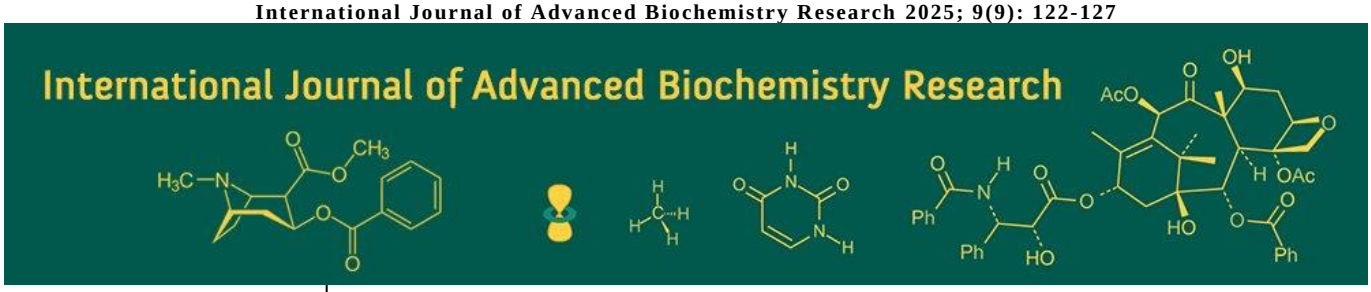

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Succession of major insect pests and their natural enemies on soybean [*Glycin max* (L) Merrill]

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Abstract
The field experiment was conducted to study the succession of major insect pests and their natural enemies on soybean during *Kharif* season 2024 at Experimental Field of Bio-Control Research & Production Centre, JNKVV, Jabalpur (MP). Eight insect pests and five natural enemies were found to be active on soybean crop *viz.*, Whitefly, *Bemisia tabaci* (Genn.), Dragonfly, *Tholymis tillarga* (Fab) and Damselfly, *Copera marginipes* (Rambur) were first observed on 14 days old crop (DOC) and continued up to 104 DOC total duration of 90 days. Jassid, *Empoasca kerri* (Pruthi) was first observed on 17 DOC and present up to 104 DOC total duration of 87 days. Stem fly, *Melanagromyza sojae* (Zehnt.), Bean leaf beetle, *Cerotoma trifurcate* (Forster), Ladybird beetle complex like seven-spotted ladybird beetle (*Coccinella septempunctata*) and zig-zag ladybird beetle (*C. transversalis*) were firstly observed 21 DOC and present up to 104 DOC and total duration of 83 days. Green semilooper, *Chrysodeixis acuta* (Walk.), Leaf folder, *Omiodes indicata* (Fab) and Spider, *Oxyopes salticus* (Hentz) were firstly observed on 28 DOC and present upto 104 DOC total duration of 76 days. Tobacco caterpillar, *Spodoptera litura* (Fab) and Bihar hairy caterpillar, *Spilarctia obliqua* (Walk) were first observed on 35 and 38 DOC respectively and present up to 104 DOC total duration of 69 and 66 days, respectively.

Keywords: Succession, *Glycine max*, soybean, insect pests, whitefly and stem fly

Introduction
Soybean (*Glycine max* L.) is an important agricultural crop grown in *Kharif* season for its rich oil and protein content. Its seeds contain about 42% protein and 20% oil, making it a significant source of nutrition by supplying nearly 60% of the world's vegetable protein and 30% of edible oil (Fehr, 1989) [7]. The major soybean producing countries in world are USA, China, Brazil, Argentina, and India. Globally, India ranks third in terms of the area under soybean cultivation and occupies fifth position in total production Patel *et al.* (2016) [15]. In the world, it is grown in an area of about 128.00 million hectare (mha) during 2023-24 with an annual production of 397.00 million tons (MT) and productivity of 3.10 ton/ha. During 2023-24, In India, it was grown over an area of about 12.08 mha with a production of 12.3 MT and productivity of 1.01 ton/ha (Anonymous, 2024a) [2]. In Madhya Pradesh, soybean ranks first with 5.26 mha area, production of 5.49 MT and productivity of 1.04 ton/ha. In Jabalpur district during 2023-24, it was cultivated in an area of about 0.018 mha with the production of 0.024 MT and productivity of 1.33 ton/ha (Anonymous, 2024b) [3]. In Jabalpur, more than 99 insect species have been documented as pests of soybean crops (Chaudhary *et al.*, 2018) [6]. The current study aimed to examine the sequence of occurrence of the insect pest complex affecting soybean along with their natural enemies.

