Field Release Performance of Chrysoperla Carnea for Population Management of Sucking Insect Pests of Cotton

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Abstract:
Chrysoperla carnea egg cards in cotton field were released for two years for population management of sucking insect pests of cotton. Releases were made at the rate of 40 cards per acre, starting from the first week of June when crop was five weeks old and continued at fortnightly interval up to the end of September. On over-all basis C. carnea caused pest population reduction of more than 40-75% of different insect pests. In first year release, reduction was 76%, 86%, 39% and 52% of aphid, jassid, thrip and whitefly population, respectively. While, results of second year study showed that the predator caused 75%, 80%, 62% and 45% pest population reduction of aphid, jassid, thrip and whitefly, respectively. Whereas, in second-year of study, C. carnea larvae were released in field cage cotton plants which caused pest population reduction of 19.5%, 31.18% and 40.23% by 1st, 2nd and 3rd instars of C. carnea, respectively.

Keywords: Chrysoperla carnea, field release, eggs, larvae.

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Introduction:
Cotton, *Gossypium hirsutum* L., the silver fibre is one of the important cash crops of Pakistan. It occupies a very prominent position in the economy of Pakistan because it provides livelihood to millions of people and is one of the major foreign exchange earner of the country. Cotton is a very delicate crop, about 150 species of insects and mites have been reported attacking cotton (Huque, 1972), causing an estimated loss of 20-40% in yield every year in Pakistan (Ahmed, 1980; Ali, 19820). Among serious pests, sucking pests like Jassid, *Amrasca devestans* (Dist.); whitefly, *Bemesia tabacci* (Genn); thrip *Thrip tabbaci* (Lind.) and Scirtothrips dorsalis and mites, *Tetranychus* spp. are important (Ahmed, 1991). Pakistan ranked 4th in area and production of cotton in world and 10th in yield per hectare (ICAC, 2005). The yield of cotton in Pakistan is low and the production potential of crop is reduced due to infestation of insect pests.

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Cotton crop is attacked by a number of insects of both sucking and chewing complexes (Mohyuddin et al., 1997) and to control these pests poorly educated farmers apply different pesticides in different combinations (Ahmad, 1999), which create a lot of problems not only for human beings and other living organisms, but also cause resistance in pests and kill natural enemies (Hagen and Tassan, 1965; Bailey, 1991. Biological control is the action of parasitoids, predators and pathogens in maintaining other organisms’ density at a lower average level than would occur in their absence (DeBach, 1965; Sattar, et al., 2007) and is gaining popularity with farmers as a component of an integrated pest management strategy against noxious insect pest, replacing pesticides (Nadeem et al, 2009).

In advanced countries, predators and parasitoids are commonly released in cotton crop as biological control agents (Reynolds et al., 1982). Among predators Chrysoperla carnea (Stephens) is one of the most popular biocontrol agents for sucking pests and other soft body phytophagous arthropods (McEwen et al., 2001; Sattar and Abro 2009 and 2011).

In current study, cotton (cv. NIAB-78) was used which is widely grown by farmers in Pakistan. NIAB-78 is an erect simpodial variety with longer branches, plant attaining a height of 50-60 cms. Leaves have nectaries, gossypol pigments and short trichomes with medium density. The objective of the experiment was to study the rate of suppression of the population of sucking insect pests of cotton through release of egg cards and larvae of C. carnea (Neuroptera: Chrysopidae ) in the field for two years.

Materials and Methods:

Cotton variety (cv. NIAB-78), was sown in the last week of April at the experimental farm of Nuclear Institute of Agriculture (N.I.A.), Tando Jam. The distance between rows and plants was 75 and 22.5 cm, respectively. The fertilizer was applied at the rate of one bag of DAP (Phosphorus) and 2.5 bags of urea (nitrogen) per acre. Basal dose of fertilizer at the rate of one bag of DAP and ½ bag of urea was applied at the time of sowing. The remaining nitrogenous fertilizer was applied at the rate of ½ bag at first, second and fourth irrigations and last ½ bag of urea at the time of peak flowering. Interculturing and weeding in the crop was done by hand when required. No pesticide was applied in and around experimental area.
Preparation of Cards for Releases: Glue was prepared from acacia gum (200 g) mixed in boiling water (1 L) for sometime to make it saturated solution of thick consistency to stay on hard paper card (2x2.5 inch), three days old 350 eggs of *C. carnea* were sprinkled randomly along with frozen eggs of *Sitotroga cerealella* (Lepidoptera: Gelechiidae) at the ratio of 1:3, as an initial host for newly hatching larvae of *C. carnea* to feed before dispersing in cotton foliage.

