

Seasonal Dynamics of Sweetpotato Whitefly

T. F. Watson and J. C. Silvertooth

Abstract

The sweet potato whitefly (SPWF), Bemisia tabaci (Gennadius), has become a serious problem of a number of agricultural crops in the southern tier of states in the U.S. In the southwestern U.S. it seriously affects summer crops such as melons and cotton, and fall, winter and spring vegetable crops such as lettuce, broccoli and cauliflower. Since this insect has no overwintering resting stage a succession of host plants is necessary in order to span the gap from cotton season to cotton season. This study characterized seasonal population trends of SPWF in cotton and then identified subsequent hosts which were important in the overwintering survival of this insect. The "off-season" hosts included certain weeds as well as cultivated crops and all appear to be important in the seasonal population dynamics of this whitefly.

Introduction

The sweetpotato whitefly (SPWF), Bemisia tabaci (Gennadius), was first collected in Arizona from cotton, Gossypium spp., in 1926 and in California in 1928 (Russell, 1975). Throughout the past decade, the importance of the SPWF as a pest in irrigated vegetable and fiber crops has increased dramatically in the desert regions of the southwestern United States in Arizona and California, and in the adjacent state of Sonora, Mexico (Brown, 1991). Populations in cotton reached unprecedented levels in 1981 in Arizona and California (Duffus and Flock, 1982; Butler and Wilson, 1984) and in vegetable crops including carrots, Daucus carota L., lettuce, Lactuca sativa L., melons, Cucumis melo L., squash, Cucurbita spp. Duch., and tomatoes, Lycopersicon esculentum Mill., in the southwestern US and west coastal, Mexico (Brown and Nelson, 1984). More recently, the problem proliferated to include additional crops over wider areas. It has now developed the capacity to infest and severely damage other crops such as alfalfa, Medicago sativa L., broccoli, Brassica oleracea L., cauliflower Brassica oleracea, and peanuts, Arachis hypogaea L., (Watson and Silvertooth, unpublished). During 1991, severe problems developed on cotton and/or vegetables in such diverse areas as Arkansas, Florida, Georgia, Tennessee, and Texas.

Damage to cotton caused by the whitefly (WF) is mostly associated with sticky lint and sooty molds caused by the honeydew produced (Gerling et al., 1980) and to a lesser extent reduced yields (Mound, 1965). The sticky cotton problem resulting from honeydew secreted by the WF may seriously reduce market price and the ability to market the fiber because of problems in ginning and milling. Where heavy infestations occur, harvesting may also be a problem.

The seasonal dynamics of WF (both banded-wing (BWFW), Trialeurodes abutilonea Haldeman, and SPWF), in cotton have been intensely studied during the past 3 years at the University of Arizona, Yuma Valley Agricultural Center (YVAC). Based upon preliminary observations prior to the initiation of this project, SPWF populations appeared to escalate markedly in later stages of the cotton production season. The characteristic explosion of SPWF in cotton seemed to occur in close coincidence with crop cut-out and the late season (top-crop) crop development. In an effort to

document the relationships between SPWF and the growth and developmental patterns of a cotton crop a field experiment was initiated in 1989. The study utilized both short- (G. hirsutum L.) and long-staple (G. barbadense L.) cotton varieties, two planting dates and two irrigation termination dates to determine the effects of these cotton production systems on the seasonal dynamics of the SPWF.

Since the SPWF has no overwintering resting stage, reproduction continues throughout the year. Thus, other hosts are necessary after the cotton season in order for the SPWF to bridge the gap to the subsequent year's cotton crop. These crops and selected weed hosts (Alkali mallow, Sida hederacea (Doug.) Torr.; Globe mallow, Sphaeralcea spp.; Ground cherry, Physalis wrightii Gray; Little mallow or cheeseweed, Malva parviflora L.; London Rocket, Sisymbrium irio L.; Spiny sowthistle, Sonchus asper (L.) Hill) have been sampled during the "off-season" to gain a better understanding of their relative importance in this regard.

Methods

The experiment was established on an Indio silt loam (coarse-silty, mixed (calcareous), hyperthermic Typic Torrifuvent). Treatments consisted of cotton types (species, i.e. Upland and Pima), planting dates (PD) and irrigation termination dates (IT). Cotton types (Upland var. DPL90 and Pima Var. S-6) served as mainplots, PD and IT combinations were factorially arranged within a randomized complete block design with four replications. In this manner, each PD*IT treatment combination consisted of an experimental unit with 16, 40 inch rows with a plot length of 300 feet. The PD and IT combinations are outlined in Tables 1 and 2.

Irrigations were applied on an as-needed basis throughout the season in a manner that maintained a non-stress condition for all experimental units. Plant nutrition was maintained optimally by use of University of Arizona guidelines and required only nitrogen (N) fertilization as nutritional inputs. The N fertility for both the Upland and Pima crops was maintained by use of petiole sampling and crop monitoring (Silvertooth and Doerge, 1990).

Sampling of WF populations in all treatments was conducted throughout the season by use of sticky traps (adults) and leaf samples (egg and immature stages). As cotton plants continued to grow, they were subdivided into either two (1991) or 3 (1989 and 1990) substrata sampling sites to determine the effect of within-plant-canopy site on population growth of this insect.

It soon became evident that the WF in cotton was an overall crop ecology problem involving alternate hosts that permitted the WF to bridge the gap from cotton season to cotton season. Therefore, plants that served as late fall, winter and early spring hosts were included in the year-round sampling plan in order to better understand the annual dynamics of SPWF populations. This has involved primarily lettuce, broccoli and cauliflower, and the weed hosts Alkali mallow, Little mallow, London Rocket and Spiny sowthistle.

Sampling sites were selected throughout the Yuma Valley to study the post-cotton season dynamics of WF populations on fall and winter vegetable crops. Both sticky traps and leaf samples were utilized to assess population changes. Fields were selected in relation to cotton fields and planting dates of the fall crops. In some instances trap lines were set to study WF dispersal away from the source and in relation to wind flow.

Results

Various agronomic and production inputs associated with the cotton production system at the YVAC are presented in Table 1. Table 2 shows season-long population trends of the SPWF in the PD and IT treatments for both Pima S-6 and DPL-90 cotton. Planting dates are commonly referred to hereafter as A1 and A2 (first and second PD, respectively). Similar abbreviations are made for IT dates as B1 and B2. The collective description of all WF stages from each treatment for each sample date clearly demonstrates the seasonal population trends and the late-season nature of this problem on cotton.

For purposes of illustrating seasonal trends of both egg and immature stages of the SPWF for each PDxIT treatment, only those data from the top stratum are presented. Figures 1 through 4 show trends for the following treatments, respectively: first planting and first irrigation termination (A1B1); first planting and second irrigation termination (A1B2); second planting and first irrigation termination (A2B1); and second planting and second irrigation termination (A2B2). Several important points are denoted in these graphs. Figures 1 and 3, both planting dates but first irrigation termination date, show lower peaks in population level and an earlier peak in the treatment with both first planting and first irrigation-termination date. Conversely, regardless of planting date, both second-irrigation termination dates peaked at higher levels and a later date.

To more clearly show the significance of the WF problem in the latter part of the growing season, figures 5 and 6 present total WF stages for the first-planting and first-termination, and second-planting and second-termination treatments, respectively. Again, the date and levels at which populations peaked clearly show the influence of late-season termination.

A review of sticky-trap data reflecting adult catches in each plot reveals a picture similar to that shown from trends of immatures on the leaf samples. Adult catches were much greater late in the season in the A2B2 treatment in both DPL-90 (Figure 7) and Pima S-6 (Figure 8). These figures represent the latter part of the seasonal curves when populations tend to increase sharply. Even though SPWF populations started at very low levels in young cotton and remained as such until well past mid-season, population increases occurred so rapidly in late season that severe damage resulted from honeydew contamination where cotton production was carried full-season.

Populations of WF moved from cotton to fall vegetables where reproduction continued on such crops as broccoli and cauliflower. Reproduction on lettuce was observed for the first time in the fall of 1991. These crops, plus suspected weed hosts, appear to be the primary link that perpetuates the WF problem from one cotton season to the next. Wind direction and speed appear to be important factors in the dispersal of SPWF. However, additional studies are needed to obtain more definitive information.

Pre- and post-cotton season:

Because of the difficulty of controlling the SPWF in cotton with insecticides, it is believed that the most desirable method of coping with this pest in cotton is to preclude such need, i.e., prevent its establishment and reproduction in cotton. Therefore, a portion of the effort on this project has been to investigate the dynamics of the SPWF during the non-cotton season on other hosts with the primary goal of finding a weak link to break the cycle from cotton season to cotton season. The following discussion and figures illustrate these efforts on this process.

a) Pre-season:

During the spring both the banded-winged and SPWF are present in the field. It appears that earlier in the year the BWWF is more prevalent, gradually declining and later being replaced in summer field crops by the SPWF. Figures 9 and 10 illustrate this in cotton and okra, Hibiscus esculentus L.,

respectively. Other spring crop hosts which appear to be important in the seasonal dynamics of the SPWF are squash, watermelons, *Citrullus lanatus* (Thumb.) Mansf., and cantaloupes (Figure 11). Other plants, including weed hosts, are currently being investigated relative to their importance as alternate hosts of the SPWF.

b) Post-season:

Late summer and fall studies have also been conducted to determine the relationship of fall populations in cotton to subsequent WF population buildup in alternate hosts such as fall and winter vegetables (lettuce, broccoli and cauliflower) and the sequencing of hosts as it relates to the re-infestation of the next year's cotton.

