# Studies on the Integrated Management ofSome Important Insect Pests of Cabbage *Brassica oleracea* var. Capitata (Linnaeus).

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## ABSTRACT

Population trends of *Brevicoryne brassicae, Pieris brassicae, Plutella xylostella* and *some other pests* on four varieties of cabbage viz., Golden Express, Golden Acre, Uttam and Pride of India raised separately for *Kharif* and *Rabi* seasons for head and seed crop in relation to environmental factors were studied during the two cropping seasons of (Head crop) 1999 and 2000; Seed crop 1998-1999 and 1999-2000, respectively.

The results revealed that *B. brassicae* and *P. brassicae* were two major pests associated with the crop from seedling to harvest; and, the population density reached to peak during October and May-June coinciding with head formation and sprouting stage. There was no distinct difference with the varietal differences to the population of these pests.

The data of the two consecutive seasons also indicated that all the varieties of cabbage screened supported large population of *B. brassicae* during sprouting stage (May and June). High temperature during September-October could be the reason for high population of the aphid ( Head crop) during the period.

Maximum percentages of plants were infested with the pest during peak population while as no plants were infested during winter months of January and February. The number of infested plants and infestation index were significantly low in November and December.

Other pests of some economic importance recorded during the studies included *Bagrada cruciferarum, Athalia proxima, Phylotretta cruciferae, Hellula undalis* and *Agrotis ipsilon* thus were categorized here as some other pests. All the varieties were free of infestation during winter months of December –February in both the *Rabi* seasons of 1998-1999 and 1999-2000. The population started increasing from March onwards reaching to peak during June when the crop was ready to harvest.

All the varieties of cabbage screened were free from infestation during December-February for both the cropping seasons of seed crop. There were very low percentage infestation in October-November and high in April-May.

The results indicated that head crop was also infested with *P. xylostella* throughout growing period. However, population of these pests were observed during the month of June, which declined after July in both cropping season. Per cent plants infestation and infestation index did not follow any trend. However, *B. brassacie* and *P. brassicae* registered their presence throughout the crop growing season with high density during June; and, all the varieties screened showed little variation. Population declined from the month of August.

The survival of *P. brassicae* reared on four varieties of cabbage i.e. Golden Express, Golden Acre, Uttam and Pride of India during the year 1999 and 2000, separately on consecutive generation revealed that there was no significant difference in the survival of larvae on four varieties of cabbage, however, significant proportion of population of the pest was found to survival on Uttam variety of cabbage.

During 1999 (85.78%) larvae survived when reared on Uttam, (82.22%) on Pride of India , however, on Golden express and Golden Acre varieties survival level was low with only (63.11 and 49.78%) larvae reached pupal stages, similarly during the year 2000 large number of larvae survived on Uttam (84.0%) followed by Pride of India (78%). There were

no significant difference in the survival of larvae when reared on Golden Express and Golden Acre reaching a survival of 72.89 and 73.33%, respectively. Comparison of survival of the pest for both the seasons also reflected a significant difference in the larval survival. During the year 1999, 1st and 2nd generations larvae showed significantly higher survival than that the last three generations, however, during 2000 2nd, 3rd and 4th generations showed non significant survival as compared to 1st and 5th generations which showed significant larval survival.

Study on the development of *P. brassicae* carried out during two years separately on four commercial varieties of cabbage for consecutive generations during the year 1999 and 2000 indicated that developmental stages including incubation, larval and pupal period, sex ratio and longevity of the moth showed non significant relationship with varieties as well as generations. During both the seasons the fecundity of *P. brassicae* varies from 113.1 to 124.7 eggs, which hatched within the range of 5.93 to 6.13 days on the four varieties of cabbage. The larval and pupal periods extended within 23.23 to 25.60 and 10.1 to 11.27 days, respectively while the sex ratio ranged between 1.06 to 1.25, longevity of males and females 14.9 to 16.1 and 13.2 to 16.9 days, respectively during the year1999 and 2000. However, the data recorded on different generations showed non significant relationship during both years. The highest fecundity was recorded in the third generation which were 123.1 to 127.8 eggs per female, higher incubation period during 2nd generation ranged from 6.08 to 6.25 days, longest larval period on 4th generation ranged from 24.17 to 25.58 days, longest pupal period on 5th generation 11.17 to 10.5 days, respectively. The data further revealed that hibernation period was extended for longer duration in 2nd generation. However, the interaction of varieties and generations showed non significant relationship during both the years in respect of all varieties.

While working on the biology it was observed that *P. brassicae* eggs required 3.2 to 17.6 days to hatch and duration of larval, pupal and adult longevity extended upto 5.6 to 14.7, 7.3 to 28.8 and 2.6 to 12.3 days, respectively during different seasons of crop growth. Five generations of the *P. brassicea* have been recorded on cabbage.

Mean population of *P. brassicae* on two varieties of cabbage i.e. Golden express and Golden Acre during the two cropping seasons of 2001 and 2002 treated with different insecticides/biocides gave significant control at 5% level of significance on 3rd, 7th and 20th day of sprays over the control. However, there was also significant difference between the insecticides and varieties in reducing the pest population. With neem and Bt on 7th and 20th day after spray gave higher control helping in reducing the population of *P. brassicae*. neem

registered population on 7th day were 10.8,10.8, 9.67 and 7.67 and on 20th day 16, 14 and 17, 14 on Golden Express and Golden Acre variety during the year 2001 and 2002, respectively. Population recorded on Bt treated plots on 7th day were 9, 9 and 7.67, 6.67 and on 20th day 25, 24 and 19, 19 on two varieties, respectively during the two cropping seasons of 2000 and 2001, respectively.

Effect of different levels of potash on the population of *P. brassicae* in combination with different treatments gave excellent control on 7th and 20th day of application. However, there was no significant variation recorded between population of the pest and different levels of potash during the two cropping seasons and on the two varieties of cabbage tested.

DDVP and endosulfan exhibited the low population on 3rd day which increased slightly on 7th day. However, the population on 20th day was increased significantly. However, population on 3rd, 7th and 20th day after spray were significantly superior over the control in all treatments and different levels of potash on both the varieties during both cropping seasons of 2001 and 2002.

Biocides, neem and Bt exhibited the lowest population on 7th and 20th day as compared to other treatments and registered superior control.

Observation recorded on 3rd, 7th and 20th day of application of spray treatments on two varieties of cabbage i.e., Golden Express and Golden acre in combination with 0, 40, 60 kg of potassium per hectare during the year 2001 and 2002, showed that all the treatments were significantly superior to control in suppressing the population of *B. brassicae*. However, there was no significant variation between the different levels of potash and varieties during both seasons of 2001 and 2002 on 3rd, 7th and 20th day after treatment.

Among the treatments Bt and neem at recommended doses proved significantly more effective in reducing the pest population of *B. brassicae* on 7th day of treatment with population load of 77.66, 66.66 on Golden Express, 70.33 and 61.0 on Golden Acre variety for the year 2001. However, during the year 2002, the population recorded was 54.66, 49.00 on Golden Express and 57.00, 53.00 on Golden Acre varieties.

Application of different levels of potash reduced the aphid population significantly on both the varieties tested during in year 2001 and 2002 at 5% level of significance. Initial kill of the aphid with carbaryl and quinalphos in combination with potash was higher on the 20th day after treatment.

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**Chapter-I**

## INTRODUCTION

Among various *Cruciferous* crops grown in Jammu and Kashmir state particularly in the valley of Kashmir, cabbage (*Brassica oleracea*) var. capitata (Linnaeus) occupies major status (Hill, 1975 and Anonymous, 1997). Cabbage is not only grown for the purpose of vegetable, but it is a agro-based industry as the seed grown under temperate climatological condition has better surveillance and earns the foreign exchange (Bose and Som, 1993). Three crops are grown in a year, June-July (Head crop), August-September (Head/Seed crop) and November-December (Seed crop) (Anonymous, 2000).

The cabbage occupies an area of about 1628 thousand hectares in the world producing 25238 thousand tonnes of cabbage heads (Bhalla and Verma, 1990), while in India total area under this crop is 78 thousand hectares producing 47 thousand tonnes of cabbage heads annually (Kaul, 1998).

In Jammu and Kashmir the cabbage is grown both for seed and head purposes during *Rabi* and *kharif* seasons, respectively (Sabherwal, 1995). The total area under seed crop is about one thousand hectares with annual production of seed about 89.5 thousand quintals fetching almost one hundred crore of rupees annually (Anonymous, 2000). In India, the total area under seed crop is 94 thousand hectares with an average yield of seed annually 84 thousand quintals.

The crop is well preferred by Europeans and Indians, because of its nutritive value as it contains protein (1.4 %), carbohydrate (5.3%) and water (92.4%). Besides, it is a rich source of minerals like iodine, phosphorus, potassium, copper and iron (Bose and Som, 1993). Out of various constraints insect and non-insect pests play an important role in lowering the yield and consequently the seed quality and quantity (Borode and Castellane, 1989; Mandal *et al.*, 1994).

From India, twenty insect pests have so far been reported feeding on various parts of cabbage grown for seed and table purposes (Bhatia and Verma, 1994 and 1995). Under temperate conditions, the major insect pests are : Cabbage butterfly, *Pieris brassicae* (Linnaeus) [Lepidoptera: Pieridae], Cabbage aphid, *Brevicoryne brassicae* (Linnaeus) [Homopetera: Aphididae], Diamond back moth *Plutella xylostella* (Linnaeus) [Lepidoptera: Plutellidae], Cabbage borer *Hellula undalis* (Fabricus) [Lepidoptera: Pieridae], Painted bug *Bagrada cruciferarum* (Kirk), Mustard sawfly, *Athalia proxima* (Klug.); Cabbage flea beetle *Phylotreta cruciferae* (Goeza) and Cutworm *Agrotis ipsilon* (Rott.) (Malik *et al.*, 1972; Bhatia, 1986; Lasota and Kok, 1989; Bhatia and Verma 1995; Anil *et al.*, 1997 and Zaz, 2001).

Among the insect pests, the caterpillars of *P. brassicae* and *P. xylostella* feed on leaves where as aphids suck the sap and infested leaves curl, crinkle or form cups (Butani *et al.*, 1977; Mailloux and Belloncik, 1995; Sabherwal, 1995; Barrantes *et al.*, 1996 and Jitender *et al.*, 2000).

The insect pest of cabbage are generally managed by insecticidal sprays (Borode and Castellane, 1989), but because of the highly profitable nature of the crop, the seed growers schedule is of 15-20 spraying of insecticides within about 7-8 months growth period of the crop leading to environmental hazards and resistance to insect pests (Chander and Kushwaha, 1986; Dhura and Hameed, 1990 and Sreekanth and Babu, 2001).

The indiscriminate discharge of pesticides in the environment have resulted in deterioration of the environmental quality and their subsequent effect on non target organisms. (Butani *et al.*, 1977; Rajput *et al.*, 1986; Anis *et al.*, 1999; Dhaliwal *et al.*, 1997; Sreekanth and Babu, 2001). The other problems being, development of resistant strains, resurgence of target pests, secondary pest outbreak and human health hazards (Dhura and Hameed, 1990; Dhaliwal *et al.*, 1997).

Further the poor farmers having inadequate resources at their disposal may not be able to afford the use of insecticides. The need, therefore, is to develop a pest management programme for cabbage particularly the seed, that reduce dependence on insecticide to bare minimum and, has more ecological compatibility with general production technology (Bhalla and Verma, 1990; Kaul, 1998). Such a programme will of necessity based on a perspective appraisal of the seed bearing capacity of the crop under the given agro- climatic conditions, size of its pest complex, nature and extent of losses caused by major insect pests, benefit/ cost ratio's of the pest control efforts and knowledge of life system of the major pests.

So far no systematic study has been carried out in Jammu and Kashmir on different varieties of cabbage in respect of determination of incidence, population dynamics, influence of environmental factors and effect of potash in combination with insecticide treatment. So this information is imperative for sound and outstandable management programme. It was considered pertinent to undertake the proposed project on "Integrated management of some important insect pests of cabbage" *Brassica olereacea* var. capitata with the following objectives:

1. To study the population dynamics of major insect pests in relation to abiotic factors on different genotypes of cabbage.
2. To study the development of *Pieris brassicae* on commercially grown varieties of cabbage and
3. Integration of some pest control components for management of *Pieris brassicae* X *Brevicoryne brassicae.*

**Chapter-II**

## REVIEW OF LITERATURE

The relevant information on the insect pest management on cabbage has been reviewed as under:

### 2.1 Population build up of *Brevicoryne brassicae, Pieris brassicae, Plutella xylostella* (Linnaeus) and some other major pests

#### 2.1.1 Population build up of *Brevicoryne brassicae* (Homoptera:Aphididae)

The population build up of the aphid has been found to vary from time to time during crop growing stages. Deshpande (1937) and Pruthi (1960) reported that the active period of the aphid vary from December to March on *cruciferous* vegetables (cabbage) in plains. According to Atwal and Singh (1969) the peak population build up of *B. brassicae* reached either in first or second half of February. The populations of *B. brassicae* were observed to vary from year to year during 1965-66, it was 1141 during 1966-67. Tandon *et al.* (1977) reported low population of the aphid in hills from October to January with peak during April to May. During peak build up (April-May) period 88 to 124 aphids/ leaf were recorded compared to 0 to 24 aphids/leaf during the period of low population (November-December).

Dhaliwal and Goma (1979) studied seasonal abundance of various insect pests on cabbage seed crop at Solan (H.P.), and found that *B. brassicae* were present throughout from mid October till harvest on all the stages of the plant growth. High infestations were recorded during November to April at upper Shilong and November to March at lower Shilong (Sachan and Gangwar, 1980). Initial population and multiplication rate of the insect remained low upto mid January and the peak population was observed in the mid of March. Infestation percentage ranged from 30 to100 during different months of the year. In severe cases the entire plant were reported heavily covered with the aphid colonies. Deshpande (1937) and Sachan and Srivastava (1975) have also reported the major period of aphid activity on cabbage crop from November to March.

Kotwal (1981) reported population build up of cabbage aphid at Solan in the first week of November 1979. Bhatia (1986) reported first population of *B. brassicae* in December and the peak population build up was noticed during second fortnight of March or in first week of April. Bhalla and Verma (1990) reported *B. brassicae* infest cabbage crop and resulted in the maximum infestation index of 3.38 in March. With 16.2 aphids/plant, the aphids increased numerically from 13.8 to 25.6, 59.4 to 447.9 and 36.39 to 158.8 plant during November, December and January, respectively. However, during first week of February, fall in the aphid population was noticed but thereafter population rise steeply to 3489.1 per plant during first week of March but in the last week of April only 3.0 aphids/plant were recorded. During 1980-81 the aphids population were noticed to be very low with first peak in first week of December (110.0 aphids/plant), second in 3rd week of January (431.3 aphids/plant) and third (449.1 aphids/plant) during third week of February. Bhalla and Verma (1990) further reported infestation index of *B. brassicae* of 3.38 in March but at that time high infestation index was recorded. But by the first week of April, a slow decline in the population level of the aphid was recorded. However, at the time of harvest high infestation was observed. Maximum number (8660) of the aphid per plant was estimated on March 17th, 1985 followed by 8506 on March 15th, 1983 and was 6163 on April 1$^{st}$ 1984. The per cent plant infestation during these three years was found to range between 12 to 100 (Bhatia and Verma, 1994). However, in general, peak activity of *B. brassicae* was obtained from mid of March to first week of April when 96 to100 per cent plant infestation was recorded. Mustafa and Masha (1994) recorded the population dynamics in 1989-91 and flight activity during 1986-90 of *B. brassicae* in the central Jordan valley. During 1991-92, 80 per cent plants were found infested at the time of peak population density, (18 aphids/ plant) on cabbage in late December (Bhatia *et al.*, 1995).

**Wiech and Jankowska (1994) recorded the infestation level of different crops by *B. brassicae* which was abundant on cabbage. One month after transplantng (Bhatia *et al.*, 1995) reported 1$^{st}$ peak in June to July and 2$^{nd}$ peak during September to October in Punjab.**

Jankowska (1995) revealed that changes in the aphid population were similar on the different varieties, but numbers differed significantly. The pests were most abundant on white cabbages and red cabbage.

Hildenhagen and Hommes (1997) have recorded two population peaks of *B. brassicae* on *cruciferous* crops (especially cabbage) during 1988-91 in Germany. The 1st peak was observed in June-July and the 2nd in September-October. The yield was more affected by attack in 2nd than the 1st peak period. Recently, Barwal (1997) reported peak activity period of *B. brassicae* in May at Kullu (HP) and the aphid was found to have major status in both the vegetative as well as reproductive phases of cole crops. Cabbage was also found to be a primary host of the aphid for over wintering as 6 to 61 aphids of *B. brassicae* per plant with 4 to 5 per cent plant infestation and 5 to 41 aphids per plant with 4 to 62 per cent plant infestation has been registered (Bhatia and Verma, 1995).

The percentage of infested plants ranged from mid of February to April. 71 per cent (Prasad, 1963), 76 to 84 per cent (Sachan and Srivastava, 1972), 60 to 100 per cent (Dhaliwal and Goma, 1979), 76 to 84 per cent (Sachan and Gangwar, 1980) and 30 to 100 per cent (Kotwal, 1981) during different months. In severe cases the entire plant was reported heavily covered with the aphid colonies 96 to 100 per cent (Mustafa and Masha, 1994) and 80 per cent (Bhatia *et al.,* 1995).

### 2.1.2 Population buildup of *Pieris brassicae* Linnaeus (*Lepidoptera: Pieridae*)

Population of *P. brassicae* in an area tends to fluctuate drastically due to the migration of the pest adults. From India, Rattol (1959) reported active period of *P. brassicae* on cruciferous plants from October to April in the plains of Punjab. The pest was found absent from May to September from plains whereas in Hills it was recorded throughout the year. Dhaliwal and Goma (1979) found cabbage crop free from infestation of *P. brassicae* till the end of February at Solan (HP). The adults were noticed in the middle of February but the first egg clusters appeared towards the end of the month. Young caterpillars were observed devouring cabbage leaves by the first week of March till first week of April. Thereafter a sharp decrease in the larval population was noticed following complete disappearance of the pest from cabbage fields by the beginning of May.

Studied carried out at different altitudes in Meghalaya during 1975-77 by Sachan and Gangwar (1980) revealed a highest population range of 15 to 25 larvae per plant of 1st and 2nd instars and 6 to 8 larvae per plant in 3rd and 4th instars of *P. brassicae.*

Gupta (1984) reported first appearance of *P. brassicae* in mid of February at Solan (H.P.) and recorded four generations until August. Thapa (1987) recorded the incidence of *P. brassicae* on cabbage in early January which continued till late April in Nepal. The egg clusters were maximum during early March and plant infestation was highest by late March and peak population occurred in early April. In Pakistan, Mushtaque and Mohyuddin (1984) recorded the highest infestation of 55 per cent on cabbage in the plains of Sialkot during March, whereas in the hills of Muree and Abottabad, the maximum infestation were observed in July. Rai *et al.* (1985) recorded incidence of *P. brassicae* during December in lower hills of Uttar Pradesh but in March-April back migration to Almore took place.

Zuranska and Ciepielewska (1985) observed the maximum number of eggs in August and early September in the northern Poland, while the maximum larval abundance was recorded 3 to 4 weeks after the appearance of the first larva in mid of August and September.

Sood (1992) recorded infestation of the butterfly during February at Nauni, Solan (H. P.). The counts showed an instant increase followed by a sudden decline in the population resulting in maximum value of infestation index in the second week of April (1.53). The pest was observed to disappear from the crop by the third week of May. The butterfly remains absent from May to September in plains and further reported breeding of the pest in the mountains during hot summer months and back migration to Indo-Gangetic plains during early October where it remained active till end of April.

Bhatia and Verma (1994) found *P. brassicae* to appear next to *B. brassicae* and *P. xylostella* at Solan. Initially, the number of larvae per plant were observed to be higher than per cent plant infestation and vice-versa during later stages of its infestation. The number of larvae per plant ranged between 140.83 to 222.5 with per cent plant infestation of 4 to 58.

Bhatia *et al.* (1995) found peak population of *P. brassicae* on cabbage in mid-December with 6580 and 6730 larvae per 100 plants during 1991-92 and 1992-93,

respectively. However, during 1976-78, Sachan and Gangwar (1980) in similar studies at Shillong, recorded a higher population range of 6 to 120 larvae of *P. brassicae* per plant on cabbage.

Bhatia *et al.* (1995) recorded six insect pests attack in cole crop in West Bengal out of which *Pieris brassicae* was most serious pest of cabbage.

Highest infestation of 55 per cent on cabbage in the plain of Pakistan was recorded by Mushtaque and Mohyuddin (1984) at Sialkote during March and March to July in Hills of India,9 (Rai *et al.* 1985) during July and mid of February (Sood, 1992).

2.1.3 Population buildup of *Plutella xylostella* Linnaeus, (*Lepidoptera: Plutellidae*)

Abraham and Padmanban (1968) reported higher abundance of diamond back moth (DBM) larvae at Kodaikanal, India on cabbage and cauliflower during the hot weather period especially April-May. They observed that larval population per plant ranged between 0.80 (February) to 18.80 (April), 0.16 (February) to 6.28 (April) and 0.28 (December) to 5.80 (April) during 1963, 1964 and 1965, respectively. The population of the pest was observed to remain fairly high (3.84 to 4.48 per plant till August but declines thereafter. Moreover, in some plots as many as 32 caterpillars were noticed on a plant. Verma *et al.* (1980) observed severe infestation in cabbage fields around Hissar (Haryana) during August; whereas, Sachan and Srinvastava (1972) recorded first incidence of the pest in September and the increase in the population was observed to be abrupt which peaked by middle of February. The population was noticed to be high upto the middle of March and declined thereafter. On an average 32 larvae per plant was found during the peak period of infestation and in some cases 123 larvae were counted from a single plant. During peak period of activity 80 to 100 per cent plants were found infested. However, the peak populations of *P. xylostella* was recorded in February, Sachan and Srivastava (1972) in Rajasthan, April-May in Tamil Nadu Abrahim and Padmanban (1968), and March April in Himachal Pradesh (Dhaliwal and Goma, 1979). Bindra *et al.* (1975) found the DBM on cabbage from October to first week of December with maximum activity in October during 1973-74. The pest was again found active from end of February to the first week of March. However, during 1974-75, pest was recorded

from end of August to the first week of September and again from the end of January to the first week of March. Deshraj *et al.* (1997) observed *P. xylostella* from March onwards with peak activity from 2nd fortnight of April at Palampur.

Dhaliwal and Goma (1979) found the presence of larvae of DBM on cabbage crop throughout the winter from December onwards at Solan (H. P.) However, the population (3 to 13 per 100 plants) was low upto February. Thereafter, a gradual increase in the population was noticed till peak larval population reached by mid of April. A sudden decline in the population of DBM after April as only 34 larvae could be detected on six plants out of one hundred plants and none thereafter.

Sachan and Gangwar (1980) recorded major variation in the population of DBM at three places in Meghalaya. At upper Shillong and adjoining areas this was noted as a pest of warmer climates. In southern Ontario (Candada) 4-5 generations were observed by Harcourt (1986) in a year with population increasing early in the season, reaching at peak in third or fourth generation and then declining. Khaire and Lawande (1986) found the peak population of DBM in the first fortnight of February in Maharashtra, India. There were two population peaks of DBM on cabbage plants in south-western Virginia (Lasota and Kok, 1989), larval density were highest in June with progressive decline to a minimum during November-December in Aragua state. In Japan, Okada (1991) reported an increase in population density from mid-April to early June and further he noticed decreased from late June to late July in cabbage fields.

Studies on seasonal occurrence of the important insect pests of cabbage, carried out by Lee (1986) at Taiwan during 1982-84, revealed that one population peak of *P. xylostella* occurred in February; two peak of *Pieris rapae crucivora* in April and October, respectively and one peak each of *C. binotalis* and *Spodoptera litura* occurred in November and December respectively. However, the populations of *Hellula undalis; Tricoplusia ni; Pieris striolata; Lipaphis erysimi* and *Myzus persicae* were of very low densities.

Similarly, Lasota and Kok (1989) recorded two to three peaks of *P. xylostella* on cabbage in SouthWestern (USA). Annamalai *et al.* (1988) have also recorded two peaks of *P. xylostella* population on summer cabbage in Japan. Ong and Soon (1989) also recorded

two peaks of *P. xylostella* on cabbage and *Brassica alboglabra,* in February-April and November respectively, at Singapore.

Bhalla and Verma (1991) recorded first incidence of *P. brassicae* from mid-February and found first early instars gregarious but later instars segregated to adjacent plants.

Nirmala Devi and Deshraj (1991) reported prevalence of DBM at Palampur (H. P.) from March onwards with its peak activity during third week of March and second week of April. Bhalla and Verma (1991) found the infestation of DBM starting from February at Nauni, Solan (H. P.). Infestation of the larvae in second week of December (0.35 larvae per plant) on cabbage at Jobner, Rajasthan which continued upto the first week of March (0.3 to 1 larvae /plant).

Studies carried out in Pakistan by Abro *et al.* (1994) revealed higher population of DBM on summer cabbage than on winter cabbage. In Himachal, it is a regular pest and accoding to Bhatia and Verma (1994) larvae appeared at the end of January where the density per plant were 3 to 11.

Park *et al.* (1993) studied the ecological characteristics including larval density of *P. xylostella* in cabbage fields of Cheju Island, Korea Republic during 1991-92 and recorded 11 to 12 generations of the pest round the year ( 5 in summer; 2 to 3 in spring and 2 in autumn). The peak larval density was recorded from mid-October to early-November. Similar studies on the ecology of *P. xylostella* carried out, during 1987-89 at Hyderabad, Pakistan Abro *et al.* (1994) revealed significantly greater populations of *P. xylostella* on summer cabbages than on winter cabbages. On the whole, cabbage and cauliflower were preferred hosts.

Rahim (1993) reported that Cabbage butterfly, *P. brassicae* L. is a serious pest of cruciferous crops, namely cauliflower, cabbage, knol khol etc., in the Punjab, NWFP and Baluchistan in Pakistan.

Bhatia and Verma (1994) recorded DBM as a regular pest of cabbage at Nauni, Solan but the larvae appeared on the crop by the end of January of first week of February. Thereafter, a gradual increase in number of larvae per plant and per cent plant infestation

were noticed and at the time of peak incidence the average density were observed to be 3.11, 2.39 and 1.76 larvae per plant during three years of investigation. Peak population was recorded between last week of March to third week of April. Larvae, pupae and adults of *P. xylostella* survived until January or February but no living individuals were found in April, in the cabbage fields of Hokkoido, Japan (Saito, 1994).

Studies carried out on 8 cruciferous vegetables in Bangladesh by Ali and Karim (1995) indicated that cabbage and cauliflower were the worst affected crops by *P. xylostella.*

Mailloux and Belloncik (1995) studied the seasonal population fluctuations of *P. xylostella* during 1984-88 in Southern Quebec (Canada) and observed 87 per cent level of infestation (3.5 larvae of *P. xylostella* per plant) on untreated cabbages and 57 per cent level of infestation on treated cabbages.

In similar studies undertaken by Dennill and Pretorius (1995), a maximum population of 0.4 larvae per plant of cabbages was recorded in Pretoria, South Africa, throughout the study period (February 1991 to February 1992) and 36 larvae per plant recorded at Dinokana, where epidemic out-breaks of *P. xylostella* occurred from October to December during 1991, 2 to 6 larvae of *P. xylostella* per plant on cabbage crops.

However, on summer cabbage, Bhatia and Verma (1995) recorded 125 to 870 larvae of *P. xylostella* per 100 plants (both years) with peak in ending July (6.79/plant) and 1$^{st}$ week of August (8.70.plant) with corresponding infestations of 6 to 62% and 6 to 70%, respectively, from 1983 to 1984 in mid hill regions of Himachal Pradesh. The population was found to increase during April, but declined abruptly in May. During April on an average 5 to 15 egg/larvae /pupae were found per leaf. Sharma and Bhalla (1996) mentioned first appearance of DBM in the field at Palampur in the first week of March, 1995 and 1996 and recorded 4.5 and 2.0 larvae per five plants, respectively. Thereafter, the population were observed to shoot up slowly to peak in the first week of April, 1994-95 and third week during 1996. Barrantes and Rodriguez (1996) reported that DBM were greatest in number after head formation. Barwal (1997) reported DBM adults emerging during April at Kullu and recorded extensive damage due to the pest during May-June.

Barrantes and Rodrishez (1996) reported that *P. xylostella* as major pest of cabbage (egg, larvae and pupae) occurred mainly on underside of the leaves the infestation was greatest after head formation. There is a correlation between pest infestation and damage intensity.

Usha *et al.* (1997) studied the seasonality of *P. xylostella* on cabbage during 1991-92 in Himachal Pradesh and recorded its peak larval population in 1$^{st}$ week of April during 1991 and 3$^{rd}$ week of April during 1992.

### 2.2 Incidence of major pests on cabbage, *Brassica oleracea* var. capitata

A number of insect pests have been reported from all over the India which damage cabbage at different growth stages. Cabbage caterpillar has been reported as a key pest of cabbage in Himachal Pradesh both at vegetative and reproductive phases of the crop (Bhalla and Verma, 1991).

Rattol (1959) reported active period of *P. brassicae* on cruciferious plants from October to April in the plains of Punjab. The pest was found absent from May to September from plains whereas in Kullu valley it was recorded throughout the year.

In Kashmir, Malik *et al.* (1972) recorded nine species of insect pests on cauliflower, cabbage, knol-khol and kale. These included *B. brassicae* and *Agrotis ipsilon* (March-October), *P. brassicae; Pontia glauconome; P. orichalcea; P. maculi pennis* and *Athalia proxima* (April-October); *Diacrisia obliqua* (May-September), 5 species of insect pests viz., *Pieris brassicae; Agrotis ipsilon; Adoretus* sp., *Plutella xylostella* and *Plusia* sp. were recorded on cruciferous vegetables in Kashmir valley (Anonymous, 1997 ).

However, 7 major and 5 minor pests on cole crops were recorded in Delhi by Butani *et al.* (1977). The major pests included *P. xylostella; P. brassicae; B. brassica, L. erysimi. A. proxima; B. cruciferarum, B. hilaris, C. binotalis* and *P. cruciferarum.* The major pests including *H. undalis; A. ipsilon; Diacrisia obliqua; Microtermes obesus* and *Thrips tabaci.*

Butani *et al.* (1977) reported *P. brassicae* as a major pest of cabbage in Katrine (HP). The pest was found to over winter through diapause and active for rest of the year.

Sachan and Gangwar (1980) observed great variation in the seasonal incidence and extent of damage by *P. brassicae* on cole crops from high hills (upper Shilong) to foothills. They further reported that the pest were present throughout the year in upper Shilong and recorded seven to eight generations of the pest. But the pest was found very active from February to mid of October coinciding with major cropping season of cole crops at higher altitude. During November to mid of February incidence were mild at mid and lower altitude with extent of damage from mild to severe during winter months.

Similarly, Talekar and Lee (1985) recorded seven important insect pests of common cabbage and Chinese cabbage during 1976 in Taiwan. *H. undalis* infested crop in hot wet summer months whereas infestation with the other pests, *P. xylostella, P. rapae crucivora; T. ni; P. striolata; M. persicae* and *L. erysimi* occurred in the cool dry months. Although all the species attacked both crops, *H. undalis; P. striolata* and two species of aphids preferred Chinese cabbage, while *P. xylostella, P. rapae crucivora* and *T. ni* preferred common cabbage.

Similarly, the incidence of *L. erysimi* and *M. persicae* were recorded by Chander and Kushwaha (1986) at Udaipur during 1978-80 from august to March on cabbage and from September to March on cauliflower.

Lee (1986) investigated the seasonal incidence of 9 insect pests of cabbage in Southern Taiwan during 1982-84 and arranged them in descending order according to their sequence of appearance as follows: *P. xylostella* was abundant in December-March; *P, rapae crucivora* (March-May & September-December); *Tricoplusia ni* (September-December); *Phyllotreta striolata* (all the year ); *L. erysimi* (periodically during the dry season) and *M. persicae* also occurred periodically late in November. Lasota and Kok (1989) studied the seasonal variation, in abundance of *Artogeia rapae* (*P. rapae)*, *T. ni* and *P. xylostella* on cabbage in South-Western Virginia.

Seasonal abundance and distribution patterns among host plants of *P. xylostella* were studied by Ong and Soon (1989) in Singapore during 1983-87 on cabbage and *Brassica*

*alboglabra*. Other pests found on these crops including *S. litura; H. undalis; C. binotalis* and *P. sinuata (P. flexuosa).*

Similarly, Raju and Sivaprakasam (1989) recorded *P. xylostella, L. erysimi; T. ni* and *A. ipsilon* as widespread on cabbage in Nilgiris district of Tamilnadu from February to June 1988. Studies carried out at Pune by Khaire and Lawande (1986) during 1981-82 revealed that *B. brassicae* and *Chaetocnema indica* as more important pests than *Empoasca devastans (Amrasca devastans); Bagrada picta (B. hilaris )* and *Athalia proxima (A. lugens)* on Chinese cabbage.

The seasonality of insect pests of cole crops has been studied extensively in India by a number of workers: Sachan and Gangwar (1990) have recorded *P. brassicae; B. brassicae; A. ipsilon,* and *A. flammatra* as the major pests of cabbage, cauliflower and knol khol in Shillong area of Meghalaya. *P. brassicae* was observed throughout the year with maximum activity from February to October, whereas the other major pests were active from July to December. The minor pests including *Plusia orichalcea*, *Tricoplusia* sp.; *P. xylostella* and *L. erysimi.*

The activity of the pyralid; *Hellula undalis* on cabbage was observed from April to October in Punjab by Singh and Singh (1993). Roy and Pande (1991) have studied *L. erysimi* on cabbage in Tripura and recorded six generations of the pest from November to April in 1987-88.

Singh *et al.* (1994) have recorded *M. persicae* as a key pest of cabbage and other *cruciferous* crops in Manipur, India and was present on the crop throughout the year.

Bhatia *et al.* (1995) in West Bengal have observed six insect pests attacking cole crops, of which *P. brassicae* was the most serious and abundant, followed by *Spilosoma obliqua* and both preferred to infest cabbage. The other pests included *B. brassicae; Thysanoplusia orichalcea; P. rapae* and *P. xylostella* as low density pests on these crops. Similarly, in Himachal Pradesh, (Bhatia and Verma, 1995) studied seasonal incidence of major insect pests of summer cabbage and recorded four regular pests on the host during

1983-84. These include: *B. brassicae* (immediately after transplanting), *P. brassicae* and *P. xylostella* (from June till harvest) and *P. orichalcea* (from August to mid September).

Bhatia *et al.* (1995) reported the studies undertaken for 2 years on seasonal incidence of major insect pests of cabbages during summer under mid-hill regions of Himachal Pradesh, India. The observations indicated that there were 4 regular pests of the crop. These included (in order of importance) B. *brassicae, P. brassicae, P. xylostella and P. orichalcea [Thysanoplusia orichalcea]*. The sequence of appearance was also in descending order.

Sabherwal (1995) recorded *P. xylostella* as an important pest of cabbage at Jammu both on early and late season crop. Cabbage aphid *B . brassicae* was reported as key pest of cauliflower/ cabbage both in vegetative and reproductive phase of the crop.

Barwal (1997) reported peak activity of *B. brassicae* in Kullu valley and aphid was found to have major status in both vegetative and reproductive phase of cole crops. *P. xylostella* is one of the major lepidopterous insect pest attacking cole crops. Its period of activity has been recorded from January to May in Alajuela, Costa Rica (Barrantes and Rodriguez, 1996); in January or February in Hokkoido (Japan) under green house conditions (Saito, 1994); from September to mid of March in Bangladesh on 8 cruciferous vegetables including cabbage and cauliflower (Ali and Karim, 1995); from mid of October to early November in Cheju island on cabbage (Park *et al.*, 1993); from October to December in Pretoria (South Africa) on cabbage (Dennill and Pretorius, 1995) and on spring, summer and autumn crops of cabbage in Jilin, China (Ma Chun Sen, 1995).

**Studied undertaken by Usha *et al.* (1997) on seasonality of *P. xylostella* on cabbage in Solan revealed its incidence from first fortnight of March till harvest.**

Kaul (1998) recorded the first incidence of the aphid during November-December and found peak population buildup during February–March in cabbage seed crop. After harvesting the crop the aphids increase was again noticed in the month of April.

Jitender *et al.* (2000) reported that in lower Kullu valley of Himachal Pradesh, India, 8 insect species (*Agrotis ipsilon, A. segetum, P. brassicae, P. xylostella, Plusia orichalcea*

[*Thysanoplusia orichalcea*], *Helicoverpa armigera, L. erysimi, B. brassicae*) were found to infest the cabbage cv. Golden Acre crops planted at one month interval from March to June 1992 and 1993. While aphids, *B. brassicae* and *L. erysimi*, were found to infest only the crops planted in March and April, *H. armigera* was not recorded in June transplanted crop; other insect species being found throughout the year.

Chaudhuri *et al.* (2001) evaluated the seasonal incidence of several insect pests *P. brassicae*; *L. erysimi* and *P. xylostella* infesting cabbage cv. *Sabitri* in West Bengal, India, during 1996-98 and recorded aphid, flea beetle, cabbage butterfly, leaf webber and moth populations were maximum during the 3$^{rd}$, 2$^{nd}$, 1$^{st}$ and 4$^{th}$ week of March, respectively, on spring crop.

Nayak *et al.* (2001) conducted the survey to determine the seasonal abundance of *L. erysimi* at weekly intervals from 1$^{st}$ week of December to 3$^{rd}$ week of February. The population per plant was less (6.08) on cabbage. The highest population was recorded during 2$^{nd}$ week of January (22.95) on cabbage.

Zaz (2001) reported on the incidence and population of *B. brassicae* on cabbage at Srinagar J&K and revealed that aphid population was associated with cabbage throughout the season with two population peaks in June and October, 52.8 aphids per plant with per cent plant infestation 0 to 25.

## 2.3 Correlation of population mean with abiotic factors

Studies, on the influence of environmental factors on vertical distribution of important pests of cole crops in Meghalaya, carried out in 1975-77 (Sachan and Gangwar, 1980) revealed that 50 species of butterflies and moths including *P. brassicae* migrate from plains to Himalayan region as well as other hills to avoid extreme hot weather during summer. However, Khaire and Lawande (1986) have recorded a maximum temperature of 31.7$^0$C and 85 per cent relative humidity during the peak population of *B. brassicae* on Chinese cabbage in 1981-82 at Maharashtra.

Annamalai *et al.* (1988) recorded rainfall as one of major mortality factor in the early larval stage of *P. xylostella,* on cabbage in Japan. Heavy rainfall in the hot wet season appeared to be detrimental to infestation but did not affect *H. undalis* (Talekar and Lee, 1985). Similarly, Wakisaka *et al.* (1991) recorded rainfall as a major mortality factor in the egg and larval stages of *P. xylostella* on broccoli in Japan. Temperature more than 30 $^0$C tended to delay development and reduced the survival of immature stages. Ong and Soon (1989) reported that population peaks of *P. xylostella* on cabbage and *B. alboglabra* in Singapore, were affected by temperature and rainfall.

Zuranska and Ciepielewska (1988) in his investigations on cabbage in the Olsztyn region of northern Poland indicated distinct differences in the sensitivity of the eggs and different larval stages of *P. brassicae* to climatic conditions, notably temperature. The 1$^{st}$ and 2$^{nd}$ –instar larvae required higher temperature, than 3$^{rd}$ and 4$^{th}$-instar larvae. The highest mortality due to climatic factors occurred in the 1$^{st}$ instar and the lowest in the 3$^{rd}$ instar.

Mustafa (1989) reported that in the Lenkoran region of Azerbaijan, the dynamics of development (seasonal occurrence, number of generations and percentage of the population entering diapause) of *P. brassicae* were shown to be particularly influenced by changes in day length and ambient temperature.

Studies carried out by Sachan and Gangwar (1990) at Shillong (Meghalaya) during 1976-78, indicated that extreme cold conditions at upper Shillong during November-February, when maximum temperature ranged from 9.77$^0$ C to 16.43$^0$ C and go to the minimum of 3.97$^0$ C and 7.54$^0$ C and sometimes even below 0$^0$ C, were detrimental for the multiplication of *P. brassicae* whereas the high rainfall during May-September did not adversely affect the built up of its population.

Studies in Tamil Nadu, on the influence of weather factors on the incidence of pests and diseases of cabbage, carried out by Raju *et al.* (1993) revealed an increase, in larval population of *P. xylostella* of 2.67 for every unit increase in rainy days and significant negative correlations of *A. ipsilon* with morning relative humidity.

Rana *et al.* (1993) worked out significant negative correlation for temperature, relative humidity and rainfall with the incidence of aphid, *L. erysimi* during 1989-90 at Hissar (Haryana). An average temperature of 14.12$^0$C and 85% and relative humidity were the most favourable conditions for the development of the pest. Relative humidity ranging from 55.70 to 69.40% was most conducive factor for population buildup whereas 50.90 per cent minimum relative humidity resulted in decline of the aphid population. Dry weather with high temperature also resulted in population decline.

