DEPARTMENT OF AGRICULTURE AND FISHERIES, SOUTH AUSTRALIA

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A S T U D Y T O U R

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DON SWINCER
ENTOMOLOGIST - APHID CONTROL TASK FORCE

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D.E. Swincer

Since the accidental introduction of the legume aphids (*Therioaphis trifolii* fm. *maculata* the spotted alfalfa aphid, and *Acyrthosiphon kondoi* the blue green aphid) into South Australia in 1977 several questions have remained unanswered. It was in an attempt to answer these questions that the present study tour was organized.

Firstly, it was not clear exactly what the pest status of the blue green aphid was in other countries, as conflicting reports were reaching Australia as members of the farming community returned from overseas trips. As the blue green aphid had only been found in New Zealand and the United States in 1975, there was still very little scientific literature on which sound judgements could be based. Important decisions involving large sums of money were being made by the Aphid Control Task Force of the South Australian Department of Agriculture and Fisheries concerning the control of the blue green aphid, and the introduction of resistant lucerne varieties, and it was imperative that the potential pest status of the blue green aphid in South Australia was established.

Secondly, several wasp parasites were being introduced into Australia for the control of the blue green aphid with little or no apparent field establishment, although conditions at times appeared favourable. Hence, this tour was partly undertaken to study the parasite complex of the blue green aphid and determine if other parasites should be introduced.

Although these were the major aims of the tour, it was also my intention to have discussions with aphidologists who were actively involved with legume aphid control in the U.S.A. from 1953 to 1963. These

discussions were to determine the role play in spotted alfalfa aphid control during that period by insecticides, parasites, predators, fungi, and host plant resistance.

The blue green aphid was only found in the United States in 1975, however similar questions were asked for that aphid to determine the major controlling factors from 1975 to 1978.

PEST STATUS OF THE BLUE GREEN APHID (B.G.A.)

The pest status of the blue green aphid in New Zealand differs from region to region, and is considered by many research personnel only a serious problem in some areas of the North Island now. In 1975-76 it became widespread in the South Island and was controlled by insecticides, especially in the Canterbury region. Since that time the aphid has reduced in numbers and farmers appear more confident in utilizing management practices such as grazing or cutting to control the aphid.

In the southern part of the North Island from Napier southwards the blue green aphid is felt to be a serious pest of lucerne. In the vicinity of Palmerston North many stands of lucerne have been severely damaged, however limited plant death has occurred. Generally the stand develops symptoms of bad management if aphids are not controlled, and weeds grow and serious losses to hay production result. In was generally agreed by the New Zealand research workers that there were two distinct flight periods of blue green aphids each year, one in the late spring and one in the late autumn. However, it was their opinion that this situation could change with a winter active lucerne variety on which aphids develop readily. Secondly, they felt there was no significant economic return by using selective insecticides such as Pirimor, as few predators are present when blue green aphid numbers are high.

Thirdly, they felt that entomopthora species of fungi could play a major role in control of blue green aphid in cool humid conditions. Finally, they agreed that only if an infestation of blue green aphids was not treated at the correct time would losses result to further hay cuts than the present one.

In the northern part of the North Island discussions were held with entomologists at Ruakura Research Station and it was felt that although blue green aphids occurred in the area, that either spraying or grazing, or cutting could be used as equal control alternatives. However, they did not consider the blue green aphid to be a serious pest of lucerne in those areas.

The pest status of the blue green aphid in the United States is a very clouded and complex issue. This is mainly brought about by the quantity of insecticides that are used on both forage and seed lucerne in the western United States for the control of a variety of insect pests. Most forage lucerne in these areas is sprayed between 3 and 5 times for insect pests of which the major ones are the Egyptian alfalfa weevil, an aphid complex which includes both pea aphid and blue green aphid, and *Spodoptera* sp. Seed lucerne may receive as many as 11 sprays in one year, however, often combination sprays are used for a range of pests similar to those of forage lucerne. In addition the lygus bug presents a serious threat to the seed industry, and large quantities of insecticide are used to combat this pest. The main pests of both forage and seed lucerne are as follows;

Annual Key Insect Pests of Lucerne in Western U.S.A.

alfalfa weevil - *Hypera postica* (Gyllenhal) - primarily a problem in mountain counties.