Material and Methods
Experimental Details
The field study was conducted to investigate the succession of major insect pests of soybean and their natural enemies during the *Kharif* season of 2024 at Experimental Field of the Bio-Control Research & Production Centre, Department of Entomology, College of Agriculture, JNKVV, Jabalpur (MP) India. The experiment was set up in a single plot area of 27 m² and sown the JS 20-116 soybean variety with a planting distance of 50 x 15 cm.

A record of major insect pests of soybean and their natural enemies was maintained from germination to maturity stage of the crop along with crop stage and age. All the observations on arthropods were recorded twice in a standard week (Plate 1 to 13). Observations of sucking pests i.e., adult whitefly and nymph and adult jassid was recorded by caging the individual plants. While, larval population of green semilooper, tobacco caterpillar, leaf folder, bihar hairy caterpillar and natural enemies like lady bird beetle and spider were recorded on the basis of per meter row length and stem fly was observed in infested plants as percent infestation. All the major insect pests of soybean and their natural enemies appeared on the crop was collected and identified properly with their systemic position and activity period. This experimental area was kept free from insecticidal spray throughout the crop season.

Results and Discussion

A detail observation on succession of major insect pests and their natural enemies on soybean crops at various growth stages was recorded and maintained in the record presented in the Table 1 and Fig 1.

Succession of insect pests of soybean

1. Whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae)

The adult whitefly was first observed on 14 days old crop (DOC) (i.e., 29th Standard Week, SW) at vegetative stage which were continued up to 104 DOC (i.e., 41st SW) and stayed on the crop for total duration of 90 days. Patel *et al*. (2016) [15] and Brahman *et al*. (2018) [5] also reported similar findings on white fly in soybean crop from vegetative to maturity stage.

2. Jassid, *Empoasca kerri* (Pruthi) (Hemiptera: Cicadellidae)

Jassids was first recorded on 17 DOC (i.e., 29th SW) and continued to infest the soybean crop up to 104 DOC (i.e., 41st SW) which were stayed on the crop for total duration of 87 days. Brahman *et al*. (2018) [5] and Khandekar *et al*. (2023) [9] reported similar findings of jassid on soybean crop from vegetative to maturity stage.

3. Stem fly, *Melanagromyza sojae* (Zehnt.) (Diptera: Agromyzidae)

The occurrence of stem fly was first recorded during the vegetative stage on 21 DOC (i.e., 30th SW) which were remained on crop up to maturity stage on 104 DOC (41st SW). The pest was stayed on the crop for total duration of 83 days. This finding is corroborated with Sapekar *et al*. (2020) [16] and Naik *et al*. (2021) [14] who recorded stem fly on soybean crop during the vegetative stage at fourthweek of July to crop maturity at third week of October.

4. Green semilooper, *Chrysodeixis acuta* (Walker) (Lepidoptera: Noctuidae)

The green semilooper was first observed on the crop at 28 DOC (i.e., 31st SW), and remained present till on 104 DOC (41st SW) which was available on crop up to the duration of 76 days. Ahirwar *et al*. (2015) [1] were also reported similar findings on soybean crop.

5. Tobacco caterpillar, *Spodoptera litura* (Fabricius) (Lepidoptera: Noctuidae)

The larval population of tobacco caterpillar was first recorded on 35 DOC at vegetative stage (*i.e*., 32nd) and remained active until the crop reached at maturity stage on 104 DOC (*i.e*., 41st SW). Therefore, the tobacco caterpillar infested the crop by staying up to 69 days. Present finding is notably supported by Naik *et al*. (2021) [14], Hemlata *et al*. (2022) [8] and Kushram *et al*. (2021) [11], as they also reported that tobacco caterpillar larvae appeared from the vegetative to maturity stage of the crop.

