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Oviposition and Larval Development of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) in Relation With Chickpea, *Cicer arietinum* L. (Fabaceae) Crop Phenology

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Abstract.- This paper presents five years (1994-1998) studies conducted on natural infestation of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on different growing stages of chickpea *Cicer arietinum* (Fabaceae). The studies revealed that the oviposition peak of *H. armigera* was presented during 1st to 3rd week of April at 60 to 100% flowering and 30 to 70% podding stage of the crop. The population peak of 2nd instar larvae was noted between 15 April 1997 (earliest) and 27 April 1995 (latest) generally at full podding stage and the population peak of 3rd instar larvae was 1st fortnight of April to 19 April 1995 to 3 April 1991 (latest) over the study period. The population peak of 4th instar was recorded from 03 May (earliest in 1995) to 26 May (latest in 1996) at full podding and 15% maturity of the crop. Highly significant linear regression and coefficient of determination were $R^2 = 0.3553$ at $p < 0.01$ d.f. = 17, $R^2 = 0.6825$ at $p < 0.001$ d.f. = 16, $R^2 = 0.7611$ at $p < 0.001$ d.f. = 21, $R^2 = 0.5521$ at $p < 0.001$ d.f. = 25 and $R^2 = 0.8168$ at $p < 0.001$ d.f. = 20 for year 1, 2, 3, 4 and 5, respectively between *H. armigera* trap catch population and number of egg $plant^{-1}$. The linear regressions between the number of adults and 1st instar larvae were significant at $p < 0.05$ and $p < 0.001$ with significant positive correlation ($r = 0.59$, $r = 0.57$, $r = 0.80$, $r = 0.71$ and $r = 0.92$ in year 1, 2, 3, 4 and 5, respectively) and regression trends between eggs and 1st instar were significant at $p < 0.05$, $p < 0.001$, $p<0.001$ and $p<0.001$ with $r = 0.43$, $r = 0.74$, $r = 0.69$, and $r = 0.89$ in year 2, 3, 4 and 5, respectively. The results of this study could be helpful in launching appropriate, economical and environmentally non-disruptive insect pest management practices with special reference to management of *H. armigera* in an integrated pest management (IPM) programmes.

Key words: Oviposition, *Helicoverpa armigera,* intergrated pest management, phenology, chickpea.

INTRODUCTION

Chickpea, *Cicer arietinum* L. (Fabaceae) is an important grain legume crop grown in Pakistan. This crop is not only cultivated in Pakistan but it is also grown in South Asian countries (Bangladesh, India, Myanmar and Nepal) accounting for about 87% of the world area of the crop (FAO, Crop Production, 2010). The total area under chickpea crop in 2010 was 1093.9 thousand hectares with chickpea production of 868.2 thousand tones (Anonymous, 2010).

The crop is normally grown rainfed in the postrainy season (October-March) in Pakistan with minimal inputs of fertilizer or pesticides and relegated to marginal lands, due to its displacement from irrigated and better water-endowed lands by higher and more stable yielding crops such as wheat (Kelley *et al.*, 2000). The crop continues to be grown largely as a subsistence crop by resource-poor farmers. The major constraints leading to low and unstable yields of chickpea are drought stress, foliar diseases (*e.g.*, ascochyta blight caused by *Ascochyta rabiei* (Pass.) Labr. and botrytis gray mold caused by *Botrytis cinerea* Pers. Ex Fr., soil-borne diseases (*e.g.*, fusarium wilt caused by *Fusarium oxysporum* Schl.) and insect pests (Johansen *et al.*, 1994). Chickpea is normally grown with minimal inputs of fertilizer or pesticides and is being increasingly relegated to marginal lands, due to its displacement from irrigated and better water-endowed lands by higher and more stable yielding crops such as wheat (Kelley *et al.*, 2000). Dent (1985) reported population studies of *Helicoverpa armigera* through pheromone trap catches and larval counts (from 1981-1984) three consecutive chickpea seasons at International Crop Research Institute for the Semi-Arid Tropics, India. He stated that peak

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catch occurred during 19-25 Nov in 1981 with a peak catch of 859 moths, 17-23 Dec in 1982 with a peak catch of 1178 moths and 3-9 Dec in 1983 with catch of 137 moths and he further stated that the trend in the size of the peak trap catch corresponded to the trend in total mean larval number but the time of peak catch did not seem to have any relation to the size of the peak catch.