The location of fall hosts relative to an infested cotton field, both distance removed and direction relative to wind flow, appears to be extremely important in vulnerability to SPWF infestations. Figure 12 illustrates the effect of distance and Figure 13 shows trends of adult, egg and immature populations in fall lettuce in fields bordered on the north or south by infested cotton. Prevailing winds are commonly from the north during this part of the year in the Yuma Valley and Figure 13 shows the effect of these northerly winds. Figure 14 shows similar population trend comparisons with cotton fields located east and north of fall cauliflower fields.

Date of alternate host availability relative to the end of the cotton season appears to be an important factor in perpetuating fall populations of SPWF. For example, Figure 15 shows declining SPWF egg population levels with each delay of plantings of lettuce and cauliflower. Another illustration (Figure 16) shows relative abundance of SPWF adults on lettuce, broccoli and cauliflower during the same time period and in the same general location, indicating that some preference may be involved in host selection. And finally, Figure 17 shows population trends of the different SPWF stages on the same host, cauliflower.

c) Winter Season:

The winter vegetable season 1990-91 monitoring data show that SPWF populations of adults, eggs, and immatures decreased drastically when winter temperatures dropped but did not disappear completely from the major vegetables, such as broccoli, cauliflower, and lettuce. Reproduction did not stop, although it was substantially lower due to the cold weather. It took intensive sampling to find eggs or immatures in their late instar stages on broccoli and cauliflower. Adults were found on lettuce but no immature stages past the second instar were found. This indicated that the SPWF did not complete its life cycle on the winter crop of this vegetable. At present (December, 1991), this may be changing as empty pupal cases have been found on lettuce, indicating that at least a small portion of a population can complete its life cycle on lettuce. Additionally, the SPWF was more abundant in and around winter vegetable fields in December 1991 than noted in the past and were also found reproducing in alfalfa. This trend could also be attributed to the rapidly changing biological nature of the SPWF. A new biotype (B) has recently been identified which is distinctly different from an earlier SPWF biotype (A) (Brown et al., 1991).

In early February, 1991, sampling was initiated on some of the most abundant weeds throughout the Yuma Valley. Alkali mallow, *Sida hederacea* (Doug.) Torr., London rocket, *Sisymbrium irio* L., and spiny sowthistle, *Sonchus asper* (L.) Hill, were sampled. All of these weeds grow undisturbed most of the time and are commonly found on ditchbanks and at the edge of cultivated fields. It is important to mention that the weeds sampled had 10-20 times more WF (BWWF & SPWF) than did the vegetables in mid-winter (early February). London rocket had BWWF and SPWF adults and eggs present, but no immatures were found. Spiny sowthistle had adults, eggs, and immatures of both species. Empty immature cases were found on this weed, thus complete reproduction was indicated. Alkali mallow contained more immatures than eggs, and the ratio of BWWF:SPWF adults was about

3:1. The number of whitefly adults on weeds diminished after early March, due to cooler rainy weather.

In March WF populations declined from the levels found in February, primarily because of unseasonably cool March weather. During late March some BWWF and SPWF adults were found on cantaloupes and early cotton between San Luis and Somerton, Arizona. There, WF seem to have come from alkali mallow on nearby ditchbanks. Intensive monitoring of the population dynamics of the SPWF suggests their movement in mid-winter to weeds from vegetable fields and from weeds to early cotton and curcubits in late-winter. Dispersal of WF is greatly dependant upon wind direction.

Figure 18 indicates that the infestation in mallow had already occurred by early February and appears to be the prime source of WF that move to cantaloupes and cotton in early April. Figures 19 and 20, egg and adult populations, respectively, show the importance of WF populations in spring cantaloupes to those subsequently occurring in cotton. These graphs depict WF populations in 3 areas of the Yuma Valley, designated North, Central and South Yuma. The relative levels of WF obtained on cantaloupes in each area correlate directly to levels subsequently obtained on cotton.

Summary

In the more southerly areas of the US cotton belt, the SPWF has become a significant problem in cotton production and has now extended its host range to include many additional agricultural crops. Therefore, the WF problem is not merely a cotton problem or a vegetable production problem but one of the general "crop ecology". This indicates the need to attack the problem on a community or regional basis in order to satisfactorily manage this pest.

In cotton, WF populations increase dramatically from mid-to late-season. Following the cotton season, WF disperse, usually downwind, to fall and winter melon and vegetable crops. Winter weather greatly slows WF development and reduces overwintering populations, nevertheless, populations do persist and are present to re-invade the subsequent cotton crop.

Our research to date indicates that the most vulnerable time of the year for the WF 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 and preclude a subsequent problem in melons or cotton.

These practices would include: residue disposal as soon as the last harvest is completed on winter vegetables; treatment of weeds along irrigation ditches with herbicides and/or insecticides; planting of melons and cotton as far away as possible, and upwind, from winter vegetable fields; delayed planting of cotton to coincide with optimum heat unit accumulation; and, use of effective insecticides to treat seedling cotton adjacent to WF sources. In order to be successful, a carefully coordinated community-wide effort would be required, with all practices possible employed on a timely basis.

From the standpoint of managing cotton for optimal lint quantity and quality, data from these experiments indicate that an earlier IT that is timed in a manner that provides adequate soil moisture for the complete maturation of the crop set up to cut-out, offers an alternative to extending the cotton production season into a top-crop development and providing a habitat suitable for SPWF growth. This is essentially an "avoidance" strategy for a cotton production system. In considering this as an option the differences in yield potential and declining quality associated with increasing numbers of SPWF must be carefully and realistically considered. It would also be advantageous to a given area or group of farmers to collectively manage the IT of cotton fields so that populations of SPWF do not pose an overwhelming threat to the few fields being maintained (irrigated) for late season production. Delays in the planting of early lettuce or other vegetable crops would also put SPWF populations at a clear disadvantage if cotton crops were terminated on a collective, community-based level.

Acknowledgement

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Table 1. Agronomic and other production data relative to cotton management for whitefly control, Yuma, Az 1990.

Inputs/Yields	A1B1		A1B2		A2B1		A2B2	
	SS	LS	SS	LS	SS	LS	SS	LS
Total N/A (lbs.)	210	210	210	210	210	210	210	210
Total irrigations	4	5	6	7	6	7	9	9
Number pesticide applications	12	12	12	12	12	12	12	12
Last application	8/20	8/20	8/20	8/20	8/20	8/20	8/20	8/20
Irrigation termination dates	7/10	7/18	8/07	8/07	8/07	8/07	9/06	9/06
Defoliation ⁴	8/16	8/16	8/30	8/30	8/30	8/30	9/19	9/19
Harvest dates	8/28	8/28	9/12	9/12	9/12	9/12	10/5	10/5
Mean number of lbs. of cotton/acre	2026	1512	3327	1633	3348	2051	3478	2268
Honeydew rating ⁵	Low	Low	Med.	Med.	Med.	Med.	High	High

¹ PD/IT legend: A1=Planting Date 1 (2/27/90); A2=Planting Date 2 (3/21/90); B1=Irrigation Termination 1; B2=Irrigation Termination 2.

² Cotton varieties: SS=DPL 90; LS=Pima S-6.

³ Number irrigations after planting.

⁴ Defoliation: Drop+ Accelerate

⁵ Visual rating of honeydew contamination of lint.

Table 2. Total number of eggs, crawlers, immatures and adults of both sweetpotato and banded-winged whiteflies/week/treatment¹ in both Pima S-6 and DPL 90.²

Date	PIMA S-6				DPL 90					
	AlB1	AlB2	A2B1	A2B2	Total	AlB1	AlB2	A2B1	A2B2	Total
5/09	33	20	16	20	89	34	18	27	21	100
5/14	16	5	16	21	66	27	15	19	14	75
5/22	2	8	8	9	27	9	6	7	10	31
5/29	2	4	4	6	15	4	2	4	4	14
6/05	5	4	4	6	18	4	2	2	3	11
6/11	1	1	1	2	5	2	0	0	1	3
6/19	3	6	6	4	19	2	3	3	2	10
6/25	4	2	3	4	14	1	0	1	2	5
7/05	14	18	9	7	48	18	12	16	13	59
7/10	21	24	5	23	93	21	5	11	17	53
7/16	28	21	28	65	141	17	19	19	6	61
7/24	159	320	139	454	1071	71	73	339	132	614
7/31	381	236	416	725	1757	416	263	209	510	1397
8/06	684	892	977	803	3357	435	744	549	572	2301
8/13	1039	1191	1564	1646	5440	713	696	960	372	2740
8/21	1898	3973	4833	6974	17677	1196	4807	2473	1639	10115
8/28	DEF	4924	4637	7222	16783	DEF	5692	2707	2912	11310
9/12		6946	6017	13071	25333		8489	9612	11051	29152
9/19		DEF	DEF	22896	22896		DEF	DEF	20608	20608

¹ Treatments: Al=Planting Date 1 (2/27/90); A2=Planting Date 2 (3/21/90); B1=Irrigation Termination 1; B2=Irrigation Termination 2.

² WF species ratios: From 5/9 to 5/22 population was 100% Bandedwing; from 5/29 to 6/19 a 50-50 sweetpotato to Banded-wing ratio; from 6/25 to 9/19 population was 100% sweetpotato.

Table 1. Agronomic and other production data relative to cotton management for whitefly control, Yuma, Az 1990.