6. Bihar hairy caterpillar, *Spilarctia obliqua* (Walker) (Lepidoptera: Erebidae)

The Bihar hairy caterpillar was first recorded on the 38 DOC and this pest was present from vegetative stage to maturity stage of the crop (i.e., 32nd to 41st SW), and as well remained in the field for 66 days. Similarly, Sapekar *et al*. (2020) [16] also reported the same result of bihar hairy caterpillar larvae from the vegetative to maturity stage of the crop.

7. Leaf folder, *Omiodes indicata* (Fabricius) (Lepidoptera: Crambidae)

The first appearance of leaf folder was noted on the soybean crop at 28 DOC (i.e., 31st SW). These leaf folder were present from early vegetative stage to maturity stage (i.e., 31st to 41st SW), spanning a period of 76 days, up to 104 DOC. Brahman *et al*. (2018) [5] and Meena *et al*. (2018) [13] also reported that infestation of leaf folder was occurred from the vegetative stage last week of July to maturity stage second week of October on soybean crop.

8. Bean leaf beetle, *Cerotoma trifurcata* (Forster) (Coleoptera: Chrysomelidae)

The first appearance of the bean leaf beetle was observed on 21 DOC (i.e., 30th SW). These beetles were also present in the field from vegetative stage to maturity stage (i.e., 30th to 41st SW), lasting for 83 days until the crop reached on 104 DOC.

Succession of natural enemies of insect pests

1. Dragonfly, *Tholymis tillarga* (Fabricius) (Odonata: Libellulidae)

The predatory dragonfly was first observed in the soybean crop at vegetative stage on 14 DOC (*i.e*., 29th SW)) and remained active until the crop reached at maturity stage on 104 DOC (*i.e*., 41st). Therefore, the dragonfly acts as a predator of pests up to a total duration of 90 days.

2. Damselfly, *Copera marginipes* (Rambur) (Odonata: Platyonemididae)

The first appearance of the predatory damselfly was recorded on 14 DOC at vegetative stage (i.e., 29th SW) and was remained on the crop to the harvesting stage (*i.e*., 41st SW), lasting for 90 days until the crop reached 104 DOC.

3. Spider, *Oxyopes salticus* (Hentz) (Araneae: Oxyopidae)

The predatory spider was first observed on 28 DOC 24 (*i.e*., 31st SW), and remained present on 104 DOC (i.e., 41st SW). It was active on the crop for a duration of 76 days. Ahirwar *et al*. (2015) [1] and Kumari *et al*. (2020) [10] reported that spiders are act as effective natural predators. The presence

of spiders during the vegetative stage to maturity stage of crop was recorded by Hemlata *et al*. (2022) [8] and Biradar *et al*. (2023) [4].

4. Lady bird beetle complex (Coleoptera: Coccinellidae)

The first appearance of the predatory Ladybird beetle complex, consisting of two distinct species *viz*., seven-spotted ladybird beetle, *Coccinella septempunctata* Linnaeus, and zig-zag ladybird beetle, *C. transversalis* Fabricius was recorded on the crop during 21 DOC. The ladybird beetle complex was present on the crop from the vegetative stage (30th SW) to maturity stage (i.e., 41st SW), remaining for a period of 83 days until the crop reached 104 DOC. Hemlata *et al*. (2022) [8] and Birader *et al*. (2023) [4] reported the similar finding of ladybird beetle on soybean crop as predatory insects on sucking insect pests.

