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Evaluation of altered sowing date on population build-up of cotton whitefly (*Bemisia tabaci* Gennadius) and its natural enemies

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Abstract
The experiment was carried out with an objective of studying the effect of altered date of sowing on population build-up of cotton whitefly and its natural enemies. The result found that, the whitefly adults and nymph's population was maximum at late sown crop on 20th June (4.96 adult/leaf and 5.96 nymphs/leaf) while, the minimum population was found at timely sown crop on 7th May (2.48 adult/leaf and 4.62 nymphs/leaf). The late sown crop was heavily attacked with CLCV disease (Cotton Leaf Curl Virus). The whitefly natural enemies mean population had significant positive correlation with adult whitefly population and with whitefly nymph mean population.

Keywords: Cotton, whitefly, date of sowing, population, natural enemies

Introduction
The Cotton (*Gossypium* spp.) crop has a global significance and is rightly designated as "King of Fibres". No other agricultural commodity in the world has exercised such a profound influence on human beings as matter as cotton. It not only provides fibre for the textile industry but also plays a role in the feed, soap and vegetable oil industries as its seed rich in oil (18 – 24%) and protein (20 – 40%). Cotton is being cultivated as many as in 70 countries of the world with a total coverage of 31.24 million hectare in 2015-16 [3]. China, India, USA and Pakistan with 71 per cent of the world's cotton area and production are the major cotton producing countries in the world.

India is the fortunate country where all four commercially fibre producing species of cotton *viz*., *Gossypium hirsutum, G. arboreum, G. herbaceum* and *G. barbadense* along with inter/ intra-species hybrids are cultivated under diverse agro climatic conditions. In India, more than 60 million people are engaged in cultivation, processing, marketing and other cotton related activities [5]. In India cotton is cultivated in 11.87 million hectare with a production of 484 million bales of seed cotton [2]. The average productivity of cotton in India is 537 kilogram lint per hectare which is low when compared to world average of 760 kilogram lint per hectare. In Haryana, cotton crop is grown in five major districts *viz*., Hisar, Fatehabad, Jind, Bhiwani and Sirsa. The total area under cotton is 6.03 lakh hectares and production is 15.00 lakh bales of 170 kilogram with productivity 423 kilogram per hectare [3]. The cotton production has greatly reduced in the year 2015 in Haryana and Punjab due to heavy attack of whitefly.

There is a constant change in pest scenario. The pest status of bollworm complex has now declined owing to the introduction of genetically engineered cotton having gene from *Bacillus thuringiensis* Berliner conferring in-built resistance against bollworms. However, sucking insect pests are still a great threat to its cultivation and necessitate insecticidal applications to avoid yield losses [7, 9].

Amongst the important key insect pests of cotton, whitefly has been reported as a major pest during mid to late cotton growing season causing 50 per cent reduction in boll production, great damage due to high population of the pest which may remove significant amounts of phloem sap to reduce plant vigour [10]. Whitefly is cosmopolitan, polyphagous, widely distributed in tropical and subtropical regions. It also acts as a vector of leaf curl virus disease and yellow mosaic virus [13]. Whitefly population is greatly affected by abiotic factors and several workers have attributed abiotic factors as one of the major contributing factors to the outbreaks of insect [16].

Hence, bio-rational management strategies like variable sowing dates are considered to be eco-friendly and give the insect-pests least chances to attack the crop or help the plants to escape from insect attack [15]. Due to the above reasons present study was done with an objective of, studying the effect of altered date of sowing on population build-up of cotton whitefly and its natural enemies.

Materials and Methods

Experimental layout

The present study was carried out at the research farm of Department of Entomology, CCS Haryana Agricultural University, and Hisar during *kharif* season, 2016 under irrigated conditions. The experiment was laid out in split plot design (SPD) with 12 treatments that has been mentioned in the tables. The American cotton variety H-1117 was used for the experiment. A spacing of 67.5 cm x 30 cm was maintained in a plot size of 20 m x 16 m (main plot size) and 5 m x 4 m (sub plot size) with a block border of 1 m between main plots and 0.5 m between sub-plots.

Treatments

The crop was sown at main plots on three different dates *viz*., 7th May, 28th May and 20th June 2016 (D1, D2 and D3) in an area of total 800 m² at 15 days interval. Each main plot was sub divided into four sub-plots and treated with four different dosages of nitrogen fertilizer *viz.*, 0, 50, 75 and 100 Kg/ha (N0, N1, N2 and N3). All the other cultural practices like weeding, hoeing, irrigation were adopted as per the recommendation of "Package of Practices of *Kharif* crops" of CCS Haryana Agricultural University, Hisar [4].

