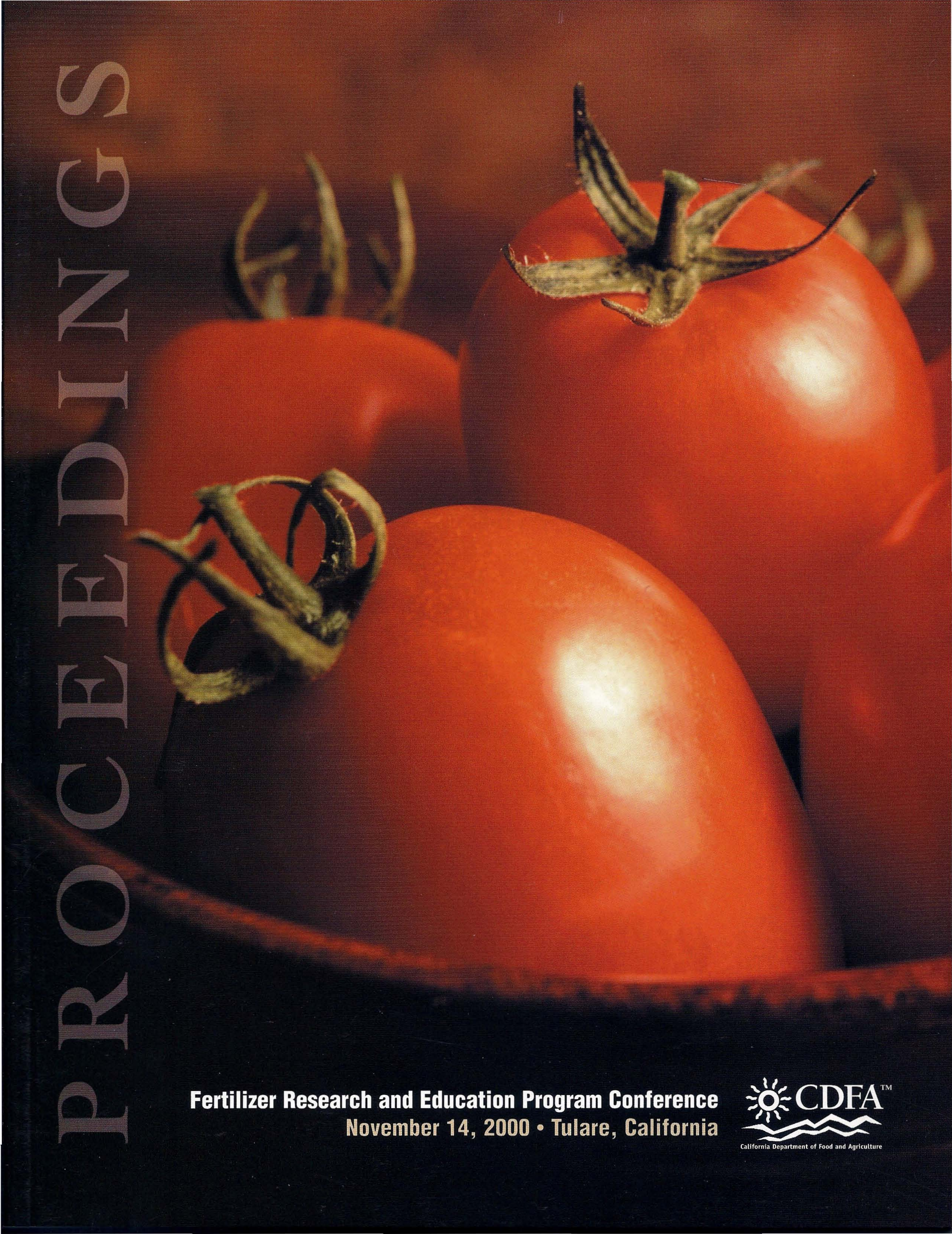

PROCEEDINGS

Fertilizer Research and Education Program Conference

November 14, 2000 • Tulare, California

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California Department of Food and Agriculture

Proceedings of the
Eighth Annual

Fertilizer Research and Education Program Conference

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Fertilizer Research and Education Program: Ten Years of Achievement

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Since 1990, the California Department of Food and Agriculture's Fertilizer Research and Education Program (FREP) has achieved great successes in funding and extending agricultural research in California. The program's mission is to advance the environmental and agronomic use and handling of fertilizer materials. A primary objective is to improve the use efficiency of commercial fertilizing materials and minimize nitrogen losses to the environment. From 1990-2000, FREP has supported close to 90 research and education projects for a total amount of $5 million in funding.

We know that in the ten tears of the program's existence, our message of the importance of safe and sound fertilizer management has reached thousands of people in California and is well-understood by growers. Implementation of some of our practices is now commonplace, but for others adoption has been slower, due to many factors such as perceived risk and a general avoidance of adapting new management strategies. Institutional barriers also exist. This is an area we will be working on improving over the next few years.

We also know that much of the research conducted would not have been funded by other organizations. In that respect, FREP is having a lasting impact on the advancement of applied agricultural research. Many FREP-sponsored projects are published in the scientific literature (see Section V of these proceedings for a list of peer-reviewed articles).

Other recent achievements include the development and distribution of a user-friendly computer-based spreadsheet for almond nitrogen recommendations. This tool developed by Patrick Brown at the University of California, Davis is designed to assist farmers, crop consultants and farm advisers determine N application levels by timing N applications with periods of greatest demands, considering all other N sources, and matching N application rates with crop load. Growers can minimize N losses from the orchard system and optimize almond fertilization. The program is available in two formats. The program (Excel file 97 or later) can be obtained by contacting us. It can also be accessed via the UC Sustainable Agriculture Research and Education Program web site (http://www.sarep.ucdavis.edu/grants/reports/brown/nmodel).

FREP's support for the Western States Agricultural Laboratory Sample Exchange Program (now called the North American Proficiency Testing Program) has assisted the program in achieving a 42% improvement in the performance of the soil laboratory industry since 1994 (R.O. Miller, 2000).

FREP is achieving excellence by supporting high quality research endeavors that have gone through a rigorous statewide competitive process including independent peer review. Projects focus on many of California's important cropping and environmentally sensitive cropping systems including almonds, tomatoes, cotton, citrus, winegrapes, horticulture, lettuce and other cool-season vegetables. New technologies such as bringing precision agriculture to California agriculture are also receiving support.

FREP's current funding priorities consist of:

- Irrigation interactions—water management as related to fertilizer use efficiency and the reduction of groundwater contamination and fertigation methodologies.
- Fertilization practices—nutrient balance, crop nutrient uptake, and partitioning; including amounts, timing, and partitioning of nutrients taken from the soil, foliar nutrient management, slow release fertilizers, green manures, and the use of agricultural composts.
- Precision agriculture (site-specific management) technologies and applications.
- Non-nutritive metals in commercial inorganic fertilizers and their relationship to agricultural crops and soils
- Development, testing, and demonstration of the use and benefits of practical field monitoring tools.
- Improving the understanding of the relationships between nutrients and pests and diseases.
- Air quality and PM 10/PM 2.5 concerns as they relate to fertilizer applications.
- Education and public information.

Regulatory Environment

We recognize that the public is very concerned about the quality of the states' waterbodies. Our goal has been to work with the research community to devise strategies for improving farming that account for growers' farming and economic conditions and ensure the results are disseminated to the agricultural community.

Many areas of the state are currently impacted by recent mandates of the US Environmental Protection Agency Clean Water Act. The California State Water Quality Control Board has developed a list (known as the 303(d) list) of the waterbodies that are impaired by high levels of contaminants including nutrients, pesticides, sediments, other toxic elements, exotic species and even trash.

In order to address the impairments, the Regional Water Quality Control Boards (RWQCB) are establishing Total Maximum Daily Load (TMDLs) for discharges into waterbodies and watersheds that include seasonal load allocations that agricultural operators are required to meet with a certain timeframe. These efforts will undoubtedly influence nutrient management practices and in some cases may require the development of nutrient management plans. As the situations develop and mature, FREP will assist in providing solutions for growers who are impacted by the regulations.

INTEGRATED NUTRIENT MANAGEMENT

While the majority of our projects have been focused on commercial fertilizers, we believe that improving the understanding of the complex dynamics resulting from manures and biosolids as well as composts and other fertility sources is worthy. To this end, we are please to announce that this year, FREP is working with the Sacramento Regional County Sanitation District and the University of California to develop increased understanding of nitrogen mineralization rates for biosolids under California conditions. A summary of this project can be found in these proceedings. We hope to pursue additional projects in the coming years.

EDUCATION AND OUTREACH

One of FREP's primary goals is to ensure that research results generated from the program are distributed to and used by growers and the fertilizer industry. FREP serves a broad audience including growers, agricultural supply and service professionals, extension personnel, public agencies, consultants, Certified Crop Advisers, Pest Control Advisers and other interested parties. FREP has also funded a number of projects designed to increase the agricultural literacy of students in the K-12 setting.

Results from FREP projects can be found in these and previous year's proceedings, and on the FREP web site (http://www.cdfa.ca.gov/inspection/frep). A complete list of completed projects can be found in Section IV of these proceedings.

Our annual conference is also one of the primary outreach. The conference typically reaches an audience of 200 – 250. Proceedings from the conference are disseminated throughout the year to interested parties. Articles about the various projects that FREP is supporting are commonly found in the popular agricultural media as well as scientific journals.

In today's world of limited budgets, we know we must work with others to achieve our objectives. To that end, FREP staff collaborates and coordinate with many other organizations with similar goals. Our partners include:

- California Chapter of the American Society of Agronomy
- California Certified Crop Adviser Program
- Sacramento Regional Wastewater Treatment Facility
- California Integrated Waste Management Board
- Monterey County Water Resources Agency
- University of California, Sustainable Agriculture Research and Education Program
- University of California, Small Farm Center
- State Water Resources Control Board, Interagency Coordinating Committee

ACKNOWLEDGMENTS

We would like to acknowledge the support of the fertilizer industry in providing funds for the program. Their foresight in creating FREP and their long-term commitment and dedication has been instrumental in achieving our successes.

We would also like to recognize the members of the Fertilizer Inspection Advisory Board Technical Advisory Subcommittee who review and recommend projects for funding. Al Ludwick, Steve Purcell, Brock Taylor, Jack Williams, Tom Beardsley, Jack Wackerman, David McEuen, John Weatherford, Tom Gerecke and Al Vargas have exhibited dedication and professionalism and have been invaluable in helping to ensure FREP's success. The members of the Fertilizer Inspection Advisory Board are also hereby acknowledged.

We greatly value the input and support received from the California Fertilizer Association. Others deserving mention include the project leaders and cooperators, as well as the dozens of professionals who review project proposals and help enhance the quality of FREP's work.

Special recognition also goes to the leadership at the California Department of Food and Agriculture including John Donahue, Director of the Division of Inspection Services, Steve Mauch, Assistant Director of the Division of Inspection Services, and Steve Wong, Branch Chief of the Agricultural Commodities and Regulatory Services Branch. Additional support form Athar Tariq, Joanna Danquah and the Branch's clerical staff is also acknowledged.

Relationship Between Fertilization And Pistachio Diseases

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INTRODUCTION

High levels of N are routinely applied to pistachio trees from a very young age in commercial pistachio orchards in California. Increasing frequency of *Botryosphaeria* panicle and shoot blight and *Alternaria* late blight of pistachio in recent years has led to speculation regarding the possible role of fertilization on disease incidence and severity. The present study is investigating the effect of various nutrient elements and their levels on the susceptibility of pistachio to *Botryosphaeria* panicle and shoot blight, caused by *Botryosphaeria dothidea*, in a greenhouse study.

OBJECTIVES

1. Determine the effects of fertilization on pistachio diseases such as *Botryosphaeria* and *Alternaria* blights in a greenhouse.
2. Determine the effects of fertilization on pistachio disease resistance/susceptibility compounds.

DESCRIPTION

Three levels (75%, 100%, and 200%) of nitrogen (N), phosphorous (P), and potassium (K) elements were established by fertilizing potted trees with modified Hoagland solution (1 liter per plant per week). The 100% solution contained 0.21 g N, 0.032 g P, and 0.234 g K and microelements per liter solution. After fertilization for 2 weeks, all trees were sprayed with 20,000 of mycelial fragments per mL suspension of *B. dothidea*. Infected leaves were recorded 15 days after inoculation and classified into five severity categories (from 0 to 4). The effects of fertilization on *Botryosphaeria* blight were assessed by using leaf disease index data.

In a second experiment, the stems of all trees were wound-inoculated with mycelial plugs, and wrapped with parafilm to protect the mycelial plug from drying. The length of lesion per stem was measured 30 days after tree inoculation. All experiments in this study were repeated once, and data were analyzed using ANOVA of SAS.

RESULTS AND CONCLUSIONS

The first year's results showed that there were no significant differences among the percentages of infected leaves among the various treatments. However, only the 200 % K rate treatment significantly reduced severity of *Botryosphaeria* blight on pistachio leaves as compared with the normal (100% N, P, K) fertilization (see Table). Results of the stem inoculation experiment were variable. A partial reason of this variability might be differences in the diameter of stems.

Effects of nutrition stress on Botryosphaeria blight in greenhouse experiments (1999/2000)

Treatment	*Total leaves*	*Infected leaves %*	*Leaf disease index*
N 75%	763	64.4 a	0.90 ab
P 75%	568	60.4 a	0.95 a
K 75%	710	62.7 a	0.83 ab
N, P, K 100%	952	58.8 a	0.87 ab
N 200%	881	60.1 a	0.80 abc
P 200%	719	57.3 a	0.71 bc
K. 200%	747	54.3 a	0.58 c

Values with different letters are significantly different at P = 0.05 level according to LSD test.

Generally, lesions were longer in thin stem than in wide stem trees. There was no clear effect of the various nutrients on length of canker.

A similar experiment was just initiated in this season, but results are not yet available since both diseases under study usually develop symptoms in late August and during September. Emphasis in the first year of the study will be given on *Botryosphaeria* panicle and shoot blight disease and in the second year on the *Alternaria* late blight disease. Leaf samples will be taken for specific analyses to determine disease resistance/susceptibility compounds. We anticipate a greater effect of fertilization to the disease after establishing more distinct fertilization levels in future tests.

High levels of K (twice as much as a grower would apply) reduced the severity of *Botryosphaeria* panicle and shoot blight of pistachio, but N or P applied at various levels did not affect severity of the disease.

The Effect Of Nutrient Deficiencies On Stone Fruit Production And Quality

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INTRODUCTION

Many nutrients are regularly applied to stone fruit trees with the belief that fruit quality and tree health will be improved. Other than nitrogen and zinc, other nutrients do not have much scientific justification for their use under typical orchard conditions.

The project will establish large sand-filled tanks in the field where nutrient deficiencies on mature peach, plum and nectarine trees will be imposed. Preliminary experiments in 10-gallon buckets have shown that deficiencies can be quickly induced, so it is possible to manipulate nutrients to approximate desired levels. The goal of this project is to develop nutrient deficiency symptoms so as better define critical levels for each nutrient.

Critical levels will be defined not only in terms of growth and productivity but, more importantly, in terms of fruit quality such as size, color firmness, sugar content and disease susceptibility. Extra tanks will also be installed so nutrient interactions by inducing multiple deficiencies and different nutrient ratios can also be investigated. This information will be useful in helping diagnose problems, deciding whether applications of certain nutrients are justified and providing scientific input into evaluation methods such as DRIS.

The study will also be utilized to produce high quality pictures of deficiency symptoms on leaves and fruit. These will be incorporated into a sturdy, laminated field guide. The pictures will also be useful for updating publications such as the University of California stone fruit production manual and providing slides for numerous extension talks and presentations.

OBJECTIVES

1. To induce nutrient deficiencies in full size peach, plum and nectarine trees growing in sand culture in the field and to study the effect of these deficiencies on tree growth, flowering, fruit quality, pest susceptibility and yield.
2. To produce high quality slides and color photo of deficiency symptoms and use these for various educational programs including a laminated field handbook, our stone fruit manual and many extension meetings.

DESCRIPTION

The aim of this study has been to develop a sand culture system for peaches, plums and nectarines where nutrient deficiencies can be imposed on mature trees. This system will allow us to study many aspects of nutrient deficiencies including their impact on tree growth, flowering, fruit quality, pest susceptibility and yield. It could also be useful for evaluating nutrient interactions, symptom development, diagnostic tools and corrective measures.

The specific goal for 2000 was to install sand tanks in the field and get trees well established by the end of the season. We wanted to grow the trees vigorously the first year so they would bear fruit the second year and be large enough to continue carrying a crop once we started restricting their growth by withholding nutrients. We have been very successful so far in accomplishing this goal.

Sixty large tanks measuring 11'x 8' and 4' deep were placed in 4 trenches in the field, 15 per trench. Sand was placed under each tank to provide a slight slope towards one end. At the lower end holes were drilled and a manifold system was installed to collect drainage water into a 55-gallon drum buried beside each tank. A 2-inch pipe extends to the surface from each drum so drainage water can be pumped out. Once the tanks were in place they were filled with sand and the trench around the tanks was backfilled with native soil.

In mid-February one tree each of Zee Lady peach, Fortune plum and Grand Pearl nectarine was planted in each tank. Trees were trained to a perpendicular V system with two 8' bamboo poles per tree used to insure uniform tree shape. An irrigation system was installed with a single fan-jet emitter per tree and was set to run automatically each day. The trees started growing well but soon developed some leaf chlorosis. Small amounts of a balanced fertilizer were applied through the irrigation system to keep the trees growing and green. A foliar zinc spray was also applied when zinc deficiency symptoms appeared on the young trees. By early May the trees were growing well and looking very healthy so uniform fertilization was cut off for the rest of the season.

In late June the first differential fertilization was applied to begin the various treatments, which include all nutrients, no nutrients, no nitrogen, no phosphorus, no potassium, no calcium, no sulfur, no magnesium and no micronutrients. The trees continued to grow well for the rest of the season and showed no signs of nutrient deficiencies by September. Deficiencies will begin to show up in 2001 as these differential fertilization treatments are continued. Leaf samples were collected from all 180 trees in July and September and will be analyzed for macro and micronutrients.

Nitrogen Management In Citrus Under Low Volume Irrigation

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INTRODUCTION

Citrus is one of the largest crops grown in California totaling 250,000 acres in 1992 (the last year estimates were made). Navel oranges make up 44% of total California citrus with 86% of the navel oranges grown in the San Joaquin valley of central California. Nitrogen is applied to citrus either as a broadcast treatment over the soil, injected into irrigation water or sprayed onto foliage. Average application of 100-200 lb of N /acre makes citrus one of the largest recipients of N in the state.

Fruit quality problems in recent years have adversely affected the movement of California citrus into the fresh market and severely hurt grower returns. Postharvest rind breakdown and pitting of navels have been particularly critical. These disorders usually do not appear until after fruit have been graded, packed and shipped to export markets where they then result in losses due to repacking charges, price allowances and loss of consumer confidence.

Nitrogen fertilization has been identified as playing a role in several citrus fruit quality issues. With the adoption of pressurized irrigation practices and the inclusion of N fertilizers in irrigation water it appears, from leaf N levels, that there has been an increase in the total amount of N applied to citrus over the past 10 to 15 years.

Groundwater contamination with nitrates has been linked to rates of N application in the past. With the advent of fertigation the potential for groundwater contamination may be increasing. It is in the best interest of growers to address this issue proactively and adopt practices that can lead to reduced groundwater contamination. To this end growers must be made aware of best management practices relative to N management.

