

EFFECT OF SOWING DATES ON INCIDENCE AND ABUNDANCE OF INSECT PESTS AND NATURAL ENEMIES IN SOYBEAN [*Glycine max* (L.) Merrill]

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Date of Receipt: 25-07-2024

Date of Acceptance: 14-08-2024

ABSTRACT

The effect of different sowing dates on incidence and abundance of insect pests and associated natural enemy population was studied by taking three staggered sowings at 15 days interval (2nd fortnight of June, 1st and 2nd fortnight of July). The data obtained from the three staggered sowings, revealed that the occurrence of insect pests and natural enemies was similar in all the staggered sowings except for their level of incidence. Peak period of infestation of tobacco caterpillar occurred only once in June 2nd fortnight sowing compared to July 1st and 2nd fortnight sowing, wherein two peaks were recorded. In case of green semilooper only one peak each was recorded in June and July 2nd fortnight sowings whereas two peaks were observed in July 1st fortnight sowing. In case of stem fly, one peak was observed in June 2nd fortnight sowing compared to July 1st and 2nd fortnight sowing wherein two peaks were recorded. Infestation of stem girdler recorded two peaks in all the three staggered sowings. The highest incidence of major insect pests was recorded in the 2nd staggered sowing with a yield of 11.50 qha⁻¹. However, 3rd staggered sowing recorded comparatively low population but with lowest yield of 9.00 qha⁻¹ due to the heavy rains in the initial period which adversely affected the crop growth and development. The normal sowing (2nd fortnight of June/1st staggered sowing) recorded low insect pest population compared to that of both the sowings with highest yield (13.50 qha⁻¹).

Key Words: insect pests, natural enemies, peak period, staggered sowing, soybean, and yield

Soybean is a major oilseed crop in the world, accounting for nearly 50 per cent of the total oil seeds acreage as well as production. Soybean contains 20 per cent oil and 40-42 per cent quality protein. In India, soybean ranks second in the vegetable oil economy only after groundnut (ICAR, 2006). The cultivated soybean contributes to 30-37 per cent of India's oil seed production with 11.67 mha of area, 8.59 mt production and a productivity of 737 kg ha⁻¹ (DES, 2016). It is cultivated in Madhya Pradesh, Maharashtra, Karnataka, Uttar Pradesh, Rajasthan, TamilNadu, Uttarakhand and Telangana as a rain-fed crop during the *Kharif* season. Madhya Pradesh alone

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² Principal Scientist and Head, Pesticide Residues Laboratory, PJTAU, Rajendranagar contributes to 49.93 per cent of the total production (Gaur *et al.*, 2015). In Telangana, it occupies about 0.24 mha with 0.254 mt of production and 1037 kg ha⁻¹ of average productivity (AAP, 2016). The crop is reported to be attacked by 275 spp. of insect pests, of which about a dozen are of economic importance (Singh and Singh, 1989). Among the pest species, leaf miner, *Aproaerema modicella* (Deventer), stem fly,

Melanagromyza sojae (Zehntner), stem girdler, *Obereopsis brevis* (Swedenborg), whitefly, *Bemisia tabaci* Gennadius, aphids, leaf hoppers and some defoliators are important. The major defoliators found on soybean are *Spodoptera litura* (Fabricius), *Gesoniagema* (Swinhoe), *Chrysodeixis acuta* (Walker), *Helicoverpa armigera* (Hubner), *Spilosoma obliqua* (Walker), *Achaea janata* L. etc. Among them, green semilooper, *C. acuta* and tobacco caterpillar, *S. litura* are insects feeding on foliage, flower and pods causing significant yield loss. Besides, several natural enemies are known to occur in the soybean ecosystem viz., ladybird beetles, *Chrysopa*, predatory pentatomid bugs, spiders, earwigs, *Apanteles* etc., throughout the crop stage (Patil *et al.*, 2015). In light of the above information and due to the fact that, soybean cultivation is confined to northern Telangana (1.66 lakh ha) and the crop is slowly expanding in central Telangana (0.11 lakh ha) with a small area in the southern Telangana zone, the present investigation was conducted to know the effect of different sowing dates on the incidence and abundance of insect pests and natural enemies.

Materials and Methods: The research was conducted in observational plots laid out in the

college farm, College of Agriculture, Rajendranagar which is situated in Ranga Reddy district (17.3°N 78.1°E) under the southern Telangana region. The variety, JS 335 was taken in black soil in three staggered sowings i.e., on 17-06-2017 (2nd fortnight of June), 1-07-2017 (1st fortnight of July) and 15-07-2017 (2nd fortnight of July) in plots of 100 square meters each. The observations on different pests and their natural enemies in each plot were recorded once in a standard week starting from 7-10 days after germination (DAG) and are given here under.

Semilooper: Number of larvae of green semiloopers was counted in mrl by shaking the plants of two rows of 0.5 mrl on muslin cloth at three random places in each plot.

Leaf miner: No. of larvae/plant in randomly selected ten plants; no. of leaf-lets and damaged leaf-lets were recorded and per cent leaf-lets was computed for each plot.

Stem fly:

a) Seedling mortality: Seedling mortality, total number of plants and number of plants that succumbed to stem fly infestation were recorded at three places randomly at 7-10 DAG in each plot and expressed in percentage.

Seedling mortality=

$$\frac{\text{Total number of}}{\text{Number of plants}} \times 100$$

b) Stem tunneling: Plant height and length of stem tunnelled in 10 randomly selected plants at physiological maturity and expressed in percentage.

X 100

$$\% \text{ Stem tunneling} = \frac{\text{Length of tunnel}}{\text{Height of the plant (cm)}} \times 100$$

Stem girdler: Total number of plants and girdled plants was recorded from one mrl at five places per plot and expressed as per cent plant infestation.

Sucking pests: Observations were recorded for estimation of major sucking pests viz., whiteflies, aphids and leaf hoppers by counting their numbers on upper, middle and lower leaves (3 numbers each) from ten randomly selected plants in each plot.

Natural enemies: The prevalence of parasitoids was estimated by collecting different stages of pest viz., eggs, larvae and pupae (five samples in each field) and observing for the emergence of any parasitoids from the collected samples of the pest stages. The

prevalence of predators was counted in ten randomly selected plants in each plot.

