

Original Research Article

Effect of sowing time on infestation of sucking pests in okra

Abstract

Okra is highly susceptible to sucking pests like leafhopper, whitefly, and red spider mite, leading to significant yield losses. While farmers rely on insecticides for pest control, excessive use poses risk to the environment. To explore alternatives, a study was conducted at CCS Haryana Agricultural University, Hisar, during *kharif* 2023 to assess the effect of sowing time on sucking pests infestation in okra. For this, okra was sown on different times *i.e.*, in the 3rd week of May, 1st and 3rd week of June, and 1st and 3rd week of July. The population of leafhopper, whitefly and red spider mite was recorded weekly, starting from the appearance of the pest. The study revealed that leafhopper population in crop sown in the 1st and 3rd week of July was *on a par*, however, significantly lower than that in other crops. Okra sown in the 1st week of July resulted in significantly lower population of whitefly than rest of the sowing times having population *on a par* with each other. Mite infestation was significantly lower in crop sown in the 3rd week of July compared to the others. Based on these findings, July appears to be the most suitable time for sowing okra to minimize sucking pests' infestation.

Keywords: Sowing time, leafhopper, whitefly, red spider mite, okra, sucking pest

Introduction

Vegetables are a vital component of the human diet, providing a wide range of essential vitamins and minerals necessary for maintaining good health. Among these, okra (*Abelmoschus esculentus* (L.) Moench) is one of the most popular crops, cultivated year-round across the country. The fruit of okra is a rich source of important nutrients, including β -carotene, thiamine, riboflavin, vitamin C, calcium, magnesium, oxalic acid, phosphorus, iron, sodium, potassium, copper, and sulfur (Anonymous, 2013-14). Additionally, okra is a significant source of both soluble and insoluble fibers, which promote intestinal health and reduce the risk of colon cancer, serum cholesterol, and heart disease (Bhutto et al., 2017). Though okra is native to South Africa, India holds the leading position in terms of both cultivated area and production. In India, okra is grown throughout the year over an area of 5.31 lakhs ha with annual production of 64.66 lakhs metric tons and productivity of 12.2 metric tons per ha. In Haryana, it occupied 0.12 lakh ha with a production of 1.19 lakh metric tons and productivity of 10.26 metric tons per ha. (Anonymous, 2022).

In spite of the respectable area and production of okra in India, there are several constraints in its cultivation, most importantly the losses caused by pest infestation. Due to its vulnerability, about 72 species of insects have been reported to attack on okra (Srinivasa and Rajendran, 2003), predominantly by sucking pests such as leafhopper (*Amrasca biguttula biguttula* Ishi.), whitefly (*Bemisia tabaci* Genn.) and red spider mite (*Tetranychus urticae* Koch.) which cause considerable losses to okra (Dadheecheta et al., 1977). Both nymphs and adults of leafhopper suck the cell sap from the underside of leaves and while feeding inject toxic saliva into plant tissues. Both the nymph and adult of whitefly also extract cell sap from the leaves which exhibit curling and drying. The affected plants demonstrate stunted growth and it resulted in about 4 per cent yield loss in the okra crop (Meenambigai et al., 2017). Besides this, these pests transmit certain viral diseases also causing huge losses to the crop (Atwal, 1994). Red spider mite appears as reddish or greenish spots on leaves and stems, and makes a fine web on as well as under the leaves and extracts cellular contents resulting in tiny pale spots or scars where the green epidermal cells have been damaged.

For managing these pests, farmers primarily rely on the use of insecticides due to their ease of application. However, various non-chemical practices, including cultural methods, biological control and the use of biorationals have also been recommended by the experts. Despite their potential benefits, many of these practices, especially cultural methods, are often overlooked in favour of the more effective and user-friendly pesticides. One of the key cultural practices that can affect the

incidence of insect pests in okra, is the timing of sowing. The sowing time determines the developmental stages of the crop and its exposure to varying climatic conditions, which in turn affect pest population and their dynamics. In India, the sowing window for okra is quite extensive (March-July), as it is primarily cultivated during both the summer and *kharif* seasons. Moreover, staggered sowing favours the pest to complete 1-2 additional generations under such conditions, which can be mitigated by manipulating the sowing time. Additionally, growing concerns about the environmental and human health risks posed by pesticides have heightened interest in alternative pest management strategies. In light of this, the present study was conducted with the objective to study the effect of sowing time on the infestation of sucking pests in okra.

Materials and Methods

The present investigation was carried out during *kharif* 2023 at CCS Haryana Agricultural University, Hisar using randomized block design. Geographically this place is located between 29.15' N latitude and 75.69' E longitude at an elevation of 186 m above sea level. The field was prepared for sowing and divided into various plots of size 5.4 × 4.2 m. All agronomic practices were followed as per the package of practices (Anonymous, 2020). Okra was sown at five different times *i.e.*, in the 3rd week of May (S₁), 1st week of June (S₂), 3rd week of June (S₃), 1st week of July (S₄) and 3rd week of July (S₅). The population-sucking pests *viz.*, leafhopper, whitefly and red spider mite was recorded weekly, starting from the appearance of the pest. Nymphal population of leafhopper (*Amrasca biguttula biguttula* Ishi.) and adult population of whitefly (*Bemisia tabaci* Genn.) were recorded from three leaves (one each from the top, middle, and bottom canopy) on each of the five randomly selected and tagged plants per plot and mean number of nymphs of leafhopper and adults of whitefly per leaf were calculated. Population of red spider mite (*Tetranychus urticae* Koch) was also recorded on the same pattern as in the case of leafhopper and whitefly. However, the population count was recorded from 1 cm² leaf area. The weather parameters, *viz.*, temperatures (minimum and maximum), relative humidity (morning and evening) and total rainfall were obtained from the Department of Agrometeorology, College of Agriculture, CCS HAU Hisar (Table 1).

