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# POPULATION DYNAMICS AND MANAGEMENT OF APHIDS (*APHIS CRACCIVORA*) IN CLUSTER BEAN (*CYAMOPSIS TETRAGONOLOBA* L. TAUB)

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**ABSTRACT**

Field experiments conducted at SKUAST-J, Chatha aimed to investigate the population dynamics and management strategies for *Aphis craccivora* infestation in cluster bean crop. The severity of insect infestation was found to be significantly influenced by climatic factors. The study concluded that aphids populations reached their peak during the 17$^{th}$ standard week, showing a positive correlation with temperature and a negative correlation with relative humidity and precipitation. Various botanicals, microbial insecticides, insect growth regulators and chemical insecticides including neem oil, garlic oil, Pongamia oil, novaluron, *Bacillus thuringiensis, Beauvaria bassiana, Metarrhizium anisopliae* and spinosad were evaluated for their efficacy against aphids on cluster beans. Results indicated that spinosad 45EC was the most effective after two applications, reducing the aphid population by 44.97%, followed by novaluron 10EC (38.53%) and neem oil (35.47%). Therefore, spinosad demonstrated the highest efficacy against *A. craccivora* aphids and is recommended for controlling aphids infestations in cluster beans under open field conditions.

***Key words :*** *Cyamopsis tetragonoloba*, Correlation, Insecticides, Management, Infestation.

## Introduction

Cluster bean, scientifically known as *Cyamopsis tetragonoloba*, holds a significant position among legume crops, particularly thriving in marginal and sub-marginal lands of arid and semi-arid regions. The lion's share of global cluster bean seed production, accounting for 80%, is attributed to India, as reported by Tripathy and Das (2013). While India leads the production, other notable cultivating countries include Pakistan, the USA, Italy, Morocco, Germany and Spain, as documented by Punia *et al*. (2009). Within India, the cultivation of guar predominantly occurs in the arid and semi-arid regions of North Western states such as Rajasthan, Gujarat, Haryana, Punjab, and extends to parts of Uttar Pradesh, Madhya Pradesh and Tamil Nadu, as indicated by Kumar in 2005. Rajasthan stands out as the largest producer, contributing to 70% of the total guar production, followed by Gujarat, Haryana, and Punjab. Primarily grown for its pods, which serve both as a vegetable and green manure crop, cluster beans offer diverse applications beyond their agricultural significance. The meal and seeds extracted from cluster beans serve as valuable high-protein cattle feed, adding to their economic importance, as highlighted by Rai and Dharmatti (2013). Additionally, cluster bean gum, a natural hydrocolloid found in the seed endosperm, known as 'Guaran', finds extensive utilization across various industries due to its unique properties. From dairy and meat products to textiles, paper, pharmaceuticals and even explosives and mining, the demand for cluster bean gum continues to rise in the international market. In terms of nutritional value, young pods of cluster beans are prized for their affordability and rich nutrient content. With 16 Kcal of energy, 3.2 grams of protein, 1.4 grams of fat, 10.8 grams of carbohydrates, along with essential vitamins and minerals such as vitamin A, vitamin C, calcium and iron per 100 grams of edible portion, cluster beans serve as a valuable dietary component, as reported by Pathak *et al.* (2009) and Muthuselvi *et al*. (2018). However, despite its numerous benefits, the productivity of cluster beans is often hindered by various biotic and abiotic factors, with insect pests playing a significant role in yield alteration. Common pests targeting cluster beans include aphids (*Aphis craccivora* Koch), jassids (*Empoasca fabae*), whiteflies (*Bemisia tabaci*), hairy caterpillars (*Ascotis impart*, Bihar hairy caterpillar), stem flies (*Ophiomyia phaseoli*) and pod borers (*Etiella zinckenella*), among others. Recognizing the importance of cluster beans and the challenges posed by pest infestation, efforts were made to assess aphid population dynamics and evaluate the efficacy of eco-friendly pesticides in managing aphids in cluster beans. This initiative was undertaken at Chatha farms in the Jammu region, aiming to contribute to sustainable agricultural practices and enhance cluster bean production. Among the eco-friendly pesticides tested were neem oil, garlic oil, Pongamia oil, nodular, *Bacillus thuringiensis, Beauvaria bassiana, Metarrhizium anisopliae,* and spinosad, with the intention of identifying effective solutions for aphid control while minimizing environmental impact.

