoxim were highly toxic to the larvae, their toxicity being 21.88-97.45 times that of lindane, which was used as a standard. The synthetic pyrethroids were 9.31-41.47 times as toxic as natural pyrethrins. Cypermethrin was the most toxic of all the compounds, being 3.27-177.18 times as toxic as individual synthetic non-pyrethroid insecticides.

The efficacy of nine insecticides *viz*., deltamethrin, fenvalerate, permethrin and cypermethrin, at 0.01%, and endosulfan, carbaryl, chlorpyriphos, quinalphos and fenitrothion at 0.05% against *A. janata* were evaluated at Ludhiana by Grewal *et al.* (1988). Chlorpyrifos, fenvalerate, quinalphos and deltamethrin gave a quick knockdown effect, causing 70.3, 64.3, 63.4 and 56.6% mortality respectively, one day after spraying. In the case of endosulfan, chlorpyrifos, quinalphos, fenitrothion, permethrin and cypermethrin the mortality had increased to 100.0 per cent four days after spraying. Parthasarathy and Rao (1989) conducted trials on relative efficacy of insecticides against *A. janata* on castor at A. P. Agricultural university, Hyderabad in 1986, the insecticide *viz.* 0.02 per cent fenvalerate, 0.07 per cent endosulfan, 0.1 per cent carbaryl and 0.07 per cent phosalone were applied once in sprays 50 days after sowing, alone or (at lower concentration) in combination with 0.25% diflubenzuron. Larval counts taken before and 2 and 7 days after treatment showed that effective control of the noctuid could be achieved by applying insecticides at low doses in combination with diflubenzuron. They also suggested that at two days after spraying fenvalerate 0.02% was the most effective with 82.94 per cent reduction of larval population of *A. janata*, while diflubenzuron 0.025% was the least effective with 19.03 per cent mean reduction.Senapati and Dash (1989) evaluated the efficacy of twelve insecticide against *A. janata* at the Regional Research Station Keonjhar, Orissa. They observed that the best control of the semilopper and higher seed yield was obtained with endosulfan 0.5 k.g a.i. / ha when sprayed thrice at 21 days interval from 48 days after sowing of castor. Leaf infestations were also significantly reduced by permethrin (0.1 kg a.i. /ha) and carbaryl (1.0 kg a.i. /ha).

Balikai *et al.* (1996) reportedthat endosulfan 35 EC/ha, fenvalerate 0.4% dust/ha, fenvalerate 20 EC/ha and methyl parathion 50 EC/ha were found to be effective in controlling *A. janata*at Karnataka.Swaran(1998) evaluated the relative toxicity of emulsions of various pyrethroids and non-pyrethroid insecticides against the *A. janata* larvae in the laboratory. On the basis of LC_{50} values, lambda-cyhalothrin, cypermethrin, deltamethrin, fenpropathrin, fenvalerate, methyl parathion and pyrethrin were 240.4, 64.7, 51.4, 23.9, 17.6, 7.5, and 4.1 times more toxic than endosulfan, respectively. Malathion and lindane were less toxic than endosulfan i.e. about 0.67 and 0.64 times, respectively as toxic as endosulfan.Ahuja *et al.* (1998) tested nine insecticides 0.07% endosulfan 35 EC, 0.025% quinalphos 25 EC, 0.05% phenthoate 50 EC, 0.05 fenitrothion 50 EC, 0.07% phosalone 35 EC, 0.036% monocrotophos 36 WSC, 0.01% fenvalerate 20 EC, 0.05% methyl parathion 50EC and 0.005% cypermethrin 10 EC. All the insecticides under field conditions were found effective against the pest. Monocrotophos, quinalphos, fenvalerate and methyl parathion had quick knock-down effect as 100% kill of the larvae was obtained within 24 h of feeding on treated castor leaves. Chakraverty (1999) reported that the acephate @ 0.75 to 1.0 kg/ha to be highly effective in controlling castor semilooper and found to be safer to bees, pollinators and natural enemies.

Basappa and Lingappa (2004) studied on the toxicity of thirteen insecticides to *A. janata* under field conditions in Dharwad, Karnataka. The treatments were: endosulfan 35 EC at 0.07%, methyl parathion 50 EC at 0.05%, monocrotophos 36 SL at 0.05%, profenofos 50 EC at 0.03%, quinalphos 20 AF at 0.05%, acephate 75 WP at 0.08%, phosalone 35 EC at 0.07%, fenvalerate 20 EC at 0.01%, fenvalerate 0.4 D at 0.40%, alphamethrin [alpha-cypermethrin] 120 EC at 0.01%, mixture of cypermethrin (4%) + profenofos (40%), methomyl 24 L at 0.006%, carbaryl 42% at 0.17% and untreated control. Fenvalerate 20 EC at 0.01% was superior among the treatments in controlling the pest at 12 days after spraying, followed by profenofos, cypermethrin + profenofos, methomyl 24 L, acephate 75 WP and methyl parathion. Quinalphos was the least effective. All the treatments produced higher yields compared to the control. Narayanamma *et al.*(2010) evaluated the newer insecticides for the management of defoliator of castor during *Kharif* 2007-08 and 2008-09. Spinosad 0.018% and indoxacarb 0.015% proved their superiority over other treatments. Both the insecticides spinosad and indoxacarb gave 100 per cent mortality on the one, three and seven days after first spray. Thiodicarb 0.075% gave 66.7, 76.7 and 100 per cent mortality on the one, three and seven days after first spray. Novaluron 0.01% gave 48.3, 83.3 and 100 per cent mortality on the one, three and seven days after first spray. Deltamethrin 0.003% gave 26.7, 66.7 and 66.7 per cent mortality on the one, three and seven days after first spray.

CHAPTER-III

MATERIALS AND METHODS

The present studies on "**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop**" were carried out at the experimental area of Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal, District: Rewari, during the *kharif* season, 2013-14. The materials used and methods adopted for studying different aspects *viz*. seasonal abundance, incidence, biology and chemical control of castor semilooper are as under:

3.1. Seasonal abundance and incidence of castor semilooper

3.1.1. Location

The present study on seasonal abundance and incidence of castor semilooper was carried out under agro-climatic conditions of South West Haryana at Bawal which is situated at 28º 10 North Latitude, and 76 º 35 East Longitude with Altitude of 229 m above Mean sea level. The mean annual rainfall of Bawal is about 569.61 mm. Meteorological data of temperature, relative humidity and rainfall recorded for the Bawal location during studies conducted have been given in the Annexure- I.

3.1.1. Sowing operations

The experiment field was prepared by ploughing once by mould board plough followed by cross harrowing and planking. Thereafter, all the plots were demarcated according to the plan of layout with provision of irrigation channels (Fig. 1). The seed of castor crop hybrid "DCH 177" was procured from the All India Co-ordinated Research Project on Castor, CCSHAU, Regional Research Station, Bawal. The seed was soaked in water for 24 hours before sowing. The sowing of castor crop was done on July 6, 2013 at experimental area of Regional Research Station, Bawal by hand dibbling method by dibble 2 seed in each dibble and distance of 120 cm between row to row (Plate 1). Thinning was done ten days after crop germination and maintaining plant to plant distance of about 60 cm. All the recommended agronomical practices of CCSHAU, Hisar were followed to grow the good crop except insect pest management through use of insecticides.

3.1.2. Observations of population abundance and incidence of castor semilooper

For studying the seasonal incidence and population of castor semilooper thirty plants were randomly selected and tagged for the observation and frequent visits were made in order to record the first incidence of castor semilooper larvae infesting castor crop. The incidence of castor semilooper was noticed on 23 July, 2013 (Plate 2).The observations were recorded at morning at weekly intervals. The observations were continued till the population of castor semilooper declined upto zero level, which was recorded on 25st November, 2013.

Plate 1: Castor crop sown for present studies

Plate 2: Incidence of castor semilooper on castor crop

3.1.3. Percentage incidence of castor semilooper on castor

For per cent seasonal incidence of larvae of castor semilooper, infested castor crop plants were recorded from each plots then calculated the percentage incidence by using the following formula

$$\text{Per cent incidence} = \frac{\text{Number of infested plant}}{\text{Total number of plants}} \times 100$$

Meteorological data on temperature ºC (maximum and minimum),per cent relative humidity (morning and evening) and rainfall (mm/ week) were obtained from the Regional Research Station, Bawal, Rewari. The data thus obtained, were statistically analysed to determine the correlation coefficient (r) value between the larval abundance and incidence of *A. janata* and the meteorological variables (abiotic factors).