Egyptian alfalfa weevil - *Hypera brunneipennis* (Boheman) - a problem in Imperial, Coachella, Central and Coastal Valley and south-western Arizona.

pea aphid - *Acyrthosiphon pisum* (Harris)

blue alfalfa aphid - *Acrythosiphon kondoi* (Shinjii)

lygus bug - *Lygus hesperus*

alfalfa caterpillar - *Colais eurytheme* Boisduval

beet army worm - *Spodoptera exigua* (Hbn.)

western yellow striped army worm - *Spodoptera praefica* (Grote)

webworms - *Loxostege* spp.

omnivorous leaf roller - *Platynota stultana*

alfalfa looper - *Autographa californica*

Depending on which group one has discussions with in the western United States often a different opinion can be obtained regarding the pest status of the blue green aphid. In fact, opinions at times can be diametrically opposed with some people feeling the blue green aphid is not a pest at all, to individuals claiming that it is an extremely serious pest of lucerne in the western United States. It appears, that the BGA is rarely a problem at Davis, whereas in Nevada earlier this year many thousands of acres were literally stunted to the ground and some plant losses although limited, did occur. In the San Joaquin Valley very little spraying appears to be done directly for the blue green aphid, however, in the Imperial Valley the blue green aphid is sprayed for most years. After discussions with people in Nevada, northern, central and southern California, and Arizona it was my opinion that in many places the pest status of BGA was never expressed because of insecticide usage especially for the Egyptian weevil in early spring. I felt that the Nevada situation was particularly pertinent to these circumstances as it was explained to me that the farmers who had a problem with blue green aphid this year, were individuals who had not sprayed for the Egyptian alfalfa weevil this spring. Even though the

pest status of the blue green aphid was a complex and clouded issue in the western United States, it was still my opinion that it fell in line with my thoughts of the blue green aphid in New Zealand.

The blue green aphid in both these countries appeared to be a serious pest to individual farmers, and at times groups of farmers however on an area or district basis often did not present a major threat. In most situations, the blue green aphid showed the response of a typical northern hemisphere aphid, in that its attack was concentrated on the apical shoots of plant species that it attacked, secondly it demonstrated remarkable clumping in the field situation, and thirdly, the severity of the aphid infestation was rarely serious enough to actually kill lucerne plants.

On individual properties in the Imperial Valley I found farmers who did not spray for insect control, and it was clear these individuals encountered blue green aphids infestations on their properties. Their frank thoughts on the blue green aphid indicated that although the aphid often severely damaged areas of their lucerne, these were limited and often did not amount to more than 10-15% of their total acreage. However, the damage done in these small patches was often as serious as that caused by the spotted alfalfa aphid.

One over-riding feature which became evident was that the blue green aphid generally is a serious pest in areas which have a mild winter for those places, however if applied to South Australian conditions this would mean much warmer winters than we normally experience.

If lucerne was grown on a large scale in Japan it was clearly evident that the blue green aphid would be a problem. In areas where lucerne was grown for seed production, insecticide sprays were necessary

to protect the crop from blue green aphid damage. The damage that did occur was typical of blue green aphid infestation in other countries demonstrating the clumping of aphids, and the damage to the apical shoot. The blue green aphid occurs in Korea but in extremely low numbers, and is not a major threat to any leguminous species in that country, even Hunter River lucerne was seen to be growing with no ill effects from the blue green aphid. The time of my visit to Korea was late summer and one would not expect to find many blue green aphids in lucerne, however, talking through an interpreter at a research farm I was informed that the lucerne was never sprayed for any pests throughout the entire year. My discussions with Professor Woon Hah Paik who is Korea's leading aphidologist, revealed that he was fully aware of the presence of the blue green aphid in Korea, however, had never found it in large numbers on any plant species in Korea, even though he had actively searched for this aphid species for many years.