## Materials and Methods

### Population dynamics of *Aphis craccivora* in cluster bean

To examine the population trends of aphids on cluster beans, an experimental trial was conducted at the Entomology Farm of SKUAST-J, Chatha. Cluster beans of the PNB 181 variety were planted in two separate plots measuring 10x10 square meters each. Throughout the crop season, the population fluctuations of aphids were observed. Fifteen plants were randomly selected and tagged, and the number of aphids on three leaves from each plant—on the twig, middle canopy, and lower plant canopy—was recorded. The weekly mean population of aphid were recorded and correlated with the weather parameters. The data on weather parameters was obtained from section of Agrometeorology, SKUAST – Jammu for the study.

### Management of Aphis craccivora in cluster bean

In an experimental endeavor conducted at the Entomology Experimental field of SKUAST-J, Chatha, cluster beans were cultivated following a Randomized Block Design, encompassing eight plots, each measuring 3×2.5 meters. The spacing adopted for raising the cluster bean was 45 × 15 cm and the crop was sprayed twice at 15 days interval comprising nine distinct treatments (Neem oil, Garlic oil, Pongamia oil, Novaluron, *Bacillus thuringiensis*, *Beauvaria bassiana*, *Metarrhizium anisopliae*, Spinosad and Control) each of the treatment was replicated thrice to check the effectiveness. As the pest infestation surpassed Economic Threshold Levels (ETL), proactive management strategies were implemented to address the burgeoning issue of aphids infestation on cluster bean. The treatments deployed throughout the experiment encompassed a diverse range, incorporating Neem oil, Garlic oil, Pongamia oil, Novaluron, *Bacillus thuringiensis*, *Beauvaria bassiana*, *Metarrhizium anisopliae*, Spinosad, alongside a control group for comparative assessment. The data collection was undertaken to meticulously document the efficacy of these above-mentioned treatments. Specifically, observations were meticulously recorded by selecting five plants at random from each plot. Aphids' population were diligently monitored on three distinct leaves, representing various levels of the plant canopy—namely, the twig, middle, and lower canopy. These observations were conducted both prior to the commencement of spraying activities and subsequently at intervals of 1-, 3, 7- and 14-days post-application, enabling a comprehensive evaluation of treatment efficacy over time. Through this systematic approach, valuable insights were gleaned into the dynamics of aphids infestation on cluster beans and the effectiveness of diverse management strategies in mitigating this agricultural menace. Knapsack sprayer was used for spraying and the sprayer was rinsed carefully after each spray. Data thus, obtained was statistically analyzed and the efficacy of the insecticides was evaluated.

### Correlation study Materials and Methods

During the summer season of the experimental year, the meteorological observatory of the instructional farm SKUAST-JAMMU, Chatha, provided the mean bright sunshine hours, wind speed, maximum and minimum temperature and relative humidity for the morning and evening. It was decided to establish a basic correlation between pest population and weather parameters in order to investigate the effects of various meteorological conditions on pest occurrence**.**

### Estimation of yield losses caused by pest complex of cluster bean

An experiment was carried out in the summer of the year to assess the losses caused by the pest complex of cluster beans. The experiment's specifics are as follows:

1. Location: SKUAST-J, Chatha Experimental Farm
2. The study's year and season are summer 2019–2020.
3. Diversification: PNB 181
4. Specifics of the treatment:
   a) Unprotected (plots): No insecticides were applied to the crop, allowing cluster bean insect pests to

**Table 1 :** Pooled Correlation between population dynamics of aphids, *Aphis craccivora* (Koch) and abiotic factors.

| Insect pest | Temperature ($^0$C) | | Relative humidity (%) | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Maximum | Minimum | Morning | Evening | |
| **Aphid, *Aphis craccivora* (Koch)** | 0.82** | 0.66** | -0.55* | -0.72** | -0.56* |

** Significant at the 0.01 level * Significant at the 0.05 level

naturally infest it.

b) Protected (plots): Starting ten days after the pests first appeared, an alternative suggested pesticide was applied to the crop to prevent harm from the pest complex.