Harvesting and Threshing

Harvesting was done separately by pulling the entire plant from the ground when the leaves turned yellow and the plants dried up and seeds became hard. For the first staggered sowing, harvesting was done on 10-10-2017; for the second, on 21-10-2017 and for the third, on 4-11-2017. The harvested crop from each plot was dried separately by spreading on the threshing floor. After complete drying, dry pod weight and grain yield were recorded separately for each of the plots.

Results

First staggered sowing:

Defoliators (Tobacco caterpillar and Green semilooper): The larvae of tobacco caterpillar (*S. litura*) were found feeding on the leaves during the vegetative stage and caused severe damage. The appearance of the pest was first recorded during the 27th SMW (0.60 l/mrl) and it gradually increased upto 32nd SMW (3.20 l/mrl). Later, it declined reaching to 0.10 l/mrl during 38th SMW. The mean population during this period was 1.21 l/mrl. The first appearance of green semilooper larvae (*C. acuta*) was recorded during 30th SMW (0.60 l/mrl) and reached to its peak during the 32nd SMW (3.10 l/mrl). Later, it decreased to 0.0 l/mrl during 38th SMW. However, during the 35th SMW, there was an increase in the larval population to 2.00 l/mrl compared to the previous week. The seasonal mean population was recorded as 0.87 l/mrl.

Stem fly and Stem girdler: The incidence of stem fly (*M. sojae*) started during the 28th SMW (7.50%). Subsequently, the pest increased gradually and attained its peak during the 33rd SMW (23.50%). From the 34th SMW, there was a gradual decrease in the % infestation, which finally reached 6.40% in the 38th SMW. The seasonal mean infestation was recorded as 10.95%. There was no seedling mortality at 7-10 DAG whereas % stem tunnelling at physiological maturity was recorded as 9.34% (Table 1.2). The infestation of stem girdler (*O. brevis*) in soybean started during the 29th SMW (7.50%) reaching its peak during the 31st SMW (24.60%). Later, there was a decrease in infestation of the pest upto the 33rd SMW (9.50%), followed by an increase till the 36th SMW (25.50%). Thereafter, it decreased, reaching 11.50% during the 38th SMW. The seasonal mean infestation was recorded as 12.38%.

Table 1.1 Seasonal incidence of insect pests and natural enemies in the 1st staggered sowing of soybean crop

SMW	S. litura (l/mrl)	C. acuta (l/mrl)	Stem fly (% infestation)	Stem girdler (% infestation)	Leaf miner				Sucking pests (3 leaves/plant)		Natural enemies (per plant)	
					L. trifoli		A. modicella		Aphids	Leaf hoppers	Coccinellids	Spiders
					l/plant	% leaf-let damage	l/plant	% leaf-let damage				
26	0.00	0.00	0.00	0.00	0.20	9.50	0.00	0.00	0.00	0.00	0.00	0.00
27	0.60	0.00	0.00	0.00	0.80	21.50	0.00	0.00	0.00	0.00	0.00	0.00
28	1.60	0.00	7.50	0.00	3.30	25.50	0.00	0.00	0.00	0.50	0.00	0.00
29	0.80	0.00	6.50	7.50	1.50	8.50	0.00	0.00	0.20	0.30	0.10	0.00
30	1.20	0.60	14.50	20.50	1.10	14.40	0.00	0.00	0.80	0.90	0.60	0.70
31	2.50	1.30	16.20	24.60	3.90	13.50	0.00	0.00	1.20	3.00	1.60	1.00
32	3.20	3.10	21.60	13.50	1.60	8.80	0.00	0.00	4.50	3.20	3.10	0.30
33	2.00	2.50	23.50	9.50	0.70	3.19	0.00	0.00	3.20	3.50	1.30	1.20
34	0.80	1.20	10.50	11.30	0.10	1.50	0.00	0.00	0.50	1.50	0.30	0.80
35	1.60	2.00	14.20	18.60	0.00	0.00	0.00	0.00	1.00	4.10	0.80	1.20
36	0.80	0.50	11.00	25.50	0.00	0.00	0.90	12.50	0.30	2.70	0.20	1.60
37	0.60	0.20	10.50	18.50	0.00	0.00	0.40	9.50	0.00	1.60	0.00	0.80
38	0.10	0.00	6.40	11.50	0.00	0.00	0.30	2.50	0.00	0.50	0.00	0.20
Mean	1.21	0.87	10.95	12.38	1.01	8.18	0.12	1.88	0.90	1.67	0.61	0.60

l/mrl – larvae per meter row length; l/plant – larvae per plant

Table 1.2. Per cent seedling mortality (7-10 DAG) and stem tunneling at physiological maturity due to stem fly

Plot	% Seedling mortality	% Stem tunneling
1 st staggered sowing	0.00	9.34
2 nd staggered sowing	7.69	11.61
3 rd staggered sowing	12.63	10.44

Leaf miners: During the period of the crop growth, both serpentine leaf miner (*L. trifolii*) and groundnut leaf miner (*A. modicella*) were recorded. The former pest was seen during the seedling and early vegetative stage of the crop, while the later was at reproductive stage of the crop.

The incidence of serpentine leaf miner started during the 26th SMW with the infestation being 0.20 l/plant, and attained the peak during the 28th and 31st SMW (3.30 and 3.90 l/plant, respectively). The seasonal mean incidence of the larvae was recorded as 1.01 l/plant. Similarly, the per cent leaf-let damage during the corresponding period was 9.50%, 25.50% and 13.50%, respectively. The seasonal mean per cent leaf-let damage was recorded as 8.18 %. In case of groundnut leaf miner, the first appearance was recorded during the 36th SMW (0.90 l/plant) with 12.50 % leaf-let damage. Subsequently, there was a gradual decrease both in larval number/plant and per cent leaf-let damage (0.30 l/plant and 2.50 %, respectively) during the 38th SMW. The seasonal mean of l/plant and per cent leaf-let damage were recorded as 0.12 l/plant and 1.88 %, respectively.

