MAHARANA PRATAP UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, UDAIPUR
RAJASTHAN COLLEGE OF AGRICULTURE, UDAIPUR

CERTIFICATE – I

Dated: / 03/20

This is to certify that **Mr. Bharat Kumar Purohit** successfully completed the Comprehensive Examination held on **9th April, 2009** as required under the regulation for the degree of **Master of Science in Agriculture.**

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CERTIFICATE – II

Dated: /03/2010

This is to certify that the thesis entitled **"Assessment of novel insecticides against the major insect pests of cucumber"** submitted for the degree of **Master of Science in Agriculture** in the subject of **Entomology,** embodies bonafide research work carried out by **Mr. Bharat Kumar Purohit** under my guidance and supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged. The advisory committee also approved the draft of this thesis on 23rd January, 2010.

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CERTIFICATE – III

Dated: / 03 /2010

This is to certify that the thesis entitled **"Assessment of novel insecticides against the major insect pests of cucumber"** Submitted by **Mr. Bharat Kumar Purohit** to the Maharana Pratap University of Agriculture and Technology, Udaipur in partial fulfillment of the requirements for the degree of **Master of Science in Agriculture** in the subject of **Entomology** after recommendation by the external examiner was defended by the candidate before the following members of the examination committee. The performance of the candidate in the oral examination on his thesis has been found satisfactory, we therefore, recommend that the thesis be approved.

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CERTIFICATE –IV

Dated: / 03 /**2010**

This is to certify that **Mr. Bharat Kumar Purohit** student of the Department of **Entomology**, Rajasthan College of Agriculture, Udaipur has made all corrections/modifications in the thesis entitled **"Assessment of novel insecticides against the major insect pests of cucumber"** which were suggested by the external examiner and the advisory committee in the oral examination held on___________. The final copies of the thesis duly bound and corrected were submitted on_________are enclosed herewith for approval.

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Enclosed: One original and two copies bound thesis forwarded to the Director Resident Instructions, Maharana Pratap University of Agriculture and Technology, Udaipur through the Dean, Rajasthan College of Agriculture, Udaipur

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Assessment of novel insecticides against the insect pests of cucumber

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ABSTRACT

During September to December 2008, a field trial was conducted to study the seasonal incidence of major insect pests of cucumber along with bioefficacy of some novel insecticides against the pests at Horticulture Farm, Rajasthan College of Agriculture, Udaipur.

The results of present investigation revealed that the incidence of jassid, *Amrasca biguttula biguttula* (Ishida) and whitefly, *Bemisia tabaci* (Gennadius) commenced during 38th SMW (17th – 23rd September), whereas, red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas) during 37th SMW (10th - 16th September). The population of jassid and whitefly touched the peak during 8th - 14th October (86.30 jassids/five plants) and 15th – 21st October (67.35 whiteflies/five plants), respectively. While, the peak incidence of red pumpkin beetle (4.00 beetles/five plants) was observed during 22nd – 28th October. The fruit fly, *Dacus cucurbitae* (Coquillet) infestation was recorded soon after fruit formation i.e. second week of October (3.03 %) and reached the maximum level (17.04 %) during the first week of November. The population of jassid, whitefly, red pumpkin beetle and fruit fly were found non significantly associated with average temperature and relative humidity.

Bioeffecacy of different insecticides *viz.*, imidacloprid 70 WG (24 and 21g a.i./ha), imidacloprid 200 SL (25 and 20 g a.i./ha), acetamiprid 20 SP (20 g a.i./ha) and thiamethoxam 25 WG (25 g a.i./ha) was evaluated against the major insect pests of cucumber. Among these, imidacloprid 200 SL @ 25 g a.i./ha was found most effective for the control of jassids and whiteflies as it accounted 74.40 and 69.18 per cent control, respectively. Likewise, the least fruit infestation on the number and weight basis (11.17 and 10.78%) was recorded in this treatment over control

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(21.01%). Acetamiprid 20 SP @ 20 g a.i. /ha was found most effective treatment to control red pumpkin beetle as it caused 47.92 per cent reduction in beetle population. All the insecticidal treatments investigated were found effective in controlling pests and did not produce any phytotoxic effect on cucumber plants.

The effects of different insecticides were also observed on the population of natural enemies. Highest reduction was observed in acetamiprid 20 SP @ 20 g a.i./ha (26.18%) treatment, whereas, the imidacloprid at various doses proved to be safer for natural enemies.

1. INTRODUCTION

Fruits and vegetables constitute an important part of our dietary menu providing minerals and vitamins necessary for growth and development of the body. India is second largest producer of vegetables in the world next to China. The estimated area under vegetables is 7.80 million hectares with an annual production of 125.89 million tones in India (The Economic Survey, 2007-08). Cucurbits are important vegetable crops in almost all states of India. In Rajasthan, cucumber is grown in 3233 hectare area with a production of 12273 tonnes. Cucumber is a warm season vegetable crop used for fresh consumption as salad and for pickling purpose. In developed countries, it is grown as a glasshouse vegetable and in developing countries as an open field vegetable. Cucumber forms an essential item of dietary in the west. India is considered to be the home of cucumber. It is an important salad crop cultivated both in north and south and lower as well higher hills in India. Fruits varying in shape, size and colour.

Cucumber is attacked by large number of insect pests. The cucumber plant is susceptible to the fruit fly, *Dacus cucurbitae* Coquillet *(Bactrocera cucurbitae*) (Lal and Sinha, 1959; Narayan and Batra, 1960; Kushwaha *et.al.*, 1973), red pumpkin beetle, *Raphidopalpa foveicollis* Lucas (Hussain and Shah, 1926), white fly, *Bemisia tabaci* Gennadius and jassid, *Amrasca biguttula biguttula* Ishida that greatly decreases leaf mass and inhibits photosynthesis.

Chemical insecticides are being used as an effective control strategy for major insect pests of cucumber but the residual problems have necessitated the development of ecofriendly technologies. The old and traditional insecticides became ineffective for the management of major insect-pests of cucumber, even if these are used at higher doses besides involving higher costs and several ecological problems. A number of insecticides have been recommended from time to time (Sharma *et al.*, 1999; Dikshit *et al.*, 2001; Rajak and Singh, 2002 and Lakshmi *et al.*, 2005).

In such situation, novel insecticidal molecules offer great scope as they maintain higher toxicity to insects at lower doses and are not persistent as conventional insecticides (Singh and Singh, 2000). Several new insecticides like imidacloprid, acetamiprid and thiamethoxam belonging to a novel class neonicotinoides of insecticides have been introduced having unique chemical structures and have been reported effective against insect pests in many crops (Yadav *et al.*, 2003 and Kuttalam *et al.*, 2008). These are also reported safe to natural enemies and environment (Ameta and Kumar, 2005b). In order to avoid the adverse consequences of traditional insecticides on non target organisms, environmental pollution, health hazards and development of resistance; it becomes necessary to evaluate the new insecticides which are not only safe to natural enemies and environment but also effective at very low doses.

Therefore, it is utmost important that some new insecticides which are effective and ecosafe can be used in integrated pest management programme in place of traditional insecticides which required at higher doses.

Keeping in view the above facts, studies on" Assessment of novel insecticides against the major insect pests of cucumber" was initiated with the following objectives:

1. To study the incidence of major insect pests of cucumber.
2. To evaluate the bioefficacy of novel insecticides against major insect pests of cucumber.
3. To find out the phytotoxic effect of insecticides on cucumber
4. To assess the bio-safety of the insecticides to natural enemies

2. REVIEW OF LITERATURE

The pertinent review on the present investigation "Assessment of novel insecticides against the major insect pests of cucumber" have been reviewed and presented under following sub heads:

2.1 Seasonal incidence of major insect pests of cucumber:

2.1.1 Jassid, *Amrasca biguttula biguttula* (Ishida)

Sidhu and Dhawan (1980) studied seasonal abundance of different insect pests on desi cotton and indicated that the population of *A. biguttula biguttula* was higher during July-August. The continous and heavy rain resulted in sharp decline of the population, while early light showers of monsoon favours the multiplication.

Senapati and Mohanty (1980) reported that there was progressive increase in jassid population in cotton from the second week of December reaching a peak level in the third week of January. The jassid population declined gradually from second week of March.

Bughio *et al.* (1986) studied incidence and population density of sucking pests complex on cotton in Pakistan and observed that jassid population remained high from fourth week of May to end of June.

Suresh *et al.* (1996) reported that jassid population was present throughout the crop season and peak period was observed in first week of August in brinjal.

Sharma and Sharma (1997) observed the highest nymphal population of jassid in cotton and okra in the first week of August. The population showed negative relationship with the maximum temperature and positive correlation with the minimum temperature as well as relative humidity.

Abou-Elhaga (1998) reported that the population of aphid, whitefly and leaf hopper in cotton occurred relatively lower number during early season and later on disappeared from the cotton field for 2-6 weeks. The population then reappeared and increased again relatively higher number during the second half of the growing season and reached at maximum level on 5th and 19th August in 1996, respectively.

Gambhiri and Kumar (1998) studied the seasonal abundance of *A. biguttula biguttula* in brinjal. They reported peak activity of jassids in the fourth week of July and had a significant positive correlation with atmospheric temperature and sunshine hours. Whereas, relative humidity and total rainfall had a negative correlation with jassid population. Singh *et al*. (2005) observed incidence of jassids in brinjal from third week of August to last week of December and their peak during the first week of November, coincided with the presence of 22.5° C average temperature and 69.0 per cent of relative humidity.

2.1.2 Whitefly, *Bemisia tabaci* (Gennadius)

Shanab and Awad-Allah (1982) reported that the population of whitefly on tomato was first appeared in the month of May. The pest reached at peak during July to October when daily mean temperature varied from 20.86º C to 27.58º C and relative humidity varied from 58.9 to 66.66 per cent. High ambient mean temperature appeared to be the most conductive factor for population built up of this pest. However, extremely high temperature normally prevailing during the summer season resulted in declining of the pest incidence, whereas, scattered rain followed by high relative humidity favoured the population built up.

Bhardwaj and Kushwaha (1984) reported that incidence of *B. tabaci* on tomato initiated little late. The incidence of aleyrodid commenced from August and continued till the end of January. Where as, Patel and Jhala ((1992) reported that the population of *B. tabaci* showed increasing trend from August onwards and the population reached at the peak during December. Thereafter, it declined gradually on different host plants.

Borah (1995) studied the incidence of insect pests of cotton in the Karbi Anglog hill district of Assam, India during 1992 and reported the presence of 12 species of pests. Among them, *A. biguttula biguttula, B. tabaci and A. gossypii* were present in considerable numbers throughout the growing period.

Abou-Elhaga (1998) reported that cotton whitefly occurred in relatively lower number during early season and later on disappeared from fields, which reappeared and increased again in relatively higher number during the second half of the growing season.

Sarangdevot (1998) studied the seasonal incidence of insect pests of brinjal and reported the maximum incidence of *B. tabaci* during second week of June. While, Jaydeb *et al.* (1999) reported whitefly peak population in okra during 4th week of July (30th standard week). Patel *et al.* (1999) reported that the first appearance of whitefly was observed at nine weeks after cotton sowing.

Ali *et al*. (2004) observed the population density of whitefly, *Bemisia tabaci* and mites, *Tetranychus urticae* Koch on brinjal crop. Whitefly appeared in mid May and reached at peak in July. The lowest population was observed in the end of September. The population density of mites was the highest in early July and lowest in the second week of September. Whereas, Bharadiya and Patil (2005) observed the maximum activity of *B. tabaci* in the fourth week of October.

2.1.3 Red Pumpkin Beetle, *Raphidopalpa foveicollis* (Lucas)

Choudhary and Ali Khan (1990) observed that red pumpkin beetle had the highest number of viable eggs and the shortest development period at 30° temperature and 70 per cent relative humidity. Similarly, Roy and Pande (1991a) found that 27.5°C was the most favourable temperature for development and survival of *R. foveicollis*. However, Roy and Pande (1991b) observed the peak population of red pumpkin beetle in the month of December and August.

Gupta *et al.* (1992) represented a positive correlation between population of red pumpkin beetle and temperature as well as relative humidity.

Borah (1999) recorded 3.9 beetles of *R. foveicollis* per plant in cucumber during rainy season followed by 2.8 and 2.1 in summer and winter season, respectively.

Rajak (2000) found that over wintering beetle of *R. foveicollis* on muskmelon becames active at an average temperature of 20º C and relative humidity of 89 per cent. The maximum population of beetle occurred at an average temperature of 28.8º C. The correlation of pest population with temperature was positive, whereas, with relative humidity it was negative.

Johri and Johri (2003) recorded the peak infestation of *R. foveicollis* (47.49%) in July at 70.55 per cent relative humidity, whereas, least infestation (3.92%) was found during February at 60.66 per cent relative humidity.

Gathala and Bajpai (2007) observed that the red pumpkin beetle population showed a positive correlation with mean temperature but significant negative correlation with mean relative humidity.

2.1.4 Fruit fly, *Dacus cucurbitae* Coquillet *(Bactrocera cucurbitae*)

Gupta *et. al.* (1992) recorded the peak population of fruit fly in during July-August on cucumber and population exhibited a positive correlation with temperature and relative humidity.

Borah (2001) revealed that sowing of cucumber from 20 April to 20 May recorded significantly lower fruit fly infestation than sowing of cucumber from 20 June to 20 July. The maximum pooled yield (291.0 q/ha) was recorded from the crop sown on 20th April and differed significantly from the rest of the sowing dates except 20th May.

Ingoley *et al*. (2002) reported that high fruit infestations in June occurred under mean maximum temperature, minimum temperature, relative humidity and rainfall of 27.1 -28.1° C, 17.7 - 19.0° C, 72.0 - 84.0 per cent and 53.3 - 61.5 mm, respectively. The peak population occurred during second and third weeks of July under mean maximum temperature of 26.9 - 27.9° C, minimum temperature of 19.9 - 20.0° C, relative humidity of 85.0 per cent and rainfall of 114.1 - 247.5 mm. Temperature, relative humidity and rainfall were positively correlated with *B. cucurbitae* incidence.

