# International Journal of Research in Agronomy

E-ISSN: 2618-0618 P-ISSN: 2618-060X © Agronomy www.agronomyjournals.com 2024; 7(1): 45-52 Received: 13-10-2023 Accepted: 16-11-2023

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# The distributppion pattern and seasonal incidence of spider (Araneae: Araneidae) prevalence in the onion ecosystem of West Bengal's red lateritic zone

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#### DOI: https://doi.org/10.33545/2618060X.2024.v7.i1a.189

#### Abstract

**Background:** One of the best methods to reduce the usage of chemical pesticides and insect pests is biological control using spiders. Natural enemies, such as predators, parasitoids, and pathogens, play a crucial role to minimize the use of chemical pesticides and insect pest complexes in onion ecosystem. The experiment was conducted in order to know the seasonal incidence and distribution pattern of Spider in onion ecosystem at Sriniketan, West Bengal, India during rabi season 2021-22. Healthy seedlings of onion were transplated on the experimental field. To check the seasonal incidence and dispersion of spider, the field was inspected on a weekly basis. Different indices of dispersion i.e mean, variance, variance-mean ratio, dispersion parameter 'K', David and Moore's index, Lexis Index, Charlier coefficient, Index of dispersion, Lloyd mean crowding index were calculated by using of pooled data and checked the distribution pattern of the predatory agent spider.

**Results:** When insect pests appeared, species of spider were discovered on the crop to reduce the pest population in the agroecosystem. Spiders were observed at different temperature, relative humidity, growth period of onion throught the cropping season. Highest Spider population was found during the 4<sup>th</sup> week of February, about 3.14 spiders per plant. The distribution of spider during the crop-growing season was clumped, infectious, and aggregative, as shown by various dispersion indices. The majority of the standard weeks' computed "K" values, however, were found to marginally depart from the negative binomial aggregative kind of dispersion.

**Conclusion:** Our study was able to characterize the population, spatial distribution of spiders in onion ecosystem and develop a comprehensive sampling plan for their population assessment. Future studies can validate this sampling scheme for major onion growing areas in the red lateritic zone of West Bengal and examine the spatial distribution of an additional natural enemy i.e. spider, to improve pest management programs for major insect pest of onion.

Keywords: Dispersion, Varience, mean, spatial distribution, Charlier coefficient, lexis index

#### Introduction

Onion (*Allium cepa* L.) is a member of the Alliaceae family and is widely regarded as the most significant crop in the world, used for both vegetables and spices. The onion bulb, which is used as a spice, contains minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg), and potassium (157 mg), as well as carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g), and several vitamins like vitamin A (0.012 mg), vitamin C (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg) (Suresh, 2007) <sup>[93]</sup>. Chemicals can kill onion insect pests, but controlling them on crops is challenging. Additionally, various pesticide resistance issues have been discovered in areas where chemicals are being applied carelessly for pest management (Rueda and Shelton, 1995) <sup>[94]</sup>. The ecosystem, human health, and other beneficial insects/pests are negatively impacted by the usage (and misuse) of chemical pesticides (Rola and Pingali, 1993; Antle and Pingali, 1994; and Tjornhom *et al.*, 1997) <sup>[95, 96, 97]</sup>. Due to its susceptibility to a broader range of diseases and pests than other crops, the inappropriate use of chemical pesticides in vegetable crop production is much more visible than in other crops (Tjornhom *et al.*, 1997) <sup>[97]</sup>.

As members of the phyllum Arthropoda, spiders belong to the class Arachnida. Like other arachnids, they have two body parts: the abdomen and the cephalothorax. Spiders differ from other arthropods in that their cephalothorax, which has four pairs of legs and is tougher, is distinct from their relatively soft and unsegmented abdomen (Palem *et al.*, 2017)<sup>[98]</sup>. They hunt insects and other terrestrial creatures since they are carnivores (Dharmaraj *et al.*, 2018)<sup>[99]</sup>. However, because they do not have teeth, spiders consume their food as liquids.