Releases of Cards in Cotton Field: Cards were released in the cotton field at morning time at the rate of 40 cards per acre placed at random every alternate row of experimental plot. The cards were attached on the lower leaf surface of the cotton leaves with the help of stapler at the upper plant canopy (Rosenheim *et al.*, 1999) to save *C. carnea* from direct sunlight and other predators like ants etc. The first release was made in the first week of June and the subsequent releases were made after every fifteen days.

Recording of data: Forty plants were tagged at random for recording the data, per acre, selecting one plant per every alternate row. Observations were made at weekly intervals. Sucking insect pest population was recoded from five leaves of each plant, selecting two leaves from bottom portion, two from middle portion and one leaf from top portion of plant. The pest population reduction caused by *C. carnea* was calculated by Abbot’s (1925) formula (Rehman, 2004). While for recording *C. carnea* population, whole plant was observed. This study was carried out for two years and had three replications. Weekly observations were made to record the population of pest and predator in the field in treated and non-treated plots.

FIELD RELEASE PERFORMANCE OF *CHrysoperla carnea* LARVAE IN CAGED COTTON PLANTS FOR POPULATION MANAGEMENT OF SUCKING PESTS OF COTTON

Studies were conducted to determine the performance of *C. carnea* larvae for the population management of sucking pests on cotton crop (cv. NIAB-78) under field conditions during second year at the experimental farm of Nuclear Institute of Agriculture, (N.I.A.) Tando Jam. First, second and third instar *C. carnea* larvae were released at fortnightly intervals on cotton plants under field conditions in net cages (2 meter height and 1.5 meter width), for population management of the sucking complex pests. Two larvae of each instar were dropped out manually on the middle portion
of each plant canopy. Daily observations were made to record data on population reduction caused by different instars (Abbot, 1925). This experiment was replicated eight times.

Results and Discussion:

Population reduction of Aphid, *Aphis gossypii* : The population reduction of *A. gossypii* after release of *C. carnea* egg cards in cotton crop under field during first year is shown in Figure 1a, indicated that predator was able to reduce pest population. Its pressure on pest population steady increased, as it was evident from percent reduction in pest population over the succeeding time intervals. At the start of season pest population was above economic injury level in both treatments. By the end of season, the population in *C. carnea* egg-card in the released treatment was almost zero, whereas, in control treatment it was 12.05 aphids per leaf. On an average release of *C. carnea* in cotton caused 76.14% reduction of pest population (Table 1). The pest population reduction in predator released treatment was significant (F= 8351.62; DF= 1, 224; P <0.001) compared with control treatment.

Release and placement of *C. carnea* egg cards in cotton crop had a significant (F= 190.66; DF= 3, 224; P <0.001) effects on aphid population reduction compared with control treatment during second cropping year (Fig.1b). At the beginning of season, in first week of June, the aphid population was 9.80 aphids/ leaf which reduced to 0.03 aphid/ leaf in the end of season. Release of *C. carnea* in cotton was able to reduce pest population more than 99% compared to control indicating that *C. carnea* was effective against aphid in cotton crop.

Population reduction of Jassid, *Amrasca devastans* : Jassid population after release of *C. carnea* egg cards as compare to control cotton plots indicated that predators were able to hold pest population in treated plot below economic threshold, whereas, in control plot it was above economic threshold during the months of June and July (Fig.1a). The difference of pest population development in treated and control plots were significant (F= 2486.89; DF= 1, 224; P <0.001). Compared with other sucking insect pest species, jassid, *Amrasca devestas* population was less severe in cotton crop during the second cropping season. For the first few observations pest population in *C. carnea* released treatment was above economic threshold, which came under control after release of predator. On overall basis, there was significant (F= 1389.94; DF= 1, 224; P <0.001) difference in population development of pest in treated and control plots (Fig. 1b).
Population reduction of Thrips, *Scirtothrips dorsalis*: Thrip population was significantly (F=777.64; DF= 1, 224; P <0.001) reduced in *C. carnea* released treatment compared with control treatment in cotton crop (Fig.1a). At the initial stage of release program, pest population was above economic injury level which was reduced to below economic injury level in *C. carnea* released treatment. On an average predator was able to reduce pest population by 37.59 percent (Table 1). At the beginning of the season, thrip population in cotton crop was almost same as previous year (Fig.1b). Predator was able to reduce pest population significantly (F= 396.72; DF= 3, 224; P <0.001) compared with control. During crop season thrip population in control plot was higher than previous year crop. On overall basis predator was able to reduce pest population by 60.3%.