The blue green aphid does not occur in Taiwan.

In South Australia I am confident that BGA will be able to over-summer as it was relatively easy to find blue green aphids in lucerne in U.S.A. which had not been sprayed with insecticides. The time of my visit to U.S.A. was mid-summer and prior to my arrival, temperatures in the San Joaquin Valley had exceeded 105^{o}F for twenty days in succession, and although not abundant, BGA could be found with a sweep net in equal numbers with pea aphids.

In addition I believe the blue green aphid will follow a similar pattern in South Australia as it has in western U.S.A., New Zealand and Argentina. On lucerne, it may be a serious threat to individual farmers or groups of farmers however I do not believe it will cause the widespread devastation that we saw in lucerne stands in the South East of the State in 1977-78, caused by the spotted alfalfa aphid. The damage

caused by the BGA in lucerne will probably be patchy and sporadic should cause serious but localised economic losses in most cases.

In the long term farmers would be well advised to plant resistant lucerne varieties to the BGA, as a severe infestation could cause economic losses equal to those caused by the spotted alfalfa aphid. However in the interim period, varieties with some tolerance to BGA, and insecticides will be the only alternative farmers have available to them. All varieties should have resistance to the spotted alfalfa aphid.

One area in which South Australia is significantly different to New Zealand and U.S.A. is our culture of the annual medicago species. No overseas experience is available regarding the effects of the blue green aphid and spotted alfalfa aphid on the annual medics. It is my belief the blue green aphid may be a far more serious threat to these species than to lucerne, and every endeavour ought to be made to quantify the damage caused to the annual medics by both of the legume aphids.

Parasite Complex for the Blue Green Aphid

With the blue green aphid following a clumped and patchy distribution as I have just described in most countries where it is found, and already beginning to show this same pattern in southern Australia, it became increasingly evident that there is an excellent opportunity for biological control of this aphid if the correct parasites and predators can be found. The parasites which have been brought into Australia to date, all originated from the one source at Riverside Campus of the University of California. These parasites were collected in Japan and have been in laboratory culture at Riverside for some time. Two things were immediately evident, the first that the cultures may have lost some field vigour whilst being laboratory reared at constant temperature and humidity for many generations. Secondly, most areas of Japan where these parasites were collected have a different range of

climatic conditions to those of Australia, and especially southern Australia.

In New Zealand I found similar parasites had been introduced and were being mass reared and distributed from DSIR at Christchurch. No field establishment had taken place at the time of my visit. My discussions with people in the United States especially California, led me to believe that these species of parasites may well be improved upon by selecting parasites from areas around the world with closer climatic conditions to those of southern Australia. Several staff members of the University of California have made recent trips to Iran and Afghanistan, and were confident that arrangements could be made to select parasites from these regions for use in biological control programmes in Australia.

Further to those discussions I made firm arrangements for South Australia to receive blue green aphid parasites from Iran. These parasites would be passed through a quarantine period with CSIRO in Sydney and starter cultures would then be passed on to South Australia in a similar fashion that other wasp parasites for the spotted alfalfa aphid and blue green aphid have proceeded in the past.

In Japan it was quite evident that several wasp parasites for the blue green aphid occurred and were widely distributed. However, my discussions with research workers in that country brought forward a great deal of unpublished information indicating that the levels of parasitism by these widely distributed wasps was often very low and if lucerne was grown, never suppressed the numbers of aphids below an economic threshold.

The same wasp parasites of the blue green aphid that are currently being investigated in Australia are also being released in California. To date no field establishment has taken place at any site

in California where wasps have been released over the past two years. In view of these findings I feel that our major efforts regarding biological control of the blue green aphid should be at multiplying and releasing the newly collected Iranian strain of *Aphidius ervi* soon to be introduced into Australia.