2.2 Bioefficacy of insecticides against major insect pests of cucumber

(1). Imidacloprid (Admire and Confidor)

Mullins and Christie (1995) reported that imidacloprid was very effective against aphid, whitefly and jassid.

Leib *et al.* (1997) reported that the Melon yield increased 10 fold when Admire was drip chemigated under plastic mulch. A 4 fold yield was increased in plastic mulch alone while it was 2.5 times yield by control of cucumber beetles (Chrysomelidae) using Admire alone. The half rate of Admire produced the same weight of marketable melons as the full rate when a single dose of the insecticide was applied after transplanting.

Gupta *et al.* (1998) conducted a field trial to determine the efficacy of Imidacloprid for the control of jassid and whitefly. The results indicated that Imidacloprid was very effective against jassid, even at 3 g/kg (seed treatment) and 0.005 per cent (foliar spray). Similarly, Brar *et al.* (1999) reported that Oxydemeton methyl and Imidacloprid significantly reduced the population of whitefly and jassid on cotton. Kumar and Santharam (1999) observed that foliar treatment with Imidacloprid resulted in 100 per cent mortality of *Aphis gossypii* in 7 days and *Amrasca biguttula biguttula* in 10 days after application.

Phadke and Phadke (2000) evaluated the comparative efficacy of Imidacloprid @ 1 ml/ 4 liters and found to be most effective. The average mortality per cent being 79, 83, and 93 per cent at 1, 3 and 5 days after treatment, respectively. All the other treatments gave poor results as compared to Imidacloprid.

Bochkarev (2001) tested the efficacy of the systemic insecticide Confidor (Imidacloprid) for the control of greenhouse whitefly (*Bemisia tabaci*) in tomato F1 hybrids Marfa and Maeva; and thrips in cucumber F1 hybrid Venturo. Soil application of Confidor proved to be most effective.

Singh and Jaglan (2001) proved imidacloprid as most effective insecticide and recorded the lowest population (6.67 and 6.00 adults/3 leaves) of whitefly after 30 days of transplanting in both 12 hrs and 24 hrs soaking periods, respectively. In general, 24 hrs of soaking proved better than 12 hrs of soaking.

Khuroo *et al.* (2003) reported that dipping of seedlings in imidacloprid resulted in the highest control of the insect pests. After transplanting, spray with imidacloprid, resulted the highest control of the insect pests.

Marklund *et al.* (2003) concluded that imidacloprid appears likely to have significant effects on whitefly behavior in both soil and foliar application routes in the field. Imidacloprid when applied on stems form an acute toxic plus repellence and negative consequences in locomotory excitation.

Mishra and Senapati (2003) reported that imidacloprid at 25 g a.i./ha gave excellent control of the jassid (83.3 – 100%) in okra during experiment period.

Ameta and Sharma (2005) studied the field bioefficacy of imidacloprid against insect pests of cotton. They reported that imidacloprid 70 WG @ 35 g a.i./ha was most effective against aphids, thrips, and jassids.

Mhaske and Mote (2005) evaluated the efficacy of imidacloprid 17.5 SL, thiamethoxam 25 WG, azadirachtin 1 per cent, triazophos 40 EC and profenofos 50 EC at different concentrations against pest complex in brinjal. Higher doses of imidacloprid (18.0 and 22.5 g/ha) and thiamethoxam (25.0 and 50 g/ha) were found most effective against jassids, thrips and whiteflies.

Mishra (2005) examined 10 insecticides and found that imidacloprid at 25 g a.i./ha and acetamiprid at 20 g a.i./ha were most effective against whitefly, *B. tabaci* infesting okra followed by dimethoate at 300 g a.i./ha.

Sardana *et al.* (2005) found imidacloprid (18 and 22.5 g a.i/ha) and thiamethoxam (25 and 50 g a.i./ha) most effective against jassids and whiteflies in brinjal crop.

Baniameri and Sheikhi (2006) reported that the mean effect of 0.25 ml imidacloprid/litre gave 58.87 ± 6.42 per cent and 43.81 ± 6.90 per cent mortality of eggs and larvae, respectively. With the 0.75 ml imidacloprid/litre treatment 67.03 ± 5.83 per cent and 50.56 ± 5.50 per cent egg and larval mortalities were observed, respectively. The mean decrease of egg numbers on leaves with the spray of 0.75 ml imidacloprid/litre was 98.09 ± 0.48 per cent in 30 days.

Chen *et al*. (2006) showed that the best insecticides for control of aphids are a 2000x dilution of 10 per cent Admire (imidacloprid) wettable granules or a 2500x dilution of 1.8 per cent abamectin.

Powell *et al*. (2006) reported that Admire treatment regimes controlled aphids. Although at least twice annual Admire treatments per year was required to control the spirea aphid during some years in citrus.

Raghuraman and Gupta (2006) tested the efficacy of acetamiprid at 40 g a.i/ha and imidacloprid at 50 g a.i/ha against the jassid, *A. biguttula biguttula* in cotton. Both the treatments were found most effective in reducing the population of jassids in cotton.

Powell *et al*. (2007) recorded that a biannual treatment with Admire reduced leaf miner damage (number of mines) in all 5 years compared with the controls. Additional Admire applications further reduced damage. A single application of Admire significantly reduced mines in 3rd of the 5 years.

Riley (2007) reported that the at-planting soil application of imidacloprid decreased foliage thrips (*F. fusca*) in tomato. Thus, where early season transmission of virus by *F. fusca* is a primary concern in tomato, imidacloprid could provide some benefit in thrips vector management by reducing the amount of thrips settling on leaves.

Sinha and Sharma (2007) conducted a field experiment to evaluate the effectiveness of six neonicotinoids against insect pests of okra. Seed treatment with imidacloprid (3.0 or 5.4 g a.i. /kg seed) and spray with thiamethoxam (25 g a.i. /ha) at 50 days after sowing were found most effective in managing *A. biguttula biguttula* population.

(2). Acetamiprid

Matsuda and Takahaski (1996) revealed that acetamiprid is suitable for controlling insect pests belonging Hemiptera, Thysanoptera, Lepidoptera, Coleoptera and Isoptera.

Lopez and Rivere (1997) reported that acetamiprid (Rescate 200) was more effective for the control of *B. tabaci* than provado (imidacloprid), endosulphan, Danitol (fenpropathrin) + triazophos, Karate (lambda-cyhalothrin) + triazophos and capture (bifenthrin) + triazophos.

Domenichini and Tiraferri (1998) conducted field experiments to determine the efficacy of acetamiprid and found that it had excellent activity against aphids, whiteflies and some species of Coleoptera and Lepidoptera.

Khurana (1998) tested five insecticides as seed treatment and eleven insecticides as spray for the control of jassid (*A. biguttula biguttula*), whitefly (*B. tabaci*) and pink bollworm (*Pectinophora gossypiella*) in cotton. With regards to seed treatment, only imidacloprid @ 5 and 10 g/kg seed was found effective in reducing the jassid population. In case of insecticidal spray, imidacloprid (10 and 40 ml a.i./ha), acetamiprid (10 and 20 ml/ha), silalurenfen (50 and 100 ml/ha), monocrotophos and oxydemeton methyl (875 ml/ha) were found effective against jassids. Imidacloprid (40 ml/ha), silalurenfen (100 ml/ha), oxydemeton methyl (875 ml/ha), acephate (12.5 kg/ha) and nimbecidine (1.25 l/ha) were found effective against whitefly.

Ramprasad *et al.* (1998) observed that acetamiprid 20 SP @ 100, 80, and 60 ml/ha suppressed the population of tobacco aphid to the highest level followed by acephate 750 g a.i./ha, oxydemeton methyl 500 g/ha and endosulfan 525 g a.i./ha.

Bellettini *et al.* (1999) evaluated the bioefficacy of acetamiprid (Sauras 200PS) at 10, 15 and 20 g a.i./ha, cypermethrin (Sherpa 200) at 12.5 g. a.i./ha and methamidophos (Tamaron BR) at 300 g a.i./ha against *Aphis gossypii* on cotton. Acetamiprid gave more than 91 per cent control at 2, 5, 7, 10 and 15 days after application while cypermethrin and methamidophos gave 54.9 and 49.8 per cent control at 2 days after application, and 0.5 and 13.4 per cent control, respectively at 15 days after application.

Santos *et al.* (1999) reported that acetamiprid (40 g a.i./ha), acetamiprid + endosulphan (20 + 350 g a.i./ha), acetamiprid + carbofuron (20 + 120 g a.i./ha), thiamethoxam (50 g a.i./ha), carbofuron (120 g a.i./ha) and carbofuron + endosulphan (120 + 350 g a.i./ha) provided more than 95 per cent control of aphid upto 8 days after treatment.

Kumar *et al.* (1999) conducted a field trial to test the bioefficacy of acetamiprid against the cotton aphid and jassid. Acetamiprid found superior than the conventional insecticides in controlling aphid and jassid.

Das *et al.* (2000) evaluated the efficacy of four insecticides *viz.,* imidacloprid, acetamiprid, acephate and profenophos against fruit borer, *E. vittella* on okra cv Satsira. Reduction in borer infestation to the extent of 15.36, 12.42, 14.25 and 15.70 per cent was noticed after 3 weeks of third and final spray of the respective insecticides. As against this, there was 44.26 per cent infestation in control.

Patil *et al*. (2001) concluded that two sprays of acetamiprid 20 SP as foliar spray at 15 g a.i. /ha on ETL basis protected the crop up to 60 days effectively.

Acharya *et al.* (2002) conducted a field trial to evaluate the bioefficacy of new insecticides *viz.,* acetamiprid, thiamethoxam, imidacloprid, NACLFMOA and abamectin against the *A. biguttula biguttula* and reported that acetamiprid (20 g. a.i./ha) and thiamethoxam and imidacloprid (25 g a.i./ha) found most effective in managing jassid.

Baskaran *et al*. (2003) reported that acetamiprid 40 g a.i./ha was the most effective insecticide for the control of nymphs and adults of spiraling whitefly.

Jayekar (2003) conducted an experiment to evaluate the bioefficacy of acetamiprid 20 SP against sucking pests of chilli and reported that the treatment of acetamiprid 20 SP @ 80 and 40 g a.i. / ha was found to be most effective in reducing the insect population followed by 20 g a.i./ha.

Kendappa *et al.* (2004) conducted a field trail to evaluate certain new insecticide against spiraling whitefly, *Aleurodicus dispercus* Russell infesting cotton. Among these, buprofen (Applaud 25 EC) 0.025 per cent and acetamiprid 0.01 per cent were the most effective in reducing nymphal population followed by acephate 0.1125%, triazophos 0.06% and fenpropathrin.

Mishra (2005) proved that acetamiprid and imidacloprid were significantly best in controlling the whitefly up to 3 weeks after application, with a population reduction of 81.02 and 82.71 per cent, respectively over control.

Gupta and Shanker (2007) evaluated the efficacy of acetamiprid along with other insecticides in tea plantation against mealy bugs (*Nipacoccus vastator* Maskell) and aphids (*Toxoptera aurantii* Boyer). They reported that Acetamiprid (25 g a.i. /ha) was most effective against mealy bug and aphid with 74 per cent reduction in population of these insect-pests.

(3). Thiamethoxam

Sharma and Lal (2002) assessed the bioefficacy of thiamethoxam (25 g a.i./ha) on aubergine cv. Pusa Kranti in comparison with beta-cyfluthrin (18.75 g a.i./ha), deltamethrin (20 g a.i./ha), profenofos (500 g a.i./ha), and endosulfan (700 g a.i./ha) against the leafhopper, *A. biguttula biguttula* and whitefly, *B. tabaci*. Thiamethoxam was superior than the other insecticide treatments against both the pests.

Mhaske and Mote (2005) reported that higher dose of imidacloprid (18 and 22.5 g/ha) and thiamethoxam (25 and 50 g/ha) were effective against jassids (Cicadellidae) upto to the 14^{th} day while it was 10^{th} day as in case of thrips (Thysanoptera) and whiteflies (Aleyrodidae) after spray.

Sinha and Sharma (2007) reported that seed treatment with imidacloprid (3.0 or 5.4 g a.i. /kg seed) and spray with thiamethoxam (25 g a.i. /ha) at 50 days after sowing were found most effective in managing *A. biguttula biguttula* population.

2.3 Phytotoxicity

Proft and Proft (1991) tested the efficacy of imidacloprid against aphid. The result indicated that imidacloprid was effective without being phytotoxic.

Jarade and Dethe (1994) conducted a field trial using imidacloprid for controlling the pests of brinjal. It was found that total chlorophyll content of leaves was increased by imidacloprid as compared to the untreated plants.

Verghese (1998) reported that all the doses of imidacloprid (0.2 ml/l to 1.6 ml/l) had no phytotoxic effect on mango trees when used for the control of mango leaf hopper *Idioscopus nagpurensis* and *I. niveosparsus*.

Kishore and Dixit (2001a) reported that imidacloprid and acetamiprid were used as seed treatment and foliar spray did not produce any phytotoxic effect on pearl millet. Similar results were also observed in tomato when treated with these insecticides (Kishore and Dixit, 2001b).

Ameta and Sharma (2005a) conducted a field trial to evaluate different doses of Imidacloprid against cotton sucking pests. The results indicated that all treatments did not cause phytotoxicity on plant.

Oomen and Kumar (2005) conducted a field experiment to evaluate the phytotoxicity of insecticides on brinjal crop and concluded that imidacloprid and beta cyfluthrin were potential insecticides to control the insect pest fauna of brinjal and produce no phytotoxic effects at the tested doses.

2.4 Effect of insecticieds on natural enemies

Kandil *et al.* (1991) studied the side effect of some insecticides commonly used against the cotton whitefly, *Bemisia tabaci*. It was observed that imidacloprid was the most effective against mature and immature stages with the least effects against predator.

Patil and Lingappa (1999) reported the toxicity of oxydemeton-methyl, imidacloprid, acephate on the grubs of *Menochilus sexmaculatus* in laboratory. The acephate was more toxic as compared oxydemeton-methyl and imidacloprid.