3.2. Biology of castor semi-lopper

The various biological parameters of *A. janata* were studied in the laboratory conditions at average room temperature (33.79ºC max. and 23.61ºC min.) and per cent relative humidity (84.80 morning and 56.02 evening) on Castor (DCH-177) from 1st August to 15th September, 2013. The food for larvae was obtained from the same hybrid of castor which was sown in the research area, Bawal. Initially a good number of full grown larvae of *A. janata* were collected from the unsprayed plot. The field collected larvae were reared in battery jars (20× 15 cm), in laboratory. Castor leaves were provided as larval food which was changed daily in morning. The pupae were obtained from these reared larvae. The freshly formed pupae were transferred into separate jars for the emergence of adults. These jars were covered with muslin cloth and labelled the date of formation of pupae.

All further observations on biology of *A. janata* were carried out simultaneously on the adult obtained from these jars. The observations on adult longevity, pre-oviposition, oviposition, post-oviposition periods, fecundity, sex ratio and adult emergence were made on ten pairs of newly emerged male and female adults. The newly emerged moth were segregated into male and female on the basis of morphological characters of pupae and adults. One pair of moth (male and female) were released in each battery jar, containing fresh leaves and paper strips for egg laying. Cotton swabs dipped in five per cent honey solution were suspended with the help of U –pins on the top in the hanging position. The cotton wool swab were replaced daily. The glass jars were kept closed by a piece of muslin cloth with the help of the rubber band. The egg laid by female moths on the leaves, paper strips, walls of battery jars and on muslin cloth were removed gently with the help of moist camel brush and kept for observing incubation period, larval period and pupal period .

3.2.1. Pre-oviposition period

The observation on pre-oviposition period were taken on ten gravid females. The pre-oviposition period was recorded as the duration in days after the adult emergence till the start of oviposition. The paper strips and leaves of castor were replaced and examined daily with the help of hand lens for egg deposition and thus average pre-oviposition period for these females was calculated.

3.2.2. Oviposition period and fecundity

The oviposition period of a female was taken as the duration in days from the day it laid the first egg till egg laying was stopped. Observation on oviposition period were also made on gravid females which were used for pre- oviposition periods. For this purpose, paper strips and leaves of castor were replaced in battery jars after every 24 hours (Plate 6). The paper strips and leaves of castor were examined with the help of hand lens and eggs laid by a female every day were recorded during its oviposition period. The total fecundity of each female was recorded during its oviposition period and thus, average oviposition period and fecundity of these females were calculated.

3.2.3. Post- oviposition period

The duration in days when egg laying by a female was stopped till its death was taken as the post-oviposition period. Ten female moths were used for determining of post-oviposition period and thus, average post-oviposition period was calculated.

3.2.4. Adult longevity

The duration of adult life was recorded from the day of emergence of adults till their death. Five percent honey solution was provided as food. Ten moths of both the sexes were observed for recording their longevity and thus, average longevity for both the sexes was calculated (Plate 5).

3.2.5. Incubation period

The Incubation period was counted as the duration in days after egg laying till their hatching. For finding out the incubation period ten Peteri-dish, having 50 eggs each were observed and thus, average incubation period was calculated. The newly emerged larvae were transferred into jars for studying the larval instars and duration.

3.2.6. Larval period and numbers of instars

The larval duration was recorded as the duration in days from the hatching of eggs till the formation of pupae. The newly hatched larvae of *A. janata* were individually placed in separate jars having castor leaves as a source of food (Plate 3). The food was replaced daily. To find out duration of different larval instars, observations were made on casting of exuvae daily and thus, the duration of different larval instars and total larval period were recorded.

Plate 3: Larva of castor semilooper

Plate 4: Pupa of castor semilooper

Plate 5: Adult of castor semilooper

Plate 6: Egg laying cage of castor semilooper

3.2.7. Pupal period

The time taken from initiation and pupa formation till emergence of moths was considered as pupal period. For observing the pupal period we placed pupae in ten jars and each jars containing twenty pupae and average pupal periods were also calculated (Plate 4).

3.2.8. Sex ratio

The sex ratio was determined by examining the pupae and it was later confirmed by adult emergence. Dani *et al.* (1980) prescribed the method to differentiate the male and female pupae on the basis of distance between the genital and anal aperture. The distance between these two apertures is less in case of male and more in case of female. In the adult, the ventral side reveals some differences. The posterior part of abdomen is narrow and tapering in the female while it is uniformly broad throughout its length in the male. For observing sex ratio, puape were placed in ten jar and each jar containing twenty pupae and the sex of adult was later conformed after the adult emergence from these pupae.

3.3. Bio-efficacy of different insecticides against castor semilooper

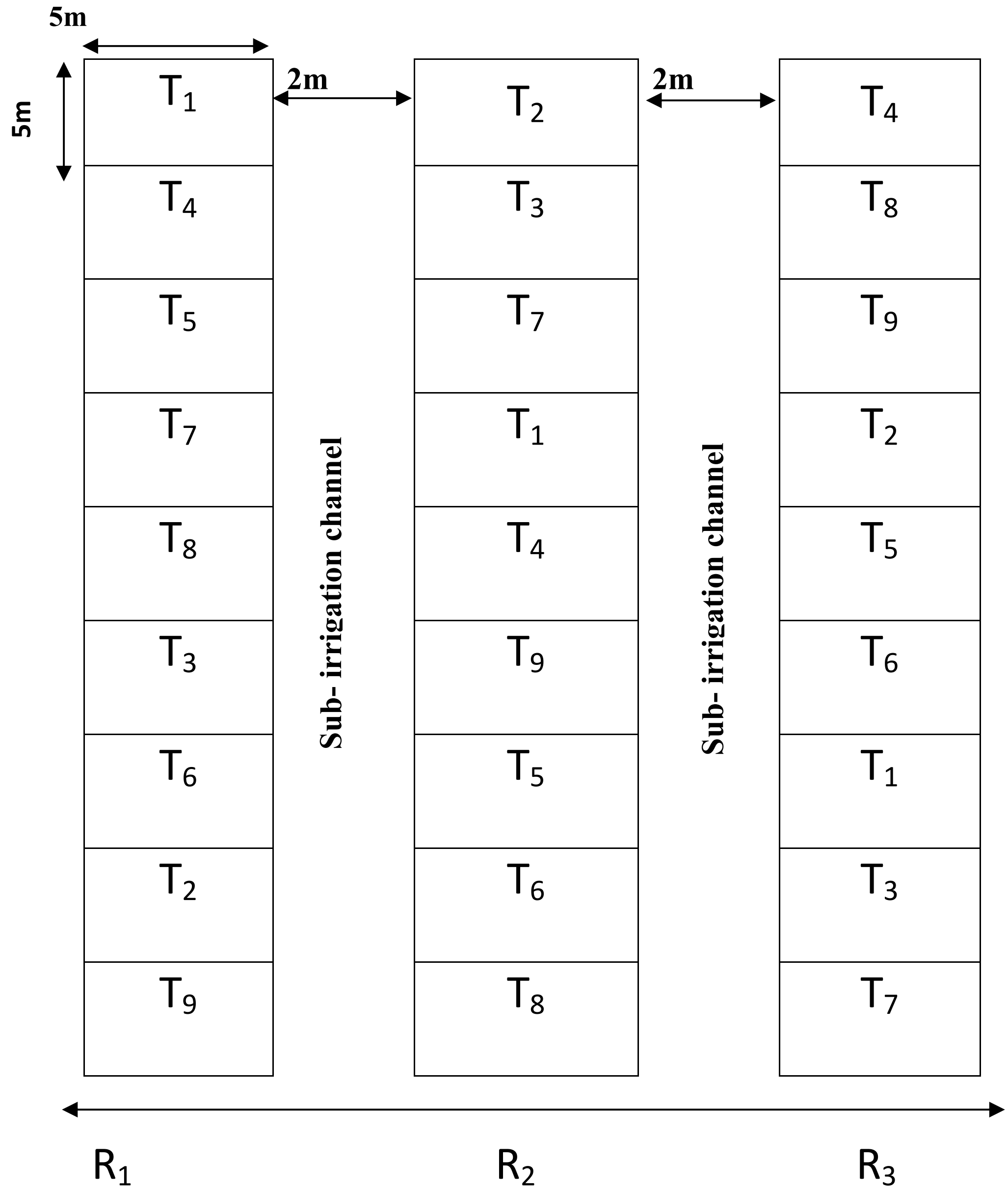
Studies on the bio-efficacy of different insecticides against castor semilooper were carried out under the field condition on the crop sown at experimental area of Regional Research Station, Bawal. There were nine treatments including the control (given in Table 1) and all the treatments were replicated thricely. The size of each plot was 5 x 5 meter with two meter inter-plot distance.