OBJECTIVES

1. Determine the effect of N applications on navel orange fruit quality and leaching losses of N.
2. Compare the effects of foliar versus soil applied N on fruit quality and leaching losses of N.
3. Evaluate the impact of N application timing on fruit quality and leaching losses of N.
4. Determine the effectiveness of various N application levels and methods on maintaining optimal N levels in navel orange trees.

RESULTS AND CONCLUSIONS

There are two components to this project. The first component is the field site that we established in the Woodlake area of Tulare County. The 15.3-acre experimental site is a mature navel orange grove (Frost Nucellar) on Troyer Citrange rootstock. The tree spacing is 22 x 20 feet. Twenty-five experimental treatments were selected for the project (See Table). Each experimental plot consists of 12 trees with the central 2 trees serving as the data trees. The cooperator's irrigation system was modified to accommodate the differential N treatments during Spring/Summer 1996. During 1999-2000, the project has continued as previously described. Tree measurements were taken in Fall 1999. On-tree fruit color measurements were also taken on a regular basis during Fall 1999 as the "orange" color developed on the fruit. Yield data were collected in April 2000.

Figures 1 and 2 report the yield (fruit numbers per tree) and the size distribution of the various treatments. In this case, the control trees yielded the lowest number of fruit. There was substantial variability in the yield data, however there was a slight trend towards larger numbers of fruit in the higher N treatments as previously reported by other researchers. There were no clear trends in the fruit size distribution data as reported here but we feel further analysis of this data is warranted.

The leaf N content of all treatments from 1996 through 1999 is presented in Figures 3 and 4. It is obvious from these figures that it has taken 4 years to clearly establish a differential N response with respect to leaf N content. In 1996, there were no trends, as one would expect since this was the initial set-up year. In 1997 and 1998 there was a trend to differential N leaf content, however there was still considerable scatter in the data. The leaf analysis of 1999 clearly shows a linear relationship between the amount of N applied and the leaf N content in the Fall period. There does not appear to be any substantial difference in the leaf N content that can be related to the method or timing of application.

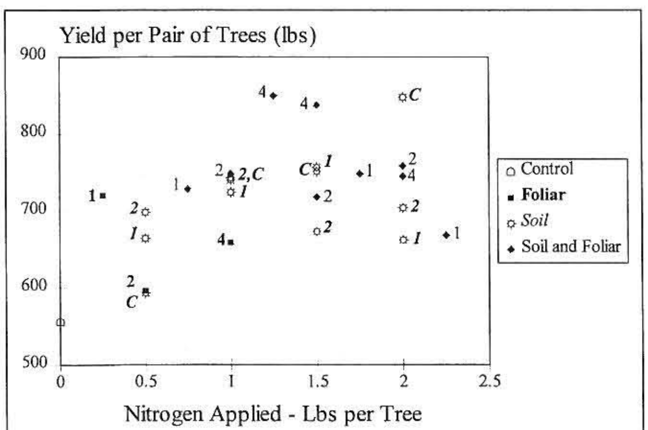
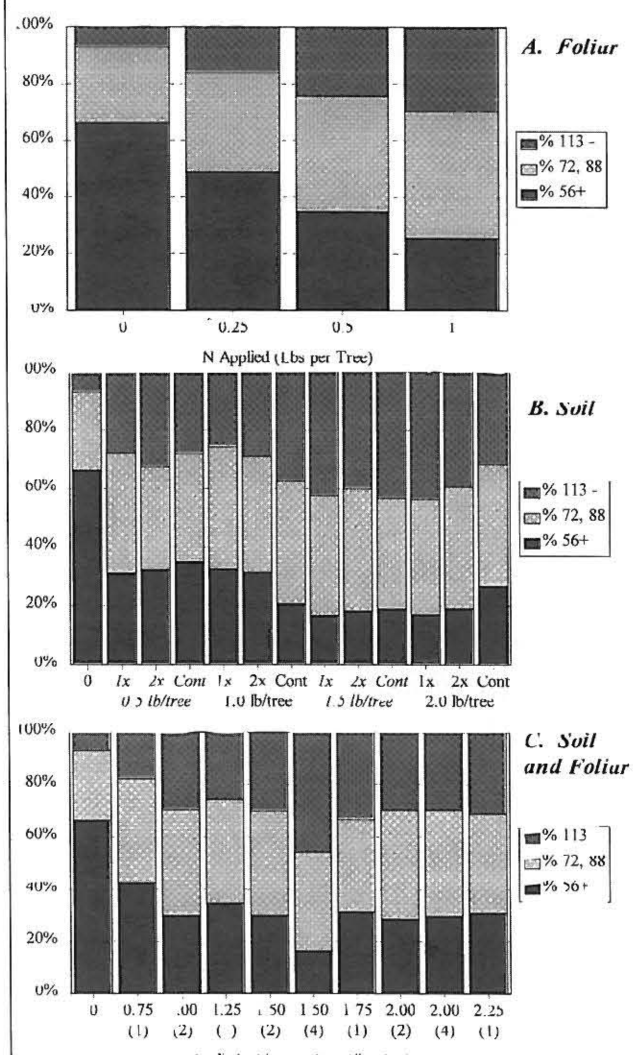


Figure 1. Average yield (lbs of fruit per pair of trees) from Woodlake, CA Research Plot. Fruit harvested in April 2000.

In March 2000, we rated the north quadrant of each data tree for the incidence of puff and crease using the protocol established by C. W. Coggins, Jr. Fifty fruit per north side of the tree was evaluated. No relationship was observed between the amount of N applied and the incidence of puff and crease (Figure 5). Additionally, the method of N application did not appear to make a difference in the incidence.

Figure 2. Per cent of fruit in small (size 113 or less), medium (size 72, 88) and large (size 56 or greater) categories. Fruit harvested in April 2000 from Woodlake Research Plot.



Schedule of experimental treatments for nitrogen management project near Woodlake, CA.

Treatment	*Soil Applied (lb/tree/yr)*	*Timing (times/yr)*	*Foliar (No. applications)*	*Total N (lb/tree/yr)*
1	0	-	-	0.00
2	0	-	1	0.25
3	0	-	2	0.50
4	0	-	4	1.00
5	0.5	1	-	0.50
6	0.5	2	-	0.50
7	0.5	C	-	0.50
8	1.0	1	-	1.00
9	1.0	2	-	1.00
10	1.0	C	-	1.00
11	1.5	1	-	1.50
12	1.5	2	-	1.50
13	1.5	C	-	1.50
14	2.0	1	-	2.00
15	2.0	2	-	2.00
16	2.0	C	-	2.00
17	0.5	C	1	0.75
18	0.5	C	2	1.00
19	0.5	C	4	1.50
20	1.0	C	1	1.25
21	1.0	C	2	1.50
22	1.0	C	4	2.00
23	1.5	C	1	1.75
24	1.5	C	2	2.00
25	2.0	C	1	2.25

Foliar Only

No. Applications z	*lb N/tree/yr*
0	0
1	0.25
2	0.50
4	1.00

Soil Only

lb N/tree/year	*Timing* y
0.5	1, 2, C
1.0	1, 2, C
1.5	1, 2, C
2.0	1, 2, C

Combination Treatments

Soil Application (lb N/tree/yr) x	*Foliar Applications (No. applications)* z	*Total lb N/tree/yr*
0.5	1, 2, 4	0.75 - 1.50
1.0	1, 2, 4	1.25 - 2.00
1.5	1, 2	1.75 - 2.00
2.0	1	2.25

z Foliar Application: Low Biuret Urea was applied to foliage at a rate of 0.25 lb/tree per application. Trees receiving one application will have urea applied in late May. Trees receiving two applications will have an additional application in late winter. Trees receiving four applications will have additional applications at the pre-bloom stage and 30 days following the late May application.

y Soil Application: All applications will be made through the irrigation system: 1 = single application per year in late winter; 2 = split application, late winter and early summer; C = Applied with every irrigation from late winter through summer.

x Soil Nitrogen will be applied as in the "C" treatment described above for the soil applications.

Nitrate–N concentration in the soil solution extracts as related to the amount of N applied as a soil application since December 1997 is presented in Figure 6. It was observed that there was a general trend towards higher soil NO_3–N levels with increasing the amount of N applied to the soil. Likewise, Figure 7 presents the NO_3–N concentrations of the soil extracts below the root zone for all treatments from December 1997 through May 2000. This data also show that as the amount of applied N increases the amount of NO_3–N in the soil also increases. The NO_3–N levels in the soil only treatments were highest at all N rates whereas the combination foliar — soil applications are lower than the soil only application. There appears to be little difference in the soil NO_3–N concentrations that can be related to the timing of the soil N application.

The second component of the project was established with the aid of the Sunkist Research Foundation. This component

Figure 3. Nitrogen contents of leaves collected at Woodlake Research Plot in fall of 1996 and 1997. Numbers in symbols represent number of foliar applications (1, 2, or 4) or soil applications (1, 2, or continuous).

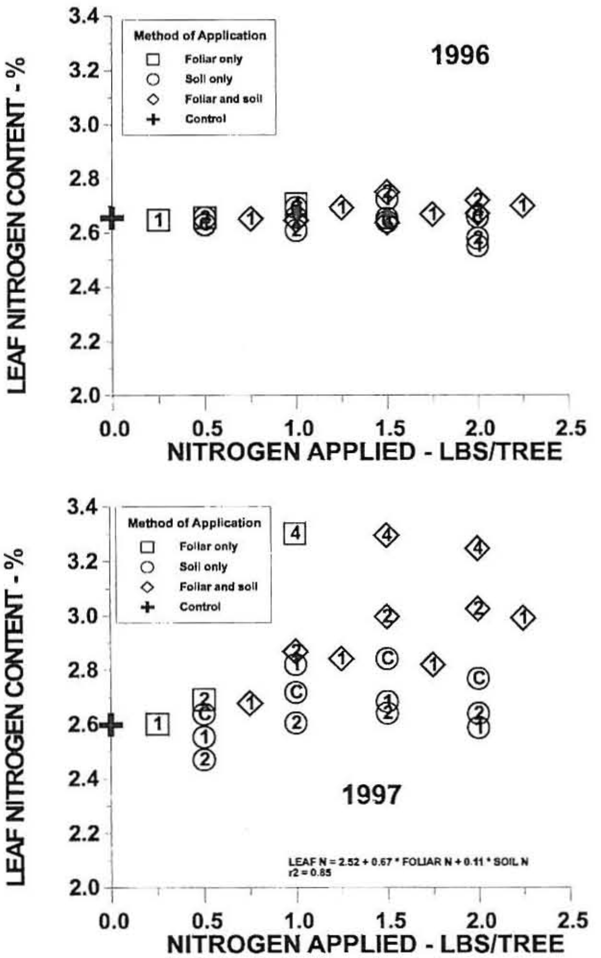
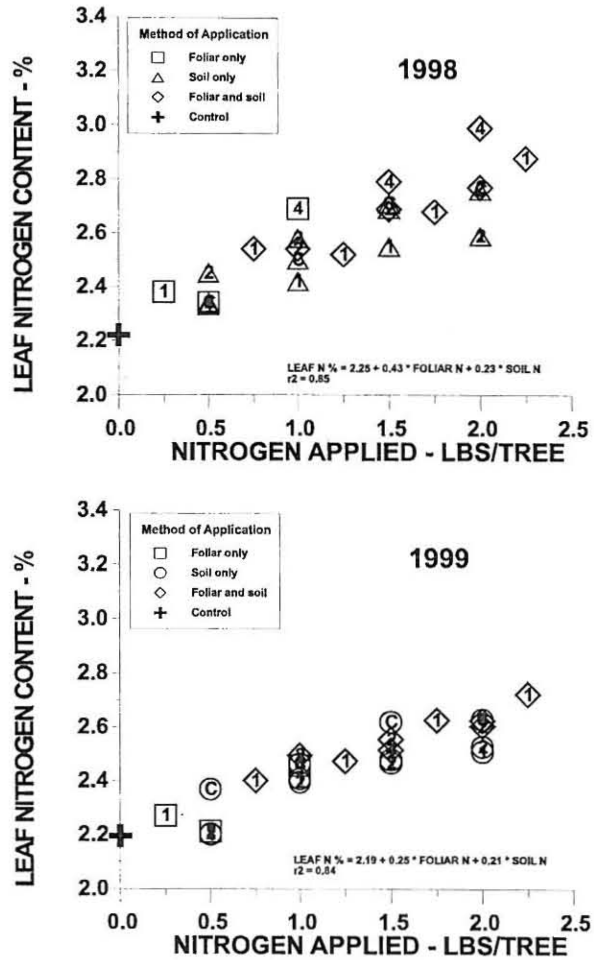


Figure 4. Nitrogen contents of leaves collected at Woodlake Research Plot in fall of 1998 and 1999. Numbers in symbols represent number of foliar applications (1, 2, or 4) or soil applications (1, 2, or continuous).



has two grower cooperators located in Orange Cove and Exeter-Woodlake. These three sites are navel orange. We have taken 6 of the treatments listed in Table 1 (treatments 8, 11, 13, 14, 23, 24) and are applying these on a per-row basis. All grove modification of the existing irrigation systems was donated by Fruit Growers Supply and the Sunkist Research Foundation. The sites have been maintained as described in previous reports. We obtained yield, packout data and storage data (from UC-KAC) in Spring 2000. There are no clear trends apparent in the data, although the data analysis is yet to be completed.

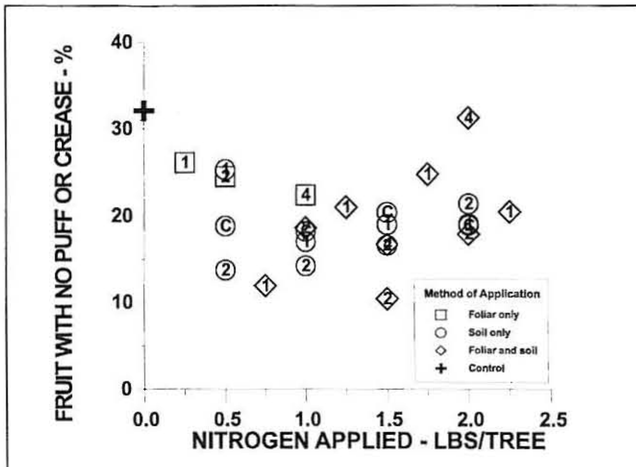


Figure 5. Fruit showing puff or crease expressed as percentage of fruit evaluated (approximately 50 fruit per tree on north half of tree) from Woodlake Research Plot. Numbers in symbols represent number of foliar applications (1, 2, or 4) or soil N applications (1, 2, or continuous).

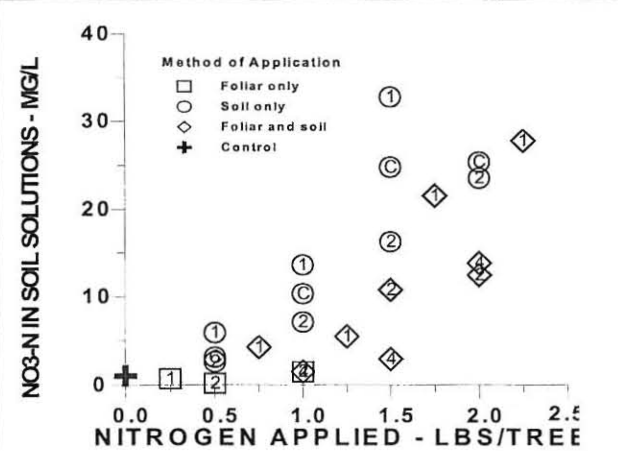
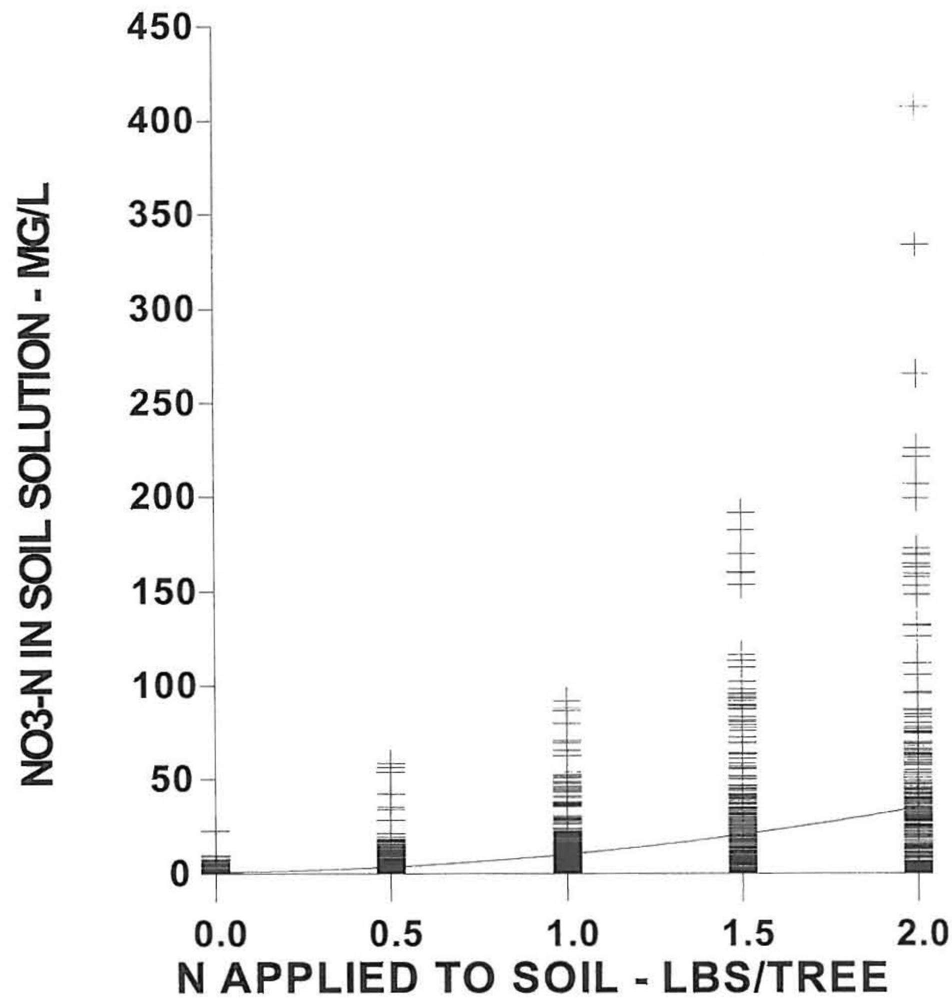


Figure 7. Average nitrate-nitrogen concentrations extracted below root zones as related to total nitrogen applied from Woodlake Research Plot. Data represent samples collected during period 12/97 through 5/00.

Figure 6. Nitrate-nitrogen concentrations in soil solutions collected from Woodlake Research Plot site during 12/97 through 5/00.



Development Of Nitrogen Best Management Practices For The 'Hass' Avocado

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OBJECTIVES

1. Quantify the nitrate pollution potential of the various N fertilization strategies.
2. Identify the threshold rate of N fertilization above which the pollution potential increases.
3. Evaluate the potential for replacing the April double dose or triple dose of soil N with foliar N.
4. Provide a ratio of enhanced-yield benefit to environmental cost for each N fertilization strategy.
5. Identify BMP's for N fertilization for the 'Hass' avocado in California.