Observations

Population of whitefly *Bemisia tabaci* was recorded at weekly interval starting from 30 days after sowing (first week of June, 2016) till maturity of the crop (second week of October). Five plants from each plot were selected randomly and tagged. Whitefly adult population was recorded by observing undersides of three fully formed leaves from upper, middle and lower canopy of the tagged plant from each plot. The nymphal population was also observed by same procedure but they were counted by using the hand lens of power 10X. The population of natural enemies (lady bird beetle, *Coccinella septempuctata;* green lace wing, *Chrysoperla carnea;* spiders, yellow wasps etc.) were recorded on randomly selected 5 plants in each plot at weekly intervals under different sets of conditions. The standard method (the beat basket method) was used for sampling. The sampled natural enemies were being separated and counted.

Data analysis

Those observations were made into average and expressed as number of adults/leaf and were correlated with date of sowing. The data were subjected to square root transformation before analysis. The statistical analysis was carried out by using the OPSTAT software, at e-library of CCSHAU, hisar. The Fisher method of analysis of variance 'F test' was used to determine the significance or non-significance between two means and in case 'F' test is significant, the critical difference (CD) was calculated for comparison [15].

Results

Population build-up of *Bemisia tabaci* adults at three DOS

The result obtained from the investigation on the influence of three dates of sowing against the incidence of whitefly (Table 1) on cotton crop indicates that the population of adult whitefly remained below economic threshold in 1st sown crop of cotton (7th May) throughout the crop period. The maximum mean population of whitefly was recorded during 38th Standard week (3.39 adults/leaf). The adult whitefly population also remain below economic threshold in 2nd sown crop (28th May) throughout the crop period, where the maximum mean population was recorded during 30th standard week (5.75 adults/ leaf) followed by 39th standard week (5.36 adults/leaf). But in case of 3rd sown crop (20th June) the adult whitefly population crosses the economic threshold many times like on 36th, 37th, 38th and 39th standard week (8.83, 10.97, 9.69 and 7.06 adults/leaf) respectively. Among the treatments the minimum mean population was found in 1st sown crop (2.48 adults/leaf) followed by 2nd sown crop (3.70 adults/leaf). While the maximum mean population was recorded from late sown crop (4.96 adults/leaf). The significant difference have been recorded in all the three treatments except 29th, 31st and 35th standard week, where the difference in the population of whitefly adults were found to be non-significant.

Table 1: Population build-up of whitefly adults on American cotton variety (H-1117) under varied dates of sowing at different standard weeks during *kharif* 2016 season

Treatment	Mean population of whitefly (adult/leaf) during different period of observation from different dates of sowing Standard week													Mean
	29	30	31	32	33	34	35	36	37	38	39	40	41	
D1 (7th May)	1.78 (1.64)	2.72 (1.90)	1.28 (1.49)	2.97 (1.94)	2.61 (1.88)	3.33 (2.05)	1.33 (1.52)	2.47 (1.81)	2.69 (1.89)	3.39 (2.07)	3.11 (2.01)	2.25 (1.75)	2.25 (1.74)	2.48
D2 (28th May)	2.00 (1.71)	5.75 (2.52)	1.11 (1.44)	3.78 (2.14)	3.72 (2.12)	3.61 (2.09)	1.61 (1.61)	4.56 (2.33)	4.67 (2.35)	4.78 (2.36)	5.36 (2.46)	3.81 (2.16)	3.39 (2.07)	3.70
D3 (20th June)	1.64 (1.60)	3.11 (2.00)	1.31 (1.51)	2.33 (1.80)	4.17 (2.24)	4.19 (2.25)	1.56 (1.58)	8.83 (3.10)	10.97 (3.40)	9.69 (3.20)	7.06 (2.79)	5.25 (2.41)	4.31 (2.28)	4.96
Mean	1.81	3.86	1.23	3.03	3.5	3.71	1.5	5.29	6.11	5.95	5.18	3.77	3.32	3.71
SE(m)±	(0.10)	(0.12)	(0.05)	(0.04)	(0.05)	(0.03)	(0.07)	(0.10)	(0.07)	(0.07)	(0.08)	(0.08)	(0.05)	
CD (P=0.05)	(N.S)	(0.48)	(N.S)	(0.17)	(0.18)	(0.12)	(N.S)	(0.39)	(0.28)	(0.30)	(0.33)	(0.33)	(0.20)	