Table 1. Insecticides used for evaluation of their efficacy against *A. janata* on castor

Sr. No	Treatments	Dosage (ga.i./ha)	Chemical name
1	T_1- Rimon10 EC (Novaluron)	75	1-[3chloro-4-(1, 1, 2-trifloro-2- trifluoromethoxy ethoxy) phenyl] -3-(2, 6-diflurobenzoyl) urea.
2	T2- Rimon10 EC (Novaluron)	100	1-[3chloro-4-(1, 1, 2-trifloro-2- trifluoromethoxy ethoxy) phenyl] -3-(2, 6-diflurobenzoyl) urea.
3	T3- Larvin 75 WP (Thiodicarb)	375	dmethyl n, n^1 – thio bis (methylimino) Carbonyloxy bis ethanimidothioate.
4	T4- Larvin 75 WP (Thiodicarb)	468	dmethyl n, n^1 – thio bis (methylimino) Carbonyloxy bis ethanimidothioate.
5	T5- Ekalux 25 EC (Quinalphos)	200	O, O- diethyl-O-(quinoxalinyl -2–yl phosphorothioate.
6	T6- Ekalux 25 EC (Quinalphos)	250	O, O- diethyl-O-(quinoxalinyl -2–yl phosphorothioate.
7	T7- Decis2.8 EC(Deltamethrin)	10.5	α,cyano-3-phenoxy benzyl-3-(2, 2-dibromovinyl)-2,2-dimethylcy-clopropane, carboxylate.
8	T8- Decis2.8 EC(Deltamethrin)	11.2	α,cyano-3-phenoxy benzyl-3-(2, 2-dibromovinyl)-2,2-dimethylcy-clopropane, carboxylate.
9	T9- Control (No spray)	-	-

LAYOUT PLAN OF EXPERIMENT

MAIN IRRIGATION CHANNEL



Gross plot size= 5m x 5m= 25 sq.m
Net plot size= 4.8m x 4.8m=23.04 sq.m
Sub irrigation channel= 2 m
Plant to plant distance= 60 cm
Row to row distance= 120 cm

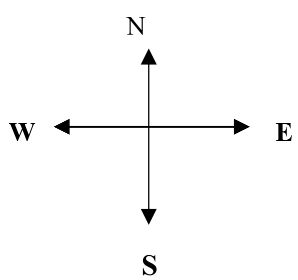


Fig.1: Layout plan of Experiment (Bio efficacy of different insecticides against castor semilooper)

Only one foliar application of different insecticides were applied with knapsack sprayer, on September, 23 when the castor semilooper population cross the economics threshold level which is 4-5 larvae per plant. Second spray was not made because after first spray of insecticides the castor semilooper larvae population remains below the economics threshold level.

3.3.1. Observation of castor semilooper before and after spray

The larval population recorded one day prior to spraying and population of larvae was counted after the first, third and seven day after spraying. The larval population data was recorded on 5 randomly selected and tagged plants in each treatments. The per cent reduction in the larval population was calculated with the help of formulae given by (Singh, 1986).

Per cent reduction of larvae = $\frac{Y'-Y}{Y} \times 100$

Per cent increase of larvae = $\frac{Y-Y}{Y'} \times 100$

Y=Mean number of larvae in treated plot.

Y'= Mean number of larvae in untreated (control) plot.

The percentage were transformed in angular transformed value for statistical analysis.

3.3.2. Economics of treatments on castor

To determine the most effective treatment, the economics of various treatments was worked out by taking the expenditure of individual treatment and the returns in terms of corresponding increased yield into account. Further, benefit cost (B: C) ratio was calculated to understand the benefit over the cost involved for each treatment.

CHAPTER-IV

EXPERIMENTAL RESULTS

The results of the present investigation entitled "**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop**" are presented under the following headings:

4.1. Seasonal abundance and incidence of castor semilooper

4.2. Biology of castor semilooper

4.3. Bio-efficacy of different insecticides against castor semilooper

4.1.1. Seasonal abundance and incidence of castor semilooper

Population dynamics studies on *A. janata* larvae in relation to meteorological parameters such as maximum and minimum temperatures, relative humidity and rainfall were conducted during 29th to 47th standard meteorological weeks (SMW) (16 July to 25 November) (Table 2). It revealed that the larval population fluctuated from 0.2-6.2 larvae per plant. The first appearance of larvae of *A. janata* was started from the 30th SMW and the population increased onward and reached to 6.1 on 32nd SMW and then the larval population decreased till the 37th SMWagain it was increased rapidly, the maximum number of larvae were found during 38th SMW. The larval population of *A. janata* were declined from 39th SMW onwards and reached to 0.2 on 46th SMW and becomes almost zero in 47th SMW.

Rainfall occurred during the 29th to 34th SMW and then 37th to 41st SMW. Rainfall was recorded highest on the 32nd and 38th SMW, which were 158.7 and 120.4 mm, respectively, whereas the larval population recorded during these standard meteorological weeks were maximum 6.1 and 6.2 larvae per plant, respectively. As the rainfall declined during 35th to 37th SMW the larval population were also decreased. This showed a positive and significant correlation (r =0.650) between larval population and rainfall.

The minimum temperature fluctuated from 25.2 to 6.2ºC, as the minimum temperature decreased on the 39th to 46th SMW, which decreased from 23.8- 6.2º C and the larval population were also decreased from 5.3 to 0.2 larvae per plant, respectively, during these SMW (Fig. 2). This showed a significant correlation (r = 0.588) between larval population and minimum temperature (Table 2).

Table 2. Larval population and incidence of *A. janata* on castor *vis a vis* weather parameters

Standard Meteorological weeks	Mean* larval population / plant	Mean per cent incidence	Temperature (º C)		Relative Humidity (%)		Rainfall (mm)
			Maximum	Minimum	Morning	Evening	
29	0.0	0.0	34.3	25.1	86.0	61.0	20.5
30	1.2	4.4	34.4	25.2	88.9	64.6	48.0
31	3.1	13.3	33.7	24.0	91.1	66.6	21.5
32	6.1	25.6	32.1	24.1	90.9	69.3	158.7
33	5.3	26.7	31.4	24.4	93.0	69.0	68.0
34	4.6	31.1	32.9	23.7	86.1	60.0	16.7
35	2.5	32.2	34.2	24.1	80.3	52.1	0.0
36	2.4	34.4	35.9	22.4	75.0	39.4	0.0
37	2.3	35.6	36.7	22.6	78.1	36.4	3.5
38	6.2	42.2	33.9	21.0	80.4	44.7	120.4
39	5.3	41.1	33.1	23.8	84.4	53.7	9.2
40	4.4	40.0	32.6	21.9	79.1	54.6	9.0
41	3.9	37.8	31.6	20.4	81.0	55.4	91.3
42	2.8	34.4	33.1	17.6	82.0	33.0	0.0
43	1.6	31.1	31.5	14.4	81.7	21.1	0.0
44	0.8	25.6	31.4	13.1	79.4	29.4	0.0
45	0.5	16.7	25.2	10.5	78.1	28.1	0.0
46	0.2	12.2	24.6	6.2	76.1	29.4	0.0
47	0.0	5.6	27.6	6.7	76.1	28.9	0.0
Correlation values (r) for larval abundance			0.373^{α}	0.588***	0.466^{α}	0.577**	0.650***
Correlation values (r) for per cent incidence			0.362^{α}	0.270^{α}	-0.194^{α}	-0.062^{α}	0.150^{α}

*= Based on 90 plants (30 plants in 3 repeats), **=Correlation is significant at 0.01 level,
***= Correlation is significant at 0.05 level, α = Non-significant.