Rahim (1993) reported that winter aphid population were negatively correlated with temperature and sunshine hours per day as well as total rainfall; and, positively correlated with average relative humidity. Flea beetle showed positive correlation with average temperate and sunshine hours per day. During spring, aphid, flea beetle and cabbage butterfly populations showed positive correlation with average relative humidity and total rainfall, but negatively correlated with average sunshine hours per day. Results indicated that an increase in temperature, sunshine hours per day and rainfall, and decrease in relative humidity favoured the multiplication of the pests on spring cabbage. Spring cabbage was infested by higher pest populations compared to winter cabbage.

Debraj *et al.* (1994) revealed that fluctuating population were correlated with abiotic factors (Temperature, Relative humidity and rainfall) in both the stages of the crop i.e. head formation and sprouting stage (ratoon crop) which showed non-significant impact on the population throughout the crop period, but humidity played crucial role in influencing the aphid population buildup in ratoon crop.

Sood *et al.* (1994) in similar studies on *P. brassicae* on cabbage and cauliflower at Solan, recorded the daily mean temperatures of 15 to 21$^0$ C in the 1$^{st}$ and 22 to 29$^0$ C in the 2$^{nd}$ generation while the relative humidity varied between 36 to 66 and 30 to 35% in the corresponding generations.

Srivastava *et al.* (1995) evaluated the impact of abiotic factors on the population dynamics of *L. erysimi* (Kalt.) and observed the range of maximum temperature 15.8 to 24.7$^0$ C, minimum temperature 10.2 to 16.0$^0$ C and relative humidity 61 to 65% prevailing in

February were conducive for the rapid multiplication of the aphid on this crop and rainfall during February/January was the main factor causing rapid multiplication while rainfall during March was negatively correlated.

Debraj and Singh (1996) evaluated the aerial population fluctuation of *B. brassicae* were monitored in yellow pan traps in a cabbage field in Imphal, India, during 1992-93. The number of migrant aphids trapped increased from 5.5 to 12 alates/ trap during the 1$^{st}$ week of January, followed by a peak of 25 alates/trap at the end of January and decline in peak during March. Minimum temperature and rainfall were significantly negatively correlated with the trap catches.

Anil *et al.* (1997) correlated the population data with different weather parameters in Taria region of Uttar Pradesh. The population *of P. xylostella* L. was found to have positive significant correlations with minimum temperature and rainfall. The aphid population also resgistered a positive and significant correlation with wind velocity.

In ecological studies on *P. brassicae* carried out at Barapani, (Meghalaya) during 1990-92, Thakur and Deka (1997) observed that a temperature ranging between 15.2 to 30 $^{0}$C was ideal for the multiplication of the pest during May-June whereas high temperature directly influenced different stages of the pest.

Cividanes (2002) reported that apeterous *B. brassicae* by visual search was found to infest kale from July with peak population in September. The rainfall and relative humidity showed significant correlation with *B. brassicae* suggesting that these factors had important functions to the mortality of the aphid.

## 2.4 Parasitisation of some important insect pests of cabbage *B. olericeae* var. capitata

Eighty per cent parasitism in *P. brassicae* eggs due to *Trichogramma evanescens* with an average larval parasitism of 10 to 8 by this species had been recorded. The major parasite, reported on young larvae of *P. brassicae* has been firstly infested by *Apenteles glomeratus* (George, 1957). Per cent parasitism due to *Diareella rapae* between 0.5 to 36.7 on cabbage aphid and reported it to be about 7 per cent throughout cruciferous growing season (Atwal

and Singh, 1969). He further reported *D. rapae* parastising on an average 0.01 and 40.7 per cent cabbage aphid during February-March 1966 respectively with an increase parasitism in April (59.7) per cent and May (73) per cent.

Rattol (1959) reported that *A. glomeratus* appeared in March and disappeared in April. Singh and Rawhat (1981) reported that *D. rapae* started its activity on dry season in mid-February as 69.37 and 96.49 per cent parasitism were registered during 2$^{nd}$ and last week of February respectively.

In Rominia 25 primary parasites were reported on DBM out of which *D. fenestralis* was most abundant. From India *D. fenestralis* was reported important dominant larval parasite of DBM (Bhalla and Chauhan 1994). Kaul (1998). Observed that *D. fenestralis* active from March to May in H. P. (India).

According to Habib (1973) primary parasites of *P. brassicae* were *D. rapae; Apheninus esychis* (Walker) and *Ephedrus* spp. Some ichenumonids were also found to be useful larval and pupal parasite of *P. brassicae.* The larval parasite reported are *D. pierissae, D. tibalis* and Promising pupal parasites *Pteromalus puparium* (Linn) were reported throughout the world (Mushtaque and Mohyuddin, 1984).

Similarly different species of genus *Brachameria* were reported as pupal parasite of *B. brassicae* (Mushtaque and Mehyuddin, 1984).

Kotwal (1981) found *Aphididious* spp. parasitising (29 to 28) per cent on *B. brassicae* population. However, *Aphididous* spp. as important species of cabbage aphids. Gupta (1984) reported 28 to 53 parastoid emerging from single fifth instar larvae. Many species (Cotesia) of (*Apenteles )* were parastoids of the larvae of *P. brassicae* which include *A. glomeratus.* (Sood, 1992 and Barwal, 1997).

Gabrys *et al.* (1990) reported that the degree of natural reduction of *B. brassicae* population by the parasitoid *D. rapae* on different *Brassicae* crops. Initially, the percentage of parasitisation was very low (<5%). The maximum parasitisation (<35%) occurred 2 weeks

after initial parasitisation and coincided with the decline of aphid population due to migration.

Okadas (1991) reported that eggs, larvae and pupae of the (*yponomeutid) P. xylostella* were sampled weekly in a cabbage field in Mie Prefecture, Honshu, Japan, during 1988. The rates of parasitism by the larval parasitoid *Apanteles plutellae [Cotesia plutellae*] and the pupal parasitoid, *Diadromus collaris* (both specific parasitoids of this host) were high from mid-June to mid-July, when the host was abundant. The rate of parasitism by the egg parasitoid *Trichogramma chilonis* increased after late June, when the host were less abundant. A high rate of parasitism was also shown by *Tetrastichus sokolowskii,* a larval-pupal parasitoid, after late July, when the host were less abundant.Now it is known that *T. sokolowskii* and *Trichogramma chilonis* are polyphagous parasitoids with very wide host range.

Rahim (1993) reported that, there existed a very good complex of natural enemies on it. However, the natural enemies were absent or observed in very low numbers at Taxilla. Therefore two parasites, *D. pierisae* (Rao) and *A. glomeratus* L. were mass bred in the laboratory and were released at these localities. In all, 40,000 adults of the parasites were released in the cabbage butterfly infested fields at 3 different sites. At the sites where parasites were released, the infestation was reduced to 21% against the control where the infestation was 45% at the time of ripening of the crop.

Rana *et al.* (1993) reported that *Coccinellid* sp., appeared on cruciferious during the month of December with the increasing numbers to 10.70 per plant, after the end of December negligible 0.2 and 0.3 in 1988 -1989 and 1989-90 which is mainly due to low temperature. An increase in the population in March at 11.9 and, 18.0 per plant and decrease in population of aphids by 2242.32 to 224.91 per plant were obtained.

Bartninkaite and Tyakayute (1994) reported that there existed an inter relationship between the *P. brassicae* and *A. glomeratus* and showed that they were inter dependent on the vegetative period of cabbage. Braconids were not so active among larvae the average number of braconides in one affected larvae were 22.2 to 36.2.

Mustafa and Masha (1994) worked on the aphid parasites of *B. brassicae* which showed mainly 2 periods of occurrence: the first early in the season during October-November, and the second in April-May. The ratio of parasitized *B. brassicae* to apterae early in the season were 10:100, and 0.2:100 at the end of season. The 2 parasitoids collected in the field were *D. rapae* and *Syrphophagus aphidivours*.

Jankowska (1995) reported that *D. rapae* caused highest parasitism on kale and Italian cabbage while lowest on Kohlrabi. He also reported five syrphid species on cabbage.

Mitchell *et al.* (1997) reported that the density of syrphid predator, *Betasyrphus serarius* increased with the increase in the density of aphid, *B. brassicae* on cabbage and that its life-cycle ranged from 24 to 26 days.

Dhaliwal *et al.* (1997) evaluated neem formulations that were safer to the parasitoids, *Microplitis similis* and *A. glomeratus [Cotesia glomerata]*, which parasitized *S. litura* and *P. brassicae* larvae, respectively. The feeding efficiency of the coccinellid predator, *C. septempunctata* on *L. erysimi*, treated with neem based insecticides, was higher than for aphids treated with endosulfan.

Usha Chauhan *et al.* (1997) reported that among nine parasitoids, *Diadegma fenestralis, Diadromus collaris* and *Cotesia* spp. were the dominant species in parasitizing *P. xylostella* L. and that 70% parasitism were observed in the last week of April.

Mitchell *et al.* (1997) found that *Diadegma insulare* was the main parasitoid and caused 72 per cent parasitism in early May for DBM larvae collected from the cabbage plants.

Metspalu *et al.* (2001) reported that massive development of large white cabbage butterfly, *P. brassicae* may occur subject to numerous predators, parasitoids and diseases *C. glormerata* (Hymenoptra –Braconidae) is a common braconid wasp that develop within the larvae of *P. brassicae*. Total infestation were 85 per cent, 68 per cent of the caterpillars parasitized out of that 20 per cent died due to diseases and 22 per cent pupates.

Nayak *et al.* (2001) conducted a survey for parastization by *D. rapae* on cabbage and observed that the initial population commenced during the 2nd week of December (4.36 per cent). The highest parasitism was observed on 3rd week of February 62 to 29.

Zaz (2001) reported that the temperature at Shalimar, Srinagar showed non significant negative correlation with the population of *B. brassica* and negative relationship with overall humidity and rainfall.

Cividanes (2002) studied the dynamics of aphid populations *B. brassicae* and estimate its impact of natural enemies. He noted that *D. rapae* showed significant correlation with *B. brassicae.* During the peak period ground spiders showed significant mortality related with population density of the pest.

Haseena *et al.* (2002) conducted field survey at fortnight intervals to investigate abundance of aphidophagus coccinellids and found predating on aphids namely *C. transversalis, Menochilus sexmaculatus* and *Harmononia octomaculata* which counted 52, 41 and 7 per cent of the cocinellids population respectively.

## 2.5 Management of some important insect pests of cabbage *B. olericeae* var. Capitata

Sachan and Srivastava (1975) reported the effectiveness for fortnightly spray of 0.03 per cent endrin or 0.075 percent lindane or 0.02 per cent carbaryl until harvest and 7 to 10 days sprays of 0.03 per cent, malathion, during the harvest of cabbage, against (*P. maculipennis* Curt., *T. ni* Hb.) and *L.erysimi* (Kalt.).

Butani *et al.* (1977) suggested the control of diamond back moth, *P. braccisae* and fleabeetle by spraying the cabbage crop with 0.1 per cent carbaryl and malathion or dusting with 5 per cent carbaryl and malathion.

Halimee *et al.* (1977) reported that efficacy of Karate, Apavap, Nogos, Sumicidin (at the rate of 395, 1235, 741 and 494 ml g/ha) against aphid *B. brassicae* (Linn.) and Cascade, Ataboron, Karate and Sumicidin (at the rate of 494, 494, 395 and 494 ml/ha) against cabbage

butter fly, *P. brassicae* (Linn.) on cabbage in two different experiments. In the first experiment Karate was compared with Sumicidin while Apavap with Nogos and Pirimore as candidate insecticides against aphid. Both candidate insecticides (Karate and Apavap) and the standards i.e. Sumicidin, Nogos and Pirimore were effective equally for the aphid control. Insecticides decreased the population by 89.03, 97.92, 93.71, 97.73 and 96.85 per cent pest population three days after treatment. It was 93.91, 97.17, 96.86, 97.64 and 99.17 per cent seven days after treatment, respectively. In the second experiment, three candidate insecticides i.e. Cascade, Ataboron and Karate were compared with Sumicidin (standard). They were comparable to standard against cabbage butterfly. The decreased 90.47, 92.68, 96.14 and 92.86 per cent pest-population three days and 99.19, 100.00, 100.00 and 99.38 per cent seven days after application, respectively. However, Ataboron and Karate were found to be the most effective followed by Sumicidin and Cascade.

Verma *et al.* (1980) while evaluating the insecticides against the pest and predators of mustard crop found the foliar sprays of phosphamidon 0.03 to 0.05 per cent to be best followed by methyl demeton 0.03 to 0.05 per cent and dimethoate 0.2 to 0.4 per cent malathion 0.05 per cent, endosulfan 0.05 to 0.1 per cent and lindane 0.1 per cent were comparatively less effective. The efficacy of insecticides giving more than 80 per cent reduction of *L. erysimi*, upto 10 days in the descending order were parathion, methyl demeton, lindane, endosulfan, malathion, phosphamidon and dimethoate.

Krishnaiah and Jagan Mohan (1983) evaluated some insecticides for the control of *P. xylostella* Linn., *Crocidolmia binotalis* Z., *L. erysimi* Kalt. and *M. persicae* Sulz. on cabbage methamidophos, dioxathion each @ 0.5 kg a.i. and endosulfan @ 0.7 kg a.i/ha gave effective control of *P. xylostella* for a fortnights while dipel+chlorphenamidine, monocrolophos, phasolane methyl and malathion each @ 1.0 kg a.i./ha suppressed the population for a week. Chlorfenvinphos, quinalphos, carbaryl and endosulfan controlled the mustard aphid population for two weeks.

Gupta (1984) reported that out of seven insecticides used, endosulfan 0.5 per cent was the most toxic insecticides against cabbage caterpillars on cabbage followed by fenitrothion

0.05 per cent, qunialphos 0.04 per cent fenthion 0.05 per cent. Malathion had lost its toxicity within two days of application. But endosulfan continued to give higher kill up to 7 days.

Rajput *et al.* (1986) in their studies on the efficacy of insecticides against diamond back moth, *P. xylostella* L. observed that insecticides including methoryl 250 g, quinalphos 250 g , carbaryl 800 g, monocrolophos 250g, methyldemeton 250g and dichlorovos 250g a.i./ha decamethrin @12.5 g a.i./ha were the next best treatments.

Kirshnaiah *et al.* (1983) evaluated the efficacy of neem extract in controlling pests of cabbage under field conditions. The extract was compared with commercially available insecticides proving sufficient control of *P. brassicae* ($1^{st}$ and $2^{nd}$ instar). None of these differed significantly from untreated plots throughout the season.

Mehta *et al.* (1988) studied the bio-efficacy of various insecticides viz., malathion, quinalphos and dichlorvos (0.05) per cent, phosphamedon and dimethoate (0.03 per cent ) and thiomate 0.025 per cent against mustard aphid *L. erysimi* (Kalt.) on cabbage. All the insecticides proved effective in checking the aphid population within 24 hours and remained active till one week.

Borode, S. A-de and Castellane (1989) evaluated the effectiveness of 6 treatments [carbaryl at 2.1 and 2.6 litres/ha, DDVP (dichlorvos) at 70 and 100 ml/100 litres water and chlorpyrifos at 0.6 and 1.5 litres/ha] against cabbage pests, including *Ascia monuste orseis*, *Thrips tabaci* and the *P. xylostella*. The insecticides were applied weekly until 10 days before harvest. All treatments were effective against the pests, with the exception of carbaryl. The plants treated with carbaryl showed the same symptoms of defoliation as untreated plants.

DeshRaj and Kumar (1990) reported that fortnightly sprays of 0.05 per cent endosulfan effectively checked the attack of cabbage caterpillar, *P. brassicae*. Lal (1990) studied the control schedule against insect pests of cabbage seed crop. The aphid *L. erysimi* was recorded before bolting, however, infestation levels of *B. brassicae* and *P. brassicae* occurred until the harvesting of seed crop. Insecticides like endosulphan at 500 g. a. i. gave most active control followed by phoslone and phosphamidon at the same concentration gave

better results. Aphids treated with these insecticides were ten times higher than that of control.

Nawale *et al.* (1991) reported that quinalphose was economical and highly effective in cabbage yield. It was followed by endosulfan and malathion 0.05 per cent in order to merit.

Narkiewicz-J (1995) evaluated the effectiveness of carbosulphan (Marshal 25 EC) for the control of *B. brassicae* and *P. brassicae* on cabbage. Marshal 25 EC applied @ 0.6 lit/hectare destroyed 95 to 100 per cent of the pest.

Mandal *et al.* (1994) conducted studies in Orissa to screen 25 varieties of cruciferious crops for resistance to aphids. The varieties Seeta, Pusa bold and Kranti were least effective where aphid variations varied from 88 to 141 aphids/20 cm both the years of 1991-92 and 1992-93.

Saucke (1994) reported that neem kernel extracts (NSKE) gave excellent control for diamond back moth, *P. xylostella* and associated pests in cabbage. Further the judicious use of Bt products with growth regulators and biological control techniques was most effective and sustainable use for IPM in cabbage.

Vasicek and Ricci (1995) evaluated the modifications of biological parameters of *B. brassicae* taking two varieties of cabbages red and green to determine varietal preference. Results showed that *B. brassicae* has four moults before adult hood, concerning number and duration of nymphal stages, pre reproductive and post reproductive period, the number of daily rearing per female and longevity. Overall *B. brassicae* showed a greater preference for the green cabbage variety.

Dhaliwal (1997) conducted field study with 2 formulations of neem: Achook and Nimbecidine for the control of insect pests on cabbage. The neem formulations were evaluated at 1, 2 and 4 kg/ha and compared to 0.5 kg a.i./ha of endosulfan used as the control. The mortality of insects were highest with 4 kg/ha of the neem formulations, 7 days after treatment. The mortality *of L. erysimi* in Achook, Nimbecidine and endosulfan was 95.77,

91.24 and 97.24 per cent, respectively. Mortality of with *P. brassicae* were 80.00, 73.33 and 86.66 per cent in which endosulfan was the most effective against all the insect pests, followed by Achook and Nimbecidine.

Sannaveerappanavar and Viraktamath (1997) conducted trials in cabbage fields in India using novel insecticides indicated that flufenoxuron (at 37.5 g a.i./ha) and teflubenzuron (at 56.25 g a.i./ha), and aqueous Neem seed kernel extract (4%) were highly effective in suppressing *P. xylostella*, followed by four Bt products, Biobit (at 500 g/ha), Delfin (at 750 g/ha), Eipe 8 L (at 1125 ml /ha) and Centari (at 625 g/ha). Cartap hydrochloride and diafenthiuron gave a moderate level of control

Liu (1999) evaluated seven experimental formulations of Bt sub sp. (Kurstaki) in the field for controlling cabbage looper, *Trichoplusia ni* (Hubner), and diamond back moth, *P. xylostella* (L.), on cabbage in 1997-98. Dipel DF, a commercial formation of Bt and SpinTor (spinosad, *Saccharopolyspora spinosa*), were used for comparison in some experiments. Under field conditions, effectiveness of these *B. thuringiensis* formulations varied greatly. When pest pressure were high, all formulations were more effective against *P. xylostella* than *T. ni;* whereas, no difference occurred when pressure was low. Five weekly applications of *B. thuringiensis* formations significantly reduced larval populations of both pest species.

Rahman *et al.* (1999) studied the efficacy of four different insecticides viz., Florbac, Atabron, Commondo and Nogos against *P. brassicae* at Tarnab, Peshawar. The experiment laid out in randomized complete block design with five treatment and three replications. Results revealed that Nogos and Commondo gave higher mortality (99.69 and 98.29 per cent) of the pest while Florbac (*B. thuringiensis* ) and Atabron were statistically similar in controlling the pest and caused 77.86 and 76.91 per cent mortality of the pest.

Ashok (1999) worked on biocides and found that four Gram-positive (Bacillus) and 4 Gram-negative phylloplane bacterial isolates from cabbage and cauliflower were selected for delivery of *B. thuringiensis* subsp. (Kurstaki) insectidical toxins to pest larvae.

Geetha *et al.* (2000) conducted field experiment in Andhra Pradesh to study the individual effect of K (0, 50, 100 and 200 kg/ha) and noted the highest dry matter production and increases the yield.

Lin *et al.* (2001) studied on resistance to cabbage butterfly *P. rapae* larvae in transgenic insects resistant cabbage sprayed with Bt. The death rate of the pest were 11.11, 12.5, 35.7, 66.67, 33.33 and 50 per cent at 1st, 2nd, 3rd, 4th and 5th instar at the pupal stage respectively with total death rate of about 94.44 per cent compared with a mortality of about 15 per cent in control. While in field the death rate of the pest was 46.59 with control mortality of about 21 to 25 per cent.

Sreeknat and Babu (2001) evaluated imidacloprid 20 EC (0.008 to 0.02 per cent), silafluofen 20 EC (0.2 per cent), deltamethrin and trizaephos 36 EC (0.075 per cent), profenphos 50% EC (0.65 per cent) diaafenthiuron 50 per cent, WP (0.025 per cent) diachlorovos 76EC (0.1 per cent) and mono crotophos 36 per cent (0.05 per cent) against *L. erysimi* on cabbage variety Golden Acre. The first one is most effective among the insecticides followed by the third.

Lal *et al.* (2002) conducted field experiments on cabbage variety Golden Acre to determine the efficacy of different insecticides fortnightly against the cabbage aphid. Among the insecticides (endosulphan) significantly reduced the aphid population to 74.43, 88.8 and 87.68 in first spray 56.29, 82.56 and 48.40 in second spray.

Sengonce and Liu (2002) evaluated the effect of biocide GCSC-BtA on population dynamics of cabbage, pests, i.e. *P. xylostella (*Plutellidae), *B. brassicae (*Aphididae*), L. sativae (*Agromyzidae*), P. vittata (*Chrysomelidae*)* in common head cabbage (*B. oleracea var.* capitata) fields in the southeastern China. The results showed that, at the end of sampling, the pest populations *of P. xylostella, B. brassicae* and *P. vittata* reached average of 39.7, 68.3 and 6.2 individuals /30 plants in the plot treated with GCSC-BtA, which were about 1.5, 11 and 0.7 times lower than those treated with methomyl, respectively. The GCSC-BtA biocide demonstrated greater effectiveness in controlling the cabbage pests, e.g., *P. xylostella, B. brassicae and P. vittata,* having final decreasing ratios of 83.60, 97.5 and 53.67 per cent compared to 57.63, 64.89 and 30.88 per cent with the methoxmyl insecticide.

Lal *et al.* (2002) evaluated two insecticides (diflubenzuron and Cartap hydrochloride) against the pupae of *P. brassicae* and *P. xylostella* serious pests of cabbage and cauliflower

in (H. P. ) India. Pupa of *P. brassicae* when dipped in dieflubenzuron (375 to 300 ppm) had 18 to 84 per cent mortality. For *P xylostella* dieflubenzuron (25 to 200 ppm) gave mortality of 22 to 86 per cent compared with mortality in control 6 per cent while as cartap hydrochloride 31 to 250 ppm registered 16 to 88 per cent. While as in *P. xylostella* the mortality varied from 16 to 86 per cent.

Hussain *et al.* (2002) evaluated the effect of K (30 and 60 kg/ha) on chilli in Orissa during 1995-96 and plant height, number of branches per plant, flowering, fruit maturity and yield were significantly affected. However, there were no relationship between the efficacy of insects with insecticides.

Sugiyama *et al.* (2002) conducted an experiment to study the effect of application of K before 20 days of transplant which reduced the infestation of *B. brassicae* and *P. brassicae* to the maximum of 36 to 76 per cent.

Vandana *et al.* (2002) evaluated sixteen varieties of cabbage for suitability and production potential at U. P. The highest biological yield was observed in Pt-23 followed by Pt-22 and green cornet. The maximum number of leaves were observed in Krishan and the minimum in Pt-5.

## 2.6 Development of *P. brassicae*

Rattol (1959) studied on the biology of *P. brassicae* and reported that the eggs were laid in clusters both on upper and lower surface of the leaf. Each cluster containing 50 to 80 eggs. The eggs hatch in 3.2 to 17.6 days in different months. The young caterpillars on hatching first feeds on its own eggs shell and feeding of the lead caterpillar stages occupies 5.6 to 14.7 days in different months during that time it moulds four times, the caterpillars remains gregarious except when forced to dispense due to scarcity of food. Pupation takes place on stem and leaves and rarely on host plants pupal stage completed in 7.3 to 28.8 days depending upon the season. Mating lasted 60 to 90 minute the females started laying eggs in

cluster @ 4.5 eggs/minute. The next day after completion. The adults live form 2.6 to 12.3 days in different months.

Gupta (1984) recorded the first appearance of *P. brassicae* in mid of May and reported that the pest completed pre-pupal and pupal stages occupying 5 to 7, 15 to 30, 1.5 to 2.0 and 8.5 to 10.0 days respectively.

Four generations of *P. brassicae* at low and mid altitudes and 2 to 3 generations at high altitudes were recorded on cabbage at Barapani, Meghalaya, from November 1990 to November 1992 (Thakur and Deka, 1997) and also revealed that there were four generations with two overlaping generations at low and mid altitudes and 2 to 3 generations at high altitudes of *P. brassicae.* The winter generations were having longer life-cycle than summer.

Ritu *et al.* (1999) worked on the development of cabbage white butterfly (*P. brassicae* ) on cabbages and cauliflowers under laboratory conditions. Each developmental stage was studied for its duration. The incubation periods for eggs were 3.6 and 4.7 days for cabbage and cauliflower, respectively. Larvae completed development in 12.4 and 12.5 days on cabbage and cauliflower, respectively.

**CHAPTER-III**

## MATERIALS AND METHODS

The materials and methods adopted for the studies entitled "Studies on Integrated Management of cabbage (*Brassica oleracea* var. Capitata Linnaeus)" having different objectives are briefly given as under:

3.0 Population dynamics of major insect pests in relation to abiotic factors on different genotypes of cabbage

The studies were carried out at Entomological Research Farm, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Shalimar during two consecutive *kharif* seasons of 1999 and 2000 for Head crop and two *rabi* seasons of 1998-99 and 1999-2000 for seed crop, respectively. Four commercially grown varieties of cabbage obtained from Division of Olericulture, SKUAST-K, Shalimar, namely Golden Express, Golden Acre, Uttam and Pride of India following the recommended package of practices SKUAST(K) (Anonymous, 1997).

A recommended dose of NPK were applied to all plots/varieties @ 80 kg N, 40 kg P and 40 kg K $ha^{-1}$ as a basal dose in addition to well rotted FYM @ 30 tonnes $ha^{-1}$. The seeds were sown on the raised beds during 2$^{nd}$ week of August for both *rabi* season (seed crops) and 2$^{nd}$ week of April for *kharif* seasons of head crop. The transplanting were carried out after twenty-five days of sowing of seeds for the both consecutive seed and head crop, respectively. The seedlings were transplanted in the plots maintaining plant to plant and row to row distance of 25×50 cm apart. All cultural practices were carried out during the crop growing period when required. For recording the population build up of major insect pests of cabbage on seed crop started from October –June and for head crop from June-September for both *rabi* and *kharief* seasons of two consecutive years. The population build up of different insect pests were recorded as follows:

### 3.1 Population build up of *Brevicoryne brassicae, Pieris brassicae, Plutella xylostella* and some other pests

#### 3.1.1 Population buildup of *B. brassicae* (L.) [Homoptera: Aphididae]

Aphid population was determined by the method of Kotwal, (1981). Weekly samples from 10 randomly selected plants in each variety were taken using random row, plant and leaf coordinates to determine aphid density per plant. From each selected plant, three leaves, one each from outer, middle and inner whorl were examined for aphid population. When

population of the aphid was low, the count was directly made on leaves *in situ.* However, when the aphid density was high, the sample leaves were put in polythene bags separately and brought to laboratory for determination by using benzene 0.1 per cent as anesthecia and removed on to a white paper with the help of camel hair brush and the mean aphid population per plant was worked out.

At higher population levels, the aphids were dislodged and put in plastic tubes containing 70 per cent ethanol. Five samples (one ml each) from five different tubes were drawn. The alcohol were drained out first and then aphids were packed in one ml volume. Thereafter, the number of aphids contained in one ml samples were counted and the average worked out as 752 ( n=5). The number of average aphids count per ml to work out the total aphids in the sample multiplied the total volume of the weekly samples. The method was used during 1998-99 only because during 1999-2000, the aphid population was low, *in situ* method was mostly employed.

The per cent plant infestation by *B. brassicae was* also worked out by counting number of infested plants and for this purpose following formula was used:

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

### 3.1.2 Population build up of *P. brassicae, P. xylostella* and some other major pests

For recording the population buildup of these insect pests, population counts were carried out on the same crops as raised for *B. brassicae* during *rabi* seasons of 1998-99 and 1999-2000 and *kharif* seasons of 1999 and 2000 of the same four commercially grown varieties of cabbage.

Twenty plants were randomly selected for weekly samples using random row and plant co-ordinates to determine number of larvae of *P. brassicae* and *P. xylostella* per plant. While counting of larvae of *P. xylostella*, it was ensured that the leaves were not violently disturbed since the larvae of *P. xylostella* were very sensitive to disturbance and drop to ground even at slight jerk.

The level of infestation of *P. brassicae* and *P. xylostella* was determined by examining 100 plants. Infestation index of the lepidopterous pests were calculated by using the following formula given by Bhalla and Verma (1990):

$$\text{Infestation index} = (\log) = \frac{\text{Mean larval population x Per cent plant infestation}}{100} + 1$$

### 3.1.3 Effect of abiotic factors on the pest complex

Data on various weather factors like temperatures ($^0$C), relative humidity (%), rainfall (mm) and sunshine hours were obtained from Meteorological Laboratory, Division of Agronomy, SKUAST(K), Shalimar, Srinagar, Kashmir.

Weekly means for maximum, minimum and average temperature ($^0$C), relative humidity (%), rainfall (mm) and sunshine (hours/ day) were worked out for both the crop growing seasons (*rabi*, 1998-99 and 1999-2000) separately and Head crop season of 1999 and 2000.

Multiple regression equation worked out by pooling the data for both the years 1998-99 and 1999-2000 of seed crop, coefficient ($R^2$) were also calculated for determining the impact of various abiotic factors on the population build up of the pests associated with cabbage crop.

### 3.1.4 Prevalence of biocontrol agents associated with *B. brassicae, P. brassicae* and *P. xylostella* infesting cabbaage

The studies were carried out in Post Graduate Laboratory of Division of Entomology, SKUAST (K), Shalimar by collecting eggs/ nymphs/ larvae/ pupae of *B. brassicae* and *P. brassicae* at 7 day intervals from fields. The insect stages, collected were reared separately in petri-dishes/perforated glass/jars/cages for emergence of predators/ parasitoids.

### 3.2 Developmental stages of *P. brassicae* on commercially grown varieties of cabbage

The studies were undertaken in the PG. Laboratory of Division of Entomology, SKUAST(K), Shalimar during 1999 and 2000 on four varieties of cabbage i.e. Golden Express, Golden Acre, Uttam and Pride of India. Laboratory culture of *P. brassicae* was started on collected egg masses in March. The egg bearing leaves were kept in petri plates (10 cm diameter) over a wet filter paper for hatching. Newly hatched larvae were transferred to fresh leaves collected from all the four varieties separately and replicated thrice and reared upto third instars. The later instars were reared in glass chimneys (20 x 15 cm) provided with fresh leaves of cabbage. The caterpillars pupated on chimney walls were detached and kept for adult emergence in glass jars (10 x 15 cm) over a thick layer of filter paper. The adults were sexed and five pair of adults were kept in Nylon screened oviposition cages 50 x 50 x 50 cm for mating and oviposition cotton swabs soaked in 5 per cent honey solution and some flowering shoots of mustard were kept inside the cage as adult food. A pot with plant of cabbage was also kept in each cage to stimulate egg laying.

Another set of experiment on the same pattern was laid in laboratory on all the four varieties replicated thrice, observation on hatchability, incubation period and per cent survival were recorded from 15 eggs masses. The adult longevity, pupal and larval period were determined sampled regularly from a cohort of 100 larvae of pupae.

### 3.3 Integration of some pest control components for management of *B. brassicae* and *P. brassicae*

A field trial comprising of two varieties e.g. Golden Express and Golden Acre was conducted in the *kharif* seasons of 2001 and 2002 at Entomological Research Field of SKUAST(K), Shalimar, Srinagar in split plot design with three replications. Each replication was divided into seven main treatments i.e. *neemgold* 0.03%*; Bacillus thuringinsis* (Kurstaki) 0.5%*; dichlorovos* 0.05%*; carbaryl* 0.01%*; endosulfan* 0.05%*; quinalphos* 0.05% and control

(water). Each main plot was further divided into three subplots to accommodate three different levels of Potassium i.e. 0 kg, 40 kg and 60 kg per hectare. A recommended dose of NPK was applied to all the plots as a basal dose in addition to well rotted FYM. Insecticides were applied after twenty days of transplanting for both cropping season of 2001 and 2002 and control plot was sprayed with water only, while potash dose were applied 25 days before transplanting. The seedling were transplanted in the plots measuring 3x 3 meters maintaining plant to plant distance of about 25 cm x 50 cm apart from row to row. The transplanting was carried during 2nd week of May for the both *kharif* seasons of 2001 and 2002. All the insecticides/biocides were sprayed with the help of foot sprayer at the rate of 600 liters per hectare.

The treatments were laid out as per following details:

***Variety : Golden express, Golden acre***

**Treatments :**

| | | | |
|---|---|---|---|
| i) | Neem | : | Neemgold 0.03% |
| ii) | Bt | : | Kurstaki 0.5% |
| iii) | Endosulfan | : | Thiodan 35 EC |
| iv) | Dichlorovos | : | Nuvan 76 EC (DDVP) |
| v) | Quinalphos | : | Ekalux 25 EC |
| vi) | Carbaryl | : | 25 EC |
| vii) | Control | : | Water |

### *3.3.1 Recording of observation*

The *B. brassicae* population was recorded from top of 10 cm of the central shoot of five randomly selected plants/plot while as *P. brassicae* population was recorded from five randomly selected plants of each plot at 3, 7 and 20 days after spray for both the years of 2001-2002 and varieties, respectively.

### *3.3.2 Statistical Analysis*

Data recorded on management trial were transformed using mean square root transformation ( $\sqrt{x+1}$). Correlation co-efficients were compared for their significance.The experimental data pertaining to all the experiments carried out in both the crop growing seasons were subjected to statistical analysis, wherever required as per the procedure given by Snedecor and Cochran (1967).

**Chapter -IV**

# EXPERIMENTAL FINDINGS

## Population dynamics

Population trends of *Brevicoryne brassicae, Pieris brassicae, Plutella xylostella* and other minor pests on four varieties of cabbage i.e., Golden Express, Golden Acre, Uttam and Pride of India, raised separately for seed and head crop, in relation to certain environmental factors like temperature ($^0$C), relative humidity (%), rainfall (mm) and sunshine (hrs) were studied for two cropping seasons of 1998-99 and 1999-2000 for seed crop; 1999 and 2000 respectively for head crop.

## Seed crop

The results of population dynamics of different varieties of cabbage (seed crop) revealed that *B. brassicae* and *P. brassicae* were two major pests associated with the crop. The population densities of these two major pests reached to their peak during October and April-June coinciding with head formation and sprouting stage of the crop (Table 1,2,8 and 9). There were no distinct differences in the varietal response to the population of these pests (Fig 1-4).

While no incidence of *P. brassicae* was noticed during January-February, very low and insignificant population of *B. brassicae* was observed during the winter months of January and February. Other pests of minor economic importance recorded during the studies (Oct-June) included *Bagrada cruciferarum, Athalia proxima, Phylotreta cruciferae, Hellula* sp. and *Agrotis ipsilon* which also were found absent on the crop during winter months of January – February.

## B. BRASSICAE

The data on the population trend of *B. brassicae* on four varieties Golden Express, Golden Acre, Uttam and Pride of India during 1998-99 and 1999-2000 suggested two population peaks in October-November and March-June, coinciding with two distinct stages

of head formation and sprouting of inflorescence. The population of aphid supported by the varieties did not differ significantly during the two crop seasons (Table 1 and 2).

The association of *B. brassicae* with the crop was for about nine months from (October to June) with significantly low populations during January-February 1998-1999. The first incidence of the pest was recorded in the first week of October in all the four varieties screened during the cropping season 1998-99 However, during the year 1999-2000,initial population was noticed in the while last week of September..

The data of two consecutive cropping seasons also indicated that all the varieties of cabbage screened supported large population of *B. brassicae* during sprouting stage (April-May) than head formation stage of the crop in October-November. In 1998-99, the population levels as high as 175, 144, 242 and 204 were observed during the last week of June on Golden Express, Golden Acre, Uttam and Pride of India respectively, at weekly average temperatures was 13.6 $^0$C, relative humidity 67 per cent and 59.7 sunshine hours with the completion of head formation and a rainfall of 47.1 mm recovered in the first three weeks of November and fall in maximum and minimum temperatures.

The population of aphid declined reaching lowest of 8, 7, 12 and 10 in the IV week of February on all the varieties tested. During January-February, the maximum temperature was between 2.5$^0$C-9.3$^0$C while the minimum temperature gone below freezing point reaching to 5.8 $^0$C.

With the increase in temperature during the second fortnight of February (Fig 1) and with the initiation of sprouting stage in March, the pest gradually buildup its population to attain its second peak in April-May. The population of *B. brassicae* during May ranged between 133-152; 109-124; 183-209 and 154-176 for Golden Express, Golden Acre, Uttam and Pride of India, respectively. In the month of May, average temperature varied between 16.1-18.3$^0$C, RH 47-67 per cent with 44.3 –72.0 hours of Sunshine. The population data also shows that there was a slight increase in the aphid population density in the IV week of March reaching 69-92 from 93-125 as a consequence of precipitation of 39.4 mm. A

decrease in the maximum temperature from 15.3 $^0$C to 11.0 $^0$C and Sunshine hours from 43.2 to 13.2 hours were recorded during this week.

During the cropping season of 1999-2000, *B. brassicae* attained two population peaks in October and April-June, coinciding with head formation and sprouting stages of cabbage (Table 2).

In first population peak in the months of October-November, aphid density was lower than observed in 1998-99, ranging between 79-99, 75-93, 100-125 and 82-102 for Golden Express, Golden Acre, Uttam and Pride of India, respectively at climatic regime which was almost similar to that of the previous cropping season. However, temperature was slightly higher in September-October and resulted in higher population of the aphid in October.

As the maximum and minimum temperatures decreased and head formation was completed, the aphid population declined gradually reaching its lowest in January. Lowest population ranging between 6.0 to 7.0 was recorded in the third week of January in all the four varieties screened, at average temperature of 0 $^0$C, 82 per cent Relative Humidity, 5.8 hours of sunshine and 9 mm rainfall.

The aphid population slightly increased with the increase in temperature in February. However, in March with the formation of sprouts, the density of the pest increased gradually to attain second peak population. In April-May, highest aphid populations were recorded which ranged between 133-138; 126-131; 168-175 and 137-143 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively.

**Correlation between population of *B. brassicae* and environmental factors**

The correlation between population of *B. brassicae* on different varieties of cabbage and environmental factors for two cropping seasons of 1998-99 and 1999-2000 are depicted (Table 3a &b).

It is evident from the data that population buildup of *B. brassicae* was having positive non-significant correlation with maximum temperature ( r = 0.389-0.399), minimum temperature ( r = 0.602-0.613) in all four varieties of cabbage during 1998-99 screened during the present study.

However, at 5 percent level of significance, a significant positive correlation existed only between maximum temperature and population buildup, although a high positive correlation was observed between minimum temperature and the aphid density.

Among the factors, relative humidity and rainfall both showed positive non-significant correlation with the aphid population throughout the cropping season. It exercised little impact on the pest population of cabbage. In fact, it influenced the population of *B. brassicae* when humidity was minimum but rainfall showed with negative relationship with the population of cabbage aphid through out the cropping season. The aphid population declined with the rainfall to resurge again after the influence was over as a result of its multiplication capacity.

## Infestation Index

The data as recorded in Table 5 showed that the per cent plant infestation by *B. brassicae* and also the infestation index was higher in 1999-2000 compared to 1998-99 for all the varieties of cabbage screened. It may also be noted that while aphid population density was very low in January-February (Table 5), the number of plants infested and also the infestation index increased even in winter months.

In 1998-99, the per cent plant infestation were between 10-66, 9-64, 8-66 and 11-68 with corresponding infestation index varying between 1.396-2.248; 1.173-2.377; 1.191-2.472 and 1.173-2.478 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. While colonization of cabbage plants was initially slow in October-November, it subsequently increased in December 1998 to January 1999. Highest number of plant infestation and also the infestation index were recorded in April-June, coinciding with the sprouting stage. Rainfall of 43.4 mm in first fortnight of March resulted in decrease in

infestation index and also the percent plant infestation in March for all the varieties of cabbage.

During 1999-2000, infestation index and also per cent plant infestation by the aphid followed the same trend as that of the previous cropping season. However, the more number of plants were colonized in the month of October as is evident from the per cent infestation and infestation index compared to 1998-99.