Chickpea can be host to a wide range of insect pests (Reed *et al.,* 1987; Ranga Rao, 1999) but acid exudation from above-ground plant parts probably acts as a partial deterrent to many of these (Reed *et al.* 1987). By far the most economically important insect pest of chickpea is the pod borer, *H. armigera* (Hübner) (Lepidoptera: Noctuidae). Substantial yield losses due to *H. armigera* have been reported by many authors across South Asia, for example, in various chickpea growing areas of India, yield losses in particular fields or plots in the range of 10-85% have been documented (Reed, 1983; Ahmed, 1984; Lal *et al.,* 1985; Yadava and Lal, 1997). In Bangladesh and Nepal, chickpea pod damage due to *Helicoverpa* pod borer in unprotected farmers' fields has been in the range of 5-15% in recent seasons (Musa, 2000; Pande and Narayana Rao, 2000). In Northern Pakistan, up to 90% pod damage due to *H. armigera* has been recorded in unprotected chickpea fields (Ahmed *et al.,* 1986; Anonymous, 1987, 1998).

In Pakistan, during chickpea season 2001-2002, an outbreak of *H. armigera* was reported by farmers growing chickpea near cotton areas (Anonymous, 2002). Substantial yield losses due to this pest have been reported in areas where the crop is grown in Pakistan (Abbasi *et al*., 2001a,b, 2007; Ahmed *et al*., 1993, 1996, 1998, 2006; Khalique and Ahmed, 2003; Ahmed and Khalique, 2002).

This paper presents five years of studies (1994-1998) conducted on natural infestation of *H. armigera* on different growing stages of chickpea crop with respect to relationship between chickpea crop phenology and *H. armigera* infestation, relationship between adult population and oviposition on chickpea crop, relationship between adult population and 1st and 2nd instar larvae on chickpea crop, and relationship between eggs and larval instars (1st to 3rd) on chickpea crop. The results of these studies could be proved to be helpful in launching appropriate and economical insect pest management practices with special reference to management of chickpea pod borer using environmentally safe Integrated Insect Pests Management practices (non-hazardous to the environment, no air and soil pollution and no phytotoxicity).

MATERIALS AND METHODS

Sampling for monitoring oviposition and instar-wise larval densities of *H. armigera* were initiated in the last week of March every year (usually near the start of oviposition and hatching) from year 1 (1994), to year 5 (1998) successive chickpea seasons. Thrice a week, twenty five plants were randomly pulled out from the unsprayed chickpea plot at National Agricultural Research Center, Islamabad City. Each plant was vigorously taped from above on white plastic sheet. Thus, the larvae dropped on the sheet were counted instar-wise. The eggs plant^{-1} were also counted and recorded. The sampling was carried out up to the 4th week of May (the time when chickpea crop attained full maturity). The data of this study were recorded over a period of successive five years through five chickpea seasons and the data were Statistically analysed using Microsoft Excel 97 computer programme. The study was done over a period of five years 1994-1998.

RESULTS AND DISCUSSION

Trends of egg laying and larval development in relation to chickpea crop phenology

The results illustrated in (Fig. 1) indicated a general trends of relationship between chickpea crop phenology and *H. armigera* infestation (egg and 1st to 5th instar larval infestation) from year 1 to year 5. The data given in Figure 1 indicated that the moth started egg laying during 2nd to 4th week of March (from 13 March 1994, 23 March 1995, 17 March 1996, 22 March 1997 and 27 March when the crop was at 10 to 15% flowering stage during year 1 to year 5 (Fig. 1). The oviposition peak was observed during 1st to 3rd week of April at 60 to 100% flowering and 30 to 70% podding stage of the crop (Fig. 1). As per observation taken on 25 plants (on