SPOTTED ALFALFA APHID IN THE U.S.A. 1953-78

After the spotted alfalfa aphid (S.A.A.) was discovered in south western United States in 1953 a great deal of scientific literature came from the research workers in that country. Much of this literature concerns the biological control of the spotted alfalfa aphid using native predators and introduced parasites. Although the techniques of rearing and establishment of the introduced parasites and predators are thoroughly described in the early literature, very little quantification of the exact roles played in the control of SAA by parasites, predators, fungi and host plant resistance appeared. It was my task on the present tour to establish the role played by these various controlling factors of the spotted alfalfa aphid in the western United States from 1953 to the present time.

Much of the current research work on aphid control in the United States is being done using a multi-disciplinary approach. This type of problem solving is basically a new inovation and was not used in the early days of spotted alfalfa aphid control in the western United States. Hence, groups of individuals working in confined disciplines were attacking the aphid problem from their particular point of view. As such, the literature reflects that attitude very clearly, where each group of individuals in a particular discipline either Entomology, Plant Breeding or Pathology perhaps over-emphasised the effects that the particular controlling agents in their discipliness were having on the spotted alfalfa aphid. However, in retrospect most

individuals whatever their discipline now fully appreciate the greatest single contribution made to spotted alfalfa aphid control in the western United States from 1953 to 1963 was undoubtedly the role of host plant resistance. It was quite evident after having discussions with Californian entomologists that although initially parasites and predators played a significant role in reducing the overall affects of the spotted alfalfa aphid, their role was over-shadowed by the development of resistant plant varieties.

Fungi appeared to play only a minor role in control of the spotted alfalfa aphid in those early days.

It is argued by many entomologists in western United States that the role of parasites and predators now is much greater that resistant varieties are available than before. With such varieties, the reproduction of the spotted alfalfa aphid is greatly reduced and parasites and predators are capable of "mopping up operations" with lower numbers of aphids to contend with. This may well be the case, however the constant use of insecticides in lucerne crops in the western United States continually presents a hazard to the potential role in aphid control that could be played by parasites and predators in those regions. Comparing this with the South Australian situation where limited insecticide usage occurs on broad acre lucerne production, one could envisage the role of paraistes and predators as far greater than that played by them in aphid control in the western United States from 1953 to the present time.

BLUE GREEN APHID CONTROL U.S.A. 1975-78

There is some contention amongst Californian entomologists as to the exact year that blue green aphid entered the United States. It is generally accepted that 1975 was the year that large numbers of the aphids were initially found in several areas. However, samples of

aphids at Riverside University which were taken in 1973 were rechecked and blue green aphids have now been found in these samples. Even further doubt has been thrown upon the record of the first blue green aphid outbreak by the presence of resistant plant varieties to the aphid having been selected as early as 1968, and there is some speculation that the aphid may have been present for at least some years prior to its discovery. It would seem understandable that some confusion initially took place, as there is a great deal of similarity between the blue green aphid and pea aphid which had been the most common species of aphid found in lucerne in the western United States for a decade prior to the appearance of the BGA.

From the time that the blue green aphid was identified to the present, there is no question that the greatest controlling factor has been the use of insecticides. Natural epizootics of fungi have also played a major role, however, attempts to utilize and manipulate these fungi have so far led with limited success. It would appear when conditions are humid and cool that the stage is set for massive natural outbreaks of entomopthora fungi. Very heavy infestations of blue green aphids have been recorded being heavily depleted by the effects of these outbreaks. As no introduced parasites have yet been established in the field, no significant contribution has yet been made by parasites apart from a small amount of parasitism by native wasps.

RESISTANT PLANT VARIETIES

It was quite evident when travelling through the Pacific regions and the western United States that the variety Hunter River, which is the predominant lucerne grown in Australia, is perhaps one of the most susceptible to attack by many insect species, and plant pathogens known in the world today. Bearing in mind the specialist needs of a lucerne variety under Australian conditions, I had discussions with both private