Planting date/irrigation termination for two cotton varieties^{1,2}

Inputs/Yields	A1B1		A1B2		A2B1		A2B2	
	SS	LS	SS	LS	SS	LS	SS	LS
Total N/A (lbs.)	210	210	210	210	210	210	210	210
Total irrigations	4	5	6	7	6	7	9	9
Number pesticide applications	12	12	12	12	12	12	12	12
Last application	8/20	8/20	8/20	8/20	8/20	8/20	8/20	8/20
Irrigation termination dates	7/10	7/18	8/07	8/07	8/07	8/07	9/06	9/06
Defoliation ⁴	8/16	8/16	8/30	8/30	8/30	8/30	9/19	9/19
Harvest dates	8/28	8/28	9/12	9/12	9/12	9/12	10/5	10/5
Mean number of lbs. of cotton/acre	2026	1512	3327	1633	3348	2051	3478	2268
Honeydew rating ⁵	Low	Low	Med.	Med.	Med.	Med.	High	High

¹ PD/IT legend: A1=Planting Date 1 (2/27/90); A2=Planting Date 2 (3/21/90); B1=Irrigation Termination 1; B2=Irrigation Termination 2.

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Table 2. Total number of eggs, crawlers, immatures and adults of both sweetpotato and banded-winged whiteflies/week/treatment¹ in both Pima S-6 and DPL 90.²

Date	PIMA S-6				DPL 90					
	A1B1	A1B2	A2B1	A2B2	Total	A1B1	A1B2	A2B1	A2B2	Total
5/09	33	20	16	20	89	34	18	27	21	100
5/14	16	5	16	21	66	27	15	19	14	75
5/22	2	8	8	9	27	9	6	7	10	31
5/29	2	4	4	6	15	4	2	4	4	14
6/05	5	4	4	6	18	4	2	2	3	11
6/11	1	1	1	2	5	2	0	0	1	3
6/19	3	6	6	4	19	2	3	3	2	10
6/25	4	2	3	4	14	1	0	1	2	5
7/05	14	18	9	7	48	18	12	16	13	59
7/10	21	24	5	23	93	21	5	11	17	53
7/16	28	21	28	65	141	17	19	19	6	61
7/24	159	320	139	454	1071	71	73	339	132	614
7/31	381	236	416	725	1757	416	263	209	510	1397
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8/28	DEF	4924	4637	7222	16783	DEF	5692	2707	2912	11310
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¹ Treatments: A1=Planting Date 1 (2/27/90); A2=Planting Date 2 (3/21/90); B1=Irrigation Termination 1; B2=Irrigation Termination 2.

² WF species ratios: From 5/9 to 5/22 population was 100% Bandedwing; from 5/29 to 6/19 a 50-50 sweetpotato to Banded-wing ratio; from 6/25 to 9/19 population was 100% sweetpotato.

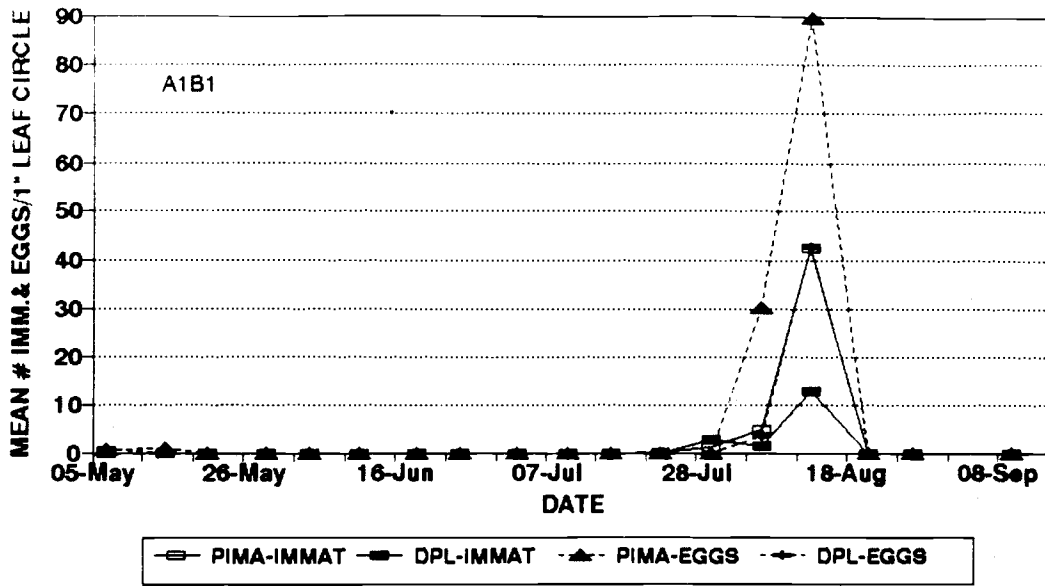


Figure 1. Seasonal sweetpotato whitefly population trends in the top stratum of Pima S-6 and DPL-90 in cotton of the first planting (A1) and first irrigation termination (B1) treatment.

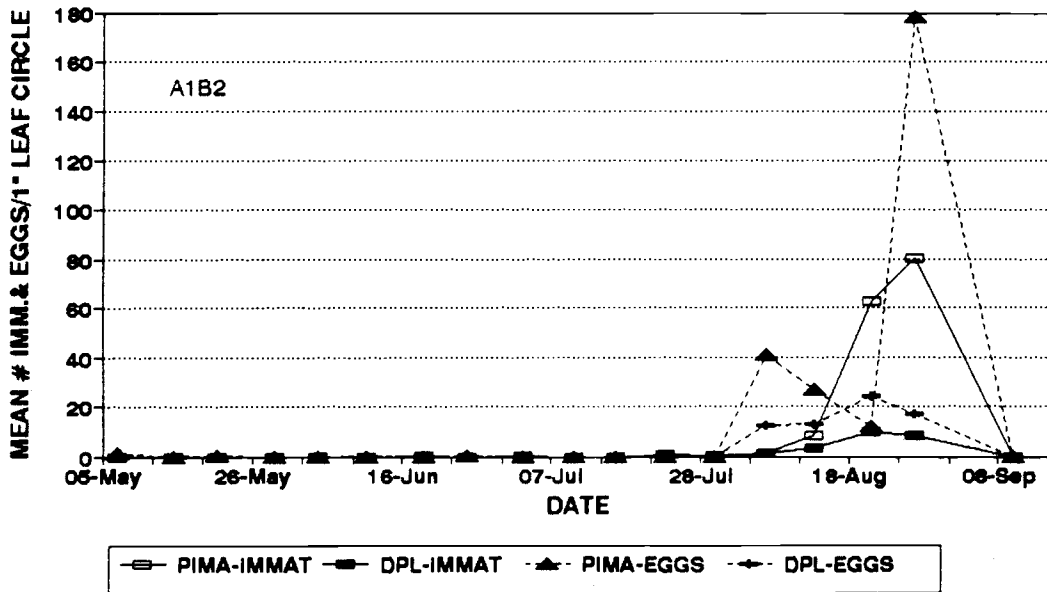


Figure 2. Seasonal sweetpotato whitefly population trends in the top stratum of Pima S-6 and DPL-90 cotton of the first planting (A1) and second irrigation termination (B2) treatment.

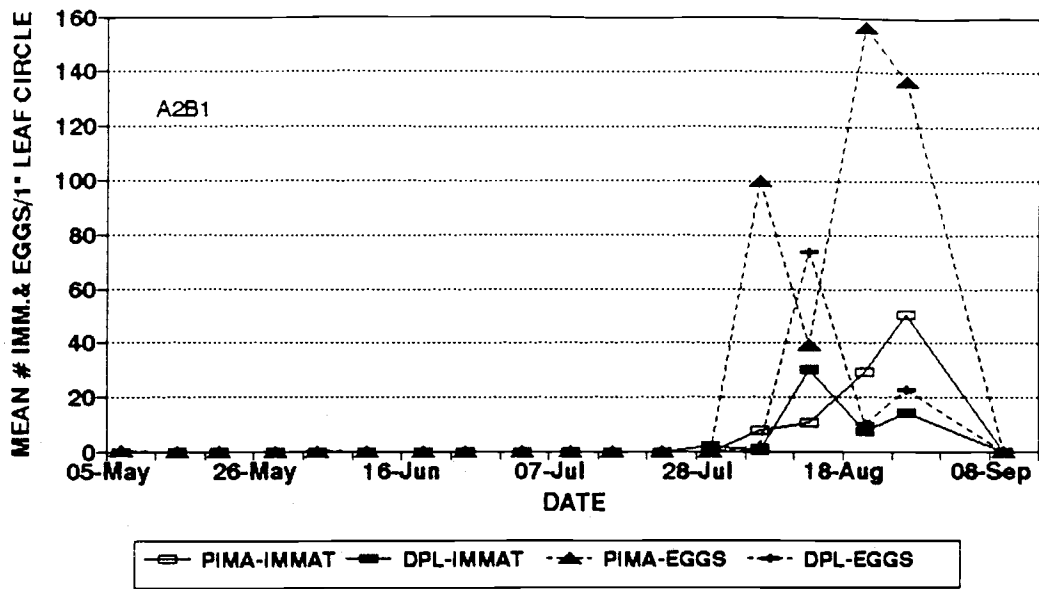


Figure 3. Seasonal sweetpotato whitefly population trends in the top stratum of Pima S-6 and DPL-90 in cotton of the second planting (A2) and first irrigation termination (B1) treatment.