The plant infestation ranged between 27-68; 28-70; 29-69 and 31-69 per cent with corresponding infestation index of 1.292-2.478; 1.358-2.483; 1.462-2.482 and 1.399-2.475 on Golden Express, Golden Acre, Uttam and Pride of India, respectively. Coinciding with the sprouting stage of the crop more number of plants were infested as is evident from the higher per cent plant infestation of 61-67 per cent and infestation index of 2.277-2.417. During January 2000 precipitation of 98.2 mm was recorded which resulted in lowering of the infestation level and also the infestation index drastically in all the varieties of the cabbage screened (Table 4 & 5)

**Correlation between infestation index of *B. brassicae* with certain abiotic factors**

Relative humidity (%) and sunshine (hrs) were found to be negative non significantly correlated with infestation index of *B. brassicae* in all the varieties of cabbage tested. While the correlation coefficient values of rainfall ranged between 0.075 to 0.250 and 0.267 to 0.305 suggesting a positive non-significant correlation than r values for relative humidity (-0.037 to -0.176 and -0.628 to -708) indicating higher negative correlation. Sunshine hours indicated a negative non significant correlation with the infestation index with r values ranging between (- 0.264 to - 0.426 and -0.513 to -0.619) for four varieties of cabbage tested.Maximum temperature was positive non-significantly correlated with population as r values ranging between 0.313 to 0.540 and 0.482 to 0.601. However, minimum temperature was found to have also positive non-significant relationship with population as r value ranging from 0.332 to 0.494 and 0.373 to 0.486, respectively on four varieties of cabbage during 1998-99and 1999-2000.

**Correlation between Homogeneity of *B. brassicae* with abiotic factors**

Temperatures and sunshine hours showed the positive homogeneity with all the four varieties of cabbage screened when the p values > 0.05 were 0.997 to 0.999, relative humidity and rainfall showed negative homogeneity during both cropping seasons of 1998-99 and 1999-2000 (seed crop), respectively (Table 7ab). *Pieris brassicae*

There was no incidence of *P. brassicae* on any of the four varieties of cabbage screened during January and February in both the cropping seasons of 1998-99 and 1999-2000. (Table 8 & 9). It may also be seen from the data that the pest registered two population peaks in October and May-June. These two population peaks synchronized with the head formation stage and sprouting stage of the crop.

While no significant variation in the population of *P. brassicae* supported by the four varieties screened was recorded except that of Uttam and Pride of India, varieties. Maintained relatively higher population of the pest during the month of October compared to Golden Express and Golden Acre during 1998-99. However, during 1999-2000 no such variation in the population of *P. brassicae* supported by the varieties tested was observed (Table 8). During 1998-99, mean population of the pest ranged between 232-284 and 200-245 on Golden Express and Golden Acre varieties, whereas it was as high as 421-512 and 386-485 on Uttam and Pride of India, In October, average temperature ranged between 13.5 to 16.5 $^{0}$C, relative humidity 66-70 per cent and 51.3 to 57.9 hours of sunshine and also no rainfall was recorded during the month. Low levels of population of *P. brassicae* were noticed in November-December that disappeared from the crop in January-February. And were in the range of 50-170; 58-198; 105-356 and 100-338 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively.

An upsurge in the population of the pest was recorded in March reaching its second peak in May-June. Highest population of the pest was observed in the month of June when the mean number of *P. brassicae* (egg and larvae) were 323, 278, 582 and 552 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively at average temperature of 18.8 $^{0}$C, relative humidity of 58 per cen`t and 66.3 hours of sunshine were recorded.

In the first two weeks of November about 43.5 mm rainfall was recorded resulting in the drastic reduction of pest population. Another spell of rainfall of about 39.4 mm in the second week of March caused a spurt in pest population 132-155, 114-133, 239-279 and 226-265 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively.

In 1999-2000, the results of population dynamics of *P. brassicae* on two varieties of cabbage Golden Express and Golden Acre were higher compared to Uttam and Pride of India (Table 9). However, there were slight variations in the population of the pest on Uttam and Pride of India among the varieties screened during October as were observed during 1998-99. November-December recorded very low populations and the crop was free from the infestation of the pest during winter months of January and February.

Population of *P. brassicae* started building it up in March to attain its second peak in May-June. Highest population of the pest was observed in the last week of June reaching 328, 258, 296 and 379 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively at average temperature ranging from 19.6 to 24.3 $^{0}$C, relative humidity 62-64% and 56-79 hours of sunshine.

**Correlation between the population of *P. brassicae* and certain abiotic factors**

The correlation between population of *P. brassicae* and abiotic factors temperatures, relative humidity, rainfall and sunshine hours are represented in (Table 10a & b).

The data suggests a positive non significant association between the population of *P. brassicae* and temperatures both minimum and maximum for all the varieties of cabbage screened during two crop seasons of 1998-99 and 1999-2000. The magnitude of correlation coefficient ( r) for maximum temperature was between 0.410-0.429 for 1998-99 and 0.457-0.476 for 1999-2000 for all the varieties screened. Similarly r value for minimum temperature for the year 1998-99 and 1999-2000 varied between 0.634 to 0.642 and 0.509 to 0.520, respectively. This explains low level of population of the pest during November-December as registered 58-198, 50-170, 105-356 and 100-338 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively during 1998-1999 and 54-159, 43-126, 65-192 and 61-179 respectively during 1999-2000.

Rainfall was negative non-significantly correlated with the population mean of the pest in both the cropping seasons. However, a negative non significant correlation was recorded between the population of *P. brassicae* and sunshine hours in all the varieties screened during 1998-99 and 1999-2000. During peak population of *P. brassicae* in the first week of May in 1998-99 and 3rd and 4th week of May 1999-2000 maximum sunshine hours were received.

**Infestation Index**

The trend in the fluctuation of the population of *P. brassicae* during the cropping seasons of 1998-99 and 1999-2000 got reflected in the percentage of cabbage plants infested. Higher percentage of the plants was infested with the pest during peak population density in October and April to June, while as no plant was found infested during winter months of January and February (Table 11).

In 1998-99, per cent plant infested in October ranged between 22-28, 23-27, 43-51 and 45-51 with corresponding infestation index of 1.512 – 1.686, 1.544 – 1.654, 2.169 – 2.420 and 2.225 – 2.380 in Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. The number of infested plants was significantly low in November-December while no plants from the varieties tested were found infested during January-February corresponding with the pest population during the period. Rainfall did influence the plant infestation. During first week of November when population fell to 6 as a result of rainfall (1.00-13.00 mm) only one per cent plants were observed to be infested with the *P. brassicae.*

Infestation of crop plants started in March reaching highest in first week of May when 33to 49 per cent plants were noticed to be infested with infestation index of 1.830 to 2.318 in all the varieties screened. This synchronized with the peak population of *P. brassicae* on all varieties during the corresponding period. Similar behaviour of the four varieties of cabbage was recorded in 1999-2000, (Table 12). Plant infestation percentage, which ranged 19-27; 22-25; 21-28 and 22-26 in October, declined drastically in November and December. During winter months of January-February plants were observed to be free from the pest infestation, which however, increased in March to reach maximum in last week of May. As many as 38-

42 per cent plants were recorded to be infested in the last week of May in all the four varieties tested.

**Correlation between infestation index of *P. brassicae* and abiotic factors**

A positive significant correlation between infestation index of *P. brassicae* and different varieties of cabbage with temperatures (mean, minimum and maximum) was recorded during both cropping seasons of 1998-99 and 1999-2000. The values of correlation coefficient varied between 0.872 – 0.928 and 0.850 – 0.874 for maximum temperature and 0.553 – 0.654 and 0.781 – 0.796 for minimum temperature for 1998-99 and 1999-2000, respectively for all the varieties of cabbage tested.

High humidity and rainfall were found to be detrimental to population buildup of *P. brassicae*. The correlation coefficient ranged between –0.707 to 0.796 and –0.764 to 0.793 for relative humidity and –0.434 to –0.470 and –0.372 to 0.407 for rainfall for the cropping season of 1998-99 and 1999-2000 respectively.

Sunshine hours had a direct positive significant relationship with infestation index of *P. brassicae* with r values ranging between 0.838-0.893 and 0.711 to 0.753 for 1998-99 and 1999-2000 respectively for four varieties of cabbage screened.Correlation between Homogeneity of *P. brassicae* with abiotic factors

Temperature and sunshine showed the positive homogeneity with all the four varieties of cabbage screened when the p values > 0.05 were 0.997 to 0.999, relative humidity and rainfall showed negative homogeneity during both years of 1998-99 and 1999-2000 respectively, (Table 14ab).

Some other pests

Besides, *B. brassicae, P. xylostella* and *P. brassicae* constituting major insect pest group, cabbage crop was found to be infested with some other pests of minor economic importance. These minor insect pests include *Hellula* sp., *Phylotreta cruciferae, Athalia proxima* and *Bargada cruciferarum* and for convenience were grouped under some other pests.

For both cropping seasons of 1998-99 and 1999-2000 all the four varieties of cabbage screened were free from the incidence of this group in December, January and February (Table 15).

During 1998-99, the mean population of this group was 13-16, 6-15; 23-29 and 18-21 in October while it was considerably low in November and ranged between 7-11; 5-9; 12-20 and 9-12 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively, corresponding to this period the average temperature varied between 7 $^0$C and 16.5 $^0$C, relative humidity 67-81 per cent and sunshine hours 25-57.9. As much as 47.7 mm rainfall was received during October-November (Table 15).

While the crop was free from the infestation of this group during December, January and February at average temperature ranging between 1-21.5 C, the population started increasing in March reaching maximum of 15-21; 10-15 $^o$C; 25-37 and 19-28 in June for the varieties Golden Express, Golden Acre, Uttam and Pride of India, respectively. The mean temperature in the month of June was between 14.6 $^0$C and 21.2 $^0$C. Relative humidity varied between 54-63 per cent and sunshine hours were between 54.5-74.3. The pest population was comparatively low in June prior to harvesting for all the varieties screened.

Similar trend in population fluctuation by this group of insect pests was observed during 1999-2000. Maximum population of this group was recorded in the month of June with population ranging between 21-23; 11-13; 30-34 and 24 - 28 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively, at maximum temperature of 22.7- to 28.2 $^0$C minimum 5.6 to 9.6 $^0$C, relative humidity of 47-67 per cent and 44.3 to 72.2 hours of sunshine. As much as 23.9 mm rainfall was recorded during the month of June (Table 16) .

At maximum temperature varying between 4.4 $^0$C –12.2 $^0$C; minimum (-4.8 to -0.2 $^0$C ), relative humidity of 68-88 per cent and 0 to 37.1 hours of sunshine, there was no incidence of the pest on any of the four varieties of cabbage screened during December to February (Table 16).

However, relatively low pest population were noticed in October-November ranging between 5-19; 3-10; 8-28 and 6-22 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. During these two months the average temperature ranged 4.8 $^0$C-17.3 $^0$C , relative humidity 63-75 per cent and sunshine hours 15.3 to 58.9.

After being absent from the crop in December to February, this group of pests resurged in April with populations ranging between 7-8, 4-5, 10-12 and 8-10 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. During this month the average temperature increased and varied between 12.3-14.8 $^0$C.

**Infestation index**

The per cent plant infestation and infestation index of other minor pests on different varieties of cabbage during the year 1998-99 and 1999-2000 is reflected in (Table 17&18). It may be seen that all varieties of cabbage screened were free from the pest infestation during December-February in both the cropping seasons. However, very low plant percentage was found to be infested in October-November and March-June. During these months, low population density of the pest was recorded (Table 17). However, the number of plants infested was relatively high in April-May in both the cropping seasons in keeping with the population density in corresponding period (Table 18).

During 1998-99, percentage of plant infestation ranged between 1-6 in all the varieties screened in October-November, while during April-May as high as 5-15 per cent infestation was recorded. Similar trend was observed in the cropping season of 1999-2000 when the infestation varied between 0-6 in November and 5-15 in April-May for all the varieties of cabbage screened.

**Correlation between abiotic factor and population of some other major pests**

The relationship of abiotic factors including temperature, relative humidity rainfall and sunshine hours with the per cent plant infestation and infestation index of other pests of minor economic importance worked out through simple correlation analysis as recorded in Table 19a&b.

The data for the cropping seasons 1998-99 and 1999-2000 on correlation suggests a positive non-significant correlation between infestion index and population of this group of

insects with temperature and sunshine. However, a negative non-significant correlation was observed between infestation index and relative humidity and rainfall.

Correlation coefficient (r) for all the varieties screened varied between 0.316-0.424 and 0.121- 0.168 for maximum and minimum temperature respectively during 1998-99. Similarly positive non significant values of r ranging between 0.316-0.336 and 0.253-0.260 were worked out for maximum and minimum temperatures respectively during 1999-2000.

Rainfall and relative humidity were found to be detrimental to the infestation index and also percentage plant infestation in both the seasons. The infestation index was found negatively correlated with relative humidity in 1998-99 (r = -0.714 to –0.724) and 1999-2000 (r = -0.405 to –0.520); rainfall for 1998-99 (r = -0.236 to –0.245) and 1999-2000, (-0.340 to -0.393), respectively.

Sunshine exercised direct and positive influence on the infestation index. Direct and positive non significant relationship between sunshine and the percentage plants infested/infestation index were observed with r value ranging between 0.645 – 0.667 and 0.483 to 0.598 for 1998-99 and 1999-2000 respectively (Table 20).

Correlation between Homogeneity of some other pests with abiotic factors

Temperature and sunshine showed the positive homogeneity with all the four varieties of cabbage screened when the p values > 0.05 were 0.997 to 0.999; relative humidity and rainfall showed negative homogeneity during both the years 1998-99 and 1999-2000, respectively (Table 14 a & b).

**Head crop**

Four different varieties of cabbage main crop (head crop) transplanted during first week of May and harvested in last week of September for both the cropping seasons of 1999 and 2000 was screened for population trends of important insect pests. The results showed that the main crop was infested with *B. brassicae, P. brassicae* and *P. xylostella* from June to September.

Density of population of *B. brassicae* was higher in the month of June and declined with the head formation in July. However, *P. brassicae* registered two population peaks in

June and September. *P. xylostella* on the other hand was observed to be low in number in the month of July compared to other months.

***B. brassicae***

The results presented in the Table 22 & 23 indicated that the pest registered its presence throughout the growing season of the crop with high density during June in both the cropping season. It was also evident from the data that all varieties of cabbage screened showed little variation in supporting the population of the pest.

The population of *B. brassicae* during the first three weeks of June in 1999 ranging between 91 to 204 in all the four varieties of cabbage screened. The population declined between 49 to 95 during first week of the July which further increased to reach 63 to 122 in the last week of September.

During the cropping season of 2000 the population was highest in the month of June ranging between 108 to 216 in all the varieties tested. A sharp decline in the population of the pest was noticed in July, 96 to 156, which reached to its lowest level 76-148 in the month of August.**Correlation between population of *B. brassicae* and environmental factors**

Th correlations between aphid population and abiotic factors on different varieties of cabbage for two cropping seasons are recorded in Table 24 a &b.

From the data it was observed that a positive non significant correlation (r=0.319-0.363) existed between population of *B. brassicae* and maximum temperature during 1999. However, this relationship was lower in the cropping season of 2000 with r values ranging between 0.227 to 0.351; minimum value being for Golden Acre and maximum for Uttam. Similar association-ship were observed between aphid population and minimum temperature where r value for 1999 ranged between 0.286 to 0.332 and 0.052 to 0.120 for the cropping season of 2000.

It is interesting to note that population of *B. brassicae* and the relative humidity exhibited a negative relationship in head crop of all the four varieties tested. Rainfall worked but to has negative correlation with the population of the aphid in Uttam and Pride of India variety during both the years of 1999 and 2000, while as positive relationship in Golden Express and Golden Acre varieties of cabbage observed during both the cropping seasons.

Value of coefficient of correlation varied between 0.170 to 0.176 in 1999 while as it was 0.012 to 0.021 in the year 2000.

**Infestation Index**

Infestation index and the per cent plant infestation of *B. brassicae* as recorded (Table 25a &b) showed that these were related to population density of the pest. At higher density the infestation index was observed to be higher. The percentage infestation of plants by aphids ranged between 16-66, 14-65, 12-66 and 12-68 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively with corresponding infestation index varying between 1.335 to 2.139, 1.303 to 2.149, 1.252 to 2.168 and 1.252 to 2.192 during 1999, respectively.

However, during the year 2000, the per cent infestation and also the infestation index was relatively low. The per cent infestation was between 8-48 in all the varieties with infestation index ranging between 1.139 to 2.025 as may be seen from the Table 25 (a,b) the population of the aphids was comparatively low in the year 2000 and hence why the infestation index was observed lower.

**Correlation between infestion index of *B. brassicae* and certain abiotic factors**

**Head Crop**

Positive non significant correlations were observed with temperatures (maximum, minimum and mean) and non significant correlation with rainfall and relative humidity, however, negative relationship with sunshine hours was observed during the year 1999. The coefficient values of mean temperature varied between 0.895 – 0.920, relative humidity 0.113- 0.146, rainfall 0.010 – 0.062 and sunshine hours (-0.635 to –0.665).

However, during the year 2000 positive non significant relationship were observed with mean temperature 0.030-0.152, relative humidity 0.558 – 0.629, rainfall 0.072- 0.133 and negative relationship with sunshine hours (-0.476 to –0.507) in all the varieties tested.

***Pieris brassicae***

Fluctuation in Population of *P. brassicae* on different varieties of cabbage is recorded in Table 27 & 28 and the results indicate that during the entire period of growth, plants were infested with *P. brassicae* larvae. The infestation of *P. brassicae* commenced in the first

week of June during both cropping seasons of 1999 and 2000. The crop registered pest population for ten plants varying between 231 to 533 in 1999 and 204 to 457 in the year 2000 on all the varieties of cabbage in the month of June. However the density of the pest started declining in July during both the cropping seasons.

Lowest population of the pest was recorded in August during both the cropping seasons of 1999 and 2000 on all the varieties of cabbage tested. In 1999 the pest population during the August recorded were 235-274, 220 to 256, 345 to 402 and 278 to 324 while it was 294-310, 225-240, 406-436 and 337-356 in the year 2000 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. August recorded an mean temperature of 20.7 to 24.5 $^0$C; 58 to 71 per cent relative humidity, 5.1 to 72.4 hours of sunshine in 1999 and 21.6$^0$C to 23.2 $^0$C, average temperature 66.0 to 74.0 per cent relative humidity and 12.00 to 60.5 hours of sunshine in 2000. As much as 20.00 and 16.1 mm rainfall was recorded during August in 1999 and 2000, respectively. September registered higher density of the pest which ranged between 365 to 417; 341 to 390; 278 to 612 and 432 to 494 in 1999 and 305 to 409; 233 to 313; 421 to 566 and 349 to 470 in 2000, while it was 294 to 310; 225 to 240; 406 to 436 and 337 to 356 during the year 2000 during the month of August. At mean temperature of 18.00-23.3 $^0$C and 16.7 $^0$C to 22.4 $^0$C, relative humidity 67 to 71 and 64 to 78 per cent and sunshine hours 49.0 to 59.9, and 41.2 to 68.2, respectively during the year 1999 and 2000.

**Correlation between *Pieris brassicae* and certain abiotic factors**

The correlation between population of *P. brassicae* and abiotic factors affecting different varieties of cabbage (Head crop) for two cropping seasons of 1999 and 2000 are recorded in Table 29 a & b.

From the data it was observed that positive non significant correlation ( r= 0.196 to 0.199) and (0.159 to 0.205) existed between population of *P. brassicae* and maximum temperature during 1999 and 2000, respectively, minimum value were for Uttam and maximum for Golden Acre with similar relationship between population and minimum temperature were (r = 0.353 to 0.355) and (r = 0.413 to 0.0420) for the cropping seasons of 1999 and 2000, respectively. It is interesting that relative humidity has a negative non significant relationship with population of *P. brassicae* on Golden Express and Golden Acre

varieties and positive non significant relationship with population on Uttam and Pride of India varieties, during both the cropping seasons of investigation.

Rainfall worked with negative relationship for all the varieties tested during 1999 and positive non significant relationship during 2000 on Golden Express and Golden Acre varieties and negative relationship on Uttam and Pride of India variety.

**Infestation Index**

Infestation index and per cent plant infestation of *P. brassicae* on four varieties of cabbage in 1999 and 2000 are presented in Table 30 (a,b).

It may be seen that the plant infestation and infestation index were directly related to the pest population. Lowest plant infestation was recorded in August varied between 2 to 17 and 3 to 8 with corresponding infestation index which ranged between 1.028 to 1.379 and 1.050 to 1.140 in both the cropping seasons of 1999 and 2000, respectively. During this month the pest population varied between 220-402 and 225-406 during the year 1999 and 2000, respectively.

During the month of September when pest population was highest, the plant infestation and infestation index varied between 40 to 62 and 40 to 60 with corresponding infestation index which varied between 2.103 to 2.842 and 1.646 to 2.003 during 1999 and 2000, respectively. Mean pest population during the period were ranging 278 to 593 and 233 to 586, respectively.

**Correlation between infestation index of *P. brassicae* and abiotic factors (Head crop)**

A non significant positive correlation was observed between the infestation index of *P. brassicae* and temperature for both the cropping seasons on all varieties of cabbage screened. The value of the coefficient of correlation found between 0.124 to 0.551 in 1999 and 0.56 to 0.231 in the cropping season of 2000.

Relative humidity was found to have negative correlation with infestation index of *P. brassicae.* Similarly rainfall was observed to has a positive non significant influence on the infestation index. However, sunshine hours did influence periodically in the horizontal spread of the infestation in both the seasons with (r values) varying between 0.128 to 0.507 during the year 1999 and 0.393 to 0.515 during the year 2000.

***Plutella xylostella***

Fluctuation in population of *P. xylostella* on four varieties of cabbage for two cropping seasons 1999 and 2000 are recorded in Table 32 and 33.

Population means were 13 to 34 and 10 to 34 in June for different varieties of cabbage in 1999 and 2000, respectively which declined to 3-8 and 3-9 in July. There were uniform population during the entire crop-growing period for both the years of 1999 and 2000. During 1999 the maximum temperature in June ranged 27 to 30 $^0$C and minimum 9.7 to 3.9 $^0$C while as it ranged 26 to 31 $^0$C and 13.2 to 17.4 $^0$C for cropping season of 2000. Rainfall 10.8 mm and 22.6 mm and relative humidity 54-63 per cent and 52-64 per cent were observed during the year 1999 and 2000 respectively. During the period of growth, means temperature ranged between 14.6 to 24.7 and 16.7 to 24.3 $^0$C respectively for both seasons with 51 to 71, 62 to 81 per cent relative humidity and 12 to 16 and 1 to 26.7 mm rainfall.

The results suggest no significant variation in the response of four varieties of cabbage screened in supporting the population of *P. xylostella*. The population build up of the pest was almost similar in all the varieties during both the cropping seasons.

**Correlation between mean population of *P. xylostella* with certain abiotic factors**

The correlation between mean population and abiotic factors are depicted in Table 34a&b. The mean population ranged between 19.44 to 34.44 and 17.06 to 30.75 during the year 1999 and 2000, respectively. Significant positive relationship determined with temperature during 1999 in all the varieties screened. Negative relationships were observed with relative humidity on Uttam and Pride of India varieties. Similarly, with railfall on Golden Express and Pride of India varieties and positive relationship with Golden Acre and Uttam varieties. However, sunshine observed positive non significant relationship with the population to *P. xylostella*, r-values ranged from 0.415 to 0.486.

During 2000 the population mean varied from 17.06 to 30.75 in all the varieties tested. Positive non significant relationship was observed with mean (r=0.176–0.400) temperature. Relative humidity observed positive non significant relationship with population of *Plutella* on Golden Express and Golden Acre varieties and negative relationship on Uttam and Pride of India varieties while as rainfall observed negative relationship with Golden Express and Golden Acre varieties and positive relationship with

Uttam and Pride of India varieties, respectively. However, sunshine had indicated positive relationship in all the varieties tested and r values ranged from 0.183 to 0.353.

**Infestation Index**

The percentage plant infestation and also the infestation index of *P. xylostella* on different varieties of cabbage during 1999 and 2000 are given in Tables 35a&b.

It may be seen from the table that infestation index and per cent plant infestation did not follow the trend as seen in population density of *P. .xylostella.* Even during low population period of July the infestation level did not vary much from other peak population period.

In 1999 infestation percentage were between 10 to 15; 11 to 17; 10 to 14 and 10 to 16 for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. Plant per cent infestation was between 10 to 14 in different varieties of cabbage during the month of July. This plant infestation level was found to be closer to the figures recorded in month of June, August and September. Similar trend was observed in the cropping season of 2000, where plant infestation level was 8 to 16 in all the varieties of cabbage screened. Overall plant per cent infestation in 2000 was 8 to 16; 9 to 15; 8 to 16 and 8 to 12 per cent for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. Corresponding Infestation index varied between 1.084 to 1.198 during 1999 and 1.033 to 1.218 during 2000, respectively.

**Correlation between infestation index and abiotic factors**

The correlation between infestation index and certain abiotic factors are presented in the Table 36. The infestation index of *P. xylostella* ranged between 1.121 to 1.149 and 1.111 to 1.134 during 1999 and 2000 on four varieties of cabbage viz., Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively. Positive non significant relationship were determined with mean temperature ( r= 0.235 to 0.404) and ( r= 0.052 to 0.301) during the two cropping seasons, respectively. Relative humidity and sunshine were having negative relationship with infestation index of Golden Acre and Golden Express varieties of cabbage for both the cropping seasons. It was positive on Uttam and Pride of Indian varieties while as rainfall were positive relationship for all the varieties tested.

**Development of *Pieris brassicae***

The development of *P. brassicae* on four commercially cultivated varieties of cabbage was observed for consecutive generations during 1999 and 2000 and the results are recorded in Table 37a&b.

**Larval period**

There was no significant difference in the duration of the larval period of *P. brassicae* when reared on different varieties of cabbage during the year 1999 and 2000 (Table 37 a & b). Mean larval period varied from 23.27 to 23.60 days in 1999 which, however, was slightly higher in 2000 ranging between 24.67 to 25.60 days. It may be seen that larval period was longer in year 2000 as compared to its duration in 1999.

Similarly, duration of larval period for consecutive generations of *P. brassicae* during the year 1999 and 2000 did not exhibit any significant difference (Table 38a &b ). It ranged between 23.17 to 24.17 days during the year1999 and between 24.67 to 25.58 days during 2000. It is also evident from the data that larval period was slightly prolonged 1.50 to 2.00 days during the year 2000 as compared to 1999.

**Pupal period**

Duration of pupal period of *P. brassicae* reared on different varieties of cabbage did not differ significantly (Table 37 a&b), pupal period ranged between 11.27; 11.07; 10.93 and 11.13 during the year 1999 when developed on Uttam, Pride of India, Golden Express and Golden Acre, respectively. However, during the year 2000 the duration of pupal period was between 10.1 and 10.7 days slightly lesser than during 1999. While Golden express recorded pupal period for 10.20 days, it was 10.1, 10.9 and 10.6 days for Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively during the year 2000.

Similar trend was observed in the duration of pupal period in different generations of *P. brassicae* (Table 38a&b ). The pupal period ranged between 11.00 to 11.33 days during the year 1999 compared to 10.17 to 10.50 during the year 2000. The duration of pupal periods were 11.00, 11.33, 11.00, 11.11 and 11.17 days for $1^{st}$, $2^{nd}$, $3^{rd}$, $4^{th}$ and $5^{th}$ generation during 1999 respectively. However, during 2000 mean pupal period were 10.17 and 10.42 days for $1^{st}$ and $3^{rd}$ ; 10.50 for $2^{nd}$ , $4^{th}$ and $5^{th}$ generation, respectively. **Fecundity**

There was no significant difference in the fecundity of *P. brassicae* reared on different varieties of cabbage during the year 1999 and 2000. Mean number of eggs laid by each female was recorded as 116.1, 113.1, 119.9 and 118.4 reared on Golden Express, Golden Acre, Uttam and Pride of India, varieties respectively during the year 1999. However, a slight increase during fecundity was observed during the year 2000. On an average 122.6, 124.7, 122.1 and 117.9 eggs laid by each female were recorded on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively during the year 2000.

Fecundity of different generations of *P. brassicae* did not differ significantly for in both the years of study. During 1999 mean number of eggs laid by each female ranged between 111.2 and 123.1 with minimum recorded in first generation and maximum in case of females of third generation. During the year 2000 the mean number of eggs laid by each female was slightly higher compared to 1999. The number of eggs laid by female varied between 111.3 to 127.8 with first generation recording minimum and maximum in case of females of $5^{th}$ generation. As many as 127.6 mean number of eggs was recorded in females of $3^{rd}$ generation.

**Longevity of cabbage butter fly**

Adult male cabbage butterfly lived for 15.87 to 16.00 days during the year 1999 and 14.9 to 16.1 during the year 2000 when reared on different varieties with no significant difference in their longevity (Table 39). Male cabbage butterfly lived for more days as compared to female. Longevity of male cabbage butterfly was similarly 15.87, 15.80, 16.00 and 15.87 days during the year 1999 and 16.1, 16.0, 15.8 and 14.9 days in 2000 when developed on Uttam, Pride of India Golden Express and Golden Acre varieties, respectively.

Female butterflies also did not differ significantly on their longevity during the year 1999 & during the year 2000 when reared on different varieties. Longevity of adult females was recorded as13.80, 13.20, 14.33 and 13.87 days during the year 1999 compared to 16.1, 16.1, 16.9 and 16.5 days during the year 2000 when reared on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively.

Longevity of adult male and female cabbage butterfly of *P. brassicae* of different generations was not significantly different during both the years of study. Male butterflies lived between 14.92 to 16.33 days during the year 1999 and between 15.01 to 16.17 days

during the year 2000. Longevity of female cabbage butterfly of different generations varied between 13.33 to 14.25 days in 1999 as compared to 15.42 to 18.25 days during the year 2000.

It may be seen from the results that longevity of female cabbage butterfly was more during the year 2000 compared to 1999 in respect of those reared on different varieties and was not observed in the longevity of male cabbage butterfly developed on different genotypes and also in various generations.

Pooled data for development of *P. brassicae* during the year 1999 and 2000 presented in Table 39 & 40, did not show any significant variation in the duration of larval period and pupal period on different varieties screened or various generation of the pest. Larval period lasted for 20.67 to 25.67 days while pupal period varied between 10.33 to 12.00 days for different generations of the pest reared on four varieties of cabbage and similarly, the fecundity did not vary significantly within generation or among cabbage butterfly ranked on different generations.

Longevity of male and female cabbage butterfly was also at par with the five generation raised on four different varieties of cabbage. Male cabbage butterfly lived longer than females. On an average longevity of males were 13.67 to 17.67 days while females longevity was between 11.67 to 15.67 days.

The incubation period of eggs by five generation reared on different varieties of cabbage did not differ significantly and varied between 5.33 to 6.00 days during both years of 1999 and 2000.

**Survival**

Eggs of *P. brassicae* fed on various varieties of cabbage for consecutive generations in a year for two cropping seasons were studied for completion of larval period and also the emergence of adults to determine the survival of pest under laboratory conditions. The results so derived are depicted in Table 41 a&b.

The data shows that there were significant difference in the survival of larvae reared on different varieties of cabbage for both the cropping seasons of 1999 and 2000.

During 1999, significantly the number of larvae survived when reared on Uttam (85.78 per cent) and Pride of India ( 82.22 per cent). However, on Golden Express and Golden Acre survival level was low with only 63.11 and 49.78 per cent larvae reached pupal stage. Similarly, during the year 2000 significantly large number of larvae survived on Uttam (84.00 per cent) followed by Pride of India (78.00 per cent). There was no significant difference in the survival of larvae when reared on Golden Acre and Golden Express recording a survival of 72.89 and 73.33 per cent, respectively. Integration comparisons for both the seasons also reflect a significant difference in the survival larvae. During the year 1999, first and second generation larvae showed a significantly higher survival than the last three generations. However, during the year 2000, $2^{nd}$, $3^{rd}$ and $4^{th}$ as showed significant survival compared to $1^{st}$ and $5^{th}$ generations which showed significant larval survival.

Data for various varieties and generations during the year 1999 indicate not only variation in the survival percentage of larvae reared on different varieties but also in various generations. Over all larval survival on Golden Acre was significantly less as compared to other varieties. Similarly, per cent survival of larvae was significantly low in respect of $3^{rd}$, $4^{th}$ and $5^{th}$ generation during the year 1999, when reared on Uttam and Pride varieties.

Overall survival during the year 1999 worked out after emergence of adults showed a significant difference in the survival among varieties as well as generations. The survival varied between 28.88 and 68.89 per cent with $1^{st}$ generation on Golden Express recording highest survival percentage on $5^{th}$ generations on Pride of India the lowest, last three generations ( $3^{rd}$, $4^{th}$ and $5^{th}$ ) recorded low level of survival when reared in all the varieties of cabbage.

During the year 2000 there were uniform per cent survival and per cent adult emergence with slight differences in all the generations except $4^{th}$ which were comparatively lower per cent survival on Golden Express variety and higher on Golden Acre, Uttam and Pride of India varieties, respectively. The survival rate varied between 40.00 to 73.33 per cent.

**Integration of Pest Management**

Efficacy of different insecticides against *B. brassicae* and *P. brassicae* on Golden Express and Golden Acre varieties of cabbage.

***B. brassicae***

Observations recorded on 3rd, 7th and 20th days of application of insecticide on Golden Express and Golden Acre varieties of cabbage indicated that all the insecticidal treatments significantly suppressed the population of *B. brassicae* during the year 2001 and 2002, respectively (Table 45-50).

Among the treatments Bt and neem at recommended doses, proved significantly more effective in reducing the pest population on 7th day of treatment with aphid population as low as 77.66, 66.66 and 70.33, 61.00 for the year 2001and 54.66, 49.00 and 57.00, 53.00 for the year 2002 on Golden Express and Golden Acre varieties, respectively. It may be also noted that initial kill by dichlorovos and endosulfan was significantly higher on 3rd day. Here reduced population to 113.0, 66.3 and 115.33, 92.00 during the year 2001 and 88.67, 67.00 and 94.00, 105.33 during the year 2002 on Golden Express and Golden Acre varieties of cabbage, respectively were observed.

While the population recorded on 7th day on DDVP and endosulfan treated plots was 84.00, 54.66 and 95.30, 85.33 during the year 2001 and 63.33, 64.33 and 70.66, 73.00 during the year 2002 on Golden Express and Golden Acre varieties, respectively. The aphid population in untreated plots increased from 220.00 to 277.66 and 224.33 to 246.66 on Golden Express variety and from 197.33 to 240.66 and from 202.00 to 261.00 on Golden Acre variety during the year 2001 and 2002, respectively on 7th day of application. However, on 20th day of application of the insecticide (carbaryl and endosulfan), a slight increase in the aphid population was recorded in almost all treatments, suggesting the initiation of deterioration of effectiveness of the treatments during both the seasons. Aphid population of 149.00, 134.33 and 131.00, 121.33 on Golden Acre variety and 117.00, 118.33 and 105.66, 133.33 on Golden Express variety were recorded during the year 2001 and 2002, respectively against the 273.66, 349.33 and 327.00, 338.66 in control plots.

After 20 days of application of insecticides, Neem and Bt, work significantly most effective in suppressing the population of *B. brassicae* on both the varieties of cabbage during 2001 and 2002 followed by DDVP and endosulfan. Quinalphos and carbaryl although reduced the pest population significantly but were less effective as compared to other treatments.

**Effect of potassium on the population of *B. brassicae***

The results recorded (Table 45-50) clearly depicted that application of different levels of potassium significantly reduced the population of *B. brassicae* on Golden Express and Golden Acre varieties of cabbage during the year 2001 and 2002 cropping seasons at 5 per cent level of significance. It was also evident from the data that there was no significant difference in the population of the pest in the plots treated with the application of 0, 40 and 60 kg $ha^{-1}$ of potassium.

While the initial kill of the aphid with the application of DDVP and quinalphos in combination with 40 and 60 kg $ha^{-1}$ of potassium was significantly higher. The pest population was significantly low after $7^{th}$ and $20^{th}$ day of application of Neem and Bt with these two doses of potassium, in significantly low pest population on $7^{th}$ day after treatment was recorded. Two varieties of cabbage Golden Express and Golden Acre did not show any significant variation in their response to the treatments, combination of insecticides and various doses of potassium in respect of the population of *B. brassicae* during the cropping seasons of 2001 and 2002.

Endosulfan and carbaryl treatments in combination with 60 kg $ha^{-1}$ of potassium recorded 123, 137 and 101, 117 population on $3^{rd}$ day of application of spray treatments on Golden Express and Golden Acre varieties, during the year 2001, while it was 105, 117 and 118, 143 population during the year 2002. However, the population recorded on the plots applied with 40 kg $ha^{-1}$ of potassium was 117, 132 and 97, 113 on Golden Express variety and 94, 112 and 108, 134 on Golden Acre, varieties during the year 2001. However, during the year 2002 population of the aphids recorded were 208.67, 259.17 and 213.67, 256.00.

There was slight increase in the aphid population recorded on $20^{th}$ day of application of the insecticides 133, 158 and 116, 143 during the year 2001 and 105, 125 and 134, 126 during the year 2002 on Golden Express, Golden Acre varieties respectively, with the application of 60 kg $ha^{-1}$ of potassium. However, with the application of 40 kg $ha^{-1}$ of potassium recorded the population of 127, 151 and 109, 137 during the year 2001 and 98, 119 and 123, 120 during the year 2002 on Golden Express variety on $20^{th}$ day of application of spray treatment. Similar trend was recorded during the both years with the population of the pest which did not differ significantly on the application of 60 and 40 kg of $ha^{-1}$ of potassium.

***P. brassicae***

Data on the mean population of *P. brassicae* on Golden Express and Golden Acre varieties of cabbage during the year 2001 and 2002 (Table 51-56) indicated that all the insecticidal treatments were significantly superior to the untreated control at 5 per cent level of significance in suppressing the pest population, difference in the observations further reveal that there were also significant differences between the insecticides in reducing the pest population with neem registering significantly higher control followed by Bt on $7^{th}$ and on $20^{th}$ day after spraying on Golden Express and Golden Acre, varieties of cabbage during the year 2001 and 2002, although the initial kill of the pest after treatment as recorded on $3^{rd}$ day was significantly very low.

Among the insecticides DDVP and endosulfan were found significantly superior to other treatments in reducing the pest population. Population levels of *P. brassicae* were 29, 25 and 27, 25 on Golden Express and Golden Acre variety respectively on plots treated with neem and Bt on $3^{rd}$ day of spray treatment which came down to 16, 25 on Golden Express and 14, 24 on Golden Acre varieites on $7^{th}$ day with the application of neem and Bt, respectively during the year 2001. Similar trend was noticed during the year 2002 cropping season on both the varieties of cabbage. However, a slight increase in the pest population was recorded on $20^{th}$ day of application. The pest population on neem and Bt treated plots increased to 17, 14 and 19, 19 on both the varieties during the year 2002. During the corresponding period the population in untreated plots increased to 41, 43 and 53, 55 on Golden Express and Golden Acre varieties on $20^{th}$ days of spray treatment during the year 2001 and 2002 respectively.

Quinalphos treated plots exhibited the population of 19, 18, 37; 32, 19 and 17 on Golden Express and Golden Acre varieties, respectively during the year 2001 as compared to 18.67, 18.33, 29.00 and 21.67, 19.33, 32.00 during the year 2002 on $3^{rd}$ , $7^{th}$ and $20^{th}$ days of spray treatment while as the population recorded on the control plots were 32, 33, 41 and 34, 35 and 43 during the year 2001 on Golden Express and Golden Acre variety. However, during the 2002, the population were 27.67, 32.62 and 53.00 and 33.33, 34.00, 55.00 on Golden Express and Golden Acre variety on 3rd ,$7^{th}$ and $20^{th}$ day.

**Effect of potassium on the population of *P. brassicae***

The results as recorded (Table 51-55) showed that application of different levels of K reduced the population of the *P. brassicae* on Golden Express and Golden Acre varieties of cabbage during the year 2001 and 2002 cropping seasons at 5% level of significance. It was also evident from the data that there was no significant difference in the population of the pests in the plots treated with the application of 40 and 60 kg $ha^{-1}$ of potassium. Population of the *P. brassicae* in the combination with potassium levels on 3rd day after application of treatment during the year 2001 were 14.83 and 17.33, treated with DDVP and endosulfan, respectively as compared to control 32.33 while as during the year 2002 were 14.89 and 17.33, respectively on Golden Express and Golden Acre varieties. During both the years of 2001 and 2002 the population on 7th day significantly reduced in combination with K levels 6.83 and 8.17 on plots treated with Bt and neem, while as on 20th day of spray treatment –the population increased during the both years, the lowest population recorded on the plots treated with neem (15.44 and 14.50) followed by Bt (24.17 and 19.50) during the both years of 2001 and 2002 as compared to control with a population of 41.35 and 54.5, respectively.

**Mortality of *Pieris brassicae* by the application of different insecticides in combination with levels of potassium on varieties of cabbage**

Observations on the mortality of *P. brassicae* recorded on 3rd, 7th and 20th day of application of spray treatment on two varieties of cabbage i.e. Golden Express and Golden Acre during the year 2001 and 2002 (Table 51-56). Data revealed that lowest mortality 9.6 and 10.9 per cent of the pest on the 3rd day was recorded in the plots treated with neem. While as mortality of 1.9 and 17.3 per cent was recorded with the application of Bt on Golden Express and Golden Acre varieties, respectively. Application of DDVP registered higher mortality of 56.7 and 27.1 followed by quinalphos 40.7 and 40.4 on Golden Express and Golden Acre varieties. However, endosulfan recorded the mortality of 40.7 and 41.7 during the year 2001.

On 7th day of spray treatment the lowest mortality recorded were on plots sprayed with quinalphos (45.5 and 45.6) followed by carbaryl 54.5 and 51.5 on both varieties i.e.