and public plant breeders through western United States. It was immediately apparent that the majority of American bred lucerne varieties would not be suitable under South Australian conditions, in addition most of the American varieties had never been grown under non irrigated conditions, and none of the varieties available had ever undergone continual grazing trials. Despite these facts, it was clear that 1 or 2 varieties were outstanding in their own right. Two varieties Pioneer 581 and WL 318, have been trialed extensively under irrigated conditions throughout the Western United States and under all climatic conditions have out-yielded and out-persisted almost every other variety. These varieties contain good bacterial wilt resistance, excellent spotted alfalfa aphid resistance, Phytophthora resistance and fair blue green aphid tolerance. There are many varieties in the United States with varying resistances to spotted alfalfa aphid, bacterial wilt and Phytophora, however in my opinion these 2 varieties had shown themselves to be by far the 2 most outstanding varieties under American conditions, in addition both these varieties had some tolerance to the blue green aphid which apart from winter active varieties, are the only semi-dormant varieties to show this tolerance to the blue green aphid. The variety WL 318, probably is more dormant than Hunter River, however Pioneer 581, would seem to have a dormancy rating very similar to Hunter River. Bearing in mind my comments on the pest status of the blue green aphid, I feel these 2 varieties could offer some hope to South Australian farmers, however both varieties are untried and untested under South Australian conditions, and a much broader evaluation programme needs to be undertaken of these 2 varieties under Australian conditions.

Two other varieties (WL 514 and CUF 101) contained much higher tolerances to the blue green aphid than the varieties just mentioned.

However WL 514, and CUF 101, are winter active varieties and generally would not be suited to South Australian conditions of dryland farming. Both of these varieties are generally accepted as hay production types with upright crowns and rapid growth, and may be suited in South Australia under conditions where Paravivo would have been grown for hay production under irrigation.

Many of the American varieties were introduced into Argentina in early 1977 when the blue green aphid accidentally was introduced to that country, and it would seem prudent to make contact with agronomists in that country to establish how well the American varieties were establishing and growing under the Argentinian system of lucerne culture. The Argentinian system of lucerne culture would seem very similar to that of South Australia, where large areas are used for dryland grazing of both sheep and cattle, and it may well be, that their experience could be invaluable to South Australia at this particular time.

There is no doubt that the introduction in limited quantities of basic seed of resistant varieties has some merit in our present predicament, however I consider that the variety Hunter River may well have some innate low frequency of resistance to the legume aphids which could be exploited. During my visit to Arizona Dr. Mervin Neilson informed me that he had produced Hunter River plants with 30% resistance to the spotted alfalfa aphid since been given seed in late 1977. His techniques of screening for host plant resistance were obviously superior to any I had encountered thus far, and Dr. Neilson had a great deal of confidence in his ability to put high levels of legume aphid resistance into the variety Hunter River. I have no doubt that using his techniques, similar work could be done in South Australia with a Hunter River type of lucerne with legume aphid resistance being achieved in about 4 to 5 years.

NEW INSECT PESTS

During my stay in the United States it was apparent that there were many insect pests of leguminous plant species in that country which were not yet in Australia. Some of these pests were relatively unimportant, and have been mentioned in the listing earlier in this report and do not warrant specific attention. There are 3 insect pests, however, which could be of extreme importance to South Australia if these were accidentally introduced. The first is the pea aphid, which although most of the American varieties contain high levels of resistance to this pest, often reaches infestation levels in the United States which warrant treatment by insecticides. It is argued by many scientists in the United States that the pea aphid has developed a biotype which is able to attack resistant plant species, and is able to withstand much higher summer temperatures. There is no documentation to date of these factors.

In New Zealand the pea aphid is considered by many researchers as serious, and in some cases more serious a threat to the lucerne industry than the blue green aphid. It is controlled in New Zealand by the use of insecticide sprays. In Australia this would mean a third aphid in the legume aphid complex which may warrant insecticide usage which can be ill afforded in the Australian system of lucerne culture.

The pea aphid is not effectively controlled by either parasites or predators in the Western United States. The main parasite used against the pea aphid, is *Aphidius smithii*, however this is found in only relatively small numbers in the field situation.

A second pest, the lygus bug, is perhaps the most serious pest of seed lucerne in the western United States. The damage losses caused by lygus bug often results in 50% losses to the seed harvest. A wide range of insecticides can be used against the lygus bug, however timing of application and insecticide resistance are both major problems. Although

the lygus bug is not a serious pest of forage lucerne, it could represent a major threat to the lucerne and perhaps medic and other small seeds industries in South Australia.