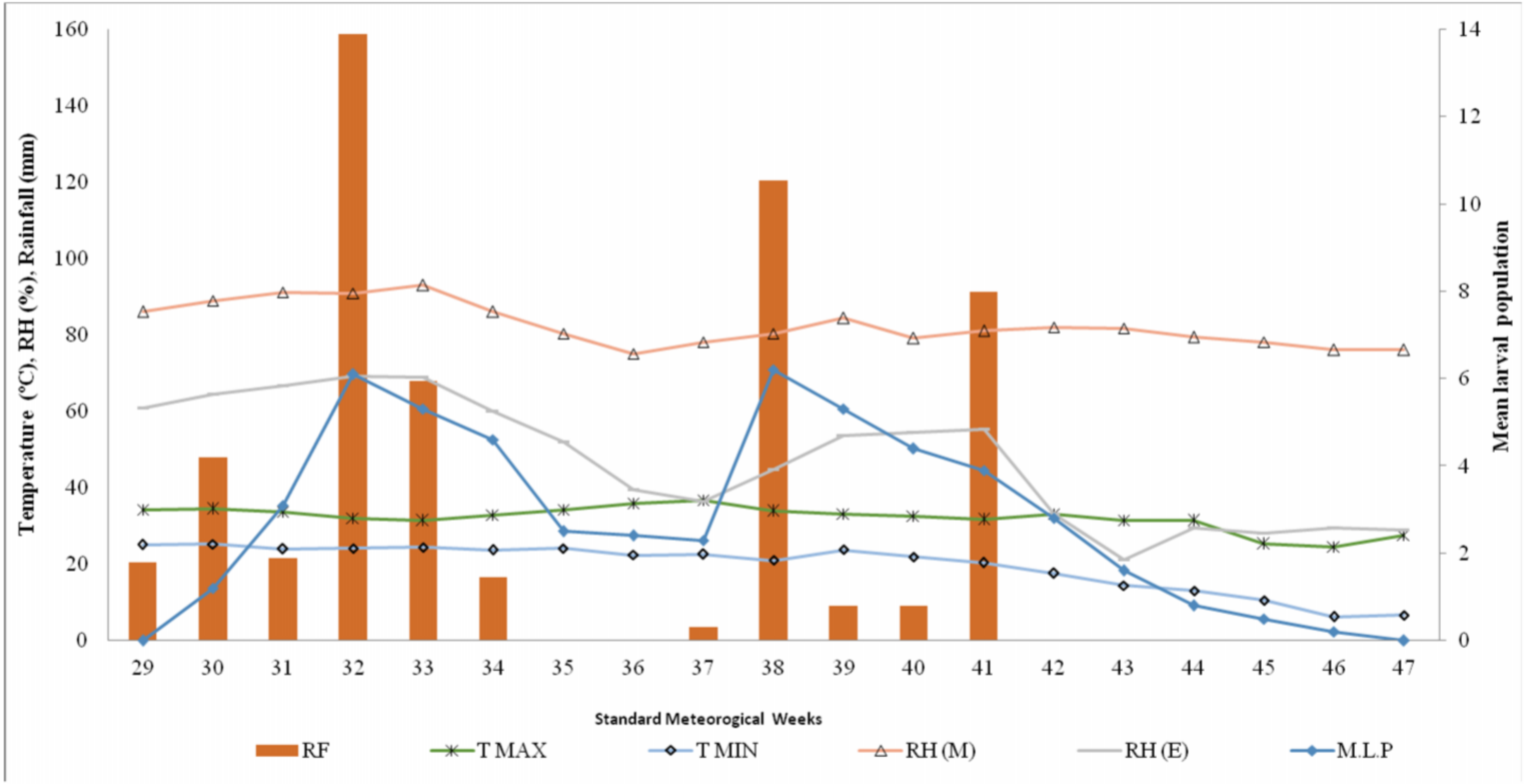


Fig.2. Mean larval population of castor semilooper and weather parameters

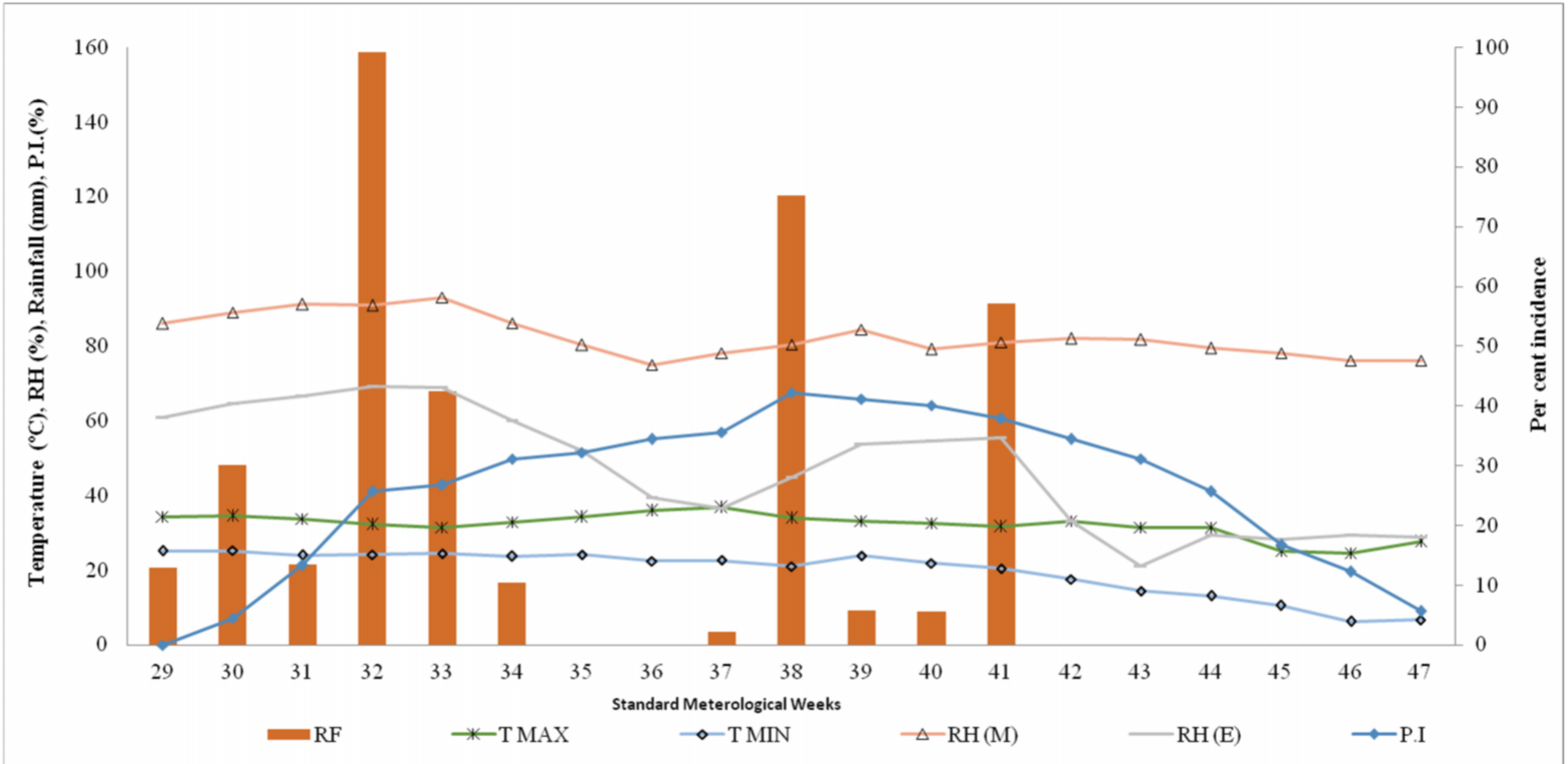


Fig.3. Per cent incidence of castor semilooper and weather parameters

The per cent relative humidity in the evening fluctuated from 69.3 to 21.1. The maximum evening relative humidity was recorded 69.3 per cent during the 32nd SMW, during this weeks the larval population was 6.1 larvae per plant. As the relative humidity decreased from 34 to 37th SMW and again from 41 to 47th SMW, the larval population were also decreased during this period indicated that a positive and significant correlation (0.577) between larval population and evening relative humidity.

The per cent infestation ranged from 4.4 to 42.2 per cent. No relationship were observed between the larval population and maximum temperature or morning relative humidity.

4.2. Biology of castor semilooper

Table3. Pre-oviposition, oviposition, post-oviposition and fecundity per female of *A.janata*on castor

Number of female	Pre-oviposition period (days)	Oviposition period (days)	Post-oviposition period (days)	Fecundity per female
1	3	4	3	314
2	1	7	3	343
3	3	5	5	323
4	3	4	3	407
5	2	5	4	375
6	3	6	3	342
7	2	5	4	326
8	3	4	3	347
9	1	5	6	370
10	2	5	3	365
Mean ± S.D.	2.3 ±0.78	5.1± 0.89	3.7± 1.00	351.2±26.84
Range	1-3	4-7	3-6	314-407

4.2.1. Pre-oviposition, oviposition, post-oviposition periods and fecundity per female of castor semilooper on castor

The data of pre-oviposition, oviposition, post-oviposition and fecundity per female of castor semilooper are presented in Table 3.The data revealed that the pre-oviposition period of female moth of castor semilooper varied from 1 to 3 days with an average of 2.3 days. The oviposition period of castor semilooper varied from 4 to 7 days with an average of 5.1days, while the post-oviposition period of *A.janata* varied from 3 to 6 days with an average of 3.7 days on castor. A single female of castor semilooper laid maximum of 407 eggs with a minimum of 314 eggs with an average of 351.2 eggs per female during her life time. The freshly laid eggs were green in colour and round in shape. It was observed that most of the eggs were deposited during night or in dark places created by wrapping the rearing jars with paper. The eggs were laid singly on leaves, muslin cloth, as well as paper strips supplied for the purpose in the battery jars under laboratory conditions.

