FNE00-315

OBSERVATIONS FOR CULTURAL CONTROL OF FLEA BEETLES ON BRASSICACEAE CROPS

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ABSTRACT

Flea beetles are a major pest for vegetable growers. Adult beetles chew holes in leaves leaving a shotgun blast appearance and larvae reportably feed on host plant roots. There are several species of flea beetles that feed on brassicaceae, the most common of which are (Coleoptera: Chrysomelidae), Phyllotreta cruciferae "crucifer flea beetle", and Phyllotreta striolata "striped flea beetle". These flea beetles are not native to our region, the crucifer flea beetle apparently migrated from Asia to British Columbia in the 1930's then migrated eastward across the contintent. Flea beetle damage is usually most severe in spring, but often persists in fields through most of summer. There can be several generations per year with the last adult generation overwintering in field edges. This generation often migrates out of crops in late summer. These overwintered adults search out new brassicaceae crops early in spring. Large populations are difficult to control with pesticides, and are often able to penetrate row covers. This study monitored flea beetles to test and refine cultural controls: crop rotation, crop timing, planting density, crop species selection, soil fertility, beneficial populations, trap cropping, and field sanitation.

METHODS AND MATERIALS

Yellow sticky traps placed at a rate of 2 per week per site were used to monitor flea beetle populations. One trap was placed in arugula (Eruca sativa) and the other in red russian kale (Brassica napus), 1-2 in. above the crop canopy. Both of these species were planted in each site along with many other brassicaceae species. There were seven sites each physically seperated by at least 150 feet. The sites were initially planted as follows: site #1 October 15, 1999 (this site contained overwintered plants monitored during spring regrowth); site #2 March 27, 2000; site #3 May 10, 2000; site #4 May 20, 2000; site #5 June 1, 2000; site #6 June 21, 2000; site #7 July 19, 2000. Some sites received additional planting after the initial planting. Traps were collected weekly and brought to the Connecticut Agricultural Experiment Station for identification. A solvent was used to remove the beetles from the traps. Using microscopes beetles were identified by species and number of beetles per trap recorded. Relative damage to crops, and general flea beetle behavior was monitored daily on site. High and low air temperatures, and soil temperature were also recorded daily on site and degree days computed from these using Arnold's method with a 50' Fahrenheit base temperature.

RESULTS

General observations in the seven sites:

Site#1, planted the previous fall, was overwintered with 2-3 foot tall plastic tunnels over the growing beds. Crops included arugula (Eruca sativa), red russian kale(Brassica napus), konserva green kale (Brassica oleracea), mizuna (Brassica rapa), and green mustard (Brassica juncea). Covers were removed in early April, and crops harvested both in November-December and March- April, after which crops flowered and produced seed. No noticeable leaf damage from flea beetles occurred during this sites entire growth period, November-May. This is very significant as other sites were severely damaged during April and May. Overwintering wintercress weeds (Barbera vulgaris) did show leaf damage in this site during this same time. In April and May the flowers of these crops attracted many beneficial insects including ladybugs, hoverflies, wasps, and bees. Sticky traps were placed from March 27- June 12, and relatively few beetles captured, less than 10 on the majority of traps.

Site #2 was planted starting March 27, 2000, crops included arugula (Eruca sativa), red russian kale (Brassica napus), white egg turnip (Brassica rapa), collard (Brassica oleraceae), green mustard (Brassica juncea), curly cress (Lepidium sativum), and champion radish (Raphanus sativus). Successive plantings of arugula were subsites #2b May 7, site #2c June 7, site #2d July 25, and site #2e September 11. Overall, sites in this area had the worst flea beetle infestation of all the sites. Numbers of flea beetles per trap were highest with a peak the week of June 6- June 12, in the arugula (#2a), 530 flea beetles on a single trap. Germination of crops started on April 3 and by April 16 noticeable damage was first observed. By April 16 , 150 degree days (Arnold's method) had accumulated. The numbers of flea beetles trapped April10-17 were 25 on arugula (#2a) and 14 on red russian kale (#2a). Significant damage did not occur until these populations rose above 100 per trap per week which occurred by May 22-29, and generally continued through the end of August, at which time the last adult generation migrated out of the site. The initial March 27 planting was harvestable with only light to moderate damage, with Brassica oleraceae (collard, konserva kale) clearly being less damaged. The succession planting of arugula (2b,2c,2d) were damaged by flea beetles so badly that they were not salable. The September 11 planting (2e) of arugula was completely undamaged. It was interesting to note that when preferred crops were tilled under in this site that flea beetles would then feed on previously undamaged brassica oleraceae (collard, konserva kale). Peak adult populations occured on June12 and July 24 likely signalling the emergence of new adult populations. Kinoshita et al. (1979) reports Phyllotreta cruciferae needing approximately 520 degree days for a complete generation. Between April 16 and June 12 there were 600 degree days, and between June 12 and July 24 there were 820 degree days. A third generation of adults likely emerged around August 20 after an additional 570 degree days though there was no population spike at this time. This 3rd adult generation would migrate out of the site to overwinter. Crop preferences were closely monitored in this site which had a wide variety of brassicaceae genera planted, and the greatest numbers of beetles. Preference was determined by visual inspection of the leaves for amount of adult feeding damage. Flea beetle preference generally seemed to be; Eruca sativa (arugula), Brassica rapa (turnip, broccoli raab, chinese cabbage, chinese mustard), Brassica juncea (mustard greens), Brassica napus (rutabega, russian kale, rape), Lepidium sativum (cress), Raphanus sativus (radish), then Brassica oleraceae (broccoli, collard, kale, cabbage, brussel sprout, cauliflower, kholrabi) in this progession by genera. Of these only Raphanus sativus (radish) and Brassica oleraceae (collard, konseva kale) were undamaged enough to be harvested and sold during peak infestation periods, though some turnips (Brassica rapa) were sold with damaged tops. A portion of the initial March 27 planting was grown under plastic hoop tunnel row covers which were removed at the end of April. Flea beetles penetrated these covers and equally damaged these crops as uncovered sections. This may have been due to the type of row cover (plastic), the manner in which they are secured (sandbags), or the fact that they need to be removed for harvest, observation, and venting.

