The Pharma Innovation Journal 2022; 11(9): 1674-1678

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 1674-1678

www.thepharmajournal.com
Received: 20-06-2022
Accepted: 29-07-2022

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Effect of different sowing dates and varieties on insect pest population of tomato (*Solanum lycopersicum* L.)

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Abstract
The negative impacts of insecticides have compelled the development of integrated approaches to manage tomato Pest complex. The two year research commenced on September 2019 - April 2020 and September 2020 - April 2021. The objective of this research study was to evaluate the impact of three different sowing dates and five varieties on the population dynamics of insect pests in tomato ecosystem. The insect pests recorded were green citrus aphid (*Aphis spiraecola*), green Looper (*Chrysodeixis eriosoma*) and fruit borer (*Helicoverpa armigera*). The tomato planted on 23rd October (D_3) recorded the highest number of aphid (11.07 aphid/plant) while for green looper the highest number (0.33 larva/plant) was recorded in D_1 (planted on 23rd September). The incidence of fruit borer gradually increased and attained its peak fruit infestation of 7.58% on D_2 (planted on 8th November). Crop varieties pusa rohini, Pusa Sheetal, rocky, sakata-914 and local cultivar were tested for its resistance against pest of tomato. The data reveals that local cultivar and Pusa Sheetal used in the study was comparably more resistant to aphid, Gren Looper and fruit borer infestation as compared to other varieties.

Keywords: Insect pest, IPM, Tomato, sowing dates, varieties

Introduction
Tomato (*Solanum lycopersicum* L.), is the second most-widely grown vegetable in India after potatoes (Prakash, 2014) [1]. Tomatoes contain many health-promoting compounds and are easily integrated as a nutritious part of a balanced diet (Martí *et al*., 2016) [2]. It is one of the essential commodities of the Indian market which can be consumed as fresh fruit or as processed products. But the production is hampered by many factors and insect pests are one of the major constraints because all parts of the plant offer food, shelter and reproduction sites for insects. A total of 41 species of insect pests belonging to 21 different families from tomato ecosystem have been recorded in India, which includes mainly sucking Pests *viz*., *Bemesia tabaci*, *Aphis gossypii*, *Myzu spersicae* and *Nezara viridula.* Other insect pests like *Spodoptera litura*, *Monolepta andrawesi*, *Poekilocerus pictus*, *Atractomorphacrenu lata*, *Liriomyza trifolii*, *H. armigera*, *Othreis fullonica* (*Eudocima fullonica*) were also recorded (Reddy and Kumar, 2004) [3]. Chaudhuri and Senapati (2001) [4] reported that, aphid (*A. gossypii*), whitefly (*B. tabaci*), Tingid bug (*Urentius hystricellus*), leaf miner (*L. trifolii*), and fruit borer (*H. armigera*) were found to be major pests of tomato in terai region of West Bengal. Similarly Naik *et al.* (2005) [5] also observed *H. armigera*, *B. tabaci* and *L. trifolii* as the major insect pests of tomato in India. The monetary loss due to these pests in India has been estimated over rupees one thousand corers per year (Jayraj *et al*., 1994) [6]. The extent of damage to crop and the consequent loss in yield due to this pest vary considerably amongst crops, regions and locations, and seasons (Wakil *et al*., 2010) [7]. To control the insect pests and to save the crop, pesticides are being used in large quantities. The use of insecticides has become indispensable because of its rapid effect, ease of application and availability. The chemical insecticides significantly curtailed the insect pests in the past but in due course it resulted in the development of resistance to insecticides in insects, environmental degradation and increase in the cost of cultivation. To overcome these unfavourable situations, Integrated Pest Management (IPM) strategies are being advocated. As a first line of pest control, IPM works to manage the crop and prevent pests from becoming a threat (EPA, 2022) [8]. In recent years, one promising combination identified is the use of host plant resistance and planting dates which has proven to be very effective, cost efficient and present little to no risk to the people or the environment.