Table 4. Adult longevity and incubation period of *A. janata* on castor

	Adult longevity (Days)*		Incubation period(days)**
Replication	**Male**	**Female**	
1	9.2	10.1	2.6
2	9.7	10.8	2.4
3	10.1	12.4	2.2
4	8.7	10.5	2.7
5	9.3	11.7	2.1
6	8.9	10.7	2.3
7	9.6	11.8	2.4
8	9.3	10.1	2.1
9	9.1	12.6	2.3
10	9.8	11.3	2.1
Mean ±S.D.	9.37± 0.40	11.2± 0.85	2.32± 0.20
Range	8.7-10.1	10.1-12.6	2.1-2.7

*** Based on 10 individuals observed per repeats, ** Based on 50 eggs observed per repeat.**

4.2.2. Adult longevity

The data pertaining to adult longevity of *A. janata* are shown in Table 4. The data revealed that longevity of male varied from 8.7 to 10.1 days on an average of 9.3 days while the female longevity varied from 10.1 to 12.6 days with an average of 11.2 days. Hence, the female lived slightly longer (11.2 days) than males (9.37 days).

4.2.3. Incubation period

The data on incubation period of castor semilooper presented in the Table 4. It is evident from the results that incubation period ranged from 2.1 to 2.7 days with an overall average of 2.32 days under laboratory conditions.

4.2.4. Duration of larval instars and total larval period

The observations on numbers of larval instars, their durations and larval period are presented in the Table 5.

Table 5. Duration of different larval instars and total larval period of *A. janata* on castor

Replication	Mean duration* of larval instars of *A. janata* (days)					Mean* larval period (days)
	I	II	III	IV	V	
1	1.5	1.8	2.0	2.1	4.1	11.5
2	1.4	1.6	2.2	2.3	4.2	11.7
3	1.2	1.9	2.3	2.6	4.4	12.4
4	1.8	1.7	2.2	2.2	4.7	12.6
5	1.6	1.5	2.1	2.3	4.1	11.6
6	1.4	1.6	1.8	2.1	4.0	10.9
7	1.8	1.7	2.3	2.4	4.6	12.8
8	1.4	2.0	1.8	2.1	4.4	11.7
9	1.3	1.5	2.4	2.5	4.3	12.0
10	1.6	1.7	1.9	2.4	4.2	11.8
Mean ±S.D.	1.5 ± 0.19	1.7 ± 0.15	2.1 ± 0.20	2.3 ± 0.17	4.3 ± 0.21	11.9 ± 0.54
Range	**1.2-1.8**	**1.5-2.0**	**1.8-2.4**	**2.1-2.6**	**4.0-4.7**	**10.9-12.8**
***Based on 10 larvae observed per repeat.**						

It revealed that larval stages of *A. janata* passed through five instars, before transforming into pupal stage. The first larval instar took 1.2 to 1.8 days to become second instar with an average of 1.5 days on castor leaves. The second instars larvae moulted to third instar in 1.5- 2.0 days with an average of 1.7 days. Similarly, the duration of third instar was observed to be 1.8- 2.4 days with an average of 2.1 days. Fourth and fifth instar larvae took 2.1 to 2.6 and 4.0 to 4.7 days with an average of 2.3 and 4.3 days, respectively. The total larval period was ranged from 10.9 to 12.8 days with an average of 11.9 days.

4.2.5. Pupal period

The mean pupal period of *A. janata* ranged between 8.3 to 9.6 days with an overall average of 8.95 days (Table 6). It was noticed that the larvae of *A. janata* pupated inside the castor leaves and also even on the muslin cloth. The pupa is brownish in colour and is covered with a whitish powdery substances.

4.2.6. Sex ratio

The data presented in the Table 6 showed that the number of male and female obtained indicated that the males were outnumbered the females. The male to female sex ratio was 1: 0.85.

Table 6. Pupal period, sex ratio and percent adult emergence of *A. janata*on castor

Replication	Mean pupal period (days)*	Sex ratio**		Per cent adult emergence**
		Number of male obtained	Number of female obtained	
1	9.1	12	8	100
2	8.5	11	9	95
3	9.3	13	7	95
4	8.6	10	10	100
5	8.3	12	8	90
6	9.4	8	12	100
7	8.5	11	8	90
8	9.6	10	10	95
9	9.3	10	11	95
10	8.9	11	9	90
Mean ±S.D.	8.95±0.43	10.8± 1.33	9.2± 1.47	95
Range	8.3-9.6	1.00	0.85	90-100
***Based on 20 pupae observed per repeat, ** Based on 20 individual observed**				

4.2.7. Per cent adult emergence

Adult emergence data was presented in the Table 6 which showed that adult emergence ranged from 90-100 per cent with an average of 95 per cent adult emergence.

4.3 Bio-efficacy of different insecticides against *A. janata* infesting castor crop

It is evident from the data given in Table 7 that all the insecticides proved better than the control at all the intervals of observations. The effectiveness of the insecticides increased with the intervals of time after spraying.

The perusal of data presented in the Table 7 suggested that at one day after spraying thiodicarb @ 468 g proved to be best toxicant causing 60.64 per cent mean reduction in the larval population, which was at par with thiodicarb @ 375 g and deltamethrin @ 11.2 g as their application resulted in 58.75 and 58.27 per cent mean reduction in the larval population. Deltamethrin @ 10.5 g caused mean larval reduction of 55.87 per cent which was at par with quinalphos @ 250 g(53.19%). However, quinalphos @ 200 g caused 51.69 per cent larval reduction which was at par with novaluron @ 100 g (48.85%). Though, novaluron @ 75 gm was the least effective with 46.05 per cent mean reduction in larval population after first day of spray. However, all the treatments were significantly superior to control which recorded 1.13 per cent mean increase of larvae population.

At three days after spraying, it was found that novaluron @ 100 g was the most effective with 82.55 per cent mean reduction in the larval population which was at par with novaluron @ 75 g causing 81.94 per cent mean reduction in the larval population. Similarly, thiodicarb @ 468 g caused larval reduction of 73.66 per cent which was at par with deltamethrin @ 11.2 g and thiodicarb @ 375 g which caused 71.88 and 71.35 per cent mean reduction in the larval population, respectively. Deltamethrin @ 10.5 g caused 68.10 reduction in larval population which was at par with quinalphos @ 250 g which reduced 65.30 per cent larval reduction. Quinalphos @ 200 g was the least effective with 62.22 per cent mean reduction in larval population. However, all the treatments were significantly superior to control which recorded 1.87 per cent increase in larval population (Table 7).

Table 7. Bio-efficacy of different insecticides against *A. janata* infesting castor

Treatment	**Mean number of larvae before spray**	**Mean* % larval reduction (Days after spray)**			**Pooled mean per cent larval reduction**
		1	**3**	**7**	
Novaluron 10 EC @75 g a.i. per ha	5.80	46.05 (42.71)	81.94 (64.87)	90.85 (72.45)	72.95 (59.97)
Novaluron 10 EC @100 g a.i. per ha	5.73	48.85 (44.32)	82.55 (65.29)	96.51 (79.20)	75.97 (62.94)
Thiodicarb 75 WP @ 375 g a.i. per ha	5.67	58.75 (50.04)	71.35 (57.62)	80.81 (64.05)	70.30 (57.21)
Thiodicarb 75 WP @ 468 g a.i. per ha	5.60	60.64 (51.13)	73.66 (59.20)	82.13 (64.97)	72.14 (58.40)
Quinalphos 25 EC @ 200 g a.i. per ha	5.67	51.69 (45.95)	62.22 (52.09)	72.00 (58.09)	61.97 (52.01)
Quinalphos 25 EC @ 250 g a.i. per ha	5.40	53.19 (46.81)	65.30 (53.92)	74.06 (59.39)	64.18 (53.35)
Deltamethrin 2.8 EC @ 10.5 g a.i. per ha	5.67	55.87 (48.36)	68.10 (55.63)	75.20 (60.16)	66.39 (54.68)
Deltamethrin 2.8 EC @11.2 g a.i. per ha	5.73	58.27 (49.75)	71.88 (58.02)	79.16 (62.83)	69.77 (56.84)
Control (No spray)	5.80	1.13** (6.09)	1.87** (7.73)	2.24** (8.61)	1.74** (7.52)
SE(m)	0.17	1.01	1.36	1.06	2.96
C.D.	NS	3.02***	4.10***	3.21***	(8.95)***
Figures in parentheses are angular transformed values					
Based on 5 plants /repeat ** per cent increase					
*** Significant at 0.05 probability levels, NS= Non-Significant					

At seven days after spraying, novaluron @ 100g was found most effective with 96.51 per cent mean reduction in the larval population, while quinalphos @ 200 g was the least effective with 72.00 per cent mean larval reduction. Novaluron @ 75 g caused 90.85 per cent larval reduction, while thiodicarb @ 468 g caused 82.13 per cent larval reduction which was at par with thiodicarb @ 375 g and deltamethrin @ 11.2 g which caused 80.81 and 79.16 per cent larval reduction, respectively. Deltamethrin @ 10.5 g results in 75.20 per cent larval reduction which was at par with quinalphos @ 250 g and quinalphos @ 200 g which caused 74.06 and 72.00 per cent reduction in larval population, respectively. However, all the treatments were significantly superior to control which recorded 2.24 per cent increase in larval population.