Site #3 planted May 10, crops included arugula, red russian kale, red giant mustard, konserva kale, and rattail radish. These crops received very minor damage and were salable beginning on June 12, which was the height of population levels in site #2. A second planting of arugula on June 21 suffered light damage as flea beetle populations rose though the number of beetles per week never reached more than 30. This second planting was also salable.

Site #4 planted May 20, crops included arugula, red russian kale, curly cress. These crops received some minor damage but remained of salable quality during their harvest period. Second plantings of arugula and chinese mustards on June 26 (Site #4b) were moderately damaged by the end of July, and were not salable by mid August. Flea beetle populations began a significant rise at this site starting on July 10.Total flea beetle population of site #4b arugula on July 10-17 was 49, on July 17-24 was 77, and by July 24-31 populations peaked at 155, then remained high until migration at the end of August. At the July 10 levels (26) little damage was noted, it took populations of over 100 beetles per trap per week to damage the crops enough for them to be unsalable.

Site #5 planted June 1, crops included arugula and red russian kale. These crops were harvested and sold with very little damage, and then turned in at the end of July. The number of flea beetles trapped never rose above 10 per week.

Site #6 planted June 21, crops included arugula and red russian kale. This site received very light damage with a population peak of 41 on first arugula (#6a) July 10-17, and 52 on a second planting of arugula (#6b) July17-24. Most traps yielded well under 20 beetles per week in this site from planting through September. This site was planted with a large variety of fall harvest brassicaceae during July and August, none of which suffered any significant damage.

Site #7 planted July 19, crops included arugula, red russian kale, and many varieties of broccoli and cabbage. All of these crops suffered heavy damage in mid August, but recovered fully when flea beetles migrated out of the site at the end of August. Later plantings in September had no damage. Populations quickly rose to a peak of 126 (arugula) on August 14-21, but just as quickly dropped to 17 (arugula) on August 28-September 4. This heavy late infestation may have been due to the complete turning under of site #3 on August 7. Newly emerging third generation adults from site #3 may have largely moved to nearest site #7 when their host plants were destroyed.

A total of 158 sticky traps were collected, and 6,811 flea beetles were counted and identified by species. Of these Phyllotreta cruciferae "crucifer flea beetle" accounted for 4,979 beetles or 74% of the total; Phyllotreta striolata "striped flea beetle" accounted for 1,196 beetles or 18% of total; Epitrix cucumeris "potato flea beetle" 283 beetles, 4% of total; Phyllotreta robusta 116 beetles, 2% of total; chaetocnema species "corn flea beetle" 283 beetles, 1% of total; Phyllotreta bipustulata 66 beetles <1% of total; and Phyllotreta zimmermani 50 beetles <1% of total. Other species identified with very small populations (less than 20) were: armoraciae, punctulata, trichaltica, dibolia, mantura, and crepidodera. The two species cruciferae and striolata account for 92% of the total number of flea beetles captured, and are clearly the species of concern for brassicaceae growers in our region. Three complete generations of cruciferae were noted in site #2, and a level approaching 100 beetles per trap per week noted as being seriously damaging to crops.

DISCUSSION

The results gathered in this experiment are useful in developing cultural control strategies. These include crop rotation, crop timing, planting density, crop species selection, soil fertility, beneficial populations, trap cropping, and sanitation. A combination of these controls was demonstrated as sucessful in producing marketable crops of brassicaceae throughout the growing season.

Effective crop rotations are the most important control strategy. Summer planting of brassicaceae crops follow their natural pattern as spring flowering, winter annuals. Many farmers report success by only planting brassicaceae for fall harvest with planting starting in late June or July. With high demand for these crops, it becomes profitable to spring plant these crops as well. This can be successful by planting in well seperated sites over the course of the season, the farther the distance the better. A common mistake is to plant fall brassicaceae near spring brassicaceae, this prolongs crop damage by flea beetles.

Proper timing of crop rotations is very important. Overwintering of brassicaceae was successful in producing marketable crops in March and April. However it seems unlikely that a crop could be planted early enough in spring to completely avoid flea beetle damage. Overwintering adults were active after only 150 degree days (April 16) and damaged crops planted on March 27 under row covers. Sites planted after May 10 (300+ degree days) in seperated areas did well in the experiment, likely due to the concentration of overwintered adults in the earlier site (#2). Sites do tend to build populations so it is advisable to keep fall harvest brassicaceae well away from any of these spring plantings.

Planting density is an important factor in relative damage and salability of crops. Since flea beetle damage to leaves can be acceptable in small amounts, a high crop to beetle ratio can lead to success. This involves planting crops thickly, and thinning if necessary. Consideration should also be given to size of planting in relation to total flea beetle population in the crop area. Larger crop sites are more sucessful, but also have the potential to build flea beetle levels even higher, especially in spring.

Crop species should be planted at the proper time. As stated earlier, brassicaceae crops generally perform best when summer planted for fall harvest. Crops selected for spring planting should be of quick growth and harvest. Many of these crops will be trying to flower if planted before the summer solstice. Mixed species plantings in spring may be useful as flea beetles are more attracted to certain crops as stated in site #2. Brassica oleraceae (collard, green kale) did well in mixed spring plantings (site #2) because the present flea beetles were far more attracted to other crops. Root vegetables turnip (Brassica rapa) and radish (Raphanus sativus) were successful under flea beetle pressure when planted early (March 27, 68 degree days).