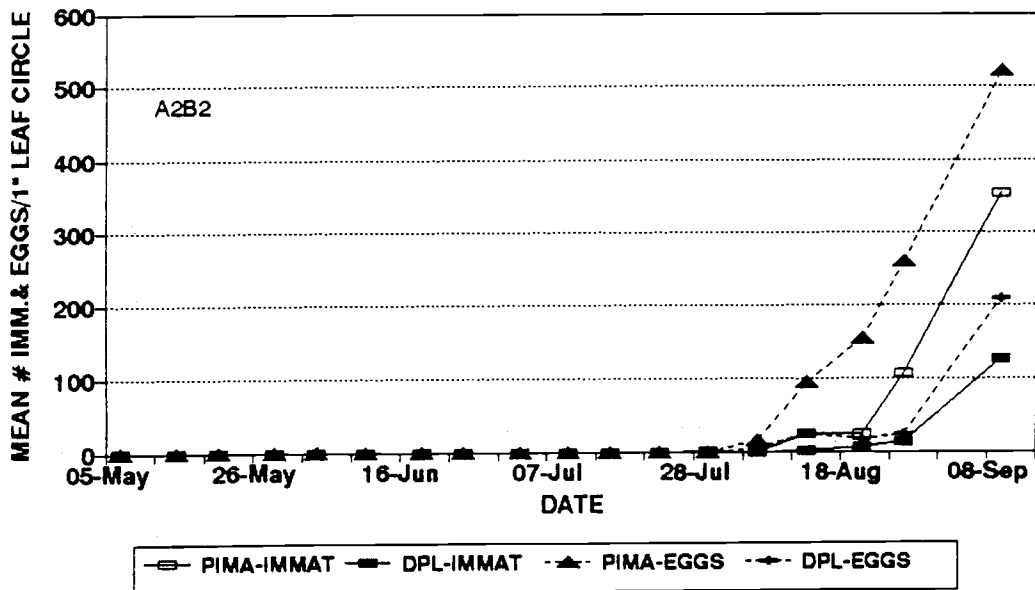


Figure 4. Seasonal sweetpotato whitefly population trends in the top stratum of Pima S-6 and DPL-90 in cotton of the second planting (A2) and second irrigation termination (B2) treatment.

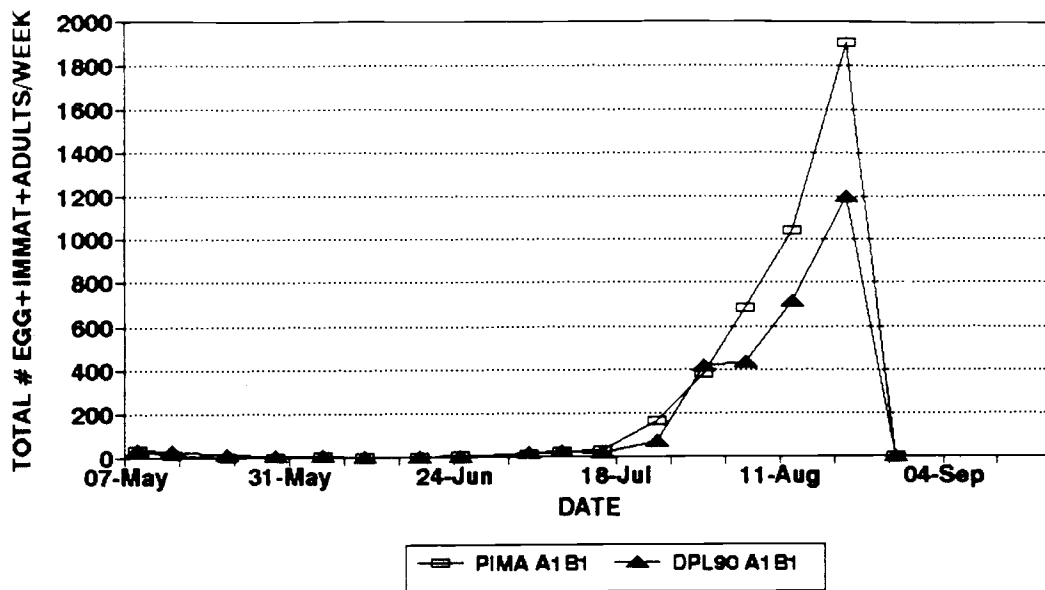


Figure 5. Comparative seasonal sweetpotato whitefly population trends in Pima S-6 and DPL-90 cotton for the first planting (A1) and first irrigation termination (B1) treatment.

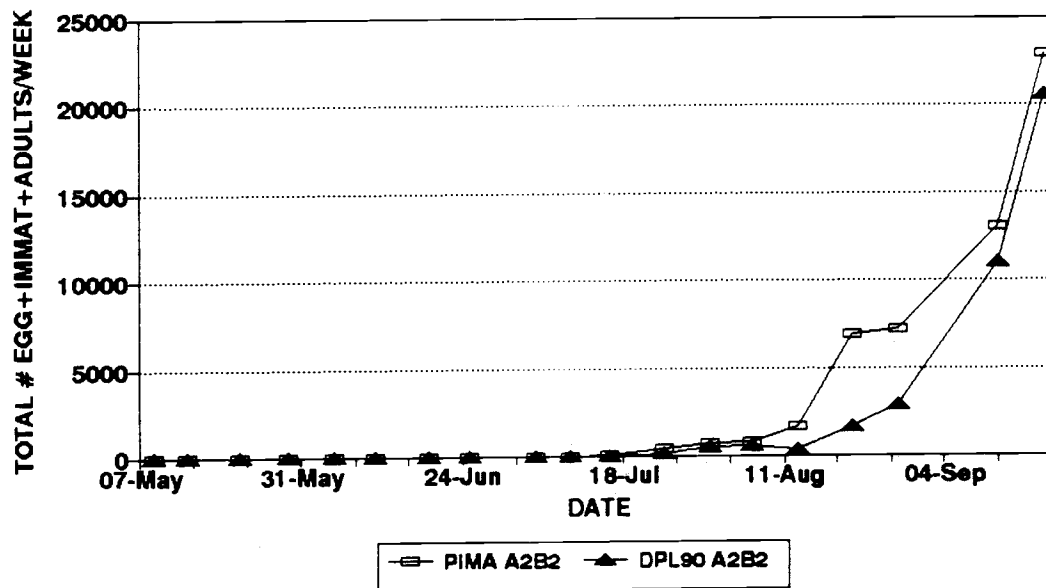


Figure 6. Comparative seasonal sweetpotato whitefly population trends in Pima S-6 and DPL-90 cotton for the second (A2) and second irrigation termination (B2) treatment.

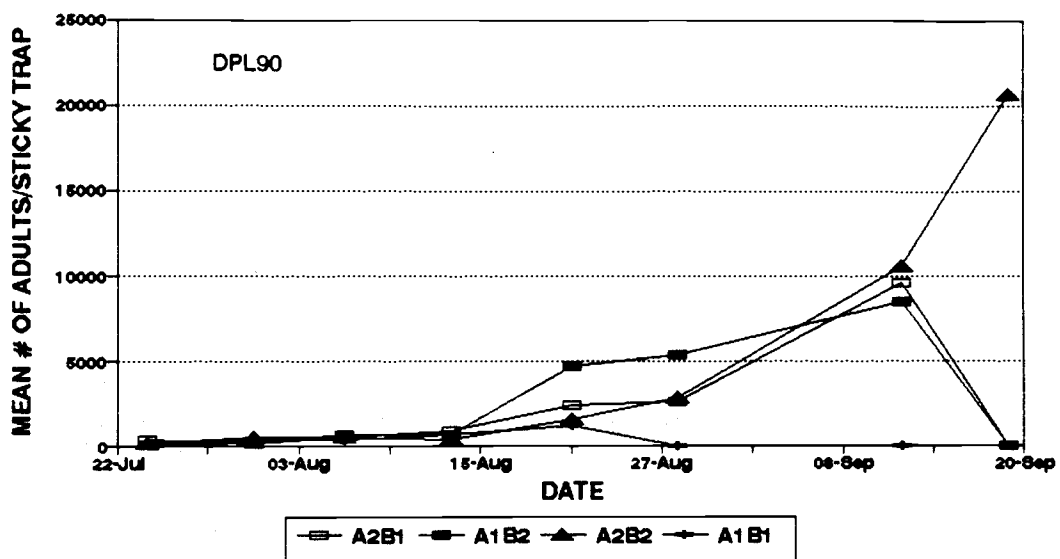


Figure 7. Comparative seasonal adult sweetpotato whitefly population trends in DPL-90 for all PD and IT treatments.