5. Sampling design in experimentation
6. Sample/treatment count: 9.8. Spacing: 45×15 cm
9. Observation to be recorded: Noteworthy observation: The yield rose in protected plots compared to unprotected (control) plots, and the formula provided by Pradhan (1969) was used to calculate preventable loss.

$$\text{Yield increased (\%)} = \frac{T\text{-}C}{C} \times 100$$

$$\text{Avoidable yield loss (\%)} = \frac{T\text{-}C}{C} \times 100$$

Where, T = Yield from treated (protected) plots (kg/ha), C = Yield from untreated (unprotected) plots (kg/ha)

### Method of recording observations

From each treatment plot, five randomly chosen plants were tagged in order to assess the effectiveness of various pesticides. Aphid observations were made using the previously adopted methodology. The pest population was observed 24 hours prior to each spraying of a separate insecticide, as well as one, five and seven days later. Thus, statistical analysis was performed on the collected data. After being weighed, documented, and translated to hectares, the grain yield obtained from each treatment was compared to the control. Prior to statistical analysis, the data on pest count were converted to percent mortality using the Henderson and Tilton (1955) formula and then converted to arcsine percentage.

$$\text{Corrected per cent mortality} = 100 \times 1 - \left( \frac{T_a - C_b}{T_b - C_a} \right)$$

**Where,**

Tb = Number of insect pests observed Ta-Cb before treatment

Ta = Number of insect pests observed Tb-Ca after treatment

Cb = Number of insect pests observed from untreated control plot before treatment

Ca = Number of insect pests observed from untreated control plot after treatment

### Yield and Economics

With a view to ascertain the effect of different insecticides on the yield, harvested grains of cluster bean was weighed separately from each net plot area. The yield was converted on hectare basis, the per cent increase in yield over control was calculated by using following formula.

$$\text{Yield increased over control (\%)} = 100 \text{ X } \left( \frac{T - C}{C} \right)$$

Where,

T = Yield of insecticidal treatment (kg/ha)

C = Yield of control (kg/ha)

## Results and Discussion

### Population Dynamics of aphids, *Aphis craccivora* (Koch)

This study provides a detailed examination of the population dynamics of aphids on cluster beans between 2019 and 2021. The results are summarised in Table 2. The study clarifies the complex relationship between aphid population dynamics and several meteorological conditions by correlational examination. Significantly, there is a strong positive corelation between the mean maximum and minimum temperatures and the population of aphids, as indicated by the highly significant ‘r’ values (r = 0.82** and r = 0.66**, respectively). On the other hand, there are noteworthy negative correlations between the aphid population and mean relative humidity in the morning and evening, with ‘r’ values of -0.55* and -0.72**, respectively. In addition, a ‘r’ value of -0.56* indicates a negative correlation between rainfall and the population of aphids. As shown in Table 2, regression analysis highlights the significant influence of abiotic factors on the dynamics of aphid populations, attributing weather-related variables to 49.30% of the variation in population