In order to catch prey and inject venom, they typically use Chelicera, the pointed appendages located in front of the cephalothorax (Cohen, 1995) <sup>[100]</sup>. Additionally, the meal is being broken down into liquid by the digestive enzymes. Biological control by means of spiders is one of the most effective ways to minimize the use of chemical pesticides and insect pests. For instance, Lang *et al.* (1999) <sup>[101]</sup> reported that the population of insect pests such as thrips, aphids, and leafhoppers was gradually reduced by the spiders in a maize crop. It was reported that spiders belonging to the Lycosidae family effectively reduced the population of plant sucking insects in tropical rice paddies (Fagan *et al.*, 1998) <sup>[102]</sup>. Spiders possess promising predatory traits, like a high kill rate per unit time and good hunting skills.

Spiders have commonly considered as polyphagous predators. For this reason it has been considered that spiders cannot be efficient in controlling pests (Debach and Rosen, 1991)<sup>[103]</sup>. However in China, for example, these invertebrate predators have been actively preserved in order to combat particular pests (Zhao, 1993)<sup>[104]</sup>. In addition, it has been discovered in Israelian and European apple orchards that they can significantly decrease insect damage to harvests (Mansour et al., 1980, Marc, 1993) <sup>[105, 106]</sup>. Marc and Canard (1997) <sup>[107]</sup> redefined the role of spiders in the agroecosystems, describing that considering their hunting strategies and location in the vegetation they can be regarded as specialist predators. Because of this, not all species are effective against a certain insect, but maintaining their diversity may be crucial for managing a variety of pests. Several functional groups can be defined by analyzing the various hunting techniques, biological cycles, and environmental localization of spider communities in vineyards (Isaia et al., 2006) [108] and orchards (Marc, 1993) [106]. It has been demonstrated that this effects the type of prey eaten. For instance, when it comes to spiders that live in orchards and move trees, it has been demonstrated that nocturnal wandering spiders such as Anyphaena accentuata (Anyphaenidae), Clubiona brevipes, C. corticalis, and C. leucaspis (Clubionidae) are effective against non-flying Aphids and Lepidoptera larvae; diurnal wandering species such as Ballus depressus (Salticidae) are effective against both non-flying Aphids and Cicadellidae; ambush species such as *Philodromus aureolus* (Philodromidae) and Diaea dorsata (Thomisidae) are effective against adult and larvae of Hymenoptera and Lepidoptera (adults and larvae). Argiope aurantia Lucas, also known as the black and yellow garden spider, is a common orb-weaving spider that can be found in the eastern United States, as well as throughout the west coast of North America and into Central America. Many different types of habitats have been recorded to have it, such as thick perennial vegetation, dry grassy hillsides, vegetable gardens, roadside margins, deciduous woodlands, and regions next to ponds, streams, and swamps provided a summary of observations regarding the distribution, systematics, and general life behaviors of A. aurantia and allied species. It has been proved that wandering spiders are crucial in maintaining herbivore populations in agricultural fields, including

Cicadellidae, Thysanoptera, and Aphididae (Lang *et al.*, 1999)<sup>[101]</sup>.

IPM is a strategy that promotes reducing the use of chemical pesticides and increasing the use of non-chemical control measures as a result of the known risks associated with chemical pesticides and their use to the environment and human health. A natural ecosystem is a system created by the dynamic interplay of biotic and abiotic components in a specific space. Plants, insects (pests, decomposers), microorganisms, and other living things are considered biotic elements, while non-biotic elements include climatic factors including temperature, relative humidity, wind, sunshine, rain, and soil. Each component in the system has unique properties and a specific purpose that, depending on the time and location, will affect the distribution and population of living things. However, improper use of pesticides disturbs the equilibrium by killing other organisms and natural enemies and reducing soil fertility. Keeping this in view the present investigation was conducted to determine the agroecology within an agricultural ecosystem.

The spatial distribution of natural enemies helps to recognize the pest-natural enemy relationship in the field. Natural enemies, like as parasitoids and predators, have the ability to spread out and locate areas in a field with high pest concentrations. The conservation and release of biological agents in the field depend on an understanding of the spatiotemporal dynamics of pests and their natural enemies, since biological management is more successful when there is a spatiotemporal overlap of prey and natural enemies. Despite the usefulness of spatiotemporal distribution tools in understanding the ecology of pests and their natural enemies, a limited number of studies have been organized to determine the spatiotemporal associations of pests and their key natural enemies.