Mathiranjan and Regupathy (2002) studied the effect of thiamethoxam 25 WG as well as imidacloprid (0.2 ml/lit.) and distilled water as control on the predatory insect, (*Chrysoperla carnea*) in laboratory. It was observed that thiamethoxam, imidacloprid had no adverse effect on the hatchability of *C. carnea*.

Satpute *et al.* (2002) conducted a field trial to determine the effect of imidacloprid (5, 7.5 and 10 g a. i. /ha) as seed treatment on the population of *Chilomenes sexmaculata* and *Chrysoperla carnea* on cotton. It was observed that the seed treatment of cotton with imidacloprid at 10 g and thiamethoxam at 4.28 g was not only safe but also attracted the predator.

Ameta and Sharma (2005b) reported that confidor (imidacloprid) was most effective against sucking insect pests of cotton but did not have any adverse effect on natural enemies.

Czepak *et al*. (2005) evaluated the selectivity of thiamethoxam (30 g a. i. /ha), diflobenzuron (6.0 g a. i. /ha), beta-cyfluthrin (800 ml/ha), lufenuron (300 ml/ha) and endosulphan (1500 ml/ha) on complex of natural enemies in cotton crop. Except lufenuron (show slight effect), all treatments did not show any negative effect on complex of predator and parasitoid present in cotton.

Bozsik (2006) examined the acute toxicity of imidacloprid, deltamethrin + heptenophos, lambda cyhalothrin and *Bacillus thuringiensis* with different concentrations and observed that imidacloprid and *B. thuringiesis* were safer to *C. septempunctata.*

Indumathi and Savithri (2006) studied effect of endosulfan (0.07per cent), malathion (0.05%), carbaryl (0.01%), azadirachtin (0.05%) and imidacloprid (0.005%) on the population of coccinellid beetles in a mango orchard. It was reported that azadirachtin was slightly safe to *Menochilus sexmaculatus* and C*occinella septempunctata*. Endosulfan was reported relatively safe to coccinellid beetle, whereas, cypermethrin had adverse effect on the coccinellid beetle population.

Kulkarni and Adsule (2006) noticed the activity of natural enemies in Confidor 200 SC treated plots along with untreated plot and revealed that it did not adversely affect the natural enemy population at recommended doses.

3. MATERIALS AND METHODS

The field experiment to investigate the seasonal incidence and bioefficacy of some novel insecticides against the major insect pests of cucumber was conducted during 2008 at Horticulture Farm, Rajasthan College of Agriculture, Udaipur. The detailed methodology used in present investigation is given as under.

3.1 Sowing of seed

The seeds of cucumber variety, Sedona were sown in well prepared field during the first week of September.

3.1.1 Preparation of field

The experimental field was prepared during the first week of July by ploughing with the help of disc plough followed by cross harrowing and planking. The sowing of the seed was done during the first week of September. The plot size was 2 X 5m^2 (10 sq.m.) and crop spacing of 0.50 X 1m^2 was maintained.

3.1.2 Horticultural practices

Intercultural operations like hoeing and weeding were performed as per the package of practices. Gap filling was done to maintain the plant density as per requirement. The farm yard manure was applied @ 200 q/ha and single super phosphate @ 400 kg/ha as single basal dose at the time of sowing. Urea @ 150 kg/ha was applied in two doses. The first half was applied at the time of sowing and second half as top dressing four weeks after sowing. The crop was irrigated as and when required during the entire experimental period.

3.1.3 Meteorological data

Observations regarding weather parameters *viz.*, temperature and relative humidity were recorded from the Meteorological observatory, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The meteorological observations of the experimental period is presented in the Appendix-I.

3.2 Specific details of the experiment

3.2.1 Seasonal incidence of insect pests

3.2.1.1 Layout of experiment:

To study the seasonal incidence of insect pests infesting cucumber crop, the experiment was laid out in plots measuring 2 x 5 m (10 sq. m.) replicated thrice as shown in Fig. I a. The variety "Sedona" was grown under natural conditions without spraying any insecticide. Row to row and plant to plant spacing was maintained at 50 cm and 1 m, respectively. Five plants /plot were selected randomly and tagged so as to record the observations throughout the experimental period. The record of each pest was maintained with a view to find out the following:

(i) First appearance of insect pests.

(ii) Peak seasonal incidence of insect pests.

(iii) Lowest seasonal incidence of insect pests.

3.2.1.2 Observations:

Population of different insect pests was recorded at weekly intervals during morning hours (7:00-9:00 am) when most of the insect species remain less active.

3.2.1.3 Sampling techniques:

The appropriate sampling techniques adopted for the estimation of population of different insect pests is given below:

Jassid:

For estimating the population of jassids, five leaves per plant were selected from the five tagged plants in each plot. The population was estimated by gently holding the leaf between the two halves of a petri plate and adults as well as nymphs were counted within it. When only nymphal stage existed, direct counting of the population was done with the help of magnifying lens.

Whitefly:

To estimate the population of whitefly, the number of insects was counted on the same leaves as that of jassids. The base of leaf was held in between fingers and thumb and twisted gently; nymphs and adults were counted quickly but carefully with least disturbance.

Red pumpkin beetle:

Incidence of red pumpkin beetle was also recorded on these five tagged plants. For sampling technique, visual counting method was followed to record the population and total number of adults present on the entire tagged plants was counted.

Fruit fly:

The incidence of fruit fly was recorded on per cent infestation basis. It was calculated on the basis of number of damaged fruits out of the total number of fruits (damaged and healthy).

$$\text{Per cent infestation} = \frac{\text{No. of infested fruits}}{\text{No. of total fruits}} \times 100$$

3.2.1.3 Statistical analysis

Population data of different insect pests thus obtained was subjected to ANOVA to find out the coefficient of correlation with average temperature and relative humidity.

Following formula was used for calculating correlation coefficient:

$$r_{xy} = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\left[\sum (x)^2 - \frac{(\sum x)^2}{n}\right]\left[\sum (y)^2 - \frac{(\sum y)^2}{n}\right]}}$$

Where,

r_{xy}	=	Sample correlation coefficient
x	=	Variable i.e. abiotic components (Average temperature and relative humidity)
y	=	Variable i.e. mean number of insect pests
n	=	Number of observations

3.2.2 BIOEFFICACY OF DIFFERENT TREATMENTS:

3.2.2.1 Lay out of experiment:

The experiment was laid out in randomized block design. The layout of the experiment depicted below as Fig. 1b. The variety, plot size and spacing were same as described earlier. The details of different treatments are given in Table 2.

Table 1. Details of the treatments

S. No.	Treatments	Doses g a.i./ha	Formulation g/ml/ha
1	T_1: Control	---	---
2	T_1: Admire (Imidacloprid) 70 WG	21	30
3	T_2: Admire (Imidacloprid) 70 WG	24	35
4	T_3: Confidor (Imidacloprid) 200 SL	20	100
5	T_4: Confidor (Imidacloprid) 200 SL	25	125
6	T_5: Pride (Acetamiprid) 20 SP	20	100
7	T_6: Thiamethoxam 25 WG	25	100

Thus, there were 7 treatments in all including control and each treatment was replicated thrice. The first spray was initiated on appearance of sucking pests and subsequent two sprays were done at 15 days intervals. A volume of 375 litre/ha of water was used in each spray.

3.2.2.2 Observations:

The observation of the population of insect *viz.*, jassid, *Amrasca biguttula biguttula* Ishida; white fly, *Bemisia tabaci* Gennadius; red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas) and fruit fly, *Dacus cucurbitae* Coquillet *(Bactrocera cucurbitae*) was recorded 24 hours before and at 1, 3, 7 and 14 days after each spray.

3.2.2.2.1 Sampling technique:

I. Insect-pests: - The sampling technique was same as that for recording seasonal incidence of insect pests.

II. Natural enemies: - Number of natural enemies was counted on five tagged plants.

3.2.2.3 Statistical analysis:

Efficacy of different treatments in controlling the insect pests was analyzed by analysis of variance. The population data was corrected by the correction factor given by Henderson and Tilton (1955) as under:

$$\text{Per cent reduction in population} = 100 \times \; 1 - \left(\frac{T_a \times C_b}{T_b \times C_a} \right)$$

Where,

T_a = Number of insects after treatment.

T_b = Number of insects before treatment.

C_a = Number of insects in untreated check after treatment.

C_b = Number of insects in untreated check before treatment.

The reduction percentage figures were transformed into arc sine and subjected to ANOVA.

3.2.3 Phytotoxicity of insecticides:

The layout of the experiment has been described *vide supra* 3.2.2.1 and represented in Fig. 1b. Fourty five days old crop was treated with the respective insecticides under investigation.

3.2.3.1 Observations:

To evaluate the Phytotoxicity, visual method was adopted.

Visual method: The burning symptoms of leaf tip and leaf surface, wilting, vein clearing and necrosis were examined on plants after spray. Leaf injury was graded on visual rating of four point scale as suggested by Kavadia and Gupta (1986).

1. Mild (+)	:	Few lesions on leaflet or less than 20 per cent leaflets of plants showing burning symptoms.
2. Moderate (++)	:	Few lesions on leaflet or less than 50 per cent leaflets of plants showing burning symptoms.
3. Severe (+++)	:	More or less all the leaflets of the plants showing burning symptoms.
4.Most severe (++++)	:	Complete mortality of the plant.

4. RESULTS

During the course of investigation, jassid, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Gennadius), red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas) and fruit fly, *Dacus ciliatus* (Loew) were recorded as major insect pests of cucumber; their number being potentially higher causing damage. Besides these major pests, red spider mite, *Tetranychus urticae (*Guenee), aphid, *Aphis gossypii* (Glover) and flea bettle, *Phyllotreta downset* (Linnaeus) were also observed on the cucumber crop.

4.1 Seasonal incidence of major insect pests of cucumber

4.1.1 Jassid, *Amrasca biguttula biguttula* (Ishida)

The data presented in Table-2 and depicted in Figure-2 clearly indicate that the jassid appeared during 38th standard meteorological week (SMW) i.e. 17th - 23rd September with a mean population of 4.60 jassids/5 plants. The population increased slowly and reached the peak in the second week of October with a mean population of 86.30 jassids/five plants. Thereafter, the population declined and reached a minimum level of 3.74 jassids/five plants during 48th SMW i.e. 26th - 2nd December.

The correlation coefficient was computed between the insect population and the weather parameters. The analysis depicted a non significant negative correlation between mean population of jassid and relative humidity ($r = -0.449$), whereas, average temperature was found to be non significant and positively correlated ($r = 0.365$).

4.1.2 Whitefly, *Bemisia tabaci* (Gennadius)

B. tabaci was recorded as one of the major insect pests in the experimental crop. The data presented in Table-2 and Figure-2 clearly depicted that the incidence of whitefly was initiated during 38th SMW i.e. third week of September with a mean population of 2.57 whiteflies/five plants. The population increased with increasing and after four weeks the population reached its maximum i.e. 67.35 whiteflies/five plants during 42nd SMW. Thereafter, a decreasing trend was observed till the first week of December.

On workingout the coefficient of correlation between the whitefly population and the abiotic factors i.e. mean temperature and relative humidity, a non significant positive correlation with mean temperature (r = 0.323) and a significant negative correlation with mean relative humidity (r = -0.656) was found.

4.1.3 Red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas)

The data presented in Table-2 and Figure-2 clearly revealed that the *R. foveicollis* was noticed at initial stage of crop growth during 37th SMW i.e. second week of September with a mean population of 1.20 beetles/five plants. The population increased gradually and after six weeks the population reached its maximum of 4.0 beetles/five plants during 43rd SMW i.e. 22nd to 28th October. Thereafter, a decreasing trend was observed till the first week of December when mean population of the insect was 2.10 beetles/five plants.

On workingout the correlation between the red pumpkin beetle population and the abiotic factors i.e. mean temperature and relative humidity, a non significant positive correlation with mean temperature (r = 0.105) and a significant negative correlation with mean relative humidity (r = -0.746) was obtained.

4.1.4 Cucumber fruit fly, *Dacus ciliatus* (Loew)

The incidence of cucumber fruit fly was recorded on the basis of per cent damaged fruits. The perusal of Table-3 and Figure-3 evinced that infestation on fruits begun from the second week of October i.e. 41th SMW and the initial infestation was recorded 3.03 per cent. The infestation increased gradually to 8.24 per cent during the third week of October. The infestation further showed an increasing trend and maximum infestation i.e. 17.04 per cent was recorded during the first week of November.

Relative humidity showed a significant (r = -0.778) negative association with the per cent infestation levels of the fruit fly. However, mean temperature had non significant positive correlation (r = 0.070) with it.

4.2 Bioefficacy of insecticides

The bioefficacy of different management schedules *viz.* three sprays of imidacloprid 70 WG @ 21 and 24 g a.i./ha, imidacloprid 200 SL @ 20 and 25 g a.i./ha, acetamiprid 20 SP @ 20 g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha were studied under present investigation. The first spray was carried out on 30th day after germination and subsequent two sprays were done each at 15 days interval. The recorded data have been presented in Table 4 to 7.

4.2.1 Jassid, *Amrasca biguttula biguttula* (Ishida)

First Spray

It is evident from Table-4 that all the treatments were significatly superior over control right from one day after spraying. Application of imidacloprid 200 SL @ 25 g a.i./ha gave the best results with mean population reduction of 55.67 per cent followed by imidacloprid 70 WG @ 24 g a.i./ha (52.94%). Spray of imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha also showed good results with the mean reduction of 46.69 and 44.60 per cent, respectively. The remaining treatments, thiamethoxam 25 WG @ 25 g a.i./ha and acetamiprid 20 SP @ 20 g a.i./ha were statistically at par to each other and brought about 40.95 and 39.66 per cent mortality in jassid population.

The results after three days of spray application showed that all the treatments were statistically different and superior over control. The highest reduction i.e. 67.83 per cent was observed in imidacloprid 200 SL @ 25 g a.i./ha. It was followed by imidacloprid 70 WG @ 24 g a.i./ha, imidacloprid 200 SL @ 20 g a.i./ha, imidacloprid 70 WG @ 21g a.i./ha, thiamethoxam 25 WG @ 25 g a.i./ha and acetamiprid 20 SP @ 20 g a.i./ha, which caused 59.79, 53.52, 49.10, 46.12 and 43.67 per cent reduction in jassid population, respectively.