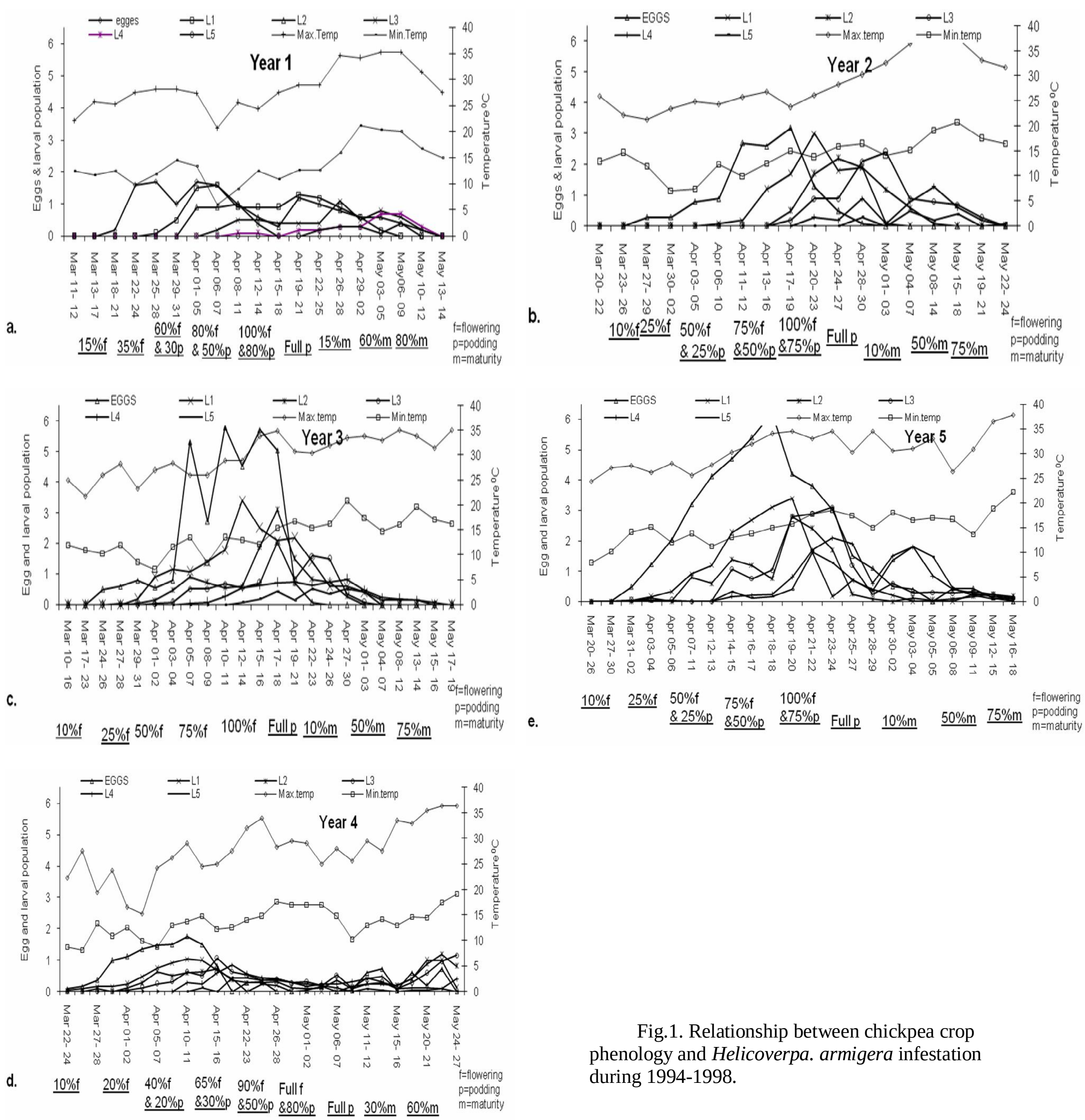

Fig.1. Relationship between chickpea crop phenology and *Helicoverpa. armigera* infestation during 1994-1998.

the basis of presence/absence of eggs), the end of egg laying varied from year to year (from 18 April to 23 May). At the end of oviposition, the crop phenology also varied from 100% podding 75% maturity over five years period depending upon the prevailing minimum and maximum temperature ranges of respective chickpea season.

The earliest appearance of 1st instar larvae was recorded on 25 March 1994 and the latest on 6 April 1995 on chickpea plants during 10 to 25% flowering stage of the crop. Peak population of 1st instar larvae was noted from 7 to 23 April at 40 to 100% flowering and 20 to 75% podding stage of the crop. The population of 1st instar larvae gradually came to an end between 01 May 1994 (earliest) and 27 May 1997 (latest) when the crop was at full podding and 60% maturity stage (Fig. 1).