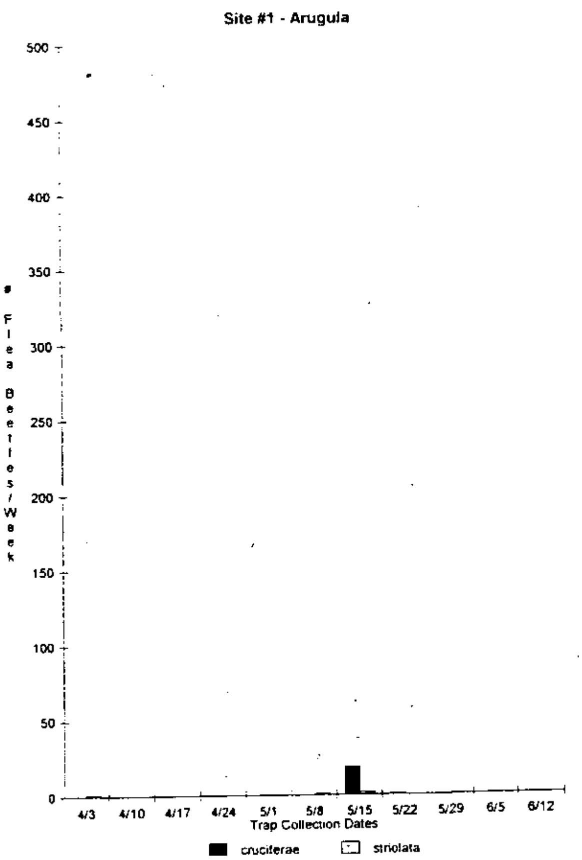
Soil fertility is a factor in rate of growth, ability to maintain dense plantings, and insect resistance. High levels of necessary nutrients in proper relation to each other are often attained by generous additions of organic matter to the site. This is vital to a quick rate of growth. This combined with dense planting helps give a higher crop to beetle ratio. High soil fertility makes heathier plants which are less attractive to insect pests, and creates an enviornment which is generally hostile to pests.

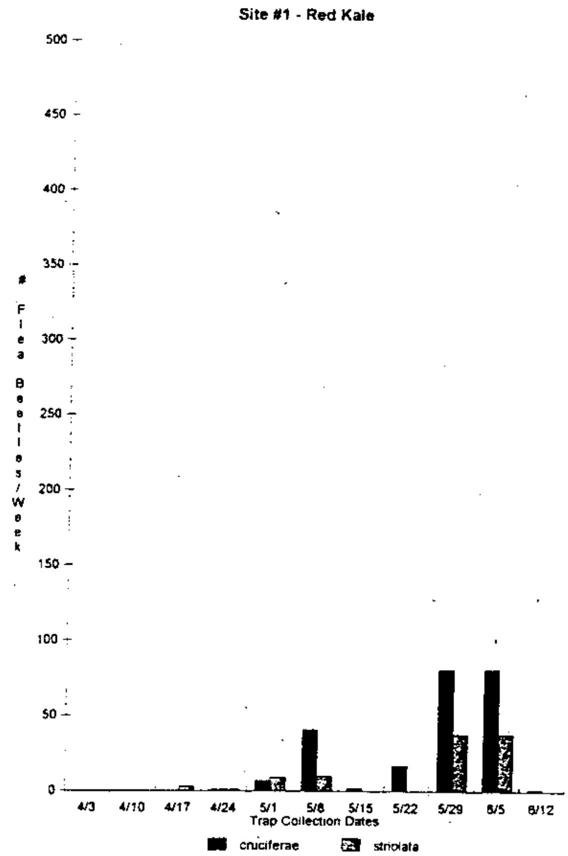
Fertile soils maintain more beneficial populations. These include spider and beetle predators, wasp parasitoids, and soil dwelling nematodes. Care should be taken to preserve and enhance these populations. Habitat and food sources can be provided by the grower. Tillage practices largely affect habitat, generally less tillage will provide more habitat. Beneficial plantings can be used to provide both food and habitat. These often include cover crops such as clover and buckwheat, but can also be provided with hedgerows and fallow areas. One food source may be the pollen of brassicaceae flowers themselves. The flowers in overwintered site #1 attracted many beneficial insects, this included many species of wasps. Microctonus vittatae, a braconid wasp, is reportably an important parasitoid of Phyllotreta striolata (striped flea beetle). Phyllotreta striolata never reached damaging levels in the experiment. Populations peaked at 83 on May 1-May 8, and only 6% of traps had catches of over 30 per week. Phyllotreta cruciferae is a more recent arrival to our region (1950's) and it is possible that natural enemies have not yet been introduced.

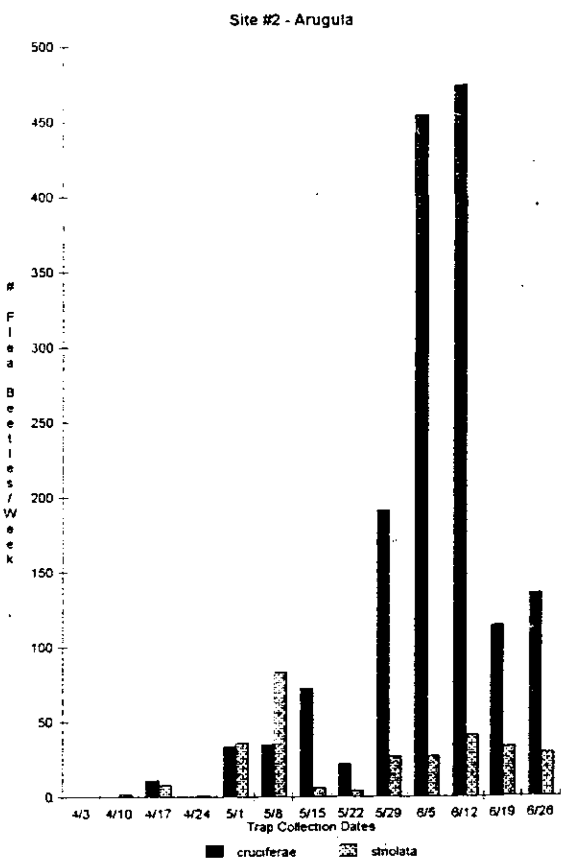
Trap cropping may be effectively used to reduce overall flea beetle populations. Flea beetles can be attracted to a trap site during spring movement by planting preferred crops. These trap crops can then be entirely turned under, destroying all host plants in the area. Timing of this should be considered, it would seem most appropriate to turn in the trap crop after spring migration is largely over (May 8th, 300 degree days), and before emergence of the new adult population(May 28, 500 degree days). If turned in to late the newly emerging adult generation may persist, and if too early the overwinter adults may have success establishing in a new host.