Sucking pests: Aphids first appeared during the 29th SMW (0.20/3leaves/plant) and attained its peak during the 32nd SMW (4.50/3leaves/plant). Thereafter, it declined with no occurrence of the aphids during the 37th and 38th SMW. The seasonal mean population was recorded as 0.90/3leaves/plant. In case of the leaf hoppers, the appearance started from the 28th SMW (0.50/3leaves/plant). It gradually increased and attained its peak during the 35th SMW (4.10/3leaves/plant) and finally reached 0.50/3leaves/plant during the 38th SMW. However, during 34th SMW, there was a decrease in the population, being 1.50/3leaves/plant. The seasonal mean observed was 1.67/3leaves/plant.

Natural enemies: The occurrence of the coccinellid beetles was first recorded during the 29th SMW (0.10/plant). It was found to gradually increase reaching its

peak during the 32nd SMW (3.10/plant) and subsequently the population decreased to 0.20/plant during the 36th SMW and no population was observed thereafter. The seasonal mean recorded was 0.61/plant. Spiders first appeared during 30th SMW (0.70/plant). The peak appearance of population was recorded during the 36th SMW (1.60/plant). In the 32nd SMW there was a decrease in population (0.30/plant) and thereafter increased with fluctuations in the population. Finally, the population reached 0.20/plant during the 38th SMW. The mean population was recorded as 0.60/plant.

The results for the incidence of insect pests and natural enemies for the first staggered sowing revealed that among the defoliators, the highest seasonal mean population was recorded for *S. litura* compared to that of the green semilooper (*C. acuta*) being 1.21 and 0.87 l/mrl, respectively. Similarly, infestation of stem girdler (12.38 %) was higher compared to stem fly infestation (10.95 %). Also, among the leaf miners, serpentine leaf miner population and damage (1.01 l/plant and 8.18 % leaf-let damage) were more compared to that of groundnut leaf miner (0.12 l/plant and 1.88 % leaf-let damage). In case of sucking pests, leaf hoppers recorded a larger population (1.67/3leaves/plant) than aphids (0.97/3leaves/plant). The mean population of coccinellids and spiders was 0.61 and 0.60 per plant, respectively.

Second staggered sowing

Defoliators (Tobacco caterpillar and Green semilooper): The appearance of the tobacco caterpillar larvae were first recorded during the 28th SMW (0.60 l/mrl) and it gradually increased and attained the peak population during the 32nd SMW (4.00 l/mrl). In the next three weeks, it declined but during 36th SMW, the population of larvae reached its second peak (3.60 l/mrl) and thereafter, it showed a gradual decline and ended up with 0.60 l/mrl in the 40th SMW. The seasonal mean recorded was 2.10 l/mrl. In case of green semilooper, the larvae were first recorded during 29th

Table 1.3. Seasonal incidence of insect of insect pests and natural enemies in the 2nd staggered sowing of soybean crop

SMW	<i>S. litura</i> (l/mrl)	<i>C. acuta</i> (l/mrl)	Stem fly (% infestation)	Stem girdler (% infestation)	Leaf miner				Sucking pests (3 leaves/plant)		Natural enemies (per plant)	
					<i>L. trifoli</i> l/plant	% leaf-let damage	<i>A. modicella</i> l/plant	% leaf-let damage	Aphids	Leaf hoppers	Coccinellids	Spiders
28	0.60	0.00	0.00	0.00	0.30	11.50	0.00	0.00	0.10	0.00	0.20	0.00
29	1.20	0.30	6.50	5.50	1.40	22.50	0.00	0.00	0.00	0.00	0.10	0.00
30	2.20	0.00	9.50	11.90	2.60	32.50	0.00	0.00	0.20	0.60	0.10	0.40
31	2.80	0.60	13.20	18.50	1.00	15.50	0.00	0.00	0.50	0.80	0.50	0.90
32	4.00	1.30	18.60	15.50	0.80	16.60	0.00	0.00	2.20	1.60	1.10	0.70
33	3.20	2.20	28.20	10.30	1.20	10.50	0.00	0.00	3.50	2.20	2.10	0.60
34	1.80	1.80	13.50	16.20	0.50	3.45	0.00	0.00	0.80	0.60	0.70	0.50
35	2.50	3.20	24.20	20.50	0.20	2.45	0.00	0.00	1.80	3.40	1.30	1.00
36	3.60	2.30	23.20	28.50	0.10	1.75	0.70	9.50	1.60	2.10	1.10	1.70
37	2.80	1.20	19.50	26.30	0.30	2.75	1.20	15.50	2.20	2.50	1.80	0.50
38	1.20	0.70	11.40	17.60	0.00	0.00	0.80	10.30	0.80	1.90	0.50	1.20
39	0.80	0.20	10.20	12.50	0.00	0.00	0.40	7.50	0.00	0.20	0.00	1.40
40	0.60	0.00	5.50	8.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
Mean	2.10	1.06	14.10	14.75	0.64	9.19	0.23	3.29	1.05	1.22	0.73	0.71

l/mrl – larvae per meter row length; l/plant – larvae per plant

SMW. It attained the peak during the 35th SMW (3.20 l/mrl) and subsequently declined to 0.00 l/mrl in the 40th SMW. The seasonal mean population was recorded as 1.06 l/mrl.

Stem fly and Stem girdler: The infestation of stem fly was first observed during 29th SMW (6.50%). Later, the pest increased gradually and attained its peak during the 33rd SMW (28.20 %). From the 35th SMW (24.20%), there was a gradual decline in the per cent infestation which finally reached to 5.50% in the 40th SMW. However, during 34th SMW, the infestation was recorded as 13.50%. The seasonal infestation was recorded as 14.10%. The per cent mortality of the seedling was recorded as 7.69%, whereas per cent stem tunnelling at physiological maturity was 11.61% (Table 1.2). The infestation of the stem girdler started during the 29th SMW (5.50%). and reached 18.50% during 31st SMW. After a reduction in population in the 32nd and 33rd SMW, it increased gradually and attained its peak during the 36th SMW (28.50%). Subsequently, there was a decrease in the infestation, which reached 8.50% in the 40th SMW. The seasonal mean infestation was recorded as 14.75%.