Table. 1. Mean monthly meteorological data during Kharif 2023

Months	Temperature (° C)		Relative Humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning	Evening	
May	37.40	21.65	62.80	31.73	14.60
June	37.60	26.45	71.63	47.75	4.70
July	35.03	27.10	86.03	68.60	25.73
August	35.86	26.62	82.84	54.50	4.20
September	35.63	24.93	87.28	55.28	3.55
October	33.16	17.64	86.62	40.60	3.84

Results and Discussion

Effect of sowing time on infestation of leafhopper in okra

In okra crops sown in the 3rd week of May and 1st week of June, leafhopper appeared 23 days after sowing (DAS). However, in crops sown during the 3rd week of June and the 1st and 3rd weeks of July, the initial appearance of leafhoppers was recorded at 17, 39, and 39 DAS, respectively (Table 2). Leafhopper population in crop sown in the 3rd week of May increased gradually reaching its peak (15.22 nymphs/leaf) in the 2nd week of July, followed by alternating periods of decline and increase, though remained above economic threshold level (ETL) of 2 nymphs per leaf until the 3rd week of August (Fig. 1). Afterwards, population remained below ETL, except in 3rd week of September when it was 3.57 nymphs per leaf.

In the crop sown in the 1st week of June, the leafhopper population steadily increased, reaching its first peak of 15.03 nymphs per leaf in the 1st week of August, followed by a gradual decline to 0.28 nymphs per leaf in the 1st week of September. The population then surged again and reached its second peak (16.87 nymphs/leaf) in the 3rd week of October, followed by sudden decline. Similarly, in the crop sown in the 3rd week of June, the leafhopper population reached its first peak of

Table 2. Effect of sowing time on infestation of leafhopper in okra

Sowing time	Leafhopper population (nymph/leaf) in different months														
	June					July					August				
	1 st week	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean
S ₁ (3 rd week of May)	0.00 (1.00)	1.20 (1.48)	3.85 (2.19)	3.98 (2.23)	3.01 (2.00)	7.87 (2.98)	15.22 (4.03)	10.67 (3.41)	14.60 (3.94)	12.09 (3.62)	15.03 (3.99)	8.87 (3.09)	9.72 (3.24)	0.55 (1.23)	8.54 (3.09)
S ₂ (1 st week of June)	---	---	0.00 (1.00)	0.62 (1.27)	0.31 (1.14)	1.12 (1.45)	2.45 (1.85)	7.47 (2.89)	8.95 (3.15)	5.00 (2.45)	15.03 (4.00)	9.52 (3.24)	8.07 (3.00)	2.97 (1.98)	8.90 (3.14)
S ₃ (3 rd week of June)	---	---	---	0.00 (1.00)	0.00 (1.00)	0.82 (1.35)	1.35 (1.53)	3.58 (2.13)	4.72 (2.38)	2.62 (1.90)	16.90 (4.23)	7.30 (2.84)	5.67 (2.55)	1.70 (1.64)	7.89 (2.98)
S ₄ (1 st week of July)	---	---	---	---	---	---	---	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.08 (1.04)	0.25 (1.10)	0.50 (1.18)	0.21 (1.09)
S ₅ (3 rd week of July)	---	---	---	---	---	---	---	---	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.22 (1.10)	0.05 (1.03)
SE(m)_±	---	---	0.09	0.10	0.08	0.06	0.04	0.13	0.12	0.06	0.10	0.22	0.13	0.11	0.08
CD (p=0.05)	---	---	0.42	0.46	0.38	0.23	0.16	0.41	0.38	0.19	0.32	0.68	0.40	0.34	0.26

S₁ (22.05.2023); S₂(06.06.2023); S₃ (21.06.2023); S₄ (05.07.2023); S₅ (20.07.2023); Figures in parentheses are $\sqrt{n+1}$ transformed value

Continued below...

Sowing time	Leafhopper population (nymph/leaf) in different months										Overall Mean
	September					October					
	1 st week	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean	
S ₁ (3 rd week of May)	0.80 (1.33)	0.47 (1.19)	3.57 (2.12)	1.85 (1.67)	1.67 (1.63)	1.75 (1.63)	0.80 (1.34)	0.00 (1.00)	0.00 (1.00)	0.94 (1.38)	5.93 (2.63)
S ₂ (1 st week of June)	1.03 (1.38)	0.28 (1.12)	3.30 (2.07)	9.97 (3.31)	3.65 (2.16)	10.35 (3.37)	12.30 (3.64)	16.87 (4.22)	8.92 (3.15)	12.11 (3.62)	6.62 (2.76)
S ₃ (3 rd week of June)	0.77 (1.32)	0.50 (1.21)	3.85 (2.20)	9.30 (3.21)	3.60 (2.14)	11.75 (3.57)	11.50 (3.53)	8.27 (3.04)	5.05 (2.46)	9.14 (3.18)	5.47 (2.54)
S ₄ (1 st week of July)	0.95 (1.39)	1.73 (1.65)	3.65 (2.15)	9.50 (3.24)	3.96 (2.22)	10.18 (3.34)	9.58 (3.25)	11.37 (3.51)	5.95 (2.63)	9.27 (3.20)	3.58 (2.14)
S ₅ (3 rd week of July)	1.05 (1.43)	4.32 (2.30)	5.50 (2.53)	4.05 (2.23)	3.73 (2.17)	9.25 (3.20)	9.28 (3.20)	12.70 (3.70)	7.07 (2.84)	9.58 (3.25)	4.11 (2.26)
SE(m)_±	0.12	0.09	0.10	0.13	0.06	0.10	0.10	0.10	0.08	0.08	0.05
CD (p=0.05)	NS	0.28	0.31	0.41	0.17	0.32	0.30	0.34	0.27	0.26	0.15