Attractive crop species can also be used to lure flea beetles off less preferred crops. In this case the trap crop is not turned under until the actual crop is harvested. The trap crop needs to be maintain for as long as crops are harvested or until late summer flea beetle migration out of the field. Enough trap crops need to be planted in relation to flea beetle numbers for this to be effective.

Field sanitation refers to reducing the potential host plants of flea beetles. Care should be taken to completly destroy trap crops and spring planted crops when harvest is through. Little is known on the effects of tillage on the soil dwelling larvae and pupae of flea beetles, but it is probably of benefit to remove the food source totally. It may be of benefit not to destroy fall harvest brassicaceae, and allow them to overwinter and flower in spring. Since most flea beetles migrate out of crop fields in late summer, the benefit of allowing


Site #1 - Arugula
Flea Beetles/Week
Trap Collection Dates
cruciferae
striolata


Site #1 - Red Kale
Flea Beetles/Week
Trap Collection Dates
cruciferae
striolata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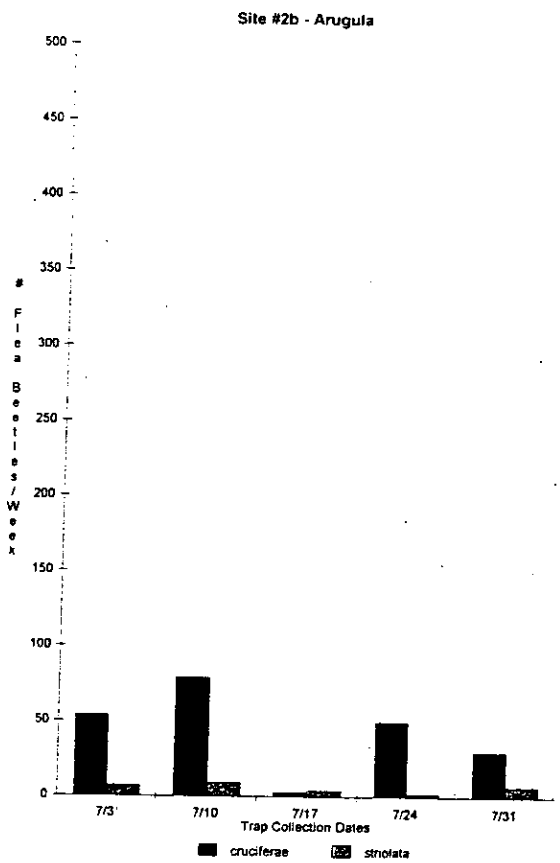
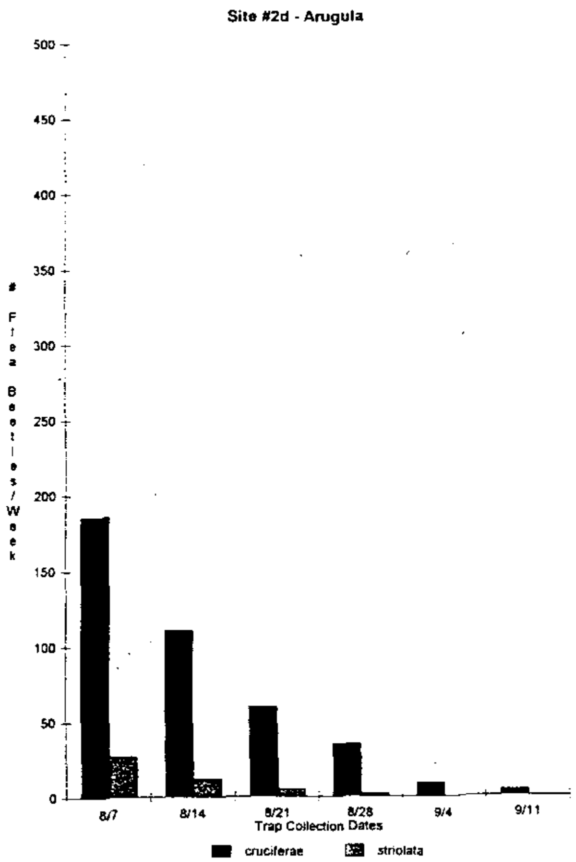
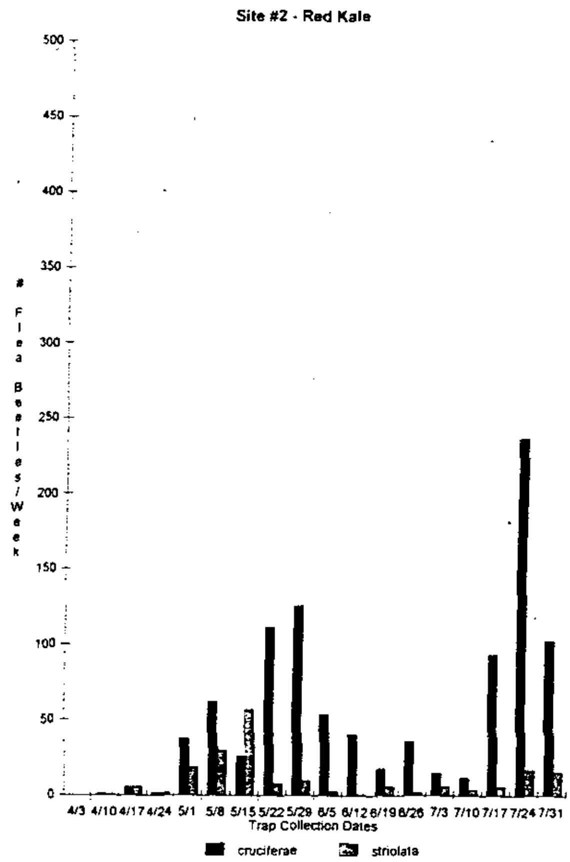
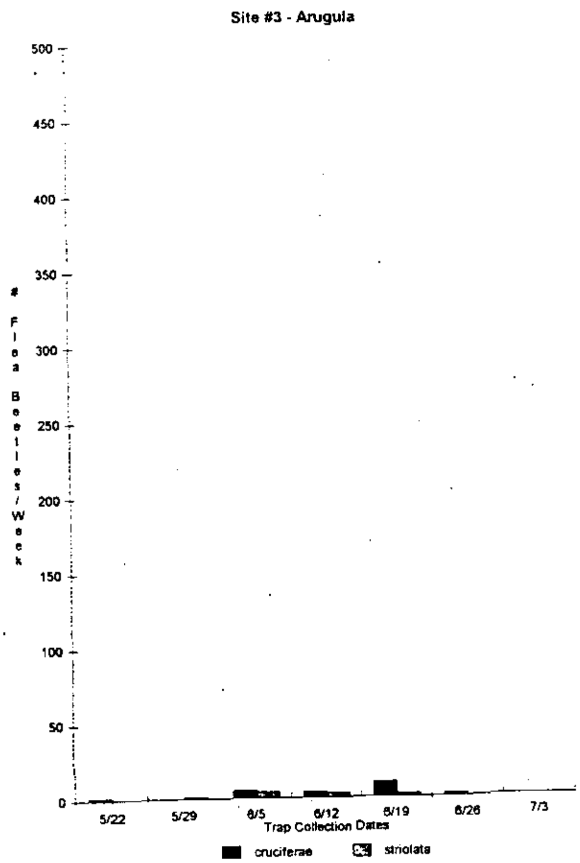
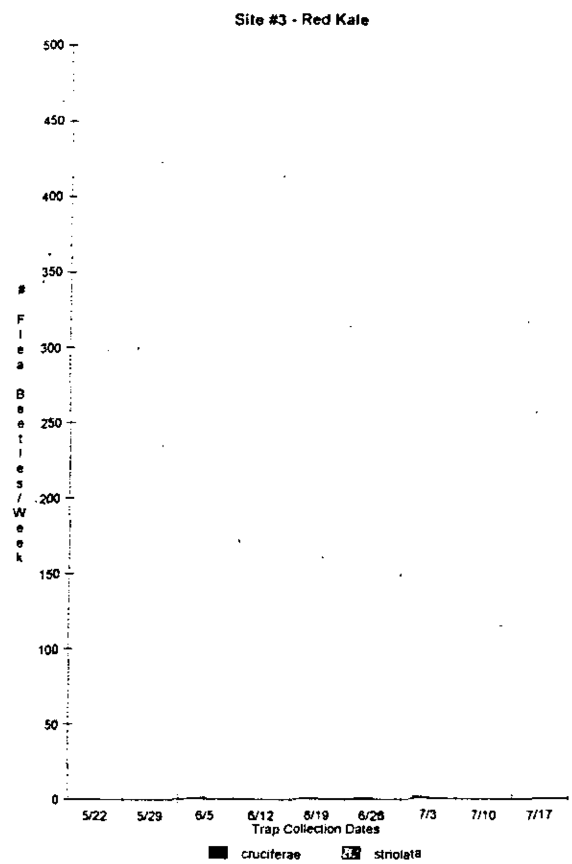
Flea Beetles/Week
Trap Collection Dates
cruciferae
striolata