DESCRIPTION

To reduce potential nitrate pollution of groundwater, avocado growers apply N fertilizer to the soil in several small doses annually. This strategy ignores tree phenology and the possibility that the tree requires more N at certain times of year. In a prior 4-year study, we determined the impact of supplying a double dose of soil N to 'Hass' avocado trees at one of several key times in the phenology of the tree in comparison to supplying a single dose of N six times per year. The results of this study demonstrated that N application time was more important than the total annual amount of N applied to sustain over multiple years higher yields, to obtain a greater proportion of commercially valuable, and to reduce the degree of alternate bearing of the 'Hass' avocado. November proved to be the best time to apply N to the soil based on both increased yield and fruit size averaged across the four years of the study and increased cumulative yield for both total lb and lb large size fruit per tree. April also proved a good time to apply N based on increased cumulative yield, i.e., both total lb and lb large size fruit per tree, and decreased alternate-bearing index compared to control trees. Applying the double dose of N in January, February, or June had no effect on yield, fruit size, or alternate bearing. The yield increases were economically significant.

In 1997, we initiated a 6-year study funded by the California Avocado Commission (CAC) to replicate our earlier study and to quantify the effects of additional strategies with the overall goal to even out alternate bearing and to increase annual and cumulative yield and fruit size. The danger is that using double or triple doses of soil-applied N to increase yield might increase the potential for nitrate groundwater pollution. We hypothesized that supplying an avocado tree with more N at times when demand is greater should not increase leached nitrate. Since yield is increased, the interpretation is that the tree utilized the extra N. Our CDFA/FREP project is coordinated with and complemented by our CAC project. We are quantifying the amount of nitrate and ammonia leaching past the root zone of 'Hass' avocado trees treated with various N fertilization strategies. The results of this research will identify Best Management Practices (BMPs) for N for the 'Hass' avocado in California. The avocado growers of California are proactive and are seeking this information.

RESULTS AND CONCLUSIONS

Yield for two harvests, 1997-98 and 1998-99, and cumulative yield is provided in this report (see Table). The yield data for the first year confirmed that time of N application is more important than the amount of N applied. This was not the case for the second harvest. The 1998-99 crop was not a normal crop. Fruit load was dramatically reduced due to the unprecedented devastation caused by the Persea mite and avocado thrips and due to the freeze in the winter of 1998/99. As a result there was very little variation in yield among treatments. The 1999-00 crop, which we will harvest this September, will also be lower than normal due to the freeze. The 2000-2001 crop will be a normal to high yield.

Funding for our CDFA/FREP project started in April 1999. Due to the abnormally low yield in 1999-00, we delayed

Effect of nine nitrogen fertilization strategies on yield of the 'Hass' avocado during an "on" year in 1998 and an "off" year in 1999.

Treatment	Total lb N/acre	Year 1998 lb fruit/tree	Year 1999 lb fruit/tree	2-year cumulative yield lb fruit/tree
2x N in August (all years)	40.0	73.6 az	37.8z	113
Grower fertilization practicey	42.5	70.7 a	40.1	110
2x N in November (prior to "on" years) and April ("off" years)	40.0	68.1 a	40.5	106
2x N in November (all years)	40.0	62.3 ab	44.6	107
Controlx	80.0	58.8 ab	49.4	108
2x N in April and November (no N in February and June) (all years)	80.0	58.8 ab	32.8	96
2x N in April ("off" years) and 3x N ("on" years)	60.0	58.6 ab	48.5	107
2x N in April (all years)	40.0	56.8 ab	42.1	99
2x N in April ("off years) and 3x N ("on" years) applied foliarly	100.0	42.3 b	44.6	87
P-value		0.06	NS	NS

zValues in a vertical column followed by different letters are significantly different at the specified P level by Duncan's Multiple Range Test

yGrower's fertilization practice is 40 lb N as ammonium nitrate/acre split into two applications made in July and August.

xControl trees received 80 lb N as ammonium nitrate/acre, divided into four, 20 lb/acre applications made in mid-April, mid-July, mid-August, and mid-November.

starting the research by approximately six months to start with the 2000-01 crop. With the delay, the CAC and CDFA projects are now synchronized with regard to crop year, which will improve the results and the overall utility of the research. We spent the six-month delay improving the methods for recovering the resin bags and for standardizing the extraction and recovery of nitrate and ammonia from the resins. We are confident that this extra research will improve the quality of the data that we are now collecting. At the time of submission, the lab had not completed the analysis of samples from the field.

Effect Of Cover Crop Or Compost On Potassium Deficiency And Uptake, And On Yield And Quality In French Prunes

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OBJECTIVES

1. Design and lay out an experiment to test the hypothesis that certain management practices within a prune orchard can affect potassium deficiency
2. Determine the effects of the four treatments (cover crop, compost, broadcast K fertilization, banded K fertilization) on leaf K content
3. Determine the effects of cover crops and mulch on soil solution potassium and on soil exchangeable potassium
4. Determine the effects of a cover crop and compost on potassium leaf deficiency, yield, and quality
5. Conduct educational /outreach sessions on K deficiency as part of CSU Chico and UC Cooperative Extension Field days, the new UC Environmentally Sound Prune System Program (ESPS), the Biological Prune Systems (BPS) Project, and through the outreach activities of commercial fertilizer suppliers and pest control advisors.
6. Determine the effects of the four treatments on soil water relations in prune orchards

DESCRIPTION

Roughly 110,000 acres of prunes are grown in California, primarily in the northern California counties of Sutter, Butte, Yuba, Tehama, Colusa, and Glenn. Prunes are a strong sink for K and prune flesh typically contains 1% of K. Potassium deficiencies are significant on French prune trees growing in California's Sacramento Valley. Deficiencies are especially apparent in heavy crop years and in heavy textured, clay soils.

Potassium deficiency symptoms may be expressed as yellowing of the leaves and marginal burn. Severe deficiencies may cause defoliation and limb dieback. Potassium deficiency can also cause decreases in both yield and fruit quality. Previous University of California research has shown that banding K at rates of up to 2,500 lb/acre will increase yields in prune orchards for 3-4 years and decease foliar dieback during the heavy crop years. Recent work by Dr. Steve Southwick, however, indicates that some growers are applying excessive amounts of potassium resulting in nutrient imbalances in the trees.

Potassium fixation by soils depends on the quantity of the soil mineral vermiculite, and to a lesser extent illite, present in the soil. These minerals are derived from granitic parent materials. The soils of the upper Sacramento Valley were formed on volcanic parent material, which do not contain little mica or vermiculite. The project leaders predict that these soils have minimal potential to fix K and that the heavy clay soils typical of the region may cause poor crop root distribution. If poor root growth is limiting K uptake, cover cropping and compost applications may increase root exploration of the soil and help to ameliorate K deficiency.

RESULTS AND CONCLUSIONS

This three-year study, initiated in 1999 is evaluating the ability of alternative management strategies of cover cropping and compost applications to enhance K uptake in French prune. The project was initiated on a farm, which had a history of K deficiency, and severe deficiency symptoms were seen this year. To date, no significant treatment effects have been found in terms of mid summer leaf K concentrations, whole tree K deficiency ratings, stem water potential, and fruit yield and quality. These results are not unexpected given the short period since treatment application.

The study will also determine whether these soils have the capacity to fix K by performing mineralogical analyses, and K adsorption and release studies. Leaf K, exchangeable K, soil solution K, foliage symptoms, and fruit yield and quality measurements are being taken as part of the study.

Fertilizer Use Efficiency And Influence Of Rootstocks On Uptake And Accumulation Of Nutrients In Wine Grapes Grown In The Coastal Valleys Of California

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INTRODUCTION

There are approximately 710,000 acres of grapevines grown in California with 42% of that acreage devoted to wine grape production. Presently, the most rapidly growing segment of the wine industry is the sale of premium wine. The majority of grapes used to produce premium wine are grown in the coastal valleys of California. Unfortunately, many vineyards in those areas are being replanted on rootstocks resistant to *Phylloxera*, a root-feeding louse. Most of the fertilization recommendations for grapevines in California were developed for vines growing in the San Joaquin Valley on their own roots. Thus, there is an urgent need to develop fertilization recommendations for premium wine grape cultivars grown on different rootstocks in the coastal areas of California.

Nitrogen is primary fertilizer used in California vineyards. Therefore, the timing and amounts of N fertilizer application are critical in optimizing its uptake to avoid leaching below the root zone and possible ground water contamination. The only direct way to measure fertilizer use efficiency is with the use of ^{15}N-labeled N fertilizer. ^{15}N is a non-radioactive isotope of N and can be quantitatively measured in plant tissue. The proposed research was designed to determine fertilizer use efficiency using ^{15}N labeled fertilizer in four different vineyards (two Chardonnay and two Cabernet Sauvignon vineyards) growing on different rootstocks, and at different locations in California. In addition, N and K budgets were to be determined on those vines and compared to more conventional means (petiole analysis at bloom time) to determine vine nutritional status.

OBJECTIVES

1. Quantify total uptake of N and K in Chardonnay and Cabernet Sauvignon scions grafted onto various rootstocks at different locations.
2. Use ^{15}N labeled fertilizer to determine fertilizer use efficiency of premium wine grapes on different rootstocks grown in the coastal valleys of California.
3. Compare the efficiency of N fertilizer uptake and total N and K uptake by the various scion/rootstock combinations with other means to determine vine nutritional status (i.e. petiole analysis at bloom and veraison and cluster N and K analysis at harvest).
4. Develop fertilization recommendations for premium wine grapes grown in the coastal regions of California.

DESCRIPTION

At berry set in the 1997 growing season ^{15}N labeled fertilizer was applied to six, individual vine replicates for each rootstock at all locations subsequent to berry set (from two to four weeks after anthesis or bloom). The amount of N applied per vine was determined by estimating yield at each site and the corresponding amount of N that would be removed in the fruit at harvest. This ranged from the equivalent of 27 to 40 lb N/acre, depending upon location. Petioles were collected in 1997 at 30 to 80% of full bloom, prior to when the fertilizer was applied and then again at bloom in 1998 and 1999. Yields at each location were measured when the sugar in the fruit indicated that particular vineyard would be harvested within one week. The fruit was returned to the UC Kearney Agricultural Center and subsequently dried. Leaves on the experimental vines were collected prior to the anticipated date they would have naturally fallen and the canes measured when the vines were pruned. Leaves and canes were dried at the UC Kearney Agricultural Center and subsequently analyzed for ^{15}N, N and K.

Table 1. Bloom-time petiole nitrate and total N concentrations in 1997, 1998 and 1999.

Location	Rootstock	NO_3-N (ppm)			Total N (% dry wt)		
		1997	1998	1999	1997	1998	1999
Carneros	5C	911	590	484	1.50	1.09	1.32
	110R	718	340	396	1.69	1.16	1.29
Gonzales	5C	768	486	650	1.06	0.81	1.10
	100R	638	481	555	0.66	0.83	1.06
	Freedom	587	695	599	0.91	0.84	1.00
Oakville	5C	68	1655	47	2.63	1.09	0.68
	110R	56	1338	57	2.60	1.01	0.72
	3309	52	1586	55	2.47	0.98	0.69
Paso Robles	5C	6191	1359	2754	2.64	1.06	1.25
	110R	4042	964	1358	2.76	1.30	1.34
	Freedom	9876	1485	1387	3.34	1.04	0.99
	140Ru	7462	1418	1947	2.64	1.26	1.07
	1103P	7878	1575	1562	2.84	1.20	1.04

Each Value is the mean of four, 75 petiole samples.

RESULTS

Petioles opposite the lowest cluster on a shoot were sampled during bloom all three years and analyzed for NO_3-N and total N (Table 1). The values for both nitrate and total N varied greatly from one location to another, year to year but somewhat less so for rootstocks at a particular location. Petiole nitrate-N values ranged from a low of 47-ppm nitrate at the Oakville site in 1999 to almost 10,000 ppm at Paso Robles in 1997. While the data in Table 1 are the means per rootstock/scion combination at each location, there was considerable variation in bloom-time petiole nitrate-N in 1999 at the Carneros and Paso Robles sites. For example, Chardonnay at Carneros on the 5C rootstock had a nitrate value of 173 ppm for one set of data vines and 796 ppm at the other site of data vines. At Paso Robles, petiole nitrate-N values of data vines on Freedom were 460 ppm at one site and 2323 ppm at the other site. The wide range in bloom-time petiole nitrate values at Carneros and Paso Robles for individual rootstock/scion combinations in 1999 were used in Figures 3 to 5. Total N in the petioles appeared to be a function of cultivar in 1997 but in 1998 and 1999 values of both cultivars only varied from 0.7 to 1.3%. There was a significant linear relationship between petiole N and nitrate-N (data not given). However, the total N values at the Oakville Cabernet vineyard in 1997 were high even though petiole nitrate-N values were very low.

The concentrations of N in the leaves, stems (main axis of the shoot) and clusters were also measured all three years and correlated with both petiole N and nitrate-N at bloom. An increase in bloom-time petiole N (from a low of 0.66 to a high of 3.34%) did not have an effect on the N concentrations of the fruit, leaves or canes. The relationship between the concentration of N in the fruit, leaves and canes at the end of the growing season and bloom-time petiole nitrate concentration showed that organ N concentration may only decrease at a bloom-time petiole nitrate concentration value less than 100 ppm.

Ammonium nitrate (NH_3NO_3), with 5 atom % excess ^{15}N, was the N fertilizer utilized in this study. Both N atoms were labeled with ^{15}N. The amount of N fertilizer given to each vine was based upon an estimated yield at each location and subsequent removal of N from the vineyard in the fruit at harvest. The amount of ammonium nitrate given to each vine at Carneros, Monterey, Paso Robles and Oakville in 1997 was approximately 34, 57, 48 and 17 g per vine. The difference in the amount per vine at each location was due to differences in estimated yield and vine density. The amount of actual N applied was 12 (33), 20 (40), 17 (27) and 6 (29) g per vine (lb /acre) at Carneros, Monterey, Paso Robles and Oakville, respectively (Table 2). The fertilizer was dissolved in water and placed beneath an emitter while the vines were being irrigated. This procedure took place from two to four weeks after full bloom (after berry set).

The total amount of ^{15}N taken up by the vine over the three year period of the study was determined (Table 2). There were significant differences among rootstocks at the Paso Robles location, no differences among rootstocks at the other locations. The sum of total N as a function of rootstock in the same organs over three years differed significantly only at the Oakville location but this may have been due partly to significant differences in biomass production among rootstocks at that site. The average N concentration of biomass

Table 2. The amount of labeled N (^{15}N), total N, total dry biomass and % N of the biomass accumulated by the data vines over the course of three growing seasons (1997, 1998 and 1999). The ^{15}N (5 atom % excess) fertilizer was applied at berry set in 1997 at all locations.[1,2]

Location	Rootstock	Applied ^{15}N Fertilizer	Total ^{15}N	Total N	Dry Wt.	Total Percent N
		(g/vine)				(% dry wt)
Carneros	5C	12	0.066	44.1	6255	0.71
	110R	12	0.078	52.7	7482	0.70
Gonzales	5C	20	0.049	52.7	6694	0.79a
	110R	20	0.051	54.5	7591	0.72b
	Freedom	20	0.047	49.9	7889	0.73b
Oakville	5C	6	0.039	26.6a	4480a	0.59b
	110R	6	0.043	57.0ab	3760 b	0.64a
	3309C	6	0.044	20.6 b	3761 b	0.62ab
Paso Robles	5C	17	0.035 c	65.3	82.61	0.79 c
	110R	17	0.049 b	67.5	8394	0.80 bc
	Freedom	17	0.074a	69.7	8701	0.80bc
	140Ru	17	0.051 b	79.7	9171	0.87a
	1103P	17	0.072a	74.0	8949	0.83 b

1) The cultivar used at Carneros and Gonzales was Chardonnay while Cabernet Sauvignon was used at the other two locations.
2) Values for the rootstocks within a column at a given location are significantly different ($p < 0.05$) if followed by a different letter. If no letters appear within the column, there are no significant differences among rootstocks.

produced by the scion (total vine N divided by total vine dry weight) was significantly affected by rootstock at three of the four locations. A comparison of the two rootstocks (5C and 110R), common to all experimental locations, showed that percent N was significantly greater for 5C at Gonzales, significantly greater for 110R at Oakville, but no significant differences between the two at Carneros and Paso Robles.

Fertilizer use efficiency (FUE) (ratio of applied ^{15}N to ^{15}N taken up by the vine) was calculated for all scion/rootstock/location combinations each year and then summed at the end of the study (Table 3). With the exception of the Paso Robles site, there were no significant differences in FUE among rootstocks. This may be due to the fact that all rootstocks were culturally treated the same (i.e. vertical trellis system, shoot positioned, hedged at a certain height and drip irrigated according to best estimates of vine water requirements). All fertilizer applications were such that the N was applied directly beneath an emitter while irrigating. The 110R rootstock had a significantly higher FUE than the 5C rootstock at Paso Robles and it was higher than 5C at the other three locations (although not significantly). The FUE of Freedom was greatest among rootstocks at Paso Robles but lowest at Gonzales.

There were somewhat larger differences in FUE among locations. Fertilizer use efficiency, when averaged across rootstocks, was 12.0, 4.9, 14.0 and 6.6% at the Carneros, Gonzales, Oakville and Paso Robles sites, respectively. There are several explanations for the differences among sites. The extremely high petiole nitrate levels in 1997 at the Paso Robles vineyard may indicate an abundance of soil N at that site thus diluting the uptake of fertilizer N. At the Gonzales site, the cooperator applied a NPK fertilizer without my knowledge again diluting the ^{15}N fertilizer applied at berry set. The higher FUE at the Carneros and Oakville sites may have been due to the fact that neither vineyard had been fertilized since planting. In addition, the Oakville vineyard had very low petiole nitrate levels when sampled at bloom in 1997 and 1999. Lastly, the proportion of labeled fertilizer taken up the first year at Carneros, Gonzales, Oakville and Paso Robles was 87, 84, 79 and 60% of that found in the vine over three years.

The amount of N required to support the growth of the fruit, leaves and canes in each year of the study as a function of location is shown in the Table 4. Differences in N uptake from year to year were related to differences in yield from year to year. Over the course of the study N requirements ranged from 145 lb N/acre to 98 lb N/acre. The lowest amount of N per ton of fruit was 1.96 lb/ton at the Oakville site in 1997 (Table 4).

Potassium also was measured in the petioles at bloom time and clusters, leaves and canes at the end of the season all three years (Table 5, 1999 data presented). The range in petiole K varied to a lesser degree from location to location and among rootstocks at a particular location than did petiole ni-

Table 3. The relationship between the amount of ^{15}N labeled fertilizer found in each rootstock/scion combination and the amount of ^{15}N fertilizer applied.

Location	Cultivar	Rootstock	1997	1998	1999	3 Years[2]
			^{15}N in vine/^{15}N applied			
			(%)			
Carneros	Chardonnay	5C	9.7	1.1	0.2	11.0
		110R	11.1	1.2	0.7	13.0
Gonzales	Chardonnay	5C	4.0	0.6	0.3	4.9
		110R	4.3	0.5	0.3	5.1
		Freedom	4.0	0.4	0.3	4.7
Oakville	Cabernet	5C	10.4	1.5	1.1	13.0
		110R	11.2	2.1	1.0	14.3
		3309C	11.5	2.1	1.1	14.7
Paso Robles	Cabernet	5C	2.1	1.2	0.7	4.0 c
		110R	3.2	1.8	0.8	5.8 b
		Freedom	6.1	1.7	0.9	8.7a
		140Ru	3.5	1.6	0.9	6.0 b
		1103P	4.8	2.2	1.5	8.5a

[2]See Table 2 "Total ^{15}N" column illustrating differences among rootstocks with regard to fertilizer use efficiency.

trate concentrations. The concentration of K in the fruit, leaves and canes among locations and rootstocks varied even less than the K in the petioles. There were significant differences in total K in the fruit and the entire vine (sum of fruit, leaves and pruning canes) after three years among the rootstocks (Table 6). Some of the differences among the scion/rootstock combinations at a given location were due to differences in yield. Differences among locations was due mainly to differences in planting density (i.e. planting density at Carneros, Gonzales, Oakville and Paso Robles was 1249, 907, 2165 and 725 vines per acre, respectively). There were significant differences in the whole vine concentration of K as a function of rootstock at three of the locations (Table 6). However, there was no significant correlation between petiole K bloom and the K concentration found in the fruit, leaves or pruning canes at the end of the season (data not given).