Materials and Methods

The present study was carried out in the experimental cum research farm of School of Agriculture Sciences and Rural Development, Medziphema, Nagaland University, situated at 25° 45' 53" N latitude and 93° 53' 04" E longitudes at an elevation of 310 meters above sea level. The experiment was laid out in split plot design with three replications, keeping sowing dates in the main plots and varieties in the sub-plot. Three different dates of sowing at fifteen days interval was selected and assigned to the main plots. The nursery bed was prepared and the seeds were sown on 23rd September (D_1), 8th October (D_2) and 23rd October (D_3) and transplanted to the main plots after 30 days of sowing from each respective date of sowing. Five different tomato varieties *viz*., Pusa Rohini (V_1), Pusa Sheetal (V_2), Rocky (V_3), Sakata-914 (V_4) and one Local Cultivar (V_5) was selected for the research study. Observation of the insect pest population began from the incidence of pests from five randomly selected plants from each plot and was recorded at 15 days interval. Count of aphid population was taken from 3 leaves of top, middle and bottom per plant. Percent fruit infestation was calculated by the following formula (Wakil *et al*., 2009) [5].

Fruit infestation percentage = B/A x 100

Where,
A = Total fruits (damaged + undamaged), and
B = Damaged fruits

The data recorded was tabulated and subjected to the square root transformation by applying the formula $\sqrt{X+0.5}$ where "X" denotes the individual pest population under observation.The data on per cent leaf and fruit infestation was subjected to arcsine or angular transformation before analysing statistically (Dhamu and Ramamoorthy, 2008) [6]. The transformed values were subjected to Fisher' method of analysis of variance 'F test' to determine the significant or non-significance between two means and in case 'F' test is significant, the critical difference (CD) was then calculated for comparison.

Results and Discussion

Influence of date of planting and varieties against aphid, *Aphis spiraecola*

The pest incidence was observed from 45 DAT which gradually increased in numbers attaining its highest peak number at 120 DAT with 11.07 aphid/plant in D_3 and lowest number with 4.71 aphid/plant at 45 DAT in D_1. The overall mean was observed highest in the third date of planting (D_3) with 9.46 aphid/plant and the least number of 7.28 aphid population was observed in the first date of planting (D_1). It can therefore be concluded that aphid infestation was recorded highest during the late planting date (D_3) *i.e.* 28th October and the lowest number of aphid population was recorded during the early planting of tomato crop (D_1) *i.e.* 23rd September (Table 1). The present finding get support from the observations of Meena *et al*. (2002) [7] and Kumari and Yadav (2004) [8] who reported that early sown crop are less infested by aphid and gave higher yield in comparison to late sown crop. The present investigaton is also in alignment with Iqbal *et al*. (2008) [9] and Wains *et al.* (2010) [10]; the authors reported the highest aphid population during the period of March. The highest mean population was observed at 120 DAT with 12.10 aphid /plant in Pusa Rohini (V_I) and the lowest at 45 DAT with 3.81aphid/plant in local cultivar (V_5) (Table 1). Similar research of screening of varieties for insect pest resistance of tomato crop were also conducted by Bustos *et al.*, 2004 [11] and Baldin *et al.*, 2005 [12]. The morphological characters of the Local variety used in this study match with the reports of Kok (1978) [13], the author reported that wild species of tomato with erect, small leaved, densely pubescent with glandular hairs were resistant to aphids, ultimately resulting in less infestation.

Influence of date of planting and varieties against green garden Looper, *Chrysodeixis eriosoma*

The pest incidence was recorded highest during the initial date of observation at 45 DAT with 0.33 larva/plant in D_1 and also the highest mean population of 0.14 numbers of *C. eriosoma* was recorded in D_1 whereas, the lowest pest incidence of 0.01 larva/plant was recorded on 135 DAT in D_2 with the least mean population also observed in D_3 (Table 2). The present finding is also in partial compliance with that of Roberts (1979) [14], where the author reported the incidence of *C. eriosoma* to be in considerable numbers in January and February but only sporactically in the months of May to October. The highest incidence of 0.42 larva/plant was recorded in the variety Pusa Rohini at 60 DAT while the total mean for all the varieties registered infestation ranging between 0.02 to 0.18 larva/plant. The Local cultivar tomato variety had significantly least incidence (0.02 larva/plant) and the rest all of which were at part (Table 2).

Influence of date of planting and varieties against tomato fruit borer, *Helicoverpa armigera*