Golden Express and Golden Acre. Highest mortality recorded were on plots sprayed with Bt 72.9 and 74.2 followed by neem 62.9 and 77.3 on Golden Express and Golden Acre, varieties, respectively.

However, on 20th day of spray treatment during the year 2001, lowest mortality recorded on plots sprayed with quinalphos 21.7 and 13.9 followed by endosulfan 24.3 and 23.2 on both the varieties of cabbage. However, highest mortality recorded on plots sprayed with neem were 61.2 and 67.5 on both varieties of cabbage, respectively. The data further revealed that all the treatments were significantly effective in suppressing the population after 3, 7 and 20 days during the year 2001.

Observation revealed that mean mortality of *P. brassicae* during the year 2002 recorded on 3rd day of spraying was lowest on plots sprayed with neem (15.0 and 15.1) followed with Bt ( 22.5 and 21.3) on the both varieties of cabbage i.e. Golden Express and Golden Acre. However, maximum mortality recorded on the plots treated with DDVP were 51.9 and 51.2 and Endosulfan 40.7 and 45.4 on the both varieties.

On 7th day of spraying the maximum mortality of 87.28, 76.7, 77.6 and 70.5 on the plots treated with Bt and neem on Golden Acre and Golden Express varieties, respectively. However, minimum mortality were 44.1 and 42.9 recorded on the plots treated with quinalphos followed by carbaryl 47.1 and 48.1 on Golden Express and Golden Acre varieties of cabbage. However, on 20th day of spraying maximum mortality recorded were 68.0 and 73.1 on the plots sprayed with neem followed with Bt 64.0 and 63.4 minimum on plots treated with quinalphos 45.1 and 38.3 and endosulfan (47.0 and 42.2) on both the varieties respectively.

The data further revealed that all the treatments were given significant results suppressing the population during both cropping seasons of 2001 and 2002, respectively at 5% level of significance.

**Effect of Potash on the mortality of *P. brassicae***

The data revealed that treatments in combination with potash level gave significant results in suppressing the population of *P. brassicae* on 3rd , 7th and 20th days of application (Table 51-56).

Lowest mortality recorded were 13.65 and 13.4 on the plots sprayed with neem followed by Bt 22.38 and 19.1 and highest mortality on plots treated with DDVP 54.7 and 52.50 followed by endosulfan (48.59 and 33.23) on 3rd day of application of insecticidal treatment during both the cropping seasons of 2001 and 2002 respectively. On 7th day the lowest mortality were recorded on the lots sprayed with quinalphos 47.88 and 43.0 followed by endosulfan 57.24 and 24.60 respectively during the year 2001 and 2002. Highest mortality recorded on the plots treated with Bt 79.2 and 64.2 followed by neem 75.0 and 73.4 respectively, during the year 2001 and 2002. The lowest mortality recorded on the plots treated with quinalphos were 47.48 and 15.1 followed by carbaryl 50.39 and 27.4, respectively and highest mortality on plots treated with Bt (74.97 and 41.4) followed by neem (72.99 and 62.80) on 7th and 20th day of application, respectively on plots in combination with potash.

Observations recorded on 3rd, 7th and 20th of application of spray treatment in combination with 0, 40 and 60 kg $ha^{-1}$ potassium during the year 2001 on Golden Express and Golden Acre varieties, respectively given significant results at 5 per cent level of significance. However, there were no significant variations among the different levels of potash and varieties of cabbage.

**Chapter-V**

## DISCUSSION

The trial and error approaches to pest control without understanding the role of the attributes of individual organisms or the environment especially the compositions of host plants have led to more serious consequences. The recent histroy of insect resistance, resurgence of pests and outbreaks of secondary pests pronouncedly suggest that the pest management requires a holistic approach. It has been now admitted that high death rates do not often hold down pest numbers. It is, therefore, time to recognize the fundamental weakness of our preoccupation with lethal agent. This preoccupation has prevented us from recalling that the insect pests have been surviving in very hostile environment much longer than we have been trying to destroy them. Certain adaptation has undoubtedly allowed them to evade extinction. The endeavour should be to precisely identify weaknesses in their life styles, which could be exploited. Because of this ignorance heavy prices have been paid every time and conventional programme of pest control have failed. These conventional programmes of pest control whether chemical or biological have been based on the admission that indiscriminate increases in mortality would serve us well. But methods that increase mortality have not helped to regulate the number of pest consistently or predictably. Several indiscriminate methods have created graver problems than that they were intended to solve. It is, therefore, imperative that more attention has to be paid to understand the strategies of survival by the insect pests so that these are counteracted effectively and more consistently.

The procedure may include scanning the environment from the organism point of view to ascertain functional relationship and attributes of pest population and the environment including the food source. Several studies have been reported the dependence of pest outbreaks on environmental conditions including composition of host plants and whether conditions in a number of Lepidoptera and Homoptera.

The cabbage *Brassica oleracea* var. capitata is an important cruciferious vegetable crop grown commercially all over the country. In India and abroad the various insect pests recorded and given major pest status on the crop include *Brevicoryne brassicae, Pieris brassicae, Plutella xylostella, Hellula undalis, Athalia proxima, Bagrada cruciferarum, Phylotretta cruciferae*; (Malik *et al.* 1972; Butani *et al.*, 1977; Talekar and Lee, 1985; Bhatia and Verma, 1994; Bhatia *et al.*, 1995; Sabherwal, 1995, Jitender *et al.*, 2000 and Zaz, 2001).

## 5.1 Population buildup of major insect pests of cabbage in relation to certain abiotic factors on different varieties of cabbage

The weekly population build up of various insect pests including *B. brassicae, P. brassicae, P. xylostella* and other pests on four commercial varieties of cabbage namely Golden Express, Golden Acre, Uttam and Pride of India raised separately for seed and head crop were studied. Population of the pests were correlated with certain abiotic factors, Per cent infestation and infestation index were further correlated to certain environmental factors for two cropping seasons.

### *B. brassicae* (Seed crop)

The data on the population trend of *B. brassicae* on four varieties of cabbage screened during two cropping seasons suggests two population peaks in October and May-June, coinciding with two distinct stages of head formation and sprouting of inflorescence. The population of aphid supported by the varieties did not differ significantly during the two cropping seasons. It is also evident from the data that the infestation of the crop with *B. brassicae* was for nine months from October to June with significantly low population during January- February. The first incidence of the pest recorded in the first week of October in all the varieties, however, low population was recorded on Pride of India and higher on Uttam variety. The population in all the varieties ranged between 75- to 204 aphids/plant, when the average weekly temperature was 21.2 $^{0}$C, RH 56 per cent and sunshine 74.3 hrs.

***B. brassicae* (Head crop)**

The pest registered its presence throughout the growing season of the crop with high density in June ranging between 91 to 216 aphids per plant followed by population level of 63 to 158 per plant in September on four varieties of cabbage screened. A sharp decline in population was recovered in July reaching as low as 76-148 aphids per plant in August. Studies carried out elsewhere also suggests peak population of *B. brassicae* in May and June.

Studies carried by Hildenhagen and Hommes (1997) indicated two population peaks of *B. brassicae* in cabbage with first peak in June and the second in September-October corroborating with present finding. Similarly, Bhatia and Verma (1995) recorded the peak density (61 aphids per plant) in the beginning of June on the cabbage; Tandon *et al.* (1977); Dhaliwal and Goma (1979); Sachan and Gangwar (1980); Khaire and Lawande (1986) and Bhatia and Verma (1994) have also observed April-May as peak period of activity of *B. brassicae*. Barwal (1997) reported peak activity period of *B. brassicae* in May at Kalu (H. P). Kaul (1998) recorded peak population during February-March in H. P. on cabbage. The present findings are also in agreement with the observations of Zaz (2001) who while observing infestation of the pest during the entire growing season recorded two population peaks in June and October.

**Percent infestation and infestation index**

In the present studies the higher per cent infestation of aphids was recorded during May-June ranging between 61-69 per cent with corresponding infestation index of 2.311 to 2.475 on all the four varieties tested for two cropping seasons of seed crops 1998 –99 and 1999-2000 and another higher per cent infestation was recorded during the month of October ranging between 36-46 per cent with corresponding infestation index of 1.755-1.993 on all the four varieties tested during both seasons. These observations are in line with the work carried by Sachan and Gangwar (1980), Kotwal (1981), Mustafa and Masha (1994), Bhatia and Verma (1995), Sabherwal (1995), and Hildenhagen and Hommes (1997) who reported higher per cent infestation during the crop growing seasons. Jankowska, (1995) in a similar

investigation reported that aphid populations were similar on the different varieties of cabbage, but number differed significantly, these reports confirm the present investigation.

***Pieris brassicae***

*P. brassicae* was recorded as most abundant pest on cabbage responsible for causing maximum damage. The pest was absent in crop during January-February, its population also depicted two peaks, one in October and the another in May-June synchronizing with head formation and sprouting stages of the crop, respectively. Population of larvae recorded during the month of October ranged between 200-512 per 10 plants. No significant variation recorded in population of *P. brassicae* supported by the four varieties screened, relatively higher population varying between 485-566 was recorded in Uttam and Pride of India, varieties during two cropping seasons compared to Golden Express and Golden Acre during 1998-99. However, during 1999-2000 no such variation in the population of *P. brassicae* supported by the four varieties tested was observed.

An upsurge in the population of the pest recorded during March reaching its peak in May-June with 323, 278, 582 and 552, population of the pest on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively, corresponding to mean temperature ranging from 19.6 to 24.3 $^{0}$C, RH 64% and 56 to 79 hours of sunshine. In September-October the population recorded on two Head crops ranged between 233-566 on all the four varieties tested.

In a similar investigation carried out in Kashmir valley, Zaz (2001) recorded two peaks of *P. brassicae* on cabbage with 3.6 larvae in the month of June. The highest population range of 0-16 larvae on cabbage per 10 plants was recorded in the 3$^{rd}$ week of August. Sachan and Gangwar (1980 & 1990) have reported similar observations on the population of *P. brassicae*. Bhatia and Verma, (1994) observations are in approximately to the results obtained in the present studies.

Dhaliwal and Gom (1979) and Sood (1992) found cabbage crop free from infestation of *P. brassicae* till the end of February at Solan, (H. P.), with adults emerging in February to lay eggs by the end of month. Similarly, Gupta, (1984) reported the appearance of adults of

*P. brassicae* in mid of February. Bhatia *et al.* (1995) found peak population of *P. brassicae* on cabbage in December with 65.8 and 67.3 larvae per plant. These report are the land support to the results of present studies.

**Percent infestation and infestation index (Seed crop)**

The trend with the fluctuations in the population of *P. brassicae* during cropping seasons got reflected in the percentage of cabbage plants infested. High percentage of plant was infested with the pest during peak population density in October and April-June, while as no plant was infested during winter months of January-February.

Per cent infestation of *P. brassicae* recorded during the two consecutive seed crops ranged between 22-51 during the month of October with corresponding infestation index of 1.512-2.380 on all the four varieties tested. Further, the highest per cent infestation recorded during the month of May-June ranged between 13-49 with corresponding infestation index of 1.307-2.318 on all the four varieties tested.

**Head crop**

Plant infestation with *P. brassicae* and infestation index was found directly related to pest population. Lowest plant infestation was recorded in September during the year 1999 and August during the year 2000 which varied between 12-21 and 8-14 on all the four varieties and corresponding infestation index was 1.252 -1.431 and 1.136- 1.247in both the cropping seasons of 1999 and 2000, respectively. During this period pest population varied between 49-110 and 98-148 in 1999 and 2000, respectively. During the month of June when pest population was highest the plant per cent infestation varied between 62-82 and 36-48 with corresponding infestation index of 2.078-2.160 and 1.739-2.025 during 1999 and 2000, respectively. Mean pest population during this period was 91-204 and 127-216, respectively. The present investigation is in line with the work carried out different workers reported as under. Zaz, (2001), 0-20 per cent infestation , Sachan and Gangwar (1990) also recorded almost same range of infestation level though Bhatia and Verma, (1994) and, Mushtaque and Mohyuddin (1984) recorded infestation level of 4-58 and 55 per cent, respectively.

**Plutella xylostella**

There were uniform populations on both Head and Seed crop with little fluctuations. Population of *P. xylostella* during two cropping seasons varied between 16-27; 13-22; 23-39 and 19-31 for the year 1999; 17-24, 10-19; 23-34 and 23-29 for the year 2000 on Golden Express, Golden Acre, Uttam and Pride of India, varieties, respectively. Suggesting no significant variation in the response of the four varieties. The infestation index and percentage plant infestation did not follow the trend as seen in population density of *P. xylostella* even during low population period. The infestation level did not vary much from other peak population periods.

The per cent infestation of *P. xylostella* during the cropping seasons of 1999 ranged from 10-17 on all the four varieties with corresponding infestation index of 1.123-1.221. However, during the year 2000 it ranged from 9-16 with corresponding infestation index of 1.100 to 1.218. The infestation index was further correlated with certain abiotic factors for determining the r values significance. The average temperature was highly significant, while as maximum and minimum temperatures were positively significant during the year 1999. However, during the year 2000 all r-values of all the abiotic factors were non-significant. Bhatia and Verma (1994) recorded 4-68 per cent plant infested, Prasad (1963) reported 8-28%. Barrantes and Rodriguez (1996) reported greatest number after head formation. The per cent infestion and corresponding infestion index of this pest ranged from 8-17 and 1.109 to 1.221for two cropping seasons on all the four varieties.

In a similar investigation infestation level of 3-4 larvae per plant of *P. xylostella* was recorded on cabbage (Zaz, 2001). Abro *et al.* (1994) recorded higher population (0-6 larvae) of *P. xylostella* per plant on cabbage. Sachan and Gangwar (1980) recorded one larva per plant. Further, the above workers in a separate experiment, during the year 1990 recorded (1-2) larvae per plants. Sachan and Gangwar (1990). Bhatia and Verma (1994) reported 1.76 larvae per plant. Two peaks of *P. xylostella* were recorded on cabbage (Lasota and Kok, 1989 and Annamalai *et al.*, 1988). Khaire and Lawande (1986) recorded pest population during February, which were in confirmity to the present findings. However, Lee (1986) recorded only one peak of the pest. Dennil and Pretorius(1995) recorded a maximum population of 0-

4 larvae per plant. Whereas Mailloux and Belloncik (1995) recorded a maximum 3-5 larvae per plant. Bhatia and Verma, (1995) recorded 1.25-8.7 larvae per plant. Different workers have recorded different peak periods of *P. xylostella* viz., in February, Sachan and Srivastava (1972), March –April, Dhaliwal and Goma (1979); Bhatia and Verma (1994); in April, Usha *et al.* (1997); April-May, Abraham and Padmanaban (1968); October-November, Park *et al.* (1993) and in March, Kaul (1998).

**SOME OTHER PESTS**

*Hellula undalis, Bargada cruciferarum, Athalia proxima* and *Trichoplusia ni* are of less economic important were absent from December to February during *Rabi* seasons of 1998-99 and 1999-2000. The population during October-November were 7-16, 5-12, 12-24 and 9-21; 5-19, 3-10, 8-24 and 6-12 on Golden Express, Golden Acre, Uttam and Pride of India, varieties, respectively. Peak population of the pests were recorded during May-June which ranged between 15-21, 10-51, 25-37 and 19-28 during 1998-99 and 21-27, 11-15, 30-39 and 24-32 during 1999-2000 on Golden Express, Golden Acre, Uttam and Pride of India, varieties, respectively.

This findings corroborates with Butani *et al.* (1977) who reported 7 major insect pests Sachan and Gangwar, (1980 & 1990), Bhatia and Verma (1994); Bhatia *et al.* (1995); Bhatia and Verma (1995) and Malik *et al.* (1972) who recorded 7-9 insect pests of cabbage, where as Talekar and Lee (1985); Lee, (1986); Lasota and Kok (1989) and Raju and Sivaprakasam (1989). Ong and Soon (1989) recorded 7 to 8 insect pests. The per cent infestation were very low during the seed crops of 1998-99 and 1999-2000 in all the varieties tested ranging from 2-13, 3-15, 5-13 and 4-13 with corresponding infestation index of 1.011-1.221, 1.028-1.221, 1.666-1.222 and 1.018-1.022, respectively.

Correlation between population of different insect pests with certain abiotic factors

**B. BRASSICAE**

Non-significant positive correlation was observed with maximum, minimum, mean temperature and relative humidity and negative non-significant correlation with sunshine and

rainfall during the both seed crop of 1998-1999 and 1999-2000. In a similar work Zaz (2001) observed negative non-significant correlation of population with overall temperature relative humidity and rainfall. Sachan and Gangwar (1980) reported increase in the population of *B. brassicae* with increase in temperature. Similarly, Rana *et al.* (1993) observed negative correlation with temperature, relative humidity and rainfall. Chander and Kushwaha, (1986), Lee (1986) observed adverse effect of rainfall on aphids. The findings of these workers are in line with the present findings.

Positive non-significant correlation was observed on head crop of 1999 and 2000 between maximum, minimum, mean temperatures and sunshine (hrs) whereas, negative non-significant correlation was observed between relative humidity and rainfall. However, when the infestation index was correlated with certain abiotic factors during seed crops of 1998-99 and 1999-2000, non significant positive correlation were observed between maximum, minimum, mean temperature and rainfall and negative non significant relationship with relative humidity (%) and sunshine (hrs) and during two head crops of 1999 and 2000, positive and significant correlation was observed between infestation index and maximum, minimum and mean temperature during the year 1999. However, correlation between infestation index and temperatures during the year 2000 was positive but non-significant.

Rana *et al.* (1993) worked out significant negative correlation between incidence of aphids with temperature, rainfall and relative humidity. Rahim, (1993) observed that the population of aphids was negatively correlated with temperature, sunshine hours, rainfall and positive correlations were computed with mean temperature and relative humidity.

Debraj *et al.* (1994) reported that the fluctuating population was related with certain abiotic factors in both the stages of cabbage crop i.e. Head and ratoon crop. In another study Debraj and Singh (1996) reported that the minimum temperature and rainfall had significant negative correlation with the population and Cividanes (2002) also reported that the relative humidity and rainfall showed significant relationship.

**PIERIS BRASSICAE**

Positive non significant correlation between population of *P. brassicae* and certain abiotic factors was observed and also with maximum, minimum, mean temperature and relative humidity during the both *Rabi* seasons of 1998-99 and 1999-2000. Negative and non-significant relationship was observed with rainfall and sunshine hours in this study but when infestation index was related with certain abiotic factors. Positive significant relationship was observed with sunshine hours, minimum and maximum temperature during the two *Rabi* seasons. High humidity and rainfall were found detrimental to the population buildup of *P. brassicae,* and abiotic factors were found to have significant negative association with the population of the pest.

In a similar studies carried out by Zuranska and Cpielewska (1988) reported that 1$^{st}$ and 2$^{nd}$ instar larvae required higher temperature than 3$^{rd}$ and 4$^{th}$ instars of *P. brassicae.* Mustafa and Masha (1994) indicated that the day length and temperature affected the percentage of population. Sachan and Gangwar (1990). Thakur and Deka (1997) and Sood *et al.* (1994) in a similar studies on *P. brassicae* recorded that mean temperature indicated significant role in population build up of the specie. Bhalla and Chauhan *et al.* (1994) recorded the influence of certain abiotic factors. These reports support the findings of the present investigation.

**PLUTELLA XYLOSTELLA**

Positive and significant relationship was observed between population of the pest and mean, maximum and minimum temperature. However, relationship of population with mean temperature was recorded non-significant. Positive relationship was noticed with relative humidity, rainfall and sunshine hours during the year 1999 and 2000. Population of *P. xylotella* showed positive and non significant correlation with temperatures and relative humidity on Golden express and Golden Acre, varieties and negative relationship with other varieties and sunshine. However, when the infestation index of the pest was related with certain abiotic factors, it showed positive non significant relationship with maximum, minimum, mean temperature and rainfall and negative non significant relationship with

relative humidity and sunshine hours during the both head season crops of 1999 and 2000 on all the four varieties of cabbage tested.

Annamalai *et al.* (1988) in a similar studies reported rainfall as a mortality factor, whereas Talekar and Lee, (1985) and Wakisaka *et al.* (1991), reported that temperature of more than 30 $^{0}$C to delay developmental and survival stages. Ong and Soon (1989) reported that temperature and rainfall affected the population peaks. Raju *et al.* (1993) reported significant and negative relationship with relative humidity.

5.2 Development of *Pieris brassicea* on commercially grown varieties of cabbage

Survival of *P. brassicae*

The survival of *P. brassicae* reared on four varieties of cabbage i.e. Golden Express, Golden Acre, Uttam and Pride of India during the year 1999 and 2000 separately on consecutive generations revealed that there was no significant difference in the survival of larval of the insect species on three varieties i.e. Golden Express, Golden Acre and Uttam, however, significant proportion of population was found to survive on Uttam variety of cabbage. During 1999 (85.78%) larvae survived when reared on Uttam, (82.22%) on Pride of India, however, on Golden Express and Golden Acre varieties survival level was low as only 63.11 and 49.78% larvae, respectively reached pupal stage. Similarly during the year 2000 large number of larvae survived on Uttam (84.0%) followed by Pride of India (78%). There were no significant difference in the survival of larvae when reared on Golden express and Golden Acre reaching a survival of 72.89 and 73.33%, respectively. Comparison of survival of the pest for both the seasons also reflected a significant difference in the larval survival. During the year 1999, 1$^{st}$ and 2$^{nd}$ generations larvae showed a significantly higher survival than the last three generations, however, during 2000 2$^{nd}$, 3$^{rd}$ and 4$^{th}$ generations showed non significant survival as compared to 1$^{st}$ and 5$^{th}$ generations showing significant larval survival.

In the present studies only five generations were recorded while Thakur and Deka (1997) recorded four generations with two overlapping generations in a year, while Sood *et al.*(1994) reported three generations in a year. Hashmi and Mehmmod (1985) recorded four generations in a year. Present studies are in line with the work conducted by different workers and thus confirming the present studies.

Developmental stage of *P. brassicae*

Study on the development of *P. brassicae* carried out during two years separately on four commercial varieties of cabbage for consecutive generations during the year 1999 and 2000 indicated that developmental stages including incubation, larval and pupal period, sex ratio and longevity of the butter fly showed non significant relationship with varieties and generations, respectively. During both the seasons the fecundity of *P. brassicae* varied from 113.1 to 124.7 eggs, which hatched within the range of 5.93 to 6.13 days on four varieties of cabbage. The larval and pupal period extended within 23.23 to 25.60 and 10.1 to 11.27 days respectively while the sex ratio ranged between 1.06 to 1.25, longevity of males and females 14.9 to 16.1 and 13.2 to 16.9 days, respectively during the year1999 and 2000. However, the results recorded here on different generations showed non significant relationship during both years. The highest fecundity recorded in the third generation was 125.45 eggs, higher incubation period during $2^{nd}$ generation ranges from 6.08 to 6.25 days, longer larval period on $4^{th}$ generation ranges from 24.17 to 25.58 days, longer pupal period on $5^{th}$ generation 11.17 to 10.5 days, respectively. The results further revealed that hibernation period was extended for longer duration in $2^{nd}$ generation. However, the interaction of varieties and generations showed non significant relationship during both the years in respect of all varieties.

Similar observations were recorded by Rattol (1959) while working on the biology of *P. brassicae* and reported that hatching of eggs within 3.2 to 17.6 days and duration of larval, pupal and adult longevity extending upto 5.6 to 14.7, 7.3 to 28.8 and 2.6 to 12.3 days, respectively during different seasons of crop growth and five generations of the *P. brassicae* have been recorded on cabbage in testing in the present studies. Thakur and Deka (1997) reported four generations with two over lapping generations in Meghaliya. Gupta (1984) reported that 5 to 7, 15 to 30, 15 to 20 and 8.5 to 10.0 days, respectively, as incubation, larval, prepupal and pupal periods. However, Ritu *et al.* (1999) studied the biology of *P. brassicae* in laboratory and reported that incubation period lasted 4.7 days with larval period extending upto 12.5 days.

*5.3* Integration of some control components for management *of P. brassicae* and *B. brassicae*

*P. brassicae*

Mean population of *P. brassicae* on two varieties of cabbage i.e. Golden express and Golden Acre during the two cropping seasons of 2001 and 2002 treated with different insecticides/biocides gave significant control at 5% level of significance on 3rd, 7th and 20th day of spray treatment over the control. There was also significant difference between the insecticides and varieties in reducing the pest population. Neem and Bt on 7th and 20th day after spray gave higher control in reducing the population of *P. brassicae*. Neem treated plots registered population on 7th day were 10.8,10.8, 9.67 and 7.67 and on 20th day 16, 14 and 17, 14 on Golden Express and Golden Acre variety during the year 2001 and 2002, respectively. Population recorded on Bt treated plots on 7th day were 9, 9 and 7.67, 6.67 and on 20th day 25, 24 and 19, 19 on two varieties, respectively during the two cropping seasons of 2000 and 2001, respectively. In a similar work carried by different workers reported the same observations as observed in the present investigation. Dhaliwal *et al.* (1997) reported 73.66 per cent control by Neem while Anis *et al.* (1999) reported 78.25 per cent control by Bt on 7th day. Lin *et al.* (2001) reported 50 per cent control by Bt and Krishnaiah and Jagan Mohan (1977) reported 60 per cent control upto 7th day by spraying 4 per cent NSKE.

Among insecticides DDVP and endosulfan were significantly superior to other treatments. Population recorded on 3rd day were 14, 22 and 10.0, 16.67 on plots treated with DDVP and 17, 17 and 16.67, 18.67 with endosulfan on Golden Express and Golden Acre varieties during the 2001 and 2002, respectively. On 7th and 20th day of spray treatment, population of *P. brassicae* recorded on the plots treated with the DDVP and endosulfan were significantly lower as compared to other insecticides excluding biocides, e.g. neem and Bt.

Present findings are in line with the work conducted by Gupta (1984) who reported endosulfan gave higher kill upto 7 days with endosulfan; Des raj and Kumar (1990) reported that 0.05 per cent endosulfan effectively checked the attack of cabbage caterpillars upto 20th day. Lal (1990) and Narkiewicz (1995) reported that endosulfan destroyed 95-100 per cent of the pest on 3rd day. Rajput *et al.* (1986) reported that DDVP was the best treatment of cabbage caterpillars.

Effect of potash on the population of *P. brassicae*

Effect of different levels of potash on the population of *P. brassicae* in combination with different treatments gave excellent control on 7th and 20th day of application. However,

there was no significant variation between population of the pest and different levels of potash during the two cropping season and on the two varieties of cabbage tested.

DDVP and endosulfan exhibited the low population on 3rd day which increased slightly on 7th day. However, the population on 20th day was increased significantly. The population on 3rd, 7th and 20th day after spray were significantly superior over the control in all treatments and different levels of potash on both the varieties during two cropping seasons of 2001 and 2002.

Biocides (neem and Bt) exhibited the lowest population on 7th and 20th day as compared to other treatments and registered superior control. Work conducted by Sugiyama *et al.* (2002) and Hussain *et al.* (2002) who reported the same findings, confirms the present investigations.

**Mortality of *P. brassicae***

Observation recorded on 3rd, 7th and 20th day of application of spray treatments on two varieties of cabbage i.e., Golden Express and Golden Acre in combination with 0, 40, 60 kg of potassium per hectare during the year 2001 and 2002, showed that all the treatments were significantly superior to control. However, there was no significant variation between the different levels of potash and varieties during both seasons of 2001 and 2002 on 3rd, 7th and 20th day after treatment.

Data revealed that mortality recorded on 3rd day on plots treated with Neem were 9.6 and 10.9 followed by and Bt 21.9 and 17.3 on Golden Express and Golden Acre varieties, respectively. On 7th day mortality recorded on neem and Bt treated plots were 72.9, 74.2 and 62.9, 77.3 and on 20th day 61.2, 67.5 and 39.1, 44.1 during the cropping season of 2001, respectively. However, during the year 2002, mortality recorded on 3rd day was 15.0, 15.1 and 22.5, 21.3, 7th day 87.20, 76.70 and 77.6, 70.5 and on 20th day 68.0, 73.1 and 64.0, 63.4 on Golden Express and Golden Acre varieties, respectively. Different workers have reported similar results which are in accordance with the presetn investigations. Krishnaiah and Jagan Mohan (1977) reported mortality of 73.8 per cent while Lal (1990), Liu (1999) and Anis *et al.* (1999) reported mortality of 50 and 78 per cent on 7th day.

DDVP exhibited mortality to the level of 56.7, 27.1, on 3rd day which increased to 60.0, 62.2 on 7th day reaching 34.2, 34.8 on 20th day during the year 2001 and 51.9, 51.2, 61.2, 63.8 and 52.2, 55.7 on 3rd, 7th and 20th day of application of treatments on Golden Express and Golden Acre varieties, respectively.

Quinalphos exhibited lowest mortality of 40.7, 40.4 and 33.7, 36.1 on 3rd day 45.5, 45.6 and 45.1, 38.3 on 7th day 21.7, 13.9 and 33.7, 36.1 on 20th day during the year 2001 and 2002 on Golden Express and Golden Acre varieties, respectively. Endosulfan exhibited highest mortality of 54.5, 31.8 and 40.7, 45.4 on 3rd day, 54.57, 43.80 and 53.3, 54.9 on 7th day, 24.3, 23.2 and 47.0, 42.2 on 20th day of spray treatments on Golden Express and Golden Acre varieties during the year 2001and 2002, respectively.

In a similar observations Narkiewicz (1995) reported 95 per cent mortality upto 7th days by spraying with DDVP and 50 per cent with endosulfan and 15 per cent mortality in control. Lin *et al.* (2001) and Butani *et al.* (1997) recorded mortality of 73 and 66 per cent by applying Endosulfan and DDVP after 3 to 5 days, respectively. These observations corroborate with the present findings.

**Effect of potassium on the mortality of *P. brassicae***

Mortality of *P. brassicae* recorded on plots treated with Bt and neem in combination with different levels of potash on 3rd day were 13.65, 13.45 and 22.38, 19.1 which increased to 72.99-75.00 and 74.97-79.20 on 7th day and lowered to 62.8, 73.4 and 41.4, 64.2 on 20th day of application of treatments during the year 2001 and 2002 on Golden Express and Golden Acre varieties, respectively.

DDVP treated plots exhibited mortality of 54.79, 52.5 on 3rd day 60.26, 60.5, on 7th day and 33.4, 54.2 on 20th day during two cropping seasons of 2001 and 2002 and on two varieties i.e., Golden Express and Golden Acre, respectively. Quinalphos treated plots exhibited mortality of 41.57, 35.3 on 3rd day, 47.48, 43.0 on 7th day and 15.1, 46.0 on 20th day of application during the year 2001and 2002, on Golden Express and Golden Acre varieties, respectively. The findings of Sugiyama (2002) and Hussain *et al.* (2002) on the effect of potassium and the mortality of *P. brassicae* confirmed the present observations.

***B. brassicae***

Among the treatments Bt and neem at recommended doses proved significantly more effective in reducing the pest population on 7th day of treatment with population load of 77.66, 66.66 on Golden Express, 70.33 and 61.0 on Golden Acre variety for the year 2001. However, during the year 2002, the population recorded were 54.66, 49.00 on Golden Express and 57.00, 53.00 on Golden Acre varieties. The present findings are in line with the observations of Liu (1999), Saucke (1994), Dhaliwal (1997), Sannaveerappanavar and Viraktamath (1997), Ashok (1999), Sengonce and Liu (2002). These workers reported that NSKE (4%) was highly effective followed by Bt upto 7th day of application. They have further referred that Bt was effective for the control of aphids.

In the present investigation the population on plots treated with DDVP and endosulfan on 3rd day were 113.2, 66.3 and 115.33, 92.00 during the year 2001; 88.67, 94.66 and 105.33, 87.00 during the year 2002, respectively, while the populations recorded on 7th day were 84.00, 54.66 and 95.33, 85.33 during the year 2001; 63.33, 64.33 and 70.66, 73.00 during the year 2002 on Golden Express and Golden Acre varieties respectively.

Effect of Potassium on the population of *B. brassicae*

Application of different levels of potash reduced the aphid population significantly on both the varieties tested during the year 2001 and 2002 at 5% level of significance. However, there was no significant difference on the plots treated with different levels of potash on 3rd , 7th and 20th days of spray treatment. Initial kill of the aphid with carbaryl and quinalphos in combination with potash was higher on 7th and 20th days after treatment. The population on the plots treated within endosulfan and carbaryl on 3rd day of application recorded was 103.67, 100.00 and 119.67, 123.00 during the year 2001 and 2002, respectively and were 90.33, 71.22 and 114.17, 94.5 on 7th day. The population levels on 20th day of application during the year 2001 were 80.5, 83.83, 98.33, 115.67, 126.06 and 141.3 on neem, Bt, DDVP, endosulfan, quinalphos and carbaryl treated plots, respectively, however, population of the aphid was lower during the year 2002 than 2001 in all the treatments in all levels of potash.

In a similar investigation Sugiyama *et al.* (2002) reported that effect of potash before 20 days of transplanting reduced the infestation of *B. brassicae* to the maximum of 52.20per cent. It is interesting to note here Hussain *et al.* (2002) reported that on no relationship between the efficacy of insects with insecticides in respect of potash at 30 and 60 kg per hectare.

Parasitization of some important insect pests of cabbage

Weekly samples of egg, larvae and pupae of *P. brassicae* from different varieties of cabbage in the field were collected and brought to laboratory for observing emergence of predators as well as parasites. The following parasites/predators were recorded and got identified from the Division of Entomology IARI, New Delhi.

Predators

- *Coccinella septumpunatata* (Linnaeus)
- *Hippodamia variegata* (Goeza)

  Family : Coccinellidae

  Order : Coleoptera

Parasites

- *Sceliphron madraspatanum pictum* (Smith)

  (Hymenoptera : Sphecidae)
- *Campoletis chloridae* (Vehida)

  (Ichneumonidae)

  *Diaeretiella rapae*

  Hymenoptera : Ichneumonidae

# CHAPTER-VI

## SUMMARY AND CONCLUSION

Present studies on integrated management of some important pests of cabbage *Brassica oleracea*, Var. capitata (Linnaeus) were carried out at Division of Entomology SKUAST (K) Shalimar during the year 1998-99 and 1999-2000. The salient findings and conclusions drawn are summarized here under:

### 6.1 Population buildup of major insect pests in relation to abiotic factors on different varieties of cabbage

*Brevicoryne brassicae*, *Pieris brassicae* and *Plutella xylostella* were the major pests recorded during the two Head crops in the year 1999 and 2000 and two Seed crops during the year 1998-99 and 1999-2000. The other pests recorded were *Hellula* sp. *Athalia* sp., *Bargada* sp. etc. during two *rabi* season crops of cabbage on all the four varieties i.e. Golden Express, Golden Acre, Uttam and Pride of India. The duration of seed crop and head crop were 9and 4 months, respectively.

The population of *B. brassicae* was recorded throughout the calender year with low population during December to February for both *rabi* seasons of 1998-99 and 1999-2000 with population ranging as low as 8 to 60; 7 to 50; 12 to 81; 10 to 69 and 6 to 38; 5 to 36; 7 to 48 and 7 to 39 on Golden Express, Golden Acre, Uttam and Pride of India varieties, respectively.

Population of *B. brassicae* was comparatively lower during *rabi* 1999-2000 ( 5 to 175) as compared to *rabi* 1998-99 (7 to 245) on all the four varieties tested. Two population peaks were recorded, one during October, (92 to 188) and (75 to 100) and another peak during June (99 to 245) and (126 to 175) coinciding with the head formation and sprouting stage of cabbage, during the *rabi* season crop of 1998-99 and 1999-2000, respectively on all the four varieties tested. The maximum population of *B. brassicae* was recorded on head crops during the year 1999 and 2000 the first peak during the month of June, (91 to 204) and (108 to 216) and minimum population were recorded during the month of August (49 to 110) and (78-148), respectively, on all the four varieties tested. However, maximum population was recorded on Uttam and minimum on Pride of India during the two cropping season of

head and seed crops, respectively. There was no distinct variation in population among the varieties tested. The relationship between mean population and certain abiotic factors on different varieties of cabbage was worked out and following observations recorded.

**Seed Crop**

Positive non-significant relationship were observed with temperature r values ranged from (0.418-0.505) and relative humidity r value ranged from (0.508-0.556). Negative non significant relationship were observed with rainfall r value ranged from (-0.025 to –0.153 ) and sunshine hours r value ranges from (-0.218 to –0.495) during the two seed crops of 1998-1999 and 1999-2000. The per cent infestation and corresponding infestation index during the two seed crops ranged from 8-68, 1.193 to 2.458 and 36-69, 1.755-2.482 and the two head crops ranged from 12-68, 1.252-2.16 and 8-48, 1.136-2.025 on all he four varieties tested.

Infestation index correlation for the build up of population on different varieties of cabbage (Seed crop) during the two seasons to certain abiotic factors has shown positive non-significant relationship with temperature (0.359-0.566) and rainfall (0.075-0.305) and negative non-significant relationship with RH (-0.037 to 0.708) and sunshine hours (-0.204 to –0.619).

Correlations between population and certain abiotic factors were also worked out on the two head crops during the two years of 1999 and 2000 on all the four varieties tested. Positive significant relationship with temperature (0.895 to 0.920) and positive non-significant relationship with relative humidity (0.113 to 0.629) and rainfall (0.010-0.133) and negative non-significant relationship with sunshine hours (-0.476 to 0.605) during the two head crops of 1999 and 2000 have been computed here in this study.

***P. brassicae***

The pest was absent during the winter months of January and February on seed crops 1998-99 and 1999-2000. First population peak in both years was recorded during the month of October (200-512) and (148-282) coinciding with the sprouting stage and head formation stage of cabbage, and another peak was recorded during the month of June (216-666) and (208-369) during the year 1998-99 and 1999-2000. However, when population was correlated with the certain abiotic factors positive non significant relationship was observed between

population with temperature (0.493 to 0.545), relative humidity (0.545-0.614) and negative non significant relationship with sunshine hours (-0.252 to –0.578) and rainfall (-0.034 to –0.0177) during the two head crops of 1998-99 and 1999-2000.

Positive non-significant relationships were also observed with temperature (0.101-0.173), sunshine (0.071-0.255) and negative non-significant relationship with relative humidity (-0.058-0.192) and rainfall (0.016-0.128) during the two head crops on all the four varieties tested during the year 1999 and 2000.

Per cent infestation and infestation index of two head crops 1998-99 and 1999-2000 were also worked out. The per cent infestation varied from 1-51 with corresponding infestation index of 1.000-2.380 and per cent infestation 2-42 with infestation index of 1.016-2.102 on the four varieties tested during the two cropping seaons.

**Some other pests**

Besides *B. brassicae* and *Plutella xyloxtella* and some other pests including *Hellula* sp., *Athalia* sp., *Bargada* sp. etc were recorded on cabbage. These *pest* were absent from December-February on both seasons of head crop. The highest population was recorded during the month of June in both the season crops with population ranging from 12-39 and 10-37. Lowest population recorded during the month of March were 5-15 and 3-12, respectively during the year 1998-99 and 1999-2000 on all the four varieties tested.

Population was correlated with certain abiotic factors during the course of study. Positive non-significant relationship was observed with temperature (0.164-0.363), sunshine (0.150-0.488) and negative non-significant relationship with relative humidity (-0.105 to –0.304), rainfall (-0.321 to –0.394) during the two seed crop seasons on all the four varieties tested.

Per cent infestation and infestation index of this pest on the four varieties varied from 1 to 15 corresponding index 1.006-1.267 during 1998-1999 and 3 to 19 with 1.028-1.432 during 1999-2000. Correlation between infestation index with certain abiotic factors on the four varieties of cabbage showed significant positive relationship with temperature (0.809-0.827) during 1998-99 and positive non significant relationship with temperature (0.594-673) and sunshine (hrs) 0.483-0.667 during the year 1999-2000and negative non significant

relationship with relative humidity (-0.405 to –0.724), rainfall (-0.236 to –0.346) during the both season crops on four varieties of cabbage tested.

***Plutella xylostella***

The population of *P. xylostella* was recorded only on head crop of 1999 and 2000. There was uniform population during the period of crop growth (June-September) in both the seasons with population range from 13 to 39 during the year 1999 and 16 to 33 during the year 2000, respectively on all the four varieties tested.

Population of *P. xlostella* was also correlated with certain abiotic factors and positive non-significant relationship was observed with temperature (0.094-0.0997) and positive significant relationship with sunshine hrs. (0.415-0.486), relative humidity (0.226-0.261) and rainfall (0.004-0.110) during the year 1999. Positive significant relationship with temperature (0.176-0.549) and rainfall (0.195-0.395) during the year 2000, on all the four varieties tested were observed. There were uniform per cent infestation and corresponding infestion index of the pest during the period of crop growth i.e. June to September and the two cropping seasons of 1999 and 2000 on the four varieties. The per cent infestation varied from 10 to 14 with corresponding infestation index 1.123 to 1.156 during the year 1999 and it also varied from 8 to 16 with corresponding infestation index of 1.117 to 1.208 during the year 2000.

Correlation between infestation index of population with certain abiotic factors on four varieties of cabbage during the two cropping seasons of 1999 and 2000 also showed non-significant positive relationship with temperature (0.052-0.404), rainfall (0.105-0.654). Negative non significant relationships with relative humidity (-0.771 to –0.478) and sunshine (-0.032 to –0.475) were computed.