DISCUSSION AND CONCLUSIONS

This study quantified the uptake of N and K as a function of scion, rootstock and location for three growing seasons. As has been found in other studies on grapevines, the fruit is the major sink for N and K. The amount of N found in the clusters at harvest, leaves as they fell from the vine and the pruning canes ranged from a low of 98 to a high of 145 lb N/acre. The actual amount of N removed from the vineyards (by harvesting the fruit) ranged from approximately 2.0 to 3.2 lb N/ ton. The amount of K removed from the vineyards via fruit harvest all three years ranged from 74 to 140 lb / acre. The amount of K found in one ton of fruit ranged from approximately 3.8 to 6.0 lb / ton.

Both location and rootstock had an effect on bloom-time petiole analysis for nitrate, total N and percent K as others have found. In fact, there was a large effect of both rootstock and location on petiole NO_3-N. The current recommendation for adequate levels of nitrate in the petioles at bloom, for Thompson Seedless grapevines, is between 500 and 1200 ppm nitrate. The data presented in Figure 5 indicate that when bloom-time petiole nitrate levels were below 200 ppm, the concentration of N in the clusters, leaves and stems (or canes) could be lower than when the levels were greater than 200 ppm. However, the concentration of N in those same organs did not significantly increase as bloom-time petiole N increased from 200 to 10,000 ppm. Viticulture researchers over the years have found that some cultivars of grapevines and/or rootstocks will normally have bloom-time petiole nitrate-N values of approximately 200 ppm without an adverse effect on vine growth. The 200-ppm value is less than the "adequate" values (500 to 1200 ppm) established for Thompson Seedless. Therefore, the data presented in this study would indicate that a value of 200-ppm nitrate in the petioles at bloom might be a universal "adequate" value applicable to most vineyard situations. This is also supported by the fact that the PI has recorded bloom-time petiole nitrate values in Thompson Seedless grapevines less than 100 ppm with no visible N deficiency symptoms. It should be pointed out that the petiole nitrate-N values at Oakville in 1999 were very low but the N concentrations in the fruit, leaves and canes were comparable to vines at other locations

Table 4. The total amount of N in the fruit at harvest, leaves as they fell from the vines and the prunings at the four vineyard locations.

Location	Total N (clusters, leaves & prunings) (lb /acre)			Total N (lb / ton fruit)		
	1997	1998	1999	1997	1998	1999
Carneros	52	38	43	2.68	2.50	2.58
Gonzales	42	24	37	2.48	2.56	2.88
Oakville	40	38	37	1.96	2.48	2.70
Paso Robles	39	41	33	3.16	3.02	2.76

Each value is the mean (averaged across rootstocks) at each location each year. Other information as found in Table 3.

where petiole nitrate values were higher. This would indicate that very low petiole nitrate-N values observed for a single growing season might not warrant the application of a N fertilizer. However, the PI is of the opinion that a N fertilizer should be applied if one found very low bloom-time petiole nitrate-N values (less than 100 ppm) for two consecutive years.

It is interesting to point out that petiole nitrate N at Oakville increased dramatically in 1998 compared to 1997 but dropped again in 1999. The Springs of 1997 and 1999 were very dry and the vines had not been irrigated prior to taking petiole samples both years. The 1998 Spring was very wet, soil water content was very high at the time petioles were sampled that year. This may indicate that rainfall could influence petiole nitrate-N values. In addition, the vineyard at Paso Robles was irrigated in 1997 prior to taking petioles for analysis while in 1998 and 1999 the vineyard had not been irrigated prior to bloom. In that situation, the irrigation may have caused the high petiole values in 1997 while not irrigating the vines in 1998 and 1999 resulted in lowered petiole nitrate values. Growers should be made aware that irrigation starting date and the amount and frequency of rainfall may impact petiole NO_3-N values.

Numerous grape growers and consultants are now using bloom-time petiole total N instead of nitrate-N to assess vine nutrient status. They are doing this since there is less variation in total N from vineyard to vineyard and from year to year than for nitrate-N. We found a four-fold difference in petiole bloom-time, total N values in this study among the data collected (as opposed to a 210-fold difference in petiole nitrate values). However, there was no correlation between organ N concentration and petiole N concentration in this study. The data would indicate values even less than 1% N in the petioles is adequate.

I also found good correlations between organ tissue N concentration at berry set and the same organ's N concentration at the end of the season (data not given). These relationships would also indicate that any of the above organs, sampled either during the growing-season or during dormancy (pruning canes) may also be useful in determining vine nutrient status when used in conjunction with petiole analysis. Perhaps some of the fertilizer moved into the soil where little of the vine's roots were present.

The data collected would indicate that the efficiency of N fertilizer utilization (FUE) by the various rootstocks differs only slightly. It is often assumed by many in the grape industry that rootstocks with greater petiole nutrients (such as higher nitrate levels) are more efficient than rootstocks that generally have lower values. The data collected in this study would indicate that not to be the case. The small differences among the rootstocks at three of the locations may be due to how the rootstock affected vine growth and that the growth then drove the uptake of the N fertilizer. The significant differences in FUE at the Paso Robles site could be due to differences in root distribution within the soil profile. Those rootstocks with higher FUE may have a higher concentration of roots in the wetted zone beneath the emitter (where the ^{15}N fertilizer was applied), thus having greater access to the fertilizer. The differences among rootstocks at Paso Robles could also have been due to the movement of the labeled fertilizer into the wetted zone at each site the fertilizer was applied.

Another indicator of a rootstock to absorb N more efficiently would be whether it had a higher concentration of N in the biomass of the scion. There were significant differences (albeit small) at three of the locations among rootstocks in total vine N concentration (Table 2). This would indicate that a particular rootstock took up greater N in relation to the amount of biomass it produced (i.e. more efficient). However, there was no apparent relationship between FUE and the N concentration in the dry biomass.

The above fertilizer use efficiencies seem quite low compared to a FUE of approximately 40% that we found on Thomp-

Table 5. Yield, percent K of petiole (sampled at bloom) clusters, leaves and canes, and total K in the fruit at harvest and combined with that found in the leaves and canes at the end of the 1999 growing season as a function of cultivar, rootstock and location.

			% K				Total K	
Location	Rootstock	Yield	Petiole	Fruit	Leaves	Prunings	Fruit	Vine
		t/acre	(% dry wt.)				(lb /acre)	
Carneros	5C	7.7	1.73	0.79	0.93	0.69	27	40
	110R	8.5	1.61	0.78	1.35	0.86	29	55
Gonzales	5C	5.5	3.03	0.81	1.18	0.77	19	34
	110R	5.4	2.67	0.83	1.50	0.53	19	35
	Freedom	5.3	3.21	0.83	1.26	0.59	19	35
Oakville	5C	5.5	3.62	1.10	1.27	0.61	29	60
	110R	4.8	3.73	1.07	1.52	0.67	24	53
	3309C	3.6	3.87	1.15	1.23	0.63	19	41
Paso Robles	5C	4.7	4.18	0.80	1.03	0.61	16	30
	110R	5.0	3.70	0.95	1.21	0.58	20	36
	Freedom	5.2	4.87	0.99	1.28	0.66	22	40
	140Ru	5.2	4.28	0.96	1.14	0.63	22	40
	1103P	3.8	4.33	1.02	1.31	0.69	17	36

Table 6. Yield, total K in the fruit, the amount of K per tonne of fruit, total K in the vine (fruit + leaves + canes) and percent K of the vine for three years as a function of location, cultivar and rootstock.

				Fruit K		Total Vine[z] K	
Location	Cultivar	Rootstock	Yield				
			(t/acre)	(lb /acre)	(lb /t)	(lb /acre)	(% dry wt)
Carneros	Chardonnay	5C	25	96	3.9	143 b	0.84 b
		110R	29	124	4.2	198a	0.96a
Gonzales	Chardonnay	5C	20	74	3.6	103	0.78
		110R	21	83	3.8	124	0.81
		Freedom	18	69	3.8	100	0.74
Oakville	Cabernet	5C	25	140	5.6	222a	1.04 b
		110R	20	119	5.8	198ab	1.10a
		3309C	17	101	6.0	165 b	1.03 b
Paso Robles	Cabernet	5C	18	82	4.6	119	0.90 b
		110R	18	85	4.8	129	0.96ab
		Freedom	18	97	5.4	143	1.03a
		140Ru	18	93	5.2	149	1.02a
		1103P	17	96	5.8	147	1.03a

[z]Values within the two Total Vine K columns at a given location are significantly different ($p<0.05$) if followed by a different letter. If no letters appear, there are no significant differences. An ANOVA was not conducted on the data in the other column

son Seedless grapevines grown in the San Joaquin Valley. It should be pointed out that the FUEs presented in this summary were based upon N found in the fruit, leaves and pruning canes while those on Thompson Seedless also analyzed the root system, trunk and fruiting wood. Those three organs contained approximately 40% of the total ^{15}N labeled fertilizer taken up by the vines in that study. It was anticipated that the labeled fertilizer in the trunk, cordons and root systems of the vines used in this study would be remobilized and found in the in the clusters, leaves and pruning canes in 1998 and 1999. The data found in Table 3 indicate the majority of ^{15}N found in those organs was taken up the first year. Other possible reasons for the differences between the Thompson Seedless study and this one are:

1.) The vineyard site in the Thompson study had a hardpan at a depth of about 3 feet (1.0 m), which may have prevented any leaching of the fertilizer below the root zone

2.) Vines in this study were irrigated at estimated full ET, which may have leached the fertilizer below the rooting zone

In support of reason 2, an additional treatment was established at Carneros where vines were irrigated at 50% of estimated full ET and fertilized with a combination of potassium nitrate and ammonium sulfate labeled with ^{15}N (left over from my Thompson study). The FUE was twice (approximately 23%) that of the full ET treatment (unpublished data).

The current bloom-time petiole values of K established for Thompson Seedless are: less than 1.0% - deficient, greater than 1.5% - adequate. The petiole K values in this study ranged from 0.78 to almost 5%. The concentration of K in the fruit, leaves and canes remained fairly constant across the above-mentioned range of bloom-time petiole K values. The data from this study would indicate that petiole K values, determined at bloom greater than 0.8% are adequate for the cultivars and rootstocks used in this study.

There were significant differences in the total K taken up by the vine as a function of rootstock at the Carneros and Oakville sites. Those differences may be explained by both greater yield and K concentrations in the vine's biomass across rootstocks (Table 6). A comparison between 5C and 110R at all locations showed that the concentration of K in the biomass was greater for 110R than 5C. Lastly, it appeared that cultivar also affected the amount of K found in the fruit.

Water And Fertilizer Management For Garlic: Productivity, Nutrient And Water Use Efficiency, And Postharvest Quality

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INTRODUCTION

Garlic is a cool season vegetable crop with a long growing season and high nutrient and water needs. California produces more than 80% of the U.S. garlic crop, and irrigation and N fertilization practices by garlic growers may vary substantially. Little information is available about the timing and amounts of irrigation, and the relationships among fertility-water management-yield, and particularly among fertility-water management-harvest and postharvest qualities.

Highest yields are probable with soil moisture depletion of as little as 25-30%. Evapotranspiration can also be used as a guideline for irrigating garlic. Irrigation cut-off date, or date of last irrigation, has a great influence on garlic yield. Yield also increases with later cutoff dates. Quality can be reduced, however, with late irrigation. Optimum N rates determined in numerous experiments conducted by the University of California over the past 20 years have varied from 100 to 400 lb N/acre. Nitrogen, as well as moisture, availability early in the growing season is essential for optimal growth. Late applications of N may be deleterious to both yield and quality. Growth is slow during the first four months after planting. Thus, the greatest N needs are during the late winter when garlic starts its early growth.

Fertilizer and water management influences harvest quality and postharvest quality. Both N and irrigation affect soluble solids and dry matter content. In general, dry matter is reduced as N fertilizer rates increase, particularly at rates higher than optimum for yield. Irrigation cutoff date is important since dry matter content increases during the season. Thus, if irrigation cutoff is too early, dry matter can be reduced.

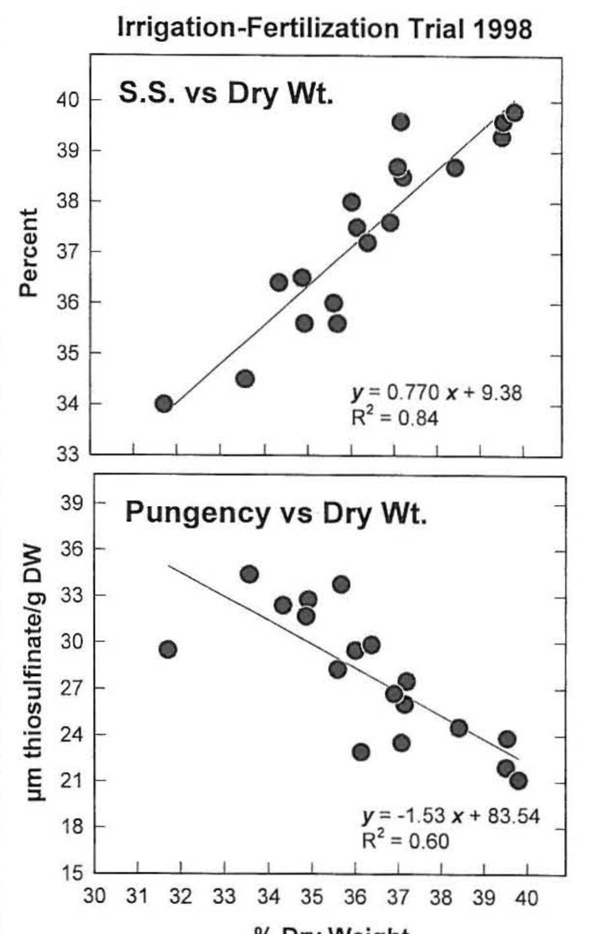

Figure 1. Relationship between soluble solids, thiosulfinates and dry weight of garlic produced under different irrigation-N fertilization regimes. Data from 1998.

Table 1. Summary of N fertilization treatments applied during 1998-99.

N Fertilization Treatment	Total Nitrogen applied (lb)	Preplant 11-62-0	Preplant Urea	Sidedress Urea[1]	First Water Run Nitrogen[2]	Second Water Run Nitrogen[3]	Third Water Run Nitrogen
F1	100	28	41	31	0	0	0
F2	175	28	41	46	30	30	0
F3	250	28	41	121	30	30	0
F4	300	28	41	151	40	40	0
F5	400	28	41	251	40	40	0

1Sidedress applied between January 28-February 4.
2First water run nitrogen applied April 1.
3Second water run nitrogen applied April 15.

Table 2. Summary of irrigation treatments applied during 1998-1999.

Irrigation Treatment	Applied Water % Evapotranspiration	Date of Last Irrigation
T1	110	10 May
T2	110	24 May
T3	130	10 May
T4	130	24 May

Garlic is approximately 40% dry weight with the major complex carbohydrate being fructan with a small portion of free sugars. Garlic flavor is due to the formation of organosulfur compounds when the main odorless precursor, alliin, is converted by the enzyme alliinase. The main compound formed by this reaction is a thiosulfinate, alicin, compound responsible for the characteristic odor and flavor of fresh garlic. The carbohydrate composition and pungency of garlic are quality parameters that have been little studied in relation to production and storage conditions.

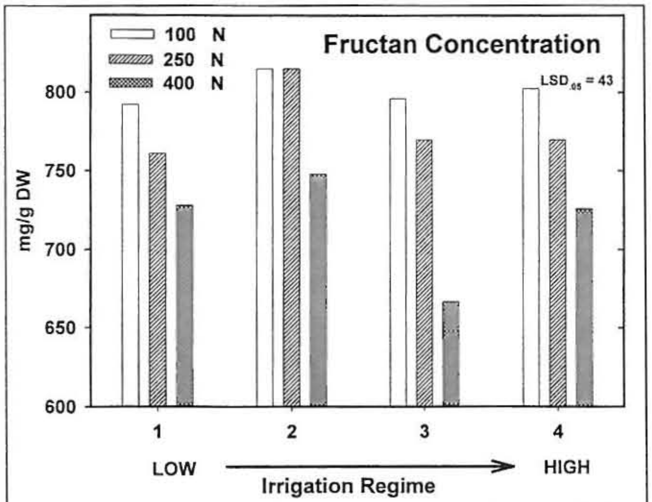

Figure 2. Fructan concentrations of garlic in relation to irrigation-N fertilization treatments. See Table 1 for details of treatments.

OBJECTIVES

The specific objectives of the research are to:

1. Relate fertilizer and irrigation management to yield, and efficiency of water and fertilizer use.
2. Determine leaf tissue concentrations of N in relation to fertilizer and irrigation practices.
3. Relate leaf tissue analyses to quality at harvest.
4. Relate the postharvest quality of garlic to different fertilization and irrigation practices.

DESCRIPTION

The garlic plots were established for the third year at the UC Westside Research and Extension Center in the fall of 1998 for summer 1999 harvest. Irrigation treatments for 1999 consisted of water applications equal to 110% (T1, T2), and 130% (T3, T4) of the potential evapotranspiration. Irrigation cutoff dates and N fertilization rates for plots for postharvest evaluation are shown in Tables 1 and 2. Yield data for the irrigation-N fertilization trial was taken from 5-foot manually harvested parts of the 20-foot plots (6 field replications). For the quality/postharvest evaluations, all garlic was manually dug in late June. After digging, bulbs were placed in mesh bags, transported to University of California, Davis and cured for 3 weeks under a field shed with good air ventilation. Outer cloves from bulbs were manually peeled for determina-

Table 3. Yield, dry weight and soluble solids content of garlic produced under different Irrigation-N fertilization regimes.

Irrigation Treatment	Nitrogen Treatment	Plot Yield Kg/1.5m	Bulb Weight g	Dry %	Soluble Solids %
T1	1	6.0	49.1	41.1	43.2
	3	7.2	61.1	40.3	43.5
	5	7.1	63.8	39.0	42.3
T2	1	5.6	52.2	41.1	43.7
	3	6.3	58.5	39.6	43.0
	5	7.1	72.5	39.5	42.1
T3	1	5.1	45.9	41.0	42.3
	3	6.2	64.1	40.3	43.6
	5	6.6	61.1	39.1	42.6
T4	1	5.1	49.5	40.6	43.3
	3	6.7	58.3	40.3	43.3
	5	6.6	58.2	39.7	43.0
LSD.05		0.5	7.6	0.8	0.4

Yield data are average of 6 field replications. Composition data are averages from 30 outer cloves from a minimum of 10 bulbs.

tion of color, texture, and soluble solids. Samples were sliced and freeze-dried for determination of carbohydrates and alliin by HPLC (high pressure liquid chromatography). The 2000 harvest, but not the 1999 harvest, is being stored for postharvest evaluations.

RESULTS AND CONCLUSIONS

Averaging across N fertilization treatments, bulb weight per 5-foot subplots was less with higher rate of irrigation treatments. No significant differences were found in weight of individual bulbs. Averaging across irrigation treatments, total bulb weight per 5-foot subplot was significantly less with 100 lb N. treatment. Average weight per bulb was also reduced with the lowest N rate. Table 3 shows yield data for each irrigation-N fertilization plot. The lowest N rate reduced total bulb weight and weight per bulb under all 4 irrigation regimes. The percent dry weight was consistently reduced at the highest N rate across the 4 irrigation treatments (Table 2). The percent soluble solids followed a similar pattern for T1 and T2 irrigation treatments, but not for T3 and T4.

