Project Number: 90-V2

THE DETECTION OF THE ALMOND LEAF SCORCH BACTERIA.

YEAR END REPORT - December 1990

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PROBLEM AND ITS SIGNIFICANCE:

Almond leaf scorch (ALS), or golden death as it is also called, is caused by a xylem-limited bacteria which has been named Xylella fastidiosa. This bacteria has been studied in detail in grapevines where it causes Pierce's disease. In almonds, however, although it has been established that the same bacteria causes almond leaf scorch, very little is known about the alternate hosts for the disease in almond orchards, the identity of the vectors under field conditions, or the development of disease in individual trees from the time inoculation occurs until symptoms appear and the tree begins to decline.

Of particular interest are the great differences observed throughout California in the percentage of almond leaf scorch in individual orchards. If the techniques are developed to study this disease in detail, it may be possible to discover why some areas are relatively unaffected by almond leaf scorch while in other areas large portions of entire orchards are killed. An understanding of the differences in the rate of disease spread in different locations could provide an effective approach to control of almond leaf scorch. Growers in the central valley have found that understanding of the vector relations of Xylella fastidiosa in grapes has been very useful in controlling Pierce's disease in valley conditions. Similar knowledge of the vector relations of Xylella fastidiosa in almond orchards would contribute to control of almond leaf scorch.

OBJECTIVES FOR THE 1990-1991 FUNDING YEAR:

(1) Continue to survey the state for almond leaf scorch infection. Throughout the course of this project, all growers and farm advisors will be encouraged to send samples to our lab for testing. Updated estimates of the extent of damaged caused by ALS in California are needed in evaluating the importance of the disease.

(2) In Davis, young almonds will be inoculated and the development of disease studied in these trees. Using various detection techniques, the distribution of the bacteria in almond trees from the time of inoculation through the development of disease will be studied under these experimental conditions.

(3) An orchard with severe ALS has been selected for detailed studies of sharpshooter populations in an effort to identify the vector of the disease. The orchard will be mapped, diseased trees marked, and observations will be made regularly to locate new infections. Collections of leafhoppers will be made throughout the

growing year by net and vacuum sweeper. Yellow sticky traps will be placed in and around the orchard; those traps will be collected and the species of xylem-feeding leafhoppers determined. Actual infectivities studies of the sharpshooters on assay plants will also be made.

ACCOMPLISHMENTS FOR THE 1990-1991 FUNDING YEAR:

1) A few reports have been recieved about almond leaf scorch observations in the central valley outside of the Tracy and Contra Costa areas where the disease is already known to be serious. In addition, farm advisor Joe Connell has sighted scattered cases in Butte county. The diseased trees are being monitored and will be tested next summer when symptoms arise.

2) Trees for inoculation have been established in the nursery. Antisera and conjugate have been demonstrated to work sucsessfully in an ELISA test on both bacterial suspensions and almond tissue. Laboratory tests indicated close to 100% correlation between symptoms in the tissues tested and and ELISA positive reaction. Samples from non-symptomatic parts of an infected tree test negative. This suggests that the bacteria are limited to the tissues in which symptoms are visible. Furthermore, it suggests that care should be taken when samples are made for ELISA survey work or other research that symptomatic tissues are included in the sample.

Orchard work has dominated the project thus far but as this work progress it is hoped that inoculation and spread studies will be initiated soon using the progress we've made with the ELISA test.

3) Two orchards in the Tracy area in which high incidence of ALS had been observed previously were selected for detailed study of disease spead, vector incidence and disease development. The trees in each orchard were mapped in detail in September when ALS symptoms were at their peak. Each individual tree was rated as one of the following: 0 = no disease symptoms; 1 = faint symptoms which may or may not be associated with ALS; 2 = early typical symptoms limited to one or two branches; 3 = strong typical symptoms involving a majority of the tree limbs; 4 = a tree which appears to by dying as a result of ALS; D = a dead tree (See appendix 1 and 2). In looking at this map, it should be remembered that the cause of death of an individual tree may or may not have been ALS. Nevertheless, it is clear from the maps that a large number of trees are involved in orchards where ALS is severe or "hot spots" as they are known. Over the next few years, we intend to monitor these trees and study both the progress of disease in individual trees and the spread of the disease in the orchards. We did have good correlation between the results of visual diagnosis of the disease and ELISA tests of samples from the trees which is encouraging since it will simplify our studies.