16.90 nymphs per leaf in the 1st week of August, followed by a sharp decline to 0.50 nymphs per leaf in the 2nd week of September. The population then increased again to a second peak of 11.75 nymphs per leaf in the 1st week of October, after which a gradual decline was observed. In the crops sown in the 1st and 3rd week of July, the leafhopper population continued to rise above the ETL after its appearance, reaching its maximum in the 3rd week of October, with 11.37 and 12.70 nymphs per leaf, respectively.

When analyzing the month-wise mean population of leafhopper across different sowing times, the data for July showed a significantly higher population (12.09 nymphs per leaf) in the crop sown in the 3rd week of May, followed by crops sown in the 1st and 3rd week of June, with 5.00 and 2.62 nymphs per leaf, respectively. No leafhopper infestation was observed in the crops sown in the 1st and 3rd week of July. In August, mean population of leafhopper in crop sown in the 3rd week of May, 1st week of June and 3rd week of June was *on a par* with each other (8.54, 8.90 and 7.89 nymph/leaf, respectively) and significantly higher than that in crop sown in 1st and 3rd week of July having 0.21 and 0.05 nymphs per leaf, respectively and *on a par* with each other. In the month of September, mean population in late sown crops (June and July) was *on a par* with each other (3.60 to 3.96 nymphs/leaf) but significantly higher than in crop sown in the 3rd week of May (1.67 nymphs/leaf). In October, leafhopper population was significantly higher (12.11 nymph/leaf) in crop sown in 1st week of June compared to others. Next to this, leafhopper population in crops sown in the 3rd week of June, 1st week of July and 3rd week of July was *on a par* with each other *i.e.*, 9.14, 9.27 and 9.58 nymphs per leaf, respectively. However, crop sown in the 3rd week of May experienced significantly lower population of leafhopper (0.94 nymph/leaf).

The overall mean population of leafhopper during the crop season revealed that okra sown in the 1st week of June registered significantly higher population (6.62 nymphs/leaf). It may be attributed to the longer duration of the crop than others, except crop sown in the 3rd week of May, which had matured by the time leafhopper population increased again in the month of October. The findings of the current studies are in close proximity of Agarwal *et al.* (1999) who reported that okra crop sown in the 1st week of June harboured higher population of leafhopper which decreased with the delay in sowing time with lowest level in crops sown in the second fortnight of July. However, Brice *et al.* (2017) reported that leafhopper population in okra sown on June 1st was lower than in crop sown on June 30th. Following to this, mean population in crop sown in the 3rd week of May as well as 3rd week of June was (5.93 and 5.47 nymphs/leaf, respectively) *on a par* with each other but significantly higher than in crop sown in the 1st and 3rd week of July which also had population *on a par* with each other *i.e.*, 3.58 and 4.11 nymphs per leaf, respectively. These findings are in agreement with Regmi *et al.* (2020) who reported that early sown crop has more leafhopper population than late sown crop, whereas, Mahmood *et al.* (1990) also reported that population of leaf hoppers peaked in early June, while lower numbers were observed in the third week of July. However, Bairwa *et al.* (2005) also mentioned that okra crop sown in 1st week of July registered lower population of leafhopper population compared to that sown later. Similarly, the study conducted by Sinha *et al.* (2007) indicates that sowing okra in June resulted in a higher leafhopper population compared to the lower population observed in crops sown during the third week of July. However, Kumar (2013) reported that leafhopper populations were highest in June-sown okra and lowest in crops sown during the third week of July, indicating a seasonal influence on pest dynamics. Sharma *et al.* (2004) recorded the highest leafhopper activity in July, which aligns with our findings. Similarly, Dhawan (1999) noted the presence of *A. biguttula biguttula* from July to October, with peak activity occurring from mid-July to late August. However, Gosalwad *et al.* (2009) reported the population peak of *A. biguttula biguttula* during the second and last weeks of October in Parbhani, Maharashtra. In Guntur, Andhra Pradesh, Sitaramaraju *et al.* (2010) and Soujanya *et al.* (2010) observed peak leafhopper abundance from the second week of October to the third week of November. Likewise, Mohapatra (2008) reported a peak in the second week of October in Western Orissa.