Although percent soluble solids and percent dry weight were well correlated (Figure 1), the relationship between fructan concentration and these two parameters were less clear. Fructan concentrations were affected by N fertilization treatment, with the highest carbohydrate content associated with the lowest N application of 100 lb /acre and the lowest fructan content associated with the highest N rate of 400 lb /acre (Figure 2). Higher free sugar concentrations were associated with the higher N application rates (Table 4). Fructan as percent of total carbohydrate remained constant across irrigation treatments (96.6 + 0.2%) and across N treatments (96.6 + 0.3%).

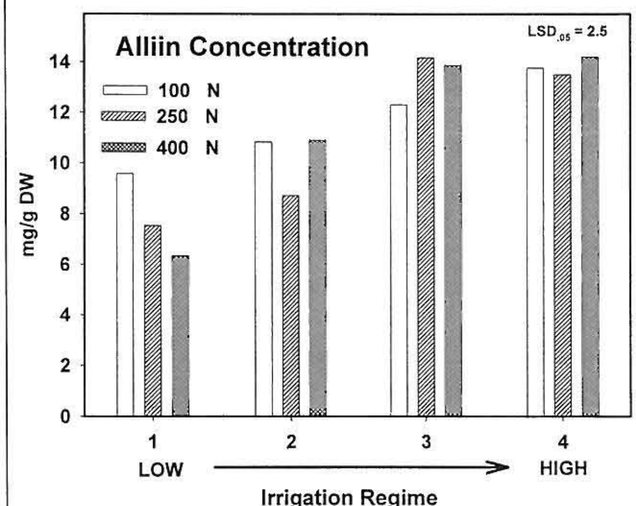

Figure 3. Alliin concentrations of garlic in relation to irrigation-N fertilization treatments. See Table 1 for details of treatments.

Alliin content was clearly affected by the irrigation treatment (Figure 3). The lowest alliin concentrations were associated with garlic from the 110% ET plots whereas the highest alliin concentrations were associated with the highest irrigation rate (130% ET). Alliin was not affected by the fertilization regime. Thiosulfinate concentrations (mostly alicin) also generally decrease with increasing dry weight (Figure 1). Alliin concentrations were generally correlated with thiosulfinate concentrations (data not shown).

Table 4. Fructan and sugar composition of garlic in relation to irrigation-fertilization treatments.

Irrigation Treatment	Nitrogen Treatment	Fructan mg/g DW	Sucrose mg/g DW	Glucose mg/g DW	Fructose mg/g DW
T1	1	792 ± 5	23.0 ± 2.5	1.6 ± 0.1	4.1 ± 0.2
	3	761 ± 5	21.4 ± 2.2	1.5 ± 0.4	3.5 ± 0.7
	5	728 ± 10	18.1 ± 3.5	1.3 ± 0.2	3.5 ± 0.3
T2	1	815 ± 5	16.2 ± 1.0	1.4 ± 0.2	4.1 ± 0.4
	3	762 ± 13	22.6 ± 2.3	0.6 ± 0.1	3.5 ± 0.3
	5	748 ± 16	23.3 ± 1.4	0.6 + 0.5	2.8 ± 0.3
T3	1	796 ± 50	21.5 ± 3.9	1.0 ± 0.3	2.5 ± 0.1
	3	770 ± 26	25.7 + 2.6	0.3 ± 0.2	2.3 ± 0.2
	5	666 ±118	27.4 + 2.0	0.2 ± 0.2	2.9 ± 0.5
T4	1	803 ± 7	24.4 ± 0.5	0.1 ± 0.0	2.2 ± 0.4
	3	770 ± 46	26.2 ± 1.1	0.1 ± 0.0	2.5 ± 0.1
	5	726 ± 27	28.3 ± 1.4	0.2 ± 0.1	2.4 ± 0.3
Average	T1	760	20.8	1.5	3.7
	T2	775	20.7	0.9	3.5
	T3	744	24.9	0.5	2.6
	T4	766	26.3	0.1	2.4
Average	F1	802	21.3	1.0	3.2
	F3	766	24.0	0.6	3.0
	F5	717	24.3	0.6	2.9

Data are average from 30 outer cloves from a minimum of 10 bulbs.

Soil Testing To Optimize Nitrogen Management For Processing Tomatoes

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INTRODUCTION

This project is developing a protocol for recommending fertilizer application rates based primarily on early-season soil testing. This testing system is based on the correlation between NO_3-N of the surface foot of soil and other N pools in the surface two feet of soil at early plant growth stages. Similar protocols have been successfully developed for corn in the northeast and midwest, and recently have been successful in broccoli and cauliflower production in California's coastal cole crop production regions. Similar work has not been done, however, for processing tomatoes.

Additional correlations are being sought as part of this project between fresh petiole sap testing, dry plant tissue testing, and N fertilizer management practices.

OBJECTIVES

1. Develop and extend information on pre-sidedress soil testing as a means for optimizing N management for processing tomatoes.

2. Evaluate the effectiveness and utility of fresh petiole sap testing using the Cardy Meter for decision making in tomato N management.

3. Investigate relationships between fresh sap N testing, dry tissue testing and current sufficiency levels being used by commercial testing labs for N fertilizer recommendations.

RESULTS AND CONCLUSIONS

During the 1998 and 1999 growing seasons, the project was carried out on a total of 14 on-farm sites in the Sacramento Valley and the West Side region of the San Joaquin Valley. Two trials were also conducted at the UC West Side Research and Extension Center (WSREC). Common processing tomato varieties were grown at each experimental site in standard crop rotations for the regions. All fields received N fertilizer sidedress applications of 0 to 250 lb/acre of urea in increments of 50 lb/acre, with six treatment replications per site. Soil samples were collected at various depths from each plot prior to N sidedress applications. The soil samples were tested for total N, potentially mineralizable nitrogen (PMN), NO_3-N and NH_4-N. Each strip plot was machine harvested, followed by measurements for total yield and fruit quality.

Concentrations of NO_3-N and total organic N as measured by pre-sidedress soil testing showed a large variability among fields (3.5-28.5 mg N/kg; Table 1). There was little difference, however, in soil NO_3-N levels within individual fields between 0-1 cm and 0-2 cm soil depth. In-season mineraliza-

Table 1. Soil N concentration prior to sidedress fertilizer application, in-season N mineralization rate, and grower's fertilizer N inputs.

Year	Field	NO_3-N (mg/kg) 0 - 30 cm	by depth 0 - 60 cm	Organic N (g/kg) 0 - 30 cm	N Mineralization % rate	Grower inputs (kg N/ha) pre-sidedress	sidedress
1998	1	6.3	7.2	0.8117	1.4	30.4	118.9
	2	7.4	8.8	0.8583	1.8	51.0	99.1
	3	22.3	28.5	0.7650	2.0	30.4	118.9
	4	8.5	6.1	0.6975	2.8	28.0	NA[Z]
1999	5	7.2	10.9	0.6575	2.3	127.3	145.6
	6	23.7	20.7	0.9050	0.9	64.2	198.2
	7	16.0	13.3	0.8200	1.2	44.0	198.2
	8	4.7	3.5	0.7875	1.8	13.4	NA[Z]
	9	15.7	15.8	1.7675	1.3	6.7	134.4
	10	10.1	12.2	1.1488	1.3	16.2	134.4

[Z]Fields at the University of California's Westside Research and Extension Center.

tion rates of soil mineral N (0.9-2.8%) and total soil organic N content (0.66-1.77 g N/kg) were generally consistent with anticipated norms for California Central Valley soils. Total pre-sidedress and sidedress fertilizer N inputs by commercial growers in non-experimental rows at project sites ranged from 140-274 kg N/ha and were consistent with typical input rates used in the industry.

Significant yield response to N application was found in only four of ten fields (Table 2). N rate effects on yield fit linear (r^2=0.62) and quadratic (r^2=0.73) response models in field 4, and a quadratic response model in field 8 (r^2=0.61; Table 2). Using Duncan's multiple range test ($p<0.05$), no significant yield increase occurred at sidedress N application rates >56 kg N/ha in fields 8, 9 and 10. In field 4, sidedress N application up to 112 kg N/ha resulted in increased yield. No fields with yield response to sidedress N application had pre-sidedress soil NO_3-N concentration above 15.7 mg/kg at 0-30 cm depth or 15.8 mg/kg at 0-60 cm depth (Table 1).

Fertilizer treatment rates had no significant effect on percent red or rotten fruit harvested in any field. Fertilizer rate effects on other fruit quality indicators were inconsistent and did not fit linear nor quadratic response models (Table 3). As an example of these inconsistencies, fields 3, 4 and 8 had statistically significant treatment effects on percent green fruit harvested using Duncan's multiple range test ($p<0.05$), but the largest percentages of green harvested fruit were in plots that received 280 kg N/ha in field 8, 56 kg N/ha in field 3, and the zero treatment in field 4. Fertilizer treatment rate effects on other fruit quality indicators (fruit weight, fruit color and soluble solids) demonstrated similar inconsistencies; most fields showed no statistically significant treatment effects on fruit quality, and comparisons between fields that did have significant treatment effects provided no observable link between treatment rate and fruit quality indicator performance.

Dried petiole NO_3-N concentration was most closely related to plant N deficiencies at the fruit set growth stage (Figure 1). Six of nine treatment replications with significant yield response to fertilizer input could be clearly demarcated from non-responsive replications at fruit set petiole sampling stage (Figure 1). All four fields (4, 8, 9, 10) with statistically significant yield response to fertilizer treatment rate also showed statistically significant differences in dried petiole NO_3-N concentration related to treatment at fruit set sampling (data not shown). In these N-responsive fields, all treatments with less than 2300 mg/kg petiole NO_3-N concentration at fruit set had significant yield response to sidedress N. Approximately 80% of treatments with dry petiole NO_3-N levels at fruit set higher than 2300 mg/kg achieved at least 95% relative yield (Figure 1).

Whole leaf total %N sampling was only conducted at fruit set, and did not show as close a relationship to plant N deficiency as dry petiole NO_3-N measured at the same plant growth stage. Although whole leaf total %N in five of six fields had statistically significant similarities with fruit set petiole NO_3-N using Duncan's multiple range test ($p<0.05$; data not shown), whole leaf total %N did not exhibit strong linear (r^2 = .32) nor quadratic (r^2 = .37) correlation to dry petiole NO_3-N measured at fruit set plant growth stage (Figure 2). A clear demarcation between yield responsive and non-responsive treatment replications indicating plant N deficiency also was not apparent from whole leaf total %N sampling data (Figure 3).

The strongest linear and quadratic correlation between dried petiole NO_3-N levels and fresh petiole sap NO_3 concentrations measured by the Cardy Meter was found at fruit set sampling stage (Figure 4). Using Duncan's multiple range test ($p<0.05$), five of six fields had a statistically significant relationship between dried petiole NO_3-N and wet petiole sap

Figure 1. Relationship of petiole NO_3-N at first bloom, fruit set and fruit color stages and relative fruit yield; data from N-responsive and non-responsive fields included. Symbols indicate whether treatment was (•) or was not (Δ) N-limited, as determined by multiple range comparison (Table 2).

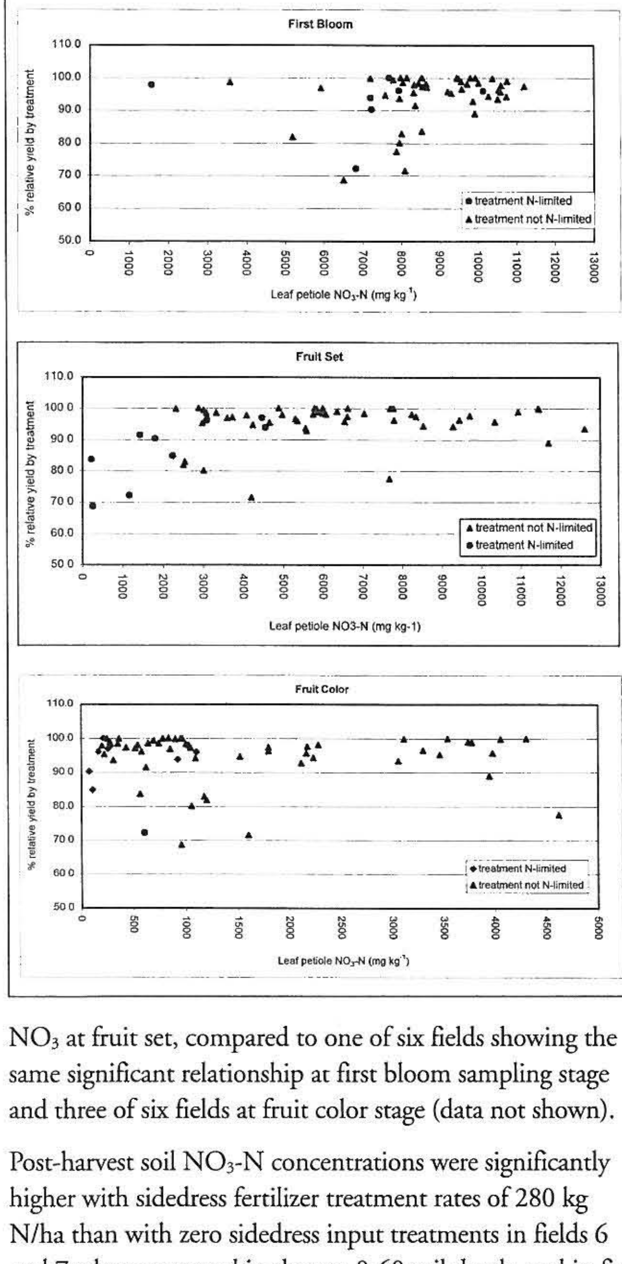
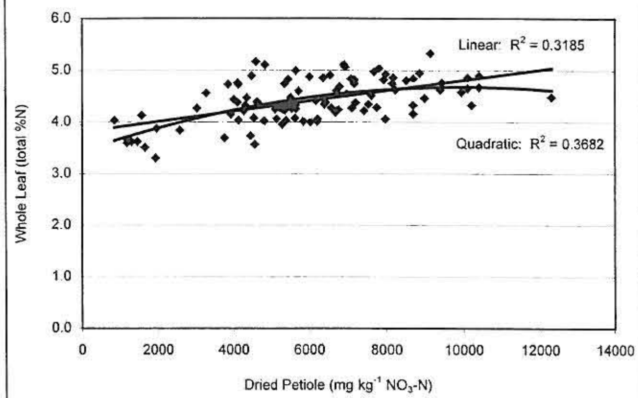


Figure 2. Linear and Quadratic correlations between dried petiole NO_3-N and whole leaf total %N measured at fruit



NO_3 at fruit set, compared to one of six fields showing the same significant relationship at first bloom sampling stage and three of six fields at fruit color stage (data not shown).

Post-harvest soil NO_3-N concentrations were significantly higher with sidedress fertilizer treatment rates of 280 kg N/ha than with zero sidedress input treatments in fields 6 and 7 when measured in the top 0-60 soil depth, and in field 6 when measured at 0-120 cm soil depth (Duncan's multiple range test; $p<0.05$) (Figure 5).

This study showed that both recommended and common industry sidedress N application rates for processing tomato production in California are excessive and could be substantially reduced without loss of yield or fruit quality. No fields in this study demonstrated yield response to sidedress N application above 112 kg N/ha N, and only four of ten fields had any significant yield response to sidedress N. Furthermore, fruit quality was virtually unaffected by sidedress N rate.

Pre-sidedress soil nitrate testing proved to be an accurate indicator of available NO_3-N at early plant growth stage when uptake of N is highest. No fields with more than 16 mg/kg NO_3-N in the top 60 cm of soil (approximately 140 kg/ha NO_3-N, at a typical bulk density of 1.35 g/cubic cm prior to sidedress demonstrated any yield response to sidedress N application. This observation indicates the possibility of a critical level of residual soil N that is sufficient to sustain proper plant growth and maximum yield without sidedress N. The similarities between PSNT NO_3-N levels at the 0-30 cm and 0-60 cm depths suggests that either measurement depth would be an accurate indicator of a residual soil N critical level.

The lack of yield response to sidedress N application in fields with >16 mg/kg NO_3-N was not surprising, since that amount represented approximately 70% of seasonal total N uptake (200 kg/ha N) for high-yield tomato production. This level of residual N was augmented by in-season soil N mineralization. Controlled-environment incubations of project field soil samples determined N mineralization rates of approximately 1-2% (Table 1), which would have provided an additional 30-160 kg N/ha N for project fields. Therefore, in-season mineralization of organic N, coupled with existing NO_3-N concentration measured by PSNT, are likely factors in the overall lack of yield response to sidedress N except at input rates below 56-112 kg N/ha.

Fields 1, 2 and 5 did not show yield response to sidedress N application despite low PSNT levels. This suggested that either in-season N mineralization was higher than the estimated range, or the crop was able to access mineral N at soil

Table 2. Effect of sidedress N rate on fruit yield in fields with significant N response.

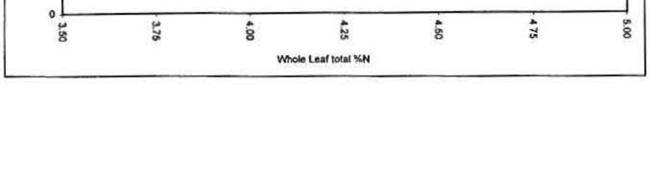
Sidedress kg N/ha	Fruit Yield (t/ha) Field 4	Field 8	Field 9	Field 10
0	97.2 c[z]	88.9 b	112.0 c	77.5 b
56	118.5 b	115.6 a	119.4 ab	88.5 a
112	129.5 ab	123.0 a	121.4 ab	90.3 a
168	138.0 a	120.7 a	118.5 ab	91.2 a
224	137.8 a	121.0 a	124.1 a	89.4 a
280	141.6 a	95.4 b	116.3 bc	87.8 a
Linear	**	NS	NS	NS
Quadratic	**	**	NS	NS

[z]Mean separation within columns by Duncan's multiple range test, P=0.05
** Significant at P=0.01

depth >60 cm. Regardless of the N source for these non-responsive fields, however, a PSNT level of <20 mg/kg NO_3-N in the top 0-30 cm (or 0-60 cm) of soil could serve as a conservative threshold level for growers to determine that no sidedress fertilization is necessary. A PSNT threshold level of ≈20 mg/kg NO_3-N recommended for processing tomato production in California's Central Valley is the same as critical levels previously established for corn (*Zea mays* L.) production in the Northeastern and Midwestern U.S. and California coastal valley lettuce and celery production.

Petiole sampling at the fruit set plant development stage proved to be the most accurate indicator of in-season plant N status. Dried petiole NO_3-N levels at fruit set sampling showed the clearest separation between treatment plots with yield response to sidedress fertilizer (N-deficient) and no yield response (not N-deficient) (Figure 1). Data from this study suggested a dried petiole NO_3-N concentration below 2300 mg/kg at the fruit set stage indicating that post-sidedress plant N deficiency was likely. A more conservative deficiency level of 2500 mg/kg at the fruit set stage would still be considerably lower than the 4000 mg/kg NO_3-N threshold offered by Lorenz and Tyler (1983) for the same sampling period. Fruit set sampling stage was also early enough in crop development that corrective action could be taken through later season water run or foliar N fertilizer applications.

Figure 3. Relationship of whole leaf total %N at fruit set stage and relative fruit yield; data from N-responsive and non-responsive fields included. Symbols indicate whether treatment was (•) or was not (Δ) N-limited, as determined by multiple range comparison (Table 2).