Table 1: List of major insect pests and their natural enemies recorded on soybean at Jabalpur during *Kharif* 2024

S. No.	Common Name	Scientific Name	Order	Family	Role of arthropods	Activity Period
1	Whitefly	*Bemisia tabaci* (Genn.)	Hemiptera	Aleyorodidae	Pest (Nymph + Adult)	3rd week of July to 2nd week of October
2	Jassid	*Empoasca kerri* (Pruthi)	Hemiptera	Cicadellidae	Pest (Nymph + Adult)	
3	Dragonfly	*Tholymis tillarga* (Fab.)	Odonata	Libellulidae	Predator (Adult)	
4	Damselfly	*Copera marginipes* (Rambur)	Odonata	Platyonemididae	Predator (Adult)	
5	Stem fly	*Melanogromyza sojae* (Zehnt.)	Diptera	Agromyzidae	Pest (Maggot)	4th week of July to 2nd week of October
6	Bean leaf beetle	*Cerotoma trifurcata* (Forster)	Coleoptera	Chrysomelidae	Pest (Adult)	
7	Ladybird beetle	(i) *Coccinella septempunctata* (L) (ii) *C. transversalis* (Fab.)	Coleoptera	Coccinellidae	Predator (Grub + Adult)	
8	Green semilooper	*Chrysodeixis acuta* (Walk.)	Lepidoptera	Noctuidae	Pest (Caterpilllar)	1st week of August to 2nd week of October
9	Leaf folder	*Omiodes indicata* (Fab.)	Lepidoptera	Crambidae	Pest (Caterpilllar)	
10	Spider	*Oxyopes salticus* (Hentz)	Araneae	Oxyopidae	Predator (Adult)	
11	Tobacco caterpiller	*Spodoptera litura* (Fab.)	Lepidoptera	Noctuidae	Pest (Caterpilllar)	2nd week of August to 2nd week of October
12	Bihar hairy caterpillar	*Spilarctia obliqua* (Walk.)	Lepidoptera	Erebidae	Pest (Caterpilllar)	