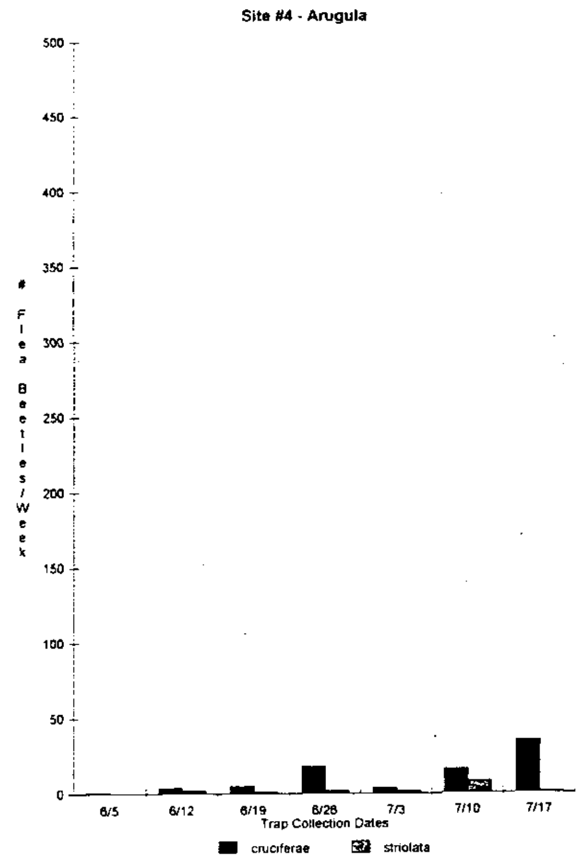

Site #2b - Arugula
Flea Beetles/Week
Trap Collection Dates
cruciferae
striolata

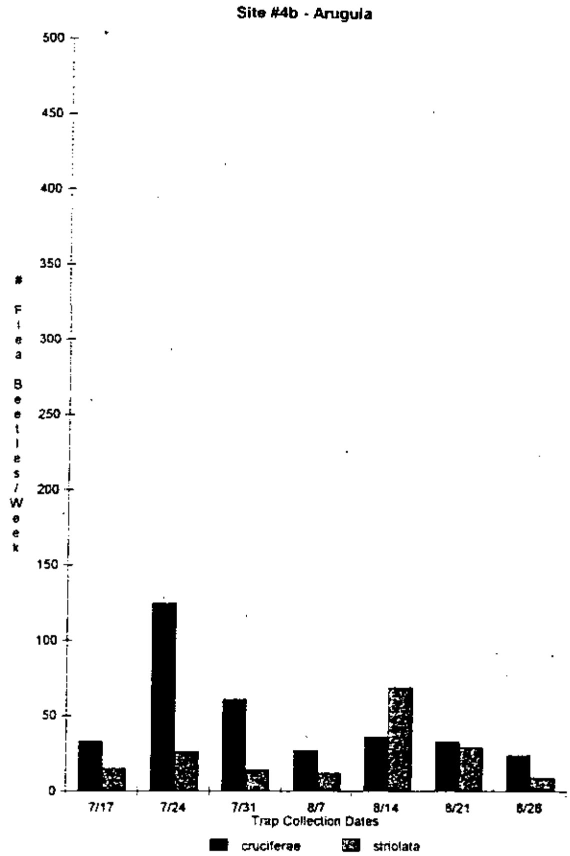

Site #2d - Arugula
500
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
8/7
8/14
8/21
8/28
9/4
9/11
Trap Collection Dates
cruciferae
striolata

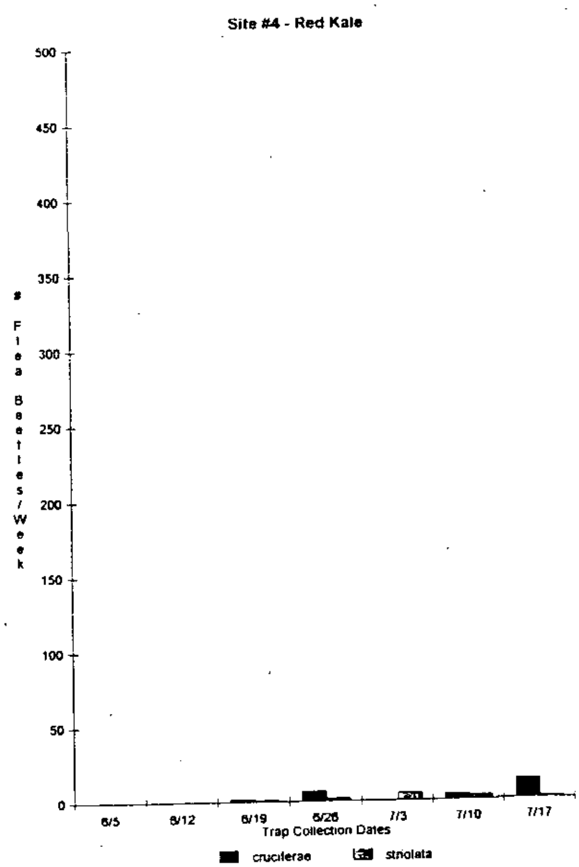

Site #2 - Red Kale
500
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
4/3
4/10
4/17
4/24
5/1
5/8
5/15
5/22
5/29
6/5
6/12
6/19
6/26
7/3
7/10
7/17
7/24
7/31
Trap Collection Dates
cruciferae
striolata


Site #3 - Arugula
500
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
5/22
5/29
6/5
6/12
6/19
6/26
7/3
Trap Collection Dates
cruciferae
striolata


Site #3 - Red Kale