Infestation of 2nd instar larvae was observed from 28 March 1997 (earliest) and 17 April 1998 (latest) at 25 to 50% flowering and 20 to 30% podding stage (Fig. 1). The peak population of 2nd instar larvae was noted between 15 April, 1997 (earliest) and 27 April, 1995 (latest) generally at full podding stage and the population of this instar came to an end between 6 May (earliest) to 30 May (latest) during year 1 to year 5 (Fig. 1).

Third instar larval infestation was recorded during 1st fortnight of April (from 03 April 1996 (earliest) to 19 April 1995 (latest) over the study period (Fig. 1) and reached at peak population level between 15 April 1997 and 03 May 1995 at full podding stage of the crop. The 3rd instar larval population ended in May (from 07 to 27 May).

The infestation of fourth instar population varied between 08 April 1994 (earliest) and 23 April 1995. The population peak of 4th instar was recorded from 03 May (earliest 1994) to 26 May (latest in 1996 at full podding and 15% maturity of the crop. The population of 4th instar gradually ended during the 2nd fortnight of May (Fig. 1). The initiation of 5th instar population was noted from 12 April of year 3 and year 4 (earliest) to 30 April 1995 (latest). Population Peak was observed between the last week of April and 1st week of May at 50 to 75% maturity of the crop and presence of 5th instar continued till harvest of the crop.

The regression analysis between the number of *H. armigera* adults (on the basis of trap catch population) and the number of eggs plant^{-1} (Fig. 2). The relationship between the two parameters was found highly significant in all the years. The linear regression equations were $y = 0.0268x+0.0867$ $R^2 = 0.3553$ at $p <0.01$ d.f. = 17, $y = 0.0272x-0.4723$ $R^2 = 0.6824$ at $p <0.001$ d.f. = 16, $y = 0.0401x-0.8011$ $R^2 = 0.7611$ at $p <0.001$ d.f. = 21, $y = 0.0441x+0.1698$ $R^2 = 0.5521$ at $p <0.001$ d.f. = 25 and $y = 0.0331x+0.5374$ $R^2 = 0.8168$ at $p <0.001$ d.f. = 20 for year 1 (1994), year 2 (1995), year 3 (1996) to 5 (1998), respectively.

The relationships among number of *H. armigera* adult population, 1st and 2nd instar larvae were shown in Figure 3. The linear regressions between the number of adults and 1st instar larvae were significant at $p<0.05$ and $p<0.001$ from year 1 to 5. The regression trend lines between the adults and number of 2nd instar larvae were also significant at $p<0.05$ and $p<0.001$ for 1996, 1998. Highly significant regression trends among the eggs and 1st to 3rd instars (Fig. 3) were noted. Regression trends between eggs and 1st instar were significant at $p <0.05$, $p <0.001$, $p <0.001$ and $p <0.001$ in year 2 to year 5, respectively. The relationship between the number of eggs and 2nd instars were also highly significant at $p <0.001$ in 1996 and 1998. In years 1 and 4, the number of 1st and 2nd instar larval populations were observed to be significantly low as compared to the larval populations of years 2 and 3. The reason for low populations in years 1 and 4 may be due to high minimum and maximum ranges of temperatures during the month of March (Fig. 3 and Fig. 1). Regression trends between the eggs and 3rd instars were significant at $p<0.05$ in 1994, 1996 and 1998 (Fig. 4).

The oviposition peak of *H. armigera* was observed between 1st to 3rd week of April at 60 to 100% flowering and 30 to 70% podding stage of the crop (Fig. 1). This was interesting to note that moth appearance always coincided with initiation of flowering of the crop irrespective of the fact that how early or late the crop starts flowering. Larvae population (from 1st to 5th instars) started appearing from 5th March (earliest) and continued till the crop was harvested (24 May) at 80% maturity of the crop (Fig. 1). The pattern of larval infestation on the chickpea crop was of the regular type and, thereafter, the infestation became contiguous on matured crop. Thus, we agree with Kaushik and Naresh (1984) who reported a regular distribution pattern at higher densities of larval population of *H. armigera* and contiguous during last week on matured chickpea crop with few green plants.