Seven days after application, imidacloprid 200 SL @ 25 g a.i./ha and imidacloprid 70 WG @ 24 g a.i./ha proved to be significantly superior over other treatments as they brought 56.18 and 54.60 per cent reduction, respectively and were at par to each other. Imidacloprid 200 SL @ 20 g a.i./ha was also found good which caused 47.78 per cent reduction in population of jassids. It was followed by imidacloprid 70 WG @ 21g a.i./ha (43.92%) which was statistically similar to acetamiprid 20 SP @ 20 g a.i./ha (42.85%), which in turn was similar with thiamethoxam 25 WG @ 25 g a.i./ha (41.31%).

Fourteen days after spray, all the treatments were significantly superior over control but reduction in jassid population was decreased. The maximum reduction was observed in imidacloprid 200 SL @ 25 g a.i. /ha which caused 49.64 per cent reduction in jassid population. It was followed by imidacloprid 70 WG @ 24 g a.i. /ha (46.37%). Rest of the treatments *viz.,* imidacloprid 200 SL @ 20 g a.i./ha, thiamethoxam 25 WG @ 25 g a.i./ha, imidacloprid 70 WG @ 21g a.i./ha and acetamiprid 20 SP @ 20 g a.i./ha gave 42.77, 42.52, 39.79 and 38.03 per cent reduction in jassid population, respectively. Among these, the two former treatments were statistically at par with each other.

Second spray

The data presented in Table 4 reveals that one day after second spray, imidacloprid 200 SL @ 25 g a.i. /ha was found most effective as it gave the maximum reduction of 59.15 per cent in population of jassid. However, imidacloprid 70 WG @ 24 g a.i./ha (57.99%) was equally effective and did not differ significantly. Both Imidacloprid 200 SL and imidacloprid 70 WG at lower doses (i.e. 20 and 21 g a.i./ha) were also found good giving 52.03 and 46.75 per cent reduction. The minimum reduction of jassid population i.e. 41.42 per cent was observed in acetamiprid 20 SP @ 20 g a.i. /ha which was followed in ascending order by thiamethoxam 25 WG @ 25 g a.i./ha (43.83%).

A similar trend of results was obtained after three days of second spray, where all the treatments showed significant difference to each other. Imidacloprid 200 SL @ 25 g a.i./ha gave maximum mean reduction of jassid population (70.67%), followed by imidacloprid 70 WG @ 24 g a.i./ha (67.98%). Imidacloprid 200 SL @ 20 g a.i./ha, imidacloprid 70 WG @ 21g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha were found moderately effective and reduced the jassid population about 62.50, 58.85 and 53.62 per cent, respectively. However, minimum per cent reduction in population was obtained from acetamiprid 20 SP @ 20 g a.i./ha (51.20%).

The data in Table 4 revealed that seven days after second spray, imidacloprid 200 SL @ 25 g a.i./ha gave maximum reduction i.e. 56.17 per cent and was at par with imidacloprid 70 WG @ 24 g a.i./ha (54.93%). The efficacy of imidacloprid 200 SL and imidacloprid 70 WG at lower doses exhibited 53.00 and 50.20 per cent reduction, respectively. The treatments thiamethoxam 25 WG @ 25 g a.i./ha and acetamiprid 20 SP @ 20 g a.i./ha were statistically at par and could cause 47.75 and 46.59 per cent reduction in jassid population.

After fourteen days of spray, imidacloprid 200 SL @ 25 g a.i./ha remained most effective as it brought 47.92 per cent reduction in the pest population followed by imidacloprid 70 WG @ 24 g a.i./ha with 46.27 per cent reduction, which was at par with imidacloprid 200 SL @ 20 g a.i./ha (46.00%). Thiamethoxam 25 WG @ 25 g a.i./ha was found to be statistically similar with imidacloprid 70 WG @ 21 g a.i./ha and both gave 41.73 and 40.33 per cent pest control. Among all the treatments acetamiprid 20 SP @ 20 g a.i./ha was found least effective (37.37%).

Third spray

The persual of data in Table 4 clearly indicated that one day after third spray, all the treatments were statistically different from each other with respect to per cent reduction in jassid population. Maximum reduction was observed in higher doses of imidacloprid 200 SL and imidacloprid 70 WG (25 and 24 g a.i./ha) (59.80 and 58.22%). It was followed by imidacloprid 200 SL @ 20 g a.i./ha (55.97%), imidacloprid 70 WG @ 21 g a.i./ha (51.97%) and thiamethoxam 25 WG @ 25 g a.i./ha (48.35%). However, acetamiprid 20 SP @ 20 g a.i./ha was found least effective and the reduction being as low as 45.00 per cent.

Three days after application, all the treatments showed good results and the reduction in jassid pouplation ranged from 74.40 to 58.78 per cent. Imidacloprid 200 SL @ 25 g a.i./ha gave maximum pest control followed by imidacloprid 70 WG @ 24 g a.i./ha (68.50%) found at par with imidacloprid 200 SL @ 20 g a.i./ha (66.46%) but statistically different from thiamethoxam 25 WG @ 25 g a.i./ha, which reduced the jassid population about 63.54 per cent. Acetamiprid 20 SP offered least protection against jassid (58.78%) and was statistically at par with imidacloprid 70 WG @ 21 g a.i./ha (60.40%).

Seven days after third spray again the response followed same trend as described above. The highest reduction was showed by imidacloprid 200 SL @ 25 g a.i./ha (65.18%), followed by imidacloprid 70 WG @ 24 g a.i./ha (62.68%), imidacloprid 200 SL @ 20 g a.i./ha (59.67%) and thiamethoxam 25 WG @ 25 g a.i./ha (54.84%). The minimum reduction was observed in treatment acetamiprid 20 SP @ 20 g a.i./ha (50.33%) which was statistically at par with imidacloprid 70 WG @ 21 g a.i./ha (52.17%).

The reduction in pest population brought about by various treatments following fourteen days after their application indicated that imidacloprid 200 SL @ 25 g a.i./ha brought maximum reduction of 58.98 per cent, which was statistically at par with its lower dose (57.34%), which in turn was at par with imidacloprid 70 WG @ 24 g a.i./ha (55.83%). It was followed by thiamethoxam 25 WG @ 25 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha with the reduction of 51.75 and 49.55 per cent in jassid population. The minimum per cent mortality was observed in acetamiprid 20 SP @ 20 g a.i./ha treatment (46.19%).

4.2.2 Whitefly, *Bemisia tabaci* (Gennadius)

First spray

It was evident from the data present in Table 5 that all the treatments were significantly superior over control right from one day after spraying. Application of imidacloprid 200 SL @ 25 g a.i./ha gave the best results and the mean reduction was 52.66 per cent. Imidacloprid 70 WG @ 24 g a.i./ha was found next most effective treatment with 46.54 per cent reduction in population of whiteflies. It was followed by imidacloprid 200 SL @ 20 g a.i./ha (44.26%), imidacloprid 70 WG @ 21 g a.i./ha (40.01%) and thiamethoxam 25 WG @ 25 g a.i./ha (36.07%). Acetamiprid 20 SP was relatively least effective as it happened to give lowest reduction (33.54%) in population of whitefly.

After three days of treatments application, the order of efficacy remained the same. Higher doses of imidacloprid 200 SL and imidacloprid 70 WG (25 and 24 g a.i./ha) brought maximum per cent reduction (i.e. 60.60 and 55.43%), while thiamethoxam 25 WG and acetamiprid 20 SP at doses 25 and 20 g a.i./ha offered minimum pest control (i.e. 43.79 and 40.69 per cent). Both imidacloprid 200 SL and imidacloprid 70 WG at lower doses being intermediate in whitefly population reduction (51.74 and 47.61%).

The efficacy of these treatments again followed the same trend after seven days of first spray. The highest reduction was shown by imidacloprid 200 SL @ 25 g a.i./ha giving 54.51 per cent reduction followed by imidacloprid 70 WG @ 24 g a.i./ha with 49.51 per cent reduction. Application of imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha brought about 46.33 and 43.33 per cent population reduction, respectively. The lowest efficacy (37.83%) was observed in acetamiprid 20 SP @ 20 g a.i./ha which was lower than thiamethoxam 25 WG @ 25 g a.i./ha (40.70%).

The similar trend in reduction of whitefly population was observed fourteen days after treatment. The reduction in population ranged from 43.52 to 32.38 per cent being maximum in imidacloprid 200 SL @ 25 g a.i./ha and minimum in acetamiprid 20 SP @ 20 g a.i./ha. Rest of the treatments gave moderate (41.67, 39.41, 35.67 and 37.69%) pest control.

Second spray

The observations presented in Table 5 revealed that one day after second spray, imidacloprid 200 SL @ 25 g a.i./ha offered best control (54.02%) which was significantly superior over other treatments. It was followed by imidacloprid 70 WG @ 24 g a.i./ha, imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha which resulted in 51.20, 46.17 and 44.27 per cent reduction in population of whitefly, respectively. The minimum reduction (39.30%) was observed in acetamiprid 20 SP @ 20 g a.i./ha which was significantly lower than thiamethoxam 25 WG @ 25 g a.i./ha (41.12%).

The reduction in the pest population by various treatments following three days after their application indicated same trend. Imidacloprid 200 SL @ 25 g a.i./ha brought maximum reduction of 65.23 per cent followed by imidacloprid 70 WG @ 24 g a.i./ha and imidacloprid 200 SL @ 20 g a.i./ha giving 62.57 and 54.43 per cent pest control. Imidacloprid 70 WG @ 21 g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha were statistically at par with each other and brought 51.64 and 50.05 per cent reduction in population of whitefly. The lowest reduction was observed in acetamiprid 20 SP @ 20 g a.i./ha giving 47.63 per cent mortality.

Seven days after second spray imidacloprid 200 SL @ 25 g a.i./ha was found most effective as it gave the maximum reduction (56.10%). However, imidacloprid 70 WG @ 24 g a.i./ha was also equally effective as the population reduction (54.43%) did not differ significantly. It was followed by imidacloprid 70 WG @ 21 g a.i./ha and imidacloprid 200 SL @ 20 g a.i./ha brought 46.36 and 46.12 per cent mortality and were statistically at par with each other. Thiamethoxam 25 WG @ 25 g a.i./ha and acetamiprid 20 SP @ 20 g a.i./ha were found least effective with 43.86 and 41.75 per cent reduction in population of whitefly.

The efficacy of all treatments after fourteen days of spraying indicated that imidacloprid 200 SL @ 25 g a.i./ha resulted in maximum reduction (45.61%) as compared to the other treatments. The next best treatments in descending order were imidacloprid 70 WG @ 24 g a.i./ha, imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha with 43.70, 41.97 and 40.49 per cent reduction in whitefly population. While, the minimum reduction (36.21%) was observvred in acetamiprid 20 SP @ 20 g a.i./ha which was significantly lower than thiamethoxam 25 WG @ 25 g a.i./ha (38.66%).

Third spray

The persual of the Table-5 clearly showed that one day after application of various treatments, imidacloprid 200 SL and imidacloprid 70 WG showed best performance. The mean reduction being higher (56.99 and 56.86%) at higher doses (i.e. 25 and 24 g a.i./ha) and there was no significant difference observed between them. Spray of imidacloprid 70 WG @ 21 g a.i./ha found superior over all the remaining treatments which brought about 50.01 per cent reduction in whitefly population. Other treatments *viz.,* imidacloprid 200 SL @ 20 g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha were statistically equal in their effect with 48.22 and 47.62 per cent mortality in pest population, respectively. Acetamiprid 20 SP @ 20 g a.i./ha was relatively least effective as it recorded the lowest reduction i.e. 43.40 per cent.

Three days after application of insecticides, the best performance was exhibited by imidacloprid 200 SL @ 25 g a.i./ha (69.18%) which was followed by imidacloprid 70 WG @ 24 g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha with the reduction of 65.53 and 60.27 per cent in whitefly population. Spray of imidacloprid 70 WG and imidacloprid 200 SL at lower doses (21 and 20 g a.i./ha) were found statistically similar with respect to pest control and brought 57.60 and 56.09 per cent reduction. It was observed that the application of acetamiprid 20 SP @ 20 g a.i./ha was least effective, which gave 49.51 per cent reduction in population of whitefly.

The reduction in pest population brought about by various treatments following seven days after their application indicated that imidacloprid 200 SL @ 25 g a.i./ha brought maximum reduction of 62.92 per cent and was followed by imidacloprid 70 WG at both the doses (24 and 21 g a.i./ha) giving 59.16 and 54.70 per cent reduction in whitefly population. However, imidacloprid 200 SL @ 20 g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha were found equally effective as the population reduction (52.37 and 50.99%) did not differ significantly. The lowest reduction (47.32%) in population of whitefly was observed in acetamiprid 20 SP @ 20 g a.i./ha.

The efficacy of all treatments after fourteen days of spraying reveals that the highest reduction was shown by imidacloprid 200 SL @ 25 g a.i./ha giving 54.67 per cent pest control. It was followed by imidacloprid 70 WG @ 24 g a.i./ha (52.00%). Application of imidacloprid 200 SL @ 20 g a.i./ha, imidacloprid 70 WG @ 21g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha gave 47.85, 46.19 and 44.58 per cent reduction in whitefly population, respectively. Least efficacy was observed as same as earlier (7^{th} day) observation in acetamiprid 20 SP @ 20 g a.i./ha (43.04%).

4.2.3 Red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas)

First spray

It is apparent from the Table 6 that the highest reduction in the beetle population at one day after application was found in acetamiprid 20 SP @ 20 g a.i./ha with 35.83 per cent. It was followed by thiamethoxam 25 WG @ 25 g a.i./ha (33.72%), which was at par with imidacloprid 200 SL @ 25 g a.i./ha giving 33.21 per cent reduction in pest population. Remaining treatments *viz.*, imidacloprid 70 WG @

24 g a.i./ha, imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha resulted in 30.17, 28.05 and 25.23 per cent reduction in beetle population.