Population reduction of Whitefly, *Bemisia tabaci*: Whitefly population reduction in *C. carnea* egg cards released cotton crop (Fig. 1a) indicated that at the initial stage pest population in both treatments (*C. carnea* egg- card released and control treatments) was almost same, and was above economic threshold. After the release of predator, pest population started to decrease slowly in *C. carnea* released plots. The overall pest population reduction in *C. carnea* released treatment was significantly (F= 5671.49; DF= 1, 224; P <0.001) less compared with control treatment. Predator was able to reduce pest population significantly (F= 595.08; DF= 3, 224; P <0.001) during the crop season. Pest population was slightly higher compared with previous year (Fig. 1a). By the end of season the pest population reduction in predator released treatment was almost about 50% in both year studies. The level of population reduction of whitefly was less compared with aphid. The monthly mean population of *C. carnea* larvae recorded in different treatments of cotton crop shown in Table II indicated that predator population was significantly higher in cotton crop in which *C. carnea* egg cards were released compared with control cotton crop plots.

Population of *C. carnea* after release in cotton crop compared with control treatment shown in Table III indicated that population of predator was significantly higher in cotton crop in which it was released. Predator population steadily built up from 0.94 predators per plant to more than 2.50 insects per plant. In control plot treatment, the same was negligible, ranging between 0.002 to 0.014 predators per plant. Predator population in treated and control plots were almost identical during two-year study period (Tables II and III).
Release of Chrysoperla Carnea Larvae in Cotton Field Cage

There was significant effect of release of *C. carnea* larvae on the population reduction of sucking insect pests (Table IV). Significantly the highest (10.11%) pest population reduction (F= 442.28; DF= 2, 84; P <0.001) was caused by the release of third instar followed by second (7.68%) and first (4.96%) instar *C. carnea* larvae. Effectiveness of *C. carnea* in reducing different insect pests population was also significant (F= 247.8; DF= 3, 84; P <0.001). *C. carnea* larvae caused the highest population reduction of aphids (10.79%) followed by whitefly (7.24%), thrips (6.60%) and jassids (5.70%).

Results of the two-year study showed that releases of *C. carnea* in cotton field reduced the population of aphid, *A. gossypii*. The cumulative population reduction by the end of season was more than 99%, whereas, on an average the same was more than 75%. The results indicated that *C. carnea* was an effective biological control against of *A. gossypii* in cotton. There are many studies reported in literature where *C. carnea* and chrysopid species have successfully controlled aphid species in many crops, for example, Kabissa *et al.*, (1996) studied the occurrence of chrysopids on cotton in relation to *H. armigera* and *A. gossypii*. Chrysopid species *Mallada desjardinsi* and *Chrysoperla* sp., occurred on cotton when both *H. armigera* and *A. gossypii* were present. Similarly, a related species *Chrysoperla rufilabris* in open field experiment significantly reduced the density of balsam twig aphid, *Mindarus abietinus* (Fondren *et al*., 2004). Kift *et al*., (2005) reported that *C. carnea* was equally effective against two clones of aphid, *M. persicae* that differed in their insecticide resistance. Compared with non-resistant clone, resistant clone had tendency to aggregate on growing points of pepper plant. Whereas, the parasitoid, *Aphidius colemani* was not so effective on resistant clone of *M. persicae* due to their aggregating behaviour. Easterbrook *et al*., (2006) carried out open field experiments on strawberry plants against strawberry aphid, *Chaetosiphon fragaefolii*. Numbers of *C. fragaefolii* were significantly reduced at release rate of eight *C. carnea* larvae per plant. A positive correlation between *C. carnea* and *M. persicae* on sunflower was observed, while no such relationship was found with *Amrasca biguttula biguttula* and *A. gossypii* on cotton (Mannan *et al*., 1995). Morphology of host plant play important role and affected the ability of *C. carnea* to reduce population of *Diuraphis noxia* on different grass species (Messina *et al*., 1995).