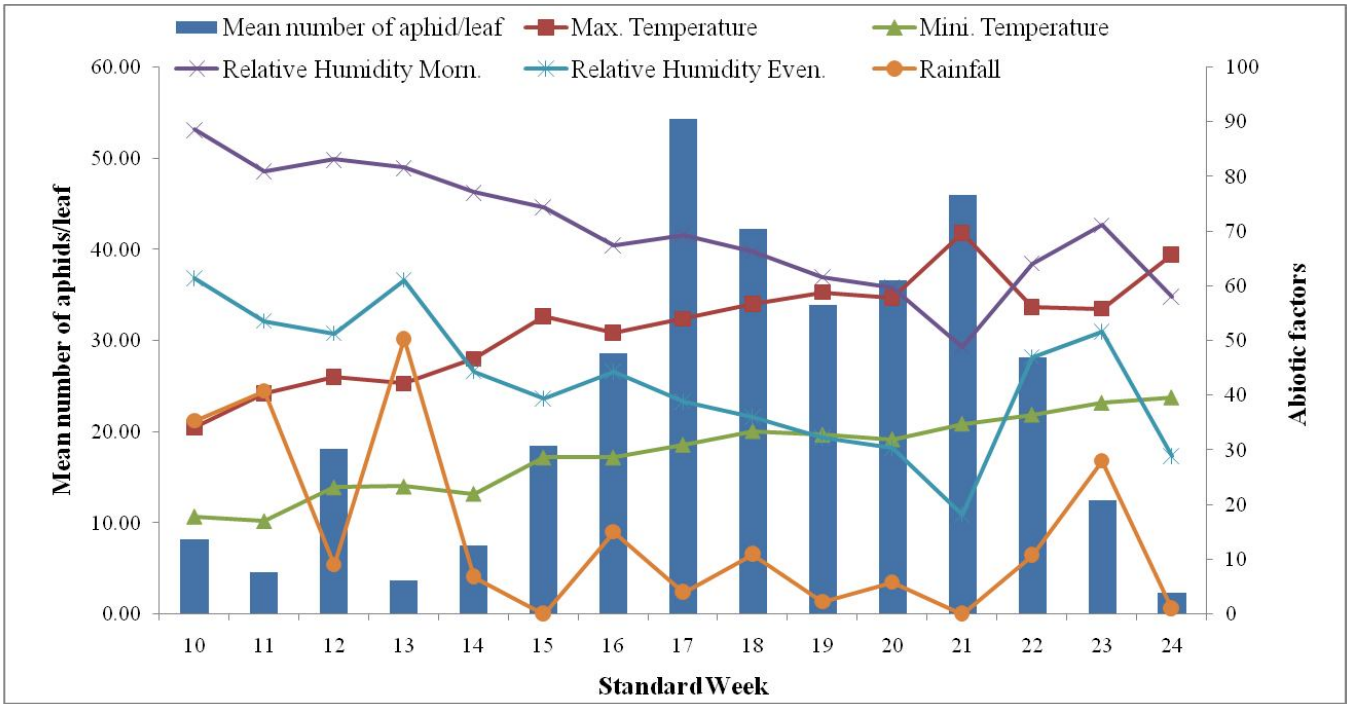


**Fig. 1 :** Population dynamics of aphids on cluster beans concerning abiotic factors.

build-up during the examined years. The population of aphids varied between 2.33 and 54.33 aphids per leaf. There was a significant increase in the number of aphids from 3.67 per leaf during the 13th standard week to 54.33 per leaf during the 17th week, which marked the peak aphid density. This was accompanied by particular weather, with high and low temperatures of 32.4 and 18.6°C, respectively, relative humidity in the morning and evening being 69.3%, 38.9% and 4.0 mm of rain falling. The aphid population then began to decline, reaching a low of 2.33 aphids per leaf by the 24$^{th}$ standard week, in accordance with modified weather conditions, such as maximum and minimum temperatures of 39.4 and 23.8°C, morning and evening relative humidity of 58.00% and 28.9% and 1.0 mm of rainfall. These results are in line with other studies by Hasan *et al*. (2009) and Mahmoud *et al*. (2017), which highlight the negative correlation with relative humidity and the positive correlation with daily mean temperature and aphid population. On the other hand, the results of the present study are consistent with those of Bhamare *et al*. (2018), who found negative associations between the aphid population and maximum temperature, afternoon relative humidity and rainfall.