### 6.2 Development of *Pieris brassicae* on commercially grown varieties of cabbage

There was no significant variation in the duration of larval and pupal period of *P. brassicae* when reared on different varieties of cabbage during 1999 and 2000. Mean larval period (23.27-23.60 and 24.67-25.60); pupal period (10.93-11.27 and 10.1-107) eggs; incubation period (5.93-6.13 and 5.92-6.19) days; fecundity (113.1-119.9 and 117.9-124.7); longevity of female butter fly (13.2-14.3 and 16.1-16.9); longevity male butter fly (15.8-16.0 and 14.9-16.1) days respectively during the year 1999 and 2000 on all the four varieties

tested. However, larval period (23.08-24.17 and 25.0-25.58), pupal period (11.0-11.3 and 10.17-10.50) incubation period (5.83-6.25) fecundity (111.2-123.1 and 111.3-127.8) days, longevity of female moths (13.33-14.25 and 15.42-18.25) days; longevity male moths (14.92-16.33 and 15.01-16.17) days, respectively during the year 1999 and 2000 on all the five generations recorded during the course of investigation.

Developmental stages of different generations of *P. brassicae* on four varieties of cabbage during 1999 and 2000 were compared. Data revealed that there was no significant variation in the duration of incubation, larval and pupal period which showed non significant results both on different generations of the pest and on different varieties screened.

Longivity of butterflies (male and female) was also at par with five generations raised on different varieties of cabbage. Male butterflies lived longer than females. Incubation period also did not differ significantly during the years 1999 and 2000.

**Survival**

Eggs of *P. brassicae* reared on various varieties of cabbage for consecutive generations in a year for two cropping seasons were studied for completion of larval period and also the emergence of adults to determine the survival of the pest. There were significant difference in hatchability (96.6-98.98 and 89.78-96.00%), larval survival (49.78-85-78 and 72.89-84.0 %) and adult emergence (41.78-50.67 and 47.56-62.67%) on the four varieties tested during the year 1999 and 2000 respectively. The comparison for both the seasons also indicated a significant difference in the larval survival were given significant difference on hatcability ranged between (93.33-98.33 and 90.00-93.89 %), larval survival (65.00-78.89 and 73.33-80.00%), adult emergence (35.00-59.44 and 46.67-55.56 %), respectively during the year 1999 and 2000 on the four varieties of cabbage tested.

Integration comparison for both the seasons also indicated a significant difference in the survival of larvae during 1999, the first and $2^{nd}$ generation larvae showed significant higher survival than the last three generations and during the year 2000, $3^{rd}$ and $4^{th}$ generation, larvae showed significant higher survival.

Data on various varieties and generations indicate variation in survival percentage. Over all level of survival on Golden Acre variety significantly was less as compared to other varieties. When compared with generations higher survival rate observed on $1^{st}$ and $2^{nd}$

generation during the years of investigations. Emergence of last three generations i.e. 3rd, 4th and 5th recorded low levels of survival.

### 6.3 Integration of some pest control components for management of *P. brassicae* and *B. brassicae*

***P. brassicae***

All the insecticidal treatments were significantly superior over the control at 5 per cent level of significance in suppressing the pest population. There were also significant difference between the insecticides in reducing the pest population with neem registering significantly higher control followed by Bt, on 7th and 20th days after spraying on both varieties of cabbage during two crop growing seasons, although the initial kill of the pest on 3rd day of spraying was very low.

Population levels of *P. brassicae* on Neem and Bt treated plots were 29 and 27 on Golden Express variety, 25 and 25 on Golden Acre variety on 3rd day which came down to 16 and 14 on Golden Express variety 25 and 34 on Golden Acre variety on 20th day during both cropping seasons of 2001.

Among the insecticides DDVP and Endosulfan were found significantly superior to other treatments in reducing the pest population on 3rd day of spray treatment.

The population levels of *P. brassicae* on 3rd day after treating with DDVP and Endosulfan during the year 2002 were recorded 1000 and 16.67, and 16.67 and 18.67; on 7th day 12.67 and 15.33; 12.33 and 15.33 on Golden Express and Golden Acre varieties, respectively. However, on 20th day of spray populations recorded were 25 and 28; 23 and 32 on both the varieties, tested. The populations of the pest recorded during the year 2002 on two varieties of cabbage were comparatively less in all the plots treated with insecticides and biocides as compared to year the 2001.

**Effect of potash on the population of *P. brassicae***

Observations recorded on the population of the pest in combination with different potash levels i.e. 0, 40,60 kg $ha^{-1}$ on 3rd day on the plots treated with DDVP exhibited population (14.83 and 14.89) and endosulfan (17.33 and 17.34) were significantly superior to biocide i.e. neem ( 25.17 and 27.00); Bt (28.07 and 25.63) in suppressing pest population.

Overall, all the treatments and levels of potash were significantly superior over the control (32.33 and 31.00) during the two crop growing seasons.

On 7th day of spray treatment, the population reduced significantly in all the treatments. However, Neem (9.28 and 8.17) and Bt (9.00 and 6.83) gave superior control as compared to insecticidal treatments. Although, all the treatments with all levels of potash gave significant control as compared to check. However, on 20th day of spray treatment the population increased during both year, the lowest population recorded on plots treated with neem (15.44 and 14.50) followed by Bt (24.17 and 19.50) which were superior to control with a population of 41.39 and 54.50, respectively, on both the varieties during the year 2001 and 2002, respectively.

**Mortality of *P. brassicae***

Observation recorded on 3rd, 7th and 20th day of application of spray treatments in combination with 0, 40, 60 kg of potassium per hectare during the year 2001 and 2002 on two varieties of cabbage showed that all the treatments are significantly superior to control. However, there were no significant variations between the different levels of potash during both seasons among the varieties, tested.

Data revealed that lower mortality were recorded on 3rd day on plots treated with neem 9.6 and 10.9 and Bt 21.9 and 17.3 on Golden Express and Golden Acre varieties. Higher mortality on 7th day mortality recorded were 72.9, 74.2 and 62.9, 77.3 and on 20th day mortality decreased to (61.2, 67.5) and (44.1, 41.4) during the cropping season of 2001. However, during 2002 it was (15.0, 15.1) and (22.5, 21.3) on 3rd day; (87.26, 76.70) and (77.6, 70.5) on 7th day and (68.0, 73.1) and (64.0, 63.4) on 20th day on Golden Express and Golden Acre varieties, respectively. DDVP exhibited highest mortality on 3rd day which was 56.7, 27.1, this however, increased (60.0, 62.2) on 7th day and the population decreased 27 and 38 on 20th day during the year 2001. Mortality of 51.9, 51.2, 61.2, 63.8 and 52.2, 55.7 were observed on 3rd , 7th and 20th day of application of DDVP on Golden Express and Golden Acre varieties during the year 2002, respectively. Quinalphos exhibited mortality of (40.7, 40.4) and (33.7, 36.1) on 3rd day, (45.5, 45.6) and (44.1, 42.9) on 7th day (21.7, 13.9) and (45.1, 38.33) on 20th day during the year 2001 and 2002 on Golden Express and Golden Acre varieties, respectively.

Endosulfan exhibited mortality of (54.5, 54.57) and (40.7, 45.4) on 3rd day, (31.8, 43.8) and (53.3, 54.9) on 7th day, (29.3, 28.0) and (47.0, 42.2) on 20th day of spray treatments on Golden express and Golden acre varieties during the year 2001and 2002, respectively.

**Effect of potassium on the mortality of *P. brassicae***

The data revealed that treatments in combination with potash levels i.e. 0, 40 and 60 kg $ha^{-1}$ gave significant results in suppressing the population of *P. brassicae* on 3rd, 7th and 20th day of application during two years on four varieties of cabbage over the control.

Low mortality was recorded on plots treated with Bt and neem in combination with different levels of potash on 3rd day were (13.65, 13.45) which increased on 7th day (72.99-75.00) and slightly lowered on 20th day of (62.8, 76.4) of application of treatments during the year 2001 and 2002 on Golden Express and Golden Acre varieties, respectively.

DDVP exhibited higher mortality of (54.79, 52.5) on 3rd day, (60.26, 60.5) on 7th day and decreased to (33.4, 54.2) on 20th day during two cropping seasons and on two varieties tested, respectively.

Lowest mortality recorded on plots treated with quinalphos on 3rd day (41.57, 35.3), on 7th day (47.48, 43.0) and on 20th day (15.1, 46.0) of application during the two treatments on Golden Express and Golden Acre varieties. However, the mortality recorded was superior over control in suppressing the population.

***B. brassicae***

Observations recorded on 3rd, 7th and 20th day of application of insecticides on two varieties of cabbage i.e., Golden Express and Golden Acre during the two cropping seasons of 2001 and 2002 showed that all the treatments significnatly suppressed the population of *B. brassicae.*

Among the treatments Bt and neem at recommended doses proved significantly more effective in reducing the pest population on 7th day of spray treatment with population as low as 70.66 and 66.66 on Golden Express variety 70.33 and 61.00 on Golden acre varieties during the year 2001 and 54.66 and 49.00 on Golden Express variety, 57.00 and 53.00 on Golden Acre variety were registered during the year 2002.

It may be noted that population recorded on the DDVP and endosulfan treated plots on 3rd day were 113.2 and 66.30 on Golden Express, 115.33 and 92.00 on Golden Acre

varieties during the year 2001 and slightly lower during the year 2002 on both the varieties tested. The population recorded on 7th day was 84.00 and 54.66 on Golden Express; 95.33 and 85.33 on Golden Acre varieties during the year 2001 and simultaneously lower population during the year 2002. The population recorded was 63.33 and 64.33 on Golden Express variety, 70.66 and 73.00 on Golden Acre varieties during the year 2001 and 2002. Aphid population recorded on control plots during the two cropping seasons were 273.66 and 249.33 on Golden Express, 327.00 and 338.66 on Golden Acre varieties as compared to plots treated with carbaryl 149.00 and 134.33 during the year 2001 117.00 and 118.33 during the year 2002 followed by quinalphose 131.0 and 121.33; 105.66 and 133.33 during the year 2001 and 2002 on 20th day of spray treatment. The application of neem and Bt found significantly effective in suppressing the pest population in both the varieties of cabbage during both years followed by DDVP and endosulfan.

**Effect of potassium on the population of *B. brassicae***

The initial kill of the aphid with the application of carbaryl and endosulfan in combination with 40 and 60 kg of potassium/hectare were significantly higher on 7th and 20th day of application of spray treatment. Endosulfan and carbaryl treated plots exhibited population of 103.67 and 100.00; 119.67 and 123.00, respectively on 3rd day of application followed by 90.33 and 71.22; 114.17 and 94.50, respectively on 7th day of application during two cropping seasons of 2001 and 2002.

The population trend on 20th day of application was highest 141.3 and 126.06 on plots treated with carbaryl, quinalphos and lowest populations were recorded on the plots treated with Bt and neem 83.33 and 80.33, respectively during the year 2001 and significantly lower population was during the year 2002 on all plots treated with insecticides in combination with potash levels

The application of different levels of potassium significantly reduced the population of *B. brassicae* on Golden Express and Golden Acre varieties during 2001 and 2002 cropping seasons at 5 per cent level of significance. It is also evident from the data that there were no significant, variations in the population of the pest treated with different levels of potash, insecticidal treatments and varieties.

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* Originals not seen

**Table 1: Population buildup of *Brevicoryne brassicae* in relation to certain abiotic factors on different varieties of cabbage (Seed crop) during the year 1998-99**

**(Population plant$^{-1}$)**

| Month/ Week | Varieties of cabbage | | | | Abiotic factors | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
| October I | 137 | 112 | 188 | 158 | 25 | 8 | 16.5 | 66 | 52.8 | 0 |
| II | 113 | 92 | 155 | 131 | 22.9 | 4.3 | 13.6 | 69 | 56.8 | 0 |
| III | 113 | 92 | 154 | 130 | 23.6 | 3.4 | 13.5 | 70 | 51.3 | 0 |
| IV | 114 | 93 | 156 | 132 | 24.4 | 2.7 | 13.6 | 67 | 57.9 | 0 |
| November I | 95 | 78 | 131 | 110 | 20.6 | 2.3 | 11.5 | 67 | 42.4 | 22.6 |
| II | 76 | 62 | 104 | 88 | 14.3 | 4.2 | 9.2 | 81 | 31.1 | 20.9 |
| III | 77 | 63 | 105 | 89 | 14.9 | 3.5 | 9.2 | 78 | 32.8 | 3.6 |
| IV | 58 | 48 | 80 | 67 | 12.8 | 1.1 | 7 | 80 | 25 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| December I | 54 | 44 | 74 | 62 | 14.2 | -1.3 | 6.5 | 79 | 38 | 0 |
| II | 42 | 34 | 57 | 48 | 12.7 | -2.8 | 5 | 77 | 39.1 | 0 |
| III | 34 | 28 | 47 | 40 | 12.7 | -4.5 | 4.1 | 73 | 39.4 | 0 |
| IV | 28 | 23 | 39 | 33 | 12.6 | -5.8 | 3.4 | 86 | 38.8 | 0 |
| January I | 16 | 13 | 22 | 19 | 5.9 | -2.1 | 1.9 | 83 | 0 | 4.2 |
| II | 12 | 10 | 16 | 18 | 4.3 | -1.5 | 1.4 | 88 | 6.5 | 27 |
| III | 15 | 12 | 21 | 13 | 6.2 | -2.6 | 1.8 | 85 | 16.2 | 17.8 |
| IV | 8 | 7 | 12 | 10 | 2.5 | -0.5 | 1 | 92 | 0 | 70 |

Cont……

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| February I | 24 | 20 | 32 | 27 | 6.5 | -0.9 | 2.8 | 83 | 23.5 | 3.8 |
| II | 35 | 29 | 48 | 40 | 7.4 | 0.8 | 4.1 | 82 | 4.2 | 10.8 |
| III | 60 | 50 | 81 | 69 | 9.7 | 4.3 | 7 | 82 | 2.8 | 6.4 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | IV | 52 | 43 | 71 | 60 | 9.3 | 2.9 | 6.1 | 81 | 9 | 19.9 |
| March | I | 68 | 41 | 93 | 79 | 15.3 | 1 | 8.2 | 67 | 43.3 | 4 |
| | II | 64 | 52 | 88 | 74 | 11 | 4.4 | 7.7 | 85 | 13.2 | 39.4 |
| | III | 75 | 61 | 103 | 86 | 14.8 | 3.2 | 9 | 71 | 25.2 | 2 |
| | IV | 71 | 58 | 98 | 83 | 13.1 | 4 | 8.6 | 77 | 21.2 | 15.3 |
| April | I | 102 | 84 | 140 | 118 | 19.8 | 4.7 | 12.3 | 62 | 37.9 | 4 |
| | II | 112 | 92 | 154 | 130 | 21.2 | 5.8 | 13.5 | 57 | 51.9 | 2.4 |
| | III | 122 | 100 | 168 | 142 | 21.6 | 8 | 14.8 | 57 | 36.6 | 5.3 |
| | IV | 123 | 101 | 169 | 144 | 24 | 5.6 | 14.8 | 47 | 56.7 | 0 |
| May | I | 147 | 120 | 202 | 170 | 28.2 | 7.1 | 17.7 | 47 | 71.5 | 0 |
| | II | 133 | 109 | 183 | 154 | 22.7 | 9.5 | 16.1 | 67 | 45.2 | 17 |
| | III | 135 | 110 | 184 | 156 | 22.7 | 9.6 | 16.1 | 61 | 44.3 | 6.5 |
| | IV | 152 | 124 | 209 | 176 | 27.5 | 9.1 | 18.3 | 59 | 72 | 0.4 |
| June | | 121 | 99 | 166 | 140 | 27 | 12.1 | 14.6 | 63 | 63.9 | 2.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | | |
| III | 148 | 121 | 203 | 171 | 26 | 9.7 | 17.8 | 58 | 54.5 | 8.2 |
| III | 178 | 146 | 245 | 206 | 29 | 13.9 | 21.5 | 54 | 72.4 | 0 |
| IV | 175 | 144 | 242 | 204 | 30 | 12.3 | 21.2 | 56 | 74.3 | 0 |

**Table 2: Population buildup of *Brevicoryne brassicae* in relation to certain abiotic factors on different varieties of cabbage (Seed crop) during the year 1999-2000**

(Population plant$^{-1}$)

| Month/ Week | Varieties of cabbage | | | | Abiotic factors | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
| October I | 99 | 93 | 125 | 102 | 25.9 | 8.7 | 17.3 | 65 | 49.5 | 0 |
| II | 83 | 79 | 105 | 86 | 24.3 | 4.9 | 14.6 | 65 | 51.3 | 0 |
| III | 86 | 81 | 108 | 89 | 26.5 | 3.6 | 15 | 64 | 58.9 | 0 |
| IV | 79 | 75 | 100 | 82 | 25.6 | 2.1 | 13.9 | 63 | 58.3 | 0 |
| November I | 67 | 64 | 85 | 70 | 20.3 | 3.2 | 11.8 | 67 | 36.1 | 0 |
| II | 50 | 47 | 63 | 51 | 15.1 | 2.2 | 8.7 | 71 | 30 | 1.4 |
| III | 44 | 42 | 56 | 46 | 13.1 | 2.5 | 7.8 | 75 | 15.3 | 8.5 |
| IV | 27 | 26 | 35 | 28 | 10.9 | -1.3 | 4.8 | 72 | 34.1 | 1 |
| December I | 23 | 22 | 29 | 24 | 10.2 | -2.2 | 4 | 76 | 26.7 | 9.2 |
| II | 27 | 26 | 35 | 28 | 10 | -0.3 | 4.8 | 75 | 22.5 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| III | 27 | 25 | 33 | 28 | 9.6 | -0.2 | 4.7 | 82 | 27.3 | 9.4 |
| IV | 28 | 26 | 34 | 29 | 12.2 | -2.6 | 4.7 | 84 | 32.5 | 2 |
| January I | 17 | 16 | 22 | 18 | 10.9 | -4.8 | 3 | 75 | 37.1 | 0 |
| II | 14 | 13 | 17 | 14 | 5.8 | -0.2 | 2.4 | 88 | 0 | 74.2 |
| III | 6 | 5 | 7 | 6 | 4.4 | -4.4 | 0 | 82 | 5.8 | 9 |
| IV | 19 | 10 | 24 | 20 | 7.7 | -0.9 | 3.4 | 82 | 20.6 | 15 |

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|---|---|---|---|---|---|---|---|---|---|
| February I | 19 | 25 | 21 | 8.3 | -1.3 | 3.5 | 83 | 28.4 | 22 |
| II | 21 | 27 | 23 | 8.3 | -0.5 | 3.8 | 76 | 22 | 1.4 |
| III | 21 | 28 | 23 | 9 | -1.1 | 3.9 | 77 | 35.3 | 13.4 |
| IV | 36 | 48 | 39 | 13.4 | -0.2 | 6.6 | 68 | 52.7 | 33.4 |
| March | 33 | 45 | 37 | 12.5 | 0.1 | 6.2 | 68 | 37.8 | 12 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| II | 35 | 46 | 38 | 12.4 | 0.3 | 6.4 | 70 | 33.3 | 16.4 |
| III | 69 | 92 | 76 | 14.3 | 1.2 | 7.7 | 68 | 40 | 1 |
| IV | 67 | 89 | 73 | 18.9 | 6.6 | 12.8 | 67 | 29 | 10 |
| April I | 74 | 98 | 81 | 20.2 | 4.6 | 12.4 | 61 | 52.4 | 0.6 |
| II | 89 | 118 | 97 | 22.6 | 4.8 | 13.7 | 65 | 56.2 | 9.2 |
| III | 95 | 127 | 104 | 23.2 | 7.8 | 16.5 | 66 | 58 | 8 |
| IV | 114 | 153 | 125 | 27.5 | 7.8 | 17.7 | 58 | 58.7 | 0 |
| May I | 111 | 148 | 121 | 29.9 | 12.4 | 21.2 | 65 | 66.6 | 15.7 |
| II | 115 | 153 | 126 | 29.1 | 12 | 20.5 | 57 | 69.8 | 5.8 |
| III | 102 | 135 | 111 | 30.2 | 12.4 | 21.3 | 63 | 72.2 | 8.5 |
| IV | 106 | 141 | 116 | 26.1 | 11.4 | 18.8 | 67 | 55.8 | 20.9 |
| June | 126 | 168 | 137 | 26 | 13.2 | 19.6 | 64 | 65 | 10.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | |
| III | 127 | 170 | 139 | 32 | 14.6 | 23.3 | 62 | 79 | 0 |
| III | 128 | 172 | 141 | 30.5 | 16.7 | 23.6 | 62 | 56 | 3 |
| IV | 131 | 175 | 143 | 31.1 | 17.4 | 24.3 | 64 | 59.2 | 9 |

**Table 3a: Correlation between population buildup of *Brevicoryne brassicae* with certain abiotic factors on different varieties of cabbage during 1998-99 (Seed crop)**

| Variety | **Mean Population plants $^{-1}$** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **Relative Humidity (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden Express | 85.81 | 0.390 | 0.604 | 0.496 | 0.555 | -0.221 | 0.028 |
| Golden Acre | 69.86 | 0.399 | 0.613 | 0.505 | 0.556 | -0.227 | 0.030 |
| Uttam | 119.8 | 0.389 | 0.602 | 0.495 | 0.553 | -0.218 | -0.025 |
| Pride of India | 99.36 | 0.390 | 0.604 | 0.496 | 0.554 | -0.220 | -0.025 |

**All values = N. S.**

**Table 3b: Correlation between population buildup of *Brevicoryne brassicae* with certain abiotic factors on different varieties of cabbage during 1999-2000 (Seed crop)**

| Variety | **Mean Population plants$^{-1}$** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. *($^0$C)** | **Relative Humidity (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden Express | 66.68 | 0.376 | 0.448 | 0.420 | 0.509 | -0.493 | 0.152 |
| Golden Acre | 63.03 | 0.379 | 0.449 | 0.421 | 0.513 | -0.495 | 0.153 |
| Uttam | 84.33 | 0.375 | 0.447 | 0.418 | -0.508 | -0.492 | -0.145 |
| Pride of India | 69.22 | 0.375 | 0.448 | 0.419 | -0.508 | -0.492 | -0.150 |

**All values = N. S.**

**Table 4: Percent infestation and infestation index of *Brevicoryne brassicae* on different varieties of cabbage (Seed crop) during 1998-99**

| Month /Week | Percentage Infestation | | | | *Infestation Index* | | | |
|---|---|---|---|---|---|---|---|---|
| | Golden Express | *Golden Acre* | Uttam | Pride of India | Golden Express | *Golden Acre* | Uttam | Pride of India |
| October I | 16 | 14 | 11 | 13 | 1.341 | 1.497 | 1.235 | 1.277 |
| II | 14 | 13 | 9 | 12 | 1.696 | 1.276 | 1.191 | 1.256 |
| III | 13 | 10 | 9 | 11 | 1.579 | 1.215 | 1.193 | 1.233 |
| IV | 10 | 9 | 8 | 9 | 1.36 | 1.194 | 1.173 | 1.173 |
| November I | 19 | 19 | 20 | 20 | 1.8336 | 1.398 | 1.417 | 1.419 |
| II | 21 | 23 | 24 | 25 | 1.439 | 1.482 | 1.503 | 1.525 |
| III | 24 | 25 | 24 | 24 | 1.497 | 1.519 | 1.499 | 1.495 |
| IV | 27 | 24 | 20 | 22 | 1.554 | 1.49 | 1.412 | 1.452 |
| December I | 37 | 36 | 38 | 39 | 1.721 | 1.699 | 1.739 | 1.763 |
| II | 38 | 35 | 36 | 40 | 1.37 | 1.656 | 1.678 | 1.754 |
| III | 41 | 38 | 42 | 41 | 1.339 | 1.67 | 1.743 | 1.721 |
| IV | 42 | 41 | 43 | 41 | 1.695 | 1.68 | 1.892 | 1.69 |
| January I | 45 | 44 | 46 | 45 | 1.526 | 1.533 | 1.551 | 1.551 |
| II | 48 | 47 | 49 | 48 | 1.615 | 1.627 | 1.669 | 1.633 |
| III | 43 | 46 | 46 | 46 | 1.543 | 1.597 | 1.611 | 1.602 |
| IV | 46 | 47 | 47 | 48 | 1.628 | 1.628 | 1.639 | 1.66 |
| February I | 36 | 45 | 47 | 50 | 1.567 | 1.726 | 1.748 | 1.793 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | II | 33 | 45 | 48 | 50 | 1.558 | 1.792 | 1.818 | 1.86 |
| | III | 34 | 46 | 49 | 53 | 1.644 | 1.867 | 1.935 | 2.007 |
| | IV | 38 | 47 | 50 | 53 | 1.746 | 1.937 | 1.966 | 2.052 |
| March | I | 27 | 26 | 24 | 28 | 2.166 | 1.541 | 1.498 | 1.584 |
| | II | 29 | 34 | 34 | 36 | 2.045 | 1.669 | 1.675 | 1.703 |
| | III | 34 | 39 | 39 | 38 | 2.076 | 1.812 | 1.805 | 1.79 |
| | IV | 41 | 40 | 41 | 41 | 2.086 | 1.847 | 1.87 | 0.863 |
| April | I | 46 | 44 | 51 | 51 | 1.969 | 1.931 | 2.076 | 2.083 |
| | II | 52 | 54 | 52 | 54 | 2.105 | 2.149 | 2.109 | 2.143 |
| | III | 51 | 56 | 53 | 52 | 2.094 | 2.203 | 2.147 | 2.114 |
| | IV | 50 | 58 | 53 | 53 | 2.082 | 2.253 | 2.148 | 2.146 |
| May | I | 62 | 62 | 58 | 58 | 2.369 | 2.371 | 2.277 | 2.279 |
| | II | 59 | 58 | 59 | 60 | 2.3 | 2.279 | 2.298 | 2.324 |
| | III | 58 | 62 | 61 | 64 | 2.227 | 2.369 | 2.341 | 2.414 |
| | IV | 56 | 56 | 54 | 54 | 2.23 | 2.229 | 2.187 | 2.188 |
| June | I | 64 | 54 | 66 | 67 | 2.406 | 2.408 | 2.452 | 2.475 |
| | II | 66 | 63 | 64 | 62 | 2.436 | 2.377 | 2.397 | 2.352 |
| | III | 66 | 63 | 63 | 68 | 2.412 | 2.354 | 2.35 | 2.458 |
| | IV | 64 | 64 | 63 | 67 | 2.232 | 2.248 | 2.22 | 2.303 |

**Table 5: Percent infestation and infestation index of *Brevicoryne brassicae* on different varieties of cabbage (Seed crop) during 1999-2000**

| Month /Week | Per cent Infestation | | | | *Infestation Index* | | | |
|---|---|---|---|---|---|---|---|---|
| | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** |
| October I | 38 | 1.757 | 36 | 1.755 | 38 | 1.763 | 38 | 1.747 |
| II | 40 | 1.807 | 41 | 1.854 | 42 | 1.857 | 42 | 1.83 |
| III | 41 | 1.837 | 42 | 1.893 | 44 | 1.918 | 43 | 1.876 |
| IV | 43 | 1.885 | 44 | 1.944 | 46 | 1.993 | 45 | 1.955 |
| November I | 46 | 1.934 | 48 | 1.938 | 46 | 1.97 | 45 | 1.938 |
| II | 47 | 1.926 | 48 | 1.911 | 48 | 1.973 | 48 | 1.986 |
| III | 41 | 1.778 | 40 | 1.743 | 42 | 1.814 | 41 | 1.832 |
| IV | 43 | 1.83 | 44 | 1.787 | 44 | 1.861 | 44 | 1.856 |
| December I | 45 | 1.771 | 47 | 1.776 | 48 | 1.855 | 50 | 1.866 |
| II | 47 | 1.759 | 50 | 1.801 | 51 | 1.911 | 54 | 1.897 |
| III | 48 | 1.78 | 50 | 1.794 | 52 | 1.926 | 54 | 1.88 |
| IV | 51 | 1.783 | 53 | 1.808 | 54 | 1.874 | 56 | 1.859 |
| January I | 27 | 1.292 | 28 | 1.358 | 29 | 1.462 | 31 | 1.409 |
| II | 29 | 1.349 | 29 | 1.388 | 31 | 1.409 | 31 | 1.399 |
| III | 34 | 1.365 | 36 | 1.466 | 38 | 1.378 | 38 | 1.485 |
| IV | 39 | 1.458 | 39 | 1.512 | 40 | 1.494 | 41 | 1.577 |
| February I | 41 | 1.753 | 42 | 1.649 | 44 | 1.717 | 45 | 1.684 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | II | 42 | 1.652 | 44 | 1.694 | 46 | 1.78 | 47 | 1.767 |
| | III | 43 | 1.71 | 45 | 1.692 | 46 | 1.785 | 48 | 1.771 |
| | IV | 46 | 1.743 | 48 | 1.773 | 49 | 1.862 | 51 | 1.82 |
| March | I | 51 | 1.97 | 53 | 2.022 | 52 | 1.972 | 53 | 1.962 |
| | II | 56 | 2.032 | 58 | 2.112 | 54 | 2.03 | 57 | 2.073 |
| | III | 58 | 2.1 | 61 | 2.2 | 55 | 2.061 | 58 | 2.154 |
| | IV | 63 | 2.205 | 64 | 2.339 | 59 | 2.182 | 61 | 2.238 |
| April | I | 67 | 2.417 | 66 | 2.402 | 61 | 2.277 | 64 | 2.311 |
| | II | 66 | 2.421 | 68 | 2.424 | 64 | 2.356 | 67 | 2.394 |
| | III | 66 | 2.421 | 68 | 2.483 | 67 | 2.436 | 67 | 2.415 |
| | IV | 68 | 2.478 | 70 | 2.249 | 69 | 2.482 | 69 | 2.475 |
| May | I | 58 | 1.163 | 51 | 2.12 | 53 | 2.136 | 53 | 2.15 |
| | II | 56 | 1.758 | 59 | 2.309 | 53 | 2.15 | 50 | 2.078 |
| | III | 56 | 1.505 | 59 | 2.275 | 53 | 2.154 | 58 | 2.286 |
| | IV | 54 | 1.141 | 56 | 2.223 | 58 | 2.257 | 50 | 2.079 |
| June | I | 44 | 1.892 | 46 | 1.913 | 48 | 2.025 | 40 | 1.848 |
| | II | 43 | 1.884 | 44 | 1.89 | 44 | 1.951 | 39 | 1.819 |
| | III | 41 | 1.857 | 42 | 1.858 | 40 | 1.85 | 38 | 1.791 |
| | IV | 40 | 1.867 | 39 | 1.797 | 38 | 1.815 | 36 | 1.739 |

**Table 6a: Infestation Index correlation for the buildup of *Brevicoryne brassicae* on different varieties of cabbage (Seed Crop) in relation to certain abiotic factors during 1998-99**

| Variety | Infestation Index | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs.) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 1.8093 | -0.379 | 0.394 | 0.373 | -0.070 | -0.383 | 0.082 |
| Golden Acre | 1.7833 | 0.313 | 0.332 | 0.359 | -0.037 | -0.264 | 0.075 |
| Uttam | 1.8201 | 0.540 | 0.494 | 0.500 | -0.176 | -0.426 | 0.250 |
| Pride of India | 1.8084 | 0.474 | 0.425 | 0.456 | -0.133 | -0.423 | 0.144 |

**All values = N. S.**

**Table 6b: Infestation Index correlation for the buildup of *Brevicoryne brassicae* on different varieties of cabbage (Seed Crop) in relation to certain abiotic factors during 1999-2000**

| Variety | Infestation Index | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs.) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 1.7579 | 0.569 | 0.387 | 0.456 | -0.695 | 0.588 | 0.268 |
| Golden Acre | 1.7344 | 0.482 | 0.373 | 0.389 | -0.628 | 0.513 | 0.267 |
| Uttam | 1.7766 | 0.601 | 0.486 | 0.566 | -0.708 | 0.619 | 0.305 |
| Pride of India | 1.7653 | 0.581 | 0.479 | 0.506 | -0.700 | 0.614 | 0.303 |

**All values = N. S.**

**Table 5a: Homogeneity Correlation of *Brevicoryne brassicae* between different varieties of cabbage (Seed crop) and certain abiotic factors during the year 1998-99**

| Aboitic factors | Varieties | | | | |
|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | P value |
| Max. Temp. ($^0$C) | 0.9678 | 0.9676 | 0.9696 | 0.9689 | 0.999 |
| Min. Temp. ($^0$C) | 0.8295 | 0.8242 | 0.8352 | 0.8313 | 0.999 |
| Mean Temp. ($^0$C) | 0.9724 | 0.9711 | 0.9739 | 0.9725 | 0.997 |
| Relative Humidity (%) | -0.8729 | -0.9722 | -0.9777 | -0.8735 | 0.999 |
| Sunshine (hrs.) | 0.8990 | 0.8890 | 0.8919 | 0.8910 | 0.999 |
| Rainfall (mm) | -0.3917 | -0.3893 | -0.3934 | -0.3919 | 0.999 |

**Table 5b: Homogeneity Correlation of *Brevicoryne brassicae* between different varieties of cabbage (Seed crop) and certain abiotic factors during the year 1999-2000**

| Aboitic factors | Varieties | | | | |
|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | P value |
| Max. Temp. ($^0$C) | 0.9412 | 0.9411 | 0.9441 | 0.9429 | 0.999 |
| Min. Temp. ($^0$C) | 0.8887 | 0.8819 | 0.8950 | 0.8908 | 0.995 |
| Mean Temp. ($^0$C) | 0.9432 | 0.9405 | 0.9456 | 0.9440 | 0.998 |
| Relative Humidity (%) | -0.8325 | -0.8318 | -0.8345 | -0.8332 | 0.999 |
| Sunshine (hrs.) | 0.7851 | 0.7834 | 0.7875 | 0.7872 | 0.999 |
| Rainfall (mm) | -0.3422 | -0.3391 | -0.3440 | -0.3426 | 0.999 |

**p-value >0.05 implies homogeneity of correlation of population with abiotic factors**

**Table 8: Population buildup of *Pieris brassicae* in relation to certain abiotic factors on different varieties of cabbage (Seed crop) during the year 1998-99**

***(POPULATION PER 10 PLANTS)***

| **Month/ Week** | **Varieties of cabbage** | | | | ***Aboitic factors*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Golden Express** | **Golden Acre** | Uttam | **Pride of India** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **RH (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
| October I | 284 | 244 | 512 | 485 | 25 | 8 | 16.5 | 66 | 52.8 | 0 |
| II | 234 | 201 | 421 | 460 | 22.9 | 4.3 | 13.6 | 69 | 56.8 | 0 |
| III | 232 | 200 | 481 | 386 | 23.6 | 3.4 | 13.5 | 70 | 51.3 | 0 |
| IV | 234 | 245 | 422 | 401 | 24.4 | 2.7 | 13.6 | 67 | 57.9 | 0 |
| November I | 198 | 170 | 356 | 338 | 20.6 | 2.3 | 11.5 | 67 | 42.4 | 22.6 |
| II | 158 | 136 | 285 | 270 | 14.3 | 4.2 | 9.2 | 81 | 31.1 | 20.9 |
| III | 159 | 138 | 286 | 271 | 14.9 | 3.5 | 9.2 | 78 | 32.8 | 3.6 |
| IV | 120 | 104 | 217 | 206 | 12.8 | 1.1 | 7 | 80 | 25 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| December I | 112 | 96 | 201 | 191 | 14.2 | -1.3 | 6.5 | 79 | 38 | 0 |
| II | 86 | 74 | 155 | 147 | 12.7 | -2.8 | 5 | 77 | 39.1 | 0 |
| III | 70 | 61 | 127 | 120 | 12.7 | -4.5 | 4.1 | 73 | 39.4 | 0 |
| IV | 58 | 50 | 105 | 100 | 12.6 | -5.8 | 3.4 | 86 | 38.8 | 0 |
| January I | 0 | 0 | 0 | 0 | 5.9 | -2.1 | 1.9 | 83 | 0 | 4.2 |
| II | 0 | 0 | 0 | 0 | 4.3 | -1.5 | 1.4 | 88 | 6.5 | 27 |
| III | 0 | 0 | 0 | 0 | 6.2 | -2.6 | 1.8 | 85 | 16.2 | 17.8 |
| IV | 0 | 0 | 0 | 0 | 2.5 | -0.5 | 1 | 92 | 0 | 70 |

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| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| February I | 0 | 0 | 0 | 0 | 6.5 | -0.9 | 2.8 | 83 | 23.5 | 3.8 |
| II | 0 | 0 | 0 | 0 | 7.4 | 0.8 | 4.1 | 82 | 4.2 | 10.8 |
| III | 0 | 0 | 0 | 0 | 9.7 | 4.3 | 7 | 82 | 2.8 | 6.4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IV | 0 | 0 | 0 | 0 | 9.3 | 2.9 | 6.1 | 81 | 9 | 19.9 |
| March I | 141 | 121 | 254 | 241 | 15.3 | 1 | 8.2 | 67 | 43.3 | 4 |
| II | 132 | 114 | 239 | 226 | 11 | 4.4 | 7.7 | 85 | 13.2 | 39.4 |
| III | 155 | 133 | 279 | 265 | 14.8 | 3.2 | 9 | 71 | 25.2 | 2 |
| IV | 148 | 127 | 267 | 253 | 13.1 | 4 | 8.6 | 77 | 21.2 | 15.3 |
| April I | 211 | 182 | 381 | 362 | 19.8 | 4.7 | 12.3 | 62 | 37.9 | 4 |
| II | 232 | 200 | 418 | 397 | 21.2 | 5.8 | 13.5 | 57 | 51.9 | 2.4 |
| III | 255 | 219 | 459 | 435 | 21.6 | 8 | 14.8 | 57 | 36.6 | 5.3 |
| IV | 258 | 221 | 459 | 436 | 24 | 5.6 | 14.8 | 47 | 56.7 | 0 |
| May I | 304 | 262 | 549 | 520 | 28.2 | 7.1 | 17.7 | 47 | 71.5 | 0 |
| II | 277 | 238 | 499 | 473 | 22.7 | 9.5 | 16.1 | 67 | 45.2 | 17 |
| III | 279 | 240 | 500 | 474 | 22.7 | 9.6 | 16.1 | 61 | 44.3 | 6.5 |
| IV | 315 | 271 | 567 | 538 | 27.5 | 9.1 | 18.3 | 59 | 72 | 0.4 |
| June I | 251 | 216 | 453 | 429 | 27 | 12.1 | 14.6 | 63 | 63.9 | 2.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| III | 306 | 263 | 552 | 523 | 26 | 9.7 | 17.8 | 58 | 54.5 | 8.2 |
| III | 370 | 318 | 666 | 632 | 29 | 13.9 | 21.5 | 54 | 72.4 | 0 |
| IV | 365 | 314 | 657 | 623 | 30 | 12.3 | 21.2 | 56 | 74.3 | 0 |

*TABLE 9: POPULATION BUILDUP OF* **PIERIS BRASSICAE** *IN RELATION TO CERTAIN ABIOTIC FACTORS ON DIFFERENT VARIETIES OF CABBAGE (SEED CROP) DURING THE YEAR 1999-2000*

| **Month/ Week** | **Varieties of cabbage** | | | | ***Aboitic factors*** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Golden Express** | **Golden Acre** | Uttam | **Pride of India** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **RH (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
| October I | 233 | 183 | 282 | 263 | 25.9 | 8.7 | 17.3 | 65 | 49.5 | 0 |
| II | 197 | 155 | 238 | 222 | 24.3 | 4.9 | 14.6 | 65 | 51.3 | 0 |
| III | 202 | 159 | 245 | 228 | 26.5 | 3.6 | 15 | 64 | 58.9 | 0 |
| IV | 188 | 148 | 227 | 211 | 25.6 | 2.1 | 13.9 | 63 | 58.3 | 0 |
| November I | 159 | 126 | 192 | 179 | 20.3 | 3.2 | 11.8 | 67 | 36.1 | 0 |
| II | 117 | 92 | 142 | 132 | 15.1 | 2.2 | 8.7 | 71 | 30 | 1.4 |
| III | 105 | 83 | 127 | 119 | 13.1 | 2.5 | 7.8 | 75 | 15.3 | 8.5 |
| IV | 65 | 51 | 78 | 72 | 10.9 | -1.3 | 4.8 | 72 | 34.1 | 1 |
| December I | 54 | 43 | 65 | 61 | 10.2 | -2.2 | 4 | 76 | 26.7 | 9.2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| II | 65 | 51 | 78 | 73 | 10 | -0.3 | 4.8 | 75 | 22.5 | 0 |
| III | 63 | 50 | 77 | 71 | 9.6 | -0.2 | 4.7 | 82 | 27.3 | 9.4 |
| IV | 64 | 51 | 78 | 72 | 12.2 | -2.6 | 4.7 | 84 | 32.5 | 2 |
| January I | 0 | 0 | 0 | 0 | 10.9 | -4.8 | 3 | 75 | 37.1 | 0 |
| II | 0 | 0 | 0 | 0 | 5.8 | -0.2 | 2.4 | 88 | 0 | 74.2 |
| III | 0 | 0 | 0 | 0 | 4.4 | -4.4 | 0 | 82 | 5.8 | 9 |
| IV | 0 | 0 | 0 | 0 | 7.7 | -0.9 | 3.4 | 82 | 20.6 | 15 |