Effect of sowing time on infestation of whitefly in okra

Okra crops sown in the 3rd week of May, 1st week of June, 3rd week of June, 1st week of July and 3rd week of July experienced the first attack of whitefly 30, 23, 17, 67 and 39 DAS, respectively (Table 3). Whitefly population gradually increased and in crop sown in the 3rd week of May, and 1st and 3rd week of June, it reached its peak (5.33, 5.93 and 6.60 adults/leaf, respectively) in 1st week of August, followed by decrease up to 2nd week of September (Fig. 2). Thereafter, whitefly population again increased but later on (2nd week of October), it started decreasing again. In crops sown in 1st week of July, whitefly population reached to its maximum (4.90 adults/leaf) in 3rd week of October while in

crops sown in the 3rd week of July, maximum population (6.32 adults/leaf) was recorded in the 4th week of September. However, whitefly population remained below ETL (6-8 adults/leaf) during the entire cropping season in case of all the sowing times, except 3rd week of June and 3rd week of July, where it was recorded 6.60 adults per leaf in the 1st week of August and 6.32 adults per leaf in last week of September, respectively.

Considering month wise population of whitefly across different sowing times, notable variations were observed. In July, okra sown in the 3rd week of May registered significantly higher population of whitefly (4.76 adults/leaf), followed by that sown in 1st and 3rd week of June (2.57 and 1.27 adults/leaf, respectively). No infestation of whitefly was observed in crop sown in the 1st week of July. Moving to the month of August, mean population of whitefly in crops sown in 3rd week of May, 1st and 3rd week of June did not differ significantly, however, no infestation was observed in crops sown in the 1st and 3rd week of July. During the month of September, mean infestation of whitefly was significantly higher (2.65 adults/leaf) in crop sown in the 3rd week of July, however, no significant difference was observed among the other sowing times with respect to whitefly population. In October, whitefly population in crop sown in the 1st and 3rd week June was equal (3.63 adults/leaf) and *on a par* with that in crop sown in the 1st week of July (3.90 adults/leaf). Population in crops sown in 3rd week of July was significantly lower (3.02 adults/leaf) than that in former sowing times but significantly higher than in crop sown in the 3rd week of May (1.56 adults/leaf). Notably, okra sown in the 3rd week of May consistently showed significantly lower population of whitefly across the month, possibly due to crop maturity.

The overall mean population of whitefly during the crop season in okra sown in the 1st as well as 3rd week of June was equal (2.17 adults/leaf) and *on a par* with that in crop sown in 3rd week of May (2.10 adults/leaf) but significantly higher than that in other crops. In crop sown in 3rd week July, the mean population of whitefly was significantly higher (1.89 adults/leaf) than in crop sown in 1st week of July (1.50 adults/leaf). Likewise, higher population of whitefly in crop sown in the month of June might be due to long exposure of the crop to the pest. Conversely, total crop period for the crops sown in July was shorter and thus avoided the whitefly attack. The current findings align with Kumaranag (2015) who also reported higher population of whitefly in okra sown in the month of June compared to that in sown in the month of July and August. However, other studies (Kalita and Dhawan, 2006; Arian *et al.*, 2020) have noted an increase in whitefly populations with delayed sowing. Whereas, Bairwa *et al.*, (2005) reported that whitefly infestation was minimum in early sown (July 7th) crop of okra increasing gradually with the delayed sowing time. These discrepancies could be attributed to variations in environmental conditions and the specific okra varieties used in each study.

Effect of sowing time on infestation of red spider mite in okra

Mite infestation in okra sown in the 3rd week of May, 1st week of June, 3rd week of June and 1st week of July initiated in the first week of August *i.e.*, 74, 60, 45 and 30 days after sowing, respectively, however, in crop sown in 3rd week of July, it first appeared in 3rd week of August (30 DAS) and continued until the end of September (Table. 4). Mite population in crop sown in the 3rd week of May reached its peak (11.88 mites/cm²) in second week of August, followed by a gradual decline (Fig. 1). However, infestation remained above ETL (2 mites/cm²) up to the 1st week of September. In case of crop sown in the 1st week of June, mite population reached its peak (14.03 mites/cm²) in the 3rd week of August, followed by gradual decline and dropping below ETL (1.23 mites/cm²) in 3rd week of September. In the crop sown in the 3rd week of June, the mite population recorded was maximum (9.55 mites/cm²) in the last week of August, decreasing thereafter and dropped below ETL by the 3rd week of September. In case of crop sown in 1st and 3rd week of July, mite population continued increasing after appearance and reached their respective peaks (9.85 and 6.08 mites/cm²) in the 1st week of September.

When the month wise mean population of mite across different sowing times is taken into account, in the month of August, population in the 3rd week of May (8.65 mites/cm²), 1st week of June (8.71 mites/cm²) and 3rd week of June (7.55 mites/cm²) was *on a par* with each other but significantly higher than in other crops. Mean population of mite in crop sown in the 1st week of July was significantly higher (3.03 mites/cm²) than in crop sown in the 3rd week of July (1.21 mites/cm²). In the month of September, however, reverse trend was observed with respect to mean population of mite. Okra sown in the 3rd week of May registered significantly lower population of mite (1.30 mites/cm²) than other crops. Next to this, mean population of mite in the 1st and 3rd week of June, and 3rd week of July was *on a par* with each other (2.59, 2.73 and 3.15 mites/cm², respectively) but significantly lower than in crop sown in the 1st week of July.