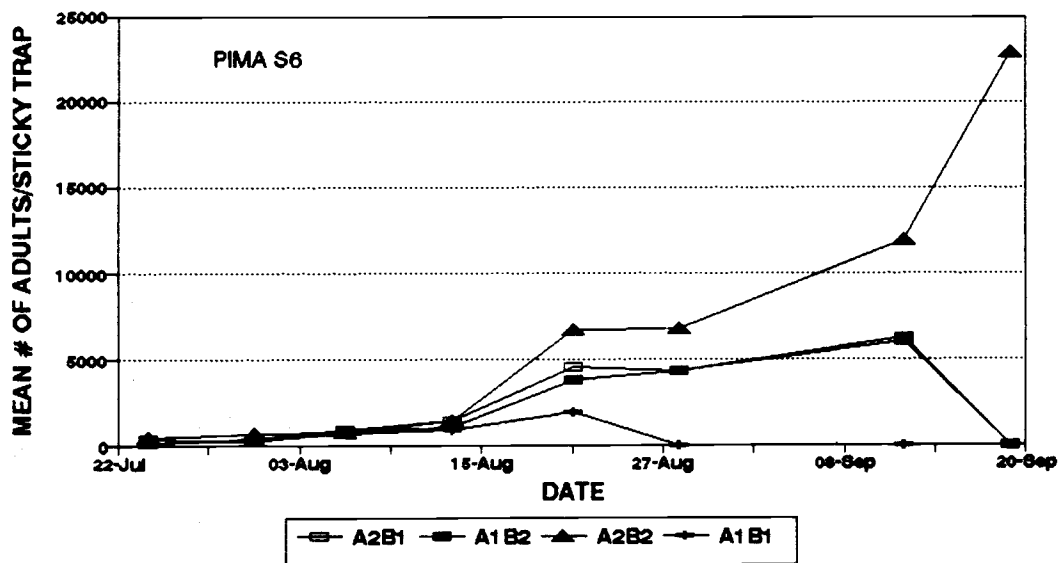


Figure 8. Comparative seasonal adult sweetpotato whitefly population trends in Pima S-6 for all PD and IT treatments.

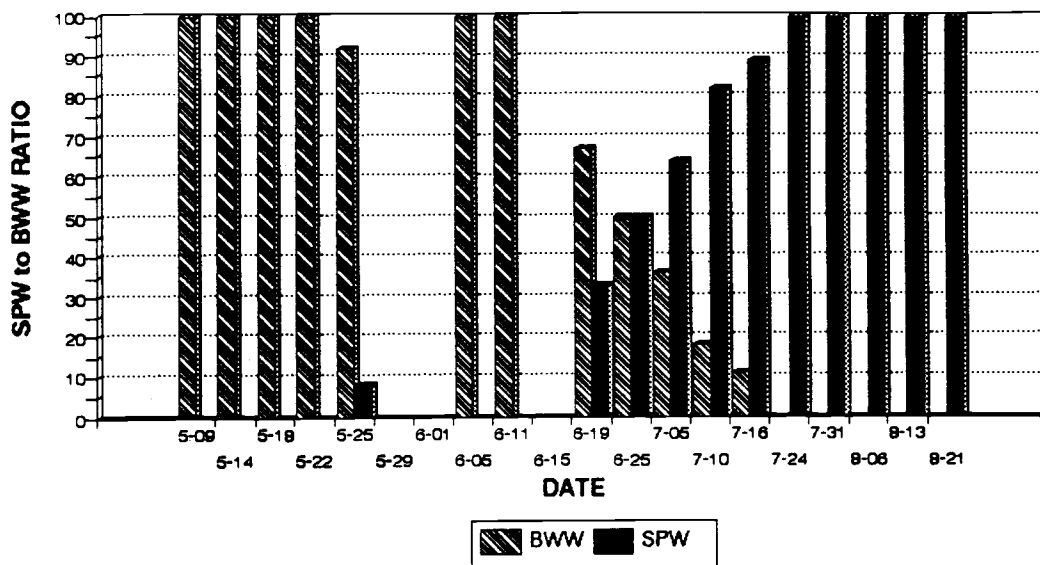


Figure 9. Seasonal ratio of bandedwing to sweetpotato whitefly in DPL-90 in the PD1 (planting date 1) treatment.

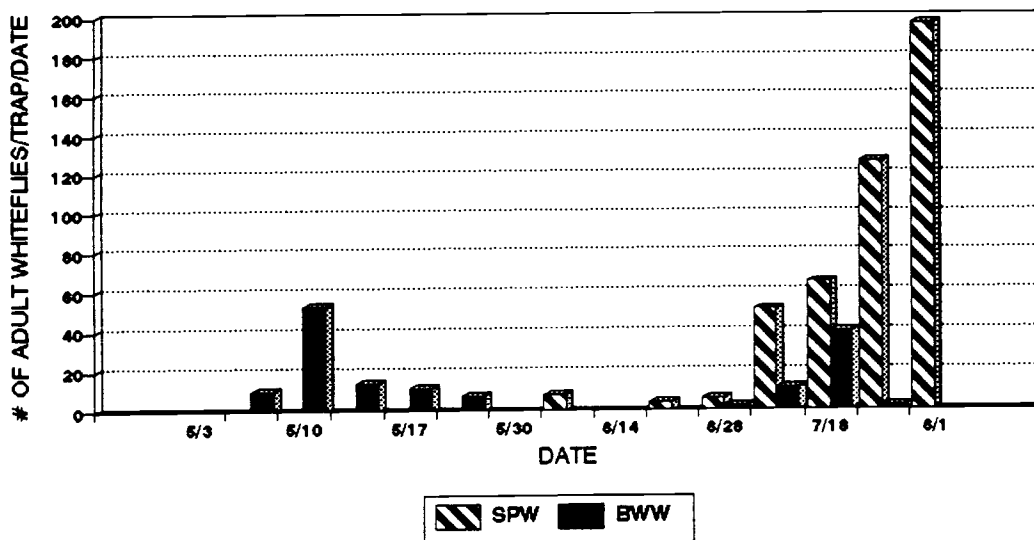


Figure 10. Seasonal occurrence of bandedwing and sweetpotato whitefly on okra.

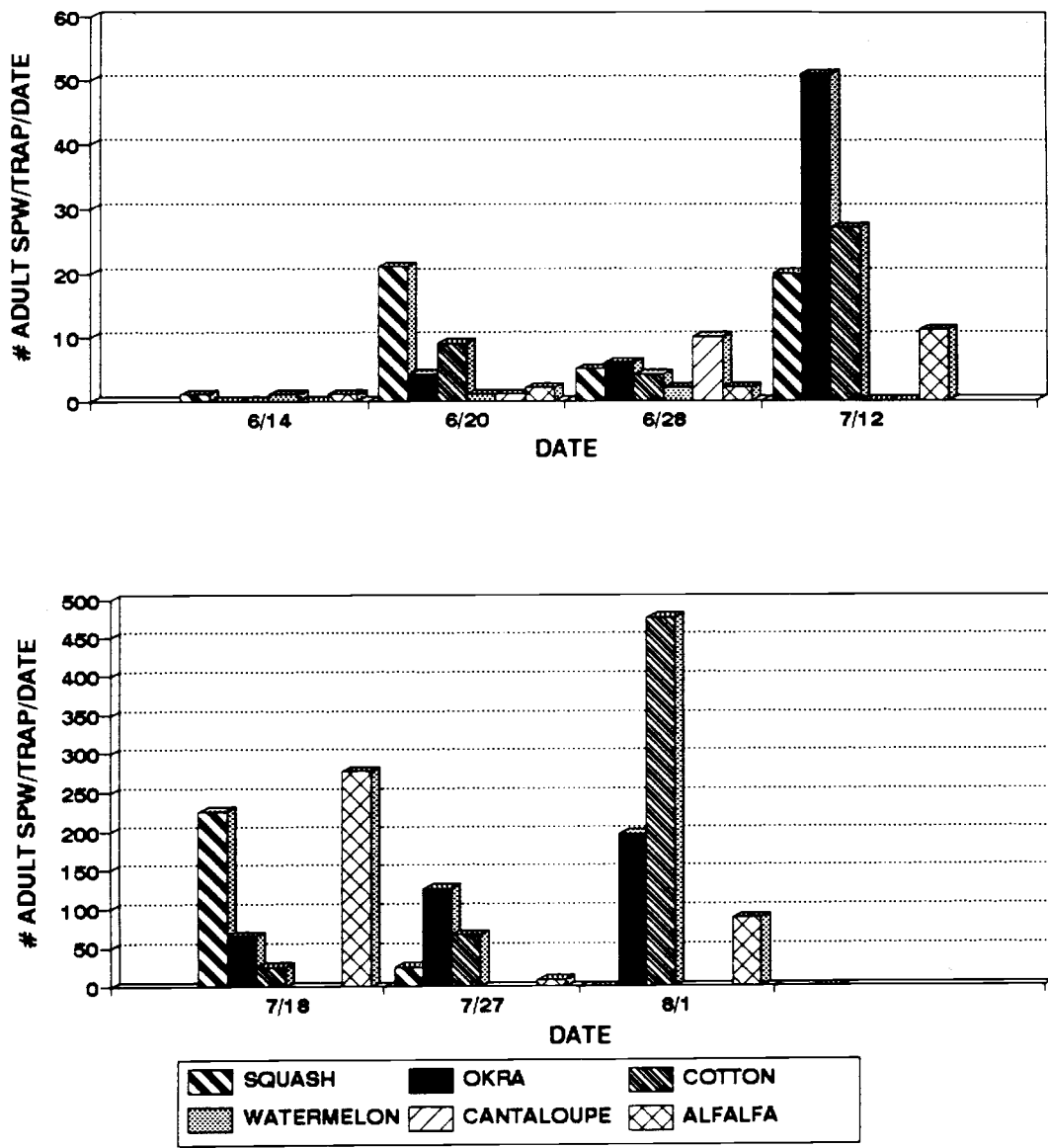


Figure 11. Seasonal sticky trap catches of adult sweetpotato whitefly in various summer crops.