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|---|---|---|---|---|---|---|---|---|---|---|
| February I | 0 | 0 | 0 | 0 | 8.3 | -1.3 | 3.5 | 83 | 28.4 | 22 |
| II | 0 | 0 | 0 | 0 | 8.3 | -0.5 | 3.8 | 76 | 22 | 1.4 |
| III | 0 | 0 | 0 | 0 | 9 | -1.1 | 3.9 | 77 | 35.3 | 13.4 |
| IV | 0 | 0 | 0 | 0 | 13.4 | -0.2 | 6.6 | 68 | 52.7 | 33.4 |
| March I | 84 | 66 | 101 | 94 | 12.5 | 0.1 | 6.2 | 68 | 37.8 | 12 |
| II | 86 | 68 | 104 | 97 | 12.4 | 0.3 | 6.4 | 70 | 33.3 | 16.4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| III | 104 | 82 | 126 | 117 | 14.3 | 1.2 | 7.7 | 68 | 40 | 1 |
| IV | 173 | 136 | 209 | 195 | 18.9 | 6.6 | 12.8 | 67 | 29 | 10 |
| April I | 168 | 131 | 202 | 188 | 20.2 | 4.6 | 12.4 | 61 | 52.4 | 0.6 |
| II | 185 | 145 | 223 | 208 | 22.6 | 4.8 | 13.7 | 65 | 56.2 | 9.2 |
| III | 223 | 175 | 269 | 251 | 23.2 | 7.8 | 16.5 | 66 | 58 | 8 |
| IV | 239 | 188 | 289 | 269 | 27.5 | 7.8 | 17.7 | 58 | 58.7 | 0 |
| May I | 286 | 225 | 346 | 322 | 29.9 | 12.4 | 21.2 | 65 | 66.6 | 15.7 |
| II | 277 | 217 | 334 | 328 | 29.1 | 12 | 20.5 | 57 | 69.8 | 5.8 |
| III | 288 | 226 | 347 | 324 | 30.2 | 12.4 | 21.3 | 63 | 72.2 | 8.5 |
| IV | 254 | 200 | 306 | 286 | 26.1 | 11.4 | 18.8 | 67 | 55.8 | 20.9 |
| June I | 265 | 208 | 319 | 298 | 26 | 13.2 | 19.6 | 64 | 65 | 10.6 |
| II | 315 | 247 | 280 | 354 | 32 | 14.6 | 23.3 | 62 | 79 | 0 |
| III | 319 | 250 | 285 | 359 | 30.5 | 16.7 | 23.6 | 62 | 56 | 3 |
| IV | 328 | 258 | 296 | 369 | 31.1 | 17.4 | 24.3 | 64 | 59.2 | 9 |

**Table 10a: Correlation between population buildup of *Pieris brassicae* with certain abiotic factors on different varieties of cabbage during 1998-99 (Seed crop)**

| Variety | **Mean Pop.** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **Relative Humidity (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden Express | 165.1 | 0.420 | 0.639 | 0.540 | 0.605 | -0.262 | -0.046 |
| Golden Acre | 143.3 | 0.429 | 0.642 | 0.545 | 0.614 | -0.272 | -0.088 |
| Uttam | 299.1 | 0.410 | 0.634 | 0.530 | 0.597 | -0.252 | -0.034 |
| Pride of India | 283.4 | 0.420 | 0.638 | 0.539 | 0.604 | -0.260 | -0.041 |

**All values = N. S.**

**Table 10b: Correlation between population buildup of *Pieris brassicae* with certain abiotic factors on different varieties of cabbage during 1999-2000 (Seed crop)**

| Variety | **Mean Pop.** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **Relative Humidity (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden Express | 141.8 | 0.475 | 0.519 | 0.508 | 0.585 | -0.577 | -0.115 |
| Golden Acre | 111.5 | 0.476 | 0.520 | 0.509 | 0.586 | -0.578 | -0.117 |
| Uttam | 162.9 | 0.457 | 0.509 | 0.493 | 0.548 | -0.576 | -0.099 |
| Pride of India | 160.1 | 0.474 | 0.518 | 0.507 | 0.583 | -0.577 | -0.115 |

**All values = N. S.**

**Table 11: Percent infestation and infestation index of *P. brassicae* on different varieties of cabbage during 1998-99**

| | *Per cent Infestation* | | | | *Infestation Index* | | | |
|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **G. Express** | **G. Acre** | **Uttam** | **P. of India** | **G. Express** | **G. Acre** | **Uttam** | **P. of India** |
| Oct. I | 28 | 24 | 51 | 48 | 1.686 | 1.573 | 2.42 | 2.289 |
| II | 22 | 27 | 43 | 45 | 1.512 | 1.654 | 2.169 | 2.192 |
| III | 26 | 25 | 44 | 51 | 1.628 | 1.6 | 2.196 | 2.38 |
| IV | 22 | 23 | 48 | 46 | 1.514 | 1.544 | 2.285 | 2.225 |
| Nov. I | 1 | 5 | 9 | 13 | 1 | 1.085 | 1.177 | 1.274 |
| II | 5 | 8 | 9 | 12 | 1.085 | 1.153 | 1.176 | 1.249 |
| III | 5 | 10 | 8 | 12 | 1.087 | 1.196 | 1.154 | 1.248 |
| IV | 4 | 8 | 10 | 11 | 1.063 | 1.15 | 1.2 | 1.223 |
| Dec. I | 3 | 5 | 5 | 7 | 1.045 | 1.084 | 1.083 | 1.13 |
| II | 4 | 5 | 7 | 11 | 1.062 | 1.083 | 1.13 | 1.224 |
| III | 8 | 7 | 10 | 12 | 1.151 | 1.13 | 1.2 | 1.247 |
| IV | 6 | 8 | 11 | 14 | 1.107 | 1.153 | 1.233 | 1.301 |
| Jan. I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Feb. | I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | I | 2 | 2 | 4 | 1 | 1.01 | 1.01 | 1.062 | 1.006 |
| | II | 13 | 9 | 10 | 13 | 1.274 | 1.177 | 1.03 | 1.276 |
| | III | 2 | 15 | 11 | 10 | 1.017 | 1.325 | 1.224 | 1.2 |
| | IV | 13 | 7 | 10 | 3 | 1.275 | 1.13 | 1.03 | 1.043 |
| April | I | 34 | 32 | 25 | 34 | 1.86 | 1.802 | 1.597 | 1.859 |
| | II | 31 | 19 | 16 | 33 | 1.473 | 1.434 | 1.354 | 1.829 |
| | III | 19 | 13 | 20 | 22 | 1.434 | 1.276 | 1.461 | 1.514 |
| | IV | 27 | 19 | 22 | 24 | 1.655 | 1.434 | 1.513 | 1.572 |
| May | I | 47 | 42 | 49 | 33 | 2.254 | 2.1 | 2.318 | 1.83 |
| | II | 33 | 13 | 42 | 33 | 1.829 | 1.307 | 2.104 | 1.829 |
| | III | 35 | 41 | 44 | 31 | 1.889 | 2.069 | 2.163 | 1.774 |
| | IV | 17 | 32 | 49 | 29 | 1.381 | 1.8 | 2.319 | 1.711 |
| June | I | 36 | 26 | 43 | 31 | 1.922 | 1.629 | 2.131 | 1.77 |
| | II | 26 | 26 | 38 | 27 | 1.626 | 1.629 | 1.98 | 1.656 |
| | III | 33 | 27 | 38 | 27 | 1.829 | 1.657 | 1.979 | 1.657 |
| | IV | 29 | 25 | 378 | 29 | 1.713 | 1.6 | 1.98 | 1.712 |

**Table 12: Percent infestation and infestation index of *P. brassicae* on different varieties of cabbage during 1999-2000**

| *Per cent Infestation* | | | | | | *Infestation Index* | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month /Week** | | **G. Express** | **G. Acre** | **Uttam** | **P. of India** | **G. Express** | **G. Acre** | **Uttam** | **P. of India** |
| Oct. | I | 24 | 24 | 24 | 25 | 1.572 | 1.572 | 1.57 | 1.598 |
| | II | 21 | 24 | 22 | 23 | 1.489 | 1.57 | 1.517 | 1.544 |
| | III | 19 | 22 | 21 | 22 | 1.432 | 1.517 | 1.487 | 1.515 |
| | IV | 15 | 15 | 17 | 15 | 1.325 | 1.325 | 1.377 | 1.327 |
| Nov. | I | 9 | 9 | 12 | 11 | 1.176 | 1.177 | 1.25 | 1.225 |
| | II | 7 | 9 | 8 | 9 | 1.13 | 1.83 | 1.151 | 1.175 |
| | III | 3 | 4 | 4 | 5 | 1.045 | 1.065 | 1.065 | 1.085 |
| | IV | 3 | 3 | 4 | 4 | 1.042 | 1.043 | 1.062 | 1.064 |
| Dec. | I | 3 | 3 | 4 | 3 | 1.045 | 1.044 | 1.062 | 1.046 |
| | II | 3 | 4 | 3 | 3 | 1.043 | 1.062 | 1.044 | 1.043 |
| | III | 3 | 3 | 3 | 3 | 1.045 | 1.045 | 1.042 | 1.043 |
| | IV | 27 | 25 | 28 | 26 | 1.657 | 1.6 | 1.686 | 1.692 |
| Jan. | I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Feb. | I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | I | 2 | 2 | 3 | 3 | 1.016 | 1.02 | 1.032 | 1.033 |
| | II | 3 | 3 | 3 | 3 | 1.046 | 1.045 | 1.045 | 1.046 |
| | III | 12 | 11 | 10 | 10 | 1.249 | 1.224 | 1.199 | 1.2 |
| | IV | 13 | 12 | 11 | 11 | 1.273 | 1.249 | 1.225 | 1.226 |
| April | I | 26 | 25 | 23 | 24 | 1.626 | 1.599 | 1.544 | 1.573 |
| | II | 27 | 27 | 27 | 27 | 1.658 | 1.656 | 1.645 | 1.657 |
| | III | 32 | 33 | 32 | 31 | 1.801 | 1.833 | 1.799 | 1.772 |
| | IV | 33 | 33 | 32 | 34 | 1.83 | 1.832 | 1.802 | 1.859 |
| May | I | 36 | 38 | 35 | 35 | 1.921 | 1.978 | 1.892 | 1.89 |
| | II | 38 | 37 | 36 | 36 | 1.982 | 1.95 | 1.92 | 1.921 |
| | III | 39 | 40 | 38 | 37 | 2.012 | 2.039 | 1.982 | 1.951 |
| | IV | 42 | 41 | 40 | 38 | 2.102 | 2.07 | 2.04 | 1.981 |
| June | I | 37 | 37 | 36 | 37 | 1.948 | 1.949 | 1.921 | 1.95 |
| | II | 36 | 36 | 35 | 35 | 1.918 | 1.918 | 1.89 | 1.892 |
| | III | 34 | 34 | 33 | 34 | 1.859 | 1.859 | 1.831 | 1.859 |
| | IV | 26 | 29 | 27 | 30 | 1.627 | 1.712 | 1.692 | 1.745 |

**Table 13a: Correlation of Infestation Index with aboitic factors on different varieties of cabbage (Seed Crop) against *Pieris brassicae* during 1998-99**

| Variety | Infestation Index | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Average Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs.) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 1.228 | 0.880* | 0.606 | 0.819* | -0.757 | 0.850* | -0.464 |
| Golden Acre | 1.105 | 0.872* | 0.553 | 0.794* | -0.707 | 0.838* | -0.434 |
| Uttam | 1.269 | 0.928** | 0.654 | 0.863* | -0.796 | 0.893* | -0.470 |
| Pride of India | 1.228 | 0.892* | 0.651 | 0.838* | -0.772 | 0.852* | -0.469 |

*Significant at 5% level of significance

**Highly significant at 1 % level

**Table13b: Correlation of Infestation Index with aboitic factors on different varieties of cabbage (Seed Crop) against *Pieris brassicae* during 1999-2000**

| Variety | Infestation Index | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | Mean Humidity (%) | Sunshine (hrs.) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 1.163 | 0.870* | 0.781 | 0.862* | -0.788 | 0.747 | -0.395 |
| Golden Acre | 1.160 | 0.850* | 0.771 | 0.843* | -0.764 | 0.711 | -0.397 |
| Uttam | 1.188 | 0.874* | 0.796 | 0.863* | -0.793 | 0.753 | -0.407 |
| Pride of India | 1.164 | 0.870* | 0.794 | 0.860* | -0.791 | 0.750 | -0.403 |

*Significant at 5% of level of significance

**Table 14a: Homogeneity Correlation of *P. brassicae* between different varieties of cabbage (Seed crop) and certain abiotic factors during the year 1998-99**

| Aboitic factors | Varieties | | | | |
|---|---|---|---|---|---|
| | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** | **P value** |
| Max. Temp. ($^0$C) | 0.9678 | 0.9676 | 0.9696 | 0.9689 | 0.999 |
| Min. Temp. ($^0$C) | 0.8295 | 0.8242 | 0.8352 | 0.8314 | 0.999 |
| Mean Temp. ($^0$C) | 0.9724 | 0.9711 | 0.9739 | 0.9725 | 0.997 |
| Relative Humidity (%) | -0.8729 | -0.8722 | -0.8777 | -0.8735 | -0.999 |
| Sunshine (hrs.) | 0.8990 | 0.8890 | 0.8919 | 0.8910 | 0.999 |
| Rainfall (mm) | -0.3917 | -0.3893 | -0.3934 | -0.3919 | -0.999 |

**Table 14b: Homogeneity Correlation of *P. brassicae* between different varieties of cabbage (Seed crop) and certain abiotic factors during the year 1999-2000**

| Aboitic factors | Varieties | | | | |
|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | P value |
| Max. Temp. ($^0$C) | 0.9412 | 0.9411 | 0.9441 | 0.9429 | 0.999 |
| Min. Temp. ($^0$C) | 0.8887 | 0.8819 | 0.8950 | 0.8908 | 0.995 |
| Mean Temp. ($^0$C) | 0.9432 | 0.9405 | 0.9456 | 0.9440 | 0.998 |
| Relative Humidity (%) | -0.8325 | -0.8318 | -0.8345 | -0.8332 | 0.999 |
| Sunshine (hrs.) | 0.7851 | 0.7834 | 0.7875 | 0.7872 | 0.999 |
| Rainfall (mm) | -0.3422 | -0.3391 | -0.3440 | -0.3426 | 0.999 |

**If p-value >0.05 implies homogeneity of correlation of population with abiotic factors**

**Table 15: Population buildup of *some other pests* in relation to certain abiotic factors on different varieties of cabbage (Seed crop) during the year 1998-99**

| Month/ Week | Varieties of cabbage | | | | Aboitic factors | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
| October I | 16 | 12 | 29 | 21 | 25 | 8 | 16.5 | 66 | 52.8 | 0 |
| II | 14 | 9 | 23 | 18 | 22.9 | 4.3 | 13.6 | 69 | 56.8 | 0 |
| III | 13 | 10 | 23 | 18 | 23.6 | 3.4 | 13.5 | 70 | 51.3 | 0 |
| IV | 14 | 10 | 24 | 19 | 24.4 | 2.7 | 13.6 | 67 | 57.9 | 0 |
| November I | 11 | 9 | 20 | 15 | 20.6 | 2.3 | 11.5 | 67 | 42.4 | 22.6 |
| II | 9 | 6 | 15 | 11 | 14.3 | 4.2 | 9.2 | 81 | 31.1 | 20.9 |
| III | 9 | 7 | 16 | 12 | 14.9 | 3.5 | 9.2 | 78 | 32.8 | 3.6 |
| IV | 7 | 5 | 12 | 9 | 12.8 | 1.1 | 7 | 80 | 25 | 0 |
| December | 0 | 0 | 0 | 0 | 14.2 | -1.3 | 6.5 | 79 | 38 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | | |
| II | 0 | 0 | 0 | 0 | 12.7 | -2.8 | 5 | 77 | 39.1 | 0 |
| III | 0 | 0 | 0 | 0 | 12.7 | -4.5 | 4.1 | 73 | 39.4 | 0 |
| IV | 0 | 0 | 0 | 0 | 12.6 | -5.8 | 3.4 | 86 | 38.8 | 0 |
| January I | 0 | 0 | 0 | 0 | 5.9 | -2.1 | 1.9 | 83 | 0 | 4.2 |
| II | 0 | 0 | 0 | 0 | 4.3 | -1.5 | 1.4 | 88 | 6.5 | 27 |
| III | 0 | 0 | 0 | 0 | 6.2 | -2.6 | 1.8 | 85 | 16.2 | 17.8 |
| IV | 0 | 0 | 0 | 0 | 2.5 | -0.5 | 1 | 92 | 0 | 70 |

Cont……

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| February I | 0 | 0 | 0 | 0 | 6.5 | -0.9 | 2.8 | 83 | 23.5 | 3.8 |
| II | 0 | 0 | 0 | 0 | 7.4 | 0.8 | 4.1 | 82 | 4.2 | 10.8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | III | 0 | 0 | 0 | 0 | 9.7 | 4.3 | 7 | 82 | 2.8 | 6.4 |
| | IV | 0 | 0 | 0 | 0 | 9.3 | 2.9 | 6.1 | 81 | 9 | 19.9 |
| March | I | 8 | 6 | 14 | 11 | 15.3 | 1 | 8.2 | 67 | 43.3 | 4 |
| | II | 8 | 5 | 13 | 10 | 11 | 4.4 | 7.7 | 85 | 13.2 | 39.4 |
| | III | 9 | 6 | 15 | 12 | 14.8 | 3.2 | 9 | 71 | 25.2 | 2 |
| | IV | 9 | 6 | 15 | 11 | 13.1 | 4 | 8.6 | 77 | 21.2 | 15.3 |
| April | I | 12 | 9 | 21 | 16 | 19.8 | 4.7 | 12.3 | 62 | 37.9 | 4 |
| | II | 13 | 10 | 23 | 18 | 21.2 | 5.8 | 13.5 | 57 | 51.9 | 2.4 |
| | III | 15 | 10 | 25 | 19 | 21.6 | 8 | 14.8 | 57 | 36.6 | 5.3 |
| | IV | 15 | 10 | 25 | 20 | 24 | 5.6 | 14.8 | 47 | 56.7 | 0 |
| May | I | 18 | 12 | 30 | 23 | 28.2 | 7.1 | 17.7 | 47 | 71.5 | 0 |
| | II | 16 | 11 | 27 | 20 | 22.7 | 9.5 | 16.1 | 67 | 45.2 | 17 |
| | III | 16 | 12 | 28 | 21 | 22.7 | 9.6 | 16.1 | 61 | 44.3 | 6.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IV | 18 | 12 | 29 | 24 | 27.5 | 9.1 | 18.3 | 59 | 72 | 0.4 |
| June<br>I | 18 | 13 | 31 | 19 | 27 | 12.1 | 14.6 | 63 | 63.9 | 2.6 |
| III | 15 | 10 | 25 | 23 | 26 | 9.7 | 17.8 | 58 | 54.5 | 8.2 |
| III | 18 | 12 | 30 | 28 | 29 | 13.9 | 21.5 | 54 | 72.4 | 0 |
| IV | 21 | 15 | 37 | 28 | 30 | 12.3 | 21.2 | 56 | 74.3 | 0 |

**Table 16: Population buildup of *some other pests* in relation to certain abiotic factors on different varieties of cabbage (Seed crop) during the year 1999-2000**

| Month/ Week | Varieties of cabbage | | | | Aboitic factors | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Ave. Temp. ($^0$C) | | Sunshine (hrs) | Rainfall (mm) |
| October I | 19 | 10 | 28 | 22 | 25.9 | 8.7 | 17.3 | 65 | 49.5 | 0 |
| II | 16 | 9 | 23 | 19 | 24.3 | 4.9 | 14.6 | 65 | 51.3 | 0 |
| III | 17 | 9 | 24 | 20 | 26.5 | 3.6 | 15 | 64 | 58.9 | 0 |
| IV | 15 | 8 | 22 | 18 | 25.6 | 2.1 | 13.9 | 63 | 58.3 | 0 |
| November I | 13 | 7 | 19 | 15 | 20.3 | 3.2 | 11.8 | 67 | 36.1 | 0 |
| II | 10 | 5 | 14 | 11 | 15.1 | 2.2 | 8.7 | 71 | 30 | 1.4 |
| III | 9 | 5 | 12 | 10 | 13.1 | 2.5 | 7.8 | 75 | 15.3 | 8.5 |
| IV | 5 | 3 | 8 | 6 | 10.9 | -1.3 | 4.8 | 72 | 34.1 | 1 |
| December | 0 | 0 | 0 | 0 | 10.2 | -2.2 | 4 | 76 | 26.7 | 9.2 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | | |
| II | 0 | 0 | 0 | 0 | 10 | -0.3 | 4.8 | 75 | 22.5 | 0 |
| III | 0 | 0 | 0 | 0 | 9.6 | -0.2 | 4.7 | 82 | 27.3 | 9.4 |
| IV | 0 | 0 | 0 | 0 | 12.2 | -2.6 | 4.7 | 84 | 32.5 | 2 |
| January I | 0 | 0 | 0 | 0 | 10.9 | -4.8 | 3 | 75 | 37.1 | 0 |
| II | 0 | 0 | 0 | 0 | 5.8 | -0.2 | 2.4 | 88 | 0 | 74.2 |
| III | 0 | 0 | 0 | 0 | 4.4 | -4.4 | 0 | 82 | 5.8 | 9 |
| IV | 0 | 0 | 0 | 0 | 7.7 | -0.9 | 3.4 | 82 | 20.6 | 15 |

Cont……

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| February I | 0 | 0 | 0 | 0 | 8.3 | -1.3 | 3.5 | 83 | 28.4 | 22 |
| II | 0 | 0 | 0 | 0 | 8.3 | -0.5 | 3.8 | 76 | 22 | 1.4 |
| III | 0 | 0 | 0 | 0 | 9 | -1.1 | 3.9 | 77 | 35.3 | 13.4 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| IV | 0 | 0 | 0 | 0 | 13.4 | -0.2 | 6.6 | 68 | 52.7 | 33.4 |
| March I | 7 | 4 | 10 | 8 | 12.5 | 0.1 | 6.2 | 68 | 37.8 | 12 |
| II | 7 | 4 | 10 | 8 | 12.4 | 0.3 | 6.4 | 70 | 33.3 | 16.4 |
| III | 8 | 5 | 11 | 9 | 14.3 | 1.2 | 7.7 | 68 | 40 | 1 |
| IV | 87 | 5 | 12 | 10 | 18.9 | 6.6 | 12.8 | 67 | 29 | 10 |
| April I | 14 | 8 | 20 | 16 | 20.2 | 4.6 | 12.4 | 61 | 52.4 | 0.6 |
| II | 15 | 8 | 22 | 18 | 22.6 | 4.8 | 13.7 | 65 | 56.2 | 9.2 |
| III | 18 | 10 | 26 | 21 | 23.2 | 7.8 | 16.5 | 66 | 58 | 8 |
| IV | 19 | 11 | 28 | 23 | 27.5 | 7.8 | 17.7 | 58 | 58.7 | 0 |
| May I | 23 | 13 | 34 | 28 | 29.9 | 12.4 | 21.2 | 65 | 66.6 | 15.7 |
| II | 22 | 12 | 33 | 27 | 29.1 | 12 | 20.5 | 57 | 69.8 | 5.8 |
| III | 23 | 13 | 34 | 28 | 30.2 | 12.4 | 21.3 | 63 | 72.2 | 8.5 |
| IV | 21 | 11 | 30 | 24 | 26.1 | 11.4 | 18.8 | 67 | 55.8 | 20.9 |
| June | 22 | 12 | 31 | 25 | 26 | 13.2 | 19.6 | 64 | 65 | 10.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | | |
| III | 26 | 14 | 37 | 30 | 32 | 14.6 | 23.3 | 62 | 79 | 0 |
| III | 26 | 14 | 38 | 31 | 30.5 | 16.7 | 23.6 | 62 | 56 | 3 |
| IV | 27 | 15 | 39 | 32 | 31.1 | 17.4 | 24.3 | 64 | 59.2 | 9 |

**Table 17: Percent infestation and infestation index of *Some other pests* on different varieties of cabbage during 1998-99**

| *Percent Infestation* | | | | ***Infestation Index*** | | | | |
|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** |
| October I | 4 | 3 | 6 | 6 | 1.018 | 1.027 | 1.075 | 1.081 |
| II | 4 | 3 | 6 | 5 | 1.049 | 1.028 | 1.076 | 1.063 |
| III | 4 | 4 | 6 | 6 | 0.016 | 1.044 | 1.076 | 1.082 |
| IV | 5 | 4 | 6 | 5 | 1.058 | 1.043 | 1.077 | 1.057 |
| November I | 2 | 2 | 2 | 2 | 1.015 | 1.016 | 1.011 | 1.015 |
| II | 2 | 2 | 1 | 2 | 1.016 | 1.015 | 1.006 | 1.013 |
| III | 1 | 3 | 2 | 3 | 1.006 | 1.028 | 1.016 | 1.027 |
| IV | 3 | 2 | 4 | 2 | 1.027 | 1.013 | 1.043 | 1.016 |
| December I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| January I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March I | 4 | 4 | 3 | 3 | 1.043 | 1.044 | 1.025 | 1.025 |
| II | 4 | 5 | 3 | 5 | 1.044 | 1.058 | 1.027 | 1.018 |
| III | 4 | 5 | 3 | 2 | 1.043 | 1.057 | 1.028 | 1.011 |
| IV | 4 | 5 | 4 | 4 | 1.044 | 1.057 | 1.041 | 1.044 |
| April I | 7 | 6 | 5 | 5 | 1.016 | 1.084 | 1.067 | 1.02 |
| II | 7 | 7 | 7 | 6 | 1.102 | 1.102 | 1.104 | 1.084 |
| III | 6 | 7 | 8 | 7 | 1.082 | 1.1 | 1.119 | 1.023 |
| IV | 6 | 5 | 8 | 5 | 1.084 | 1.066 | 1.122 | 1.02 |
| May I | 9 | 15 | 11 | 13 | 1.141 | 1.267 | 1.179 | 1.022 |
| II | 10 | 13 | 11 | 9 | 1.159 | 1.225 | 1.181 | 1.142 |
| III | 11 | 14 | 12 | 13 | 1.179 | 1.245 | 1.2 | 1.022 |
| IV | 13 | 15 | 13 | 12 | 1.221 | 1.265 | 1.221 | 1.201 |
| June I | 2 | 5 | 6 | 6 | 1.011 | 1.019 | 1.073 | 1.075 |
| II | 3 | 3 | 5 | 4 | 1.028 | 1.028 | 1.066 | 1.018 |
| III | 3 | 3 | 6 | 6 | 1.028 | 1.033 | 1.081 | 1.081 |
| IV | 0 | 3 | 7 | 8 | 0 | 1.031 | 1.1 | 1.12 |

**Table 18: Percent infestation and infestation index of *Some other pests* on different varieties of cabbage during 1999-2000**

| Month /Week | Percent Infestation | | | | *Infestation Index* | | | |
|---|---|---|---|---|---|---|---|---|
| | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** |
| October I | 4 | 3 | 6 | 6 | 1.018 | 1.027 | 1.075 | 1.081 |
| II | 4 | 3 | 6 | 5 | 1.049 | 1.028 | 1.076 | 1.063 |
| III | 4 | 4 | 6 | 6 | 0.016 | 1.044 | 1.076 | 1.082 |
| IV | 5 | 4 | 6 | 5 | 1.058 | 1.043 | 1.077 | 1.057 |
| November I | 2 | 2 | 2 | 2 | 1.015 | 1.016 | 1.011 | 1.015 |
| II | 2 | 2 | 1 | 2 | 1.016 | 1.015 | 1.006 | 1.013 |
| III | 1 | 3 | 2 | 3 | 1.006 | 1.028 | 1.016 | 1.027 |
| IV | 3 | 2 | 4 | 2 | 1.027 | 1.013 | 1.043 | 1.016 |
| December I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| January I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February I | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| II | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| III | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IV | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March I | 4 | 4 | 3 | 3 | 1.043 | 1.044 | 1.025 | 1.025 |
| II | 4 | 5 | 3 | 5 | 1.044 | 1.058 | 1.027 | 1.018 |
| III | 4 | 5 | 3 | 2 | 1.043 | 1.057 | 1.028 | 1.011 |
| IV | 4 | 5 | 4 | 4 | 1.044 | 1.057 | 1.041 | 1.044 |
| April I | 7 | 6 | 5 | 5 | 1.016 | 1.084 | 1.067 | 1.02 |
| II | 7 | 7 | 7 | 6 | 1.102 | 1.102 | 1.104 | 1.084 |
| III | 6 | 7 | 8 | 7 | 1.082 | 1.1 | 1.119 | 1.023 |
| IV | 6 | 5 | 8 | 5 | 1.084 | 1.066 | 1.122 | 1.02 |
| May I | 9 | 15 | 11 | 13 | 1.141 | 1.267 | 1.179 | 1.022 |
| II | 10 | 13 | 11 | 9 | 1.159 | 1.225 | 1.181 | 1.142 |
| III | 11 | 14 | 12 | 13 | 1.179 | 1.245 | 1.2 | 1.022 |
| IV | 13 | 15 | 13 | 12 | 1.221 | 1.265 | 1.221 | 1.201 |
| June I | 2 | 5 | 6 | 6 | 1.011 | 1.019 | 1.073 | 1.075 |
| II | 3 | 3 | 5 | 4 | 1.028 | 1.028 | 1.066 | 1.018 |
| III | 3 | 3 | 6 | 6 | 1.028 | 1.033 | 1.081 | 1.081 |
| IV | 0 | 3 | 7 | 8 | 0 | 1.031 | 1.1 | 1.12 |

**Table 19a: Correlation between Population buildup of some other pests with certain abiotic factors on different varieties of cabbage during 1998-99 (Seed crop)**

| Variety | Mean Pop. | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Av. Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 8.94 | 0.338 | 0.140 | 0.185 | -0.218 | 0.433 | -0.384 |
| Golden Acre | 6.31 | 0.424 | 0.168 | 0.363 | -0.304 | 0.488 | -0.394 |
| Uttam | 15.28 | 0.316 | 0.121 | 0.164 | -0.205 | 0.411 | -0.321 |
| Pride of India | 11.83 | 0.319 | 0.138 | 0.167 | -0.208 | 0.414 | -0.381 |

**All values = N. S.**

**Table 19b : Correlation between population buildup of some other pests with certain abiotic factors on different varieties of cabbage during 1998-99 (Seed crop)**

| Variety | Mean Pop. | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Av. Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 12.75 | 0.334 | 0.263 | 0.311 | -0.131 | 0.167 | -0.355 |
| Golden Acre | 5.97 | 0.336 | 0.270 | 0.319 | -0.139 | 0.177 | -0.357 |
| Uttam | 15.69 | 0.316 | 0.253 | 0.295 | -0.105 | 0.150 | -0.351 |
| Pride of India | 13.03 | 0.331 | 0.260 | 0.306 | -0.126 | 0.159 | -0.355 |

**All values = N. S.**

**Table 20a: Correlation of Infestation Index with aboitic factors on different varieties of cabbage (Seed Crop) against some other pests during 1998-99**

| Variety | Infestation Index | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Average Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs.) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 0.7143 | 0.787 | 0.743 | 0.819 | -0.721 | 0.658 | -0.238 |
| Golden Acre | 0.1737 | 0.778 | 0.735 | 0.809 | -0.714 | 0.645 | -0.236 |
| Uttam | 0.7164 | 0.797 | 0.753 | 0.827 | -0.724 | 0.667 | -0.245 |
| Pride of India | 0.7161 | 0.794 | 0.751 | 0.825 | -0.723 | 0.664 | -0.245 |

**All values = N. S.**

**Table 20b : Correlation of Infestation Index with aboitic factors on different varieties of cabbage (Seed Crop) against some other pests during 1999-2000**

| Variety | Infestation Index | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Average Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs.) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden Express | 0.7022 | 0.664 | 0.603 | 0.648 | -0.428 | 0.511 | -0.344 |
| Golden Acre | 0.6508 | 0.632 | 0.525 | 0.594 | -0.405 | 0.483 | -0.340 |
| Uttam | 0.7226 | 0.689 | 0.628 | 0.673 | -0.520 | 0.598 | -0.340 |
| Pride of India | 0.7193 | 0.686 | 0.627 | 0.670 | -0.449 | 0.531 | -0.346 |

**All values = N. S.**

**Table 21a: Studies on homogeneity correlation of some other pests on different varieties of cabbage with abiotic factors for the year 1999-2000**

| Aboitic factors | Varieties | | | | |
|---|---|---|---|---|---|
| | Golden Express | Golden Acre | Uttam | Pride of India | P value |
| Max. Temp. ($^0$C) | 0.9412 | 0.9411 | 0.9441 | 0.9429 | 0.999 |
| Min. Temp. ($^0$C) | 0.8887 | 0.8819 | 0.8950 | 0.8908 | 0.995 |
| Mean Temp. ($^0$C) | 0.9432 | 0.9405 | 0.9456 | 0.9440 | 0.998 |
| Relative Humidity (%) | -0.8325 | -0.8318 | -0.8345 | -0.8332 | 0.999 |
| Sunshine (hrs.) | 0.7851 | 0.7834 | 0.7875 | 0.7872 | 0.999 |
| Rainfall (mm) | -0.3422 | -0.3391 | -0.3440 | -0.3426 | 0.999 |

**Table 21b: Studies on homogeneity correlation of some other pests on different varieties of cabbage with abiotic factors for the year 1999-2000**

| Aboitic factors | Varieties | | | | |
|---|---|---|---|---|---|
| | G. Express | G. Acre | Uttam | P. of India | P value |
| Max. Temp. ($^0$C) | 0.9412 | 0.9411 | 0.9441 | 0.9429 | 0.999 |
| Min. Temp. ($^0$C) | 0.8887 | 0.8819 | 0.8950 | 0.8908 | 0.995 |
| Mean Temp. ($^0$C) | 0.9432 | 0.9405 | 0.9456 | 0.9440 | 0.998 |
| Relative Humidity (%) | -0.8325 | -0.8318 | -0.8345 | -0.8332 | 0.999 |
| Sunshine (hrs.) | 0.7851 | 0.7834 | 0.7875 | 0.7872 | 0.999 |
| Rainfall (mm) | -0.3422 | -0.3391 | -0.3440 | -0.3426 | 0.999 |

**If p-value >0.05 implies homogeneity of correlation of population with abiotic factors**

**TABLE 22: STUDIES ON POPULATION BUILDUP OF BREVICORYNE BRASSICAE ON DIFFERENT VARIETIES OF CABBAGE (HEAD CROP) FOR THE YEAR 1999**

| Month/ Week | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Ave. Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| June I | 103 | 95 | 183 | 140 | 27 | 12.1 | 14.6 | 63 | 63.9 | 2.6 |
| II | 109 | 91 | 177 | 135 | 26 | 9.7 | 17.8 | 58 | 54.5 | 8.2 |
| III | 122 | 101 | 197 | 151 | 29 | 13.9 | 21.5 | 54 | 72.4 | 0 |
| IV | 126 | 105 | 204 | 156 | 30 | 12.3 | 21.2 | 56 | 74.3 | 0 |
| July I | 58 | 49 | 95 | 73 | 29.3 | 14 | 21.7 | 61 | 62.9 | 8.6 |
| II | 66 | 55 | 107 | 82 | 33.7 | 15.7 | 24.7 | 51 | 79.7 | 0 |
| III | 67 | 56 | 109 | 83 | 32.1 | 16 | 24.1 | 53 | 62.9 | 0 |
| IV | 68 | 57 | 111 | 85 | 31.9 | 16.3 | 24.1 | 57 | 70.7 | 7.7 |
| August I | 68 | 57 | 110 | 84 | 32.8 | 16.2 | 24.5 | 58 | 70.9 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| II | 58 | 49 | 95 | 72 | 30.1 | 13.9 | 22 | 68 | 72.4 | 4 |
| III | 68 | 57 | 110 | 84 | 30.5 | 16.2 | 23.4 | 71 | 60.7 | 16 |
| IV | 59 | 49 | 95 | 72 | 27.5 | 14 | 20.7 | 71 | 45.1 | 0 |
| September I | 91 | 76 | 147 | 112 | 29.5 | 13.7 | 21.6 | 68 | 59.9 | 1.2 |
| II | 94 | 78 | 152 | 116 | 31.1 | 13.4 | 22.3 | 67 | 68.4 | 0 |
| III | 98 | 82 | 158 | 121 | 31.1 | 15.5 | 23.3 | 70 | 59 | 12.8 |
| IV | 76 | 63 | 122 | 94 | 25.1 | 11 | 18 | 71 | 49 | 10.4 |

**TABLE 23: POPULATION BUILDUP OF BREVICORYNE BRASSICAE ON DIFFERENT VARIETIES OF CABBAGE (HEAD CROP) FOR THE YEAR 2000**

| Month/ Week | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Ave. Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| June I | 127 | 108 | 174 | 131 | 26 | 13.2 | 19.6 | 64 | 65 | 10.6 |
| II | 151 | 128 | 207 | 207 | 32 | 14.6 | 23.3 | 62 | 79 | 0 |
| III | 153 | 130 | 210 | 210 | 30.5 | 16.7 | 23.6 | 62 | 56 | 3 |
| IV | 158 | 134 | 216 | 216 | 31.1 | 17.4 | 24.3 | 64 | 59.2 | 9 |
| July I | 106 | 90 | 145 | 145 | 31.8 | 16.3 | 24 | 67 | 68.6 | 3.2 |
| II | 113 | 96 | 155 | 155 | 30 | 17.5 | 23.8 | 71 | 43.2 | 13.3 |
| III | 113 | 96 | 155 | 155 | 29 | 17.4 | 23.2 | 74 | 30.6 | 14 |
| IV | 114 | 96 | 156 | 156 | 27.8 | 17.5 | 22.7 | 81 | 31.8 | 26.7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| August I | 108 | 91 | 147 | 147 | 28.9 | 16.6 | 22.8 | 73 | 55.1 | 7 |
| II | 103 | 87 | 141 | 141 | 30.5 | 15.9 | 23.2 | 69 | 60.5 | 0 |
| III | 93 | 78 | 127 | 127 | 29.6 | 14.3 | 22 | 66 | 56.2 | 3 |
| IV | 108 | 91 | 148 | 148 | 26.6 | 16.6 | 21.6 | 74 | 12 | 6.1 |
| September I | 94 | 79 | 127 | 127 | 30.4 | 14.3 | 22.4 | 68 | 60.2 | 2 |
| II | 132 | 112 | 181 | 181 | 30.1 | 10.4 | 20.3 | 64 | 68.2 | 0 |
| III | 125 | 106 | 171 | 171 | 25.5 | 12.9 | 19.2 | 78 | 41.2 | 26.2 |
| IV | 109 | 92 | 149 | 149 | 24.6 | 8.8 | 16.7 | 74 | 51.8 | 1 |

**Table 24a : Correlation between population buildup of *Brevicoryne brassicae* with certain abiotic factors on different varieties of cabbage during 1999 (Head crop)**

| Variety | **Mean Pop.** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **Relative Humidity (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden express | 83.19 | 0.360 | 0.329 | 0.292 | -0.221 | 0.444 | 0.172 |
| Golden acre | 70.00 | 0.319 | 0.286 | 0.250 | -0.219 | 0.407 | 0.170 |
| Uttam | 135.75 | 0.363 | 0.332 | 0.392 | -0.253 | 0.445 | -0.176 |
| Pride of India | 103.75 | 0.361 | 0.331 | 0.294 | -0.222 | 0.444 | -0.174 |

**All values = N. S.**

**Table 24b: Correlation between population buildup of *Brevicoryne brassicae* with certain abiotic factors on different varieties of cabbage during 1999-2000 (Head crop)**

| Variety | **Mean Pop.** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Av. Temp. ($^0$C)** | **Relative Humidity (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden express | 69.60 | 0.229 | 0.052 | 0.157 | -0.471 | -0.296 | 0.021 |
| Golden acre | 69.01 | 0.227 | 0.052 | 0.156 | -0.363 | -0.213 | 0.019 |
| Uttam | 74.31 | 0.351 | 0.120 | 0.267 | -0.475 | 0.308 | -0.021 |
| Pride of India | 71.37 | 0.230 | 0.052 | 0.157 | -0.473 | 0.301 | -0.021s |

**All values = N. S.**

**Table 25a: Infestation Index correlation for the buildup of *Brevicoryne brassicae* on different varieties of cabbage (Head Crop) in relation to certain abiotic factors during 1998-99**

| | *Percent Infestation* | | | | *Infestation Index* | | | |
|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** |
| June I | 64 | 64 | 66 | 67 | 2.408 | 2.406 | 2.452 | 2.475 |
| II | 66 | 63 | 64 | 62 | 2.377 | 2.436 | 2.397 | 2.352 |
| III | 66 | 63 | 63 | 68 | 2.354 | 2.412 | 2.35 | 2.458 |
| IV | 64 | 64 | 63 | 67 | 2.248 | 2.232 | 2.22 | 2.303 |
| July I | 61 | 58 | 60 | 56 | 2.076 | 2.13 | 2.118 | 2.04 |
| II | 64 | 59 | 62 | 60 | 2.073 | 2.159 | 2.128 | 2.088 |
| III | 66 | 64 | 64 | 58 | 2.185 | 2.214 | 2.184 | 2.068 |
| IV | 66 | 65 | 60 | 60 | 2.166 | 2.19 | 2.083 | 2.084 |
| August I | 47 | 45 | 49 | 50 | 1.792 | 1.83 | 1.867 | 1.889 |
| II | 48 | 48 | 50 | 51 | 1.832 | 1.828 | 1.87 | 1.886 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| III | 46 | 48 | 48 | 46 | 1.813 | 1.773 | 1.816 | 1.785 |
| IV | 44 | 46 | 47 | 46 | 1.75 | 1.72 | 1.771 | 1.756 |
| September I | 18 | 14 | 12 | 12 | 1.236 | 1.302 | 1.202 | 1.199 |
| II | 16 | 16 | 16 | 13 | 1.282 | 1.281 | 1.281 | 1.228 |
| III | 18 | 18 | 16 | 14 | 1.28 | 1.33 | 1.288 | 1.255 |
| IV | 21 | 18 | 19 | 17 | 1.328 | 1.393 | 1.349 | 1.316 |