On the basis of mean per cent reduction in larval population at different intervals after spraying of insecticides, it is evident that all the insecticides proved significantly better than control. Novaluron @ 100 g recorded significant mortality over other treatments. Novaluron @ 100 g was at par with novaluron @ 75 g, thiodicarb @ 468 g, thiodicarb @ 375 g and deltamethrin @ 11.2 g with their mean larvae mortality ranged 75.97 to 69.77 per cent. Deltamethrin @ 10.5 g caused 66.39 per cent larval reduction which was at par with quinalphos @ 250 g and quinalphos @ 200 g which causes 64.18 and 61.97 per cent mean reduction in larval population.

Table 8. Economics of insecticides treatments against castor semilooper infesting castor hybrid DCH-177

Treatments	Cost of insecticides including labour charges /ha	Mean yield (kg/ ha)	Increased yield over control (kg/ ha)	Value of increased yield (Rs./ha)	Net profit (Rs./ha)	Benefit cost ratio
1	2	3	4	5	(5-2)= 6	(6÷2)=7
Novaluron10 EC @ 75 g a.i. per ha	615	3310	355	10650	10035	16.32
Novaluron 10 EC @100 g a.i. per ha	720	3383	428	12840	12120	16.83
Thiodicarb75WP @ 375 g a.i. per ha	1200	3233	278	8340	7140	5.95
Thiodicarb 75WP @ 468 g a.i. per ha	1425	3295	340	10200	8775	6.16
Quinalphos 25EC @ 200 g a.i. per ha	648	3087	132	3960	3312	5.11
Quinalphos 25EC @ 250 g a.i. per ha	735	3133	178	5340	4605	6.27
Deltamethrin 2.8EC @ 10.5 g a.i. per ha	544	3173	218	6540	5996	11.02
Deltamethrin 2.8EC @ 11.2 g a.i. per ha	560	3213	258	7740	7180	12.82
Control (No spray)	-	2955	-	-	-	-

1. The rate of insecticides
   1. Novaluron=Rs.420/litre
   2. Thiodicarb = Rs. 1800/ Kg
   3. Quinalphos = Rs. 435/ litre
   4. Deltamethrin = Rs. 650/litre
2. Labour charge @ Rs.300 /ha
3. Market rate of castor @Rs.3000 /q

*Only one spray is made at the economics threshold level (4-5 larvae per plant)

4.3.1.1. Economics and benefit cost ratio of insecticidal treatments

The data presented in the Table 8 showed that all the treatments gave profit over the control. The maximum yield (3383 kg/ ha) of castor seed was found in treatment where novaluron@ 100 g was sprayed with net profit of Rs. 12120/ ha and highest benefit cost ratio of 1: 16.83 closely followed by novaluron @ 75 g which gave net profit of Rs. 10650 /ha with a benefit cost ratio of 1:16.32. Thiodicarb @ 468 g followed the above two treatments with the net profit of Rs. 8775 /ha and gave the benefit cost ratio of 1: 6.16. The other treatments *viz*., deltamethrin @ 11.2 g, thiodicarb @ 375 g, deltamethrin @ 10.5 g, quinalphos @ 250 g and quinalphos @ 200 g gave net profit of Rs.7180, 7140, 5996, 4605 and 3312 per hectare with the benefit cost ratio of 1:12.82, 1:5.95, 1:11.02, 1: 6.27 and 1: 5.11, respectively.

CHAPTER-V

DISCUSSION

The castor semilooper, *A.janata* is one of the important pest of castor crop in many states of India, particularly in Haryana, it is a serious pest of castor. So far as little work had been reported on its population abundance, incidence, biology and its chemical control in Haryana. During the present investigations an attempt was made to study these aspects of castor semilooper. The results obtained in the present investigation are discussed in this chapter in the light of available literature with following heading.

5.1.1. Population abundance and incidence of castor semilooper

Studies conducted on population abundance of *A. janata* larvae in relation to meteorological parameters were conducted during 29th to 47th standard meteorological weeks (16 July to 25 November), indicated that population was significantly influenced by minimum temperature, evening relative humidity and rainfall exhibited a positive relationship with the larval population. The first appearance of larvae of *A. janata* was started from 30th SMW. The larval population increased onward and reached to 6.1 larvae per plant, this was due to the maximum rainfall (158.7 mm) and evening relative humidity (69.3 per cent) was recorded on 32nd SMW which favour the foliage growth of castor as well as the larval population of castor semilooper. The larval population declined from 33rd to 37th SMW which was due to the low rainfall during this period. After which the steep rise in the population of 6.2 larvae / plant was observed during the 38th SMW which was due to the high rainfall (120.4 mm). There after the larval population were declined from 39th SMW onwards and reached to 0.2 on 46th SMW and becomes almost zero in 47th SMW, this was due to the decrease in rainfall, minimum temperature and evening relative humidity (Table 2).

Apparently rainfall have direct influence on larval population though rainfall could affect the temperature and relative humidity. It was observed that larval population (6.1 and 6.2 larvae per plant) of castor semilooper increased rapidly due to the 158.7 and 120.4 mm rainfall in the 32nd and 38th SMW, which is in accordance with Magar (2006) who reported that increase in the larval population of *A. janata* was associated with increase in the rainfall. Whereas Madhuri *et al*. (2006) reported that rainfall was negatively correlated with the larval population of castor semilooper which may be due to the variation in the environmental condition and time period of investigation.

The evening relative humidity and population build up were observed to be positively correlated whereas morning relative humidity was negatively correlated with larval population of castor semilooper. The present findings are not at par with the findings of

Madhuri *et al*. (2006) and Rathod *et al*. (2009) that evening relative humidity was negatively correlated with the larval population of castor semilooper and morning relative humidity was positively correlated where the range between the morning and evening relative humidity was very low where as in Haryana condition the range was very high as discussed under result.

In relation to the minimum temperature, larval population declined as the temperature decreased which showed positive correlation whereas maximum temperature was non-significant with larval population of castor semilooper. The present findings are not in line with Madhuri *et al*. (2006) who reported the minimum temperature was significant and negative whereas the maximum temperature was non-significant and negative relationship. This variation was due to variable climatic condition prevailing at the time of investigation and the range between maximum and minimum temperatures.

The present findings on the mean per cent incidence revealed that per cent incidence caused by *A. janata* ranged from 4.4 to 42.2 per cent. The present findings are in conformity with that of Gaikwad and Bilapate (1992) recorded 36.4 per cent incidence on castor crop under field conditions.

5.2.1. Pre-oviposition, oviposition and post oviposition periods

The present investigation showed that the pre-oviposition, oviposition and post-oviposition periods of castor semilooper were 2.3, 5.1 and 3.7 days, respectively. The present findings are similar to that of earlier research workers, Karmawati and Tobing (1988), Gaikwad and Bilapate, (1993) who reported pre-oviposition period of 2.5 and 2 days, respectively. Whereas Basappa and Lingappa (2001b) reported the pre-oviposition period of 3-4 days, which might be due to the different rearing conditions and quality of food fed to the moth during the present investigations. The findings of oviposition period are close conformity with, Pande *et al.* (1967) and Gaikwad and Bilapate, (1993). The present findings of post- oviposition period are in close proximity with Gaikwad and Bilapate, (1993) and Basappa and Lingappa (2001b) who reported that the post-oviposition period of 3-6 days.

5.2.4. Fecundity per female of castor semilooper

The number of eggs laid varied from female to female. On an average a single female of castor semilooper laid 351.2±26.84 eggs with a range 314 – 407 eggs during her life span. Almost similar observations were made by Subramania, 1921; Grunwald, 1930; Pande, 1967; Vyas, 1994 and Bhaduria *et al.*, 2002. However, Karmawati and Tobing (1988) reported that the total number of progeny produced per female averaged 1305 which were exceptionally high. This had been attributed to different rearing conditions, quality of food provided by them.