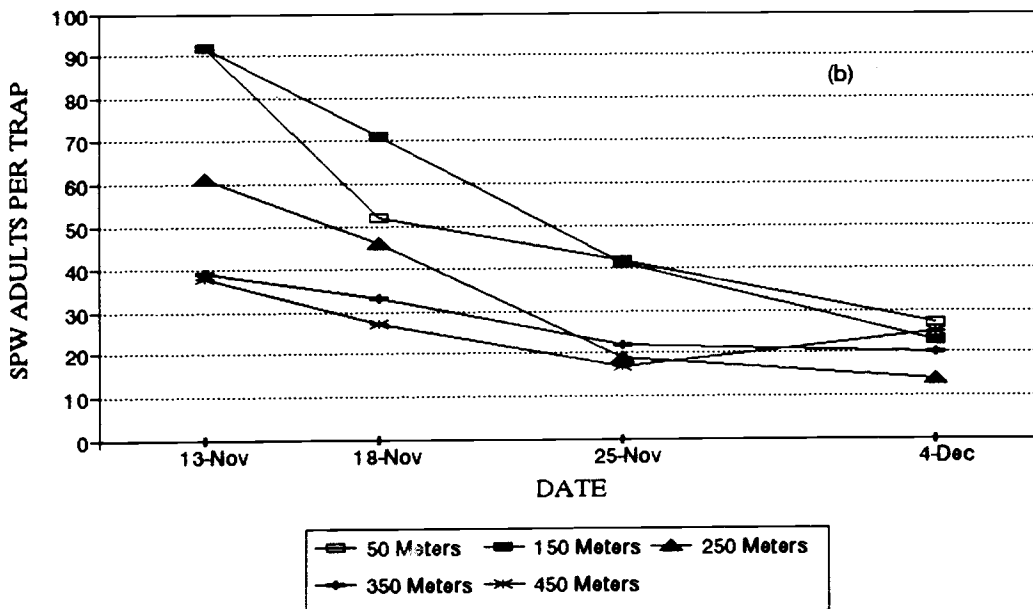
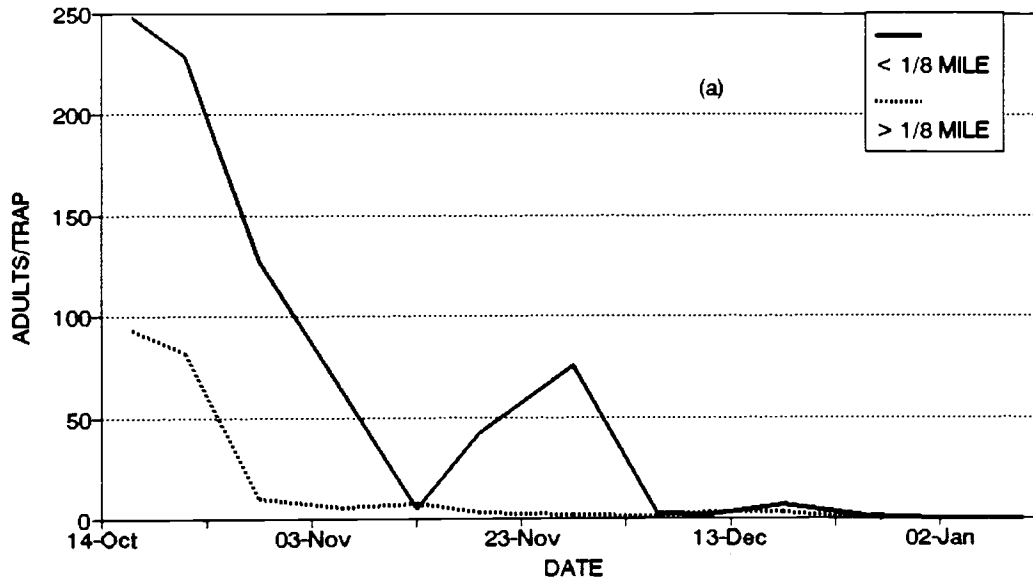


Figure 12. Comparative adult sweetpotato whitefly population trends in lettuce trapped less than or greater than 1/8 mile from adjacent cotton (a) or at specified distances from the cotton source (b).

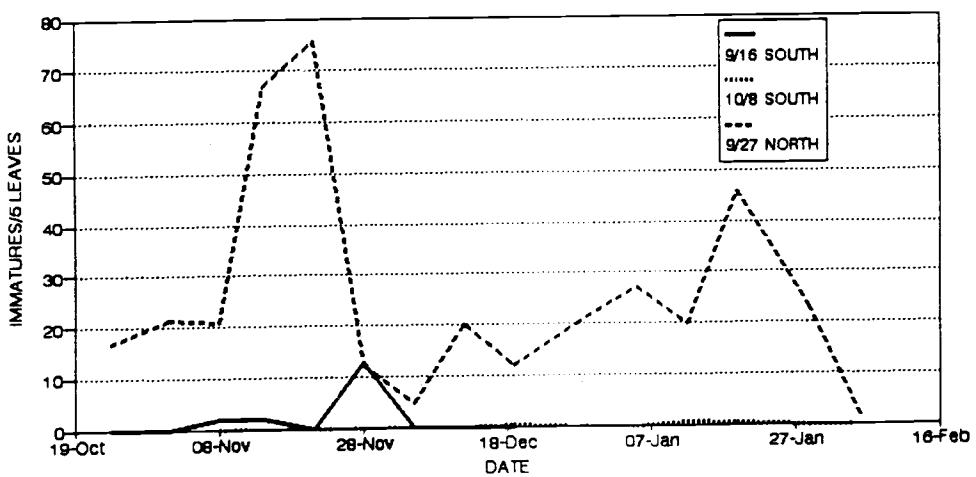
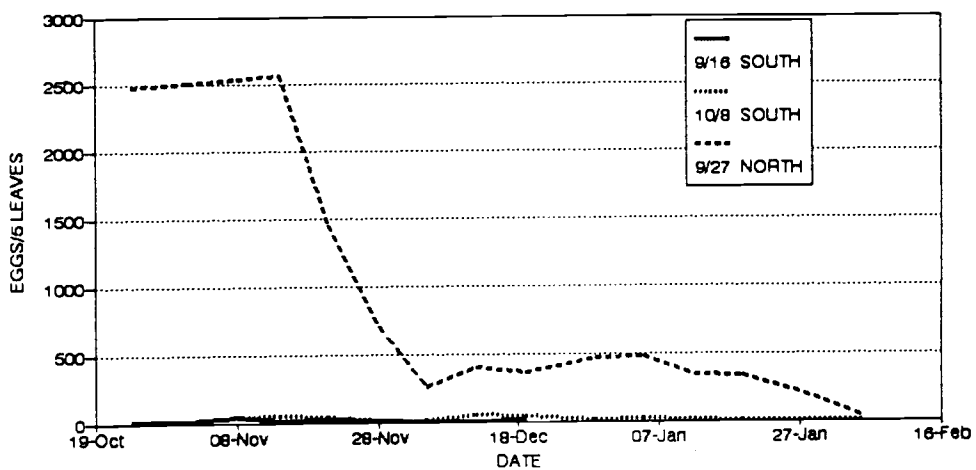
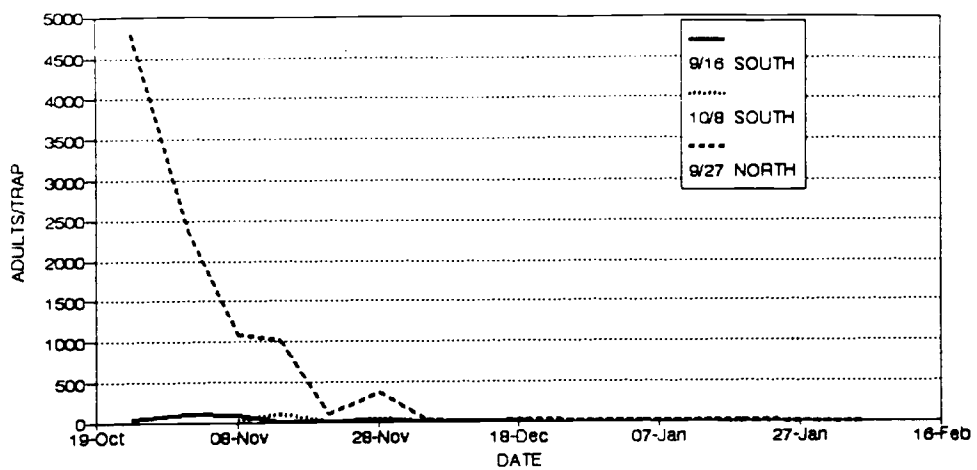


Figure 13. Fall population trends of sweetpotato whitefly in lettuce with cotton located either to the south or north.