**Table 25b: Infestation Index correlation for the buildup of *Brevicoryne brassicae* on different varieties of cabbage (Head Crop) in relation to certain abiotic factors during 1999-2000**

| | *Per cent Infestation* | | | | Infestation Index | | | |
|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** | **Golden Express** | **Golden Acre** | **Uttam** | **Pride of India** |
| June I | 44 | 1.892 | 46 | 1.913 | 48 | 2.025 | 40 | 1.848 |
| II | 43 | 1.884 | 44 | 1.89 | 44 | 1.951 | 39 | 1.819 |
| III | 41 | 1.857 | 42 | 1.858 | 40 | 1.85 | 38 | 1.791 |
| IV | 40 | 1.867 | 39 | 1.797 | 38 | 1.815 | 36 | 1.739 |
| July I | 13 | 1.234 | 10 | 1.197 | 8 | 1.144 | 10 | 1.182 |
| II | 11 | 1.201 | 11 | 1.196 | 11 | 1.199 | 8 | 1.139 |
| III | 13 | 1.238 | 14 | 1.251 | 11 | 1.199 | 12 | 1.196 |
| IV | 12 | 1.217 | 12 | 1.217 | 14 | 1.139 | 16 | 1.242 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| August<br>I | 12 | 1.209 | 14 | 1.247 | 10 | 1.174 | 11 | 1.17 |
| II | 10 | 1.168 | 12 | 1.211 | 10 | 1.172 | 12 | 1.183 |
| III | 9 | 1.149 | 12 | 1.207 | 9 | 1.152 | 11 | 1.17 |
| IV | 8 | 1.136 | 9 | 1.148 | 9 | 1.149 | 12 | 1.171 |
| September<br>I | 21 | 1.347 | 12 | 1.376 | 21 | 1.33 | 23 | 1.406 |
| II | 23 | 1.379 | 24 | 1.402 | 24 | 1.389 | 25 | 1.445 |
| III | 24 | 1.405 | 28 | 1.467 | 27 | 1.452 | 29 | 1.55 |
| IV | 26 | 1.434 | 28 | 1.46 | 20 | 1.335 | 21 | 1.405 |

**Table 26: Correlation of Infestation Index with Aboitic factors on different varieties of cabbage (Head Crop) against *B. brassicae* during 1999 and 2000**

| Variety | Infestation Index | | Max. Temp. ($^0$C) | | Min. Temp. ($^0$C) | | Mean Temp. ($^0$C) | | Relative Humidity (%) | | Sunshine (hrs.) | | Rainfall (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Express | 1.888 | 1.465 | 0.898* | 0.061 | 0.928** | 0.156 | 0.904 | 0.057 | 0.126 | 0.606 | -0.650 | -0.492 | 0.028 | 0.118 |
| Golden Acre | 1.886 | 1.403 | 0.890* | 0.016 | 0.927** | 0.140 | 0.895 | 0.030 | 0.113 | 0.558 | -0.635 | -0.476 | 0.010 | 0.072 |
| Uttam | 1.915 | 1.427 | 0.903* | 0.109 | 0.929** | 0.254 | 0.920 | 0.152 | 0.146 | 0.629 | -0.665 | -0.507 | 0.062 | 0.133 |
| Pride of India | 1.899 | 1.414 | 0.901* | 0.078 | 0.900* | 0.199 | 0.911 | 0.093 | 0.134 | 0.617 | -0.662 | -0.800 | 0.036 | 0.131 |

*** Significant at 5% level**

**** Significant at 1% level**

*TABLE 27: POPULATION BUILDUP OF* **PIERIS BRASSICAE** *ON DIFFERENT VARIETIES OF CABBAGE (HEAD CROP) FOR THE YEAR 1999*

| **Month/ Week** | **Golden Express** | **Golden Acre** | Uttam | **Pride of India** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp. ($^0$C)** | **RH (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|---|---|---|
| June I | 247 | 231 | 362 | 292 | 27 | 12.1 | 14.6 | 63 | 63.9 | 2.6 |
| II | 301 | 281 | 441 | 356 | 26 | 9.7 | 17.8 | 58 | 54.5 | 8.2 |
| III | 363 | 340 | 533 | 430 | 29 | 13.9 | 21.5 | 54 | 72.4 | 0 |
| IV | 358 | 335 | 526 | 424 | 30 | 12.3 | 21.2 | 56 | 74.3 | 0 |
| July I | 236 | 221 | 347 | 280 | 29.3 | 14 | 21.7 | 61 | 62.9 | 8.6 |
| II | 265 | 248 | 389 | 314 | 33.7 | 15.7 | 24.7 | 51 | 79.7 | 0 |
| III | 270 | 252 | 397 | 320 | 32.1 | 16 | 24.1 | 53 | 62.9 | 0 |
| IV | 275 | 257 | 404 | 326 | 31.9 | 16.3 | 24.1 | 57 | 70.7 | 7.7 |
| Aug. | 274 | 256 | 402 | 324 | 32.8 | 16.2 | 24.5 | 58 | 70.9 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| I | | | | | | | | | | |
| II | 274 | 256 | 402 | 324 | 30.1 | 13.9 | 22 | 68 | 72.4 | 4 |
| III | 235 | 220 | 345 | 278 | 30.5 | 16.2 | 23.4 | 71 | 60.7 | 16 |
| IV | 237 | 221 | 347 | 280 | 27.5 | 14 | 20.7 | 71 | 45.1 | 0 |
| Sept. I | 365 | 341 | 536 | 432 | 29.5 | 13.7 | 21.6 | 68 | 59.9 | 1.2 |
| II | 377 | 352 | 553 | 446 | 31.1 | 13.4 | 22.3 | 67 | 68.4 | 0 |
| III | 394 | 368 | 278 | 446 | 31.1 | 15.5 | 23.3 | 70 | 59 | 12.8 |
| IV | 417 | 390 | 612 | 494 | 25.1 | 11 | 18 | 71 | 49 | 10.4 |

*TABLE 28: POPULATION BUILDUP OF* **PIERIS BRASSICAE** *ON DIFFERENT VARIETIES OF CABBAGE (HEAD CROP) FOR THE YEAR 2000*

| **Month/ Week** | **Golden Express** | **Golden Acre** | Uttam | **Pride of India** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Ave. Temp. ($^0$C)** | **RH (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|---|---|---|
| June I | 267 | 204 | 368 | 306 | 26 | 13.2 | 19.6 | 64 | 65 | 10.6 |
| II | 317 | 242 | 438 | 363 | 32 | 14.6 | 23.3 | 62 | 79 | 0 |
| III | 321 | 245 | 444 | 268 | 30.5 | 16.7 | 23.6 | 62 | 56 | 3 |
| IV | 330 | 253 | 457 | 379 | 31.1 | 17.4 | 24.3 | 64 | 59.2 | 9 |
| July I | 326 | 250 | 451 | 374 | 31.8 | 16.3 | 24 | 67 | 68.6 | 3.2 |
| II | 324 | 248 | 447 | 371 | 30 | 17.5 | 23.8 | 71 | 43.2 | 13.3 |
| III | 315 | 241 | 436 | 361 | 29 | 17.4 | 23.2 | 74 | 30.6 | 14 |
| IV | 309 | 236 | 427 | 354 | 27.8 | 17.5 | 22.7 | 81 | 31.8 | 26.7 |
| August I | 310 | 237 | 429 | 356 | 28.9 | 16.6 | 22.8 | 73 | 55.1 | 7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| II | 315 | 240 | 436 | 362 | 30.5 | 15.9 | 23.2 | 69 | 60.5 | 0 |
| III | 299 | 229 | 414 | 343 | 29.6 | 14.3 | 22 | 66 | 56.2 | 3 |
| IV | 294 | 225 | 406 | 337 | 26.6 | 16.6 | 21.6 | 74 | 12 | 6.1 |
| September I | 305 | 233 | 421 | 349 | 30.4 | 14.3 | 22.4 | 68 | 60.2 | 2 |
| II | 409 | 313 | 566 | 470 | 30.1 | 10.4 | 20.3 | 64 | 68.2 | 0 |
| III | 345 | 265 | 479 | 398 | 25.5 | 12.9 | 19.2 | 78 | 41.2 | 26.2 |
| IV | 335 | 256 | 462 | 384 | 24.6 | 8.8 | 16.7 | 74 | 51.8 | 1 |

**Table 29a :Correlation of population mean of *Pieris brassicae* with abiotic factors on different varieties of cabbage during 1999 (Head crop)**

| Variety | **Mean Pop.** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Mean Temp.* ($^0$C)** | **Relative Humidity* (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden express | 305.5 | 0.199 | 0.355 | 0.103 | -0.189 | 0.074 | -0.018 |
| Golden acre | 285.6 | 0.199 | 0.355 | 0.103 | -0.192 | 0.074 | -0.018 |
| Uttam | 429.6 | 0.196 | 0.353 | 0.101 | 0.181 | 0.071 | -0.016 |
| Pride of India | 360.4 | 0.198 | 0.0354 | 0.102 | 0.188 | 0.072 | -0.017 |

**All values = N. S.**

**Table 29b : Studies on Correlation of population mean of *Pieris brassicae* with abiotic factors on different varieties of cabbage during 2000 (Head crop)**

| Variety | **Mean Pop.** | **Max. Temp. ($^0$C)** | **Min. Temp. ($^0$C)** | **Av. Temp. * ($^0$C)** | **Relative Humidity * (%)** | **Sunshine (hrs)** | **Rainfall (mm)** |
|---|---|---|---|---|---|---|---|
| Golden express | 302.8 | 0.170 | 0.419 | 0.168 | -0.065 | 0.214 | 0.109 |
| Golden acre | 231.2 | 0.205 | 0.420 | 0.173 | -0.098 | 0.255 | 0.128 |
| Uttam | 417.7 | 0.159 | 0.413 | 0.150 | 0.058 | 0.203 | -0.103 |
| Pride of India | 343.5 | 0.171 | 0.419 | 0.163 | 0.063 | 0.203 | -0.103 |

**All values = N. S.**

**Table 30a: Percent infestation and infestation index of *P. Brassicae* pests on different varieties of cabbage during 1999**

| | Percent Infestation | | | | Infestation Index | | | |
|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **Golden Express** | ***Golden Acre*** | **Uttam** | **Pride of India** | **Golden Express** | ***Golden Acre*** | **Uttam** | **Pride of India** |
| June I | 36 | 26 | 43 | 31 | 1.922 | 1.629 | 2.131 | 1.77 |
| II | 26 | 26 | 38 | 27 | 1.626 | 1.63 | 1.98 | 1.656 |
| III | 33 | 27 | 38 | 27 | 1.829 | 1.657 | 1.98 | 1.657 |
| IV | 29 | 25 | 378 | 29 | 1.812 | 1.6 | 1.882 | 1.713 |
| July I | 23 | 35 | 24 | 11 | 1.542 | 1.892 | 1.555 | 1.225 |
| II | 21 | 33 | 20 | 11 | 1.486 | 1.831 | 1.462 | 1.224 |
| III | 21 | 31 | 22 | 11 | 1.486 | 1.771 | 1.517 | 1.228 |
| IV | 26 | 31 | 29 | 12 | 1.629 | 1.774 | 1.709 | 1.25 |
| August I | 2 | 3 | 15 | 13 | 1.028 | 1.045 | 1.326 | 1.276 |
| II | 2 | 4 | 13 | 13 | 1.027 | 1.065 | 1.276 | 1.279 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| III | 3 | 4 | 13 | 10 | 1.043 | 1.047 | 1.276 | 1.2 |
| IV | 2 | 4 | 17 | 9 | 1.028 | 1.065 | 1.379 | 1.778 |
| September I | 51 | 62 | 43 | 50 | 2.465 | 2.842 | 2.168 | 2.35 |
| II | 44 | 43 | 43 | 43 | 2.198 | 2.166 | 2.165 | 2.133 |
| III | 44 | 50 | 42 | 52 | 2.198 | 2.223 | 2.103 | 2.142 |
| IV | 48 | 58 | 40 | 62 | 2.326 | 2.413 | 2.072 | 2.732 |

**Table 30b: Percent infestation and infestation index of *P. brassicae* on different varieties of cabbage during 2000**

| Month /Week | | *Percent Infestation* | | | | Infestation Index | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Golden Express** | ***Golden Acre*** | **Uttam** | **Pride of India** | **Golden Express** | ***Golden Acre*** | **Uttam** | **Pride of India** |
| June | I | 37 | 37 | 36 | 37 | 1.749 | 1.733 | 1.769 | 1.785 |
| | II | 36 | 36 | 35 | 35 | 1.74 | 1.729 | 1.756 | 1.736 |
| | III | 34 | 34 | 33 | 34 | 1.711 | 1.695 | 1.701 | 1.708 |
| | IV | 26 | 29 | 27 | 30 | 1.564 | 1.593 | 1.579 | 1.615 |
| July | I | 24 | 24 | 24 | 28 | 1.433 | 1.474 | 1.429 | 1.51 |
| | II | 21 | 20 | 22 | 24 | 1.385 | 1.362 | 1.4 | 1.418 |
| | III | 19 | 18 | 19 | 21 | 1.348 | 1.324 | 1.345 | 1.343 |
| | IV | 14 | 17 | 17 | 19 | 1.244 | 1.308 | 1.338 | 1.288 |
| August | I | 7 | 7 | 8 | 7 | 1.122 | 1.124 | 1.14 | 1.108 |
| | II | 6 | 7 | 6 | 7 | 1.101 | 1.123 | 1.103 | 1.107 |
| | III | 4 | 4 | 4 | 4 | 1.066 | 1.069 | 1.068 | 1.062 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| IV | 3 | 3 | 3 | 3 | 1.051 | 1.05 | 1.05 | 1.043 |
| September I | 41 | 40 | 41 | 42 | 1.68 | 1.684 | 1.646 | 1.741 |
| II | 49 | 47 | 45 | 46 | 1.809 | 1.822 | 1.729 | 1.82 |
| III | 57 | 55 | 45 | 49 | 1.963 | 1.452 | 1.755 | 1.93 |
| IV | 60 | 58 | 48 | 53 | 2.003 | 1.986 | 1.806 | 2.022 |

**Table 31: Correlation of Infestation Index with Aboitic factors on different varieties of cabbage (Head Crop) against *P. brassicae* during 1999 and 2000**

| Variety | Infestation Index | | Max. Temp. ($^0$C) | | Min. Temp. ($^0$C) | | Average Temp. ($^0$C) | | Relative Humidity (%) | | Sunshine (hrs.) | | Rainfall (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Express | 1.680 | 1.475 | 0.276 | 0.125 | 0.407 | 0.621 | 0.331 | 0.429 | -0.110 | -0.234 | 0.139 | 0.415 | 0.030 | 0.007 |
| Golden Acre | 1.665 | 1.470 | 0.124 | 0.056 | 0.237 | 0.561 | 0.117 | 0.421 | -0.097 | -0.219 | 0.128 | 0.393 | 0.005 | 0.004 |
| Uttam | 1.748 | 1.514 | 0.551 | 0.231 | 0.562 | 0.665 | 0.518 | 0.545 | -0.537 | -0.397 | 0.507 | 0.515 | 0.063 | 0.240 |
| Pride of India | 1.728 | 1.498 | 0.420 | 0.200 | 0.545 | 0.646 | 0.469 | 0.516 | -0.140 | -0.308 | 0.165 | 0.454 | 0.046 | 0.016 |

**TABLE 32: POPULATION BUILDUP OF PLUTELLA XYLOSTELLA ON DIFFERENT GENOTYPES OF CABBAGE (HEAD CROP) FOR THE YEAR 1999**

| Month/ Week | Golden Express | Golden Acre | *Uttam* | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Ave. Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| June I | 16 | 13 | 23 | 19 | 27 | 12.1 | 14.6 | 63 | 63.9 | 2.6 |
| II | 20 | 16 | 28 | 23 | 26 | 9.7 | 17.8 | 58 | 54.5 | 8.2 |
| III | 24 | 19 | 34 | 28 | 29 | 13.9 | 21.5 | 54 | 72.4 | 0 |
| IV | 23 | 19 | 34 | 28 | 30 | 12.3 | 21.2 | 56 | 74.3 | 0 |
| July I | 24 | 20 | 35 | 28 | 29.3 | 14 | 21.7 | 61 | 62.9 | 8.6 |
| II | 27 | 22 | 39 | 32 | 33.7 | 15.7 | 24.7 | 51 | 79.7 | 0 |
| III | 26 | 22 | 38 | 31 | 32.1 | 16 | 24.1 | 53 | 62.9 | 0 |
| IV | 27 | 22 | 39 | 31 | 31.9 | 16.3 | 24.1 | 57 | 70.7 | 7.7 |
| Aug. I | 27 | 22 | 39 | 32 | 32.8 | 16.2 | 24.5 | 58 | 70.9 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| II | 24 | 20 | 35 | 29 | 30.1 | 13.9 | 22 | 68 | 72.4 | 4 |
| III | 26 | 21 | 37 | 30 | 30.5 | 16.2 | 23.4 | 71 | 60.7 | 16 |
| IV | 23 | 19 | 33 | 27 | 27.5 | 14 | 20.7 | 71 | 45.1 | 0 |
| September I | 24 | 19 | 35 | 28 | 29.5 | 13.7 | 21.6 | 68 | 59.9 | 1.2 |
| II | 24 | 20 | 36 | 29 | 31.1 | 13.4 | 22.3 | 67 | 68.4 | 0 |
| III | 26 | 21 | 37 | 30 | 31.1 | 15.5 | 23.3 | 70 | 59 | 12.8 |
| IV | 20 | 16 | 29 | 23 | 25.1 | 11 | 18 | 71 | 49 | 10.4 |

**TABLE 33: POPULATION BUILDUP OF PLUTELLA XYLOSTELLA ON DIFFERENT GENOTYPES OF CABBAGE (HEAD CROP) FOR THE YEAR 2000**

| Month/ Week | Golden Express | Golden Acre | Uttam | Pride of India | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Ave. Temp. ($^0$C) | RH (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| June I | 20 | 16 | 27 | 24 | 26 | 13.2 | 19.6 | 64 | 65 | 10.6 |
| II | 23 | 10 | 33 | 28 | 32 | 14.6 | 23.3 | 62 | 79 | 0 |
| III | 24 | 19 | 33 | 28 | 30.5 | 16.7 | 23.6 | 62 | 56 | 3 |
| IV | 24 | 19 | 34 | 29 | 31.1 | 17.4 | 24.3 | 64 | 59.2 | 9 |
| July I | 24 | 19 | 34 | 29 | 31.8 | 16.3 | 24 | 67 | 68.6 | 3.2 |
| II | 24 | 19 | 33 | 29 | 30 | 17.5 | 23.8 | 71 | 43.2 | 13.3 |
| III | 23 | 19 | 32 | 28 | 29 | 17.4 | 23.2 | 74 | 30.6 | 14 |
| IV | 23 | 18 | 32 | 27 | 27.8 | 17.5 | 22.7 | 81 | 31.8 | 26.7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Aug. I | 23 | 18 | 30 | 25 | 28.9 | 16.6 | 22.8 | 73 | 55.1 | 7 |
| II | 23 | 19 | 32 | 27 | 30.5 | 15.9 | 23.2 | 69 | 60.5 | 0 |
| III | 22 | 18 | 32 | 28 | 29.6 | 14.3 | 22 | 66 | 56.2 | 3 |
| IV | 22 | 17 | 31 | 26 | 26.6 | 16.6 | 21.6 | 74 | 12 | 6.1 |
| Sept. I | 22 | 18 | 31 | 27 | 30.4 | 14.3 | 22.4 | 68 | 60.2 | 2 |
| II | 20 | 16 | 28 | 24 | 30.1 | 10.4 | 20.3 | 64 | 68.2 | 0 |
| III | 19 | 15 | 27 | 23 | 25.5 | 12.9 | 19.2 | 78 | 41.2 | 26.2 |
| IV | 17 | 13 | 23 | 20 | 24.6 | 8.8 | 16.7 | 74 | 51.8 | 1 |

**Table 34a: Correlation of population mean of *Plutella xylostella* with abiotic factors on different varieties of cabbage during 1999 (Head crop)**

| Variety | Mean Pop. | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden express | 23.81 | 0.873* | 0.851* | 0.997** | 0.242 | 0.446 | 0.063 |
| Golden acre | 19.44 | 0.893* | 0.854* | 0.997** | 0.261 | 0.486 | 0.110 |
| Uttam | 34.44 | 0.856* | 0.837* | 0.994** | 0.226 | 0.415 | 0.004 |
| Pride of India | 28.00 | 0.876* | 0.837* | 0.995** | 0.229 | 0.422 | 0.046 |

***** Significant at 5%

**Highly significant at 1%

**Table 34b : Correlation of population mean of *Plutella xylostella* with abiotic factors on different genotypes of cabbage during 2000(Head crop)**

| Variety | Mean Pop. | Max. Temp. ($^0$C) | Min. Temp. ($^0$C) | Mean Temp. ($^0$C) | Relative Humidity (%) | Sunshine (hrs) | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| Golden express | 22.06 | 0.162 | 0.333 | 0.376 | 0.532 | 0.329 | -0.386 |
| Golden acre | 17.06 | 0.286 | 0.390 | 0.400 | 0.549 | 0.353 | -0.395 |
| Uttam | 30.75 | 0.008 | 0.236 | 0.176 | -0.256 | 0.183 | 0.195 |
| Pride of India | 26.37 | 0.024 | 0.293 | 0.205 | -0.428 | 0.232 | 0.199 |

**All values = N. S.**

**Table 35a: Percent infestation and infestation index of *Plutella xylostella* on different varieties of cabbage (Head crop) during 1999**

| | *Percent Infestation* | | | | **Infestation Index** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **G. Express** | **G. Acre** | **Uttam** | **P. of India** | **G. Express** | **G. Acre** | **Uttam** | **P. of India** | |
| June I | 10 | 12 | 11 | 13 | 1.123 | 1.141 | 1.138 | 1.166 | |
| II | 13 | 14 | 13 | 15 | 1.153 | 1.172 | 1.166 | 1.188 | |
| III | 15 | 17 | 14 | 16 | 1.198 | 1.221 | 1.168 | 1.193 | |
| IV | 10 | 11 | 12 | 13 | 1.012 | 1.119 | 1.163 | 1.163 | |
| July I | 10 | 13 | 10 | 11 | 1.078 | 1.117 | 1.078 | 1.052 | |
| II | 10 | 11 | 10 | 11 | 1.09 | 1.105 | 1.09 | 1.066 | |
| III | 10 | 11 | 12 | 13 | 1.084 | 1.114 | 1.101 | 1.101 | |
| IV | 10 | 14 | 13 | 14 | 1.084 | 1.126 | 1.101 | 1.108 | |
| August I | 10 | 11 | 12 | 14 | 1.115 | 1.119 | 1.12 | 1.13 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| II | 10 | 13 | 10 | 12 | 1.123 | 1.114 | 1.124 | 1.147 | |
| III | 13 | 14 | 13 | 14 | 1.172 | 1.144 | 1.135 | 1.221 | |
| IV | 13 | 13 | 13 | 12 | 1.163 | 1.149 | 1.14 | 1.168 | |
| September I | 11 | 12 | 10 | 12 | 1.129 | 1.141 | 1.123 | 1.144 | |
| II | 11 | 14 | 13 | 14 | 1.129 | 1.156 | 1.16 | 1.168 | |
| III | 11 | 13 | 12 | 10 | 1.138 | 1.166 | 1.137 | 1.23 | |
| IV | 13 | 11 | 10 | 12 | 1.156 | 1.122 | 1.123 | 1.147 | |

**Table 35b: Percent infestation and infestation index of *Plutella xylostella* on different varieties of cabbage (Head crop) during 2000**

| | Percent Infestation | | | | Infestation Index | | | |
|---|---|---|---|---|---|---|---|---|
| **Month /Week** | **G. Express** | ***G. Acre*** | **Uttam** | **P. of India** | **G. Express** | **G. Acre** | **Uttam** | **P. of India** |
| June I | 9 | 10 | 9 | 8 | 1.1 | 1.128 | 1.117 | 1.109 |
| II | 12 | 12 | 11 | 12 | 1.033 | 1.137 | 1.143 | 1.158 |
| III | 16 | 15 | 16 | 14 | 1.218 | 1.181 | 1.208 | 1.172 |
| IV | 9 | 9 | 10 | 10 | 1.1 | 1.115 | 1.13 | 1.111 |
| July I | 10 | 11 | 12 | 11 | 1.084 | 1.099 | 1.052 | 1.066 |
| II | 8 | 9 | 8 | 9 | 1.048 | 1.07 | 1.043 | 1.07 |
| III | 9 | 9 | 10 | 10 | 1.07 | 1.086 | 1.09 | 1.047 |
| IV | 11 | 12 | 11 | 12 | 1.093 | 1.125 | 1.105 | 1.057 |
| August I | 9 | 9 | 10 | 10 | 1.1 | 1.115 | 1.1 | 1.136 |
| II | 12 | 11 | 12 | 10 | 1.148 | 1.334 | 1.134 | 1.111 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| III | 10 | 12 | 11 | 10 | 1.125 | 1.192 | 1.152 | 1.12 |
| IV | 10 | 11 | 11 | 10 | 1.115 | 1.1 | 1.119 | 1.134 |
| September I | 10 | 10 | 12 | 12 | 1.115 | 1.132 | 1.144 | 1.141 |
| II | 12 | 12 | 11 | 10 | 1.137 | 1.114 | 1.135 | 1.125 |
| III | 12 | 11 | 10 | 12 | 1.151 | 1.099 | 1.125 | 1.165 |
| IV | 12 | 9 | 8 | 9 | 1.37 | 1.115 | 1.08 | 1.1 |

**Table 36: Correlation of Infestation Index with Aboitic factors on different varieties of cabbage (Head Crop) against *P. xylostella* during 1999 and 2000**

| Variety | Infestation Index | | Max. Temp. ($^0$C) | | Min. Temp. ($^0$C) | | Average Temp. ($^0$C) | | Relative Humidity (%) | | Sunshine (hrs.) | | Rainfall (mm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 | 1999 | 2000 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Express | 1.1292 | 1.1139 | 0.337 | 0.172 | 0.221 | 0.071 | 0.237 | 0.139 | -0.077 | -0.251 | -0.184 | -0.210 | 0.105 | 0.255 |
| Golden Acre | 1.1217 | 1.1109 | 0.332 | 0.163 | 0.122 | 0.018 | 0.235 | 0.052 | -0.073 | -0.077 | -0.132 | -0.032 | 0.654 | 0.138 |
| Uttam | 1.1495 | 1.1341 | 0.418 | 0.236 | 0.516 | 0.281 | 0.404 | 0.301 | 0.498 | 0.453 | 0.475 | 0.270 | 0.332 | 0.386 |
| Pride of India | 1.1391 | 1.1173 | 0.411 | 0.229 | 0.237 | 0.080 | 0.268 | 0.176 | 0.461 | 0.363 | 0.326 | 0.281 | 0.270 | 0.288 |

**All values = N. S.**

Table 37a : Variations in the development stages of *P. brassicae* raised on different varieties of cabbage during 1999

| Variety | Fecundity | Incubation period (days) | Larval period (days) | Pupal period (days) | *SEX RATIO* | | *LONGEVITY OF BUTTERFLIES (DAYS)* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | Male | Female |
| Golden express | 116.1 | 6.00 | 23.47 | 11.07 | 1.11 | 1.00 | 15.87 | 13.80 |
| Golden acre | 113.1 | 5.93 | 23.27 | 10.93 | 1.06 | 1.00 | 15.80 | 13.20 |
| Uttam | 119.9 | 6.13 | 23.60 | 11.27 | 1.21 | 1.00 | 16.00 | 14.33 |
| Pride of India | 118.4 | 6.07 | 23.53 | 11.13 | 1.13 | 1.00 | 15.87 | 13.87 |
| **C.D** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

Table 37b: Variations in the development stages of *P. brassicae* raised on different varieties of cabbage during 2000

| Variety | Fecundity | Incubation period (days) | Larval period (days) | Pupal period (days) | *SEX RATIO* | | *LONGEVITY OF BUTTERFLIES (DAYS)* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | Male | Female |
| Golden express | 122.1 | 6.00 | 25.13 | 10.2 | 1.22 | 1.00 | 15.8 | 16.1 |
| Golden acre | 117.9 | 5.93 | 24.67 | 10.1 | 1.18 | 1.00 | 14.9 | 16.4 |
| Uttam | 124.7 | 6.13 | 25.60 | 10.7 | 1.25 | 1.00 | 16.1 | 16.9 |
| Pride of India | 122.6 | 6.07 | 25.53 | 10.6 | 1.25 | 1.00 | 16.0 | 16.5 |
| **C.D** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

Table 38a : Variations in the development stages of *P. brassicae* raised on different generations of cabbage during 1999

| Generation | Fecundity | Incubation period (days) | Larval period (days) | Pupal period (days) | *SEX RATIO* | | *LONGEVITY OF BUTTERFLIES (DAYS)* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | Male | Female |
| Ist | 111.2 | 6.167 | 23.17 | 11.00 | 1.06 | 1.00 | 14.92 | 14.25 |
| 2nd | 115.8 | 6.250 | 23.67 | 11.33 | 1.10 | 1.00 | 15.50 | 14.01 |
| 3rd | 123.1 | 5.917 | 23.08 | 11.00 | 1.18 | 1.00 | 16.33 | 13.83 |
| 4th | 118.9 | 6.000 | 24.17 | 11.11 | 1.21 | 1.00 | 15.67 | 13.33 |
| 5th | 115.2 | 5.833 | 23.25 | 11.17 | 1.09 | 1.00 | 15.75 | 13.50 |
| **C.D** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

**Table 38b : Variations in the development stages of *P. brassicae* raised on different generations of cabbage during 2000**

| Generation | Fecundity | Incubation period (days) | Larval period (days) | Pupal period (days) | *SEX RATIO* | | *LONGEVITY OF BUTTERFLIES (DAYS)* | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Male | Female | Male | Female |
| Ist | 111.3 | 6.25 | 24.67 | 10.17 | 1.19 | 1.00 | 15.01 | 15.42 |
| 2nd | 120.2 | 6.08 | 25.33 | 10.50 | 1.18 | 1.00 | 15.42 | 16.67 |
| 3rd | 127.6 | 6.08 | 25.00 | 10.42 | 1.18 | 1.00 | 15.83 | 15.83 |
| 4th | 122.2 | 6.00 | 25.58 | 10.50 | 1.12 | 1.00 | 16.17 | 18.25 |
| 5th | 127.8 | 5.92 | 25.58 | 10.50 | 0.9 | 1.00 | 15.92 | 16.25 |
| C.D | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 39: Summary of developmental stages of different generations of *Pieris brassicae* of cabbage during 1999**

| Variety | Gene-ration | Fecundity | Incubation period (days) | Larval period (days) | Pupal period(days) | *SEX RATIO* | | *LONGEVITY OF BUTTERFLIES (DAYS)* | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Male** | Female | **Male** | **Female** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Golden express | 1 | 119.67 | 6.00 | 25.33 | 11.33 | 0.8 | 1.00 | 14.00 | 15.33* |
| | 2 | 100.00 | 6.33 | 24.00 | 10.66 | 1.3 | 1.00 | 16.00 | 15.00* |
| | 3 | 126.67 | 5.67 | 21.00 | 11.00 | 1.2 | 1.00 | 16.00 | 13.00 |
| | 4 | 111.33 | 6.00 | 24.67 | 11.33 | 0.8 | 1.00 | 16.00 | 12.67* |
| | 5 | 122.67 | 5.67 | 22.67 | 12.00 | 1.3 | 1.00 | 17.33* | 15.67* |
| Golden acre | 1 | 119.33 | 6.00 | 23.00 | 10.67 | 1.2 | 1.00 | 17.33* | 15.67* |
| | 2 | 124.33 | 6.33 | 24.67 | 11.67 | 1.1 | 1.00 | 16.33 | 14.33 |
| | 3 | 126.00 | 6.00 | 23.00 | 10.67 | 1.3 | 1.00 | 16.33 | 14.67* |
| | 4 | 120.67 | 6.00 | 22.33 | 11.00 | 1.2 | 1.00 | 15.67 | 13.33 |
| | 5 | 101.67 | 6.33 | 24.33 | 11.33 | 0.8 | 1.00 | 13.67 | 11.33 |
| Uttam | 1 | 100.67 | 6.33 | 23.67 | 11.33 | 1.02 | 1.00 | 14.33 | 14.33 |
| | 2 | 113.67 | 6.00 | 23.00 | 11.00 | 1.03 | 1.00 | 14.67 | 13.00 |
| | 3 | 119.67 | 6.00 | 25.33 | 11.00 | 1.37 | 1.00 | 15.33 | 13.00 |
| | 4 | 129.00 | 6.00 | 24.00 | 10.33 | 1.38 | 1.00 | 13.67 | 13.67 |
| | 5 | 102.67 | 6.00 | 22.00 | 11.00 | 1.28 | 1.00 | 16.00 | 12.00 |
| Pride of India | 1 | 105.33 | 6.33 | 20.67 | 10.67 | 1.25 | 1.00 | 14.00 | 11.67 |
| | 2 | 125.33 | 6.33 | 23.00 | 12.00 | 1.02 | 1.00 | 15.00 | 14.00 |
| | 3 | 120.00 | 6.00 | 23.00 | 11.33 | 0.86 | 1.00 | 17.67* | 14.679 |
| | 4 | 114.67 | 6.00 | 25.67 | 11.33 | 0.02 | 1.00 | 17.33* | 13.67 |
| | 5 | 134.00* | 5.33 | 24.00 | 10.33 | 1.06 | 1.00 | 16.00 | 15.00* |
| | | **30.91** | | | | | | | |

*Significant at 5%  level of significance.

**Table 40: Summary of developmental stages of different generations of *Pieris brassicae* of cabbage during 2000**

| **Variety** | **Gene-ration** | **Fecundity** | **Incubation period (days)** | **Larval period (days)** | **Pupal period (days)** | ***SEX RATIO*** | | ***LONGEVITY OF BUTTERFLIES (DAYS)*** | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Male** | Female | **Male** | **Female** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Golden express | 1 | 93.33 | 6.00 | 25.33 | 10.67 | 1.40 | 1.00 | 16.33 | 20.33 |
| | 2 | 97.33 | 6.00 | 24.00 | 10.33 | 1.17 | 1.00 | 14.67 | 20.67 |
| | 3 | 131.00 | 6.33 | 21.00 | 10.33 | 1.25 | 1.00 | 15.67 | 14.00 |
| | 4 | 132.33 | 6.67 | 24.67 | 10.00 | 1.40 | 1.00 | 16.00 | 13.33 |
| | 5 | 156.00* | 5.67 | 22.67 | 9.67 | 1.07 | 1.00 | 17.67* | 14.33 |
| Golden acre | 1 | 121.67 | 6.00 | 23.00 | 9.67 | 1.22 | 1.00 | 15.00 | 12.00 |
| | 2 | 130.00 | 6.00 | 24.67 | 10.33 | 1.17 | 1.00 | 16.67 | 19.67 |
| | 3 | 140.00* | 5.67 | 23.00 | 10.33 | 1.15 | 1.00 | 15.67 | 16.33 |
| | 4 | 129.33 | 6.33 | 22.33 | 10.33 | 0.85 | 1.00 | 16.67 | 19.67 |
| | 5 | 102.33 | 6.33 | 24.33 | 10.00 | 0.95 | 1.00 | 15.00 | 13.00 |
| Uttam | 1 | 105.00 | 6.67 | 23.67 | 10.33 | 1.12 | 1.00 | 15.00 | 13.00 |
| | 2 | 136.67* | 5.67 | 23.00 | 10.33 | 0.91 | 1.00 | 16.67 | 14.33 |
| | 3 | 130.00 | 6.33 | 25.33 | 11.00 | 1.46 | 1.00 | 16.67 | 19.00 |
| | 4 | 128.00 | 5.67 | 24.00 | 10.67 | 1.34 | 1.00 | 16.33 | 19.33 |
| | 5 | 111.00 | 6.00 | 22.00 | 10.67 | 0.85 | 1.00 | 15.33 | 18.67 |
| Pride of India | 1 | 122.33 | 6.33 | 20.67 | 10.00 | 1.30 | 1.00 | 14.00 | 16.33 |
| | 2 | 116.67 | 6.67 | 23.00 | 11.00 | 1.53 | 1.00 | 13.67 | 12.00 |
| | 3 | 109.33 | 6.00 | 23.00 | 10.00 | 0.93 | 1.00 | 15.33 | 14.00 |
| | 4 | 99.33 | 5.33 | 25.67 | 11.00 | 0.76 | 1.00 | 15.67 | 20.67 |
| | 5 | 141.67* | 5.67 | 24.00 | 11.62 | | 1.00 | 15.67 | 19.00 |

* Significant at 5% level of significance

**Table 41a: Percent Survival of different generations of *Pieris brassicae* on cabbage during 1999.**

| Generation | Percent eggs hatched | Percent larvae survival | Percent Adults emerged | Percent Survival |
|---|---|---|---|---|
| Ist | 98.33* | 78.89* | 59.44* | 59.44* |
| 2nd | 97.78* | 76.11* | 55.56* | 55.55* |
| 3rd | 98.33* | 65.00 | 37.22 | 37.77 |
| 4th | 96.67* | 65.56 | 37.22 | 37.22 |
| 5th | 93.33 | 65.56 | 35.00 | 35.00 |
| **C.D** | **3.33** | **5.90** | **4.87** | **4.71** |

* Significant at 5% level of significance

**Table 41b : Percent Survival of different generations of *Pieris brassicae* on cabbage during 2000.**

| Generation | Percent eggs hatched | Percent larvae survival | Percent Adults emerged | Percent Survival |
|---|---|---|---|---|
| Ist | 93.33* | 80.00* | 53.33* | 53.3 |
| 2nd | 90.56 | 77.78 | 52.22* | 52.2 |
| 3rd | 93.89* | 75.56 | 55.56* | 55.6 |
| 4th | 92.22 | 73.33 | 46.67* | 46.7 |
| 5th | 90.00 | 78.89* | 65.00* | 65.0 |
| **C.D** | **3.25** | **5.22** | **3.09** | **NS** |

* Significant at 5% level of significance.

**Table 42a : Percent Survival of *Pieris brassicae* on different varieties of cabbage during 1999.**

| Variety | Percent eggs hatched | Percent larvae survival | Percent Adults emerged | Percent Survival |
|---|---|---|---|---|
| Golden express | 96.00 | 63.11* | 43.56 | 43.55 |
| Golden acre | 96.00 | 49.78* | 41.78 | 41.77 |
| Uttam | 98.98* | 85.78* | 50.67* | 51.11* |
| Pride of India | 98.67 | 82.22* | 43.56 | 43.55 |
| **C.D** | **2.98** | **5.28** | **4.35** | **4.21** |

* Significant at 5% level of significance.

**Table 42b : Percent Survival of *Pieris brassicae* on different varieties of cabbage during 2000.**

| Variety | Percent eggs hatched | Percent larvae survival | Percent Adults emerged | Percent Survival |
|---|---|---|---|---|
| Golden express | 90.22 | 73.33 | 52.89** | 52.8 |
| Golden acre | 89.78 | 72.89 | 47.56 | 47.5 |
| Uttam | 96.00* | 84.00* | 62.67* | 62.6 |
| Pride of India | 92.00 | 78.00* | 55.11* | 55.1 |
| **C.D** | **2.91** | **4.67** | **2.77** | **NS** |

* Significant at 5% level of significance.

**Table 43 : Summary of percent survival of *Pieris brassicae* on different generations of cabbage during 1999**

| Variety | Gener-ation | Percent eggs hatched | Percent larvae survival | Percent Adults emerged | Percent Survival |
|---|---|---|---|---|---|
| Golden express | 1 | 100.00* | 88.89* | 68.89* | 68.89* |
| | 2 | 100.00* | 86.67* | 62.22* | 62.22* |
| | 3 | 97.78* | 88.89* | 42.22 | 44.44* |
| | 4 | 95.56* | 84.44* | 42.22 | 42.22* |
| | 5 | 100.00* | 80.00* | 37.78 | 37.78 |
| Golden acre | 1 | 97.78* | 84.44* | 53.33* | 53.33* |
| | 2 | 100.00* | 80.00* | 55.56* | 55.55* |
| | 3 | 97.78* | 86.67* | 37.78 | 37.78 |
| | 4 | 95.56* | 82.22* | 37.78 | 37.77 |
| | 5 | 88.89 | 77.78* | 33.33 | 33.33 |
| Uttam | 1 | 97.78* | 80.00* | 57.78* | 57.78* |
| | 2 | 93.33 | 80.00* | 53.33* | 53.33* |
| | 3 | 97.78* | 44.44 | 33.33 | 33.33 |
| | 4 | 10.00* | 48.89 | 33.33 | 33.33 |
| | 5 | 95.56* | 62.22* | 40.00* | 40.00* |

| | | | | | |
|---|---|---|---|---|---|
| Pride of India | 1 | 97.78* | 62.22* | 57.78* | 57.78* |
| | 2 | 97.78* | 57.78* | 51.11* | 51.11* |
| | 3 | 100.00* | 40.00 | 35.56 | 35.55 |
| | 4 | 95.56* | 46.67 | 35.56 | 35.55 |
| | 5 | 88.89 | 42.22 | 28.88 | 28.89 |
| **C.D** | | **6.66** | **11.80** | **9.74** | **9.42** |

* Significant at 5% level of significance.