Table 3. Effect of sowing time on whitefly infestation in okra

Sowing time	Whitefly population (adult/leaf) in different months														
	June					July					August				
	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean	
S ₁ (3 rd week of May)	0.00 (1.00)	0.03 (1.02)	1.22 (1.48)	0.63 (1.27)	3.90 (2.21)	5.08 (2.46)	4.95 (2.44)	5.10 (2.46)	4.76 (2.40)	5.33 (2.51)	2.62 (1.88)	0.18 (1.09)	0.30 (1.14)	2.11 (1.76)	
S ₂ (1 st week of June)		0.00 (1.00)	0.67 (1.28)	0.33 (1.15)	1.08 (1.44)	2.47 (1.85)	3.25 (2.05)	3.48 (2.12)	2.57 (1.89)	5.93 (2.61)	1.90 (1.70)	0.48 (1.22)	0.43 (1.19)	2.19 (1.78)	
S ₃ (3 rd week of June)	---	---	---	---	0.25 (1.12)	0.52 (1.23)	1.50 (1.58)	2.80 (1.95)	1.27 (1.50)	6.60 (2.75)	2.50 (1.84)	0.75 (1.32)	0.00 (1.00)	2.46 (1.86)	
S ₄ (1 st week of July)	---	---	---	---	---	---	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	
S ₅ (3 rd week of July)	---	---	---	---	---	---	---	---	---	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	0.05 (1.02)	0.00 (1.00)	
SE(m)±	---	---	0.09	0.05	0.05	0.11	0.07	0.08	0.03	0.09	0.11	0.05	0.04	0.05	
CD (p=0.05)	---	---	NS	NS	0.17	0.40	0.23	0.26	0.11	0.27	0.36	0.14	0.12	0.14	

S₁ (22.05.2023); S₂(06.06.2023); S₃ (21.06.2023); S₄ (05.07.2023); S₅ (20.07.2023); Figures in parentheses are $\sqrt{n+1}$ transformed value Continued below.....

Sowing time	Whitefly population (adult/leaf) in different months										Overall Mean
	September					October					
	1 st week	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean	
S ₁ (3 rd week of May)	0.08 (1.04)	0.07 (1.03)	0.63 (1.27)	3.45 (2.11)	1.06 (1.43)	3.45 (2.11)	1.43 (1.56)	0.00 (1.00)	0.00 (1.00)	1.56 (1.60)	2.10 (1.76)
S ₂ (1 st week of June)	0.00 (1.00)	0.00 (1.00)	0.67 (1.29)	4.23 (2.29)	1.23 (1.49)	4.52 (2.35)	4.38 (2.32)	3.72 (2.17)	1.92 (1.71)	3.63 (2.15)	2.17 (1.78)
S ₃ (3 rd week of June)	0.17 (1.07)	0.00 (1.00)	0.67 (1.28)	4.48 (2.34)	1.33 (1.53)	3.82 (2.17)	3.77 (2.18)	4.62 (2.37)	2.32 (1.82)	3.63 (2.15)	2.17 (1.78)
S ₄ (1 st week of July)	0.00 (1.00)	0.28 (1.13)	0.37 (1.16)	4.75 (2.39)	1.35 (1.53)	3.75 (2.17)	4.43 (2.33)	4.90 (2.43)	2.52 (1.88)	3.90 (2.21)	1.50 (1.58)
S ₅ (3 rd week of July)	0.38 (1.17)	2.07 (1.75)	1.83 (1.68)	6.32 (2.70)	2.65 (1.91)	3.33 (2.08)	2.85 (1.96)	3.47 (2.11)	2.42 (1.85)	3.02 (2.00)	1.89 (1.70)
SE(m)±	0.06	0.03	0.07	0.06	0.04	0.10	0.07	0.04	0.03	0.05	0.02
CD (p=0.05)	NS	0.10	0.20	0.19	0.11	NS	0.21	0.13	0.09	0.14	0.06

Table 4. Effect of sowing time on red spider mite infestation in okra

Sowing time	Mite population (mite/cm ²) in different months											Overall Mean
	July	August					September					
	4 th week	1 st week	2 nd week	3 rd week	4 th week	Mean	1 st week	2 nd week	3 rd week	4 th week	Mean	
S ₁ (3 rd week of May)	0.00 (1.00)	5.85 (2.60)	11.88 (3.56)	11.15 (3.48)	5.72 (2.56)	8.65 (3.09)	2.03 (1.74)	1.15 (1.46)	1.48 (1.57)	0.53 (1.24)	1.30 (1.52)	4.98 (2.44)
S ₂ (1 st week of June)	0.00 (1.00)	4.08 (2.25)	7.65 (2.94)	14.03 (3.88)	9.07 (3.17)	8.71 (3.12)	6.00 (2.64)	2.45 (1.83)	1.23 (1.49)	0.63 (1.27)	2.59 (1.89)	5.65 (2.58)
S ₃ (3 rd week of June)	0.00 (1.00)	4.03 (2.24)	8.02 (2.99)	8.60 (3.04)	9.55 (3.22)	7.55 (2.92)	7.97 (2.99)	2.18 (1.73)	0.48 (1.22)	0.28 (1.13)	2.73 (1.93)	5.14 (2.48)
S ₄ (1 st week of July)	0.00 (1.00)	0.60 (1.27)	1.60 (1.61)	3.92 (2.21)	6.02 (2.63)	3.03 (2.00)	9.85 (3.29)	1.17 (1.46)	2.45 (1.85)	0.88 (1.37)	3.59 (2.14)	3.31 (2.07)
S ₅ (3 rd week of July)	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	1.27 (1.50)	3.02 (2.00)	1.21 (1.49)	6.08 (2.65)	4.87 (2.42)	1.03 (1.42)	0.62 (1.27)	3.15 (2.03)	2.18 (1.78)
SE(m)±	---	0.11	0.17	0.19	0.19	0.11	0.10	0.16	0.10	0.05	0.06	0.07
CD (p=0.05)	---	0.34	0.53	0.58	0.60	0.35	0.32	0.49	0.30	NS	0.20	0.23