500
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
5/22
5/29
6/5
6/12
6/19
6/26
7/3
7/10
7/17
Trap Collection Dates
cruciferae
striolata


Site #4 - Arugula
Flea Beetles/Week
500
450
400
350
300
250
200
150
100
50
0
6/5
6/12
6/19
6/26
7/3
7/10
7/17
Trap Collection Dates
cruciferae
striolata


Site #4b - Arugula
Flea Beetles/Week
500
450
400
350
300
250
200
150
100
50
0
7/17
7/24
7/31
8/7
8/14
8/21
8/28
Trap Collection Dates
cruciferae
striolata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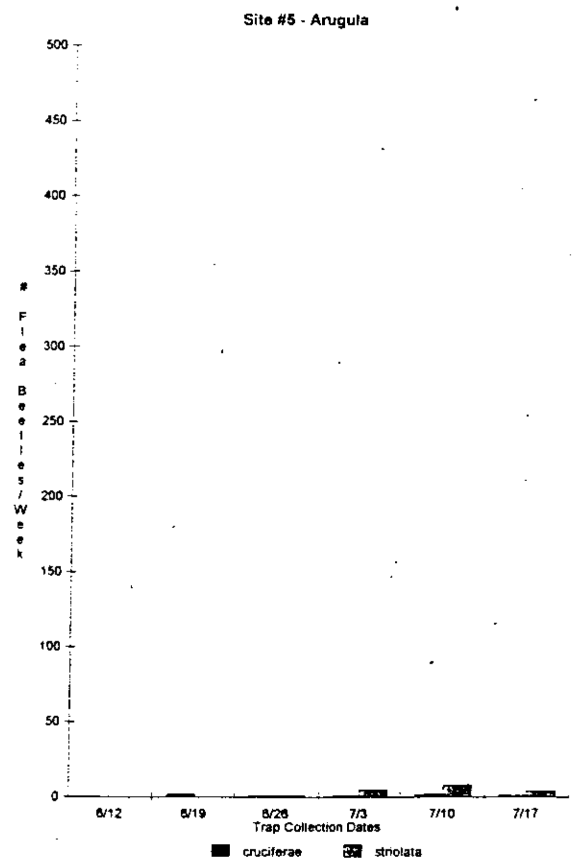
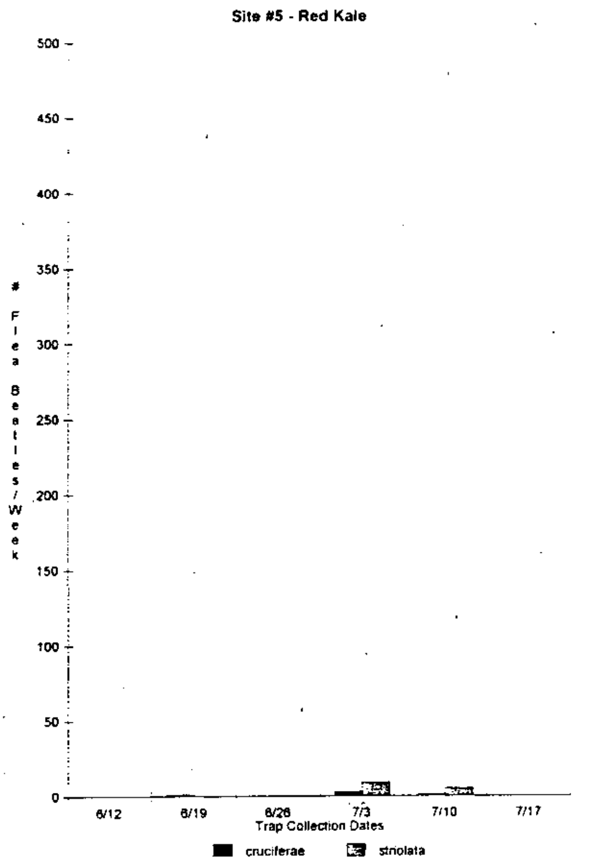
Flea Beetles/Week
500
450
400
350
300
250
200
150
100
50
0
6/5
6/12
6/19
6/26
7/3
7/10
7/17
Trap Collection Dates
cruciferae
striolata