Fresh petiole sap NO_3 concentration as measured by the Cardy Meter showed the strongest correlation with dried petiole NO_3-N (r^2 = .64; Figure 4) at fruit set sampling. However, fresh petioles sap NO_3 did not demonstrate as clear a demarcation between treatment plots that were yield responsive to sidedress fertilizer inputs (N-deficient) and non-yield responsive (not N-deficient), suggesting that Cardy Meter wet sap petiole sampling is inferior to dried petiole sampling in determining the need for later-season fertilizer inputs to correct N deficiencies and obtain maximum yields.

The absence of a strong correlation between sidedress N rate and dried whole leaf N measured at fruit set stage was probably due to limits on plant N uptake ability. Suggested nutrient sufficiency levels for tomatoes are at 3.0% N (flowering) to 2.5% N (first ripe fruit) of total whole leaf dry biomass. All whole leaf samples analyzed for this study had >3.0% N dry biomass fruit set (Figure 3). These above-sufficiency, in-season levels of whole leaf %N serve to confirm the reasoning why a relative lack of yield response to sidedress fertilizer inputs in all fields, and no yield response in fields with existing pre-sidedress soil NO_3-N levels of >16 mg/kg in the top 0-60 cm of soil, were observed.

Although post-harvest soil NO_3-N levels were generally higher in field plots receiving 280 kg N/ha at sidedress than in those receiving zero treatments, it was surprising that the differences were statistically significant in two of six fields at 0-60 cm depth and one of six fields at 0-120 cm depth. Previous studies have found post-harvest nitrate levels considerably higher with larger sidedress fertilizer inputs, especially at greater depths.

This project is the MS thesis work of Henry Krusekopf, who provided the bulk of this summary.

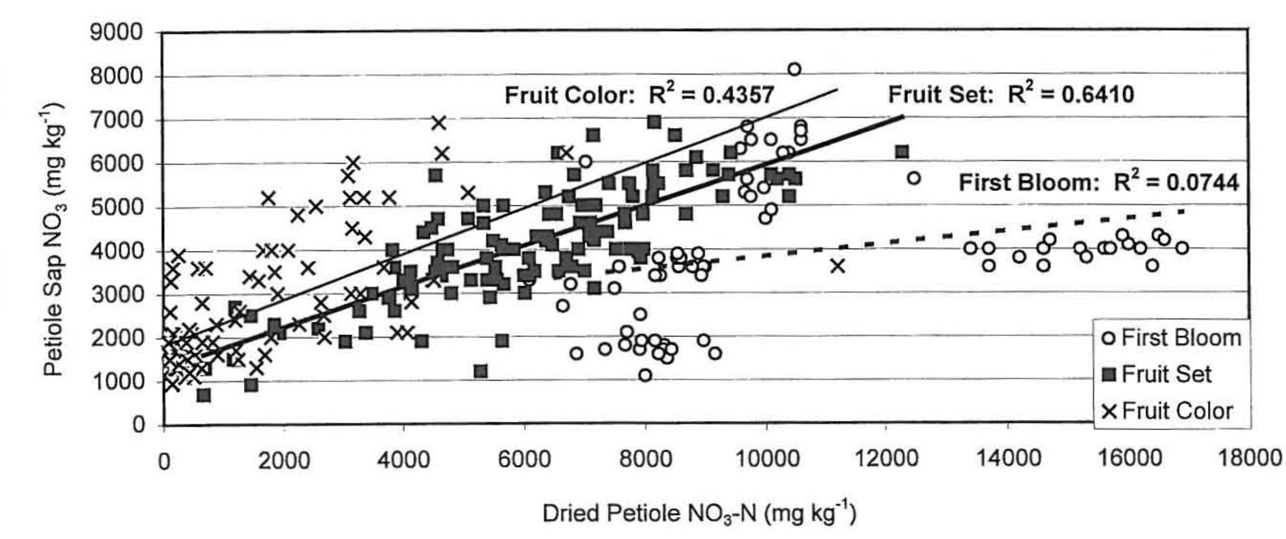


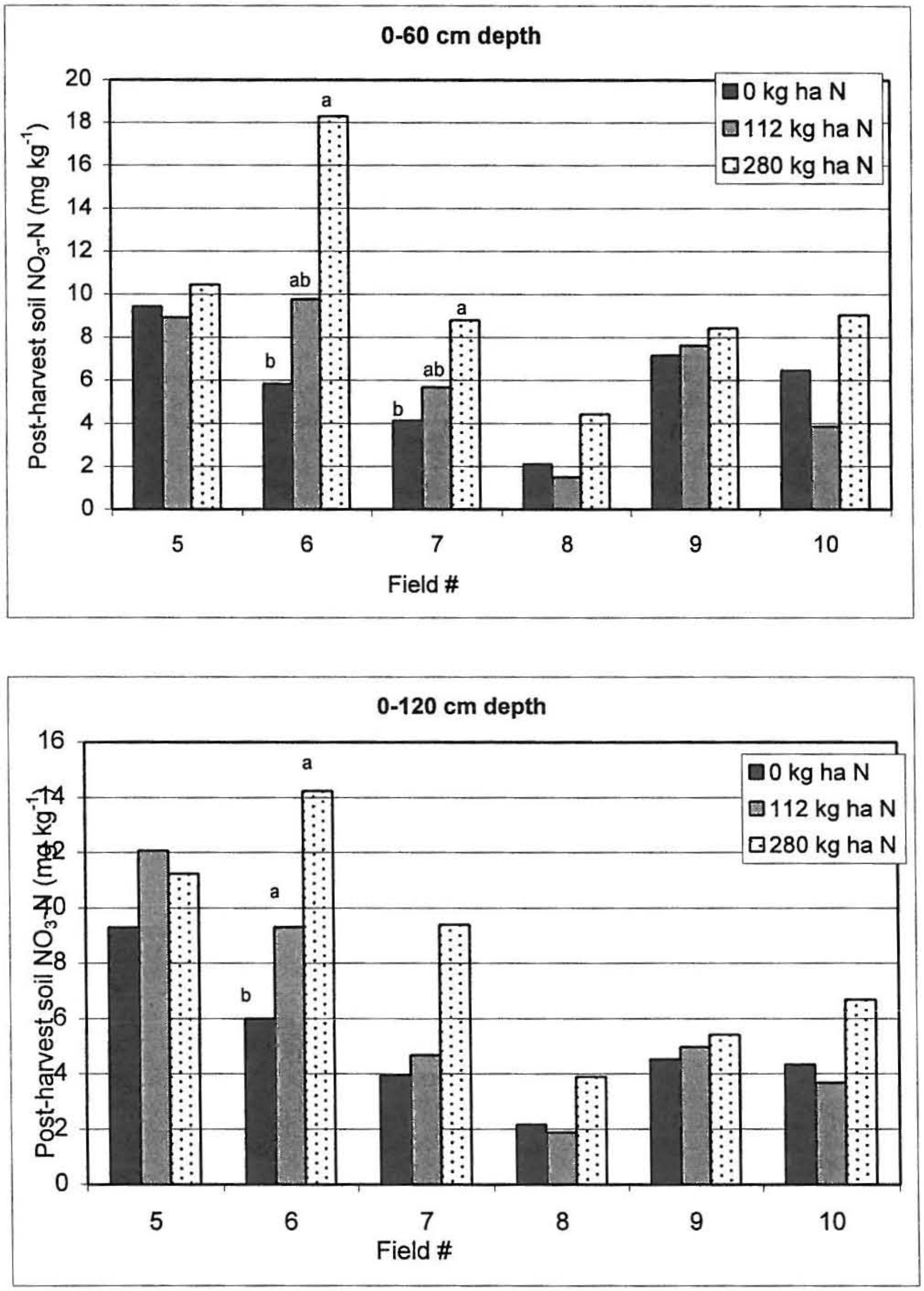
Figure 4. Linear relationships between treatment means of petiole wet sap NO_3 (Cardy Meter) and dried petiole NO_3-N measured at first bloom, fruit set and fruit color sampling.

Table 3. Fields with Fruit Quality Indicators Exhibiting Sidedress N Treatment Effects.

	Fruit Quality Indicator					
Field	*%Red*[a]	*% Green*[a]	*%rots*[a]	*fruit wt.*[b]	*color*[c]	*solids*[d]
1						
2						
3		*				
4		*			*	*
5						
6						
7				*		
8		*				*
9						
10				*		

* Significant fruit quality difference due to treatment rate; Duncan's multiple range test, p=0.05
[a] Percent red, green and rotten unsorted fruit collected on harvester
[b] Total weight of sorted red fruit divided by number of fruit weighed
[c] Blended juice color; ration of green (566 nm) to red (650 nm) light reflected from the juice
[d] Soluble solids content (SS, °brix)

Figure 5. Post-harvest soil NO_3-N concentrations (mg/kg) in top 0-60 and 0-120 cm soil depth. Fields with statistically significant (Duncan's multiple range test; $p<0.05$) sidedress N rate treatment effects on post-harvest soil nitrate levels are denoted by lettering above columns.



Winter Cover Crops Before Late-season Processing Tomatoes For Soil Quality And Production Benefits

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OBJECTIVES

1. Document the contribution of a winter leguminous cover crop to plant nutrition, yield and fruit quality in processing tomatoes in an on-farm field trial.
2. Document the impact of a winter cover crop on soil permeability and winter runoff versus. fallow, pre-bedded ground.
3. Educate other growers and support industry about trial results and cover cropping technique.

DESCRIPTION

Planting fall cover crops in fields that will later be planted to processing tomatoes is a departure from the conventional cultural practice among tomato growers of minimizing weed vegetation prior to seedbed preparation. Vetch cover cropping may help reduce winter weed competition, increase soil organic matter, fix atmospheric N and reduce winter runoff. Incorporating the green manure crop can be a challenge for tomato growers as planting schedules are driven by pre-contracted harvest delivery dates.

Field tests in 1998, 1999 and 2000 in the southern Sacramento Valley near Woodland, were established with a fall planting of a common vetch-pea mix. We found benefits to this practice. Trials were 3-acre plantings in commercial fields with cooperator Blake Harlan of Harlan & Dumars, Inc. The cover crop was drilled into dry beds in the fallow period between two consecutive rotations of tomatoes. The cover crops were germinated with late fall rains. As expected, in all years, cover crop growth was slow during the winter and early spring. The peas were able to grow and develop during the cooler temperatures, compared to vetch, which grew more rapidly during late February and March. Ideally, vetch should be allowed to reach its maximum growth, normally by early April in the Sacramento Valley, before chopping and incorporating the plant biomass to maximize the benefit. In year 2000, our cooperator believed the drier weather conditions during the time of vetch incorporation may have caused plants to become wire-like and thus more difficult to chop and incorporate into the soil. In an effort to retain beds, multiple passes of several tillage tools were needed to prepare the seed bed including a pre-irrigation using sprinklers. An early termination of the crop may have been preferable. Disking the vetch/pea mix and re-bedding was also an option. After the vetch was incorporated and the beds prepared, greenhouse-grown tomato plants were transplanted between late March to April.

Over the years, our plot design remained a randomized complete block with 6 replications with each plot 3 beds wide by 100 feet long. We always evaluated two factors: 1) fallow versus. cover cropping with a vetch-pea mix and 2) spring-applied sidedress N rates of either 0, 50, 100, or 150 lb N/acre. Sidedressed N, as urea, was applied soon after transplants were well established. All other cultural practices were those commonly used by growers in the area. Furrow irrigation combined with spring rain accounted for all the irrigation the crop received in 1998. Sprinklers were used to establish the transplants in 1999 and 2000.

We monitored growth of the tomato plants during the season. Plant tissue samples, petiole as well as whole leaf, were collected at 3 separate growth stages and sent to the UC DANR lab at Davis. Tomato yields suffered when grown solely on the N fixed by the vetch-peas and without benefit of supplemental applied N. We did not see a substantial fertilizer N benefit from the cover crop nor detect large N differences from lab analysis of tissue samples. Tissue analysis of the cover crop indicated 100 to 200 lb of N was 'available' from the leguminous plants.

In the year 2000 trial, the vetch and peas established well with the fall rains, but suffered with a dry December and January. Vetch was more drought tolerant and became the dominant species. We estimated ~200 lb N/acre was fixed by the cover crop.

In 1999 and 2000, a Wilcox Performer® bed mulcher was used to incorporate the cover crop. The ease of cover crop incorporation was different between the two years due primarily to soil moisture. In 1999, the bed mulcher chopped and incorporated the cover crop in two passes and repeated a week later in a single pass for final incorporation and bed shaping. In 2000, multiple passes were required in addition to a pre-irrigation. Prior to incorporation of the cover crop, soil was sampled in cooperation with consultation from Louise Jackson of the Department of Vegetable Crops, University of California-Davis. In all years, tomatoes were transplanted about 2 to 3 weeks after cover crop incorporation.

RESULTS AND CONCLUSIONS

In 1998, we were encouraged by a 5% yield increase and a soluble solids improvement with the cover crop over the fallow-bed treatment. Applied N alone did not explain the yield enhancement. We speculate that incorporation of a leguminous biomass may have been important in changing underground factors such as soil microbial activity. Soluble solids were also increased from 4.7 to 4.9%. Fruit color was reduced from 23.7 to 24.3 as measured by the Processing Tomato Advisory Board. In 1999, yields were also increased, this time by 7%, although fruit quality was reduced.

In February and March 1999, we compared runoff from grouped sets of field-length (~1000') rows of cover crop and fallow beds. Seasonal runoff from the cover crop furrows was 60% or less compared to the fallow furrows. Three techniques were employed over a multiple storm period to assess tail water runoff from fallow versus cover crop beds: 1) a flow meter attached to a sump-type pump; 2) a stage recorder measuring water levels behind a v-notch weir; 3) a 1' x 5' cylinder set in a furrow to measure total water captured. In year 2000, runoff was reduced over 4 times in the cover cropped section compared to the fallow beds.

Harvest of the year 2000 trial is scheduled for mid-September. In addition, a field trial has been expanded to Sutter County. A summary report will be completed in the late fall of 2000.

We anticipate winter grown cover cropping may be attractive to tomato growers transplanting after late April. This planting period will maximize vegetative growth of the vetch cover crop and leave sufficient time to incorporate the green manure crop.

Efficient Irrigation For Reduced Non-point Source Pollution From Low Desert Vegetables

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Grower cooperators will be located as we approach the second phase of the experiments.

INTRODUCTION

Efficient water management remains a high priority in the southwestern United States. While the scarcity of water is a major impetus for improving water use efficiency in agriculture, inefficient irrigation practices are also a factor in water quality related issues. The influence of irrigation practices on salt loading of surface waters has long been recognized. Abundant evidence from southern California and Arizona indicates irrigation practices are a significant factor contributing to N losses from soils used for vegetable production. Recent data from Arizona showed that as irrigation levels increased above the amount required to replace evapotranspiration, N leaching below the root zone increased and crop recoveries of N decreased.

There is a tendency for vegetable growers to apply generous amounts of water to produce because of anxiety about crop quality and the lack of sufficient information to do otherwise. For example, while water consumptive use for lettuce is estimated to be approximately 8 inches, amounts applied frequently exceed 3 feet. Additionally, concerns about salt accumulation having an adverse affect on land sustainability often prompts growers to employ a generous leaching requirement. A perceived lack of practical technologies on irrigation scheduling is another major obstacle to progress in implementing efficient irrigation practices. It is the opinion of the authors that once efficient scheduling and water management strategies are confirmed and demonstrated to vegetable growers in the desert, progress in efficient irrigation will be hastened. However, it is of the utmost importance to show growers that this can be achieved without compromising crop yield and quality and long-term land sustainability. We also must provide education and training in the use of these technologies.

The first phase of this project will experimentally evaluate irrigation scheduling technologies and management practices as well as the influence of irrigation and N fertilization on crop response, N-leaching, and salt balance. The second phase of this project will include training in the use of these technologies and their demonstration in commercial production operations.

OBJECTIVES

1. Evaluate and develop irrigation scheduling criteria for lettuce and melons produced in the low desert and evaluate the influence of irrigation and N fertilization on crop growth, crop N nutrition, N leaching, and salt balance.
2. Conduct an outreach program aimed at promoting and implementing efficient irrigation practice.

DESCRIPTION

Over 98% of all lettuce and a significant percentage of the melons produced in the desert are furrow irrigated and studies were conducted to develop efficient furrow irrigation practices. The first experiments were aimed at verifying or modifying management allowable depletion (MAD) values. The second evaluations were aimed at validating crop coefficients. The third experiments were aimed at developing guidelines for improved system performance for furrow irrigated vegetable production systems.

Because a significant portion of the melon acreage has been converted from furrow to buried drip, studies were also conducted with drip-irrigated melons.

Evaluation of Management Allowable Depletion (MAD) Values, Crop Coefficients (kc), and System Performance for Furrow Irrigated Lettuce and Melons

For the first experiments, treatments were selected such that irrigation were applied at MAD values ranging from 20 to 80% soil water depletion (SWD) in the surface 2 feet. Neutron probe access tubes were installed to a depth of 4.5 feet in all plots. Soil moisture measurements were made at least three times weekly. Irrigation was applied to all replications of a treatment when the mean SWD of the treatments reached the targeted SWD. Growth and yield data were collected so that we could identify MAD values associated with maximum crop production. Data from the treatments receiving optimal irrigation was used calculate kc values from ET as measured by soil water depletion and Penman ET_0 values.

Other studies were conducted to evaluate furrow irrigation performance as influenced by system parameters and variables. During each irrigation event we determined inflow hydrographs, water advance and recession, and water depth profile along the furrow length. These results were used to determine infiltration and roughness parameters using a volume balance approach. A hydrological model will be calibrated and validated using field data. The model will be used to identify system variables which optimize water application efficiency for furrow irrigated desert vegetables.

Bromide tracers were applied to selected plots to evaluate the influence of irrigation practices on anion leaching. Ceramic suction cups were used to collect soil solution samples after each irrigation or rainfall event. Additionally soil samples were collected to a depth of 4.5 feet immediately after crop harvest.

Irrigation for Drip Irrigated Melons

Studies were established to evaluate irrigation scheduling approaches for drip irrigated vegetables. This particular experiment focused on evaluating crop coefficients and the interaction between N management and irrigation management. Treatments were four irrigation regimes ranging from 0.2 to 0.8, Penman ET_0 values. These treatments were in factorial combination with three N fertilizer treatments. Daily irrigation was computed from average ET_0 values as calculated from the previous week weather data. The influence of irrigation regimes on melon's growth and yield were determined from weekly measurements of plant growth and dry matter accumulation as well as marketable yields at maturity.

RESULTS AND CONCLUSIONS

Evaluation of Management Allowable Depletion (MAD) Values, Crop Coefficients (Kc), and System Performance for Furrow Irrigated Lettuce and Melons

The relationship between depletion of available moisture to 1 to 2 feet soil depths and the relative yield of iceberg lettuce across all experiments show yields decline rapidly as available soil moisture is depleted below 40% available water. Lettuce is a shallow-rooted crop and the data show that there is no advantage to monitoring soil moisture depletion to 2 feet instead of one foot. We propose using a MAD of 35% for scheduling irrigation of iceberg lettuce. We hope to complete MAD values for melons this coming season.

Preliminary data suggest crop coefficients (kc values) for lettuce are approximately 0.1 and increase to 0.6 to the rapid growth phase. Interestingly, these data agree closely with lysimeter estimates determined previously. We are still in the process of compiling much of this data and hope to complete validation of kc values for lettuce and melons this coming year.