Leaf miners: During the 2nd staggered sowing, both serpentine leaf miner and groundnut leaf miners were noticed. The serpentine leaf miner was recorded during the seedling and early vegetative stage of the crop whereas the groundnut leaf miner appeared during the reproductive stage of the crop. The serpentine leaf miner appeared during the 35th SMW (0.20 l/plant) with 1.50 % leaf-let damage. The peak larval population was recorded during the 37th SMW (1.40 l/plant) whereas per cent leaf-let damage during the 36th SMW (9.50%). Later, the larval population and per cent leaf-let damage declined. The seasonal mean larvae per plant (l/plant) and per cent leaf-let damage was recorded as 0.28 l/plant and 2.03%, respectively. In case of groundnut leaf miner, the pest was first observed during the 36th SMW with 0.70 l/plant and 9.50% leaf-let damage. There was a gradual decline in both larva/plant and per cent leaf-let damage, which ended with 0.40 l/plant and 7.50 %, respectively during the 39th SMW. The seasonal means of larva/plant and per cent leaf-let damage were 0.23 l/plant and 3.29%, respectively.

Sucking pests: Aphids first appeared during the 28th SMW (0.10/3leaves/plant) and gradually increased, attaining its peak during the 33rd SMW (3.50/3leaves/

plant). The second peak was observed during the 37th SMW (2.20/3leaves/plant). In the 38th SMW, the population declined to 0.80/3leaves/plant. Thereafter, no population was recorded. The seasonal mean population was recorded as 1.05/3leaves/plant. In case of leaf hoppers, the appearance was noticed from the 30th SMW (0.60 /3leaves/plant). It increased gradually to 3.40/3leaves/plant during the 35th SMW. Subsequently, it declined to 0.20/3leaves/plant during the 39th SMW. However, during 34th SMW there was a decrease in the population to 0.60/3leaves/plant. The seasonal mean observed was 1.22/3leaves/plant.

Natural enemies: The occurrence of the coccinellid beetles was first recorded during the 28th SMW (0.20/plant). It was found to increase gradually, reaching its peak during the 33rd SMW (2.10/plant) before declining to 0.50/plant during 38th SMW with no population being observed in the following two weeks. The seasonal mean was recorded as 0.73/plant. Spiders first appeared during 30th SMW (0.40/plant). The peak appearance of population was recorded during 36th SMW (1.70/plant) with fluctuations in the population and finally reached 0.40/plant during the 40th SMW. The mean population was recorded as 0.71/plant.

The data recorded during the second staggered sowing with respect to insect pests and natural enemies revealed that among the defoliators, the highest seasonal mean population was recorded for *S. litura* larvae, compared to that of *C. acuta* (2.10 and 1.06 l/mrl, respectively). Similarly, infestation of the stem girdler was higher (14.75%) compared to stem fly infestation (14.10%). Also, among leaf miners, serpentine leaf miner recorded more larval population and damage (0.64 l/plant and 9.19 % leaf-let damage) compared to that of groundnut leaf miner (0.23 l/plant and 3.29% leaf-let damage). In case of sucking pests, leaf hoppers recorded a greater population (1.22/3leaves/plant) than aphids (1.05/3leaves/plant). The natural enemies like coccinellids and spiders had a mean population of 0.73 and 0.71 per plant, respectively.

Third staggered sowing

Defoliators (Tobacco caterpillar and Green semilooper): The appearance of the *S. litura* larvae was first noticed during the 34th SMW (0.60 l/mrl) and the peak population was recorded during the 39th SMW (3.70 l/mrl) in the case of the third staggered sowing.

However, during 38th SMW, the population was 1.50 l/mrl. Subsequently, the population declined to 0.60 l/mrl during the 44th SMW. The seasonal mean population was 1.50 l/mrl. The first appearance of the *C. acuta* larvae was recorded during 35th SMW (0.50 l/mrl) and gradually increased and attained the peak during 39th SMW (2.20 l/mrl). In the next week the population declined to 0.10 l/mrl and thereafter, there was no incidence. The seasonal mean population was recorded as 0.53 l/mrl.

Stem fly and Stem girdler: The infestation of stem fly was first observed during the 34th SMW (4.10%). Later, the pest increased gradually and attained its peak during the 37th and 39th SMW (20.50%). Thereafter a gradual decline in the per cent infestation was seen, which reached 8.50% in the 42nd SMW. However, during the 43rd and 44th SMW, and the infestation recorded was 13.50 and 12.60 %, respectively. The seasonal mean infestation was recorded as 13.12%. The per cent mortality of the seedling at 7-10 DAG recorded as 12.63% whereas per cent stem tunneling at physiological maturity was 10.44% (Table 4.9). The infestation of the stem girdler started during the 34th SMW (6.60%) and reached 20.50% during the 37th SMW. Later, there was a decrease in the infestation which reached to 8.50% in the 44th SMW. However, during 41st and 42nd SMW, it increased to 14.20 and 15.60%, respectively. The seasonal mean infestation was recorded as 12.34%.

Leaf miners: The serpentine leaf miner appeared during the 28th SMW (0.30 l/plant) and attained its first peak during the 30th SMW (2.60 l/plant). Later, there was a decrease in the larval population, and by the 38th SMW no population was seen. A second peak was noticed in the 33rd SMW (1.20 l/plant). The seasonal mean no. of larvae per plant (l/plant) was recorded as 0.64. Similarly, per cent leaf-let damage recorded during 28th SMW was 11.50% and it attained a peak during the 30th SMW (32.50%). Later, there was a gradual decline in the per cent leaf-let damage upto 37th SMW (2.75%) and thereafter, no damage was recorded. The seasonal per cent leaf-let damage was recorded as 9.19%. In case of the groundnut leaf miner, it first appeared during the 37th SMW (0.30 l/plant) causing 8.50% leaf-let damage. The peak occurrence of larval and per cent leaf-let damage was recorded during 39th SMW (0.60 l/plant and 9.50%, respectively). Subsequently, it declined. The seasonal

mean of larva/plant and per cent leaf-let damage was recorded as 0.19 l/plant and 3.40%, respectively.

Sucking pests: Aphids first appeared during the 35th SMW (0.80/3leaves/plant) and attained the highest population of 2.80/3leaves/plant during the 39th SMW. Later, the population declined and reached to 0.20/3leaves/plant during the 43rd SMW. The seasonal mean population was recorded as 0.70/3leaves/plant. In case of leaf hoppers, it was first observed in the 35th SMW (0.30/3leaves/plant). Which gradually increased and attained its peak during the 37th SMW (1.70/3leaves/plant). Subsequently, it declined to 0.60/3leaves/plant during 44th SMW. However, during the 39th SMW, a second peak was reached with 1.60 leaf hoppers/3leaves/plant. The seasonal mean observed was 0.69/3leaves/plant.