In addition, all weeds in the area were identified as the first step in the process of determining which alternate hosts are important sources of the ALS bacteria X. fastidiosa in the epidemiology of the disease (See appendix 5; the page numbers in this appendix refer to the page number for each weed species in the Grower's Weed Identification Handbook, UC Press.) Monitoring of the weed species in the area should provide information about both possible hosts of the vector leafhoppers and possible reservoirs of the bacteria which causes the disease.

Yellow sticky cards placed at regular intervals within an almond orchard in which a high incidence of leaf scorch was detected were exposed starting in February 1990 and changed twice monthly to determine the incidence of potential natural vector species of sharpshooter leafhoppers and spittlebugs (including those reported to transmit the leaf scorch bacterium under experimental conditions). Traps were placed within the canopy of trees at heights of 1 and 1/2 half meter at locations along the outside row and through the center of the orchard. (See appendix 3 and 4 for maps of trap sites.)

Although phloem and mesophyll feeding species of leafhoppers were frequently trapped in large numbers, captures of vector candidate, xylem-feeding species amounted to only two Draeculacephala minerva (trapped in mid summer) and no other sharpshooter species or spittle bugs prior to September. Therefore, in late September, additional traps were exposed 1) at ground level below each of the 51 trees in which two other traps were already in place at 1 and 1/2 meter and 2) within the natural growth around the perimeter of the orchard. Additionally, vacuum collections of live leafhoppers were made at two-week intervals starting in September to further determine which vector candidates were present in or near the orchard. Collections were made at two orchard sites known to be heavily affected by leaf scorch. Ten separate samples were collected on each collection date from various wild and cultivated broad leafed plants and grasses found inside and/or adjacent to each orchard and known from the literature to host one or more of the four genera of sharpshooter leafhoppers recorded as occurring in the general area. Several green spittlebugs were collected as immatures on an asteraceous weed found just outside one orchard and two adult spittlebugs were collected with the vacuum collector outside one orchard, but no additional sharpshooters were collected by vacuuming or by trapping on cards from September until November.

Thus, in this single season, relatively few insects known to be vectors of ALS were trapped. Unless this years results were unusual, it may be that this disease is efficiently transmitted by a relatively small population of vectors. Although several years data would be needed to demonstrate this hypothesis, if it should prove true the development of control procedures might be simplified.

