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Host Plants Associated with Outbreaks of Whitefly as it Relates to Population Management in Cotton in Sindh, Pakistan

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Abstract: Cultivated vegetables, selected ornamental plants and weed hosts have been sampled throughout the year during 1997 to gain a better understanding of the pest and their relative importance in this regard. Key factors identified as contributing to the problem in cotton are; intensive use of pesticides, mild winters (Permitting greater survival), the year round sequence of suitable hosts (both cultivated and weeds), thus providing the bridge which permits populations to cycle from cotton season to cotton season by continuing to reproduce, albeit more slowly on less suitable hosts and in winters.

Overall whitefly numbers were much higher on brinjal. The important ornamental hosts were Lantana and hibiscus which ameliorate cold winter conditions and therefore enhance over winter survival of whitefly Whitefly populations decrease drastically but do not disappear completely from the major vegetables when winter temperature drop. It is important to mention that the bringal had ten times more whiteflies than did the other vegetables and weed hosts. Sonchus was found excellent weed host of whitefly. Our research to date , indicates that the most vulnerable time of the year for the whitefly is late winter when populations are at their lowest level. At this time a combination of several practices on an area wide basis might result in breaking the cycle.

Key words: Cotton, whitefly, hostplants, population management

Introduction

The whitefly *Bemisia tabaci* has become a predominant pest in various cultivated crops in Pakistan. Cotton whitefly is highly polyphagous feeding on 437 plants belonging to 63 families recorded from 67 countries. In Pakistan it is known to attack 104 plants belonging to 24 families of these 16 belong to Malvaceae, 15 to Leguminosae, 13 to Cucurbitacea, 11 to Cruciferae, 10 to Solanaceae, 8 to Compositae and 7 to Euphorbiaceae (Anonymous, 1985). There are greater than 500 host plants species of SPWF (Mound and Halsey 1978) they are not equally suitable for SPWF reproduction (Lenteren and Noldus 1990) and relatively few plant species have been associated with large regional increases of whitefly population level in agricultural systems (Byrne *et al.*, 1990). This can be attributed in part to the limited acreage of many host plants, host plant occurrence during cool periods of the year, limited host suitability for whitefly reproduction (Coudriet *et al.*, 1985) association with natural enemies of whiteflies (Stansley and Schuster, 1991) or a combination of these factors.

Management of the whitefly *Bemisia tabaci* (Gennadius), in the cotton crop has become a complex and difficult problem. This is a result of several factors, all of which favour survival and increase of this pest. In the past, severe out-breaks have been reported on specific crops, e.g. on cotton in 1981 (Duffus and Flock 1982), on irrigated vegetables and fiber crops in Arizona, California and Sonora, Maxico at various times during the past decade (Brown 1990), on Carrots, Lettuce, Melons, Squash, Duch, and Tomatoes, in this same south-western desert area (Brown and Nelson 1984), and more recently on many other crops, weed and ornamental hosts, including such crops as alfalfa, broccoli, cauliflower and peanuts (Watson *et al.*, 1992).

Since the whitefly has no over wintering resting stage, reproduction continues throughout the year. Thus other hosts are necessary after the cotton season in order for the whitefly to bridge the gap to the subsequent years cotton crop. These crops and selected weed hosts xanthium, memola, sonchus have been sampled during the "off season" to gain a better under-standing of their relative importance in this regard.

The recent history of the whitefly in Pakistan points to the following factors which we consider to be of great importance in explaining the problem. Sampling of over-wintering populations in some parts of Sindh on both cultivated and weed hosts have shown progressively higher early season whitefly numbers and consequently, both earlier infestations in cotton and earlier population explosions during the growing season. Another important factor relating to the increasing whitefly problem has been the failure to control population outbreaks, either because of in effective insecticides or incorrect control practices.

The objectives of this study were to record changes in whitefly populations in selected fields of vegetables and important ornamental and weed plants in the cotton growing districts of Sindh.

Materials and Methods

Study sites were main cotton growing areas of lower and central Sindh province on which various studies on whitefly have been conducted.

Sampling usually was performed at fortnightly intervals. Study sites were continually changing in a localized area to accommodate the sequence of hosts as they became available and to eliminate the senescing hosts as their contribution to the seasonal dynamics of whitefly declined.