Natural enemies: The occurrence of coccinellid beetles was first recorded during the 35th SMW (0.30/plant) and attained peak during 39th SMW (0.90/plant). Thereafter, the population declined and reached 0.10/plant during 43rd SMW. The seasonal mean recorded was 0.35/plant. Spiders first appeared during the 35th SMW (0.40/plant). The peak appearance of population was recorded during the 37th SMW (1.20/plant). Later, it declined and reached 0.30/plant in the 44th SMW. The mean population was recorded as 0.42/plant (Table 1.4).

The data recorded during the third staggered sowing with respect to insect pests and natural enemies revealed that, among the defoliators, the highest seasonal mean population was recorded with *S. litura* compared to that of green semilooper (*C. acuta*) (1.50 and 0.53 l/mrl, respectively). Similarly, infestation of the stem fly was higher (13.12%) compared to stem girdler infestation (12.34%). Also, among leaf miners, serpentine leaf miner recorded more larval population (0.28 l/plant) compared to that of groundnut leaf miner (0.19 l/plant) whereas per cent leaf-let damage was greater by groundnut leaf miner (3.40%) than serpentine leaf miner (2.03%). In case of sucking pests, the population of aphids (0.70/3leaves/plant) was more than leaf hoppers (0.69/3leaves/plant). The natural enemies like coccinellids and spiders had a mean population of 0.35 and 0.42/plant, respectively.

RESULTS AND DISCUSSION

The seasonal mean and peak incidence of major insect pests in the three staggered sowings are discussed hereunder:

Tobacco caterpillar

The incidence of *S. litura* was noticed from the 26th SMW to the 38th SMW in the first staggered sowing, between 28th and 40th SMW in 2nd staggered sowing and between 34th and 44th SMW in 3rd staggered sowing (Fig.7). The present findings are in line with Yeotikaret *et al.* (2015) who recorded the incidence during the 32nd to 35th SMW. Babu *et al.* (2017) recorded the incidence from the 30th SMW to the 38th SMW whereas Matti and Deotale (2017) reported its from 35th to 46th SMW.

(2007) and Ahirwar (2010), who recorded two peaks one each during 35th to 37th SMW and 37th to 39th SMW, although Anjali (2012) observed three peaks *i.e.*, during the 32nd, 34th and 37th SMW.

Thus, it can be inferred that among the three staggered sowings, the first staggered sowing taken up in the June 2nd fortnight had only one peak period of infestation of *S. litura* compared to the July 1st and 2nd fortnight sowings wherein two peaks were recorded. Also, the mean population of *S. litura* was relatively lower (1.21 l/mrl) in the June sown crop than in the July sown crop (2.10 and 1.50 l/mrl, respectively) (Table 1.5). The results are in line with Santhosh (2008) who recorded significantly higher incidence of *S. litura* in late sown crop (2nd week of July) than early sown crop (2nd week of June). Kalyan

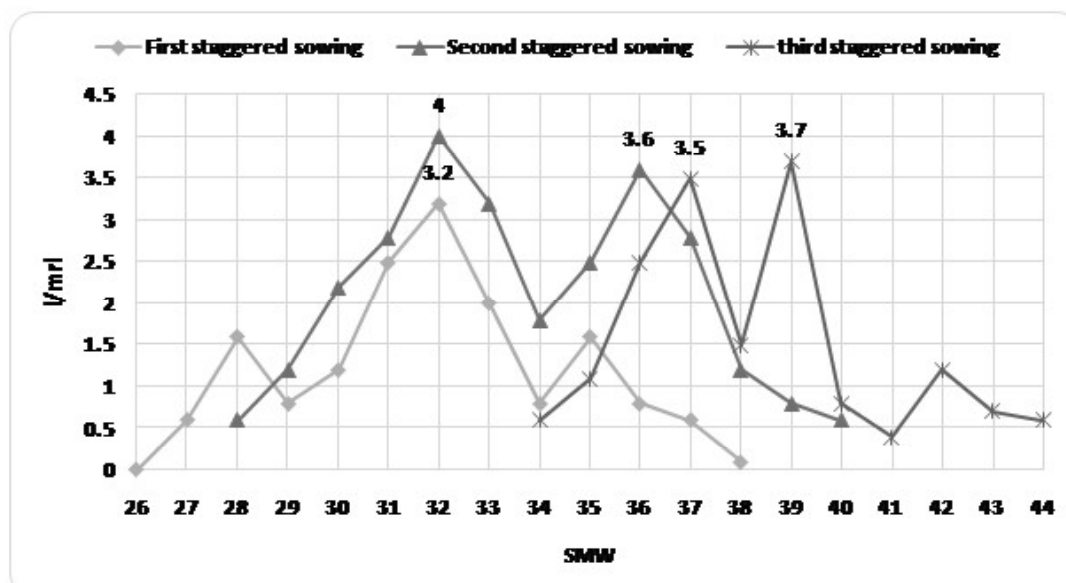


Fig 7. Peak occurrence of *S. litura* in the three staggered sowings

The population of *S. litura* attained its peak during the 32nd SMW in the first (3.20 l/mrl) and second staggered sowings (4.00 l/mrl). A similar observation was recorded by Gaur *et al.* (2015) in the 33rd SMW. However, other workers *viz.*, Raju *et al.* (2013), Yadav *et al.* (2015a), Vijay (2013), Padiwal (2007), Kalyan and Ameta (2017b) also observed a single peak but during 37th to 41st SMW depending upon the time of sowing. A second peak was recorded at 36th SMW (3.60 l/mrl) in the 2nd staggered sowing. Similarly, two peaks were seen in the 3rd staggered sowing at 37th (3.70 l/mrl) and 39th (3.70 l/mrl) SMW. From this data, it can be inferred that there was an increase in population of *S. litura* in two spells *i.e.*, during the 32nd SMW and during the 36th to 39th SMW, irrespective of the date of sowing of the crop. The present findings are in line with the works of Kumawat

and Ameta (2017a) also recorded significantly higher incidence of *S. litura* in late sown crop (3rd week of July) than early sown crop (1st week of July).