Compared to other sucking insect pests, the population of *Amrasca devastans* was less severe in cotton; it ranged between 0.01 and 4.22 insects per leaf. After release of *C. carnea* in cotton,
A predator was able to cause reduction in the population of *A. devastans*. The results of a two-year study indicated that *C. carnea* caused on average 76.07 to 83.7% reduction in *A. devastans* population. Daane et al., (1996) examined the effectiveness of *C. carnea* against two vineyard leafhopper species, *Erythroneura variabilis* and *E. elegantula* for three years. The average reduction of leafhoppers in *C. carnea* released plots, compared with no release were 29.5% in cages, 15.5% in 3-vine plots and 9.6% in commercial vineyards. Greater reduction of leafhopper was achieved when chrysopids were released as larvae compared with eggs. Shrewsbury and Smith-Fiola (2000) determined the efficacy of *C. carnea* against azala lace bug, *Stephanitis pyrioides* in nursery and found that 5 and 20 larvae per plant resulted in an average *S. pyrioides* mortality of 79 and 97%, respectively. Release of *C. carnea* (25000 larvae/ hectare controlled leafhopper, *Amrasca biguttula biguttula*, *B. tabaci*, *A. gossypii* and fruit worms of okra (Praveen and Dhandapani, 2001).

Thrips an important insect pest of cotton in Pakistan causing economic damage to the crop. Its population in cotton remains above economic injury levels and needs intervention in the form of chemical pesticides or release of biological control agent to keep its population in check. In present study release of *C. carnea* in cotton effectively reduced the population of pest compared with control. Compared to aphid and jassid population reduction, *C. carnea* was less effective in population reduction of *T. tabacci*. Dhandapani et al., (2003) found *C. carnea* 2 per onion plant were found effective against *T. tabaci* and other sucking pests. Hoddle and Robinson (2004) released *C. carnea* for the population management of avocado thrips, *Scirtothrips perseae* in orchards and carried out laboratory studies. Under field conditions *C. carnea* failed to significantly reduce *S. perseae* populations in comparison to non-treated control plots; which was attributed to life cycle of thripids, eggs are oviposited with in plant tissue, there are only two exposed feeding larval instars, two pupal stages pupate within protective cracks on branches or in soil beneath the host plant and winged vagile adults minimize exposure to natural enemies. In laboratory study *C. carnea* larvae feed voraciously on immature *S. perseae* and did not show preferences for particular instars. Hanumantharaya et al., (2008) released *C. carnea* for the population management of sucking insect pests of sunflower found that release of *C. carnea* reduced *T. tabaci* population significantly compared to control. Gurbanov (1984) made three releases of *C. carnea* eggs and larvae for the control of sucking pests and *H. armigera* at a predator: prey ratio of 1: 1. A week after first release, the abundance of *A. gossypii*, thrips, spider mites and eggs, and larvae of *H.
armigera had fallen by 98.5, 95, 100 and 50%, respectively. Release of 2 to 3 day old larvae of C. carnea in cotton consistently reduced bollworm and tobacco budworm populations significantly. Reductions were obtained by releasing 247,000 C. carnea larvae per ha. (Ridgway et al., 1977).

Whitefly, Bemisia tabaci is a very important insect pest of agro-ecosystem, attacking many economically important crops including cotton. In Pakistan, whitefly has been implicated as a vector of cotton curly leaf virus disease. After release of C. carnea in cotton crop, pest population was reduced, but the reduction was not as prominent as in case of A. gossypii or A. devastans, on an average C. carnea caused population reduction of 44.08 and 51.48% in two year studies. Gerling et al., (1997) recorded population fluctuation of C. carnea and B. tabaci for four years in cotton. C. carnea occurred together with B. tabaci and their larvae fed on B. tabaci nymphs, it was not an efficient controlling agent. The presence of larvae of C. carnea on cotton leaves inhibited the visit and oviposition by B. tabaci adults. This effect persisted when the predator larvae had left the leaves (Butler and Henneberry, 1988). Zia et al., (2008) used C. carnea in sustainable biological control program of whitefly, B. tabaci population management in cotton. The effectiveness of C. carnea varied in different genotypes on various weeks of observations. C. carnea exhibited maximum reduction in whitefly population (57.35%) in 4th week of August in variety MNH 552. Syed et al., (2005) compared development of C. carnea on two hosts and observed that C. carnea preferred B. tabaci over A. devastans, since larvae developed more rapidly on B. tabaci. Rehman (2004) worked on the efficacy of C. carnea for the control of sucking insect pests of cotton observed that the efficacy of C. carnea varied depending upon cotton genotype. On over-all basis C. carnea was less effective against thrips, compared with whitefly and jassids.