Infiltration and roughness parameters were calculated from irrigation evaluations. These parameters were used to calibrate a Zero inertia model. We are currently in the process of using independent field data to validate the model. Once models are validated we will perform simulations to identify design management criteria associated with optimal efficiency.

As of the writing of this report we have not completed analysis and compilation of soil solution and soil data for bromide and nitrate in these experiments.

Irrigation for Drip Irrigated Melons

The irrigation regimes applied ranged from 0.36 to 0.8 ET_0 and from 0.17 to 0.66 ET_0 the first and second experiments, respectively. There were no statistically significant differences in dry matter accumulation to irrigation regime in the first experiment. At the latter sample times, growth on plots receiving N fell behind those receiving N. It seemed the high irrigation regimes delayed maturity because they produced significantly less yield at the first harvest date and significantly more yield at the last harvest date. Interestingly, midrib NO_3-N values declined for the highest irrigation regime at the final sample date. Based on the results of the first experiment, we made the decision to lower all irrigation regimes for subsequent experiments. The second experiment was compromised by the irrigation practices of our neighbor located immediately north of our plots. Results from the third experiment are currently being analyzed.

Nitrogen Fertilization And Grain Protein Content In California Wheat

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INTRODUCTION

The nitrogen fertilization requirements for wheat depend on factors such as yield potential, the previous crop and residual fertility from it, soil fertility, and plans for irrigation. Nitrogen applications are made preplant, with seed, at tillering and/or at various other growth-stages during the season. In practice, total seasonal N applications may vary from 0 to over 300 lb N/acre, with some acreage over-fertilized and some acreage under-fertilized because of the difficulty of matching fertilizer need with yield potential in each growing season. Also, grain protein content may be higher or lower than the desirable level despite the use of identical rates of N fertilization. Anthesis-time (flowering-time) N applications, in combination with irrigation, can be made to increase grain protein content and improve baking quality. Such applications can increase grain protein content by 1-3%. However, growers currently are unable to determine what the ending protein status of the crop is likely to be under such management – that is, is the potential 3% increase from 11 to 14% or from 8 to 11%. If the former is true, the grower may qualify for a price premium based on grain protein content. If the latter is true, no price premium will be available. In order to produce high quality wheat consistently and economically, growers need to be able to determine: (1) if anthesis-time N fertilization is needed to reach the target (13%) grain protein level and, if so, (2) how much N must be applied. Wheat growers (primarily in the Central Valley), crop consultants, farm and advisors will be able to apply findings from the project in their attempt to produce high quality wheat in a cost-effective manner.

Research conducted throughout California by Ken Cassman and associates at the University of California, Davis, Department of Agronomy and Range Science from 1986–1989 revealed the promise and problems associated with attempts to predict grain protein response from anthesis-time N applications. Such applications were most efficient at raising grain protein content if the proportion of the N requirement provided by preplant application was low. The N-partitioning mode of the plant appeared to be established before anthesis. Nitrogen acquired after anthesis was partitioned in a predetermined ratio between grain and vegetative tissues, and the mode remained in effect across a wide-range of post-anthesis N supply levels. If the preplant N proportion was high, excessive plant biomass was produced and anthesis-applied N was inefficiently partitioned to the grain. For optimal production of high protein wheat, the preplant N amount had to be high enough for the yield potential to be realized, yet not so high that excessive vegetative biomass was produced.

Table 1. Nitrogen fertilization and grain protein content in California wheat. Effects of anthesis-time nitrogen applications on yield and agronomic characters of "Kern" wheat in 2000. Sacramento Valley Sites: Chico State University Farm, Butte County; Erdman Ranch, Colusa County; and UC Davis Agronomy Farm, Yolo County

Site/ Treatment	*Anthesis-N Rate (lb/acre)*	*Yield (lb/bu)*	*Test Weight (lb/bu)*	*1000 Kernel Weight (g)*	*Plant Height (in.)*	*Lodging (harvest)*	*Days to Head (From 3/1)*	*Days to Mature (From 3/1)*	*BYDV*	*Septoria tritici blotch*
Butte Co										
1	0	5800 (02)	64.5	44.7	33	-	-	-	-	-
2	30 (as NH_4NO_3)	5540 (03)	64.4	43.8	33	-	-	-	-	-
3	60 (as NH_4NO_3)	5910 (01)	64.7	46.3	34	-	-	-	-	-
4	30 (as Foliar Urea)	5490 (04)	64.6	45.2	35	-	-	-	-	-
Mean		5680	64.6	45.0	33	-	-	-	-	-
CV (%)		4.6	0.2	2.9	5.4					
LSD (.05)		ns	ns	ns	ns					
Colusa Co.										
1	0	5240 (04)	62.3	49.8	-	1.3	-	-	-	-
2	30 (as NH_4NO_3)	5470 (01)	62.5	49.7	-	1.5	-	-	-	-
3	60 (as NH_4NO_3)	5310 (03)	62.7	50.8	-	1.5	-	-	-	-
4	30 (as Foliar Urea)	5460 (02)	63.1	49.9	-	1.3	-	-	-	-
Mean		5370	62.6	50.0	-	1.4	-	-	-	-
CV (%)		5.0	0.2	0.9		36.4				
LSD (.05)		ns	0.5	ns		ns				
UC Davis										
1	0	5560 (01)	64.9	46.7	35	1.8	25	75	3	1.5
2	30 (as NH_4NO_3)	5430 (04)	64.6	48.2	34	1.8	25	74	3	1.5
3	60 (as NH_4NO_3)	5530 (02)	64.4	47.3	34	1.5	25	75	3	1.8
4	30 (as Foliar Urea)	5490 (03)	64.8	46.2	36	1.8	25	75	3	2
Mean		5500	64.7	47.1	35	1.7	25	75	3	1.7
CV (%)		5.6	0.2	1.6	2.9	31.6	-	3.2	-	39.8
LSD (.05)		ns	ns	ns	ns	ns		ns		ns
3-Location Summary										
1	0	5530 (02)	-	-	-	-	-	-	-	-
2	30 (as NH_4NO_3)	5480 (04)	-	-	-	-	-	-	-	-
3	60 (as NH_4NO_3)	5580 (01)	-	-	-	-	-	-	-	-
4	30 (as Foliar Urea)	5480 (03)	-	-	-	-	-	-	-	-
Mean		5520		-	-	-	-	-	-	-
CV (%)		5.1								
LSD (.05)		ns								

Rating scale for diseases (area of flag-1 leaf affected at soft dough stage) and lodging: 1=0-3%, 2=4-14%, 3=15-29%, 4=30-49%, 5=50-69%, 6=70-84%, 7=85-95%, 8=96-100

BYDV ratings (see scale above) were based on percentage of plants showing foliar symptoms.

Numbers in parentheses indicate relative rank in column.

Another finding was that flag-leaf N content at anthesis was positively correlated with grain N content (but not with grain yield) at maturity. If flag-leaf N content was greater than 4%, additional N usually was not required to achieve the target (13%) grain protein content. In order to accurately estimate anthesis-time N requirements, however, it is necessary to be able to predict both final grain N content and grain yield at anthesis.

The experiments conducted by Cassman and associates were done with cultivars "Anza" and "Yolo", low protein cultivars adapted to the Sacramento Valley, and "Yecora Rojo" and "Klasic", higher protein cultivars adapted to the San Joaquin Valley. The cultivars used in the current experiments are "Kern" and "Kronos". "Kern is a recently released cultivar that is intermediate in protein content compared with the low protein cultivars "Anza" and "Yolo" and the high protein

Table 2. Nitrogen fertilization and grain protein content in California wheat. Effects of anthesis-time nitrogen applications on grain yield, biomass, and nitrogen tissue content of "Kern" wheat in 2000. Sacramento Valley Sites: Chico State University Farm, Butte County; Erdman Ranch, Colusa County; and UC Davis Agronomy Farm, Yolo County

			Anthesis				14 Days Post Anthesis			
Site/ Treatment	Anthesis-N Rate (lb/acre)	Yield (lb/acre)	Flag Leaf SPAD CT	Flag Leaf N %	Stem N %	Biomass (g/m-row)	Flag Leaf SPAD CT	Flag Leaf N %	StemN %	Biomass (g/m-row)
Butte Co										
1	0	5800/(02)	40.3	3.39	1.44	217.0	42.5	3.15	1.21	212.3
2	30 (as NH_4NO_3)	5540/(03)	40.7	3.52	1.52	217.5	43.8	3.44	1.45	216.5
3	60 (as NH_4NO_3)	5910/(01)	40.4	3.45	1.48	215.8	43.8	3.35	1.41	187.3
4	30 (as Foliar Urea)	5490/(04)	42.0	3.66	1.53	212.0	41.4	3.17	1.32	209.0
Mean		5680	40.8	3.50	1.49	215.6	42.9	3.28	1.35	206.3
CV (%)		4.6	3.39	7.5	6.4	7.6	4.45	8.0	12.4	13.5
	$LSD_{(0.05)}$	ns	ns	ns	ns	ns	ns	ns	ns	ns
Colusa Co.										
1	0	5240/(04)	43.8	3.69	1.54	182.5	42.7	3.09	1.18	256.0
2	30 (as NH_4NO_3)	5470/(01)	45.1	3.75	1.53	222.0	44.6	3.42	1.28	250.8
3	60 (as NH_4NO_3)	5310/(03)	44.4	3.71	1.54	172.8	44.3	3.45	1.28	208.0
4	30 (as Foliar Urea)	5460/(02)	44.2	3.79	1.59	194.0	45.8	3.59	1.25	241.0
Mean		5370	44.4	3.73	1.55	192.8	44.4	3.39	1.25	238.9
CV (%)		5.0	4.19	5.7	7.5	19.0	3.53	6.0	5.7	13.6
	$LSD_{(0.05)}$	ns	ns	ns	ns	ns	ns	0.3	ns	ns
UC Davis										
1	0	5560/(01)	43.4	3.63	1.52	194.5	44.2	2.85	1.05	206.8
2	30 (as NH_4NO_3)	5430/(04)	42.4	3.32	1.44	173.0	45.0	3.47	1.25	194.5
3	60 (as NH_4NO_3)	5530/(02)	41.7	3.20	1.39	175.5	44.3	3.33	1.18	230.3
4	30 (as Foliar Urea)	5490/(03)	42.6	3.10	1.42	176.0	43.8	3.14	1.15	193.3
Mean		5500	42.5	3.31	1.44	179.8	44.3	3.20	1.16	206.2
CV (%)		5.6	4.81	6.7	5.6	15.5	2.2	4.0	5.7	10.1
	$LSD_{(0.05)}$	ns	ns	0.4	ns	ns	ns	0.2	0.1	ns

Numbers in parentheses indicate relative rank in column. SPAD CT: Minolta SPAD-502 Chlorophyll Meter readings.

Soil Nitrogen (ppm):	NO_3-N	NH_4-N
Butte: Preplant	21.33	25.35
At anthesis	1.00	15.98
Colusa: Preplant	28.88	10.50
At anthesis	0.93	6.80
UC Davis: Preplant	16.25	11.40
At anthesis	2.05	7.43

cultivars "Yecora Rojo" and "Klasic". "Kronos" is the most widely grown durum wheat cultivar in California. In recent years, durum wheat has replaced common (bread) wheat in portions of the San Joaquin Valley. Grain protein content for durum, as for bread wheat, is a critical quality factor. Nitrogen management for durum also is important for minimizing black point. Black point is a cause for rejection of durum wheat by mills since black specks from milled durum wheat discolor the semolina that is produced.

OBJECTIVES

The primary objective of this two-year project is to link N status and crop yield potential (based on crop biomass) at anthesis with a desired level of response of grain N content (i.e., final grain protein content of 13%) to specific rates of anthesis-applied N. Experiments were designed to measure the response of grain protein content to different rates (0, 30, and 60 lb N/acre) of anthesis-time N fertilization under different pre-anthesis N management practices (thus different yield potentials). Efficacy of broadcast vs. foliar-applied N also is being compared. Future work will focus on identifying predictive quick tests for use in fine-tuning anthesis-time N application rates.

DESCRIPTION

The project is managed within the framework of the UC Statewide Small Grain Evaluation program led by Project Leader, Lee Jackson, Extension Agronomist and Statewide Cereal Specialist. Experimental sites are among those used in the UC Regional Cereal Testing Program. For the 1999/2000 season, three sites were established in the Sacramento Valley using the common wheat cultivar "Kern" and three sites were established in the San Joaquin Valley using the durum wheat cultivar "Kronos". The sites in the Sacramento Valley were the Chico State University farm in Chico (Butte County), the Erdman ranch near Grimes (Colusa County), and the UC Davis Agronomy Farm. The sites in the San Joaquin Valley were the Dupont Research Farm (Madera County), the J.G Boswell farm in Corcoran (Kings County), and the J.G Boswell Kern Lake Ranch (Kern County). University of California Cooperative Extension Farm Advisors Cass Mutters (Butte County), Doug Munier (Glenn County), Jerry Schmierer (Colusa County), Ron Vargas (Madera County), Steve Wright (Tulare/Kings Counties), and Brian Marsh (Kern County) were responsible for arranging for use of grower fields, working with and advising the growers on field management operations, and assisting in the application of anthesis-time N, collection of biomass samples and tissue samples for N determination, and plot harvest. Project Leader Lee Jackson's Staff Research Associate Ray Wennig coordinated the sowing of the experiments, collection of soil samples, application of anthesis-time N treatments, collection of biomass and tissue samples, flag-leaf chlorophyll meter readings, harvest of the plots, and data analysis.

Plots (each 25' x 12') were sown in fall, 1999, at each site using randomized complete block designs with four replications. Composite soil samples (0-12" depth) were taken at each site at the time of sowing and also just prior to the application of anthesis-N to provide information on the differing N-status of each site. Crop management through anthesis followed accepted grower practices at each site, thus providing differing crop biomass and N status environments. Variable rates of N (0, 30, and 60 lb N /acre as ammonium nitrate and 30 lb N/acre as foliar-applied urea) were applied at anthesis. Plots were irrigated following the N application. Crop biomass and N content of specific tissues (flag-leaf and uppermost stem internode) were measured at the time of anthesis-applied N, 14 days post-anthesis, and at harvest. Flag-leaf chlorophyll meter readings also were taken at the time of anthesis-applied N and 14 days post-anthesis. Crop biomass samples at each sampling date consisted of plants from 1-meter row/plot cut at the ground level. Subsamples of flag leaves and uppermost stem internodes were drawn from the biomass samples for total tissue N determination. Grain yield, grain N content, bushel weight, kernel weight and harvest index were measured at harvest. Crop biomass samples were partitioned into straw and grain for harvest index determination.

RESULTS AND CONCLUSIONS

The sites and grower practices used provided different N-supply and grain yield environments at each location. Anthesis-N applications did not affect grain yield or agronomic characteristics (test weight, kernel weight, plant height, lodging, maturity, or disease severity at any location (Tables 1 and 3), despite different yield potentials at each site and different soil N supply available both preplant and at anthesis (immediately prior to the application of anthesis-N) (Tables 2 and 4).

Average flag leaf N-content at anthesis (just prior to applying the anthesis N treatments) ranged from 3.39 to 3.66% at Butte, from 3.69 to 3.79% at Colusa, from 3.10 to 3.63% at Davis, from 3.06 to 3.38% at Madera, from 3.67 to 3.88% at Kings, and from 3.77 to 3.87% at Kern, indicating inherent within site variability. At the measured levels of flag leaf N-content at anthesis (all lower than 4%), responses of grain protein content to anthesis-applied N are expected. Average uppermost internode N-content at anthesis showed a similar level of within site variability to flag leaf N-content, ranging from 1.44 to 1.52% at Butte, from 1.53 to 1.59% at Colusa, from 1.39 to 1.52% at Davis, from 1.21 to 1.42% at Madera, from 1.51 to 1.62% at Kings, and from 1.43 to 1.49% at Kern.

Flag leaf N-content and uppermost internode N-content at 14 days post-anthesis (14 days following application of the anthesis N treatments) generally were lower than those measured at the time of the application of the treatments (Tables 2 and 4). There were significant differences, however, in flag leaf N-content among anthesis-N treatments at some locations (Colusa, UC Davis), and a trend toward increases in tissue-N levels above those for the zero rate of anthesis-applied N for the 30 and/or 60 lb/acre rate of N as NH_4NO_3 at Butte, Madera, Kings and Kern. There were significant increases in tissue-N levels above those for the zero rate of anthesis-applied N for the 30 lb/acre rate of N as foliar urea at Colusa and UC Davis, and a trend toward increases at Madera, Kings, and Kern but not at Butte.

Flag leaf chlorophyll readings (with a Minolta SPAD-502 Chlorophyll Meter) taken 14 days post-anthesis were not significantly affected by the different rates of N applied at anthesis (Tables 2 and 4). Flag leaf chlorophyll may have peaked prior to the measurements and decreased by the time readings were taken due to translocation of N from the flag leaf to the developing grain. We will do a time-course of SPAD readings next season to identify the optimum time to take the measurements for best correlation with final grain protein content and tissue-N content. Uppermost internode N-content at 14 days post-anthesis, as with flag leaf chlorophyll, did not reflect differences in flag-leaf N-content at that time of sampling.

Flag leaf chlorophyll of the durum wheat cultivar "Kronos" tended to be higher, by 5 to 10 SPAD units, than those of the common wheat cultivar "Kern" at similar flag-leaf N-contents (Tables 2 and 4). Different critical values for relating SPAD readings to N content (and ultimately to the need for anthesis-N topdressing to achieve target grain protein levels) may be needed for the different classes of wheat grown in the Sacramento and San Joaquin Valley environments of California.

At the time of this report (September 1) analysis of grain protein content had not been completed. Harvest biomass samples also still were being processed. Measurements of biomass at the time of anthesis-N applications, biomass at 14 days post anthesis, biomass at harvest, and final grain protein content all are needed before the relationship between tissue N-content at anthesis and final grain protein content can be clarified.

Table 3. Nitrogen fertilization and grain protein content in California wheat. Effects of anthesis-time nitrogen applications on yield and agronomic characters of "Kronos" Durum wheat in 2000. San Joaquin Valley Sites: Dupont Research Facility, Madera County; J.G. Boswell Ranch, Corcoran, Kings County; and J.G. Boswell Kern Lake Ranch, Kern County

Site/ Treatment	*Anthesis-N Rate (lb/acre)*	*Yield (lb/acre)*		*Test Weight (lb/bu)*	*1000 Kernel Weight (g)*	*Plant Height (in)*	*Lodging (harvest)*	*Black Point[1]*
Madera Co								
1	0	5650	(03)	63.4	64.5	38	1.0	1.0
2	30 (as NH_4NO_3)	6000	(01)	63.3	64.9	36	1.0	1.0
3	60 (as NH_4NO_3)	5910	(02)	63.0	66.1	36	1.3	1.0
4	30 (as Foliar Urea)	5580	(04)	63.4	63.1	36	1.3	1.0
Mean		5790		63.3	64.7	36	1.1	1.0
CV (%)		11.4		0.4	5.3	1.6	33.1	-
LSD (.05)		ns		ns	ns	ns		
Kings Co								
1	0	6390	(02)	62.6	63.9	35	6.5	1.0
2	30 (as NH_4NO_3)	6340	(03)	62.4	61.7	35	6.5	1.0
3	60 (as NH_4NO_3)	6510	(01)	62.4	62.9	34	6.5	1.0
4	30 (as Foliar Urea)	6250	(04)	62.3	63.4	35	6.5	1.0
Mean		6370		62.4	63	35	6.5	1.0
CV (%)		7.5		0.7	3.7	1.7	6.3	-
LSD (.05)		ns		ns	ns	ns	ns	
Kern Co								
1	0	4110	(03)	58.1	49.0	-	8.0	1.0
2	30 (as NH_4NO_3)	4570	(01)	57.6	48.3	-	8.0	1.5
3	60 (as NH_4NO_3)	3780	(04)	58.0	46.5	-	8.0	1.0
4	30 (as Foliar Urea)	4310	(02)	57.7	47.8	-	8.0	1.5
Mean		4190		57.8	47.9		8.0	1.3
CV (%)		16.7		1.4	3			46.2
LSD (.05)		ns		ns	ns			ns
3-Location Summary								
1	0	5380	(03)	-	-	-	-	-
2	30 (as NH_4NO_3)	5640	(01)	-	-	-	-	-
3	60 (as NH_4NO_3)	5400	(02)	-	-	-	-	-
4	30 (as Foliar Urea)	5380	(04)	-	-	-	-	-
Mean		5450						
CV (%)		11.4						
LSD (.05)		ns						

[1]Rating scale for black point and lodging: 1=0-3%, 2=4-14%, 3=15-29%, 4=30-49%, 5=50-69%, 6=70-84%, 7=85-95%, 8=96-100.