Site #5 - Arugula
Flea Beetles/Week
500
450
400
350
300
250
200
150
100
50
0
6/12
6/19
6/26
7/3
7/10
7/17
Trap Collection Dates
cruciferae
striolata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500
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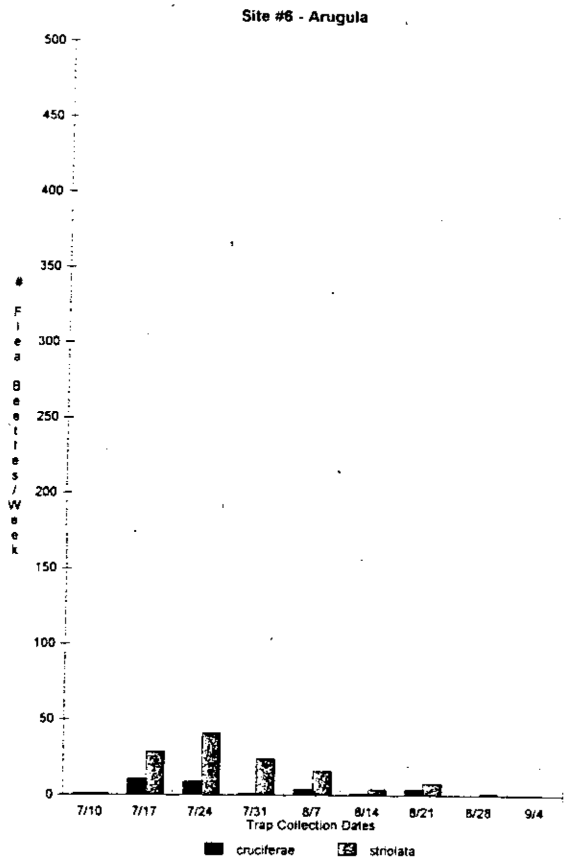
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
6/12
6/19
6/26
7/3
7/10
7/17
Trap Collection Dates
cruciferae
striolata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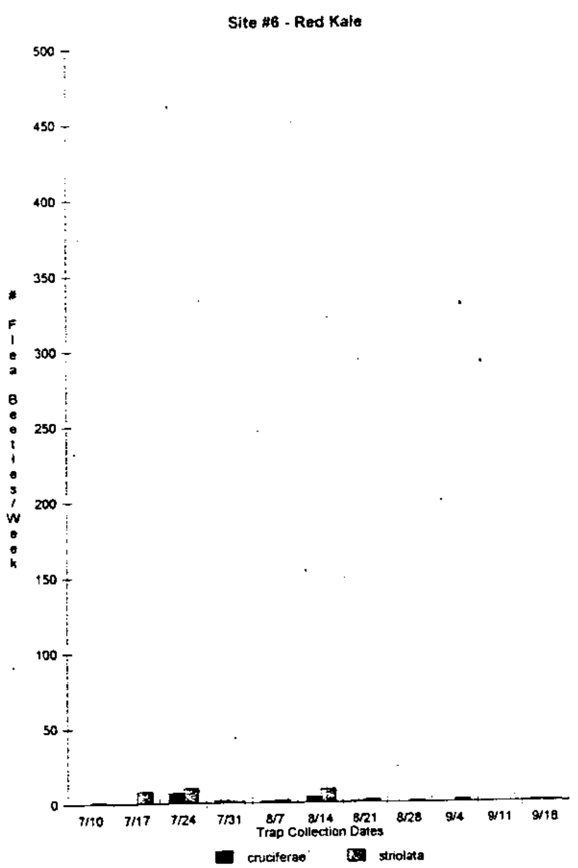
500
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
7/10
7/17
7/24
7/31
8/7
8/14
8/21
8/28
9/4
Trap Collection Dates
cruciferae
striolata


Site #6 - Red Kale
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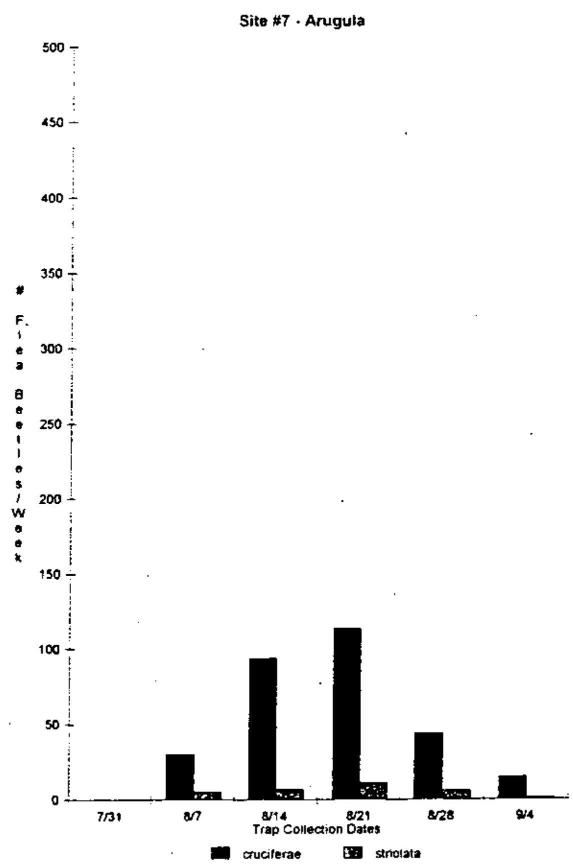
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
7/10
7/17
7/24
7/31
8/7
8/14
8/21
8/28
9/4
9/11
9/18
Trap Collection Dates
cruciferae
striolata