Release of C. carnea cards in cotton crop caused population reduction of sucking insect pests of cotton. Pest population reduction of different pests ranged between more than 40-75%, whereas larvae caused 90% reduction in pest population.
Table I: Seasonal mean (±SE) population reduction (%) of various sucking insect pests after release of *C. carnea* egg-cards in cotton (cv.NIAB-78) under field conditions

| Insect species       | Mean population per leaf | Two years average |
|----------------------|---------------------------|------------------|
|                      | First year | Second year |                      |
| Aphid, *A. Gossypii* | 76.14±26.26 | 75.02±33.05 | 75.58 |
| Jssid *A. devastans* | 83.70±6.08 | 76.07±5.22 | 79.88 |
| Thrips *S. Dorsalis* | 37.59±3.18 | 60.32±4.36 | 48.95 |
| Whitfly *B. tabacci* | 51.48±4.75 | 44.08±3.96 | 47.78 |

Table II: Monthly mean population of *C. carnea* per plant in cotton field, first year.

| Months   | Mean population per plant | T-value | P-value | DF |
|----------|---------------------------|---------|---------|----|
|          | Treated                 | Untreated |       |    |    |
| June     | 0.553±0.0070 d          | 0.011±0.0023 e | 73.49 | 0.000 | 8  |
| July     | 1.807±0.085 c           | 0.025±0.0019 e | 20.94 | 0.000 | 7  |
| August   | 2.619±0.019 a           | 0.032±0.0016 e | 137.41 | 0.000 | 7  |
| September| 2.500±0.030 b           | 0.021±0.0012 e | 82.88 | 0.000 | 7  |
Table III: Monthly mean population of *C. carnea* per plant in cotton field, second year.

| Months | Mean population per plant | T-value | P-value | DF |
|--------|---------------------------|---------|---------|----|
|        | Treated                   | Untreated|         |    |
| June   | 0.941±0.0146 d            | 0.002±0.0016 e | 63.50  | 0.000 | 7 |
| July   | 2.009±0.0151 c            | 0.030±0.0018 e | 129.44 | 0.000 | 7 |
| August | 2.201±0.0074 b            | 0.021±0.0047 e | 246.64 | 0.000 | 11|
| September | 2.518±0.0302 a       | 0.014±0.0026 e | 82.53  | 0.000 | 7 |

Table VI: Mean population reduction (%) sucking insect pest after release of *C. carnea* larvae in field cage of cotton.

| Insects | *C. carnea* larval instars | Total Control (%) | Mean±S.E. |
|---------|---------------------------|-------------------|-----------|
|         | 1st                       | 2nd               | 3rd       |
| Aphids  | 8.25±0.19 e               | 11.38±0.12 b      | 12.73±0.64 a | 32.36 | 10.79±1.326 A |
| Jassids | 3.70±0.27 h               | 5.33±0.13 g       | 8.08±0.13 e | 17.10 | 5.70±1.278 D |
| Thrips  | 3.96±0.18 h               | 6.38±0.11 f       | 9.46±0.17 d | 19.80 | 6.60±1.591 C |
| Whiteflies | 3.93±0.08 h              | 7.62±0.18 e       | 10.17±0.16 c | 21.56 | 7.24±1.811 B |
| Total Control % | 19.85 | 31.18 | 40.23 | 90.82 |
| Mean±S.E. | 4.96±1.098 C              | 7.68±1.319 B      | 10.11±0.975 A |

Means sharing similar letter in a row or in a column are statistically non-significant (P>0.05).
Small letters represent comparison among interaction means and capital letters are used for overall mean.

(a) First Year
Fig. 1: Population reduction (%) of sucking insect pests after release of *C. carnea* egg-cards in cotton (cv.NIAB-78) field.

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