Figures in parentheses are square root transformed value $\sqrt{(n+1}$)

Population build-up of *Bemisia tabaci* nymphs at three DOS

The trend observed in case of the nymphal population was found to be similar as in case of adult whitefly population. As evident from Table-2, the population of whitefly nymph was low throughout the crop period in case of 1st date of sown

crop (7th May) and the peak was observed during 30th standard week (6.78 nymphs/leaf), which was followed by 37th standard week (6.22 nymphs/leaf). The whitefly nymph population was also low in 2nd date of sown crop (28th May) throughout the crop period except 30th (11.97 nymphs/leaf) standard week, which were found to be the maximum mean population and it was followed by 39th standard week (8.25 nymphs/leaf). In case of 3rd date of sown crop (20th June) the whitefly nymph population was found high on 36th, 37th and 38th standard weeks (13.03, 12.86 and 8.36 nymphs/leaf) respectively, while the remaining period their population was found low. Among the treatments the minimum mean population was found in 1st sown crop (4.62 nymphs/leaf), While the maximum mean population was recorded from 3rd sown crop (5.96 nymphs/leaf) followed by 2nd sown crop (5.67 nymphs/leaf). The significant difference has been recorded in all the three treatments throughout the crop period except 29th, 33rd, 35th, 40th and 41st standard weeks, where the difference in the population of whitefly nymphs were found to be non-significant. The Fig-1 depicts that the overall mean whitefly adults and nymphs population was maximum at late sown crop on 20th June (4.96 adult and 5.96 nymphs) while, the minimum population was found at timely sown crop on 7th May (2.48 adult and 4.62 nymphs). On the basis of above results it was concluded that cotton variety (H-1117) sown late in the season (20th June) leads to increase the whitefly population than normal date of sowing. So, to get rid of whitefly attack one should avoid the late sowing of cotton.

Table 2: Population build-up of whitefly nymph on American cotton variety (H-1117) under varied dates of sowing at different standard weeks during *kharif* 2016 season

Treatment	Mean population of whitefly (nymph/leaf) during different period of observation from different dates of sowing Standard week													Mean
	29	30	31	32	33	34	35	36	37	38	39	40	41	
D1 (7th May)	1.99 (1.73)	6.78 (2.75)	3.53 (2.11)	5.00 (2.39)	4.97 (2.41)	5.75 (2.57)	2.14 (1.76)	5.50 (2.51)	6.22 (2.65)	5.22 (2.46)	5.36 (2.49)	3.28 (2.07)	4.28 (2.28)	4.62
D2 (28th May)	1.72 (1.63)	11.97 (3.51)	2.36 (1.80)	5.81 (2.55)	6.22 (2.62)	6.31 (2.64)	2.64 (1.90)	6.78 (2.75)	7.14 (2.81)	6.89 (2.76)	8.25 (2.99)	3.09 (2.02)	4.56 (2.33)	5.67
D3 (20thJune)	1.89 (1.68)	5.83 (2.54)	1.92 (1.66)	3.36 (2.04)	4.94 (2.39)	7.47 (2.87)	2.31 (1.81)	13.03 (3.68)	12.86 (3.65)	8.36 (3.02)	7.92 (2.93)	3.17 (2.04)	4.42 (2.31)	5.96
Mean	1.87	8.19	2.60	4.72	5.38	6.51	2.36	8.44	8.74	6.82	7.18	3.18	4.42	5.42
SE(m)±	(0.03)	(0.08)	(0.04)	(0.04)	(0.06)	(0.02)	(0.04)	(0.04)	(0.06)	(0.04)	(0.02)	(0.06)	(0.05)	
CD (P=0.05)	(N.S)	(0.31)	(0.15)	(0.15)	(N.S)	(0.08)	(N.S)	(0.14)	(0.23)	(0.11)	(0.10)	(N.S)	(N.S)	