The pest incidence was observed from 75 DAT (0.72% fruit damage) in D_1, 75 DAT (0.73% fruit damage) in D_2 and 90 DAT (2.15% fruit damage) in D_3 which gradually increased and attained its peak fruit damage of 7.58% at 120 DAT in D_2 and the lowest of 0.72% at 45 DAT in D_1. The overall mean was observed highest in second date of planting (D_2) with 3.34% fruit damage and the least number of 2.51% fruit damage was observed in the third date of planting (D_3) (Table 3). The data recorded is in accordance with Harshita *et al*. (2018) [15] who observed peak infestation of *H. armigera* during March of 2015-16 and 2016-17. The study conducted by Shinde *et al*. (2013) [16] and Rishikesh *et al*. (2015) [17] is also in alignment with our research findings where the authors observed peak period activity of fruit borer at fruit maturing stage *i.e.* March to April. The pooled data for this pest shows the highest fruit infestation of 8.07% was recorded in the variety Sakata-914 (V_4) at 120 DAT while lowest was observed in Rocky (V_3) at 75 DAT with 0.16% fruit damage. The results revealed that none of the tomato varieties were found free from damage to fruit borer *H. armigera*, the total mean percentage fruit damage varied among various tomato varieties, Pusa Rohini, Sakata-914 and Rocky were all at par *i.e.* 3.70%, 3.50% and 3.32% respectively while the varieties Pusa Sheetal and Local cultivar recorded minimum per cent fruit damage *i.e.* 2.72% and 2.17% respectively (Table 3). Sharma *et al.* (2001) [18] also evaluated thirty one advance generation lines of tomato derived from 13 inter varietal crosses against *H. armigera* and reported that none of the tomato genotypes was immune to its attack but four cultivars, *viz*. 2546-1-2-1, 4237-11 B (Bulk), 0245-1-1 and 0247-1-3-1 were the most promising.

Thus the comprehensive information on the integrated pest management in tomato ecosystem would also be helpful in developing better pest management strategies.

Table 1: Pooled data on the effect of date of planting and varieties on abundance of aphid (*Aphis spiraecola*) population in tomato ecosystem during 2019-2020 and 2020-2021

Treatment	Number of aphid (*Aphis spiraecola*)/plant							
	Pooled data 2019-2020 and 2020-2021							
	45 DAT	**60 DAT**	**75 DAT**	**90 DAT**	**105 DAT**	**120 DAT**	**135 DAT**	**Mean**
Date of Planting								
D_1: 23rd September 2019	4.78	6.29	6.81	7.26	8.37	9.16	8.27	7.28
	(2.28)	(2.58)	(2.68)	(2.76)	(2.95)	(3.09)	(2.94)	
D_2: 8th October 2019	5.77	6.78	7.47	8.25	8.93	9.48	8.37	7.86
	(2.48)	(2.69)	(2.81)	(2.94)	(3.05)	(3.14)	(2.96)	
D_3: 23rd October 2019	6.24	9.23	9.05	9.97	10.55	11.07	10.08	9.46
	(2.57)	(3.10)	(3.08)	(3.22)	(3.31)	(3.39)	(3.24)	
S.Em±	0.02	0.03	0.03	0.02	0.02	0.02	0.03	
CD (P= 0.05)	0.08	0.09	0.08	0.07	0.08	0.07	0.10	
Varieties								
V_1: Pusa Rohini	7.14	9.36	9.22	10.83	11.46	12.10	10.87	10.14
	(2.76)	(3.13)	(3.11)	(3.36)	(3.45)	(3.54)	(3.36)	
V_2: Pusa Sheetal	4.23	6.18	6.51	6.86	8.03	8.77	7.61	6.88
	(2.16)	(2.57)	(2.63)	(2.70)	(2.91)	(3.03)	(2.84)	
V_3: Rocky	6.35	7.99	8.38	9.23	10.46	10.89	9.91	9.03
	(2.61)	(2.90)	(2.98)	(3.12)	(3.31)	(3.37)	(3.22)	
V_4: Sakata-914	6.46	8.76	9.28	9.79	10.28	10.81	9.84	9.32
	(2.63)	(3.03)	(3.12)	(3.20)	(3.28)	(3.36)	(3.21)	
V_5: Local Cultivar	3.81	4.89	5.50	5.76	6.20	6.94	6.31	5.63
	(2.07)	(2.31)	(2.44)	(2.49)	(2.58)	(2.72)	(2.61)	
S.Em±	0.03	0.02	0.02	0.03	0.03	0.03	0.03	
CD (P= 0.05)	0.07	0.07	0.06	0.07	0.07	0.08	0.09	

Note: Figures in the table are mean values and those in parenthesis are square root transformed values.