The spatial distribution of natural enemies can be characterized using several methods, including variance-mean raio, dispersion parameter 'K', David and Moore's index, Lexis Index, Charlier coefficient, Index of dispersion, Lloyd mean crowding index. The methods have their strengths and weaknesses, and the combination of the these methods is recommended in ecological studies. In onion fields, the important natural enemy hover flies, lady bird beetles, Dragon flies, Damsel flies, Spiders prey on major insect pest complexes. Although these predator groups play an important ecological role in balancing the prey–natural enemy dynamics in onion fields. Therefore, this study aimed to determine the characterize the population, spatial and temporal distribution of spiders in onion ecosystem and develop a comprehensive sampling plan for their population assessment.

# Materials and Methods

A field experiment was conducted to work out the seasonal incidence and distribution pattern of insect pest of onion. during the rabi season of 2021-22 at Horticulture Research farm, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal which is situated between 23.24° North latitude and 87.42° East longitudes having an altitude of 40 m above the mean sea level. During the crop's growing season, all advised agronomical methods were used, with the exception of plant protection techniques. During the second half of November, seedlings of the Sukh sagar variety that had been growing for a month were transplanted in order to raise the crop in plots with a 40 cm row to row and 30 cm plant to plant spacing.

# **Data collection**

Insitu observation of population build up of natural enemies

were recorded following random sampling technique by taking 10 plants randomly from each plot out of 21 plots. Three leaves, one from the plant's top, middle, and bottom canopies, were used to collect the data. Observations were recorded at weekly interval starting from 51<sup>st</sup> standard meterological week to 11<sup>th</sup> standard meterological week with respesct to certain weather parameters during the crop growing season.

All the data of weather parameters i.e temperature, relative humidity, rainfall and sunshine hours were collected from Metrlogical Office, Sriniketan, Bolpur, West Bengal.

## Statistical analysis and calculation

We recorded the insects in the current study's agroecosystem in order to determine the prevalence of insect pests and natural enemies on crops. We then used Microsoft Excel 2010 to compute the average, mean, and figures drawing.

The data thus obtained was organised into a frequency distribution with several indexes like mean  $(\bar{X})$ ,variance  $(S^2)$ ,variance-mean ratio  $(S^2/\bar{X})$ , dispersion parameter 'K'[{ $\bar{X}^2/(S^2-\bar{X})$ }], David and Moore's index { $(S^2/\bar{X}) - 1$ }, Lexis Index [ $\sqrt{(S^2/\bar{X})}$ ], Charlier coefficient [{ $\sqrt{(S^2 - \bar{X})}$ }, Index of dispersion [(n-1)\*( $S^2/\bar{X}$ )], Lloyd mean crowding index [ $\bar{X} + {(S^2/\bar{X}) - 1}$ ], were calculated as per the procedure suggested by Elliot (1977). The degree of crowding experienced by an individual was worked out for all the standard work by following Llyod's method (1967) and designated as Lloyd index of mean crowding [ $\bar{X} + {(S^2-1)/\bar{X}} = 1$ ] and Lloyd index of patchiness[ $\bar{X} + {(S^2-1)/\bar{X}}$ ].

#### i) Ratio of variance to mean (VMR)

The simplest approach for calculating insect dispersion was the variance to mean ratio, proposed by Patil and Stiteler (1974).VMR=  $(S^{2/}\bar{X})$  where S<sup>2</sup> denotes variance and  $\bar{X}$  denotes mean.

For a "Poisson" distribution, VMR equals 1, for a positive binomial distribution, it is less than 1, and for a negative binomial distribution, it is larger than 1. The number >1 denotes contagiousness, <1 denotes regularity, and =1 denotes random distribution in the population dispersion data provided by VMR.

#### ii) David and Moore's clumping index (IDM)

The index of clumping (IDM) formulated by David and Moore (1954) was used to confirm the following distribution: IDM=

 $\{(S^{2/}\ \bar{X})-1\}.$  For the poisson distribution, the IDM returns a value of zero. For the negative binomial distribution, it returns a positive value.

# iii) The Lexis Index

The following formula was used to calculate the Lexis Index in order to determine the dispersion of natural enemies:  $\sqrt{(S2 / \bar{X})}$ . This index has a value of >1, 1, and =1 for infectious, regular, and random distribution, respectively.