Generally sampling was accomplished by randomly observation of whitefly adults and nymphs on a per leaf basis through the entire growing season for the following crops during 1997. Population of Tomato was observed from 15 leaves from top, middle and bottom portions. Whitefly on Cabbage were sampled on the third youngest, sixth youngest and oldest leaf respectively. Cucurbits were sampled from the second or third expanded leaf from the apical meristem. Whitefly adults and nymphs on bringal were sampled between the first and the fifth oldest leaf. Whitefly on Kadu was sampled on top, middle and bottom leaves. Weed host plants that served a latefall, winter and early spring, were included in the year round sampling plan in order to better understand the annual dynamics of whitefly populations. This has involved Abutilon,

Sonchus, Memola, Mako, Xanthium and Mohabat booti plants. Whitefly adults and nymphs were observed from 15 leaves of each weed host respectively. Monthly average temperatures and rains were also plotted for 1997.

Results

(a) Distribution of whitefly on different cultivated vegetable host plants at different locations: The results indicate from Table 1 that maximum population of whitefly on brinjal was 11.3, 12.9, 33.2 and 35.9 in Tharparkar (March), Sanghar (May), Hyderabad and Nawabshah (January) respectively.

The population of whitefly on Kadu was 1.2, 1.6, 3.5 and 10.0 in Tharparkar (February), Sanghar and Hyderabad (March) and Nawabshah (May).

Maximum population of whitefly on Cauliflower was 11.6, 3.4, 7.0 and 34.1 during December (Tharparkar), January (Sanghar, Hyderabad) and December (Nawabshah).

Maximum whitefly on Tomato was also observed 4.9, 4.0, 15.3 and 4.8 in Districts Tharparkar (February), Sanghar (January), Hyderabad (February) and Nawabshah (October).

Maximum population on Cucurbits was 2.0, 2.6, 3.0 and 3.0 in April (Tharparkar and Sanghar) and during May (Hyderabad

Table 1: Whitefly population per leaf on vegetables in different districts of sindh during 1997.

Months	Tharparkar District					Sanghar District					Hyderabad District					Nawabshah District				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
January	7.4	0.4	2.0	1.8	0.2	11.8	0.2	3.4	1.8	0.1	33.2	0.1	7.0	1.9	0.1	35.9	0.1	24.1	1.1	0.4
	3.1	0.4	1.6	2.5	0.4	6.2	0.3	2.4	4.0	0.2	25.9	0.1	3.5	12.1	0.1	27.2	0.1	9.9	1.9	0.5
February	1.5	0.6	1.0	4.9	0.5	4.8	0.7	1.1	2.4	0.3	26.8	1.9	0.9	15.3	0.2	13.7	1.0	8.1	2.0	0.6
	3.2	1.2	2.3	1.4	0.6	3.6	0.4	3.2	1.4	0.4	9.5	2.0	0.3	8.9	0.3	5.1	5.9	9.2	2.1	0.7
March	11.3	0.6	3.4	0.4	0.7	7.9	1.6	1.8	0.9	1.5	23.9	3.5	0.6	2.1	1.4	8.9	3.6	4.1	1.3	0.4
	2.3	0.4	1.0	0.5	0.6	12.9	0.6	1.0	0.9	1.6	18.7	1.1	0.3	2.5	2.5	9.4	1.4	3.2	1.4	0.6
April		0.2		1.5	2.0		1.2		1.4	1.5		1.1		3.5	2.9		1.4		1.1	1.9
		0.3		1.4	2.0		0.7		1.8	2.6		1.6		3.9	2.8		5.0		1.3	1.0
May		0.1			1.5		0.4			1.8		0.5			3.0		10.0			2.5
		0.2			1.9		0.4			1.0		0.1			2.9		1.9			2.0
June		0.1					0.9					0.2					0.9			2.5
		0.3					0.3					0.1					1.0			3.0
July													0.7							
													0.9							
August													1.0							
													1.2							
Sept.													1.5							
													2.2							
Oct.																4.7			2.7	
																5.0			4.8	
Nov.			6.9					3.1					4.2			23.8		25.7	0.4	
			10.5					3.2					5.6			20.1		21.8	0.4	
Dec.			11.6					3.0					5.2			19.8		31.5	0.2	
			9.3					3.2					6.0			32.3		34.1	0.1	

1= Brinjal 2= Kadu 3= Cauliflower 4= Tomato 5= Cucurbits

Table2: Whitefly population per leaf on ornamental plants in different districts of sindh during 1997