Finally the insect which I regarded as potentially the most serious pest which could enter South Australia, was the Egyptian alfalfa weevil. This insect is not regarded as particularly serious in the western United States, however several factors led me to believe the Egyptian alfalfa weevil could be a devastating insect if accidentally introduced into South Australia. In my opinion the Egyptian alfalfa weevil not only represents a threat to our lucerne industry, but could be a major threat to our entire agricultural system. Unlike the Sitona weevil, the Egyptian alfalfa weevil feeds entirely above the ground, the young larvae climb the plant and feed on the newly developing buds, whereas the adults feedon both the developing buds and on older plant material. Bearing this in mind, it is difficult to see sandy soils being an effective physical barrier to the Egyptian alfalfa weevil in its establishment of lucerne and medic pastures, as was the case with the Sitona weevil. The Egyptian alfalfa weevil is readily controlled with several applications of insecticides through the year, and for this reason it is not considered a major threat in the United States. In areas of rangeland grazing, high in the mountain country of California, the Egyptian alfalfa weevil has steadily removed all *Medicago* and *Trifolium* species of plants from that country. As this country is uneconomic under American conditions, the effects of the Egyptian alfalfa weevil are not considered serious. However, under South Australian conditions where much of our grazing country is dryland and is economic only because of the existence of *Trifolium* and *Medicago* species, the Egyptian alfalfa weevil could represent a major threat to our agricultural system. In addition, continued insecticide applications in these dryland grazing pastures in South Australia, for Egyptian alfalfa weevil control

would not be economic.

The wasp parasite *Bathyplectes curculionis* which was brought in as a parasite of the alfalfa weevil *(Hypera postica)* is not effective against the Egyptian alfalfa weevil. The Egyptian alfalfa weevil is capable of encapsulating the egg of that parasite, and as such although parasitized by the wasp no larvae develop. Secondly, the development of resistant varieties against the Egyptian alfalfa weevil has been notoriously slow, as has been the case with many other chewing insect pests of lucerne. Unlike the aphid, which has a close symbiotic relationship with the lucerne plant, the Egyptian alfalfa weevil is extremely difficult to breed resistance for. One can envisage resistant varieties being developed in the long term future, however in the meantime we are left with chemical sprays as the only viable method of control.

CONCLUSIONS

1. In New Zealand, Japan and western U.S.A. the blue green aphid has the potential to be a serious pest on a limited area basis in lucerne. It would seem doubtful that the B.G.A. could cause the wholesale devastation in lucerne that was experienced in the south east of this State in 1977-78 caused by the spotted alfalfa aphid.

   B.G.A. only occurs in low numbers in Korea, however it is not heavily parasitized. This aphid does not occur in Taiwan or Hong Kong.

   No overseas experience is available as to the effect of the legume aphids on the annual medic species, and this is one area which should be monitored carefully due to the role played by these plant species in our agricultural system.

2. The parasites currently being studied for B.G.A. control in Australia can now be improved upon following recent visits to Iran by Californian entomologists. Their opinion is that more effective

parasites could be obtained from areas with climatic similarities to southern Australia.

Arrangements have been made for parasites to be forwarded from Iran to S.A.D.A.F. through C.S.I.R.O. quarantine facilities.

3. A far greater role is played by host plant resistance in S.A.A. control in the U.S.A. than was originally suggested. Bearing this in mind, the limited introduction of basic seed of one or two resistant lucerne varieties which may be successful under our climatic conditions would seem worthwhile employing as part of our overall strategy of legume aphid control in South Australia.

4. Insect pests abound in other countries which potentially may be just as serious as the legume aphids to our lucerne industry. The Egyptian alfalfa weevil is one insect which if accidently introduced could place our entire agricultural system in southern Australia in doubt.