#### iv) Dispersion index (ID)

The "Index of Dispersion," suggested by Patil and Stiteler, confirmed the distribution pattern (1974).  $I_{D}{=}~(n{-}1){*}(S^{2}{/}~\bar{X})$  where the number of samples drawn is n, while ID stands for the dispersion index.

### v) Mean crowding index (X\*) according to Lloyd's

Mean crowding (X\*), as suggested by Lloyd, was shown to illustrate the expected impact of interpersonal rivalry or interference (1967). The formula for calculating the sample estimate of mean crowding (X\*) is  $X^*=X + \{(S2/X) - 1\}$ , where values greater than zero denote an over-distributed or regular distribution and values less than one denote an under-distributed distribution. Mean crowding is heavily dependent on the indexes of clumping intensity and population density.

# **Result and Discussion**

#### Spider

The population of Spider (Table-01) first appeared on the  $3^{rd}$  week of December ( $51^{st}$  SMW) and the population was about 1.71 spider per plant. The abiotic conditions at that time were; maximum temperature 23.67 °C, minimum temperature 10.33 °C, relative humidity 79%, rainfall 0.00 mm and sunshine hours 6.24. Highest Spider population was found during the  $4^{th}$  week of February, about 3.14 spiders per plant. At this time, abiotic conditions were maximum temperature 27.69 °C, minimum temperature 13.76 °C, relative humidity 74.29%, rainfall at the rate of 0.00 mm and sunshine hours 7.27. Second highest spider population was found on 3rd week of February ( $7^{th}$  SMW) about 2.86 spiders per plant found when the maximum temperature 24.5 °C, minimum temperature 11.67 °C, relative humidity 77.86%, rainfall 3.22 mm and sunshine hours 8.69.

 Table 1: Seasonal incidence of Spider (Araneae: Araneidae) seen on onion ecosystem with respect to certain abiotic parameters during the year

 2021-22

Standard	Population of	ve Standard Week				
Week	Spider/ Plants	Maximum Temperature (°C)	Minimum Temperature (°C)	Relative Humidity (%)	Rain Fall (mm)	Sunshine Hours
51 <sup>st</sup>	1.71	23.67	10.33	79	0.0	6.24
52 <sup>nd</sup>	1.86	24.53	13.74	89.14	0.34	2.64
1 st	1.71	23.27	10.47	93	0	5.74
2 <sup>nd</sup>	2.28	24.24	14.56	92.14	2.7	2.04
3 <sup>rd</sup>	1.86	22.43	10.77	87.14	0	6.11
4 <sup>th</sup>	1.86	22.26	13.8	86.29	0.77	2.79
5 <sup>th</sup>	2	21.31	8.9	71.86	0	4.84
6 <sup>th</sup>	1.86	21.99	12.94	85.86	6.8	5.44
7 <sup>th</sup>	2.86	24.5	11.67	77.86	3.22	8.69
8 <sup>th</sup>	3.14	27.69	13.76	74.29	0	7.27
9 <sup>th</sup>	2.14	28.65	17.33	84.75	5.53	7.25

Table 2: Spatial distribution pattern of Spider (Araneae: Araneidae) in Onion ecosystem in red lateritic zone of West Bengal (2021-22)