APPENDIX 1

ALMOND LEAF SCORCH PROJECT
DISEASE RATING MAP
SEP. 1990
SITE 1

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11233
032100
00300100
0100201143
01243200000
0042330000142
110022223212111
0000040010003100
403011020000133220
10012012D2101110002
034444411003413230012
0323444040000213231110
0100122222D2111012011012
313440300400000000001033
20110400410011001301D120012
D411303332111000102012322300
000203010000000000000001200002
4000000000000000030000002100011
210111001111210000000200222122223
33200001000013401000000200133000000
330000010100300100010000000100000000
121000210132D3434300013322200010100010
2020000000000000000000010000000000000000
00030000000030000300000000010000400000010
0000002000020000000000000000000300000021002
0000000000000000010000300000000300000000000000
10000000000000000000000400003000300000D00000000
000100010000000100000002000000000000222011000222
03000401000000000000100400000000000000000000000020010
000000000000000000010000000031100000110000100010212
320012000000022020000100022000010D010110000221011010
020000000000000000003100000000001000000200000000000001
300003013010000000002000014000000300303000000000000001001
202000200000233220020022D120022000200001002022002212330
32120000000000000000001100000010000034000140300010000020
103000000004101310320000110001100332300000000000000000120
00200010000013310002000033DD22D221200110000001000020210
004000113040004010004000000110100000000300000002003200
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0103000004000040044000000000400000000000000000000000000D
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0040004030022400000000000000300100000001203030000000
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1000100000000001000000400000000000000000003400000002
D000212200020122000000000200020D00000000000000000003
0000000100003000000000000000000000000000000040030000
00000000030004410000020000000000000000000303000001
2000222000000020D2000000D0020000D0000100000000D00
000000000000000000000000040000000000000000003000000000
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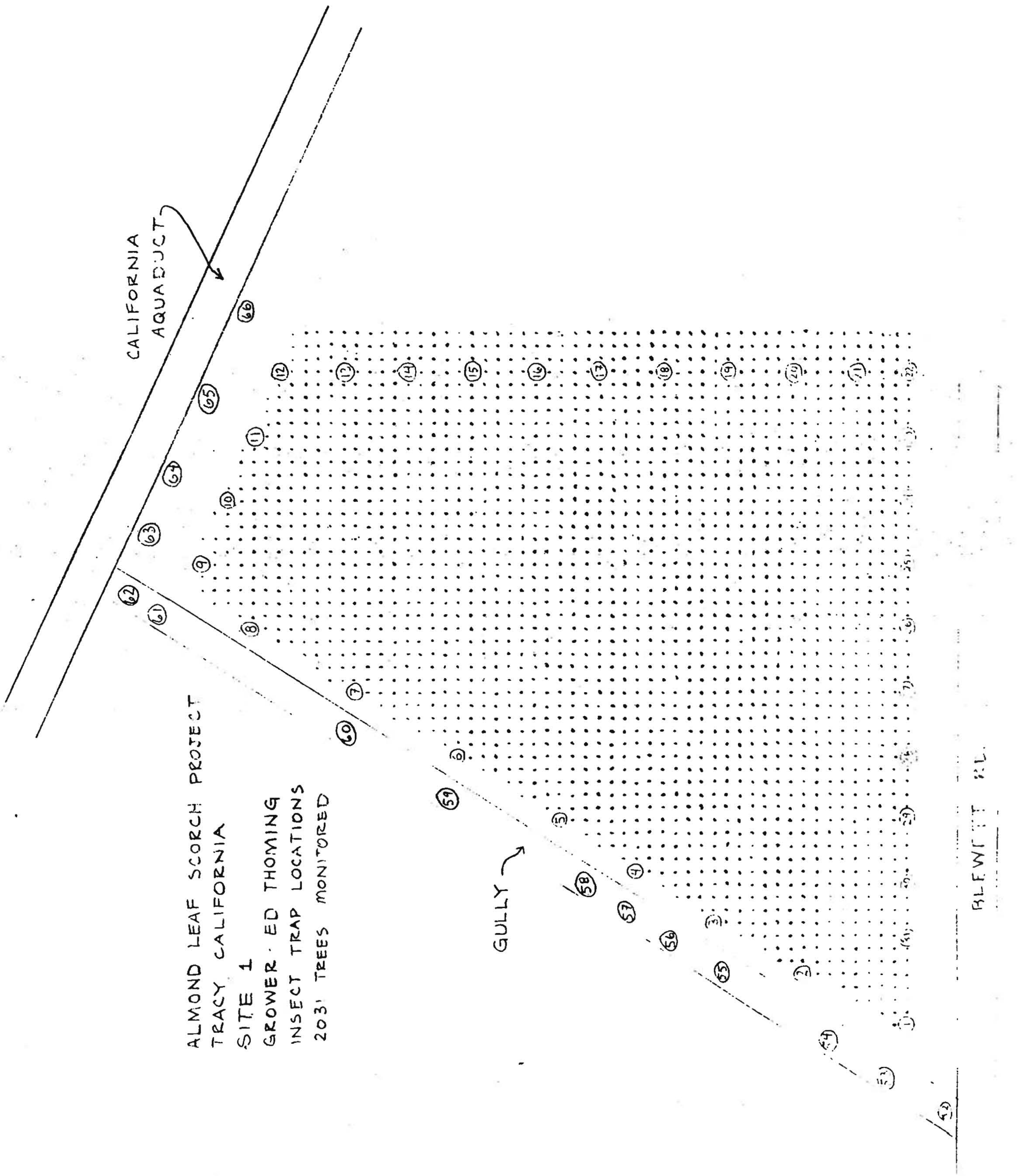
APPENDIX 2

ALMOND LEAF SCORCH PROJECT
DISEASE RATING MAP
SEP. 1990
SITE 2

0	0	0	0	0	0	1	0	0	0	0	0	0	0	0			D	0	0
1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	3	0	0	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4	0	3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	2	0	3	0	0	0	3	2	0	0
		0	0	0	3	1	0	0	0	0	0	3	0	0	4	4	3	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0
0	0	0	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
0	0	0	0	0	D	0	0	2	0	0	0	0	0	D	0	0	0	0	0
0	1	0	0	1	1	0	0	2	D	0	0	2	0	D	0	0	2	0	D
3	4	0	0	4	3	4	4	0	0	0	4	4	0	0	0	0	0	D	0
D	0	0	0	0	0	1	0	0	0	0	3	0	0	2	2	2	3	4	3