Table 2: Pooled data on the effect of date of planting and varieties on abundance of green garden looper (*Chrysodeixis eriosoma*) population in tomato ecosystem during 2019-2020 and 2020-2021

Treatment	Number of green garden looper (*Chrysodeixis eriosoma*) / plant							
	Pooled data 2019-2020 and 2020-2021							
	45 DAT	**60 DAT**	**75 DAT**	**90 DAT**	**105 DAT**	**120 DAT**	**135 DAT**	**Mean**
Date of Planting								
D_1: 23rd September 2019	0.33	0.29	0.11	0.02	0.05	0.09	0.07	0.14
	(0.90)	(0.88)	(0.78)	(0.72)	(0.74)	(0.77)	(0.75)	
D_2: 8th October 2019	0.26	0.29	0.15	0.09	0.03	0.11	0.01	0.13
	(0.86)	(0.88)	(0.80)	(0.77)	(0.72)	(0.77)	(0.72)	
D_3: 23rd October 2019	0.20	0.25	0.15	0.16	0.07	0.04	0.00	0.12
	(0.83)	(0.86)	(0.80)	(0.81)	(0.75)	(0.73)	(0.71)	
S.Em±	0.01	0.01	0.01	0.01	0.003	0.008	0.005	
CD (P= 0.05)	0.03	0.04	0.04	0.03	0.011	0.026	0.016	
Varieties								
V_1: Pusa Rohini	0.31	0.42	0.06	0.17	0.08	0.11	0.06	0.17
	(0.90)	(0.96)	(0.74)	(0.81)	(0.76)	(0.78)	(0.74)	
V_2: Pusa Sheetal	0.26	0.34	0.17	0.06	0.00	0.00	0.00	0.12
	(0.86)	(0.92)	(0.81)	(0.74)	(0.71)	(0.71)	(0.71)	
V_3: Rocky	0.27	0.27	0.34	0.14	0.00	0.12	0.07	0.17
	(0.87)	(0.87)	(0.92)	(0.80)	(0.71)	(0.78)	(0.75)	
V_4: Sakata-914	0.38	0.33	0.12	0.09	0.14	0.17	0.02	0.18
	(0.93)	(0.91)	(0.79)	(0.76)	(0.80)	(0.81)	(0.72)	
V_5: Local Cultivar	0.10	0.01	0.01	0.00	0.01	0.00	0.00	0.02
	(0.77)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	
S.Em±	0.02	0.01	0.01	0.01	0.005	0.011	0.008	
CD (P= 0.05)	0.05	0.03	0.04	0.03	0.014	0.030	0.022	

Note: Figures in the table are mean values and those in parenthesis are square root transformed values.

Table 3: Pooled data on the effect of planting and varieties on abundance of tomato fruit borer (*Helicoverpa armigera*) population in tomato ecosystem during 2019-2020 and 2020-2021

Treatment	Percent fruit infestation / plant							
	Pooled data 2019-2020 and 2020-2021							
	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	Mean
Date of Planting								
D_1: 23rd September 2019	0.00	0.00	0.72 (1.02)	3.12 (1.88)	6.03 (2.54)	7.28 (2.78)	5.63 (2.46)	3.26
D_2: 8th October 2019	0.00	0.00	0.73 (1.05)	3.14 (1.90)	5.90 (2.53)	7.58 (2.84)	6.03 (2.55)	3.34
D_3: 23rd October 2019	0.00	0.00	0.00 (0.71)	2.15 (1.60)	4.65 (2.25)	6.09 (2.55)	4.71 (2.27)	2.51
S.Em±	-	-	0.01	0.01	0.01	0.01	0.01	
CD (P= 0.05)	-	-	0.03	0.04	0.03	0.03	0.03	
Varieties								
V_1: Pusa Rohini	0.00	0.00	1.45 (1.32)	3.88 (2.09)	6.69 (2.68)	7.68 (2.85)	6.22 (2.59)	3.70
V_2: Pusa Sheetal	0.00	0.00	0.00 (0.71)	2.15 (1.61)	4.85 (2.30)	6.23 (2.59)	5.02 (2.34)	2.61
V_3: Rocky	0.00	0.00	0.16 (0.79)	3.27 (1.94)	6.07 (2.56)	7.79 (2.88)	5.93 (2.54)	3.32
V_4: Sakata-914	0.00	0.00	0.83 (1.11)	2.96 (1.85)	6.19 (2.58)	8.07 (2.93)	6.46 (2.64)	3.50
V_5: Local Cultivar	0.00	0.00	0.00 (0.71)	1.75 (1.48)	3.83 (2.07)	5.15 (2.37)	3.66 (2.02)	2.06
S.Em±	-	-	0.01	0.01	0.01	0.01	0.02	
CD (P= 0.05)	-	-	0.04	0.03	0.04	0.04	0.04	

Note: Figures in the table are mean values and those in parenthesis are square root transformed values.

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