The data on efficacy of the treatments three days after spraying showed that acetamiprid 20 SP @ 20 g a.i./ha and thiamethoxam 25 WG @ 25 g a.i./ha performed best with mean reduction of 41.75 and 39.39 per cent in beetle population, respectively. Imidacloprid 200 SL and imidacloprid 70 WG at higher doses (25 and 24 g a.i./ha) were statistically at par with each other (36.49 and 35.55%). However, imidacloprid 70 WG @ 24 g a.i./ha again found at par with imidacloprid 200 SL @ 20 g a.i./ha (33.67). The least population reduction i.e. 31.51 per cent was found in imidacloprid 70 WG @ 21 g a.i./ha.

Seven days after application, acetamiprid 20 SP @ 20 g a.i./ha was found most effective as it gave the maximum reduction (38.13%). However, thiamethoxam 25 WG @ 25 g a.i./ha was also equally effective as the population reduction (36.81%) did not differ significantly. It was followed by imidacloprid 200 SL @ 25 g a.i./ha (33.32%), which was at par with imidacloprid 70 WG @ 24 g a.i./ha (32.79%) which in turn was at par with imidacloprid 200 SL @ 20 g a.i./ha (31.14%). The minimum per cent reduction was observed in imidacloprid 70 WG @ 21 g a.i./ha treatment (26.44%).

The reduction in beetle population brought about by various treatments following fourteen days after their application indicated that acetamiprid 20 SP @ 20 g a.i./ha brought maximum reduction of 32.83 per cent followed by thiamethoxam 25 WG @ 25 g a.i. (30.70%), which was at par with imidacloprid 200 SL @ 25 g a.i./ha (29.96%). Remaining treatments *viz.*, imidacloprid 70 WG @ 24 g a.i./ha, imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha could reduce the population about 28.16, 26.76 and 25.28 per cent, respectively.

Second spray

The persual of the Table 6 clearly revealed that one day after application of treatments, acetamiprid 20 SP @ 20 g a.i./ha and imidacloprid 200 SL @ 25 g a.i./ha performed best. Both the treatments were found statistically at par with each other and brought about 38.07 and 36.80 per cent reduction in beetle population. Likewise, thiamethoxam 25 WG @ 25 g a.i. /ha and imidacloprid 70 WG @ 24 g a.i. /ha were also statistically similar with 33.98 and 32.70 per cent reduction, respectively. Imidacloprid 200 SL and imidacloprid 70 WG at lower doses offered least protection against red pumpkin beetle (30.71 and 29.75%) and were statistically at par with each other.

Three days after application, all the treatments showed good results and the mean population reduction ranged from 47.12 to 35.24 per cent. Acetamiprid 20 SP @ 20 g a.i./ha gave maximum pest control, followed by imidacloprid 200 SL @ 25 g a.i./ha (42.20%), which was at par with thiamethoxam 25 WG @ 25 g a.i./ha (41.03%). Spray of imidacloprid 70 WG @ 24 g a.i./ha was found moderately effective as it brought about 38.41 per cent reduction in beetle population. The minimum reduction was observed in imidacloprid 70 WG @ 21 g a.i./ha (35.24%) which was found statistically at par with imidacloprid 200 SL @ 20 g a.i./ha (36.07%).

The data on efficacy of these treatments after seven days of spraying indicated that acetamiprid 20 SP @ 20 g a.i./ha resulted in highest reduction (41.29%) of beetle population. While, the lowest reduction (31.37%) was observed in imidacloprid 70 WG @ 21 g a.i./ha, which was at par with thiamethoxam 25 WG @ 25 g a.i./ha (32.74%), which in turn was at par with imidacloprid 200 SL @ 20 g a.i./ha (34.34%). Application of imidacloprid 200 SL and imidacloprid 70 WG at higher doses brought about 39.31 and 36.68 per cent reduction in beetle pouplation.

After fourteen days of spray, acetamiprid 20 SP @ 20 g a.i./ha offered highest control (34.50%) in red pumpkin beetle population and was at par with imidacloprid 200 SL @ 25 g a.i./ha (33.88%). Thiamethoxam 25 WG @ 25 g a.i./ha found next best treatment which caused about 31.92 per cent reduction in beetle population and was at par with imidacloprid 70 WG @ 24 g a.i./ha (30.47%), which in turn was at par with imidacloprid 200 SL @ 20 g a.i./ha (29.73%). The lowest mean reduction in red pumpkin beetle population (28.07%) was observed in imidacloprid 70 WG @ 21g a.i./ha.

Third spray

One day after third spray, application of acetamiprid 20 SP @ 20 g a.i./ha gave maximum reduction (40.25%) which was followed by imidacloprid 200 SL @ 25 g a.i./ha (37.96%). Thiamethoxam 25 WG @ 25 g a.i./ha and imidacloprid 70 WG @ 24 g a.i./ha (34.08%) were found moderately effective as they brought 36.04 and 34.08 per cent reduction of red pumpkin beetle population, respectively. Application of imidacloprid 200 SL @ 20 g a.i. /ha brought 31.43 per cent in reduction population of beetle and was statistically at par with imidacloprid 70 WG @ 21g a.i./ha (30.15%).

The data recorded after three days of spray revealed that the highest reduction was obtained in acetamiprid 20 SP @ 20 g a.i./ha (47.92%) followed by imidacloprid 200 SL @ 25 g a.i./ha which gave 44.97 per cent reduction in population of red pumpkin beetle and found at par with thiamethoxam 25 WG @ 25 g a.i./ha (43.90%). The reduction in beetle population was 40.64 per cent in imidacloprid 70 WG @ 24 g a.i./ha which was statistically at par with imidacloprid 200 SL @ 20 g a.i./ha (39.87%), which in turn was at par with imidacloprid 70 WG @ 21g a.i./ha (37.52%)

The results obtained after seven days of spraying were almost similar to the result obtained three days after treatment. Highest reduction in red pumpkin beetle population was observed in acetamiprid 20 SP @ 20 g a.i./ha (44.27%). It was followed by imidacloprid 200 SL @ 25 g a.i./ha (41.78%) which was found statistically at par with thiamethoxam 25 WG @ 25 g a.i./ha (40.22%). Imidacloprid 70 WG @ 24 g a.i. /ha caused 38.28 per cent reduction in beetle population and found moderately effective. Application of imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21g a.i./ha were found least effective treatments against red pumpkin beetle with 36.14 and 34.67 per cent reduction, respectively.

The reduction in the beetle population caused by various treatments following fourteen days after their application indicated that acetamiprid 20 SP @ 20 g a.i./ha brought maximum reduction of 39.70 per cent which was followed by imidacloprid 200 SL @ 25 g a.i./ha (37.87%). Thiamethoxam 25 WG @ 25 g a.i./ha brought 35.50 per cent reduction in beetle population and was found at par with imidacloprid 70 WG @ 24 g a.i./ha (35.24%), which in turn was at par with imidacloprid 200 SL @ 20 g a.i./ha (33.88%). The least reduction in population of red pumpkin beetle was obtained from imidacloprid 70 WG @ 21g a.i. /ha (32.16%).

4.2.4 Cucumber fruit fly *Dacus ciliatus* (Loew)

In order to identify a suitable treatment against the fruit fly on cucumber, different treatments were evaluated. Each treatment involved three applications and first application was done at after one month of sowing, second and third at fifteen days interval of first spray.

Observations on the number and weight basis of the damaged and the healthy fruits were recorded separately at each picking and the total weight of healthy and damaged fruits of all the picking were pooled together for computing mean per cent fruit damage.

The data pertaining to the efficacy of different treatments against fruit fly have been presented in the Table-7. It can be noticed that all the treatments were significantly superior over control in terms of mean per cent fruit damage (both on number and weight basis).

4.2.4a Per cent damaged fruits on number basis:

Results revealed that all the insecticides were significantly superior over untreated control in reducing the mean fruit infestation by fruit fly. Minimum fruit damage (11.17%) was recorded in imidacloprid 200 SL @ 25 g a.i./ha treated plots. It was followed by thiamethoxam 25 WG @ 25 g a.i./ha (13.14%) which was at par with imidacloprid 70 WG @ 24 g a.i./ha (13.53%). The mean number of fruit infestation in acetamiprid 20 SP @ 20 g a.i./ha was 14.80 per cent. Imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 21 g a.i./ha were moderately effective against fruit fly infestation where 16.53 and 17.95 per cent fruit infestation was recorded respectively. Maximum infestation of fruit fly was observed in untreated control which was 21.01 per cent.

4.2.4b Per cent damaged fruits on weight basis:

The fruit damage on weight basis showed a similar trend as that of fruit damage on number basis. The mean infestation of fruits on the weight basis after total picking in untreated control was as high as 20.23 per cent. Results indicated that imidacloprid 200 SL @ 25 g a.i./ha showed lowest fruit damage which was 10.78 per cent infestation followed by thiamethoxam 25 WG @ 25 g a.i./ha (12.19%), which was at par with imidacloprid 70 WG @ 24 g a.i./ha (12.84%). Data clearly revealed that acetamiprid 20 SP @ 20 g a.i./ha and imidacloprid 200 SL @ 20 g a.i./ha were found moderately effective and showed statistical similarity with respect mean per cent fruit damage on weight basis i.e. 14.29 and 15.26 per cent, respectively. Imidacloprid 70 WG @ 21g a.i./ha showed comparatively higher fruit infestation (16.50%) which was at par with imidacloprid 200 SL @ 20 g a.i./ha but differed statistically with acetamiprid 20 SP @ 20 g a.i./ha.

4.3 Phytotoxicity of inseticides

A field experiment was conducted to test the phytotoxicity of insecticides *viz.,* imidacloprid 70 WG (24 and 21 g a.i./ha), imidacloprid 200 SL (25 and 20 g a.i./ha), acetamiprid 20 SP (20 g a.i./ha) and thiamethoxam 25 WG (25 g a.i./ha). Fourty five days old cucumber crop was treated with all the treatments investigated and phytotoxic symptoms were recorded by visual observation and presented in Table-8.

Results revealed that under field conditions application of different treatments showed no phytotoxic effects on the cucumber crop.

4.3.1 Effect of insecticides on natural enemies

To find out the effect of different insecticidal treatments on natural enemies, observations were recorded on the population of natural enemies, like coccinellids was recorded at 1, 3, 7 and 14 days after third spray.

The perusal of data clearly depicted that one day after treatment, imidacloprid 200 SL @ 20 g a.i./ha caused minimum reduction (15.57%) in natural enemies population. Both the doses of imidacloprid 70 WG (24 and 21 g a.i./ha) were found statistically at par with it and brought about 16.03 and 16.80 per cent reduction in population of natural enemies. However, higher dose of imidacloprid 70 WG had no significant difference with imidacloprid 200 SL @ 25 g a.i./ha (18.12%) and thiamethoxam 25 WG @ 25 g a.i./ha (18.69%). Highest reduction in population of natural enemies was observed in the acetamiprid 20 SP @ 20 g a.i./ha treatment gave 20.41 per cent reduction and was at par with thiamethoxam 25 WG.

Three days after treatment, imidacloprid 70 WG @ 21 g a.i./ha gave minimum reduction (19.66%) which was at par with imidacloprid 200 SL @ 20 g a.i./ha and imidacloprid 70 WG @ 24 g a.i./ha brought 19.96 and 20.24 per cent reduction in natural enemies population. Maximum population reduction of natural enemies was observed in acetamiprid 20 SP @ 20 g a.i./ha (26.18%) which was at par with thiamethoxam 25 WG @ 25 g a.i./ha (23.75%), which in turn was at par with imidacloprid 200 SL @ 25 g a.i./ha (24.09%).

After seven days, the results indicated that imidacloprid 200 SL @ 20 g a.i./ha brought minimum reduction of 16.45 per cent in population of natural enemies and was at par with imidacloprid 70 WG @ 21 g a.i./ha (18.23%) which in turn was at par with imidacloprid 200 SL @ 25 g a.i./ha (19.86%), imidacloprid 70 WG @ 24 g a.i./ha (20.11%) and thiamethoxam 25 WG @ 25 g a.i./ha (20.21). Both the latter treatments were also found statistically at par with acetamiprid 20 SP @ 20 g a.i./ha which gave highest reduction in natural enemies population (22.01%)

5. DISCUSSION

5.1 Seasonal Incidence of major insect pests of cucumber:

Studies conducted on the seasonal incidence of insect pests of cucumber revealed that jassid, whitefly, red pumpkin beetle and fruit fly regularly caused considerable damage to the cucumber crop.

5.1.1 Jassid, *Amrasca biguttula biguttula* (Ishida)

The pest population occurred throughout the crop season and attained a peak (86.30 jassids/five plants) during the second week of October. The results obtained in the present investigation are thus in close agreement with the earlier reports of Gambhiri and Kumar (1998), who observed higher incidence of jassids during the August and September, which might be due to local weather conditions prevailed during the study period. On the basis of data obtained under the present investigation, it can be concluded that the temperature range 20.15 to 28.25° C along with high relative humidity provided favourable conditions for the multiplication of jassids. The findings confirmed the results obtained by Singh *et al.* (2005) who reported temperature ranging from 20.0 to 22.5° C with 69 per cent relative humidity as the most suitable conditions for the longevity of adult. However, it was adversely affected at 45 per cent relative humidity.

5.1.2 Whitefly, *Bemisia tabaci* (Gennadius)

B. tabaci appeared from the third week of September and remained active up to December and peak population (67.35 whiteflies/five plants) was observed during third week of October. On the basis of data obtained under the investigation, it can be concluded that temperature range as mentioned above 20.15 to 28.25° C provided favourable conditions for the multiplication of whiteflies. Thus, the present findings corroborate the findings of Shanab and Awad-Allah (1982) who reported that the pest reached at peak during July to October when the daily mean temperature varied from 20.86° C to 27.58° C and relative humidity varied from 58.90 to 66.66 per cent. The present finding also supported by Bharadiya and Patil (2005) who reported maximum activity of whiteflies during October.