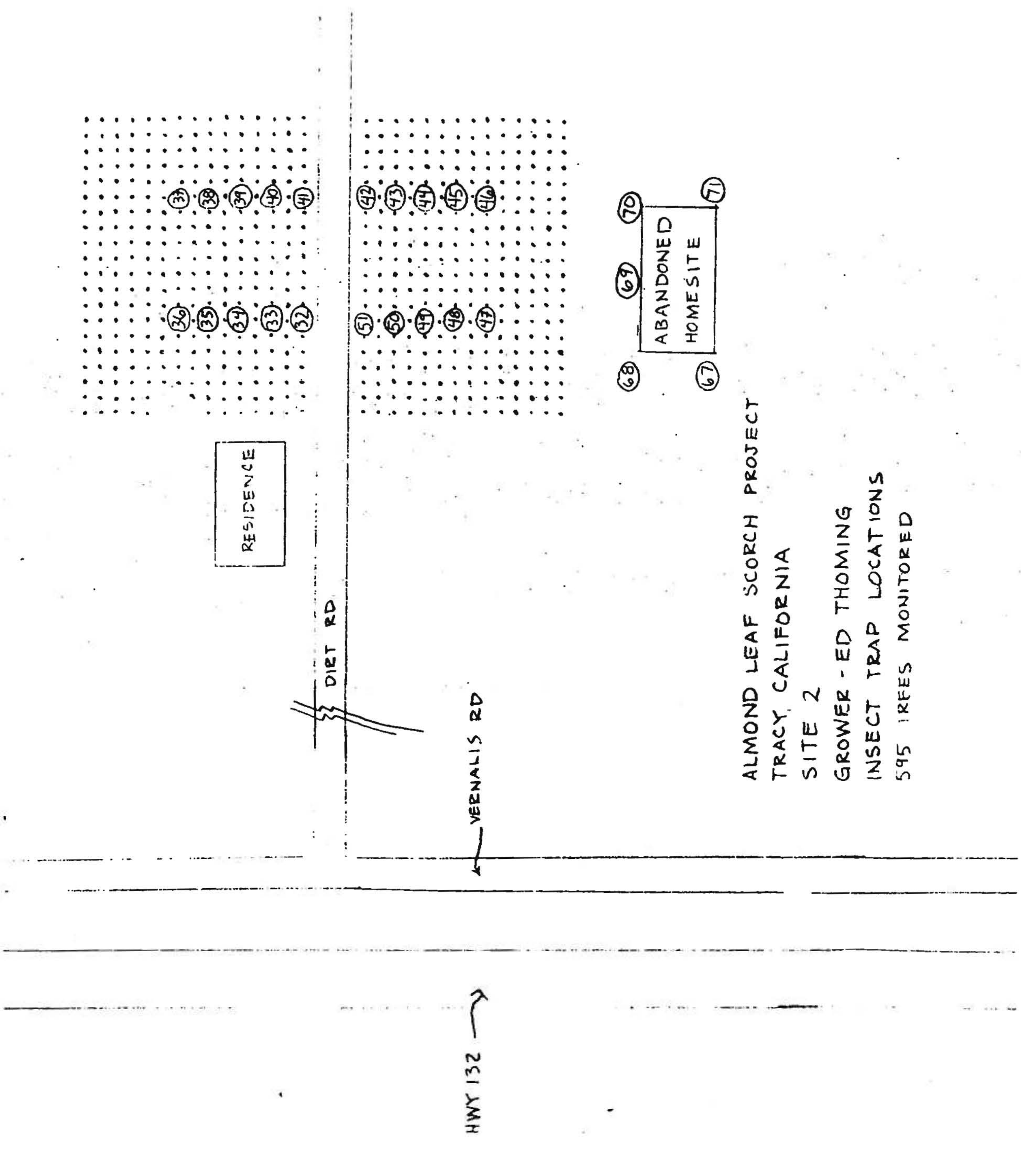
0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	2	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	0	0
0		0	0	0	0	0	0	0	0	0	0	3	1	0	4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	D	0	0	0	0	0		0	0	0	0	1	0
	0	0		0	0	0		0	0	0	0		0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3	2	3	0	0	0		0	1	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	D	0	0	0	1	0	1
0	0	0	0	3	0	0	0	0	0		0	0	0	0	0		0	0	0
			0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0