One of the main criteria for any monitoring system used for forecasting trap captures, eggs and larval population should have consistency between the trap catch and corresponding infestation estimate. Sixteen years research experience of the authors on chickpea indicated that there was observed a clear relationship between the chickpea phenology and pest behavioural showing that *H. armigera* appeared to have an instinctive

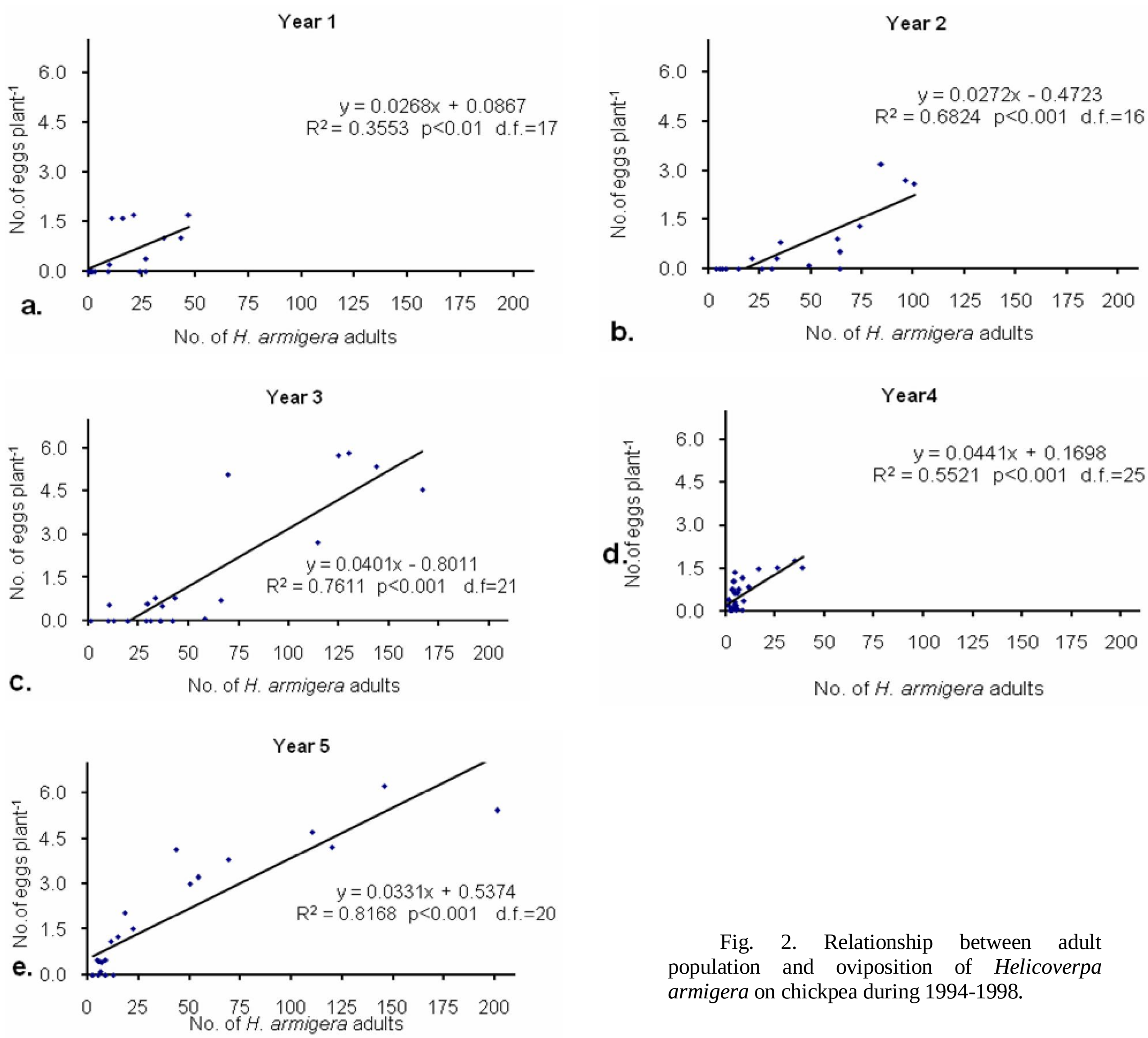

Fig. 2. Relationship between adult population and oviposition of *Helicoverpa armigera* on chickpea during 1994-1998.

behavioural association with the developmental stages of chickpea crop (Ahmed and Khalique, 2002).