5.1.3 Red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas)

R. foveicollis was first appeared from the second week of September and remained active up to December and peak population (4.00 beetles/five plants) was observed during the fourth week of October. On the basis of data obtained under the investigation, it can be concluded that temperature 20.15 to 28.25° C provided favourable conditions for the multiplication of beetles. Thus, the present results support the findings of Roy and Pande (1991b) who reported the maximum population of red pumpkin beetle in the month of December and August. The obtained results are linked with Borah (1999) who recorded 3.9 beetles per plant in cucumber during rainy season followed by 2.1 in winter season. The findings are also linked with Rajak (2000) who found the positive correlation with pest population and temperature, whereas, negative with relative humidity.

5.1.4 Fruit fly, *Dacus cucurbitae* Coquillet (*Bactrocera cucurbitae*).

The fruit fly was observed as an important pest showing an extent of damage ranging from 3.03 – 17.04 per cent on cucumber fruits. The data revealed that the infestation on fruits started soon after the fruits were formed. Gupta *et al.* (1992) reported that the infestation of fruits had positive correlation with temperature and relative humidity. Literature could not be traced regarding fruit infestation in September sown crop. However, Ingoley *et al.* (2002) reported a temperature and relative humidity range of 17.7° - 28.1° C and 72.0 -84.0 per cent favour the multiplication of red pumpkin beetle.

5.2 Bioefficacy

5.2.1 Jassid, *Amrasca biguttula biguttula* (Ishida)

The present investigation indicated that maximum reduction was observed on the third day after treatment in all the three sprays. Amongst different insecticidal treatments, imidacloprid at various doses proved to be the most effective treatment against jassid. Similar results were obtained by Mullins and Christie (1995) who also reported that imidacloprid was very effective against sucking insect-pests. Results of present investigation showed that imidacloprid 200 SL @ 25 g a.i./ha caused maximum reduction in population of jassid which significantly superior over other treatments. Earlier experiments of Acharya *et al.* (2002) support the present findings, who also reported imidacloprid (25 g a.i./ha) as a most effective treatment for controlling jassid. The results were also comparable with the results of Kumar and Santharam (1999) and Phadke and Phadke (2000) who reported that imidacloprid was an effective controlling agent of sucking pests. Thus imidacloprid 200 SL @ 25 g a.i./ha is an optimum dose for controlling jassid.

Lower doses of imidacloprid (24 - 20 g a.i./ha) and thiamethoxam (25 g a.i./ha) were also found effective and brought about 68.50 to 60.40 per cent reduction in the population of jassid. The present results are in conformity with the results of Mhaske and Mote (2005) who reported that imidacloprid (18.0 and 22.50 g a.i./ha) and thiamethoxam (25 and 50 g a.i./ha) were most effective against jassid, thrips and whiteflies in brinjal crop.

5.2.2. Whitefly, *Bemisia tabaci* (Gennadius)

Among different treatments tested, imidacloprid 200 SL @ 25 g a.i./ha was found most effective treatment as it was reported by Mullins and Christie (1995) and Brar *et al.* (1999) earlier. The results of present investigation were also in agreement with Mishra (2005) who observed that imidacloprid @ 25 g a.i./ha was most effective against whitefly infesting okra. Overall, it can be concluded that imidacloprid 200 SL @ 25 g a.i./ha is an optimum dose for controlling whitefly.

Imidacloprid 70 WG (24 and 21 g a.i./ha), imidacloprid 200 SL (20 g a.i./ha) and thiamethoxam 25 WG (25 g a.i./ha) were also moderately effective treatments which reduced the population of whitefly upto 56.09 per cent. The finding concord with the results of Sardana *et al.* (2005) who found the imidacloprid (18.0 and 22.5 g a.i./ha) and thiamethoxam (25 and 50 g a.i./ha) most effective against sucking insect-pests.

5.2.3 Red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas)

The efficacy of different treatments against red pumpkin beetle was deliberated under present investigations. Acetamiprid 20 SP and imidacloprid 200 SL were found significantly superior over all the treatments. Since no works could traced on the bioeffecacy of imidacloprid and acetamiprid against red pumpkin beetle infesting cucumber crop, hence, the results could not be compared with. Some studies on other beetles are available. On the basis of results, the present findings are agreement with the earlier reports of Kulkarni and Adsule (2006) who observed that imidacloprid 200 SL (25 g a.i./ha) could be effective in controlling the beetles in grape vine orchards. Imidacloprid was found highly effective to rice leaf beetle, rice water weevil (Iwaya and Tsuboi, 1992; Shiokawa *et. al.*, 1994 and Jian Zhong *et.al.*, 1996). Although, efficacy of imidacloprid was high against colorado beetle (Capella *et.al.*, 2004).

5.2.4 Fruit fly, *Dacus cucurbitae* Coquillet (*Bactrocera cucurbitae*).

The efficacy of different treatments against fruit fly was studied in terms of mean fruit damage on number and weight basis. Imidacloprid 200 SL @ 25 g a.i./ha found statistically superior to all other treatments. It was followed by thiamethoxam 25 WG @ 25 g a.i./ha and imidacloprid 70 WG @ 24 g a.i./ha which were found at par with each other. Since, the work on the efficacy of different insecticides tested in the present investigation is not traceable, hence, the present findings could not be compared with.

5.3 Phytotoxicity

In the present investigation, no visual phytotoxic effect in the form of burning symptoms and lesion were observed from any of the insecticidal treatment. Even imidacloprid 200 SL and imidacloprid 70 WG at their highest doses of 25 g and 24 g a.i./ha did not produce any lesion or burning symptoms on leaflets. The present findings are agreement with Trabanino *et al.* (1997) who reported that imidacloprid did not cause any symptom of phytoxicity. Proft and Proft (1991) reported that imidacloprid was effective against aphids without being phytotoxic. Ameta and Sharma (2005a) also reported that imidacloprid did not cause phytotoxicity on plant. Oomen and Kumar (2005) evaluated the phytotoxicity of insecticides on brinjal crop and concluded that imidacloprid and beta-cyfluthrin were potential insecticides to control the insect pest fauna of brinjal and produces no phytotoxic effects at the tested doses.

5.4 Effect on natural enemies

The lowest per cent reduction in the population of natural enemies was found (19.66%) in plots treated with imidacloprid 70 WG @ 21 g a.i./ha against 26.18 per cent in acetamiprid 20 SP @ 20 g a.i./ha. The increase in doses of imidacloprid resulted in increase in per cent reduction of natural enemies. According to Ameta and Sharma (2005b) imidacloprid was quite safer to natural enemies. Likewise, Bozsik (2006) observed that imidacloprid and *B. thuringiesis* seemed to be safer for *C. septempunctata.* Likewise, Kulkarni and Adsule (2006) also concluded that imidacloprid did not adversely affect the natural enemies population.

6. SUMMARY

A field trial was conducted to investigate seasonal incidence of insect pests of the cucumber and bioefficacy of some novel insecticides against the pests at Horticulture Farm, Rajasthan College of Agriculture, Udaipur during Septmber - December 2008.

The four insect pests *viz.*, jassid, *Amrasca biguttula biguttula* **(**Ishida), whitefly, *Bemisia tabaci (*Gennadius), red pumpkin beetle, *Raphidopalpa foveicollis* (Lucas) and fruit fly, *Dacus cucurbitae (*Coquillet) *(Bactrocera cucurbitae*) were recorded on cucumber. The incidence of jassid was started during 38th SMW i.e. 17th – 23rd September with a mean population of 4.60 jassids/five plants and reached the peak during second week of October (86.30 jassids/five plants). The occurrence of whitefly was also initiated during third week of September with a mean population of 2.57 whiteflies/five plants. The maximum population of whitefly i.e. 67.35 whiteflies/ five plants was observed during 15th -21st October. October onward the population of these pests followed a decreasing trend and reached the level of 3.74 jassids/ five plants and 9.40 whiteflies/ five plants. The correlation coefficient between mean temperature and population of jassid and whitefly was positive, while, with mean relative humidity it was negative.

The incidence of red pumpkin beetle was initiated during 10th – 16th September with a mean population of 1.20 beetle/ five plants. The highest incidence (4.00 beetles/ five plants) was found during the last week of October. The population of red pumpkin beetle was positively correlated with mean temperature (r = 0.105), whereas, it had negative association with mean relative humidity (r = -0.746).

The incidence of the fruit fly (on the basis of mean fruit infestation) commenced from the second week of October and reached at maximum level (17.04 per cent mean fruit infestation) during the first week of November. The infestation declined in the subsequent pickings. Average temperature and relative humidity had no significant influence on the infestation of the fruit fly on cucumber.

Among the various treatments tested against insect pests of cucumber, spray of imidacloprid 200 SL @ 25 g a.i./ha was found most effective, which caused maximum reduction in population of jassid and whitefly on 1st, 3rd, 7th and 14th day in all three sprays schedules. Similarly, the minimum fruit infestation on number and weight basis was also observed in imidacloprid 200 SL at the same dose. Rest of the treatments *viz.*, imidacloprid 70 WG and thiamethoxam 25 WG were also found effective and could be used as next best alternatives for the pest control in cucumber. In case of red pumpkin beetle, acetamiprid 20 SP @ 20 g a.i./ha brought maximum reduction (47.92%) in population and was followed by thiamethoxam 25 WG @ 25 g a.i./ha and imidacloprid 70 WG @ 24 g a.i./ha, which were almost equally effective in reducing the beetle population. None of the insecticidal treatments tested under present investigation produced any phototoxic symptoms on the cucumber plants.

Acetamiprid highly affected population of natural enemies after third day of III spray, whereas imidacloprid at various doses was found safer and caused quite low reduction in natural enemies population.

Table 7: Efficacy of different treatments against fruit fly in cucumber

Treatments	Dose g a.i./ha	Mean per cent fruit damage	
		Number Basis	Weight Basis
Control	-	21.01 (27.27)	20.23 (26.72)
Imidacloprid 70 WG	21	17.95 (25.05)	16.50 (23.95)
Imidacloprid 70 WG	24	13.53 (21.58)	12.84 (20.98)
Imidacloprid 200 SL	20	16.53 (23.98)	15.26 (22.98)
Imidacloprid 200 SL	25	11.17 (19.51)	10.78 (19.14)
Acetamiprid 20 SP	20	14.80 (22.62)	14.29 (22.20)
Thiamethoxam 25 WG	25	13.14 (21.24)	12.19 (20.42)
S. Em±	-	0.39	0.42
CD 5%	-	1.20	1.29
CV %	-	2.94	3.27

* Figures in parenthesis are angular transformed values

Table 4- Efficacy of different treatments against jassids in cucumber

* Figures in parenthesis are angular transformed values

Treatments	Dose g a.i./ha	Percent reduction in jassid population days after sprays											
		First spray				Second spray				Third spray			
		1st day	3rd day	7th day	14th day	1st day	3rd day	7th day	14th day	1st day	3rd day	7th day	14th day
Imidacloprid 70 WG	21	44.60 (41.89)	49.10 (44.48)	43.92 (41.51)	39.79 (39.11)	46.75 (43.13)	58.85 (50.09)	50.20 (45.11)	40.33 (39.42)	51.97 (46.12)	60.40 (51.00)	52.17 (46.24)	49.55 (44.74)
Imidacloprid 70 WG	24	52.94 (46.68)	59.79 (50.64)	54.60 (47.63)	46.37 (42.91)	57.99 (49.59)	67.98 (55.54)	54.93 (47.82)	46.27 (42.86)	58.22 (49.73)	68.50 (55.86)	62.68 (52.35)	55.83 (48.35)
Imidacloprid 200 SL	20	46.69 (43.10)	53.52 (47.02)	47.78 (43.72)	42.77 (40.84)	52.03 (46.16)	62.50 (52.24)	53.00 (46.72)	46.00 (42.70)	55.97 (48.43)	66.46 (54.62)	59.67 (50.57)	57.34 (49.21)
Imidacloprid 200 SL	25	55.67 (48.25)	67.83 (55.45)	56.18 (48.55)	49.64 (44.79)	59.15 (50.27)	70.67 (57.23)	56.17 (48.54)	47.92 (43.80)	59.80 (50.65)	74.40 (59.62)	65.18 (53.84)	58.98 (50.17)
Acetamiprid 20 SP	20	39.66 (39.03)	43.67 (41.35)	42.85 (40.88)	38.03 (38.07)	41.42 (40.05)	51.20 (45.68)	46.59 (43.04)	37.37 (37.68)	45.00 (42.12)	58.78 (50.05)	50.33 (45.19)	46.19 (42.81)
Thiamethoxam 25 WG	25	40.95 (39.78)	46.12 (42.77)	41.31 (39.99)	42.52 (40.69)	43.83 (41.45)	53.62 (47.07)	47.75 (43.70)	41.73 (40.23)	48.35 (44.05)	63.54 (52.85)	54.84 (47.77)	51.75 (46.00)
S. Em±	---	0.431	0.658	0.576	0.389	0.546	0.758	0.593	0.530	0.486	0.782	0.613	0.543
CD5%	---	1.32	2.02	1.77	1.20	1.68	2.33	1.82	1.62	1.49	2.40	1.88	1.67
CV %	---	2.02	2.83	2.66	1.92	2.45	2.98	2.61	2.61	2.09	2.93	2.51	2.34