-	Tharparkar district				Sanghar district				Hyderabad district				Sanghar district			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
January	0.1	0.2	0.3	0	0.02	0.5	0.2	0	0.02	0.03	0.1	0	0.1	0.2	0.15	0
	0.1	1.0	0.5	0	0.05	1.1	0.4	0	0.05	0.06	0.2	0	0.1	0.4	0.25	0
February	0.2	1.5	0.1	0.01	0.05	1.5	0.1	0.05	0.5	0.5	0.03	0.01	0.2	1.0	0.07	0.05
	1.2	2.2	0.2	0.02	0.1	2.7	0.15	0.1	1.0	1.7	0.06	0.01	0.4	2.3	0.07	0.1
March	1.5	1.2	0.01	0.03	0.2	1.0	0.15	0.1	1.5	0.4	0	0.01	0.5	1.3	0	0
	1.7	1.1	0.03	0.01	0.5	0.2	0.05	0.1	2.9	0.8	0.01	0		1.2	1.3	0	0
April	2.0	0.2	0.02	0	1.0	0.5	0.05	0	2.95	0.2	0.03	0		0.5	0.5	0	0
	2.1	0.1	0.04	0	1.2	0.1	0.01	0	1.0	0.4	0.04	0		0.2	0.01	0	0
May	1.5	0.03	0.2	0	0.2	0.05	0.02	0	0.5	0.3	0.08	0		0.1	0.02	0	0
	1.2	0.1	0.4	0	0.3	0.05	0.2	0	0.2	0.4	0.05	0		0.1	0.02	0	0
June	1.3	0.15	0.45	0	0.2	0.1	0.4	0	0.4	0.5	0.1	0		0.2	0.1	0	0
	1.2	0.1	0.3	0	0.3	0.01	0.3	0	0.25	0.6	0.1	0		0.2	0.1	0.15	0
July																	
August																	
Sept.																	
Oct.																	
Nov.																	
Dec.																	

1= Hibiscus 2= Lantana 3= China rose 4= Boganvalia

Table 3: Whitefly population per leaf on weed hosts in different district of sindh during 1997

	Tharparker district						Tharparker district						Tharparker district						Tharparker district					
	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Jan	0.1	0.1	0	0.5	0	0.5	0.1	0.1	0	1.0	0	1.2	0	0.5	0	1.0	0	0.9	0.1	0.1	0	1.0	0	0.8
	0.2	0.2	0	1.1	0	0.1	0.2	0.2	0	1.2	0	0.3	0	0.9	0	1.3	0	1.0	0.1	0.2	0	1.1	0	0.3
Feb	0.1	0.3	0	0.1	0	0.05	0	0.1	0	0.1	0	0.4	0	0.2	0	0.1	0	0.8	0.1	0.1	0	0.1	0	0.9
	0.1	0.4	0	0.2	0	0.06	0	0.1	0	0.2	0	0.6	0	0.3	0	0.1	0	0.7	0.1	0.2	0	0.1	0	1.0
Mar	0.1	0.2	0	0	0	0.5	0	0	0	0	0	0.4	0	0.2	0	0.1	0	0.5	0	0.1	0	0.1	0	0.8
	0.1	0.1	0	0	0	0.1	0	0	0	0	0	0.1	0	0.3	0	0.1	0	0.4	0	0.1	0	0.1	0	0.7
Apr	0.1	0	0	0.1	0	0.7	0	0	0	0	0	0.2	0.1	0	0	0.2	0	0.1	0	0	0	0.1	0	0.5
	0.1	0	0	0.1	0	0.8	0	0	0	0	0	0.1	0.1	0	0	0.3	0	0.2	0	0	0	0.1	0	0.3
May	0.1	0	0.1	0.1	0	0	0.5	0	0.5	0.1	0.1	0	0.1	0	0.3	0.2	0.3	0	0	0	0.3	0.3	0.4	0
	0.1	0	0.1	0.1	0	0	1.1	0	1.0	0.1	0.1	0	0.1	0	0.5	0.3	0.5	0	0	0	0.5	0.5	0.8	0
June	0.3	0	0.4	0.1	0	0	1.7	0	1.5	0.1	0.3	0	0	0	0.5	0.5	1.0	0	0	0	0.6	0.4	0.9	0
	0.2	0	0.5	0.2	0	0	2.7	0	2.2	0.1	0.4	0	0	0	0.6	1.5	1.2	0	0	0	0.8	0.5	1.0	0
July																								
Aug																								
Sept																								
Oct																								
Nov		0.5						0.1						0.5						0.8				
		0.8						0.5						0.7						1.0				
Dec		1.5						1.0						2.0						1.5				
		2.0						1.5						2.5						1.9				

1 = Abutilon 2 = Sonchus 3 = Memola 4 = Mako 5 = Xanthium 6 = Mohabat booti

Table 4: Meteorological data for 1997 recorded at Cotton Research Institute, Sakrand