Sl. no.	Standard week	Mean (X̄)	Varience (S <sup>2</sup> )	Varience- mean ratio (S²/X̄)	$\begin{array}{c} \text{Dispersion} \\ \text{parameter 'K'} \\ \{\bar{X}^2  / (S^2 \! \! \cdot \! \bar{X})\} \end{array}$	Reciprocal of K (=1/K)	David Moore's index {(S <sup>2</sup> /X̄)-1}	Lexis index $\sqrt{(S^2/\bar{X})}$	Index of dispersion {(n-1)(S <sup>2</sup> /X̄)}	Charlier coeeficient [100 {√(S²-X̃)}/ X̄]	$\begin{array}{l} Lloyd \ mean \\ crowding \ index \\ [(\bar{X})+\{(S^2/\bar{X})\text{-}1\}] \end{array}$	Llyod patchiness index [X+{(S²/X)-1}]/X
1	51 <sup>st</sup>	2.14	2.48	1.16	13.47	0.07	0.16	1.08	6.95	27.25	2.30	2.21
2	52 <sup>nd</sup>	2.29	2.57	1.12	18.73	0.05	0.12	1.06	6.73	23.11	2.41	2.34
3	1 <sup>st</sup>	2.57	2.95	1.15	17.38	0.06	0.15	1.07	6.89	23.99	2.72	2.63
4	2 <sup>nd</sup>	2.86	3.48	1.22	13.19	0.08	0.22	1.10	7.30	27.53	3.08	2.94
5	3 <sup>rd</sup>	3.14	3.81	1.21	14.72	0.07	0.21	1.10	7.28	26.07	3.35	3.21
6	4 <sup>th</sup>	3.42	3.95	1.15	22.07	0.05	0.15	1.07	6.93	21.29	3.57	3.47
7	5 <sup>th</sup>	3.42	5.62	1.64	5.32	0.19	0.64	1.28	9.86	43.37	4.06	3.61
8	6 <sup>th</sup>	3.29	4.24	1.29	11.39	0.09	0.29	1.14	7.73	29.63	3.58	3.38
9	7 <sup>th</sup>	3.43	4.62	1.35	9.89	0.10	0.35	1.16	8.08	31.80	3.78	3.53
10	8 <sup>th</sup>	3.57	4.29	1.20	17.70	0.06	0.20	1.10	7.21	23.77	3.77	3.63
11	9 <sup>th</sup>	3.71	3.9	1.05	72.44	0.01	0.05	1.03	6.31	11.75	3.76	3.72



Fig 1: Incidence of Spider (Araneae: Araneidae) influenced by different abiotic factors in onion ecosystem of red lateritic zone (2021-22)

# Confirmation of negative bionomial distribution of spider population

# Index of dispersion

Index of dispersion(Id) value generally depart from unity i.e the values of this index were 7.86, 6.13, 9.02, 7.63, 10.13, 8.00, 8.43, 9.06, 8.69, 9.19, 8.80 and 6.89 for 51<sup>st</sup> SMW, 52<sup>nd</sup> SMW, 1<sup>st</sup> SMW, 2<sup>nd</sup> SMW, 3<sup>rd</sup> SMW, 4<sup>th</sup> SMW, 5<sup>th</sup> SMW, 6<sup>th</sup> SMW, 7<sup>th</sup> SMW, 8<sup>th</sup> SMW and 9<sup>th</sup> SMW respectively. If it tends to zero it signifies regular distribution but in the experiment it was clearly demonstrated that the range of value of IDM was more than one for spiders in all the standard meterological weeks, which again substantiate aggregative distribution.

# **Dispersion parameter "K"**

'K' of the negative binomial is an index of aggregation in the population and the present observed values for most of the week's found to be either below 8 or slightly exceeding 8 indicating clumping behaviour of individuals. However, the findings were 5.52, 86.49, 3.40, 8.38, 2.70, 5.58, 4.94, 3.64, 6.39, 5.90, 4.58 and 17.38 for 51<sup>st</sup> SMW, 52<sup>nd</sup> SMW, 1<sup>st</sup> SMW, 2<sup>nd</sup> SMW, 3<sup>rd</sup> SMW, 4<sup>th</sup> SMW, 5<sup>th</sup> SMW, 6<sup>th</sup> SMW, 7<sup>th</sup> SMW, 8<sup>th</sup> SMW and 9<sup>th</sup> SMW respectively. It is absolutely proved that the findings are not truly in accordance with the statement of Southwood (1978) wherein he proposed that 'K' value always remains <8 in aggregative distribution.

#### **Reciprocal of "K"**

Reciprocal of 'K' were found to be more than zero with positive sign for all the weeks. The range of this parameter was 018, 0.01, 0.29, 0.12, 0.37, 0.18, 0.20, 0.27, 0.16, 0.17, 0.22 and 0.06

for 51<sup>st</sup> SMW, 52<sup>nd</sup> SMW, 1<sup>st</sup> SMW, 2<sup>nd</sup> SMW, 3<sup>rd</sup> SMW, 4<sup>th</sup> SMW, 5<sup>th</sup> SMW, 6<sup>th</sup> SMW, 7<sup>th</sup> SMW, 8<sup>th</sup> SMW and 9<sup>th</sup> SMW respectively which implied contagious nature of distribution of spider (Araneae: Araneidae) on the red lateritic zone.