Treatments	Dose g a.i./ha	Percent reduction in whitefly population days after sprays											
		First spray				Second spray				Third spray			
		1st day	3rd day	7th day	14th day	1st day	3rd day	7th day	14th day	1st day	3rd day	7th day	14th day
Imidacloprid 70 WG	21	40.01 (39.23)	47.61 (43.63)	43.33 (41.16)	35.67 (36.66)	44.27 (41.70)	51.64 (45.93)	46.36 (42.91)	40.49 (39.51)	50.01 (45.00)	57.60 (49.37)	54.70 (47.69)	46.19 (42.81)
Imidacloprid 70 WG	24	46.54 (43.01)	55.43 (48.11)	49.51 (44.71)	41.67 (40.20)	51.20 (45.68)	62.57 (52.28)	54.43 (47.54)	43.70 (41.37)	56.86 (48.94)	65.53 (54.05)	59.16 (50.28)	52.00 (46.14)
Imidacloprid 200 SL	20	44.26 (41.70)	51.74 (45.99)	46.33 (42.89)	39.41 (38.88)	46.17 (42.80)	54.43 (47.54)	46.12 (42.77)	41.97 (40.37)	48.22 (43.98)	56.09 (48.49)	52.37 (46.35)	47.85 (43.76)
Imidacloprid 200 SL	25	52.66 (46.52)	60.60 (51.12)	54.51 (47.58)	43.52 (41.27)	54.02 (47.30)	65.23 (53.88)	56.10 (48.50)	45.61 (42.48)	56.99 (49.02)	69.18 (56.28)	62.92 (52.48)	54.67 (47.68)
Acetamiprid 20 SP	20	33.54 (35.39)	40.69 (39.63)	37.83 (37.95)	32.38 (34.68)	39.30 (38.82)	47.63 (43.64)	41.75 (40.24)	36.21 (36.99)	43.40 (41.20)	49.51 (44.72)	47.32 (43.46)	43.04 (41.00)
Thiamethoxam 25 WG	25	36.07 (36.90)	43.79 (41.42)	40.70 (39.63)	37.69 (37.87)	41.12 (39.88)	50.05 (45.02)	43.86 (41.47)	38.66 (38.44)	47.62 (43.63)	60.27 (50.93)	50.99 (45.56)	44.58 (41.89)
S. Em±	---	0.453	0.638	0.562	0.414	0.462	0.689	0.589	0.445	0.504	0.768	0.556	0.456
CD5%	---	1.39	1.96	1.72	1.27	1.42	2.12	1.81	1.36	1.55	2.35	1.71	1.40
CV %	---	2.27	2.87	2.68	2.19	2.19	2.90	2.71	2.25	2.26	3.07	2.36	2.10

Table 5- Efficacy of different treatments against whiteflies in cucumber

* Figures in parenthesis are angular transformed values

Treatments	Dose g a.i./ha	Percent reduction in red pumpkin beetle population days after sprays											
		First spray				Second spray				Third spray			
		1st day	3rd day	7th day	14th day	1st day	3rd day	7th day	14th day	1st day	3rd day	7th day	14th day
Imidacloprid 70 WG	21	25.23 (30.15)	31.51 (34.13)	26.44 (30.92)	25.28 (30.18)	29.75 (33.04)	35.24 (36.41)	31.37 (34.05)	28.07 (31.97)	30.15 (33.30)	37.52 (37.75)	34.67 (36.07)	32.16 (34.53)

Table 6- Efficacy of different treatments against red pumpkin beetles in cucumber

Imidacloprid 70 WG	24	30.17 (33.31)	35.55 (36.59)	32.79 (34.93)	28.16 (32.04)	32.70 (34.87)	38.41 (38.29)	36.68 (37.26)	30.47 (33.48)	34.08 (35.71)	40.64 (39.59)	38.28 (38.22)	35.24 (36.41)
Imidacloprid 200 SL	20	28.05 (31.97)	33.67 (35.45)	31.14 (33.91)	26.76 (31.14)	30.71 (33.64)	36.07 (36.90)	34.34 (35.86)	29.73 (33.00)	31.43 (34.08)	39.87 (39.14)	36.14 (36.95)	33.88 (35.59)
Imidacloprid 200 SL	25	33.21 (35.18)	36.49 (37.15)	33.32 (35.24)	29.96 (33.18)	36.80 (37.34)	42.20 (40.50)	39.31 (38.81)	33.88 (35.58)	37.96 (38.03)	44.97 (42.10)	41.78 (40.26)	37.87 (37.98)
Acetamiprid 20 SP	20	35.83 (36.76)	41.75 (40.25)	38.13 (38.13)	32.83 (34.95)	38.07 (38.09)	47.12 (43.34)	41.29 (39.98)	34.50 (35.95)	40.25 (39.37)	47.92 (43.80)	44.27 (41.70)	39.70 (39.06)
Thiamethoxam 25 WG	25	33.72 (35.49)	39.39 (38.87)	36.81 (37.34)	30.70 (33.63)	33.98 (35.65)	41.03 (39.81)	32.74 (34.89)	31.92 (34.38)	36.04 (36.89)	43.90 (41.50)	40.22 (39.35)	35.50 (36.57)
S. Em±	---	0.426	0.674	0.594	0.408	0.529	0.698	0.619	0.499	0.550	0.789	0.536	0.516
CD5%	---	1.31	2.07	1.82	1.25	1.62	2.14	1.90	1.53	1.69	2.42	1.65	1.59
CV %	---	2.54	3.67	3.42	2.54	3.02	3.60	3.40	2.96	3.07	3.92	2.80	

* Figures in parenthesis are angular transformed values

Abou-Elhaga, H.H. 1998. Seasonal abundance of certain cotton pests and their natural enemies in southern Egypt. *Assia Journal of Agricultural Science*, 29(**3**): 253-267.

Acharya, S., Mishra, H.P. and Dash, D. 2002. Efficacy of insecticides against okra jassid, *Amrasca biguttula biguttula* Ishida. *Annals of Plant Protection Sciences*, **10**: 230-232

Ali, F., Badshah, H., Rehman, A. and Shah, S.B. 2004. Population density of cotton whitefly *Bemisia tabaci* and mites *Tetranychus urticae* on brinjal and their chemical control. *Asian journal of plant science* 3 (**5**): 589-592.

Ameta, O.P. and Sharma, K.C. 2005a. Bioefficacy of imidacloprid (Confidor) against sucking insect pests of cotton. *Insect Environment*, **11**: 9-13.

Ameta, O.P. and Sharma, K.C. 2005b. Evaluation of confidor for the management of sucking insect pests of cotton. *Pestology*, 29 **(2)**:35-40.

Baniameri, V. and Sheikhi, A. 2006**.** Imidacloprid as a soil application against whitefly, *Bemisia tabaci* in greenhouse cucumber. *Bulletin OILB/SROP*, 29(**4**): 101.

Baskaran, V., Jagdishwar, D., Subbaratnam, G.V. and Reddy, S.A. 2003. Efficacy of newer insecticides against spiraling whitefly (*Aleurodicus disperses* Russell). *Pestology*, 27(**4**): 16-19.

Bellettini, S., Bellettini, N.M.T., Fontes, A.R. and Sanches, V. 1999. Efficacy of insecticides as sprays for the control of aphid (*Aphis gossypii*, Glover, 1877) on cotton. *Anais of Congresso Brasileirode Algodao; Oalgodao no Seculoxx, Perspectivar para O Seculo XXI, Ribeirao Prcto, SP, Brasil*, 293-295.

Bharadia, A.M. and Patil, B.R. 2005. Succession of insect pests of brinjal in north Gujarat. *Pest Management and Economic Zoology*, **13**: 159-161.

Bhardwaj, S.C. and Kushwaha, K.S. 1984. Whitefly, *Bemisia tabaci* (Genn.) (Hemoptera: Aleyrodidae) infesting tomato in Rajasthan. *Bulletin of Entomology*, 25(**1**): 76-77.

Bochkarev, S.V. 2001. Confidor in protected soil. *Zashchita I Karantin Rastenii*, **5**: 22-23.

Borah, R.K. 2001. Effect of sowing dates on incidence of fruit fly (*Bactrocera cucurbitae* Coq.) and yield of cucumber (*Cucumis sativus* L.) in the Hills Zone of Assam. *Annals of Biology*, 17(**2**): 211-212.

Borah, R.K. 1995. Incidence of insect pests in cotton (*Gossypium hirsutum* L.) in the hill zone of Assam. *Annals of Agricultural Research*, 16 (**2**): 218-219.

Borah, R.K. 1999. Seasonality and varietal preference of red pumpkin beetle, *R. foveicollis* on cucumber (*C. Sativus*) in Assam. *Indian Journal of Agricultural Sciences*, **69**: 180-181

Bozsik, A. 2006. Susceptibility of adult *Coccinella septempunctata* (Coleoptera: Coccinellidae) to insecticides with different modes of action. *Pest Management Science*, **62:** 651-654.

Brar, D.S., Sohi, A.S., Singh, J. and Singh, J. 1999. Efficacy of insecticides against *Amrasca biguttula biguttula* (Ishida) and *Bemisia tabaci* (Gennadius) on hirsutum cotton. *Insect Environment*, 5 (**2**): 83.

Bughio, A.R., Hussain, T. and Qureshi, Z.A. 1986. Incidence and population density of sucking pest complex on cotton. *Proceedings of Pakistan Congress of Zoology*, **6**: 93-98.

Capella, A., Guarnone, A., Domenichini, P. and Airoldi, M. 2004. Acetamiprid (EPIK), a new neonicotinoid for pest control in orchards, vegetables and ornamentals. *Informatore Fitopatologico*, 54(**4**): 43-47

Chen Z.L., Ye, G.X. and Zhang, R.Z. 2006. Observation on the aphids of plum and its control. *South China Fruits*, **2**: 78.

Choudhary, Z.A. and Ali Khan, M.A. 1990. Effect of temperature and relative humidity on the development and fecundity of the red pumpkin beetle, *R. foveicollis* Lucas. *Indian Journal of Entomology*, **52**: 274-278.

Czepak, C., Fernandes, P.M., Albernaz, K.C., Rodrigues, O.D., Silva, L.M., Silva, E.A.D., Takatsuka, F.S. and Borges, J.D. 2005. Selectivity of insecticides on the complex of natural enemies in cotton crop (*Gossypium hirsutum* L.). *Pesquisa Agropecuaria Tropical*, **35:** 123-127.

Das, S.N., Ray S., Chatterjee, M.L. and Raj, S. 2001. Bioefficacy, yield benefit and cost effectively of some new modules against okra fruit borer, *Earias vittella* (L.) Noctuidae: Lepidoptera. *Journal of Interacademicica*. 5 (**3**): 346-351.

Dikshit, A.K., Lal, O.P., and Kumar, R. 2001. Persistence and bioefficacy of insecticides in okra and sponge guard. *Journal of Entomological Research*, 25 (**2**): 131-136.

Domenichini, P. and Tiraferri, S.R. 1998. Results of the field trials carried out with acetamiprid Reg., a new systemic insecticide, during 1995-1997. *Atti Giornate fitopatologiche, Scicli e Ragusa, 3-7 maggio, 1998*, 167-172.

Economic Survey 2007-08. Economic Division, Ministry of Finance, New Delhi, pp. 157.

Gambhiri, P.C. and Kumar, A. 1998. Intensity of infestation, varietal preference and control of *Amrasca biguttula biguttula* (Ishida) and *Leucinodes orbonalis* (Guen.) on brinjal. Abstracts. *National seminar on Entomology in* 21st *century*. April 30-May 2, 1998 at Udaipur.

Ghathala, S.L. and Bajpai, N.K. 2007. Seasonal incidence of red pumpkin beetle, *Raphidopalpa foveicollis* on major cucurbitaceous crops in south east Rajasthan. *India Journal of Applied Entomology*, 21 **(2):** 98-99.

Gupta, D., Verma, A.K. and Gupta, D. 1992. Population fluctuations of the maggots of fruit fly (*Dacus cucurbitae* Coquillett and *D. tau* Walker) infesting cucurbitaceous crops. *Advances in Plant Sciences*, **5**: 518-523.

Gupta, G.P., Agnihotri, N.P., Sharma, K., Gajbhiye, V.T. and Sharma, K. 1998. Bioefficacy and residue of Imidacloprid in cotton. *Pesticide Research Journal,* 10 (**2**): 149-154.

Gupta, M. and Shanker, A. 2007. Bioefficacy of Imidacloprid and acetamiprid against *Nipaecoccus vastator* and *Toxoptera auranthi* in tea. *Indian Journal of Applied Entomology*, **21**: 75-78.

Henderson, C.F. and Tilton, E.W. 1955. Test with acaricides against the brown wheat mite. *Journal of Economic Entomology,* 48: 157-161

Hussain, M.A. and Shah, A.S. 1926. The red pumpkin beetle, *A. abdominalis* (Feb.) and its control, with a short note on *A. atripennis* (Febr.). *Mem. Agric. India Ent. Ser.,* 31-54.

Indumati, N. and Savithri, P. 2006. Toxic effects of insecticides on predatory coccinallid beetles in the Mango ecosystem. *Indian Journal of Entomology*. **68**: 187-189.

Ingoley P., Mehta, P.K and Verma, K.S. 2002. Seasonal occurrence of fruit fly, *Bactrocera cucurbitae* Coq., on cucumber in midhills of Himachal Pradesh. *Himachal Journal of Agricultural Research*, 28(**1/2**): 48-53.

Iwaya K. and Tsuboi S. 1992. Imidacloprid – a new substance for the control of rice pests in Japan. *Pflanzenschutz Nachr., Bayer (English ed.)* **45**: 197-230.

Jarade, N.T. and Dethe, M.D. 1994. Effective control of brinjal sucking pest using imidacloprid. *Plant Protection Bulletin*, Faridabad, **46**:2-3.

Jaydeb, G., Ghosh, S.K., Chatterjee, R.K. and Senapati, S.K. 1999. Pest constraints of okra under tarai region of West Bengal. *Indian Journal of Entmology,* 61 (**4**): 362-371.

Jayekar, N.E., Mundhe, D.R., Wandnerkar, D.W., Zanwar, P.R. and Narwade, B.P. 2003. Evaluation of Acetamiprid 20 SP against sucking pests of chilli. *Pestology*, 27 (**11**): 17-20.

Jian Zhong S., Jichao F., Li Ru X., Jin Sheng Y., Xue Sheng S., Sun J.Z., Fan Xia L.R., Yang J.S. and Shen X.S. 1996. Studies on insecticidal activity of imidacloprid and its application in paddy fields against the brown planthopper, *Nilaparvata lugens*. *Acta Entomologica Sinica*, **39**: 37-45.

Johri, R. And Johri, P.K. 2003. Survey for seasonal biology and intensity of attack of red pumpkin beetle, *R. foveicollis* Lucas at Kanpur in Uttar Pradesh. *Journal of Applied Zoological Research* **14**: 144-147.