Green Semilooper

The incidence of *C. acuta* was noticed from the 30th SMW to the 37th SMW in the first staggered sowing, between the 29th and 39th SMW in the 2nd staggered sowing and between 35th and 40th SMW in 3rd staggered sowing (Fig. 8). The present findings are in line with Ahirwar *et al.* (2015b) who recorded the incidence during 32nd to 38th SMW; Netam *et al.* (2013a) from 32nd to 37th SMW, Gaur *et al.* (2015) and Vijay (2013) during 33rd to 39th SMW. Meena (2005) from 31st SMW to 37th SMW while Matti and Deotale (2017) reported it from the 35th to 46th SMW.

Table 1.4. Seasonal incidence of insect pests and natural enemies in the 3rd staggered sowing of soybean crop

SMW	<i>S. litura</i> (l/mrl)	<i>C. acuta</i> (l/mrl)	Stem fly (% infestation)	Stem girdler (% infestation)	Leaf miner				Sucking pests (3 leaves/plant)		Natural enemies (per plant)	
					<i>L. trifoli</i> l/plant	% leaf-let damage	<i>A. modicella</i> l/plant	% leaf-let damage	Aphids	Leaf hoppers	Coccinellids	Spiders
34	0.60	0.00	4.10	6.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	1.10	0.50	13.50	8.50	0.20	1.50	0.00	0.00	0.80	0.30	0.30	0.40
36	2.50	0.20	16.50	16.20	0.80	9.50	0.00	0.00	1.60	0.80	0.80	0.60
37	3.50	1.10	20.50	20.50	1.40	7.50	0.30	8.50	0.20	1.70	0.10	1.20
38	1.50	1.80	13.50	13.50	0.70	3.10	0.20	5.50	0.80	0.80	0.50	0.50
39	3.70	2.20	20.50	13.20	0.00	0.80	0.60	9.50	2.80	1.60	0.90	0.70
40	0.80	0.10	10.10	8.50	0.00	0.00	0.10	2.20	0.10	0.20	0.30	0.30
41	0.40	0.00	11.10	14.20	0.00	0.00	0.00	0.50	0.60	0.30	0.70	0.10
42	1.20	0.00	8.50	15.60	0.00	0.00	0.10	1.50	0.60	0.50	0.20	0.20
43	0.70	0.00	13.50	10.50	0.00	0.00	0.50	3.50	0.20	0.80	0.10	0.40
44	0.60	0.00	12.60	8.50	0.00	0.00	0.30	6.20	0.00	0.60	0.00	0.30
Mean	1.50	0.53	13.12	12.34	0.28	2.03	0.19	3.40	0.70	0.69	0.35	0.42

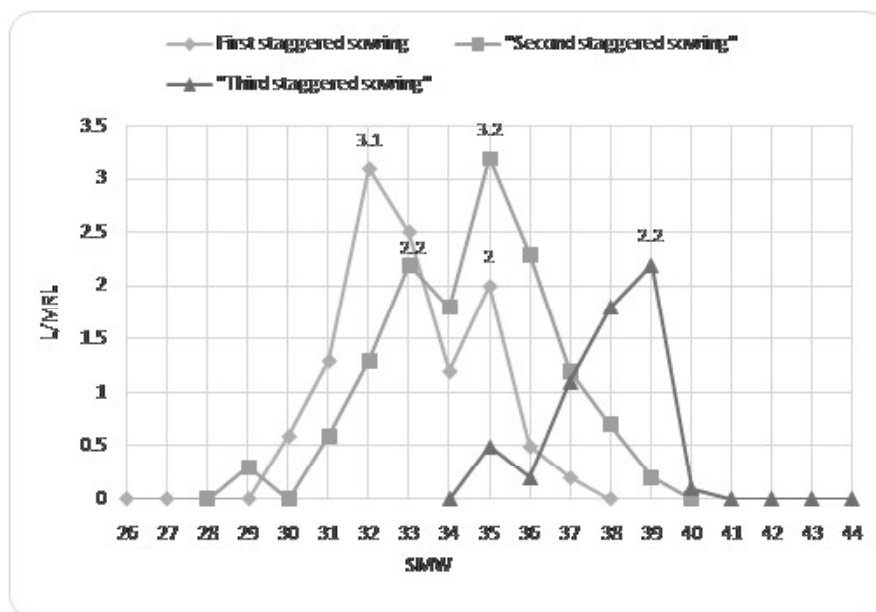
l/mrl – larvae per meter row length; l/plant – larvae per plant

Table 1.5. Seasonal mean and peak incidence of major insect pests in the three Staggere dsowings

Staggered sowings	Defoliators (l/mrl)		Stem fly (% infestation)	Stem girdler (% infestation)	Yield (qha ⁻¹)
	<i>S. litura</i>	<i>C. acuta</i>			
1 st	Peaks (no.)	1	2	1	13.50
	Mean	1.21	0.87	10.95	
2 nd	Peaks (no.)	2	2	2	11.50
	Mean	2.10	1.06	14.10	
3 rd	Peaks (no.)	2	1	2	9.00
	Mean	1.50	0.53	13.12	

The population of *C. acuta* attained its peak during the 32nd SMW (3.10 l/mrl) and 35th SMW (2.00 l/mrl) in the first and during 33rd and 35th SMW in 2nd staggered sowing, which corroborate with Yadav *et al.* (2015a); Rajpoot and Choudhary (2015). However, only one peak was observed in the 3rd staggered sowing *i.e.* 39th SMW (2.20 l/mrl). Yeotikaret *et al.* (2015), Babu *et al.* (2017), Ahirwar (2010), Kumawat (2007), Meena *et al.* (2017) and Gupta (2006) also reported only one peak during the season.

Thus, it can be inferred that among the three staggered sowings, the population of *C. acuta* was above ETL in the first (3.10 l/mrl) and second (3.20 l/mrl) staggered sowings compared to the 3rd staggered sowing with the mean population being 0.87, 1.06 and 0.53 l/mrl in the three sowings, respectively. Santhosh (2008) also recorded significantly higher incidence of semilooper in late sown crop (2nd week of July) than early sown crop (2nd week of June). On

Fig 8. Peak occurrence of *C. acuta* in the three staggered sowings

From the data it can be inferred that there was an increase in population of *C. acuta* in two spells *i.e.* during the 32nd to 35th SMW and during the 39th SMW irrespective of the date of sowing of the crop. The present findings are in line with the works of Kalyan and Ameta (2017b) and Anjali (2012) who reported two peaks during the 33rd to 39th SMW and 34th to 39th SMW, respectively.

the contrary, Kalyan and Ameta (2017a) recorded a significantly higher incidence of *C. acuta* in late sown crops (3rd week of July) than an early sown crop (1st week of July). Also, Meena and Sharma (2006) revealed minimum larval population in early sowing (25th June), followed by mid (10th July) and late (25th July) sowings.