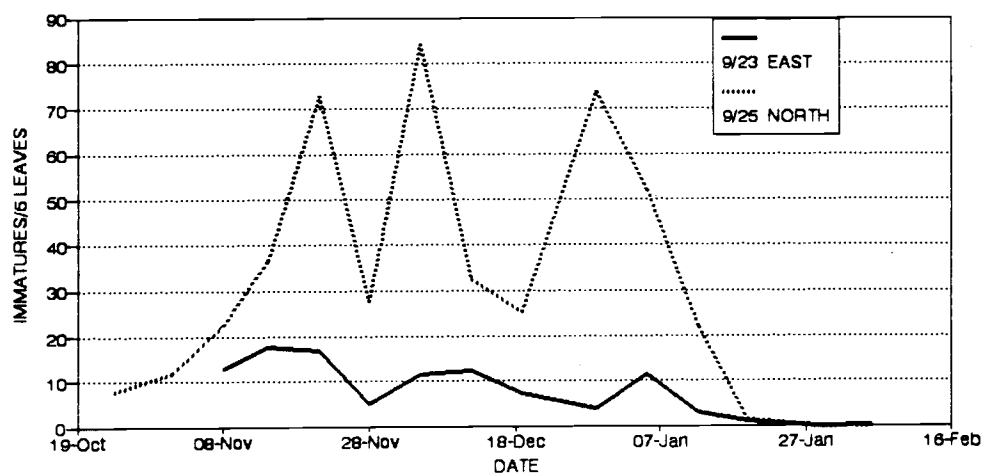
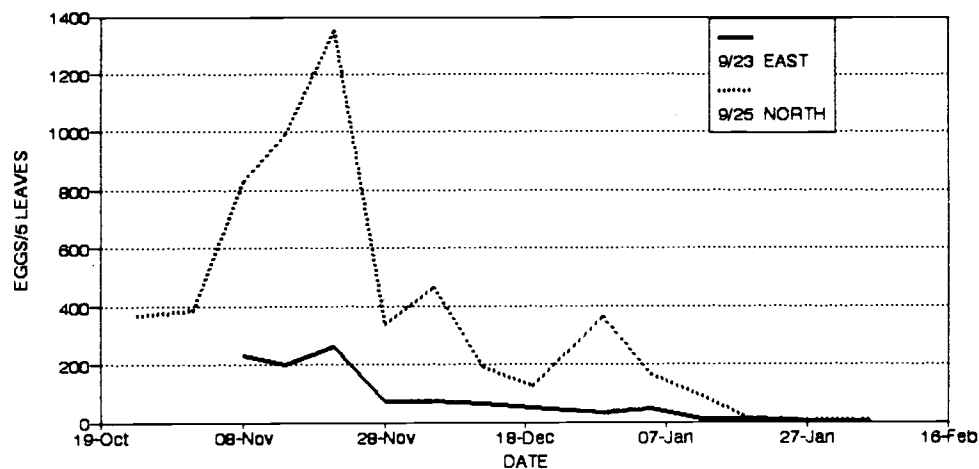
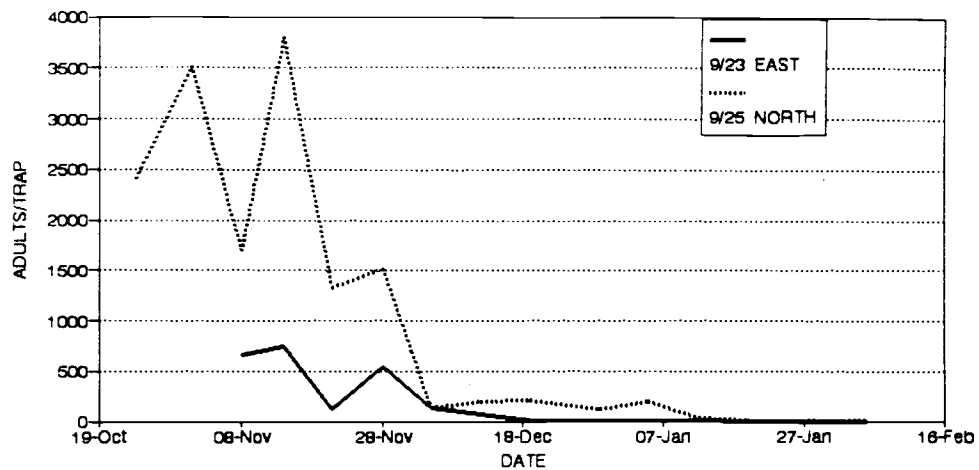


Figure 14. Seasonal population trends of sweetpotato whitefly in cauliflower with cotton located either to the east or north.

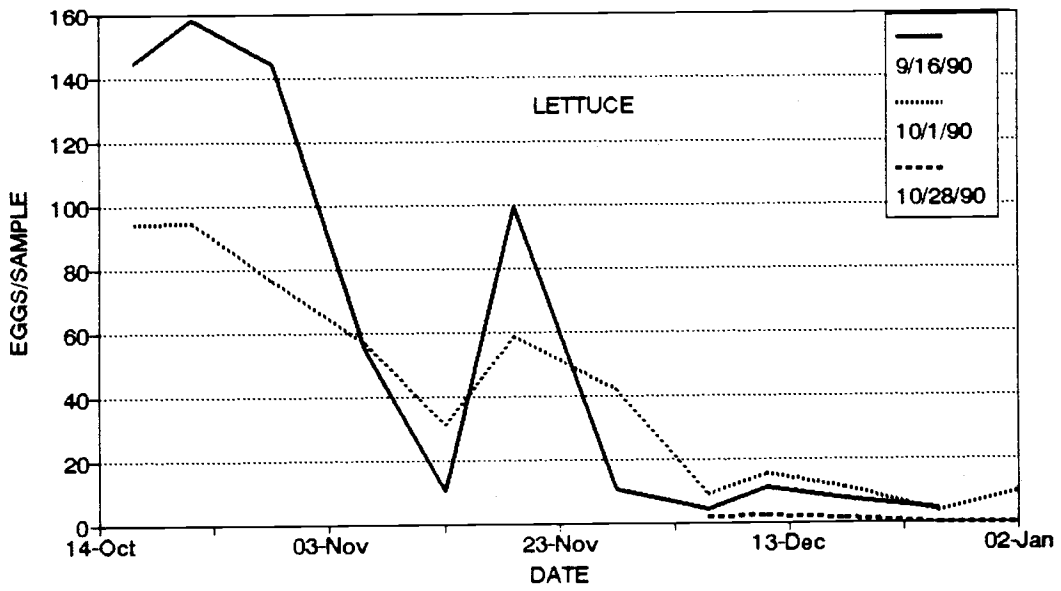
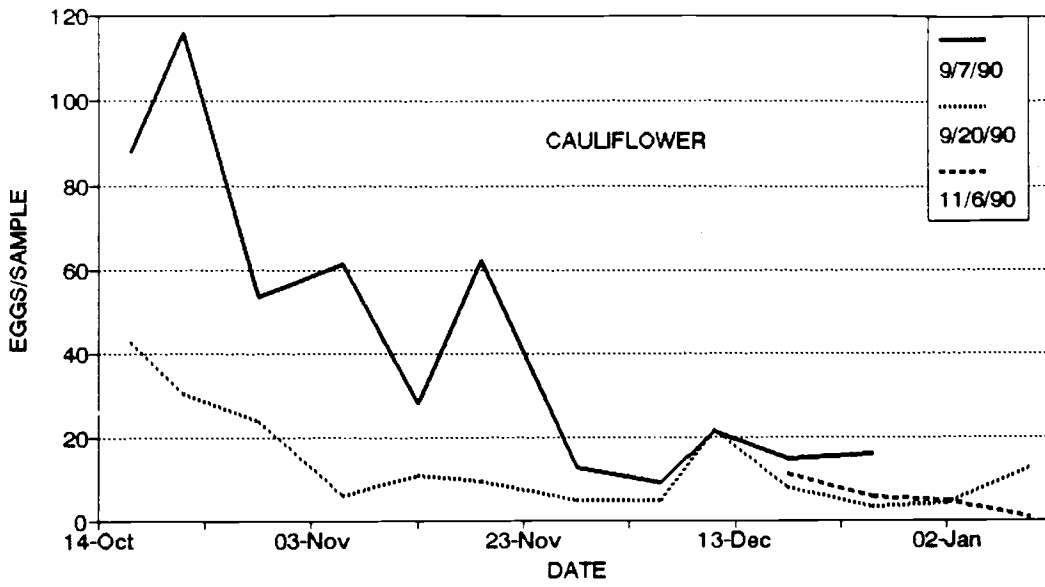


Figure 15. Influence of planting date on sweetpotato whitefly egg populations in Fall cauliflower and lettuce.

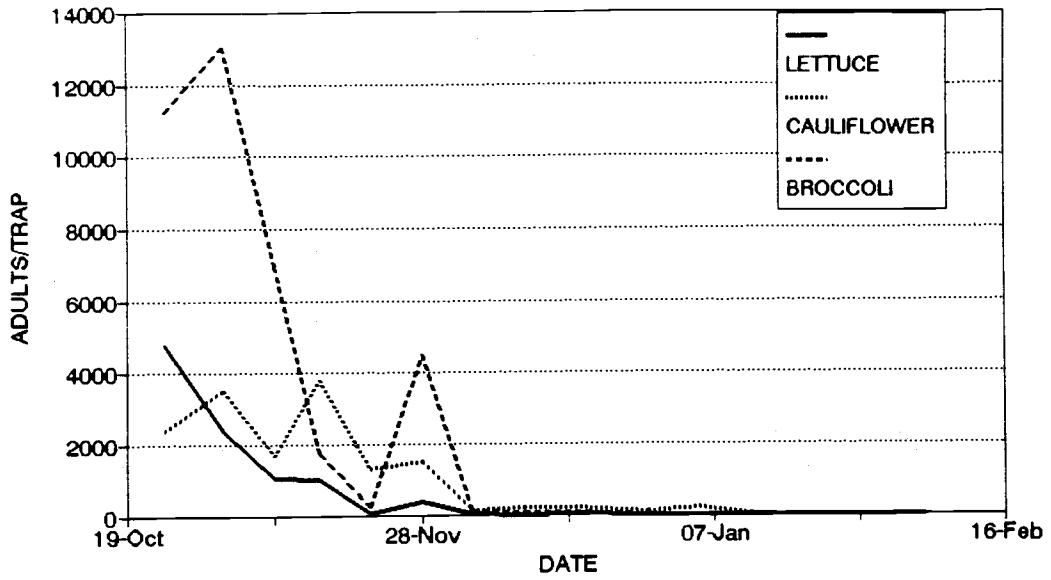


Figure 16. Comparative adult sweetpotato whitefly populations in lettuce, cauliflower and broccoli with cotton located to the north.