Highly significant linear regression and coefficient of determination $R^2 = 0.3553$ at $p < 0.01$ d.f. = 17, $R^2 = 0.6825$ at $p < 0.001$ d.f. = 16, $R^2 = 0.7611$ at $p < 0.001$ d.f. = 21, $R^2 = 0.5521$ at $p < 0.001$ d.f. = 25 and $R^2 = 0.8168$ at $p < 0.001$ d.f.=20 for year 1 to 5, respectively were observed between *H. armigera* trap catch population and number of eggs plant^{-1} (Fig. 2). These results corresponded with the statement of Latheef *et al.* (1991) who reported a weak, but linear relationship between the number of corn earworm *Helicoverpa zea* Boddie (Lepidoptera: Noctuidae) eggs and trap catches when corn was at the whorl stage of growth. Izquierdo (1996) observed positive correlation between egg densities and trap catches of *H. armigera* on tomato and carnation crops.

Palaniswamy *et al.* (1990) reported that there was observed no correlation between egg mass densities and pheromone trap catch of European corn borer, *Ostrinia nubilalis* (Hübner.) (Lepidoptera: Pyralidae). Srivastava and Srivastava (1995) monitored *H. armigera* by pheromone trap in chickpea and stated that trap catches of the moth

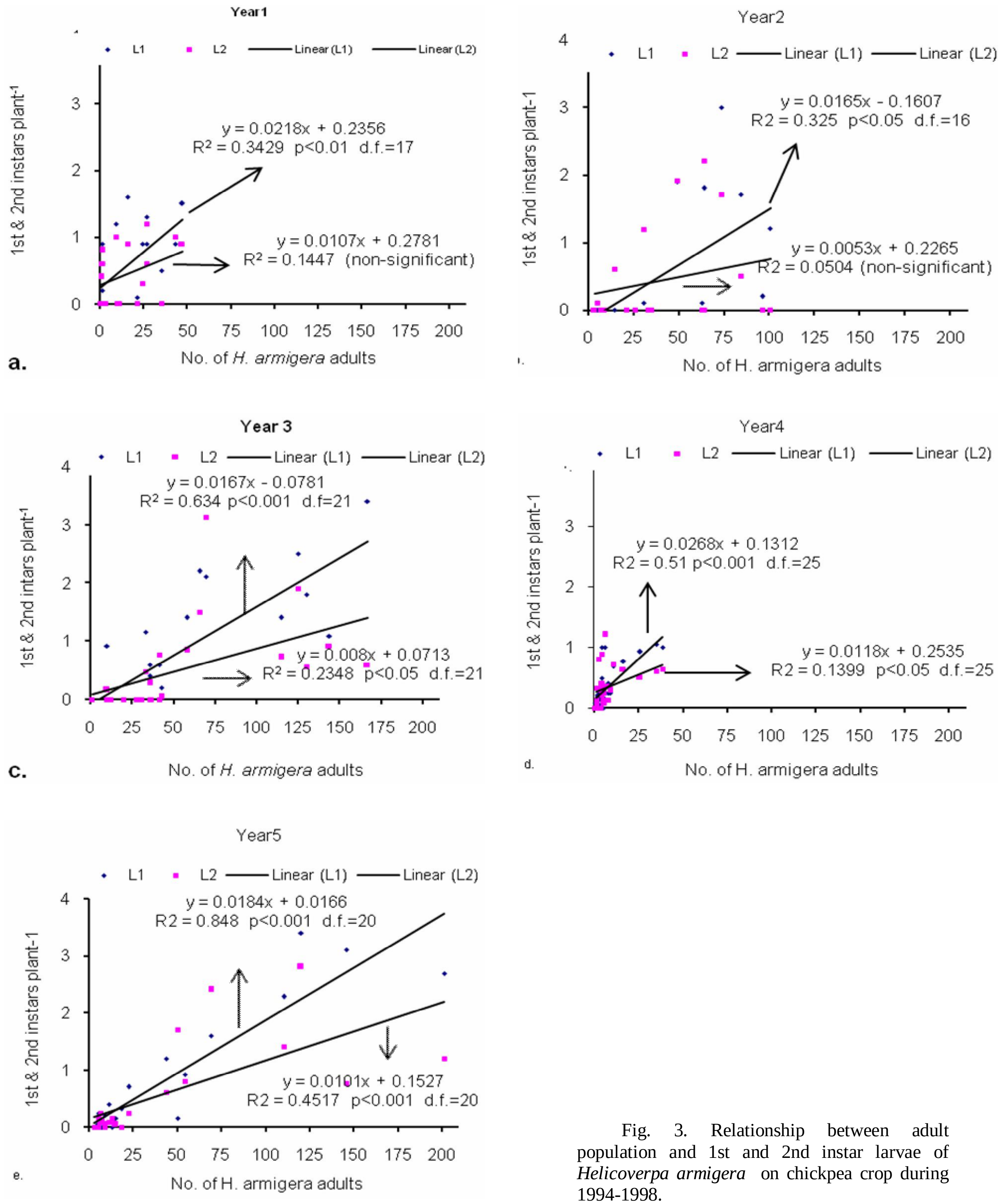

Fig. 3. Relationship between adult population and 1st and 2nd instar larvae of *Helicoverpa armigera* on chickpea crop during 1994-1998.