## Management of *Aphis craccivora* (Koch) on Cluster bean

A field study with nine different treatments was conducted to evaluate the effectiveness of various treatments against aphids, a common sucking insect pest of cluster beans. Three botanicals, three microbiological agents, one insect growth regulator, two insecticides, and a water spray as control were used in these treatments. Data were gathered from three randomly chosen plants in each replication and the evaluation of field bio-efficacy was based on the percentage reduction in the nymphal population of key insect pests following application at intervals of 1, 3, 7 and 14 days. The collected data, as Table 4 illustrates, highlights significant changes in treatment effectiveness over time. The performance of the tested pesticide Spinosad is especially noteworthy; after fourteen days of the second spray, it showed the greatest reduction in aphid population, showing a reduction of 44.97%. This efficacy is comparable to plots treated with *Beauveria bassiana*, which showed a 44.80% reduction. Applying *Metarrhizium anisopliae*, which produced a 42.47% reduction, and novaluron, which produced a 38.53% reduction, led to further noteworthy reductions. The use of neem oil led to a reduction of 35.47%, whereas treatments with pongamia oil and *Bacillus thuringiensis* produced comparatively smaller reductions of 7.40% and 7.60%, respectively. After 14 days of the second spray, garlic oil showed the least amount of efficiency among the treatments, reducing the population of aphids by 4.90%. These results support earlier studies by Yadav *et al.* (2015) and Katare *et al.* (2018), demonstrating the effectiveness of certain therapies in reducing the aphid population. In particular, spinosad 45 SC worked well as an insecticide, notably lowering aphid populations up to 14 days after application,

**Table 2 :** Pooled regression equations and co-efficient of multiple determination ($R^2$) of *Aphis craccivora* (Koch) concerning abiotic factors.

| Regression linear equations of aphid | Multiple correlation (R) | Co-efficient of determination ($R^2$) | F-value (P-value) |
|---|---|---|---|
| $Y = 337.337 - 6.30X_1 + 3.03X_2 - 1.62X_3 - 1.21X_4 - 0.28X_5$ | 0.21 | 0.49 | 1.75 |

Where, Y = Mean number of aphid population / leaf, $X_1$= Maximum temperature, $X_2$ = Minimum temperature, $X_3$ = RH, morning, $X_4$=RH evening, $X_5$= Rainfall (mm)

**Table 3 :** Pooled bio-efficacy of eco-friendly insecticide against aphids (*Aphis craccivora* Koch).

| S. no. | Pesticide(s) | First spray | | | | | Second spray | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1DBS | Per cent reduction of aphid population | | | | Per cent reduction of aphid population | | | |
| | | | 1 DAS | 3 DAS | 7 DAS | 14 DAS | 1 DAS | 3 DAS | 7 DAS | 14 DAS |
| 1. | Neem oil | **17.60** | 56.80 (48.89) | 64.70 (53.53) | 44.93 (42.07) | 44.47 (41.80) | 54.27 (30.36) | 69.13 (33.91) | 46.47 (38.06) | 35.47 (15.10) |
| 2. | Garlic oil | **17.78** | 16.72 (24.11) | 30.27 (33.35) | 33.77 (35.50) | 4.00 (11.52) | 18.02 (25.10) | 30.93 (33.77) | 34.27 (35.81) | 4.90 (12.72) |
| 3. | Pongamia oil | **17.33** | 23.20 (28.77) | 28.40 (32.18) | 38.47 (38.31) | 8.00 (16.38) | 25.07 (30.02) | 29.57 (32.93) | 39.23 (38.77) | 7.40 (15.75) |
| 4. | Novaluron | **16.66** | 63.80 (52.99) | 74.17 (59.43) | 62.80 (52.39) | 44.97 (42.09) | 66.37 (20.54) | 72.37 (28.69) | 64.43 (38.12) | 38.53 (15.03) |
| 5. | *Bacillus thuringiensis* | **16.67** | 7.87 (16.26) | 28.93 (32.52) | 38.07 (38.07) | 6.87 (15.18) | 8.70 (17.14) | 26.27 (30.80) | 36.27 (37.01) | 7.60 (15.99) |
| 6. | *Beauvaria bassiana* | **17.80** | 19.33 (26.07) | 28.33 (32.14) | 52.47 (46.39) | 33.13 (35.12) | 18.47 (17.35) | 31.27 (34.59) | 53.60 (30.84) | 44.80 (20.01) |
| 7. | *Metarrhizium anisopliae* | **16.56** | 21.87 (27.87) | 30.47 (33.48) | 59.47 (50.44) | 36.93 (37.40) | 24.07 (18.42) | 32.97 (33.79) | 54.90 (35.23) | 42.47 (22.16) |
| 8. | Spinosad | **16.60** | 16.60 (24.02) | 48.17 (43.93) | 72.20 (58.15) | 48.80 (44.29) | 16.60 (24.89) | 48.17 (44.37) | 72.20 (58.80) | 44.97 (42.88) |
| 9. | Control (water spray) | **16.67** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | SeM ± | 0.63 | 0.59 | 0.56 | 0.67 | 0.58 | 0.54 | 0.49 | 0.28 | 0.64 |
| | CD at 5 % | N. S. | **1.80** | **1.72** | **2.05** | **1.78** | **1.65** | **1.51** | **0.87** | **1.97** |