**Table 44 : Summary of percent survival of *Pieris brassicae* on different generations of cabbage during 2000**

| Variety | Gener-ation | Percent eggs hatched | Percent larvae survival | Percent Adults emerged | Percent Survival |
|---|---|---|---|---|---|
| Golden express | 1 | 97.78* | 84.44* | 60.00* | 60.00* |
| | 2 | 95.56* | 82.22* | 62.22* | 62.22* |
| | 3 | 95.56* | 82.22* | 64.44* | 64.44* |
| | 4 | 97.78* | 82.22* | 53.33* | 53.33* |
| | 5 | 93.33* | 88.89* | 73.33* | 73.33* |
| Golden acre | 1 | 95.56* | 82.22* | 53.33* | 53.33* |
| | 2 | 91.11 | 80.00* | 53.33* | 53.33* |
| | 3 | 93.33* | 77.78* | 57.78* | 57.77* |
| | 4 | 93.33* | 73.33 | 51.11* | 51.11* |
| | 5 | 86.67 | 77.78* | 60.00* | 60.00* |
| Uttam | 1 | 91.11 | 77.78* | 53.33* | 53.33* |
| | 2 | 88.89 | 75.56* | 48.89* | 48.89* |
| | 3 | 91.11 | 73.33* | 53.33* | 53.33* |
| | 4 | 88.89 | 62.22 | 42.22 | 42.22 |

| | | | | | |
|---|---|---|---|---|---|
| | 5 | 88.89 | 75.56* | 66.67* | 66.67* |
| | 1 | 88.89 | 75.56* | 46.67* | 46.66* |
| | 2 | 86.67 | 73.33* | 44.44 | 44.44 |
| | 3 | 88.89 | 68.89 | 46.67* | 46.66* |
| | 4 | 95.56* | 75.56* | 40.00 | 40.00 |
| Pride of India | 5 | 91.11 | 73.33* | 60.00* | 60.00* |
| | | **6.51** | **10.44** | **6.19** | **6.189** |
| **C.D** | | | | | |

* Significant at 5% level of significance.

**Table 45: Effect of different level of potash and treatments on the population of *B. brassicae* on cabbage for the year 2001**

Mean population/ 5 plants ( 3days after treatment)

| *VARIETY* | *POTASH LEVELS ( KG HA$^{-1}$)* | *TREATMENT* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *NEEM (0.03%)* | *BT. (0.03%)* | *DDVP (0.05%)* | *CARBARYL (0.01%)* | *ENDOSULFAN (0.05%)* | *QUINALPHOS (0.05%)* | *CONTROL (WATER)* | *MEAN* |
| *Golden Express* | *0* | *133.00* | *126.00* | *101.00* | *119.00* | *106.00* | *112.0* | *206.0* | *129.00* |
| | 40 | 153.00 | 138.00 | 115.00 | 132.00 | 117.00 | 123.0 | 222.0 | 142.86 |
| | 60 | 164.00 | 145.00 | 123.00 | 137.00 | 123.00 | 128.0 | 232.0 | 150.28 |
| | **Mean** | **150.00** | **136.33** | **113.00** | **129.33** | **115.33** | **121.0** | **220.0** | **140.71** |
| *Golden Acre* | *0* | *126.0* | *116.0* | *57.0* | *101.0* | *81.0* | *107.0* | *176.0* | *109.14* |
| | 40 | 134.0 | 127.0 | 68.0 | 112.0 | 94.0 | 118.0 | 202.0 | 122.14 |
| | 60 | 142.0 | 133.0 | 74.0 | 117.0 | 101.0 | 125.0 | 214.0 | 129.43 |
| | **Mean** | **134.0** | **125.33** | **66.3** | **110.0** | **92.0** | **116.66** | **197.33** | **120.24** |
| | | **Potash × Treatment** | | | | | | | |
| | *0* | *129.5* | *121.0* | *79.0* | *110.0* | *93.0* | *109.5* | *191.0* | *119.07* |
| | 40 | 143.5 | 132.5 | 91.5 | 122.0 | 105.5 | 120.0 | 212.0 | 132.45 |
| | 60 | 186.0 | 139.0 | 98.5 | 127.0 | 112.0 | 126.5 | 223.0 | 144.62 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mean** | **153.0** | **130.83** | **89.67** | **119.67** | **103.67** | **118.67** | **208.67** | **132.04** |

*C. D at 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | NS | Variety× Potash | = | 13.590 |
| Potash | = | 9.6092 | Variety× Treatment | = | 20.758 |
| Treatment | = | 14.6783 | Potash × Treatment | = | 25.4235 |
| | | | Variety× Potash× Treatment | = | 35.9542 |

**Table 46: Effect of different level of potash and pesticides on the population of *B. brassicae* on cabbage for the year 2001**

Mean population/ 5 plants ( 7 days after treatment)

| *VARIETY* | *TREATMENT* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *POTASH LEVELS ( KG HA$^{-1}$)* | *NEEM (0.03%)* | *BT. (0.03%)* | *DDVP (0.05%)* | *CARBARYL (0.01%)* | *ENDOSULFAN (0.05%)* | *QUINALPHOS (0.05%)* | *CONTROL (WATER)* | *MEAN* |
| *Golden Express* | | | | | | | | |
| *0* | *68.00* | *58.00* | *73.00* | *10.01* | *85.00* | *96.00* | *256.00* | *106.43* |
| 40 | 80.00 | 68.00 | 86.00 | 122.00 | 97.00 | 110.00 | 282.00 | 120.71 |
| 60 | 85.00 | 74.00 | 93.00 | 129.00 | 104.00 | 117.00 | 295.00 | 128.14 |
| **Mean** | **77.66** | **66.66** | **84.00** | **120.00** | **95.33** | **107.66** | **277.66** | **118.43** |
| *Golden Acre* | | | | | | | | |
| *0* | *60.00* | *52.00* | *44.00* | *99.00* | *75.00* | *80.00* | *216.00* | *89.43* |
| 40 | 72.00 | 63.00 | 57.00 | 110.00 | 87.00 | 93.00 | 242.00 | 103.43 |
| 60 | 79.00 | 68.00 | 63.00 | 116.00 | 94.00 | 99.00 | 264.00 | 111.86 |
| **Mean** | **70.33** | **61.00** | **54.66** | **108.33** | **85.33** | **90.67** | **240.66** | **103.24** |
| **Potash × Treatment** | | | | | | | | |
| *0* | *64.00* | *55.00* | *58.50* | *104.00* | *80.00* | *88.00* | *235.00* | *97.93* |
| 40 | 76.00 | 65.50 | 73.13 | 116.00 | 92.00 | 101.50 | 262.00 | 112.31 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 60 | 82.00 | 70.00 | 78.00 | 122.50 | 99.00 | 108.00 | 279.5 | 119.80 |
| **Mean** | **74.00** | **63.50** | **69.89** | **114.17** | **90.33** | **99.17** | **259.17** | **110.03** |

*C. D at 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | 0.7929 | Variety× Potash | = | 1.3733 |
| Potash | = | 0.9711 | Variety× Treatment | = | 2.0977 |
| Treatment | = | 1.4833 | Potash × Treatment | = | 2.5692 |
| | | | Variety× Potash× Treatment | = | 3.6334 |

**Table 47: Effect of different level of potash and pesticides on the population of *B. brassicae* on cabbage for the year 2001**

| | | Mean population/ 5 plants ( 20 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS ( KG HA$^{-1}$)*** | ***NEEM (0.03%)*** | ***BT. (0.03%)*** | ***DDVP (0.05%)*** | ***CARBARYL (0.01%)*** | ***ENDOSULFAN (0.05%)*** | ***QUINALPHOS (0.05%)*** | ***CONTROL (WATER)*** | ***MEAN*** |
| *Golden Express* | *0* | *73.00* | *78.00* | *97.0.0* | *138.00* | *114.00* | *120.00* | *252.00* | *124.57* |
| | 40 | 85.00 | 86.00 | 111.00 | 151.00 | 127.00 | 133.00 | 272.00 | 137.86 |
| | 60 | 92.00 | 90.00 | 119.00 | 158.00 | 133.00 | 140.00 | 297.00 | 147.00 |
| | **Mean** | **83.33** | **84.66** | **109.00** | **149.00** | **124.66** | **131.00** | **273.66** | **136.47** |
| *Golden Acre* | *0* | *67.00* | *72.00* | *78.00* | *123.00* | *95.00* | *110.00* | *226.00* | *110.15* |
| | 40 | 80.00 | 85.00 | 91.00 | 137.00 | 109.00 | 124.00 | 253.00 | 125.57 |
| | 60 | 86.00 | 92.00 | 97.00 | 143.00 | 116.00 | 130.00 | 269.00 | 133.28 |
| | **Mean** | **77.66** | **83.00** | **88.66** | **134.33** | **106.66** | **121.33** | **249.33** | **123.00** |
| | | **Potash × Treatment** | | | | | | | |
| | *0* | *70.00* | *75.00* | *87.50* | *130.50* | *104.50* | *114.67* | *239.00* | *117.31* |
| | 40 | 82.5 | 85.5 | 101.00 | 143.67 | 118.00 | 128.50 | 312.33 | 138.79 |
| | 60 | 89.00 | 91.00 | 108.00 | 149.83 | 124.5 | 138.00 | 282.83 | 140.02 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mean** | **80.50** | **83.83** | **98.33** | **141.33** | **115.67** | **126.06** | **278.06** | **132.04** |

*C. D at 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | 0.6142 | Variety× Potash | = | 1.0638 |
| Potash | = | 0.7522 | Variety× Treatment | = | 1.6249 |
| Treatment | = | 1.1490 | Potash × Treatment | = | 1.9901 |
| | | | Variety× Potash× Treatment | = | 2.8144 |

**Table 48: Effect of different level of potash and treatments on the population of *B. brassicae* on cabbage for the year 2002**

| | | Mean population/ 5 plants ( 3 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS ( KG HA$^{-1}$)*** | ***NEEM (0.03%)*** | ***BT. (0.03%)*** | ***DDVP (0.05%)*** | ***CARBARYL (0.01%)*** | ***ENDOSULFAN (0.05%)*** | ***QUINALPHOS (0.05%)*** | ***CONTROL (WATER)*** | ***MEAN*** |
| *Golden Express* | *0* | *118.00* | *112.00* | *75.00* | *106.00* | *82.00* | *92.00* | *190.00* | *110.71* |
| | 40 | 129.00 | 122.00 | 91.00 | 113.00 | 97.00 | 107.00 | 231.00 | 127.14 |
| | 60 | 134.00 | 127.00 | 100.00 | 117.00 | 105.00 | 115.00 | 252.00 | 135.71 |
| | **Mean** | **127.00** | **120.33** | **88.67** | **112.00** | **94.66** | **104.66** | **224.33** | **124.52** |
| *Golden Acre* | *0* | *132.00* | *129.00* | *74.00* | *119.00* | *90.00* | *93.00* | *185.00* | *117.43* |
| | 40 | 149.00 | 144.00 | 89.00 | 134.00 | 108.00 | 110.00 | 206.00 | 134.28 |
| | 60 | 158.00 | 152.00 | 98.00 | 143.00 | 118.00 | 120.00 | 215.00 | 143.43 |
| | **Mean** | **146.33** | **141.66** | **87.00** | **132.00** | **105.33** | **107.66** | **202.00** | **131.71** |
| | | **Potash × Treatment** | | | | | | | |
| | *0* | *125.00* | *120.5* | *74.50* | *114.0* | *86.00* | *92.50* | *187.50* | *114.31* |
| | 40 | 139.00 | 133.00 | 90.00 | 125.00 | 102.50 | 108.50 | 220.0 | 131.19 |
| | 60 | 146.00 | 139.50 | 99.00 | 130.00 | 111.50 | 117.50 | 233.50 | 139.57 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mean** | **136.67** | **131.00** | **87.33** | **123.00** | **100.00** | **106.00** | **213.67** | **128.36** |

*C. D. 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | 0.8240 | Variety× Potash | = | 1.4272 |
| Potash | = | 1.001 | Variety× Treatment | = | 2.1800 |
| Treatment | = | 1.5415 | Potash × Treatment | = | 2.6700 |
| | | | Variety× Potash× Treatment | = | 3.7759 |

**Table 49: Effect of different level of potash and treatments on the population of *B. brassicae* on cabbage for the year 2002**

| | | Mean population/ 5 plants (7 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS ( KG HA$^{-1}$)*** | ***NEEM (0.03%)*** | ***BT. (0.03%)*** | ***DDVP (0.05%)*** | ***CARBARYL (0.01%)*** | ***ENDOSULFAN (0.05%)*** | ***QUINALPHOS (0.05%)*** | ***CONTROL (WATER)*** | ***MEAN*** |
| *Golden Express* | *0* | *46.00* | *42.00* | *53.00* | *83.00* | *59.00* | *73.00* | *234.00* | *84.28* |
| | 40 | 56.00 | 50.00 | 65.00 | 95.00 | 73.00 | 82.00 | 270.00 | 98.71 |
| | 60 | 62.00 | 55.00 | 72.00 | 102.00 | 80.00 | 87.00 | 290.00 | 106.86 |
| | **Mean** | **54.66** | **49.00** | **63.33** | **93.33** | **70.66** | **80.66** | **246.66** | **96.62** |
| *Golden Acre* | *0* | *50.00* | *47.00* | *54.00* | *87.00* | *64.00* | *78.00* | *242.00* | *88.86* |
| | *40* | *58.00* | *54.00* | *66.00* | *98.00* | *75.00* | *89.00* | *263.00* | *100.43* |
| | 60 | 63.00 | 58.00 | 73.00 | 103.00 | 80.00 | 95.00 | 278.00 | 107.14 |
| | **Mean** | **57.00** | **53.00** | **64.33** | **96.66** | **73.00** | **87.33** | **261.00** | **98.14** |
| | | **Potash × Treatment** | | | | | | | |
| | 0 | 49.50 | 44.50 | 53.50 | 86.00 | 61.50 | 75.50 | 238.00 | 86.95 |
| | 40 | 57.00 | 52.00 | 65.50 | 95.00. | 74.00 | 85.50 | 250.00 | 96.98 |
| | 60 | 61.50 | 56.50 | 72.50 | 102.50 | 79.50 | 91.50 | 281.00 | 106.43 |
| | **Mean** | **56.00** | **51.00** | **63.83** | **94.50** | **71.72** | **84.00** | **256.00** | **96.79** |

*C. D. 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | 1.2785 | Variety× Potash | = | 2.2144 |
| Potash | = | 1.5660 | Variety× Treatment | = | 3.3825 |
| Treatment | = | 2.3918 | Potash × Treatment | = | 4.1427 |
| | | | Variety× Potash× Treatment | = | 5.8587 |

**Table 50: Effect of different level of potash and treatments on the population of *B. brassicae* on cabbage for the year 2002**

| | | Mean population/ 5 plants ( 20 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS ( KG HA$^{-1}$)*** | ***NEEM (0.03%)*** | ***BT. (0.03%)*** | ***DDVP (0.05%)*** | ***CARBARYL (0.01%)*** | ***ENDOSULFAN (0.05%)*** | ***QUINALPHOS (0.05%)*** | ***CONTROL (WATER)*** | ***MEAN*** |
| *Golden Express* | *0* | *51.00* | *58.00* | *76.00* | *106.00* | *85.00* | *96.00* | *291.00* | *109.00* |
| | 40 | 62.00 | 71.00 | 88.00 | 119.00 | 98.00 | 107.00 | 332.00 | 125.28 |
| | 60 | 68.00 | 78.00 | 95.00 | 125.00 | 105.00 | 114.00 | 358.00 | 134.86 |
| | **Mean** | **60.33** | **69.00** | **86.33** | **117.00** | **96.00** | **105.66** | **327.00** | **126.04** |
| *Golden Acre* | *0* | *55.00* | *60.00* | *79.00* | *109.00* | *115.00* | *122.00* | *308.00* | *121.14* |
| | 40 | 64.00 | 68.00 | 91.00 | 120.00 | 127.00 | 135.00 | 344.00 | 135.57 |
| | 60 | 68.00 | 73.00 | 98.00 | 126.00 | 134.00 | 143.00 | 364.00 | 143.71 |
| | **Mean** | **62.33** | **67.00** | **89.00** | **118.33** | **125.33** | **133.33** | **338.66** | **133.47** |
| | | **Potash × Treatment** | | | | | | | |
| | *0* | *53.00* | *59.00* | *77.50* | *107.50* | *100.00* | *109.00* | *299.50* | *115.07* |
| | 40 | 63.00 | 69.50 | 89.50 | 119.50 | 112.50 | 121.0 | 338.00 | 130.43 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 60 | 680.00 | 75.5 | 96.50 | 126.00 | 119.50 | 128.50 | 361.00 | 139.29 |
| **Mean** | **61.33** | **68.00** | **87.83** | **117.67** | **110.67** | **119.50** | **332.83** | **128.26** |

*C. D. 5%*

| | | | | | |
|---|---|---|---|---|---|
| Varieties | = | 9.7101 | Variety× Potash | = | 16.8190 |
| Potash | = | 11.8931 | Variety× Treatments | = | 25.6921 |
| Treatments | = | 18.1670 | Potash × Treatments | = | 31.4662 |
| | | | Variety× Potash× Treatments | = | 44.5000 |

**Table 51: Effect of different level of potash and treatments on the population of *P. brassicae* on cabbage for the year 2001**

| | | Mean population/ plant ( 7 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS (KG HA$^{-1}$)*** | ***NEEM 0.03 (%)*** | ***BT. 0.03 (%)*** | ***DDVP 0.05 (%)*** | ***CARBARYL 0.1 (%)*** | ***ENDOSULFAN 0.05 (%)*** | ***QUINALPHOS 0.05 (%)*** | ***CONTROL WATER*** | ***MEAN*** |
| *Golden Express* | *0* | *23* | *20* | *10* | *17* | *13* | *15* | *26* | *17.62* |
| | | (11.5) | (23.1) | (61.5) | (34.6) | (50.0) | (42.3) | -- | (31.86) |
| | 40 | 30 | 26 | 15 | 23 | 18 | 20 | 33 | 23.90 |
| | | (9.1) | (21.2) | (54.5) | (30.3) | (45.4) | (39.4) | -- | (28.56) |
| | 60 | 34 | 29 | 17 | 26 | 20 | 22 | 37 | 26.48 |
| | | (8.1) | (21.6) | (54.0) | (29.7) | (49.9) | (40.5) | -- | (29.11) |
| | **Mean** | **29** | **25** | **14** | **22** | **17** | **19** | **32** | **22.67** |
| | | **(9.6)** | **(21.9)** | **(56.7)** | **(31.5)** | **(31.8)** | **(40.7)** | **--** | **(29.84)** |
| *Golden Acre* | *0* | *19* | *18* | *16* | *18* | *12* | *13* | *23* | *15.86* |
| | | (17.4) | (21.7) | (30.4) | (21.7) | (47.8) | (43.5) | -- | (26.07) |
| | 40 | 28 | 26 | 23 | 25 | 18 | 19 | 32 | 23.19 |
| | | (12.5) | (18.7) | (28.1) | (21.9) | (43.7) | (40.6) | -- | (20.51) |
| | 60 | 34 | 31 | 27 | 29 | 21 | 22 | 35 | 29.19 |
| | | (2.8) | (11.4) | (22.8) | (14.3) | (40.0) | (37.1) | -- | (18.34) |
| | **Mean** | **27** | **25** | **22** | **24** | **17** | **18** | **34** | **22.75** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(10.9)** | **(17.3)** | **(27.1)** | **(19.3)** | **(43.8)** | **(40.4)** | **--** | **(21.64)** |
| | | | | **Potash × Treatment** | | | | |
| *0* | *20.83* | *19.00* | *10.00* | *16.50* | *12.50* | *14.00* | *24.83* | *16.81* |
| | (16.11) | (23.48) | (59.73) | (33.55) | (49.66) | (43.62) | -- | (32.31) |
| 40 | 28.67 | 26.00 | 15.50 | 23.00 | 16.00 | 19.50 | 34.17 | 23.55 |
| | (16.09) | (23.91) | (54.64) | (32.69) | (52.68) | (42.93) | -- | (31.85) |
| 60 | 34.67 | 30.5 | 19.00 | 27.67 | 21.50 | 23.50 | 38.00 | 27.83 |
| | (8.76) | (19.74) | (50.0) | (27.18) | (43.42) | (38.16) | -- | (26.75) |
| **Mean** | **28.07** | **25.17** | **14.83** | **22.39** | **17.33** | **19.00** | **32.33** | **22.73** |
| | **(13.65)** | **(22.38)** | **(54.79)** | **(31.14)** | **(48.59)** | **(41.57)** | **(--** | **(30.30)** |

*C. D at 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | NS | Variety× Potash | = | 1.648 |
| Potash | = | 1.165 | Variety× Treatments | = | 2.517 |
| Treatments | = | 1.780 | Potash × Treatments | = | 3.083 |
| | | | Variety× Potash× Treatments | = | 4.360 |

*Values in parenthesis denote percent mortality by application of treatment as compared to control

**Table 52: Effect of different level of potash and treatments on the population of *P. brassicae* on cabbage for the year 2001**

| | | Mean population/ plant ( 7 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS (KG HA$^{-1}$)*** | ***NEEM 0.03 (%)*** | ***BT. 0.03 (%)*** | ***DDVP 0.05 (%)*** | ***CARBARYL 0.1 (%)*** | ***ENDOSULFAN 0.05 (%)*** | ***QUINALPHOS 0.05 (%)*** | ***CONTROL WATER*** | ***MEAN*** |
| *Golden Express* | *0* | *8* | *7* | *11* | *14* | *13* | *15* | *28* | *13.38* |
| | | (71.4) | (75.0) | (60.7) | (50.0) | (53.67) | (46.40) | -- | (51.02) |
| | 40 | 10 | 9 | 13 | 16 | 15 | 18 | 34 | 16.43 |
| | | (49.8) | (73.5) | (61.8) | (52.9) | (55.9) | (47.0) | -- | (48.7) |
| | 60 | 12 | 11 | 15 | 18 | 17 | 21 | 37 | 18.71 |
| | | (67.6) | (70.2) | (59.4) | (51.3) | (54.0) | (43.0) | -- | (49.38) |
| | **Mean** | **10** | **9** | **13** | **16** | **15** | **17** | **33** | **16.17** |
| | | **(62.9)** | **(72.9)** | **(60.6)** | **(54.4)** | **(54.5)** | **(45.5)** | **--** | **(49.70)** |
| *Golden Acre* | *0* | *7* | *8* | *12* | *15* | *13* | *17* | *31* | *14.71* |
| | | (77.4) | (74.2) | (61.3) | (51.6) | (58.1) | (45.2) | -- | (52.54) |
| | 40 | 7 | 9 | 13 | 16 | 16 | 19 | 34 | 16.19 |
| | | (79.4) | (73.5) | (61.8) | (52.9) | (52.9) | (44.1) | -- | (52.08) |
| | 60 | 10 | 10 | 17 | 20 | 19 | 21 | 40 | 19.62 |
| | | (75.0) | (75.0) | (57.5) | (50.0) | (52.5) | (47.5) | -- | (51.00) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mean** | **8** | **9** | **14** | **17** | **16** | **19** | **35** | **16.84** |
| | **(77.3)** | **(74.2)** | **(60.2)** | **(51.5)** | **(54.5)** | **(45.6)** | **--** | **(51.87)** |
| | | | | **Potash × Treatment** | | | | |
| *0* | *7.83* | *7.50* | *11.50* | *14.50* | *11.50* | *16.00* | *29.50* | *14.05* |
| | (73.46) | (74.58) | (61.02) | (50.85) | (61.02) | (45.76) | -- | (52.38) |
| 40 | 8.50 | 9.00 | 13.17 | 16.00 | 15.50 | 18.50 | 33.50 | 16.31 |
| | (74.63) | (73.13) | (60.69) | (52.24) | (53.73) | (44.78) | -- | (51.30) |
| 60 | 11.50 | 10.50 | 16.17 | 19.00 | 17.00 | 20.50 | 39.50 | 16.17 |
| | (70.89) | (77.21) | (59.06) | (48.10) | (56.96) | (51.90) | -- | (52.02) |
| **Mean** | **9.28** | **9.00** | **13.61** | **16.50** | **14.67** | **18.33** | **34.17** | **15.51** |
| | **(72.99)** | **(74.97)** | **(60.26)** | **(50.39)** | **(57.24)** | **(47.48)** | **--** | **(51.90)** |

*C. D at 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | NS | Variety× Potash | = | 1.466 |
| Potash | = | 1.037 | Variety× Treatment | = | 2.240 |
| Treatment | = | 1.584 | Potash × Treatment | = | 2.743 |
| | | | Variety× Potash× Treatment | = | 3.879 |

*Values in parenthesis denote percent mortality by application of treatment as compared to control

**Table 53: Effect of different level of potash and treatment on the population of *P. brassicae* on cabbage for the year 2001**

| | | Mean population/plant ( 20 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS (KG HA$^{-1}$)*** | ***NEEM 0.03 (%)*** | ***BT. 0.03 (%)*** | ***DDVP 0.05 (%)*** | ***CARBARYL 0.1 (%)*** | ***ENDOSULFAN 0.05 (%)*** | ***QUINALPHOS 0.05 (%)*** | ***CONTROL WATER*** | ***MEAN*** |
| *Golden Express* | *0* | *13* | *22* | *24* | *26* | *28* | *30* | *37* | *25.60* |
| | | ((64.9) | (40.5) | (35.1) | (29.7) | (24.3) | (18.9) | -- | (30.48) |
| | 40 | 16 | 25 | 27 | 29 | 31 | 32 | 41 | 28.60 |
| | | (61.0) | (39.0) | (34.1) | (29.3) | (24.4) | (21.9) | -- | (29.96) |
| | 60 | 19 | 28 | 30 | 32 | 34 | 34 | 45 | 31.40 |
| | | (57.8) | (37.8) | (33.3) | (28.9) | (24.4) | (24.4) | -- | (29.51) |
| | **Mean** | **16** | **25** | **27** | **29** | **31** | **32** | **41** | **28.50** |
| | | **(61.2)** | **(39.1)** | **(34.2)** | **(29.3)** | **(24.3)** | **(21.7)** | **--** | **(29.98)** |
| *Golden Acre* | *0* | *12* | *22* | *26* | *27* | *30* | *34* | *39* | *27.14* |
| | | (69.2) | (43.6) | (33.3) | (30.8) | (23.1) | (12.8) | -- | (30.40) |
| | 40 | 14 | 24 | 28 | 32 | 34 | 38 | 44 | 29.81 |
| | | (68.2) | (45.4) | (36.4) | (27.3) | (22.7) | (13.6) | -- | (30.51) |
| | 60 | 16 | 26 | 30 | 34 | 35 | 39 | 46 | 33.05 |
| | | (65.2) | (43.5) | (34.8) | (26.0) | (23.9) | (15.2) | -- | (29.80) |
| | **Mean** | **14** | **24** | **28** | **31** | **33** | **37** | **43** | **30.00** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(67.5)** | **(44.1)** | **(34.8)** | **(28.0)** | **(23.2)** | **(13.9)** | **--** | **(30.2)** |
| | | | | **Potash × Treatment** | | | | |
| *0* | *12.50* | *22.00* | *25.00* | *26.50* | *29.00* | *32.60* | *37.67* | *26.38* |
| | (66.8) | (41.6) | (33.6) | (29.6) | (23.0) | (13.45) | -- | (29.7) |
| 40 | 15.83 | 24.50 | 27.50 | 30.5 | 31.50 | 34.50 | 40.00 | 29.19 |
| | (60.4) | (38.7) | (31.2) | (23.7) | (21.2) | (13.7) | -- | (27.0) |
| 60 | 18.00 | 26.00 | 30.00 | 33.00 | 35.50 | 38.00 | 46.50 | 32.43 |
| | (61.3) | (44.0) | (35.5) | (29.0) | (23.6) | (18.3) | -- | (30.2) |
| **Mean** | **15.44** | **24.17** | **27.50** | **30.00** | **32.00** | **34.83** | **41.39** | **29.33** |
| | **(62.8)** | **(41.4)** | **(33.4)** | **(27.4)** | **(22.6)** | **(15.1)** | **-** | **(28.9)** |

*C. D at 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | NS | Variety× Potash | = | 1.88698 |
| Potash | = | 1.33429 | Variety× Treatment | = | 2.88241 |
| Treatment | = | 2.03817 | Potash × Treatment | = | 3.53020 |
| | | | Variety× Potash× Treatment | = | 4.99250 |

*Values in parenthesis denote percent mortality by application of treatment as compared to control

**Table 54: Effect of different level of potash and treatments on the population of *P. brassicae* on cabbage for the year 2002**

| | | Mean population/plant ( 3days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS (KG HA$^{-1}$)*** | ***NEEM 0.03 (%)*** | ***BT. 0.03 (%)*** | ***DDVP 0.05 (%)*** | ***CARBARYL 0.1 (%)*** | ***ENDOSULFAN 0.05 (%)*** | ***QUINALPHOS 0.05 (%)*** | ***CONTROL WATER*** | ***MEAN*** |
| *Golden Express* | *0* | *17* | *15* | *10* | *14* | *11* | *12* | *21* | *14.28* |
| | | *(19.0)* | *(28.6)* | *(52.4)* | *(33.3)* | *(47.6)* | *(42.8)* | -- | *(32.0)* |
| | 40 | 25 | 23 | 14 | 22 | 18 | 20 | 29 | 21.57 |
| | | (13.8) | (20.7) | (51.7) | (24.1) | (37.9) | (31.0) | -- | (25.6) |
| | 60 | 29 | 27 | 16 | 26 | 21 | 24 | 33 | 25.14 |
| | | (12.1) | (18.2) | (51.5) | (21.2) | (36.7) | (27.3) | -- | (23.8) |
| | **Mean** | **23.67** | **21.67** | **10.0** | **20.67** | **16.67** | **18.67** | **27.67** | **20.33** |
| | | **(15.0)** | **(22.5)** | **(51.9)** | **(26.2)** | **(40.7)** | **(33.7)** | **--** | **(27.1)** |
| *Golden Acre* | *0* | *21* | *19* | *10* | *16* | *11* | *14* | *25* | *16.57* |
| | | (16.0) | (24.0) | (60.0) | (36.0) | (56.0) | (44.0) | -- | (33.7) |
| | 40 | 30 | 28 | 18 | 25 | 20 | 23 | 35 | 25.57 |
| | | (14.2) | (20.0) | (48.6) | (28.6) | (42.8) | (34.2) | -- | (26.9) |
| | 60 | 34 | 32 | 22 | 30 | 25 | 28 | 40 | 30.14 |
| | | (15.0) | (20.0) | (45.0) | (75.0) | (37.5) | (30.0) | -- | (31.8) |
| | **Mean** | **28.33** | **26.33** | **16.67** | **23.67** | **18.67** | **21.67** | **33.33** | **24.09** |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **(15.1)** | **(21.3)** | **(51.2)** | **(46.5)** | **(45.4)** | **(36.1)** | **--** | **(30.8)** |
| | | | | **Potash × Treatment** | | | | |
| *0* | *19.00* | *18.67* | *10.00* | *15.00* | *11.00* | *13.00* | *23.00* | *15.67* |
| | (17.4) | (18.8) | (56.5) | (34.8) | (17.7) | (43.5) | -- | (26.9) |
| 40 | 30.00 | 27.50 | 16.50 | 24.50 | 19.00 | 22.50 | 33.50 | 24.78 |
| | (10.4) | (17.9) | (50.7) | (26.9) | (43.3) | (32.8) | -- | (26.0) |
| 60 | 32.00 | 29.00 | 18.17 | 25.83 | 22.00 | 25.67 | 36.50 | 27.02 |
| | (12.3) | (20.5) | (50.2) | (29.2) | (39.7) | (29.7) | -- | (25.9) |
| **Mean** | **27.00** | **25.06** | **14.89** | **21.78** | **17.33** | **20.39** | **31.00** | **22.49** |
| | **(13.4)** | **(19.1)** | **(52.5)** | **(30.3)** | **(33.2)** | **(35.3)** | **--** | **(26.3)** |

*C. D at 5%*

| | | | | | | |
|---|---|---|---|---|---|---|
| Varieties | = | 1.8574 | Variety× Potash | = | 1.65367 | |
| Potash | = | 1.1693 | Variety× Treatments | = | 2.52604 | |
| Treatments | = | 1.7862 | Potash × Treatments | = | 3.09370 | |
| | | | Variety× Potash× Treatments | = | 4.37520 | |

*Values in parenthesis denote percent mortality by application of treatment as compared to control

**Table 55: Effect of different level of potash and treatments on the population of *P. brassicae* on cabbage for the year 2002**

| | | Mean population/ plant ( 7 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS (KG HA$^{-1}$)*** | ***NEEM 0.03 (%)*** | ***BT. 0.03 (%)*** | ***DDVP 0.05 (%)*** | ***CARBARYL 0.1 (%)*** | ***ENDOSULFAN 0.05 (%)*** | ***QUINALPHOS 0.05 (%)*** | ***CONTROL WATER*** | ***MEAN*** |
| *Golden Express* | *0* | *8* | *6* | *11* | *14* | *12* | *15* | *28* | *13.42* |
| | | *(71.4)* | *(78.6)* | *(60.7)* | *(50.0)* | *(57.1)* | *(46.40)* | -- | *(52.0)* |
| | 40 | 10 | 8 | 13 | 18 | 16 | 19 | 34 | 16.85 |
| | | (70.6) | (76.5) | (61.8) | (47.0) | (52.9) | (44.1) | -- | (50.4) |
| | 60 | 11 | 9 | 14 | 20 | 18 | 21 | 36 | 18.43 |
| | | (69.4) | (75.0) | (61.1) | (44.4) | (50.) | (41.7) | -- | (48.8) |
| | **Mean** | **9.67** | **7.67** | **12.67** | **17.33** | **15.33** | **18.33** | **32.67** | **16.23** |
| | | **(70.5)** | **(76.7)** | **(61.2)** | **(47.1)** | **(53.3)** | **(44.1)** | **--** | **(50.4)** |
| Golden Acre | 0 | 6 | 5 | 10 | 15 | 13 | 17 | 29 | 13.57 |
| | | (79.3) | (82.7) | (65.5) | (48.3) | (55.2) | (41.4) | -- | (53.2) |
| | 40 | 8 | 7 | 13 | 18 | 16 | 20 | 35 | 16.71 |
| | | (77.1) | (80.0) | (62.8) | (48.5) | (54.3) | (42.8) | -- | (52.2) |
| | 60 | 9 | 8 | 14 | 20 | 17 | 21 | 38 | 18.14 |
| | | (76.3) | (78.9) | (63.1) | (47.4) | (55.3) | (44.7) | -- | (52.2) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mean** | **7.67** | **6.67** | **12.33** | **17.67** | **15.33** | **19.33** | **34.3** | **16.14** |
| | **(77.6)** | **(87.2)** | **(63.8)** | **(48.1)** | **(54.9)** | **(42.9)** | **--** | **(52.5)** |
| | | | | Potash × Treatment | | | | |
| *0* | *7.00* | *5.50* | *10.50* | *14.50* | *12.50* | *16.00* | *28.50* | *13.50* |
| | (75.4) | (80.7) | (63.1) | (49.1) | (56.1) | (43.8) | -- | (52.6) |
| 40 | 8.50 | 7.00 | 13.33 | 16.50 | 13.17 | 18.50 | 34.17 | 15.88 |
| | (75.1) | (79.5) | (61.0) | (51.7) | (61.4) | (45.8) | -- | (53.5) |
| 60 | 9.00 | 8.00 | 15.17 | 18.00 | 15.83 | 21.50 | 35.50 | 17.57 |
| | (74.6) | (77.5) | (57.3) | (49.3) | (55.4) | (39.4) | -- | (50.5) |
| **Mean** | **8.17** | **6.83** | **13.0** | **16.33** | **13.83** | **18.67** | **32.72** | **15.65** |
| | **(75.0)** | **(79.2)** | **(60.5)** | **(50.0)** | **(57.6)** | **(43.0)** | **--** | **(52.2)** |

*C. D. 5%*

| | | | | | |
|---|---|---|---|---|---|
| Variety | = | NS | Variety× Potash | = | 1.44164 |
| Potash | = | 1.01939 | Variety× Treatment | = | 2.20210 |
| Treatment | = | 1.55715 | Potash × Treatment | = | 2.69710 |
| | | | Variety× Potash× Treatment | = | 3.81420 |

*Values in parenthesis denote percent mortality by application of treatment as compared to control

**Table 56: Effect of different level of potash and treatments on the population of *P. brassicae* on cabbage for the year 2002**

| | | Mean population/ plant ( 20 days after treatment) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***VARIETY*** | ***TREATMENT*** | | | | | | | |
| | ***POTASH LEVELS (KG HA$^{-1}$)*** | ***NEEM 0.03 (%)*** | ***BT. 0.03 (%)*** | ***DDVP 0.05 (%)*** | ***CARBARYL 0.1 (%)*** | ***ENDOSULFAN 0.05 (%)*** | ***QUINALPHOS 0.05 (%)*** | ***CONTROL WATER*** | ***MEAN*** |
| *Golden Express* | *0* | *14* | *17* | *22* | *24* | *25* | *26* | *46* | *24.86* |
| | | (69.6) | (63.0) | (52.2) | (47.8) | (45.6) | (43.5) | -- | (45.9) |
| | 40 | 18 | 20 | 25 | 28 | 29 | 30 | 54 | 29.14 |
| | | (66.7) | (63.0) | (53.7) | (48.1) | (46.3) | (44.4) | -- | (46.0) |
| | 60 | 19 | 20 | 29 | 29 | 30 | 31 | 59 | 30.85 |
| | | (67.8) | (66.1) | (50.8) | (50.8) | (49.1) | (47.4) | -- | (47.4) |
| | **Mean** | **17.0** | **19.0** | **25.0** | **27.0** | **28.0** | **29.0** | **53.0** | **28.28** |
| | | **(68.0)** | **(64.0)** | **(52.2)** | **(48.9)** | **(47.0)** | **(45.1)** | **--** | **(46.4)** |
| *Golden Acre* | *0* | *11* | *15* | *19* | *22* | *26* | *28* | *50* | *24.43* |
| | | (78.0) | (70.0) | (62.0) | (56.0) | (48.0) | (44.0) | -- | (51.1) |
| | 40 | 15 | 20 | 24 | 28 | 31 | 33 | 56 | 29.57 |
| | | (73.2) | (64.3) | (57.1) | (50.0) | (44.6) | (41.0) | -- | (47.2) |
| | 60 | 16 | 22 | 26 | 31 | 33 | 35 | 50 | 31.71 |
| | | (68.0) | (56.0) | (48.0) | (38.0) | (34.0) | (30.0) | -- | (39.1) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Mean** | **14.0** | **19.0** | **23.0** | **27.0** | **30.0** | **32.0** | **55.0** | **28.57** |
| | **(73.1)** | **(63.4)** | **(55.7)** | **(48.0)** | **(42.2)** | **(38.33)** | **--** | **(45.8)** |
| | | | | **Potash × Treatment** | | | | |
| *0* | *13.00* | *17.50* | *22.00* | *27.50* | *26.00* | *25.50* | *49.50* | *25.86* |
| | (73.7) | (64.6) | (55.5) | (44.4) | (47.5) | (48.5) | -- | (47.5) |
| 40 | 14.50 | 19.50 | 25.50 | 29.00 | 28.00 | 30.50 | 56.50 | 29.07 |
| | (74.3) | (65.5) | (54.9) | (48.7) | (49.5) | (46.0) | -- | (48.4) |
| 60 | 16.00 | 21.50 | 27.50 | 30.50 | 30.00 | 32.50 | 57.50 | 30.78 |
| | (72.2) | (62.6) | (52.2) | (46.9) | (47.8) | (43.5) | -- | (46.4) |
| **Mean** | **14.50** | **19.50** | **25.00** | **29.00** | **28.00** | **29.50** | **54.50** | **28.57** |
| | **(73.4)** | **(64.2)** | **(54.2)** | **(46.7)** | **(48.3)** | **(46.0)** | **--** | **47.4)** |

*C. D. 5%*

| | | | | | | |
|---|---|---|---|---|---|---|
| Variety | = | NS | Variety× Potash | = | 2.06361 | |
| Potash | = | 1.45919 | Variety× Treatment | = | 3.15220 | |
| Treatment | = | 2.22895 | Potash × Treatment | = | 3.86070 | |
| | | | Variety× Potash× Treatment | = | 5.45980 | 2.74348 |

*Values in parenthesis denote percent mortality by application of treatment as compared to control