Stem fly

The incidence of stem fly was noticed from the 28th SMW to the 38th SMW in the first staggered sowing, between the 29th and 40th SMW in 2nd staggered sowing and between the 34th and 44th SMW in 3rd staggered sowing (Fig. 9). The present findings are in line with Fand *et al.* (2017) who recorded the incidence starting from the first week after sowing and continuing up to the 44th week until harvest. Similarly, Kumar *et al.* (2012) and Sharma *et al.* (2014) reported that the infestation occurred at all the stages of crop growth, right from seedling to maturity.

(20.50%). From this data it can be inferred that there was an increase in infestation of stem fly in two spells *i.e.*, during the 33rd SMW and during the 36th to 39th SMW irrespective of the date of sowing of the crop. The present findings are in line with the works of Yadav (2013), Ahirwar (2010) and Anjali (2012).

Thus, it can be inferred that from among the three staggered sowings, the first staggered sowing taken up in June 2nd fortnight had only one peak period of infestation of stem fly compared to July 1st and 2nd fortnight sowing wherein two peaks were recorded.

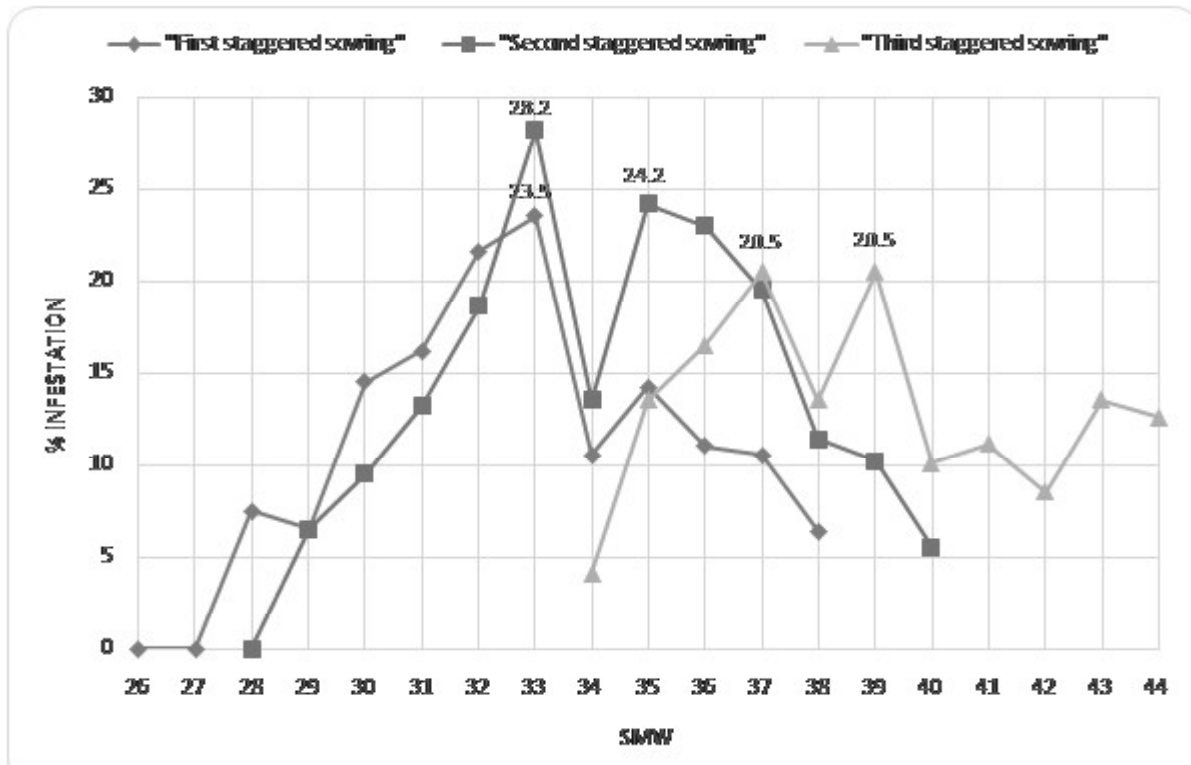


Fig 9. Peak occurrence of stem fly in the three staggered sowings

The stem fly infestation attained its peak during the 33rd SMW in the first staggered sowing aligns with the reports of Meena (2005) and Motaphale *et al.* (2017a). Similarly, Padiwal (2007), Yadav *et al.* (2015a), Patel (2013) and Vijay (2013) also recorded only one peak. In the case of 2nd staggered sowing, the first peak (23.50%) coincided with the peak of the 1st staggered sowing (33rd SMW), while the second (24.20%) was recorded at 36th SMW. Similarly, two peaks were seen in the 3rd staggered sowing at 37th SMW and 39th SMW, with the same level of infestation

Also, the mean infestation of stem fly was relatively lower (10.95%) in June sown crop than July sown crop (14.10 and 13.12%) (Table 1.2). The results are in line with Meena and Sharma (2006) who recorded that the early sown crop (25th June) had significantly lower infestation of stem fly and semilooper than the crop sown on 10th July (mid) and 25th July 2002 (late). Similar results were found by the Kundu and Srivastava (1991) who reported that sowing of crop immediately after monsoon, attracted lower stem fly than in case of delayed sowing.

Stem Girdler

The incidence of stem girdler was noticed from 29th SMW to 38th SMW in the first staggered sowing, between the 29th and 40th SMW in the 2nd staggered sowing and between 34th and 44th SMW in 3rd staggered sowing (Fig.10). The present findings are in line with Yadav (2013) who recorded it from the 33rd to the 40th SMW whereas Gaur *et al.* (2015) from 37th to 39th SMW and Ahirwar *et al.* (2015a) from 37th to 41st SMW.

are in line with the works of Kumawat (2007) and Yadav (2013) who recorded peak incidence from 35th to 37th SMW and 36th to 40th SMW, respectively.