INSTITUTIONS AND PERSONNEL VISITED

NEW ZEALAND

Department of Scientific and Industrial Research

1. Private Bag, Christchurch

Dr. W.P. Thomas	(Warren)
Dr. M.W. Dunbier	(Mike)
Dr. P.A. Burnett	(Peter)
Dr. W.D. Pearson	(Dan)
Dr. P. Palmer	(Pat)
Dr. J.A.K. Farrell	(John)
Mr. B.H. Rohitha	

2. Private Bag, Palmerston North

Dr. M.J. Essen	(Jim)
Dr. A. Taylor	(Tony)
Mr. D. Gaynor	(David)

Ministry of Agriculture and Fisheries

1. Private Bag, Christchurch

Mr. T.E.T. Trought (Trevor)

2. Private Bag, Palmerston North

Dr. W.M. Kain (Bill)

Mr. S. Atkinson (Sam)

3. Ruakura Agricultural Research Centre, Private Bag Hamilton

Dr. R. East (Rod)

Mr. G.M. Dixon

Mr. G. Du-toit (Gideon)

U.S.A.

Dow Chemical Company U.S.A.

Dr. G. Hanson (Gordon)

Dr. W. Osborne (Wendle)

Dr. L. Larson (Larry)

University of California

1. Department of Entomology and Sciences Berkeley California 94720

Dr. A. Gutierrez (Andy)

Dr. R. van den Bosch

2. Field Station - Parlier

Dr. C.G. Summers (Charlie)

3. Field Station - El-Centro

Dr. W.F. Lehman (Bill)

4. Department of Entomology, Riverside, California 92502.

Dr. D. Gonzales (Dan)

Mr. W. White (Walt)

Dr. I. Hall (Irv)

Dr. W. Ewart (Bill)

Dr. R.C. Dickson (Bob)

5. Department of Entomology, Davis, California, 95616

Dr. O.M. Bacon (Oscar)

6. Department of Agronomy, Davis, California 95616.

Dr. V.L. Marble (Vern)

Prof. Stanford

Dr. L. Teuber (Larry)

CAL-WEST Private Alfalfa Breeders, Davis, California

Dr. D. Smith (Don)

Northrup King Co.

Dr. W. Knipe (Bill)

Pioneer Hi-bred International - Fresno, California

Dr. D.M. Reece (Dale)

Dr. M.K. Miller (Marvin)

Waterman-Loomis Bakersfield, California

Dr. I.I. Kawaguchi (Ike)

Department of Food and Agriculture, Sacremento, California

Dr. T. Kono (Tok)

Dr. P. Crane (Phil)

Mr. R. Harris (Rick)

Dr. R.L. Dunkle (Rick)

Dr. C.D. Hunter (Charles)

Dr. K.M. Brunetti (Kathy)

Mr. D.B. Boley (Don)

University of Nevada - Reno, Nevada

Dr. O.J. Hunt (Joe)

Dr. B. Hartman (Boyd)

Dr. R. Lauderville (Bob)

U.S.D.A. - Tucson, Arizona

Dr. M.V. Nielson (Merv)

U.S.D.A. - Lincoln, Nebraska

Dr. G. Manglitz (George)

University of Nebraska, Lincoln Nebraska

Dr. W.R. Kehr (Bill)

JAPAN

Prefectural University of Kyoto, Kyoto, Japan

Dr. H. Takada

National University of Kyoto, Kyoto, Japan

Prof. S. Iwao

Dr. E. Kuno

Mr. T. Inoue

National Grassland Research Institute, Nishinasuno

Dr. M. Miyazaki

Dr. S. Nato

KOREA

Dow Chemical Co. Pacific - Seoul

Dr. S.H. Hong

University of Seoul - Suwan

Prof. W.H. Paik

Dr. J.C. Paik

TAIWAN

Taiwan National University, Taipei

Dr. T.Y. Ku

Taiwan Foresty Research Institute, Taipei

Dr. C.C.C. Tao

Mrs. Y.C. Chang

Dow Chemicals Pacific, Taipei

Dr. G.C. Liu

HONG KONG

Dow Chemicals Pacific, Hong Kong Island

Mr. R.A. Dallalba

Dr. A. Clark

Mr. M. McQuilan

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