Site #7 - Arugula
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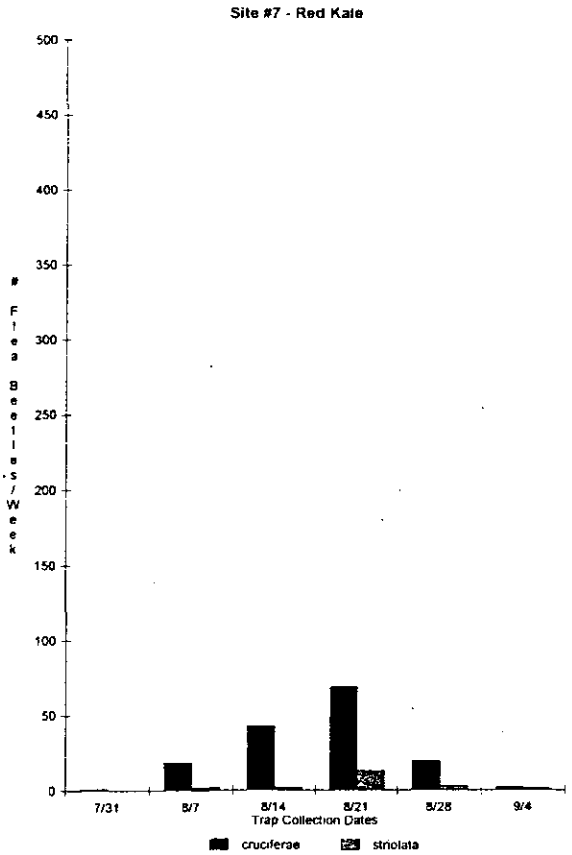
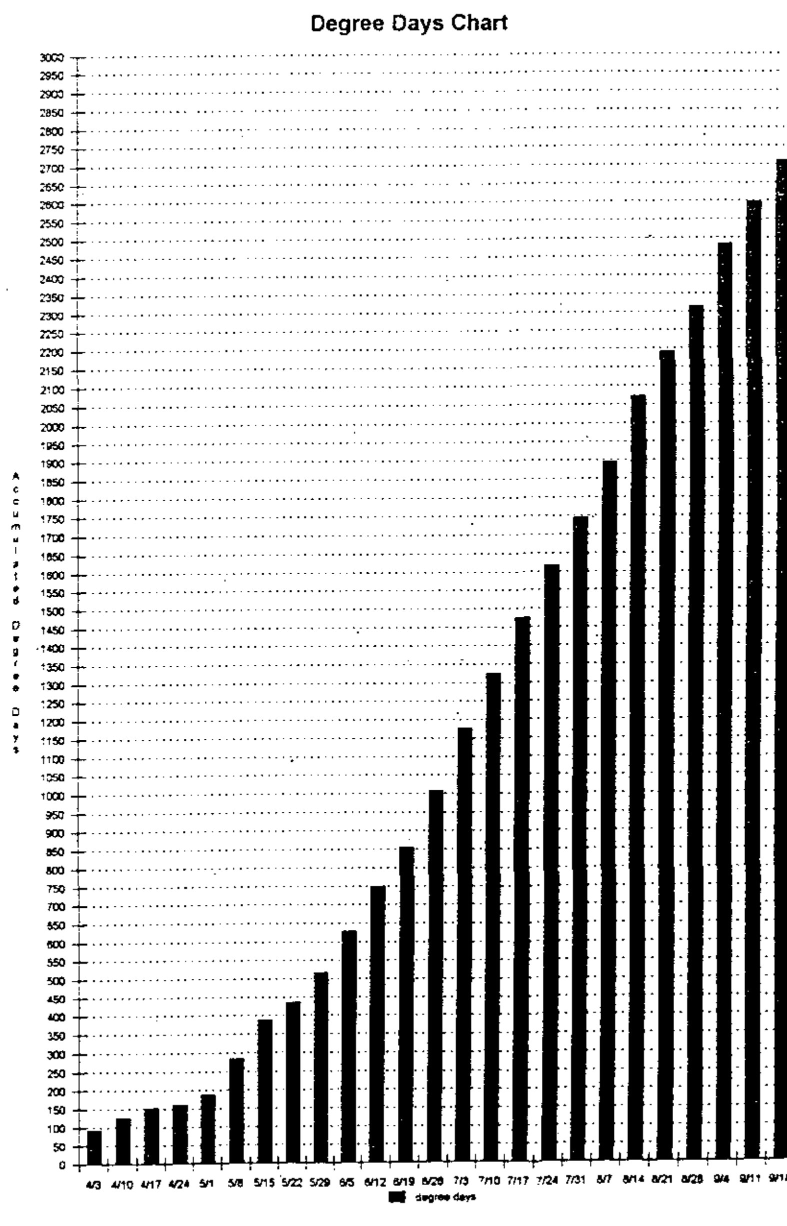
450
400
350
300
250
200
150
100
50
0
Flea Beetles/Week
7/31
8/7
8/14
8/21
8/28
9/4
Trap Collection Dates
cruciferae
striolata



Site #7 - Red Kale
Flea Beetles/Week
Trap Collection Dates
7/31
8/7
8/14
8/21
8/28
9/4
cruciferae
striolata



Degree Days Chart
Accumulated Degree Days
degree days