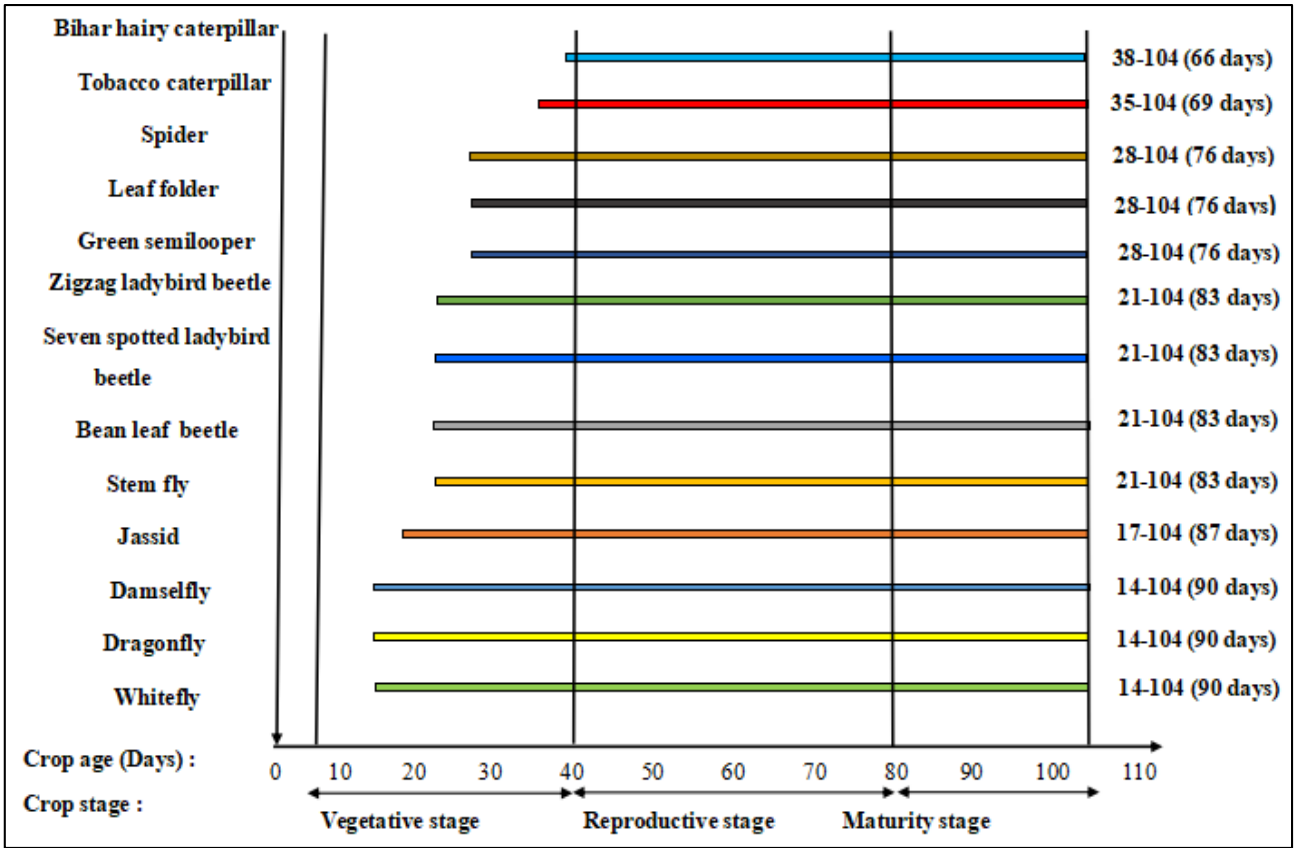

Fig 1: Succession of arthropods on soybean crop at Jabalpur during kharif 2024

Arthropods recorded on soybean crop

Plate 1: Adult Whitefly *Bemisia tabaci* (Genn.)

Plate 2: Adult Jassid *Empoasca kerri* (Pruthi)

Plate 3: Stem fly Maggot *Melanagromyza sojae* (Zehnt.)

Plate 4: Green semilooper larva *Chrysodeixis acuta* (Walk.)

Plate 5: Tobacco caterpillar larva *Spodoptera litura* (Fab.)

Plate 6: Bihar hairy caterpillar larva *Spilarctia oblique* (Walk.)

Plate 7: Leaf folder larva *Omiodes indicate* (Fab.)

Plate 8: Bean leaf beetle *Cerotoma trifurcate* (Forster)

Plate 9: Adult Dragonfly *Tholymis tillarga* (Fab.)

Plate 10: Adult Damselfly *Copera marginipes* (Rambur*)*

Plate 11: Adult Spider *Oxyopes salticus* (Hentz)

Plate 12: Seven spotted ladybird beetle *Coccinella septumpunctata* (L.)

Plate 13: Zig-zag ladybird beetle *Coccinella transversalis* (Fab.)

Conclusion

The results revealed that succession of all arthropods i.e., whitefly, jassid, dragonfly and damselfly were first observed during 3rd week of July 2024 while, stemfly, bean leaf beetle and ladybird beetle was observed 4th week of July 2024 whereas, green semilooper, leaf folder and spider was first appeared from 1st week of August 2024 while, tobacco caterpillar and bihar hairy caterpillar first occurred from 2nd week of August 2024. All the arthropods were stayed on the crop up to 2nd week of October 2024. The results revealed that a diverse community, consisting of a total 13 species was recorded on soybean crop during the course of investigation. Among them, four species of Lepidoptera i.e., tobacco caterpillar (*S. litura*), green semilooper (*C. acuta*), Bihar hairy caterpillar (*S. obliqua*) and leaf folder (*O. indicate*) which distribution was occupied 31%, three species of Coleoptera i.e., bean leaf beetle (*C. trifurcate*), lady bird beetle complex (*C. septempunctata* and *C. transversalis*) (23%), two species each of Hemiptera i.e., whitefly (*B. tabaci*) and jassid (*E. kerri*) (15%) and Odonata i.e., dragonfly (*T. tillarga*) and damselfly (*C. marginipes*) (15%), and one species each of Araneae i.e., spider (*O. salticus*) (8%) and Diptera i.e., stemfly (*M. sojae*) (8%).

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