APPENDIX 3



ALMOND LEAF SCORCH PROJECT
TRACY CALIFORNIA
SITE 1
GROWER · ED THOMING
INSECT TRAP LOCATIONS
2031 TREES MONITORED
CALIFORNIA AQUADUCT
GULLY

APPENDIX 4


ALMOND LEAF SCORCH PROJECT
TRACY, CALIFORNIA
SITE 2
GROWER - ED THOMING
INSECT TRAP LOCATIONS
595 TREES MONITORED
ABANDONED HOMESITE
RESIDENCE
DIRT RD
VERNALIS RD
HWY 132
36 35 34 33 32
37 38 39 40 41
42 43 44 45 46
51 50 49 48 47
67 68 69 70 71

APPENDIX 5

Along "drainage ditch", includes area at corner of CA Aquaduct

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1. Tolguacha (Jimsonweed) Datura meteloides pg 7

2. Prickly lettuce Lactuca serriola pg 1

3. Common Sunflower Helianthus annuus pg 11

4. Alkali heliotrope Heliotropium curassavicum pg 116

5. London rocket Sisymbrium irio (dried, dead) pg 5

6. Mare's Tail Conyza canadensis pg 16

7. Cocklebur Xanthium strumarium pg 19

8. Cheeseweed Malva parviflora pg 20

9. Lambsquarter Chenopodium album pg 22

10. Curly Dock Rumex crispus pg 51

11. Turkey mullein Eremocarpus setigerus pg 55

12. Common spikeweed Hemizonia pungens (spittlebug) pg 106

13. Russian Thistle (Tumbleweed) Salsola iberica Sennen pg 21

14. Pale Smartweed Polygonum lapathifolium pg 177

15. Common Cattail Typha latifolia pg 87

16. Dallisgrass Paspalum dilatatum pg 41

17. Yerba Buena

18. Wild radish Raphanus sativus pg 78

19. Field Bindweed Convolvulus arvensis pg 74

20. Bluecurls (Camphor weed) Trichostema lanceolatum pg 117

21. Alkali Sida Sida hederacea pg 76

22. Australian Saltbrush Atriplex semibaccata pg 124

23. Gum Plant (alias tarweed or gumweed) Grindelia camporum Greene

24. Puncture vine Tribulus terrestris pg 24

25. Bermuda Grass Cynodon dactylon pg 72

26. Annual sowthistle   Sonchus oleraceus   pg 4

27. Short-pod Mustard   Brassica geniculata   pg 113

Interior of orchard

1. Common chickweed   Stellaria media   pg 50

2. Annual sowthistle   Sonchus oleraceus

3. Puncture vine   Tribulus terrestris

4. Prostrate spurge   Euphorbia maculata   pg 159

5. Bermuda Grass   Cynodon dactylon

6. Short-pod Mustard   Brassica geniculata

7. Common Dandelion   Taraxacum officinale   pg 95

8. Large Crabgrass   Digitaria sanguinalis   pg 32

9. Whitestem Filaree   Erodium moschatum   pg 110

Along California Aquaduct near willows

1. Black Nightshade   Solanum nigra   pg 142

2. Yellow starthistle   Centaurea solstitialis   pg 31

3. Bearded Sprangletop   Leptochloa fascicularis (dried) pg 39

4. Field Bindweed   Convolvulus arvensis

5. Umbrella Plant   Cyperus difformis   pg 181

6. Cheeseweed   Malva parviflora

7. Bermuda Grass   Cynodon dactylon

8. Annual sowthistle   Sonchus oleraceus

9. Wild radish   Raphanus sativus

10. Curly Dock   Rumex crispus

11. Cheeseweed   Malva parviflora

12. Cocklebur   Xanthium strumarium

13. Mare's Tail   Conyza canadensis

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December 11, 1990

Susan P. McCloud
Research Director
Almond Board of California
P.O.Box 15920
Sacramento, Ca. 95852

Dear Susan,

Enclosed please find my reseach Report for the year 1990-1991.

If you or any members of the board would like clarification of any of this material or additional information about this project, I would be pleased to provide it.

I would like to convey my thanks to the Board for their support.

Yours sincerely,

Deborah A. Golino
Research Plant Pathologist