Figures in parentheses are square root transformed value $\sqrt{(n+1)}$

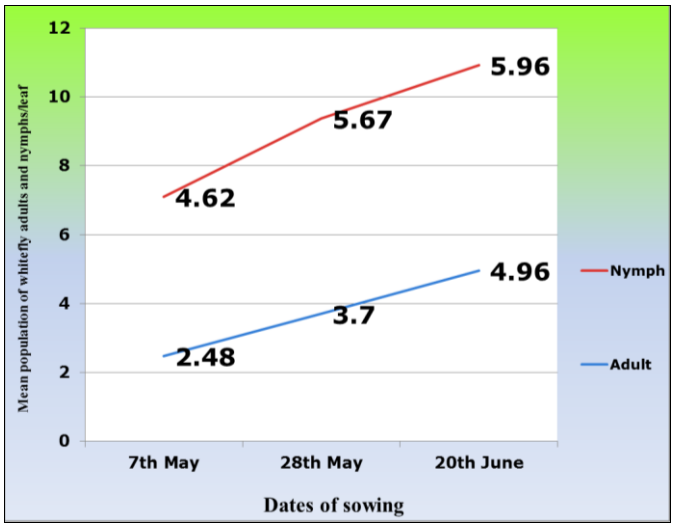

Fig 1: Mean population of adults and nymphs of whitefly at different dates of sowing

mean population had significant positive correlation with adult whitefly population (r=0.723) and with whitefly nymph mean population (r=0.725).

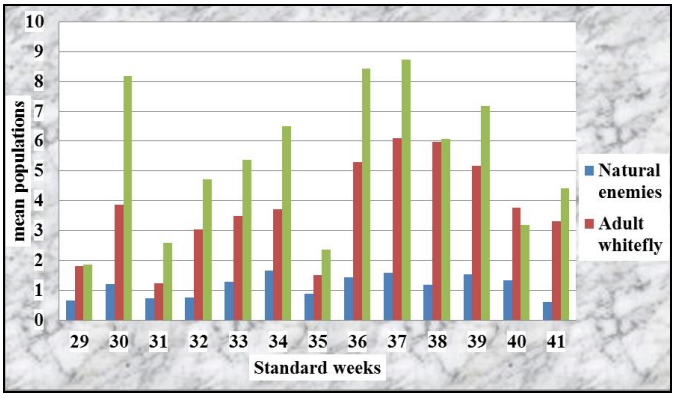

Fig 2: Population of whitefly (adults and nymphs/leaf and natural enemies/plant) on different standard weeks

Population dynamics of natural enemies of *B. tabaci* on cotton

Population of natural enemies of cotton whitefly have been shown graphically in the Fig-2. The natural enemies encountered include Spiders, *Chrysoperla*, Coccinellids, Yellow wasp, Dragonfly etc. The graph shows that the natural enemy population starts appearing at a higher rate during 29th and 30th standard week then their population varies accordingly with the various factors. The peak population was found during 34th standard week (1.66 natural enemies/leaf) followed by 37th standard week (1.57 natural enemies/leaf). The present study revealed that whitefly natural enemies

Discussion

The present finding shows the population of whitefly adults was highest in late sown cotton while population of whitefly adults was least in early sown cotton. The findings of Devi and Ram [6] support the above results. The results are also in agreement with the findings of Acharya and Singh [1] which shows that early sown (30th April) crop had lowest and late sown (30th May) crop had highest incidence of whitefly. Nagargoje *et al.* [12] and Karavina *et al.* [8] found maximum population of whitefly in delayed sowing condition while whitefly population development was very less in case of early sowing condition. The present findings are also at par

with Kumar *et al.* [9] who revealed that in normal dates of sowing, significantly lowest average whitefly population with significant reduction in yellow vein mosaic disease (4.48 and 17.58% respectively) and highest fibre recovery were observed at harvesting stage on Kenaf crop. The finding of Mohamed [11] is also similar to the above result which says that the population density of *B. tabaci* nymphs was affected significantly by the tested planting date, the earliest planting date (March, 15th) harboured the lowest population of *B. tabaci* nymphs (7.35 and 6.94 nymphs/in.2) in the two seasons, respectively. The findings of Rathod [14] also suggested that early sowing of sesame during 15th June to 5th July resulted in escaping or minimizing the incidence of both gall fly and capsule borer as well as in higher yield. Though the pests and crops are different but findings of the present study and the above one are similar. Thus, early crop sowing should be considered to escape the insect incidence.

Conclusion

The overall mean whitefly adults and nymphs population was maximum at late sown crop on 20th June (4.96 adult/leaf and 5.96 nymphs/leaf) while, the minimum population was found at timely sown crop on 7th May (2.48 adult/leaf and 4.62 nymphs/leaf).

On the basis of above results it was concluded that cotton variety (H-1117) sown late in the season (20th June) leads to increase the whitefly population than normal date of sowing. So, to get rid of whitefly attack one should avoid the late sowing of cotton.

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