Figures in parenthesis angular transformed values. N.S.=Non-Significant; DBS=Days before Spray, DAS=Days after spray.

in line with data published by Konar *et al*. (2016). Such strong effectiveness highlights spinosad's potential as a useful product for controlling aphids in cluster bean cultivation.

### Yield of different insecticidal treatments

The yield performance of cluster bean under different treatments is delineated in Table 5. Notably, the treatment employing Spinosad at 0.3% concentration yielded the highest grain output, reaching 12050 kg/ha. This achievement was statistically on par with the yields obtained from *Beauvaria bassiana* at 3.0% concentration and *Metarrhizium anisopliae* at 4.0% concentration, which recorded yields of 12000 kg/ha and 11020 kg/ha, respectively. Following closely in yield performance were insecticidal treatments such as Novaluron at 0.12%, Neem oil at 5.0%, *Bacillus thuringiensis* at 2.5% and Pongamia oil at 4.0%, yielding 9122 kg/ha, 8500 kg/ha, 7200 kg/ha and 6955 kg/ha, respectively. Conversely, the treatment involving Garlic oil at 3.0% concentration exhibited the lowest yield of cluster beans at 6500 kg/ha, with no significant difference observed from the control treatment, which yielded 2870 kg/ha. Assessing the percentage increase in yield over the control, varied results were observed across treatments, ranging from 233.33% to 517.94%. Notably, the treatment utilizing Spinosad at 0.3% concentration demonstrated the highest percentage increase in yield over control at 517.94%. Following this trend were treatments with *Beauvaria bassiana* at 3.0% concentration and *Metarrhizium anisopliae* at 4.0%

concentration, showcasing percentage increases of 515.38% and 465.12%, respectively. Subsequent treatments such as Novaluron at 0.12% and Neem oil at 5.0% displayed percentage increases of 367.79% and 335.89% respectively. Similarly, Bacillus thuringiensis at 2.5% and Pongamia oil at 4.0% demonstrated percentage increases of 367.79% and 335.89% respectively. These findings corroborate with previous studies conducted by earlier researchers, affirming the efficacy of certain treatments in enhancing cluster bean yield.

## Conclusion

In conclusion, cluster beans, pivotal in arid and semi-arid regions are globally significant, with India leading production. Despite challenges from pests like aphids, our study reveals the effectiveness of eco-friendly pesticides like Spinosad, *Beauvaria bassiana* and *Metarrhizium anisopliae* in controlling infestations. Weather factors notably influence aphid populations, emphasizing the need for adaptive pest management strategies. These findings underscore the importance of sustainable practices to optimize cluster bean productivity while minimizing environmental impact. Continued research and integrated pest management will be vital in sustaining cluster bean cultivation and meeting rising global demand.

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