#### **David and Moore's index**

David and Moore's index signifies regularity in distribution when the values lies below zero but in the above experiment the calculated values always found to be more than zero i.e. 0.31, 0.02, 0.50, 0.27, 0.69, 0.33, 0.41, 0.51, 0.45, 0.53, 0.47 and 0.15 for 51<sup>st</sup> SMW, 52<sup>nd</sup> SMW, 1<sup>st</sup> SMW, 2<sup>nd</sup> SMW, 3<sup>rd</sup> SMW, 4<sup>th</sup> SMW, 5<sup>th</sup> SMW, 6<sup>th</sup> SMW, 7<sup>th</sup> SMW, 8<sup>th</sup> SMW and 9<sup>th</sup> SMW respectively. So the distribution was supposed to be clumped or non-random one.

#### Lexis index

Lexis index calculated was more than one in all the weeks i.e. all values departed towards positive side from the unity. The pooled values of this parameter were 1.14, 1.01, 1.23, 1.13, 1.30, 1.15, 1.19, 1.23, 1.20, 1.24, 1.21 and 1.07 for 51<sup>st</sup> SMW, 52<sup>nd</sup> SMW, 1<sup>st</sup> SMW, 2<sup>nd</sup> SMW, 3<sup>rd</sup> SMW, 4<sup>th</sup> SMW, 5<sup>th</sup> SMW, 6<sup>th</sup> SMW, 7<sup>th</sup> SMW, 8<sup>th</sup> SMW and 9<sup>th</sup> SMW respectively. So it again signifies that the distribution of spider (Araneae: Araneidae) followed a contagious and not a random one (only possible when the value equals to unity).

#### **Charlier coefficient index**

In case of regular distribution Charlier coefficient would be imaginary but in the present investigation it was found significantly more than zero suggesting contagious nature.

#### Lloid patchiness index

The Lloid patchiness indexes showing the degree of aggreqativeness. The range varied from 1.89, 1.87, 2.00, 2.40, 2.23, 2.04, 2.20, 2.13, 3.02, 3.31, 2.36 and 2.63 for 51<sup>st</sup> SMW, 52<sup>nd</sup> SMW, 1<sup>st</sup> SMW, 2<sup>nd</sup> SMW, 3<sup>rd</sup> SMW, 4<sup>th</sup> SMW, 5<sup>th</sup> SMW, 6<sup>th</sup> SMW, 7<sup>th</sup> SMW, 8<sup>th</sup> SMW and 9<sup>th</sup> SMW respectively. So the values supported that the distribution of spider (Araneae: Araneidae) was aggregative in nature.

# Conclusion

Natural enemies can effectively minimize pest populations when they coincide spatially and temporally with those populations. Therefore, to improve the effectiveness of biological management, the geographical linkage between pests and natural enemies is also required in addition to temporal synchronization. The objectives of this research assessment were to identify pertinent gaps in the body of literature, appraise the current level of knowledge on the spatial association of a predatory agent such as spider in onion ecosystems, and assess its use in precision pest management programs. Using spiders for biological control is one of the best ways to reduce the amount of chemical pesticides and insect infestations. Adequate statistical techniques for studying the geographical pattern and relationship of pests and natural enemies, particularly in field crops, are spatial analysis by different indices. The dynamic spatial relationship between pests and their natural enemies is influenced by a multitude of biotic and abiotic factors. Different indices of dispersion showed aggregative, clumped and contagious nature of distribution of natural enemies in crop growing season. However calculated 'K' values of most of the standard weeks observed to be slightly deviated from the negative binomial aggregative type of dispersion. Additional research can validate this sample strategy for key onion-growing regions in the red lateritic zone of West Bengal and examine the spatial distribution of spider (Araneae: Araneidae), to improve pest management strategies for the primary insect pest of onions.

#### Acknowledgement

The first author expresses his heartfelt gratitude to Dr. Swarnali Bhattacharya Assitant Professor, Department of Agricultural Entomology, Dr. Palash Mondal Associate Professor, Department of Agricultural Entomology, Dr. Hirak Chatterjee Professor, Department of Agricultural Entomology and Dr. Joydip Mondal Associate professor, Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana(Institute of Agriculture), Sriniketan (W.B.) India for their excellent guidance, suggestions and regular encouragement during the course of investigation.

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