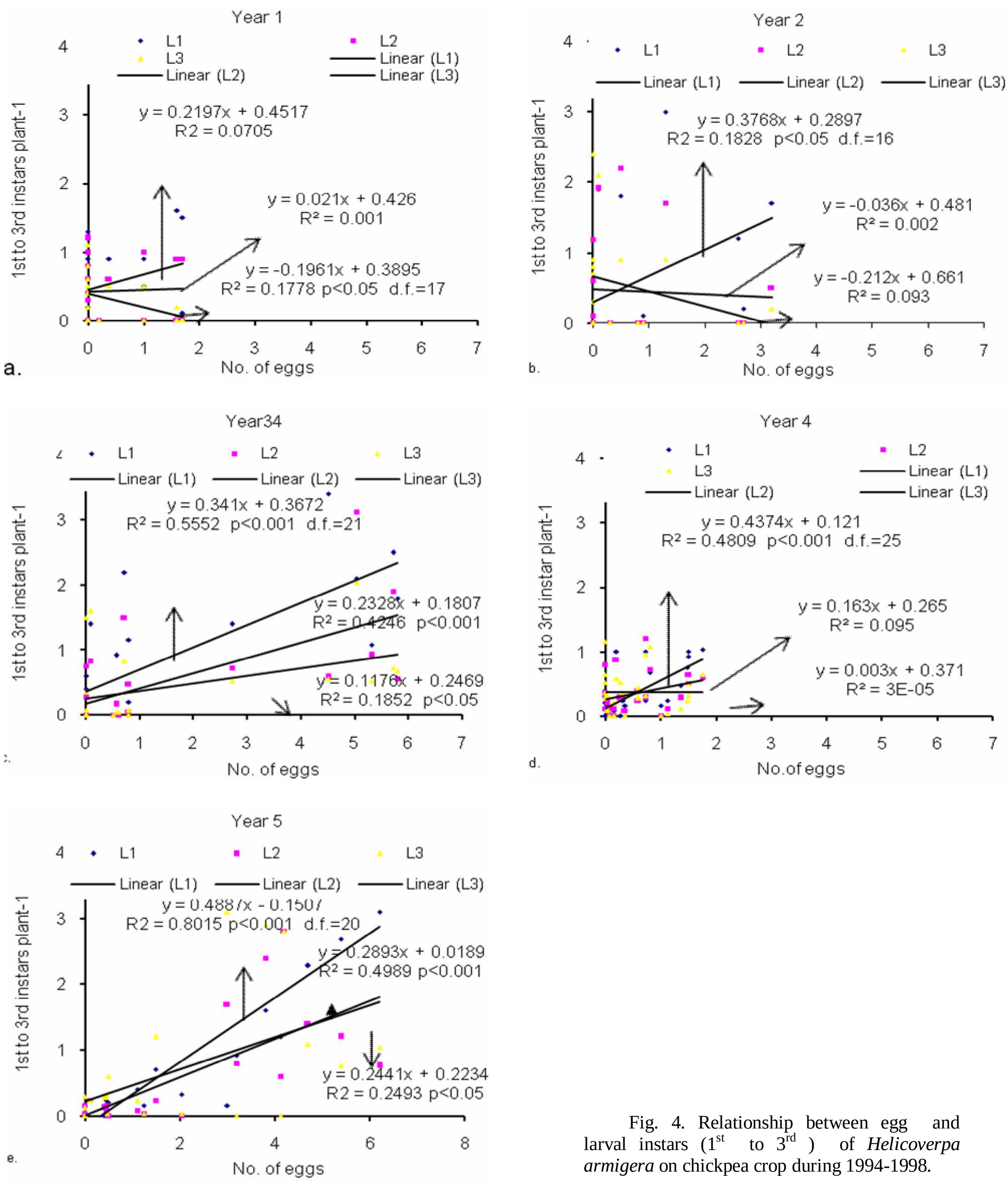

Fig. 4. Relationship between egg and larval instars (1st to 3rd) of *Helicoverpa armigera* on chickpea crop during 1994-1998.

were invariably followed by the peaks in egg and larval counts in 1986 and 1987, they also reported positive correlation (r=0.35 in 1986 and r=0.69 in 1987) between moth catches and egg counts. We also observed a significant positive correlation between trap catches and eggs (r = 0.60, r = 0.83, r

= 0.87, r = 0.75 and r = 0.90 in year 1, 2, 3, 4 and 5, respectively and thus agreed with the finding of Srivastava and Srivastava (1995). Thorpe *et al.* (1993) reported a similar observation stating a significant relationship between trap catch and egg mass density of gypsy moth, *Lymantrai dispar* (Linnaeus) (Lepidoptera: Lymantriidae) and observed significant slopes with R^2-values of 0.60 and 0.65 for the low and high lure traps, respectively.

The linear regressions between the number of adults and 1st instar larvae were significant at $p < 0.05$ and $p < 0.001$ with significant positive correlation (r = 0.59, r = 0.57, r = 0.80, r = 0.71 and r = 0.92 in year 1, 2, 3, 4, and 5, respectively) (Fig. 3). The regression trend lines between adult and 2nd instar larvae were significant at $p < 0.05$ (for year 3 and 4), and $p < 0.001$ (for year 5) with positive correlation (r = 0.38, r = 0.22, r = 0.48, r = 0.37 and r = 0.67 for year 1, 2, 3, 4, and 5, respectively) (Fig. 3). Evenden *et al.* (1995) also observed that male moth catches of *Lambdina fiscellaria* Guenée (Lepidoptera: Geometridae) were significantly correlated with larval and pupal counts within the same generation. Allen *et al.