Month	1995				1996				1997			
	Average maximum temp. (°C)	Average minimum temp. (°C)	Mean relative humidity (%)	Rain-fall (mm)	Average maximum temp. (°C)	Average minimum temp. (°C)	Mean relative humidity (%)	Rain-fall (mm)	Average maximum temp. (°C)	Average minimum temp. (°C)	Mean relative humidity (%)	Rain-fall (mm)
Jan.	22.97	9.02	64.41	7.75	23.48	8.74	62.07	Drizzling	23.17	5.82	60.9	4.0
	(18.0-28.0)	(5.8-12.2)	(58.0-71.0)		(19.0-26.5)	(3.0-11.0)	(49.0-70.0)		(19.0-28.5)	(5.0-11.0)	(53.0-68.0)	
Feb.	26.55	11.12	61.05	Drizzling	27.85	9.23	65.39	6.10	26.83	11.21	62.13	Nil
	(22.5-31.5)	(7.2-14.7)	(52.0-72.0)		(23.0-32.0)	(7.0-11.5)	(54.0-71.0)		(20.0-35.0)	(8.0-17.0)	(52.0-70.0)	
Mar.	30.24	13.5	60.19	Drizzling	33.17	16.40	62.44	Nil	29.61	15.37	62.08	8.3
	(24.7-36.0)	(7.8-19.4)	(52.0-67.5)		(28.0-41.0)	(12.0-22.5)	(51.0-71.5)		(22.0-35.5)	(10.0-21.0)	(45.0-85.5)	
Apr.	37.13	19.73	60.25	27.7	40.42	20.04	53.07	Nill	35.15	21.57	56.01	11.8
	(32.0-42.0)	(14.2-26.1)	(47.0-78.0)		(34.0-46.5)	(12.0-29.0)	(47.0-61.5)		(30.0-42.0)	(14.0-26.0)	(43.0-67.0)	
May	49.8	23.6	57.79	Nil	43.37	24.96	59.99	2.8	41.98	23.37	56.0	2.3
	(39.5-47.0)	(20.0-26.0)	(50.0-63.0)		(40.0-47.5)	(19.0-28.5)	(49.0-75.0)		(34.0-44.0)	(19.5-30.0)	(7-45.0-63.5)	
June	44.42	24.5	60.44	Nil	43.31	27.98	65.64	Drizzling	41.35	25.93	72.96	47.07
	(42.0-48.7)	(22.0-27.0)	(51.0-72.5)		(32.0-50.0)	(26.0-29.0)	(53.0-73.5)		(37.0-44.0)	(18.5-29.0)	(59.0-85.0)	
July	37.48	27.6	75.37	145.3	40.27	27.46	72.19	Drizzling	40.06	25.93	77.13	11.6
	(31.5-47.5)	(25.0-30.0)	(62.0-92.0)		(38.0-43.0)	(26.0-28.5)	(64.0-79.0)		(37.0-44.0)	(18.5-29.0)	(72.5-85.0)	
Aug.	37.82	27.67	78.32	11.6	37.98	28.45	76.42	Nil	37.68	28.04	74.69	23.26
	(36.0-40.0)	(25.0-29.0)	(75.0-85.0)		(34.0-41.0)	(25.0-29.0)	(71.8-85.0)		(31.0-41.0)	(25.0-29.0)	(64.0-84.0)	
Sept.	37.8	22.85	76.65	Nil	37.72	24.19	74.56	Nil	34.67	24.83	77.14	2.05
	(35.5-39.3)	(13.0-28.0)	(71.5-85.0)		(34.5-40.5)	(20.0-27.5)	(63.0-81.0)		(34.5-40.0)	(23.0-27.0)	(64.5-85.0)	
Oct.	36.07	20.25	75.25	Drizzling	36.02	18.87	62.54	Nil	32.23	21.66	74.63	38.0
	(30.5-39.0)	(13.0-28.0)	(56.0-85.0)		(32.5-39.5)	(12.8-23.0)	(54.0-71.0)		(28.0-37.5)	(16.0-25.0)	(66.0-79.0)	
Nov.	32.12	12.73	62.56	Nil	30.57	11.79	60.53	Nil	28.41	14.64	67.55	2.2
	(23.5-36.0)	(6.0-18.0)	(44.5-75.0)		(25.0-35.0)	(6.0-17.5)	(51.0-75.0)		(24.0-34.5)	(9.5-24.0)	(56.0-78.0)	
Dec	25.02	10.76	59.66	Drizzling	25.01	8.26	54.85	Drizzling	23.46	10.31	65.82	Nil
	(22.0-28.5)	(5.0-13.0)	(47.0-67.5)		(23.0-28.0)	(4.0-11.5)	(41.0-63.5)		(18.5-26.0)	(4.5-13.5)	(61.0-73.0)	

The figures in brackets show the range of the parameter concerned

and Nawabshah Districts).