S₁ (22.05.2023); S₂(06.06.2023); S₃ (21.06.2023); S₄ (05.07.2023); S₅ (20.07.2023); Figures in parentheses are $\sqrt{n+1}$ transformed value

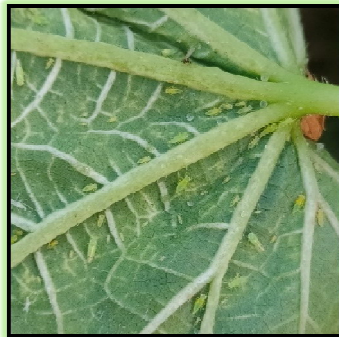


Image 1-Red spider mite Image 2-Leafhopper

Image 3 -Whitefly

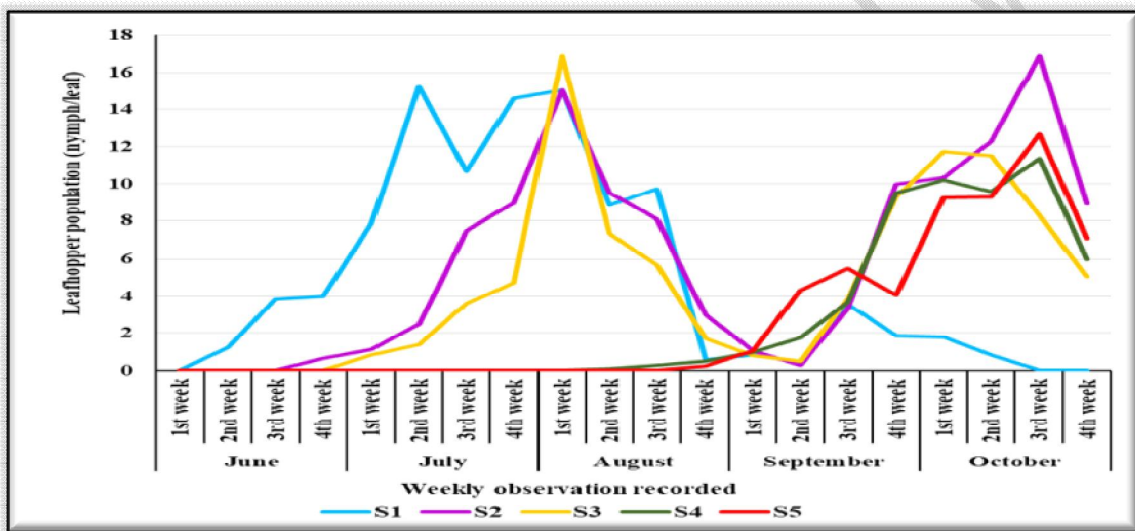


Fig. 1. Effect of sowing time on leafhopper population

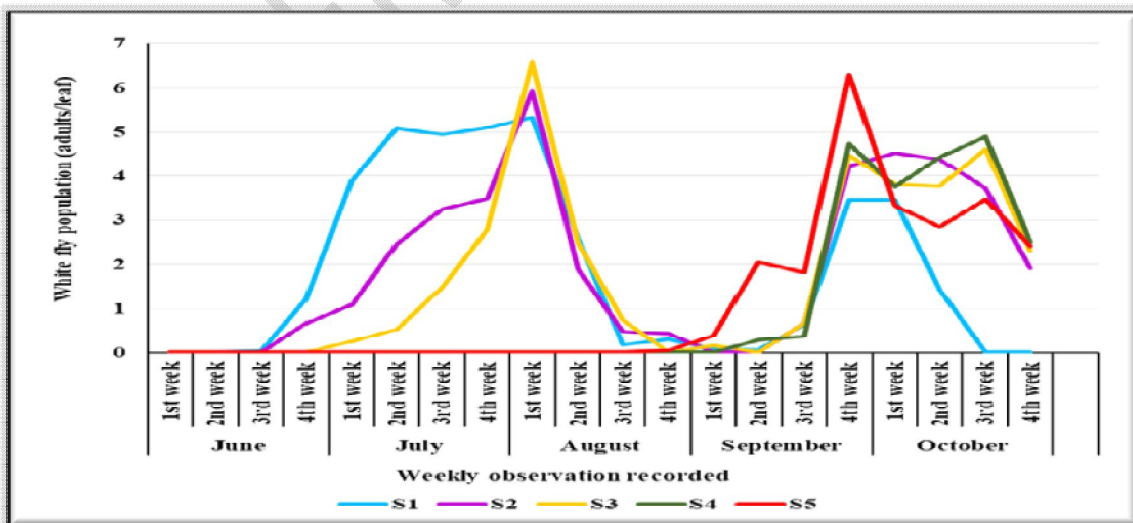


Fig. 2. Effect of sowing time on whitefly population

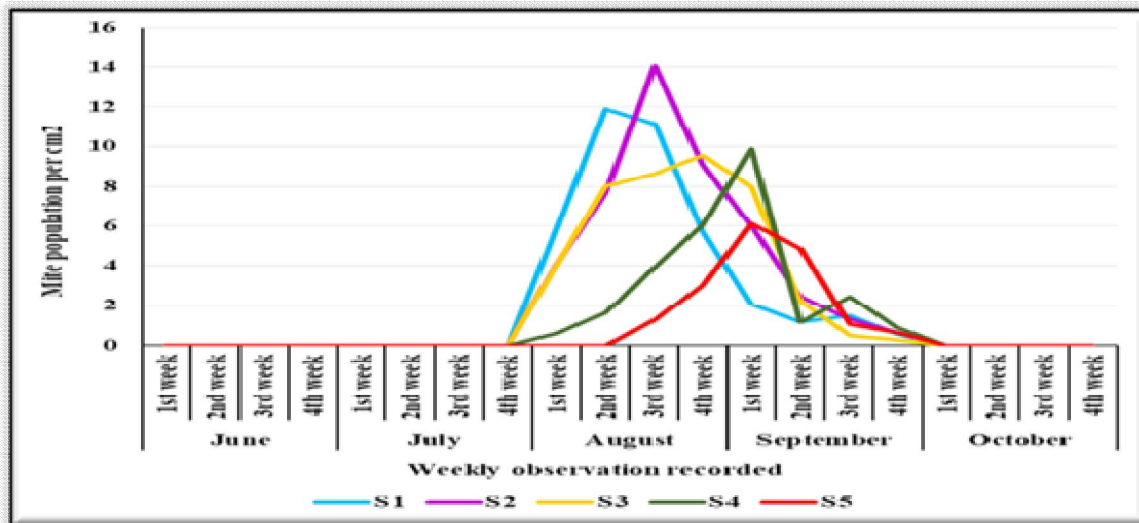


Fig. 3. Effect of sowing time on red spider mite population

Overall mean population of mite in crop sown in the 3rd week of May (4.98 mite/cm²), 1st week of June (5.65 mite/cm²) and 3rd week of June (5.14 mite/cm²) was *on a par* with each other but significantly higher than in other crops. Crop sown in the 3rd week of July registered significantly lower population (2.18 mite/cm²) than sown in the 1st week of July (3.31 mite/cm²). The higher population in early sown crops might be due to favorable crop stages and environmental conditions that encourage mite infestations. Conversely, at the onset of mites, late sown crops had less canopy development, resulting in lower populations compared to early sown crops. These findings are consistent with Naga *et al.* (2017), who also reported that okra sown in the last week of July harboured lower population of mite than sown in 1st week of July. However, these are at variance with those of Kumaranag (2015) who reported that okra crop sown in the month of June harboured lower population of mite than sown in the month of July and August. Thind *et al.* (2020) reported that mite population peaked during high temperatures, particularly at 42°C, with minimal rainfall, aligning with observations of increased incidence in the hot dry summer months, including August and September, which matches with our findings. Likewise, mite populations, specifically *Tetranychus urticae*, showed a strong positive correlation with maximum and minimum temperature, with significant peaks observed during high-temperature periods (Kumar & Singh, 2020, Jadhav *et al.*, 2016). These discrepancies could also be attributed to variations in environmental conditions prevailed at places of study during the study period.

Conclusion

The timing of sowing is a crucial factor in okra cultivation, significantly influencing the population of insect and mite pests. Proper sowing time can optimize the plant's growth environment, reducing pest populations and helping farmers achieve higher marketable yield with lower production costs. It was observed that okra crop sown in the month of July had lower infestation of sucking pests (leafhopper, whitefly and mite) compared to that sown in the month of May and June.

Disclaimer (Artificial intelligence)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

References

Agarwal N, Bhanot JP, Sharma SS (1999). Effect of sowing dates, variety and control measures on incidence of leafhopper, *Amrascabis guttalliguttula* (Ishida) and yield of okra. *Haryana Journal of Agronomy*, 15(2): 158-166.