Thus, it can be inferred that two peaks were recorded in all the three staggered sowings and among the three staggered sowings, the first and second staggered sowings recorded almost similar peaks of infestation of stem girdler compared to that of 3rd staggered sowing. Also, the mean infestation of stem

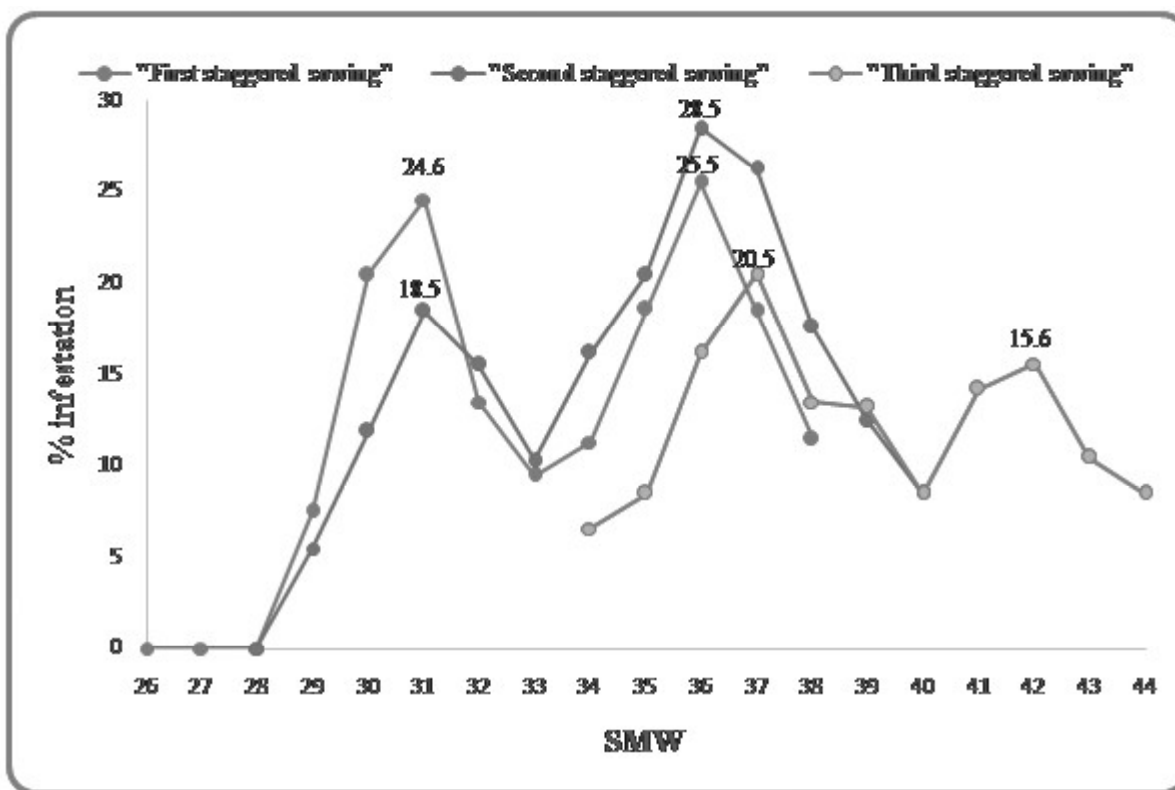


Fig 10. Peak occurrence of stem girdler in the three staggered sowings

The infestation of stem girdler attained its peak during the 31st SMW and 36th SMW in both the first and second staggered sowing. Similarly, the peak occurrence in 3rd staggered sowing was recorded two times, the first almost coinciding with the second peak of the first and second staggered sowing, and the second peak at the 42nd SMW. However, Netam *et al.* (2013a), Meena (2005), Rajpoot and Choudhary (2015), Yeotikaret *et al.* (2015) and Kalyan and Ameta (2017b) recorded single peaks depending on the time of sowing. From this data, it can be surmised that there was an increase in infestation of stem girdler in two spells *i.e.*, during 31st and 36th to 37th SMW, irrespective of the date of sowing of the crop. The present findings

girdler was comparatively higher in the second staggered sowing/first fortnight of July (14.75%) than the first staggered sowing/first fortnight of June (12.38%) and the third staggered sowing/second fortnight of July (12.34%) (Table 1.5). The results are in line with Meena and Sharma (2006) who reported that the early (25th June) and mid (10th July) sown crop had a similar level of infestation of stem girdler compared to late (25th July) sown crop. Similar opinion was expressed by Rai and Patel (1990) who reported lower infestation of stem girdler in late planted soybean. Kalyan and Ameta (2017a) also recorded significantly higher population of stem girdler in timely sown crop (first week of July) than late sown crop (third week of July).

The highest incidence of major insect pests was recorded in the 2nd staggered sowing with a yield of 11.50 q ha⁻¹. However, the 3rd staggered sowing recorded comparatively low population but with the lowest yield of 9.00 q ha⁻¹ due to the heavy rains in the initial period, which adversely affected the crop growth and development. The normal sowing (2nd fortnight of June/1st staggered sowing) recorded low insect pest population compared to that of both the sowings with highest yield (13.50 q ha⁻¹). Sontakke and Mishra (1994) recorded the lowest pest incidence and higher yield in timely sowing (20th June to 5th July). Chandel and Gupta (1995) reported that delay in the sowing of soybean resulted in a decrease in yields. Similarly, damage by insect pests was recorded to be lower in early sown crop during June and maximum grain yield was recorded in early and timely sown soybean by Patilet *et al.* (2015), Sastawaet *et al.* (2004) and Sinha and Netam (2013). Similarly, Kalyan and Ameta (2017a) recorded significantly higher yield in the early sown crop (first week of July) than in the late sowing (third week of July).

Thus, the study revealed that occurrence of insect pests and natural enemies was similar in all the staggered sowings, except for their level of incidence. The normal sowing (second fortnight of June/ 1st staggered sowing) recorded low insect pest population compared to that of the second and third staggered sowings and recorded the highest yield.. Hence, it can be concluded that taking up the crop during the 2nd fortnight of June (normal sowing) was found economical over late sowings in the southern Telangana region.

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