5.2.5. Adult longevity

In the present investigation, the adult longevity of male varied from 8.7 to 10.1 days with an average of 9.37 days while the female longevity varied from 10.1 to 12.6 days with an average of 11.2 days indicating shorter life of males than the females. However, the present findings are in close proximity with Srivastava and Pande, 1966; Pande, 1967 and Holihosusr, 1985 whose reported that the males are short lived as compared to the females. The difference in adult longevity might be attributed to genetic make-up of the population. However, Karmawati and Tobing (1988) reported the adult longevity varied from 22 to 32 days. This wide variation in adult longevity might be due to variable rearing conditions prevailing at the time of investigation and different quality of food fed to the adult during the investigations.

5.2.6. Incubation period

The incubation period varied from 2.1 to 2.7 days with an average of 2.32± 0.20 days. These findings are in agreement with earlier researchers (Grunwald, 1930; Gaikwad and Bilapate, 1992; Khan 1946; Cherian and Basheer, 1947; Smee, 1962; Srivastava and Pande, 1966; Pande, 1967; Byale and Bilapate, 1990; and Bhaduria *et al.*, 2002) who reported the incubation period of castor semilooper ranged from 2-3 days. However, Pande *et al.* (1967), Karmawati and Tobing (1988) and Basappa and Lingappa (2001b) reported 3-5, 3-4 and 3-4 days, respectively as incubation period which differed with the results of present investigations. The variations in the incubation period can be attributed to the rearing temperature, R.H. and quality of food given to the larvae and adult of *A. janata* during the period of investigations.

5.2.7. Number of larval instars and their duration

According to Khan (1946), there were four larval instars of *A. janata* whereas, Srivastava and Pande (1966) reported five larval instars. Similarly Pande *et al*., 1967; Ramdev and Rao, 1979; and Byale and Bilapate, 1990 reported five instars of *A. janata* on castor leaves. According to Khan (1946), the first three instars were of equal duration (2 days) and fourth instar took longer duration (5-7 days) on castor leaves. Srivastava and Pande (1966) reported the first instar last for 1 to 2 days, second and third lasts for 1 to 3 days, fourth larval instar for 2 to 5 days and the fifth instar lasts for 2 to 5 days. These results are in close proximity with Ramdev and Rao (1979) reported a period of 5.45 days for 5^{th} larval instar. Byale and Bilapate (1990), reported duration of 1.54, 1.39, 1.60, 1. 55 and 4.40 days for I, II, III, IV and V instars, respectively.

The result of present studies revealed that the larvae of *A. janata* passed through five instars, before transforming into pupal stages and larvae took 1.5, 1.7, 2.1, 2.3 and 4.3 days during I, II, III, IV and V instars on castor leaves, respectively. The result of present investigation in relation to the number of instars and instars duration of *A. janata* on castor leaves are in agreement with earlier workers (Srivastava and Pande, 1966; Pande *et al*., 1967; Ramdev and Rao, 1979 and Byale and Bilapate 1990). However, four larval instars were reported by Khan (1946). This might be due to the different techniques adopted during rearing of *A.janata*.

5.2.8. Larval period of castor semilooper

The larval duration of *A. janata* in the present studies ranged from 10.9 -13 days with an average of 11.9 days and those are in agreement with the Khan, 1946; Smee, 1962; Srivastava and Pande, 1966; Pande *et al.*, 1967; Pant and Anand, 1975; Karmawati and Tobing, 1988; Byale and Bilapate, 1990; Gaikwad and Bilapate, 1993 and Bhaduria *et al.,* 2002 who observed larval duration of 12-13,9-15, 11-17, 10-16, 12-15, 8-12, 9-13, 11.71 and 10.38 days, respectively. However, Cherian and Basheer (1947) reported larval period of 9-23 days. These variations might be due to quality and quantity of food and environmental conditions in which larvae were reared.

5.2.9. Pupal period of castor semilooper

In the present investigation the pupal period of *A. janata* ranged between 8.3 to 9.6 days with an average of 8.95 days which is in agreement with Karmawati and Tobing,1988; Byale and Bilapate, 1990; and Basappa and Lingappa,2001b who reported that the pupal period varied from 8-10, 8.30 ± 1.12, and 9-11 days, respectively. In contrast to above findings, Khan (1946) reported that the pupal period of castor semilooper varies from 11 to 27 days. This variation in the pupal period might be due to the variation in temperature and different food provided to the larvae.

5.2.10. Per cent adult emergence

In present findings the adult emergence ranged from 90-100 per cent with an average of 95 per cent adult emergence. The present findings are similar to the work of Byale and Bilapate (1990) and Bhaduria *et al.* (2002) who reported per cent emergence ranged from 96.04 and 95.00 per cent, respectively.

5.2.11. Sex ratio

In present findings male and female ratio of moths emerged was 1: 0.85 indicating the preponderance of males. The present findings are similar to the findings of Srivastava and Pande (1966) who observed that the sex ratio was 1: 0.75 and reported that males slightly outnumbered than the female.

5.3.1. Bio-efficacy of different insecticides against *A. janata*

After one day of spraying of different insecticides on larvae of *A .janata*, it was found that thiodicarb @ 468 g was most effective insecticide, which gave 60.64 per cent mean reduction in the larval population, followed by thiodicarb @ 375 g (58.75%), deltamethrin @ 11.2 g (58.27%), deltamethrin @ 10.5 g (55.87%), quinalphos @ 250 g (53.19%), quinalphos @ 200 g (51.69%) novaluron @ 100 g (48.85%) and novaluron @ 75 gm (46.05%), respectively. One day after spray, thiodicarb gave maximum larval mortality due to the highly toxic in nature and contact poison of carbamates group of insecticides, whereas novaluron caused least reduction in larval population because of insect growth regulators in nature. The result of present investigation after one day of spraying was similar to work done by Narayanamma *et al.* (2010) who reported that thiodicarb gave more larval reduction (66.7%) after one day of spraying as compared to novaluron which gave 48.3 per cent larval reduction.

When larval reduction was recorded after 3 days of spraying, it was observed that novaluron 100 g was the most effective with 82.55 per cent mean reduction in the larval population, followed by novaluron @ 75 g (81.94%), thiodicarb @ 468 g (73.66%), deltamethrin @11.2 g (71.88%), thiodicarb @ 375 g (71.35%), deltamethrin @ 10.5 g (68.10%) quinalphos @ 250 g (65.30%), quinalphos @ 200 g (62.22%), respectively. Novaluron is a growth regulator, so larval mortality increased as increase in the time of spraying of insecticide. All the insecticides continued to give higher mortality of *A. janata* larvae whereas the novaluron gave maximum mortality after increase in the time duration due to growth regulator in nature. Similar findings were observed by Dalaya *et al.,* 1983; Basappa and Lingappa, 2004 and Narayanamma *et al.* (2010).

The data revealed that at seven days after spraying novaluron @ 100g was the most effective with 96.51 per cent mean reduction in the larval population, while quinalphos @ 200 g was the least effective with 72.00 per cent mean larval reduction. Thiodicarb @ 468 g caused 82.13 per cent larval reduction which was followed by thiodicarb @ 375 g (80.81%), deltamethrin @ 11.2 g (79.16%) deltamethrin @ 10.5 g (75.20%) quinalphos @ 250 g (74.06%) and quinalphos @ 200 g (72.00%), respectively. All the insecticides continued to give higher mortality of *A. janata* larvae after seven days of spraying. The findings are similar to findings of Dalaya *et al.,* 1983; Basappa and Lingappa, 2004 who observed that after exposure of larvae for longer time quinalphos was the least effective. Narayanamma *et al.*(2010) reported that novaluron and thiodicarb gave 100 per cent mortality of *A. janata* larvae, seven days after spraying.

5.3.1.1. Economics and benefit cost ratio of castor hybrid DCH-177 in different insecticidal treatments

Maximum yield (3383 kg/ha) of castor seed was found in the treatment where novaluron @ 100 g was sprayed and it was significantly superior over all other treatments. Benefit cost ratio indicated that all the treatments were cost effective than control, and novaluron @ 100 g was found to be most effective and economical (1:16.83) among all treatments. Very little information is available on the economics and seed yield in above insecticides treatments although, Basappa and Lingappa, (2004) reported that treatment differences in their efficacy was reflected in yield. All the treatments were superior in yield over control. Highest benefit cost ratio was found in fenvalerate which was (1: 13.80).

CHAPTER-VI

SUMMARY AND CONCLUSION

The present studies on "**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop**" were carried out at the experimental area of Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal, District: Rewari, during the *kharif* season, 2013-14.