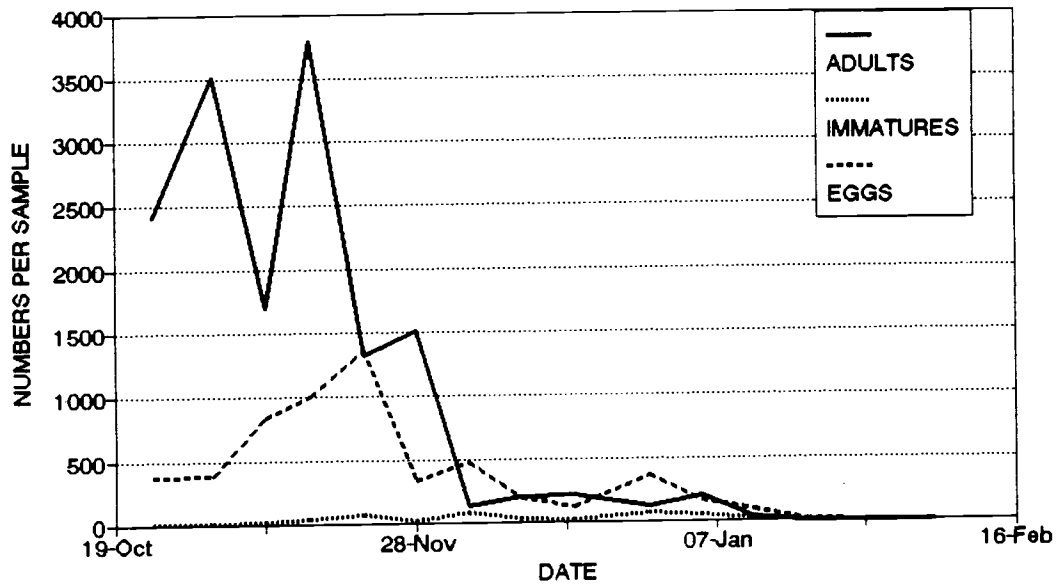


Figure 17. Population trends of adult, egg and immature stages of SPWF in cauliflower with cotton located to the north.

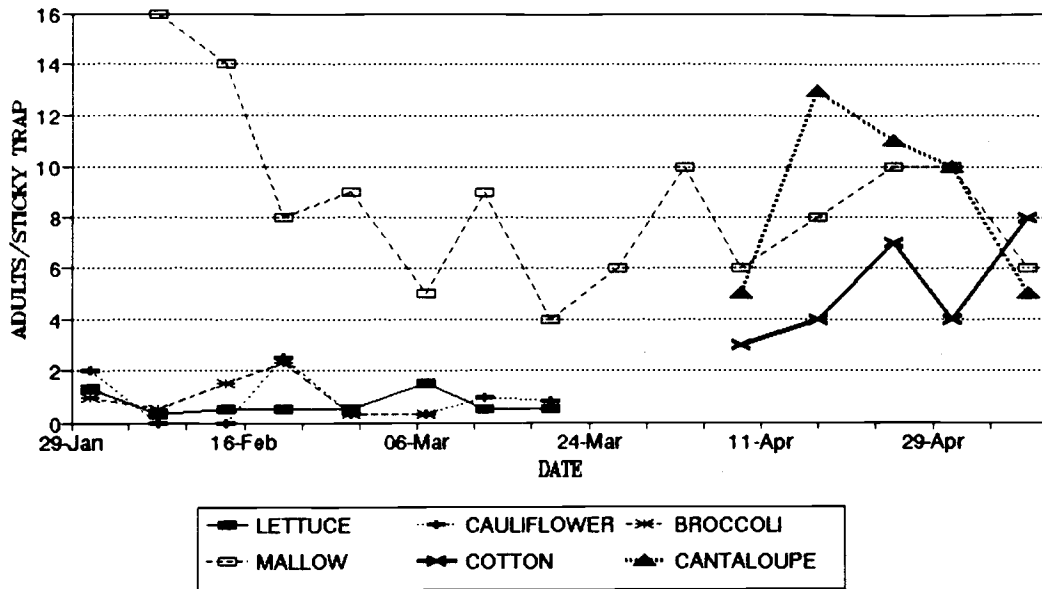


Figure 18. Host sequence of SPWF populations in late winter and spring relative to subsequent infestations in cantaloupe and cotton (1991).

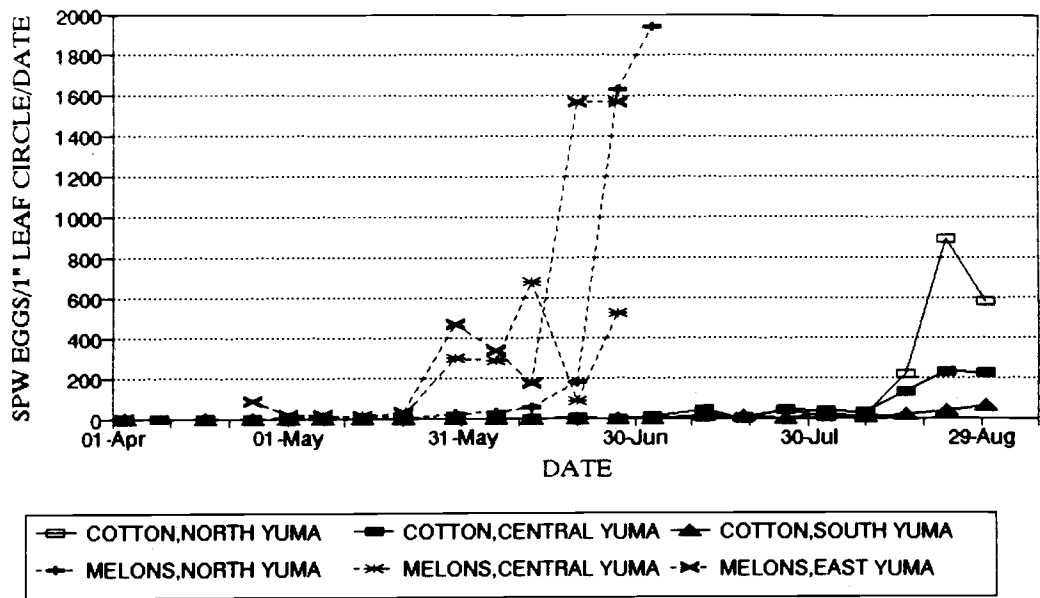


Figure 19. Correlation of SPWF egg populations in spring cantaloupe with later development in cotton.

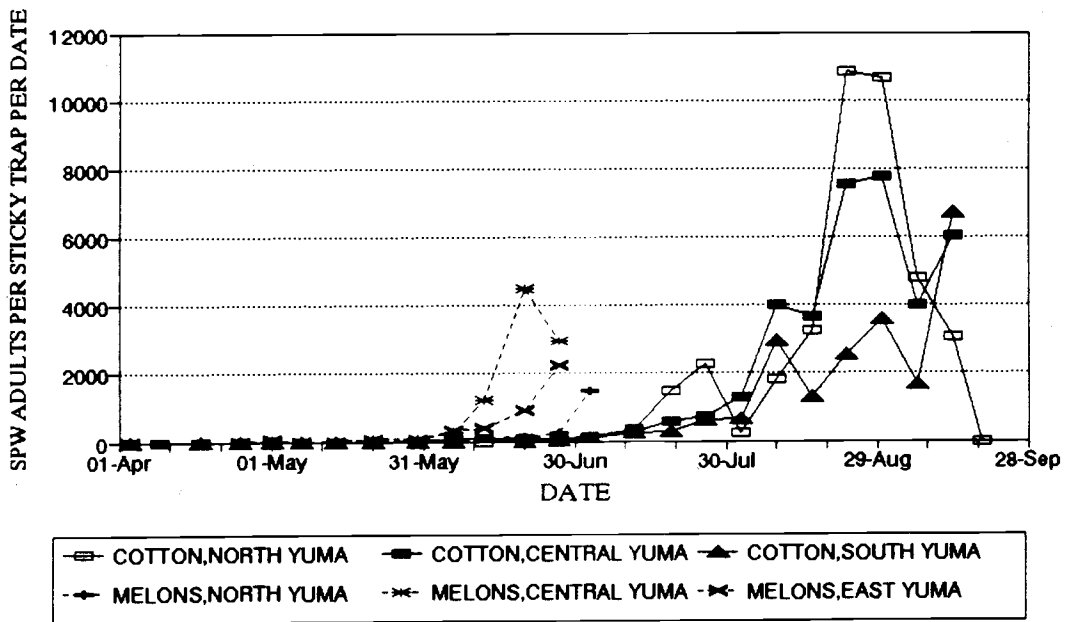


Figure 20. Correlation of SPWF adult populations in spring cantaloupes with later development in cotton.