Kandil, M.A., El-Kabbany, S.M., Sewfy, G.H. and Abdallah, M.D. 1991. Efficacy of some insecticides against the cotton whitefly, *Bemisia tabaci* (Genn.) with special regard to their side effect on predators. *Bulletin of the Entomological Society of Egypt, Economic Series*, 9-17

Kavadia, V.S. and Gupta, H.C.L. 1986. Generation of data on bioefficacy, residues and shelf life of pesticides formulation. *Final Technical Report, Sukhadia University, Deptt. of Entomology, Rajasthan College of Agriculture*, Udaipur.

Kendappa, G.N., Mallicarjunapp S., Shankar, G. and Mithyantha, M.S. 2004. Evaluation of certain insecticides against spiraling whitefly, *Aleurodicus disperses* Russell (Aleyrodidae: Homoptera) on cotton. *Pestology*, 28 (**3**): 32-33

Khurana, A.D. 1998. Bioefficacy of insecticide used as seed treatment and spray against jassids, whitefly and pink boll worm of cotton. National Conference on Entomology in 21th Century, April 30th – May 2nd, 1998, held in Udaipur.

Khuroo, M.S., Khare, C.P., Tiwari, P.K. and Shrivastava, S.K. (2003). Possibilities of imidacloprid incorporation for the management of whitefly, *Bemisia tabaci* Gann. on chilli. *Environment and Ecology*, 21(**1**): 214-217.

Kishore, P. and Dixit, A.K. 2001a. Persistence and bioefficacy of insecticides against shoot fly, *Atherigona approximata* Malloch in pearl millet. *National Conference on Plant Protection*, February 23-25, 2001 held at Udaipur.

Kishore, P. and Dixit, A.K. 2001b. Persistence and bioefficacy of insecticides against shootfly *Atherigona approximata* Malloch in pearl millet. *National Conference on Plant Protection,* February 23-25, 2001. held at Udaipur.

Kulkarni, N.S. and Adsule P.G. 2006. Effect of confidor 200 SL (imidacloprid) for the management of flea beetle, thrips and jassids of grape. *Pestology,* 30(**4**):52-56

Kumar, K. and Santharam, G. 1999. Effect of Imidacloprid against aphids and leaf hopper on cotton. *Annals of Plant Protection Science*, 7 (**2**): 248-250.

Kumar, V.D.V.N.H., Subramanian, R. and Natarajan, P. 1999. Evaluation of Acetamiprid, A new insecticidal compound against cotton aphid *Aphis gossypii* and jassid, *Amrasca biguttula biguttula. Pestology*. 26-30.

Kushwaha, K.S., Pareek, B.L., and Noor, A. 1973. Fruit fly damage in cucurbits at Udaipur. *Udaipur University Research Journal*, **11:**22–23.

Kuttalam, S., Kumar, B.V., Kumaran, N. and Boomathi, N. 2008. Evaluation of bio-efficacy of flubendimide 480 SC against fruit borer *H. armigera* (Hub.) in tomato. *Pestology* **32:** 13-16.

Lakshmi, M.V., Rao, G.R. and Rao, P.A. 2005. Efficacy of different insecticides against red pumpkin beetle, *R. foveicollis* Lucas on pumpkin. *Journal of Applied Zoological Research,* **16**:73-74

Lall, B.S. and Sinha, S.N. 1959. Studies on the biology of the melon fly, *Dacus cucurbitae* (Coq.) (Diptera: Tephritidae). *Science & Culture*, **25**:159–161.

Leib, B.G., Jarrett, A.R., Orzolek, M.D. and Mumma, R.O. 1997. Reduced potential for water quality degradation when Admire is applied via drip irrigation under plastic mulch. *Paper American Society of Agricultural Engineers*, (972107): 17.

Lopez, R.L. and Rivera, I.R.T. 1997. Rescate 200 (acetamiprid) a new alternative for silver leaf whitefly control in the Maxicali valley, Maxico. *Proceeding Beltwide Cotton Conference*, New Orleans, LA, USA, 6-10.

Marklund, S.K., Peterson, L.J., Hauser, T.A., Chapman, A.E., Kolmes, S.A., Nichols, R.L. and Dennehy, T.J. 2003. Influence of imidacloprid, a chloronicotinyl insecticide on host choice and movement patterns of *Bemisia argentifolii* (Homoptera: Aleyrodidae) on cantaloupe plants (*Cucumis melo* L.). *Journal of the Kansas Entomological Society*, 76(**4**): 672-675.

Mathiranjan, V.G. and Regupathy, A. 2002. Effect of thiamethoxam 25 WG on *Chrysoperla carnea*. *Annals of Plant Protection Sciences,* **10**: 374-375.

Matsuda, M. and Takahashi, H. 1996. Mospilan R (Acetamiprid, NI-25), a new systemic insecticides. *Agrochemicals Japan*, **68**: 20-21.

Mhaske, B.M. and Mote, U.N. 2005. Studies on evaluation of new insecticides against brinjal pest complex. *Journal of Maharashtra Agricultural Universities*, **30**: 303-306.

Mishra, H.P. 2005. Efficacy of some newer insecticides against the whitefly, *Bemisia tabaci* Genn. infesting okra. *Orissa Journal of Horticulture,* **33:** 76-78.

Mishra, H.P. and Senapati, B. 2003. Evaluation of new insecticides against okra jassid (*Amrasca biguttula biguttula*). *Indian Journal of Agricultural Sciences,* 73(**10**): 576-578.

Mullins, W. and Christie, D. 1995. Management of aphids, whitefly and plant bugs with foliarly applied Imidacloprid. *Proceeding Beltwide Cotton Conference,* San Antonio, USA, **2**: 868-870.

Narayanan, E.S. and Batra, H.N. 1960. *Fruit Flies and Their Control*. Indian Council of Agricultural Research, New Delhi, India, pp. 1–68.

Oomen, S. and Kumar, A. 2005. Phytotoxicity of Imidacloprid and Beta-cyfluthrin in brinjal. *Indian Journal of Applied Entomology,* **19**: 165-166.

Patel, H.M. and Jhala, R.C. 1992. Studies on host range and host preference and population dynamics of whitefly, *B. tabaci* (Genn.) in south Gujarat, India. *Gujarat Agricultural University Research Journal,* 17 (**12**): 76-81.

Patel, J.D., Patel, G.M. and Rote, N.B. 1999. Succession of important pests of cotton in north Gujarat. *Journal Applied Zooogical Research*, 10(**1**):9-11.

Patil, B.V., Bheemanna, M., Badari Prasad, P.R., Gowdar, S.B. and Kumar, V.D.V.N.H. 2001. Bioefficacy of Acetamiprid 20 SP against early sucking pests in irrigated cotton. *Pestology*, 25(**9**):29-33.

Patil, C.S. and Lingappa, S. 1999. Intrinsic toxicity of insecticides to the grubs of *Menochilus sexmaculatus* Fab. (Coccinellidae: Coleoptera). *Insect Environment*. **5:** 40.

Phadke, A.D. and Phadke, B. 2000. Evaluation of Vertiguard along with conventional and non conventional insecticides and repellents for the control of brinjal whitefly. *Pestology*, **25**: 28-32.

Powell, C.A., Burton, M.S., Pelosi, R.R., Rundell, P.A., Ritenour, M.A. and Bullock, R.C. 2006. Six-year evaluation of brown citrus and spirea aphid populations in a citrus grove and the effects of insecticides on these populations. *HortScience*, 41(**3**): 688-690.

Powell, C.A., Burton, M.S., Pelosi, R.R., Rundell, P.A., Ritenour, M.A. and Bullock, R.C. (2007). Seasonal abundance and insecticidal control of citrus leaf miner in a citrus orchard. *HortScience*, 42(**7**): 1636-1638.

Proft, L.S. and Proft, K.M. 1991. Control of aphid vectors of yellow dwarf virus by spraying and seed treatment. *Mededli ngenvan de facyulteit landbouwetens Chappen Riijs Universiteit Gen*t, **56**:1181-1196.

Raghuraman, M. and Gupta, G.P. 2006. Effect of neonicotinoids on jassid, *Amrasca devastans* (Ishida) in cotton. *Annals of Plan Protection Sciences,* **14**: 65-68.

Rajak, D.C. 2000. Studies on population fluctuations of red pumpkin beetle on muskmelon (*Cucumis melo L*). *Agriculture Science Digest,* **20**: 54-55

Rajak, D.C. and Singh, H.M. 2002. Comparative efficacy of pesticides against red pumpkin beetle, *Raphidopalpa foveicollis* on musk melon. *Annals of Plant Protection Sciences*, **10**:147-148

Ramprasad, G., Shreedhar, U., Sitaramaih, S. and Rao, S.N. 1998. Evaluation of neonicotinoids against tobacco aphid on flue cured Virginia tobacco. *International Conference on Pests and Pesticides Management for Sustainable Agriculture*, 11-13 December 1996, held at Kanpur.

Riley, D.G. 2007. Effect of imidacloprid on settling behavior of *Frankliniella occidentalis* and *Frankliniella fusca* (Thysanoptera: Thripidae) on tomato and peanut. *Journal of Entomological Science*, 42(**1**): 74-83.

Roy, D.C. and Pande, Y.D. 1991a. Seasonal incidence, host preference and feeding rate of red Pumpkin beetle (*R. foveicollis*) in Tripura. *Indian Journal of Agricultural Sciences*, **61**: 603-607.

Roy, D.C. and Pande, Y.D. 1991b. Biological studies on the red pumpkin beetle, *R. foveicollis* Lucas (Coleoptera: Chrysomelidae) in Tripura. *Indian Journal of Agricultural Sciences*, **12**: 1-6

Santos, W.J., dos-Santos, K.B., dos-Santos, W.J. and dos-Santos, K.B. 1999. Control of aphid, *Aphis gossypii* and thrips, *Frankliniella schultzei* on cotton. *Anais of Congresso Brasileirode Algodao; Oalgodao no Seculoxx, Perspectivar para O Seculo XXI, Ribeirao Prcto, SP*, Brasil, 175-177.

Sarangdevot, S.S. 1998. Investigation on seasonal incidence, avoidable losses and development of control schedule against insect pests of brinjal. M. Sc. (Ag.) Thesis, Department of Agril. Zool. and Entomology, Rajasthan College of Agriculture, Udaipur, RAU, Bikaner.

Sardana, H.R., Bambawale, O.M., Singh, D.K. and Kada, L.N. 2005. Monitoring of insecticides residue in IPM and non IPM fields of okra and brinjal. *Indian Journal of Plant Protection*, **33**: 197-201.

Satpute, N., Katole, S., Nimbalkar, S. And Satpute, U. 2002. Attraction of seed treatment of imidacloprid and thiamethoxam to the population of C*heilomens sexmaculata* and *Chrysoperla carnea* on cotton. *Journal of Biological Control*, **16**: 81-83.

Senapati, B. and Mohanty, G.D. 1980. A note on the population fluctuation of sucking pests of cotton. *Madras Agricultural Journal*, 67 (**9**): 624-630.

Shanab, L.M. and Awad-Allah, S.S. 1982. Studies on the whitefly, *Bemisia tabaci* (Genn.) infesting tomato at Mansoura district, Egypt. *Acta Phytopathological Academic Scientiarum Hungarical*, 17 (**1/2**):147-155.

Sharma, D.R. and Lal, O.P. (2002). Bio-efficacy of thiamethoxam in comparison to recommended insecticides against leafhopper and whitefly of brinjal (*Solanum melongena* L.). *Journal of Entomological Research*, 26(**3**): 257-262.

Sharma, G.M. and Sharma, P.D. 1997. Population dynamics of cotton leaf hopper, *A. biguttula biguttula* (Ishida) on cotton and okra. *Annals of Biology*, 13 (**1**): 179-183.

Sharma, S.S., Bhanot, J.P. and Kalra, V.K. 1999. Host preference, extent of damage and control of red pumpkin beetle, *R. foveicollis* Lucas. *Journal of insect science*, **12**: 168-170

Shiokawa K., Tsuboi S., Iwara, K. and Mriya, K. 1994. Development of chloronicotinyl insecticide, imidacloprid. *Journal of Pesticides Science*, **19**: 329-232.

Sindhu, A.S. and Dhawan, A.K. 1980. Seasonal abundance of different insect pests on desi cotton (*Gossypium arborium* L.). *Journal of Research Punjab Agriculture University*, 17 (**3**): 275-281.

Singh, D. and Jaglan, R.S 2001. Efficacy of seedling root dip method of insecticides against whitefly (*Bemisia tabaci* Genn.) on brinjal. *Journal of Entomological Research*, 25(**4**): 293-298.

Singh, D.S. and Singh, J.P. 2000. Relative toxicity of *Spilactia obliqua* larvae against some pyrethroid and non-pyrethroid insecticides. *Indian journal of entomology* **62:** 289-294.

Singh, S., Kumar, A. and Awasthi, B.K. 2005. Study of sucking and leaf feeding insect in relation to weather parameters on the brinjal crop. *Vegetable Science*, **32**: 210-212.

Sinha, S.R. and Sharma, R.K. 2007. Efficacy of Neem and synthetic pesticides against insect pests of okra .*Indian Journal of Entomology*, **69**: 350-352.

Suresh, M., Bijaya, P. and Singh, T.K. 1996. Seasonal incidence of insect pests on brinjal and a note on the biology of *Leucinoids orbonalis* Guen. in Manipur. *Utter Pradesh Journal of Zoology* **16**: 151-155

Trabanino, E., Aldana, H. and Salguero V. 1997. Effect of imidacloprid on whitefly control in melon. Guatemala City, Guatemala, 1-4 September, 1997. *Proceedings of the Interamerican Society for Tropical Horticulture*, **41**: 46-49.

Verghese, A. 1998. Effect of imidacloprid on mango hopper. *Pest Management in Horticultural Ecosystem*, **9**: 70-74.

Yadav, J.L., Chouhan, R. and Yadav, P.R. 2003. Relative toxicity of foursysemic pyrethroids and endosulphan to *H. armigera* from Hisar (India). Indian journal of entomology **65**: 115-116.