Seasonal abundance/ incidence of castor semilooper *A. janata*

Population abundance studies on *A. janata* larvae in relation to meteorological parameters such as maximum and minimum temperatures, relative humidity and rainfall were conducted during 29th to 47th standard meteorological weeks (16 July to 25 November). The first appearance of larvae of *A. janata* was started from the 30th SMW. Initially the population was very low (0.2 larvae per plant) and increased abruptly and reached to the maximum (6.1 larvae per plant) in 32nd SMW. After this there was a decline in the population (2.3 larvae per plant) up to 37th SMW. Thereafter, the number of larvae reached to maximum (6.2 larvae per plant) during 38th SMW. After this population started decline and reached to 0.2 larvae per plant in 46th SMW and becomes almost zero in 47th SMW.

The first peak of larval population was recorded during the 32nd SMW (6.1 larvae per plant) and second was observed during the 38th SMW (6.2 larvae per plant). This may be attributed to high rainfall (158 and 120 mm) during this period 33rd to 37th SMW and 39th to 47th SMW, the population decline abruptly due to low rainfall and low evening relative humidity. Correlation indicated that minimum temperature, evening relative humidity and rainfall exhibited a positive relationship with the larval population.

The mean per cent incidence of *A. janata* was first noticed during 30th SMW on castor crop at Bawal. The incidence ranged from 4.4 per cent during 30th SMW and 42.2 per cent during 38th SMW. The maximum larval population (6.2 larvae per plant) was observed during the 38th SMW. As the larval population decreased from the 39th SMW onward the per cent incidence was also decreased. No significant correlation was observed between the per cent incidence and maximum and minimum temperature and morning and evening relative humidity and rainfall.

Biology of castor semilooper

The duration of egg stage varied from 2.1 to 2.7 days with an overall average of 2.32± 0.20 days. The larvae passed through five instars stages before transforming into pupal stage. Mean duration of five instars were 1.5 ± 0.19, 1.7 ± 0.15, 2.1 ± 0.20, 2.3 ± 0.17 and 4.3 ± 0.21 days, respectively. The duration of fifth instar was maximum (4.0-4.7 days).The total larval period ranged between 10.9-12.8 days with an average of 11.9 ± 0.54 days. The pupa is brownish in colour and is covered with a whitish powdery substances. Pupation took place inside the castor leaves. The pupal period ranged from 8.3 to 9.6 days with an overall average of 8.95 ± 0.43 days. The average moth emergence was 95 per cent with the pre-ponderance of males and their ratio was 1:0.85 (male: female). The pre-oviposition, oviposition, and post-oviposition periods ranged from 1-3 (2.3 ±0.78), 4-7(5.1± 0.89) and 3-6 (3.7± 1.00) days. The longevity of male varied from 8.7 to 10.1 days on an average of 9.37± 0.40 days while the female longevity varied from 10.1 to 12.6 days with an average of 11.2± 0.85 days. Hence the female lived slightly longer than (11.2 days) than males (9.3 days). On an average a female laid 351.2 ± 26.84 eggs during its life span.

Bio-efficacy of different insecticides against *A. janata*

Bio-efficacy of four insecticides with different doses were tested against *A. janata* infesting castor crop. All the insecticides proved better than the control at all the intervals of observations. The effectiveness of the insecticides increased with the intervals of time after spraying. One day after spraying thiodicarb @ 468 g proved to be best toxicant causing 60.64 per cent mean reduction in the larval population, followed by thiodicarb @ 375 g, deltamethrin @ 11.2 g, deltamethrin @ 10.5 g, quinalphos @ 250 g, quinalphos @ 200 g, novaluron @ 100 g and novaluron @ 75 g proved to be least effective with 46.05 per cent mean reduction in larval population. At three days after spraying, it was found that novaluron @ 100 g was the most effective with 82.55 per cent mean reduction in the larval population, followed by novaluron @ 75 g, thiodicarb @ 468 g, deltamethrin @ 11.2 g, thiodicarb @ 375 g, deltamethrin @ 10.5 g, quinalphos @ 250 g. However, 62.22 per cent mean reduction in larval population was observed with quinalphos @ 200 g. At seven days after spraying novaluron @ 100 g proved to be best toxicant causing 96.51 per cent mean reduction in the larval population, followed by novaluron @ 75 g, thiodicarb @ 468 g, thiodicarb @ 375 g, deltamethrin @ 11.2 g, deltamethrin @ 10.5 g, quinalphos @ 250 g. Minimum larval reduction of 72.00 per cent was observed with quinalphos @ 200 g. However, all the treatment found to be superior to control. Novaluron @ 100 g was found to be most effective with overall 75.97 mean reduction in larval population and gave highest castor yield of 3383 kg /ha with net profit of Rs.12120 /ha and benefit cost ratio of 1:16.83.

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APPENDIX I

Week wise meteorological data during the period of investigation

Year : 2013 | Latitude : 28°10'N

State : Haryana | Longitude: 76°35'E

District: Rewari | Altitude : 229m

Month	Standard meteorological weeks	Temperature (º C)		Relative humidity (%)		Rainfall (mm)
		Maximum	Minimum	Morning	Evening	
July	29	34.3	25.1	86.0	61.0	20.5
	30	34.4	25.2	88.9	64.6	48.0
	31	33.7	24.0	91.1	66.6	21.5
August	32	32.1	24.1	90.9	69.3	158.7
	33	31.4	24.4	93.0	69.0	68.0
	34	32.9	23.7	86.1	60.0	16.7
	35	34.2	24.1	80.3	52.1	0.0
September	36	35.9	22.4	75.0	39.4	0.0
	37	36.7	22.6	78.1	36.4	3.5
	38	33.9	21.0	80.4	44.7	120.4
	39	33.1	23.8	84.4	53.7	9.2
October	40	32.6	21.9	79.1	54.6	9.0
	41	31.6	20.4	81.0	55.4	91.3
	42	33.1	17.6	82.0	33.0	0.0
	43	31.5	14.4	81.7	21.1	0.0
November	44	31.4	13.1	79.4	29.4	0.0
	45	25.2	10.5	78.1	28.1	0.0
	46	24.6	6.2	76.1	29.4	0.0
	47	27.6	6.7	76.1	28.9	0.0

Source: CCSHAU, Regional Research Station, Bawal

ABSTRACT

Title of thesis	**:**	**Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop.**
Full name of the degree holder	**:**	**Yashdev Singh**
Admission No.	**:**	2010A23M
Title of degree	**:**	M.Sc. (Entomology)
Name and address of major advisor	**:**	**Dr. Balbir Singh** DES (Entomology),KVK, Bawal
Degree awarding University/ Institute	**:**	Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana (India)
Year of award of degree	**:**	2014
Major subject	**:**	Entomology
Total number of page in thesis	**:**	37+ iv + I
Number of words in the abstract	**:**	298

Keywords: *Achaea janata* L., Abundance, Biology, Chemical control and Incidence

The present study was conducted at Chaudhary Charan Singh Haryana Agricultural University, Hisar, Regional Research Station, Bawal, Haryana (India) during the *Kharif* season of 2013-14. The larvae of castor semilooper remain active from 30th to 47th standard meteorological weeks. The maximum larval population was recorded on the 32th (6.1 larvae per plant) and 38th SMW (6.2 larvae per plant). The rainfall during this period ranged from 120 to 158 mm. The correlation between various abiotic factors indicates that minimum temperature, evening relative humidity and rainfall exhibited a positive relationship with the larval population. The incidence caused by *A. janata* was first noticed during the 30th SMW which ranged from 4.4 to 42.2 per cent during the 30th and 38th SMW and subsequently larval population started decline from the 39th SMW onwards the per cent incidence was also decreased.

The average duration of eggs stage lasts for 2.32± 0.20 days. The larvae passed through five instars stages and mean duration of five instars stages were 1.5 ± 0.19, 1.7 ± 0.15, 2.1 ± 0.20, 2.3 ± 0.17 and 4.3 ± 0.21 days, respectively. Average larval and pupal period lasts 11.9 ± 0.54and 8.95 ± 0.43days. The average moth emergence was 95 per cent with the pre-ponderance of males and their ratio was 1:0.85 (male: female). The pre-oviposition, oviposition, and post-oviposition periods ranged from 1-3, 4-7 and 3-6 days, respectively. The female lived slightly longer (11.2 days) than as compared to males (9.3 days). On an average a female laid 351.2 ± 26.84 eggs during its life span. Novaluron @ 100 g was the overall most effective with 75.97 mean per cent reduction in larval population and gave highest yield to the extent of 3383 kg /ha with highest net profit of Rs.12120 /ha and cost benefit ratio of 1:16.83.

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Yashdev Singh

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"I, **Yashdev Singh,** Admission No. **2010A23M,** undertake that I give copyright to the CCS HAU, Hisar of my thesis entitled **"Bionomics and chemical control of castor semilooper (*Achaea janata* L.) in castor crop"**

I also undertake that patent, if any, arising out of the research work conducted during the programme shall be filed by me only with due permission of the competent authority of CCSHAU, Hisar.

Yashdev Singh