* (1986) observed that mean trap catch of *Choristoneura fumiferana* (Clemens) was significantly correlated with densities of 2nd larval stage ($R^2 = .52$).

Regression trends between eggs and 1st instar were significant at $p < 0.05$, $p < 0.001$, $p < 0.001$ and $p < 0.001$ with r = 0.43, r = 0.74, r = 0.69, and r=0.89 in year 2, 3, 4, and 5, respectively. The relationship between the number of eggs and 2nd instars were also highly significant at $p < 0.001$ with r = 0.65 and 0.71 in year 3 and 5, respectively (Fig. 4). Regression trends between the eggs and 3rd instars were significant at $p<0.05$ with r = -42 r = 0.42 and r = 0.50 in year 1 3, and 5, respectively (Fig. 4). Srivastava and Srivastava (1995) monitored *H. armigera* by pheromone trap in chickpea and reported significant and positive correlation between egg and larval count r=0.89 and r=0.94 for the year 1986 and 1987, respectively.

We have noted that temperature played a significant role in egg laying and larval population build up in almost all the years (1994 to 1998). The Maximum larval populations of *H. armigera* were observed between 2nd and 4th week of April, therefore, during this period the insect can cause severe economic damage to the chickpea crop. On the basis of five years larval developmental data, it can be recommended that Integrated Pest Management strategies can be adopted just in the 1st week of April to protect the crop from insect attack.

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