It is important to mention that the brinjal had many times more whiteflies than did the other vegetables. Whitefly populations of adults and immatures decrease, drastically during the winter on vegetables but do not disappear completely from the major vegetables when winter temperature drop. Reproduction did not stop, although it was substantially lower due to the cold weather.

In general data collected during the winter vegetables season show that whitefly population of adults, eggs and immatures decrease drastically but do not disappear completely from the major vegetables, except Cauliflower and Brinjal when winter temperatures drop.

During April and May whitefly adults and nymphs were found on Cucurbits and they act as major breeding sides. Intensive monitoring of the population dynamics of whitefly suggests their movement is from vegetable fields to weeds in mid-winter and from weeds to Cucurbits and early cotton. Dispersal of whitefly is greatly dependent upon wind direction. The number of whitefly adults per leaf on old vegetable crops generally increased in the spring and decreased in the fall along with changes in temperature. Relatively low numbers of whiteflies were noted in cotton before the end of the Cucurbits season during 1997 but following Cucurbits harvest and decline of brinjal in the area, whitefly numbers began to increase rapidly in cotton. The results are in agreement with Riley and Wolfenbarger (1993) that decline in whitefly populations began after harvesting and cotton stalk destruction and was associated with available vegetable hosts.

(b) Population of whitefly on Ornamental plants

The important ornamental hosts were Lantana and hibiscus which ameliorate cold winter conditions and therefore

enhance over winter survival of whitefly. Maximum population of whitefly on lantana was (2.2 per leaf) during February in Tharparkar, (2.7) in Sanghar, (1.7) in Hyderabad and (2.3) in Nawabshah.
Maximum population of whitefly on Hibiscus was (2.1) in Tharparkar during April, (1.2) in sanghar, (2.95 and 1.2) during March in Hyderabad and Nawabshah districts.
Maximum population on China Rose was (0.5, 0.41, 0.20 and 0.25) during January in Tharparkar, Sanghar, Hyderabad and Nawabshah districts (Table 2).
Population of whitefly was also observed on Boganvalia but very small numbers during February and March in all the Districts.
Lantana contained more immatures than other ornamentals.

(c) Whitefly populations on weeds
During 1997 sampling was initiated on some of the most abundant weeds and Sonchus and Mako were found excellent host of whitefly during December and January among the Abutilon, Sonchus, Memola, Mako, Xanthium and Mohabat booti in Tharparkar, Sanghar, Hyderabad and Nawabshah districts (Table 3).
All of these weeds grow undisturbed most of the time and are commonly found on ditch-banks and at the edge of cultivated fields. It is important to mention that the weeds sampled had more whiteflies than did the Ornamentals in mid-winter.
In general observation Sonchus had whitefly adults and eggs present but no immatures were found. Abutilon had only adults. Mako had adults and pupae. Empty pupal cases were found on Memola weed. Xanthium contained both adults and immatures and Mohabat booti contained maximum nymphs.
Monitoring of whitefly on weeds suggests their moments in from vegetable fields to weeds in mid-winter and from weeds to Cucurbits and early cotton. The results are in agreement with the report of Watson *et al.* (1992) on the seasonal dynamics of whitefly populations including their buildup in cotton as the season progresses, their moments in to fall and winter vegetables and weeds and from these to spring vegetables and melons and back to cotton again. Norman *et al.* (1993) suggested that recommendations for cultural control might be having a positive effect on whitefly management.

Suggestions for whitefly Management: The populations of whitefly in summers were associated with cotton crop development. Conversely decline in whitefly populations began after harvesting and cotton stalk destruction and was associated with available host crops, crop sequencing appears to play a critical role in whitefly population dynamics. Be aware of surrounding whitefly crop hosts and over wintering weed hosts. These should be controlled and crop residue should be removed as soon as possible.
Additional considerations yet to be refined are the importance of biological control agents, including parasites, predators and pathogens, and the location and separation of subsequent plantings of hosts such as cotton from a potential whitefly source crop. It also points to the need to utilize whatever integrated strategy that is developed on a community-wide basis. It will be essential for all agricultural commodity groups to unite in developing a management strategy to cope with the whitefly problem.

* Avoid planting next to crops infested with whitefly
* Delay the planting of fall vegetables until whitefly migration has diminished
* Recommendations for cultural controls might be having a positive effect on whitefly management.
* Use insecticides selectively and in accordance with action thresholds to preserve beneficial insects and minimize the selection for insecticide resistant whiteflies.
* Adopt spraying methods that improve coverage, especially underneath leaves.

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