- Anonymous, (2013-14). Okra: area under cultivation. National Horticulture Board website: <http://nhb.govt.in/bulletin-vegetables.html>.
- Anonymous, (2020). Package of practices for flower, fruit and vegetable crop production and preservation. Second Edition. Directorate of Extension Education, CCS Haryana Agricultural University, Hisar, India.
- Anonymous, (2022). Okra: area under cultivation. Ministry of Agriculture and Farmers Welfare, Government of India. <https://www.indiastat.com/>.
- Arian AR, Kalroo AM, Khuro SN, Anjum R, Lakho AR, Kalhoro AD (2020). Effect of sowing dates on different cotton varieties by Cotton Leaf Curl Virus (CLCuV) at CCRI, Sakrand. *International Journal of Cotton Research and Technology*, 56(1-4): 42-49.
- Atwal SN (1994). Agricultural pests of India and South-East Asia, Kalyani Publishers, New Delhi, India. pp. 529.
- Bairwa DK, Kanwat PM, Kumawat KC (2005). Effect of dates of sowing on the incidence of jassids, whiteflies and shoot and fruit borer of okra. *Annals of Agricultural Research*, 26(3): 458-459.
- Bhutto ZA, Magsi FH, Soomro AA, Ahmed M, Channa NA, Lashari SH, Mangi S, Junejo AA (2017). Integrated pest management of okra insect pests. *International Journal of Fauna and Biological Studies*, 4(3): 39-42.
- BriceA, Verma SC, Sharma KC, Sharma PL, Mehta DK. (2017). Effect of sowing dates and IPM modules on jassid and blister beetle in okra under mid hills of Himachal Pradesh. *Journal of Entomology and Zoology Studies*, 5: 757-61.
- Dadheech LN, Nath G, Jat NR, Srivastava BP (1977). Insecticidal control of the pest complex. *Pesticide*, 11: 28-31.
- Dhawan AK (1999). Major insect pests of cotton and their integrated management. In: R. K. Updadhay, K. G. Mukerji and R. L. Rajak (eds): *IPM System in Agriculture Vol 6, Cash Crops*. Aditya Books Pvt. Ltd., New Delhi, pp. 165-225.
- Gosalwad SS, Kamble SK, Wandnerkar DW, Awaz BH (2009). Population dynamics of major insect pests of cotton and their natural enemies. *Journal of Cotton Research and Development*, 23: 117-125.
- Jadhav YT, Mane SR, Shinde DS (2016). Seasonal Incidence, Correlation and Regression among Weather Parameters against Mites on Summer Okra. *International Journal of Plant Protection*, Vol. 9, No. 2, 494-497 ref. 11. doi: 10.15740/HAS/IJPP/9.2/494-497.
- Thind J, Singh R, Brar M, Bhullar (2020). Effect of abiotic factors on seasonal incidence of mites on pear trees in Amritsar region. *Journal of entomology and zoology studies*, 8(4): 2128-2138. doi: 10.22271/J.ENTO.2020.V8.I4AG.7440.
- Kalita MK, Dhawan P (2006). Management of yellow vein mosaic and leaf curl diseases of okra by adjusting date of sowing and row to row spacing. *Indian Journal of Agricultural Sciences*, 76(12): 762.
- Kumaranag KM (2015). Population dynamics and integrated management of major insect pests in okra seed crop. Ph.D. Thesis, Chaudhary Charan Singh Haryana Agricultural University, Hisar.
- Kumar D. (2013). Management of major insect pests of okra (*Abelmoschus esculentus* (L.) Moench.) in agro-climatic condition of Ranchi (Doctoral dissertation, Birsa Agricultural University, Kanke, Ranchi, Jharkhand).
- Kumar R, Singh PP (2020). Population dynamics of sucking pest complex of okra with relation to abiotic factors. *Journal of entomology and zoology studies, Journal of Entomology and Zoology Studies*, 8(3): 1083-1090.
- Meenambigai C, Bhuvanewari K, Mohan K, Sangavi R. (2017). Pesticides usage pattern of okra *Abelmoschus esculentus* (L) Moench in Tamil Nadu. *Journal of Entomology and Zoology Studies*, 5(6): 1760-1765.
- Mohapatra LN (2008). Population dynamics of sucking pests in hirsutum cotton and influence of weather parameters on its incidence in Western Orissa. *Journal of Cotton Research and Development*, 22: 192-194.
- Naga BL, Sharma A, Khinchi SK, Kumawat KC (2017). Effect of dates of sowing of okra, *Abelmoschus esculentus* (L.) Moench on the incidence of mite, *Tetranychuscinnabarinus* (Boisduval). *Journal of Entomology and Zoology Studies*, 5(3): 896-898.
- RaworthDA (2001). Control of two-spotted spider mite by *Phytoseiulus persimilis*. *Journal of Asia pacific Entomology*, 4(2): 157-163.
- Regmi R, Poudel S, Regmi RC, Shrestha J (2020). Effect of sowing dates and nitrogen levels on population of okra jassids (*Amrascabiaguttulabiguttula* Ishida). *Indonesian Journal of Agricultural Research*, 3(2): 127-135.

- Sharma PD, Jat KL, Takar B (2004). Population dynamics of insect pest on American cotton in Haryana. *Journal of Cotton Research and Development*, 18: 104–106.
- Sitaramaraju S, Parsad NVVSD, Krishnaiah PV (2010). Seasonal incidence of sucking insect pests on Bt cotton in relation to weather parameters. *Annals of Plant Sciences*, 18: 49–52.
- Soujanya PL, Prasad NVVSD, Rao PA (2010). Population dynamics of sucking pests and their relation to weather parameters in Bt, stacked Bt and non Bt cotton hybrids. *Trends in Biosciences* 3: 15–18.
- Srinivasa R, Rajendran R (2003). Joint action potential of neem with other plant extracts against the leaf hopper *Amrasca devastans* (Distant) on okra. *Pest Management and Economic Zoology*, 10(1): 131-136.
- Surajit Sinha, Rai Singh, Rajvir Sharma (2007). Management of insect pests of okra through insecticides and intercropping. *Annals of Plant Protection Sciences*, 15(2): 321-324.
- Tariq Mahmood, Khokhar KM, Banaras M, Ashraf M (1990). Effect of environmental factors on the density of leaf hopper, *Amrasca devastans* (distant) on okra. *International Journal of Pest Management*, 36(3): 282-284. doi: 10.1080/09670879009371488.

UNDER PEER REVIEW