Numbers in parentheses indicate relative rank in column.

Table 4. Nitrogen fertilization and grain protein content in California wheat. Effects of anthesis-time nitrogen applications on grain yield, biomass and nitrogen tissue content of "Kronos" Durum wheat in 2000. San Joaquin Valley Sites: Dupont Research Facility, Madera County; J.G. Boswell Ranch, Corcoran, Kings County; and J.G. Boswell Kern Lake Ranch, Kern County.

			Anthesis				14 Days Post Anthesis			
Site/ Treatment	Anthesis-N Rate (lb/acre)	Yield (lb/acre)	Flag Leaf SPAD CT	Flag Leaf N %	Stem N %	Biomass (g/m-row)	Flag Leaf SPAD CT	Flag Leaf N %	Stem N %	Biomass (g/m-row)
Madera Co										
1	0	5650/(03)	49.2	3.38	1.42	176.3	50.0	2.98	0.90	255.8
2	30 (as NH_4NO_3)	6000/(01)	48.8	3.27	1.37	173.0	51.1	3.10	1.03	243.5
3	60 (as NH_4NO_3)	5910/(02)	50.0	3.33	1.37	188.3	52.4	3.74	1.14	244.3
4	30 (as Foliar Urea)	5580/(04)	45.5	3.06	1.21	170.8	50.5	3.43	1.10	238.3
Mean		5790	48.4	3.26	1.34	177.1	51.0	3.31	1.04	245.4
CV (%)		11.4	5.14	10.1	8.3	12.9	6.38	12.6	14.3	12.7
LSD (.05)		ns	ns	ns	ns	ns	ns	ns	ns	ns
Kings Co										
1	0	6390/(02)	53.6	3.87	1.54	222.3	52.0	3.27	0.98	267.5
2	30 (as NH_4NO_3)	6340/(03)	54.7	3.88	1.62	252.5	52.9	3.72	1.20	241.8
3	60 (as NH_4NO_3)	6510/(01)	53.0	3.82	1.51	257.0	53.9	3.67	1.17	294.8
4	30 (as Foliar Urea)	6250/(04)	54.0	3.67	1.57	237.0	52.7	3.60	1.14	278.0
Mean		6370	53.8	3.81	1.56	242.2	52.9	3.57	1.12	270.5
CV (%)		7.5	2.43	5.1	5.2	10.9	1.85	6.9	18	14.4
LSD (.05)		ns	ns	ns	ns	ns	ns	ns	ns	ns
Kern Co										
1	0	4110/(03)	51.2	3.87	1.43	244.0	46.6	3.22	1.30	265.5
2	30 (as NH_4NO_3)	4570/(01)	51.3	3.81	1.49	237.5	45.8	3.06	1.35	302.8
3	60 (as NH_4NO_3)	3780/(04)	49.0	3.77	1.48	219.8	45.6	3.39	1.34	258.0
4	30 (as Foliar Urea)	4310/(02)	50.8	3.81	1.44	238.5	48.0	3.36	1.26	312.3
Mean		4190	50.6	3.82	1.46	234.9	46.5	3.26	1.31	284.6
CV (%)		16.7	4.57	5.0	8.1	11.7	4.59	6.7	9.6	15.1
LSD (.05)		ns	ns	ns	ns	ns	ns	ns	ns	ns

Numbers in parentheses indicate relative rank in column. SPAD CT: Minolta SPAD-502 Chlorophyll Meter readings.

Soil Nitrogen (ppm):	NO_3-N	NH_4-N
Madera: Preplant	42.40	44.00
At anthesis	0.63	2.78
Kings: Preplant	23.85	37.38
At anthesis	5.58	6.50
Kern: Preplant	24.25	5.80
At anthesis	4.98	22.28

Development And Demonstration Of Nitrogen Best Management Practices For Sweet Corn In The Low Desert

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INTRODUCTION

Sweet corn acreage in the US is about 235,760 acres (95,449.4 hectares) with Florida being the major production area. California ranks second with approximately 28,800 acres of production. Sweet corn is an important crop produced during the fall and spring in the low desert. Large amounts of N fertilizer per acre are typically used to produce high quality sweet corn. Rates of N applied to sweet corn in the desert often exceed ~270 lb N/acre. Nitrogen is applied at planting, multiple side dressings and with the irrigation water. Public health concerns about nitrate contamination of ground and surface water has prompted improved N management strategies for crop production in the desert.

OBJECTIVES

1. Evaluate and demonstrate efficient N fertilizer practices for sweet corn, including the use of rate, timing, placement and use of controlled release N fertilizers to develop Best Management Practices.
2. Develop and demonstrate diagnostic tools for N management of desert-grown sweet corn.
3. Evaluate the effect of N management on post-harvest quality of sweet corn.

DESCRIPTION

Sweet corn growers have different cultural practices. One of our cooperators applies three N fertilizer applications after planting, not including pre-plant application. This cooperator grows a spring and a fall sweet corn crop. With this cooperator our experiments consist of the following 8 treatments in a 2^3 factorial design.

1. No sidedress N	5. First and second sidedress
2. First sidedress N only	6. First and second sidedress
3. Second sidedress only	7. Second and third sidedress
4. Third sidedress only	8. First, second and third sidedress

Our other grower cooperator applies two N fertilizer applications after planting, not including preplant application. This cooperator only grows a spring sweet corn crop. With this cooperator our experiments consist of the following 4 treatments in a 2^2 factorial design.

1. No sidedress N
2. First sidedress N only
3. Second sidedress
4. First and second sidedress

Rates of N in each sidedress application were those actually used by cooperating growers and ranged from 30 gallons per acre (gpa) to 50 gpa of UN32 (approximately 70 to 118 kg N/ha).

Four field experiments were conducted in 1999 to evaluate, and demonstrate to growers several diagnostic tools. The experiments were designated as 47, 47A, 47B, 47C and were conducted in grower fields in the Thermal and Indio areas of the Coachella Valley.

The crop (sweet corn), planting date, final harvest and location of each experiment are shown below.

Experiment	Planting Date	Harvesting Date	Location
47	2-13-99	6-3-99	Thermal
47A	3-17-99	6-18-99	Indio
47B	8-20-99	11-1-99	Thermal
47C	8-30-99	11-16-99	Thermal

In all experiments sweet corn was seeded to stand in single rows. Individual plots in all sites were approximately 700 ft^2; 50 ft x 14.0 ft in size. All pest control and cultural operations were performed using standard practices. All stands were established using sprinkler irrigation and later on water was applied by furrow irrigation.

Postharvest evaluations were conducted on experiment 47B and 47C. Samples were packed in wax cartons, cooled overnight at a commercial operation, and shipped overnight express mail with ice packs in experiment 47B and no ice packs in 47C. Samples of 12-15 ears were taken from each of 4 field replications per treatment. Samples were placed at 32°F when received at the Mann Laboratory at University of California, Davis. Initial evaluations were begun on the day of reception but took up to 24 hours to complete. For storage, samples were held at 41°F (5°C) in the commercial cartons and evaluated after 6 and 12 days.

RESULTS AND CONCLUSIONS

Studies conducted in 1999 were designed to evaluate the response of sweet corn to sidedress N fertilizer applications and test the effectiveness of various diagnostic plant tests as predictive tools. To do this we had to build up a database sufficiently large to correlate and recalibrate plant and soil tissue tests if needed. The information presented is for experiments conducted in 1999 and the data are still too preliminary to present conclusions. Experiments for fall 2000 are now in progress. Unfortunately, most of the fields selected in 1999 had high residual N values and positive responses to N fertilizer were minimal. The results are presented in Tables 1-3. Only the corn in experiment 47 showed an occasional positive response to N fertilization.

For stalk nitrate-evaluations, we used the critical values reported by Doerge et al. 1991. These values were 9000 ppm at the 3-leaf stage, 12,000 ppm at the 6-leaf stage, 11,000 ppm at the 9-leaf stage, and 9000 ppm at the 12-leaf stage. With the exception of experiment 47, all stalk NO_3-N concentrations were above those critical concentrations previously identified and there were no positive responses to N fertilization. For experiment 47, we did diagnose some defi-

Table 1. Comparison of predicted and actual response of sweet corn to sidedress N based on stalk values.

Experiment No.	*Sidedress*	*Stalk*	*Diagnosis*	*Predicted Response*	*Actual Response Yield*	*Diagnostic Accuracy*
47A	1	9875	D	+	-	E_1
47	2	5125	D	+	+	C
	2	5125	D	+	-	E_1
47A	2	9750	S	-	-	C
	2	10000	S	-	-	C
47B	2	16250	S	-	-	C
	2	16250	S	-	-	C
47C	2	21250	S	-	-	C
	2	22500	S	-	-	C
47	3	9500	S	-	-	C
	3	9750	S	-	-	C
	3	8250	D	+	+	C
	3	10000	S	-	-	C

S=Sufficient; D=Deficient; (+)= positive response; (-)= negative response; E_1= Error in diagnosis by predicting positive response that did not occur; C= correct response.

ciencies. However, there were also some errors in our method of diagnosis.

We used 20 ppm as a preliminary soil test critical level. With the exception of experiment 47, all soil NO_3-N levels were above this preliminary critical concentration and there were no positive responses to N fertilization. In experiment 47, the quick soil test diagnosed sufficiency, but our diagnosis was not always correct in that we predicted no response and yet there was a response. This indicates an error on our part.

Overall, our data indicate a general lack of response to N fertilization due to abundant residual soil N. During the 2000 experiments we are looking for sites with low residual N so that we can evaluate plant and soil tests as tools for managing N in the desert.

In Experiment 47B there were no differences in maturity, tip or ear fill of sweet corn from the fertilization treatments (Table 4). Pericarp toughness was slightly less in some of the treatments. About 15% of the total dry weight of the kernels (average = 21%) was pericarp. There were no differences in the sugar content of the kernels at harvest. Color of the husks and kernels did not vary among the fertilization treatments.

Sweet corn was stored in commercial waxed cartons at 41°F (5°C) and had marketable visual quality at 6 and 12 days of storage (Table 5). Noticeable superficial decay appeared on the silks by day 6 but did not increase with further time in storage (perhaps related to drying of the silks with longer time in storage). There were no differences in the visual quality of the stored corn among the treatments. Dry weight percentage did not change significantly during the 12 days, but soluble solids decreased on average by 25% (13.9% at day 0 vs 10.4% at day 12). There were no consistent differences in soluble solids among the fertilization treatments, although by day 12 corn from the control treatment had higher % soluble solid content.

In Experiment 47C quality and maturity were much more variable than in the corn from 47B. Samples from field replication 3 in particular were immature and had poorly formed and filled ears. Poor quality ears were eliminated as much as possible. Differences in maturity, tip fill and ear fill of corn were minimal among the treatments (Table 6). The dry weight content and pericarp content of the kernels did not differ among the field treatments either. There were significant but small differences in color of the kernels, probably due to differences in maturity than true differences due to fertilizer treatments but not on the husks (Table 7).

The stored corn in Experiment 47C had lower quality after 12 days than did corn from experiment 47B (Table 8). By 12 days, visual quality of the husks and silks was below what could be considered marketable, however the husked ears were still of good quality. Superficial decay on the silks was also higher than in experiment 47B, but again visible colonization of decay organisms by day 6 was similar to that observed on day 12. This indicates that molds cannot grow well at 41°F and their initial growth was favored by cooling delays from the unrefrigerated overnight transport to the laboratory in this experiment. In future experiments, samples will be sent with ice packs or under refrigerated transport. The green color of the husks decreased with storage time. Dry weight percentage did not change significantly during the 12 days,

Table 2. Comparison of predicted and actual response of sweet corn to sidedress N based on conventional soil values.

Experiment No.	*Sidedress*	*Conventional Soil (ppm)*	*Diagnosis*	*Predicted Response*	*Actual Response Yield*	*Diagnostic Accuracy*
47	1	24.3	S	-	-	C
47A	1	86.6	S	-	-	C
47B	1	73.7	S	-	-	C
47C	1	65.1	S	-	-	C
47	2	35.4	S	-	+	E_2
	2	33.2	S	-	-	C
47A	2	44.1	S	-	-	C
	2	80.2	S	-	-	C
47B	2	91.1	S	-	-	C
	2	114.2	S	-	-	C
47C	2	50.3	S	-	-	C
	2	134.8	S	-	-	C
47	3	107.2	S	-	-	C
	3	129.2	S	-	-	C
	3	104.7	S	-	+	E_2
	3	149.5	S	-	-	C

S=Sufficient; (+)= positive response; (-)= negative response; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 3. Comparison of predicted and actual response of sweet corn to sidedress N based on quick soil values.

Experiment No.	Sidedress	Quick Soil	Diagnosis	Predicted Response	Actual Response Yield	Diagnostic Accuracy
47	1	32.2	S	-	-	C
47A	1	31.1	S	-	-	C
47B	1	81.6	S	-	-	C
47C	1	73.4	S	-	-	C
47	2	36.2	S	-	+	E_2
	2	24.9	S	-	-	C
47A	2	38.2	S	-	-	C
	2	64.4	S	-	-	C
47B	2	74.3	S	-	-	C
	2	61.9	S	-	-	C
47C	2	52.6	S	-	-	C
	2	87.1	S	-	-	C
47	3	34.8	S	-	-	C
	3	37.0	S	-	-	C
	3	29.3	S	-	+	E_2
	3	41.8	S	-	-	C

S=Sufficient; (+)= Positive response; (-)= Negative response; E_2= Error in diagnosis by predicting no response to N but a positive response occurred; C= correct response.

Table 4. Quality at harvest of sweet corn, Experiment 47B, 1999.

Fertilization Treatment	Maturity[1]	Tip Fill[2]	Ear Fill[2]	Pericarp[3] Toughness	% Dry Weight	Pericarp[4] % of Dry Weight	Sugar[5] g/g Dry Weight
4	1.9	2.0	2.8	7.14	19.7	17.7	335
3	2.0	2.2	2.8	7.51	22.4	14.4	314
2	2.0	2.2	3.0	7.64	21.4	13.3	314
1	1.9	2.4	2.8	7.16	22.0	13.5	338
Average	2.0	2.2	2.9	7.36	21.4	14.7	325
$LSD_{(0.05)}$	ns	ns	ns	0.50	ns	1.8	ns

1 Maturity: 1=immature, kernels small, 2=optimum maturity, 3=overmature, kernel sap milky; evaluation of 5 ears per field rep.

2 Tip fill and ear fill (kernel fill): 1=kernels not fill end or length of ear, 2=moderately well filled, 3=well filled; evaluation of 5 ears per field rep.

3 Pericarp toughness determined on 20 kernels per field rep. (4 measurements x 5 ears/rep.) by measuring the resistance to penetration of a 2-mm flat cylinder probe on TA-XT texture analyzer, 2 mm deep.

4 Pericarp content was determined as a percent of total dry weight by homogenizing and filtering a sample of kernels, 1 determination per composite sample per field rep.

5 Sugar determined by a colorimetric phenol assay on 1 ethanol extract of a composite sample per field rep.

but soluble solids decreased by an average of 15% over the 12 days. In experiment 47C, soluble solids were lower (11.1% on day 0) than in corn samples in experiment 47B (13.9% at day 0). There were significant differences in soluble solids due to fertilization treatments.

Table 5. Postharvest quality of sweet corn, Experiment 47B stored at 41 °F for 0, 6 and 12 days, 1999.

Fertilization Treatment	*Days at 5°C (41°F)*	*Visual [1] Quality Husk*	*Visual [1] Quality Ear*	*Visual [1] Quality Silks*	*Decay [2] on Silks*	*% Dry Weight*	*% Soluble [3] Solids*
4	0	9.0	9.0	9.0	1.0	19.7	13.8
3	0	9.0	9.0	9.0	1.0	22.4	14.0
2	0	9.0	9.0	9.0	1.0	21.4	13.8
1	0	9.0	9.0	9.0	1.0	22.0	14.1
Average		9.0	9.0	9.0	1.0	21.4	13.9
4	6	7.0	8.0	6.2	2.6	21.0	12.8
3	6	7.3	7.4	6.0	2.6	20.7	12.5
2	6	7.2	7.7	6.0	2.5	20.3	12.4
1	6	7.2	7.6	6.5	2.4	21.1	12.9
Average		7.2	7.7	6.2	2.5	20.8	12.7
4	12	6.5	7.6	6.2	2.6	20.1	10.5
3	12	6.4	7.8	6.1	2.6	20.0	10.2
2	12	6.4	7.6	6.1	2.3	19.8	9.9
1	12	5.8	7.7	5.4	3.1	21.4	11.2
Average		6.2	7.7	6.0	2.6	20.3	10.4
$LSD_{(0.05)}$		0.5	0.7	0.7	0.4	ns	0.6

[1]Visual quality of intact ear in husk, silks and husked ear was scored on a scale of 9 to 1, where 9=excellent, 7=good, 5=fair, 3=poor and 1=unuseable; a score of 6 is the limit of salability.

[2]Decay on silks was scored on a 1 to 5 scale, 1=none, 2=slight, 3=moderate, 4=moderately severe, 5=severe.

[3] Soluble solids was determined on 1 composite cleared juice sample per field rep. on a temperature compensated refractometer.

Table 6. Quality at harvest of sweet corn, Experiment 47C, 1999.

Fertilization Treatment	*Maturity [1]*	*Tip Fill [2]*	*Ear Fill [2]*	*Pericarp [3] Toughness, Newtons*	*% Dry Weight*	*Pericarp [4] % of Dry Weight*
4	2.0	2.3	3.0	7.24	18.2	16.0
3	1.9	2.2	3.0	7.32	17.9	15.7
2	2.0	2.3	3.0	7.40	18.4	14.7
1	1.8	2.3	2.8	6.77	17.4	16.2
Average	1.9	2.3	3.0	7.18	18.0	15.6
$LSD_{(0.05)}$	0.2	ns	0.1	0.28	Ns	ns

[1]Maturity: 1=immature, kernels small, 2=optimum maturity, 3=overmature, kernel sap milky; evaluation of 5 ears per field rep.

[2]Tip fill and ear fill (kernel fill): 1=kernels not fill end or length of ear, 2=moderately well filled, 3=well filled; evaluation of 5 ears per field rep.

[3]Pericarp toughness determined on 20 kernels per field rep. (4 measurements x 5 ears/rep.) by measuring the resistance to penetration of a 2-mm flat cylinder probe on TA-XT textureanalyzer, 2 mm deep.

[4]Pericarp content was determined as a percent of total dry weight by homogenizing and filtering a sample of kernels, 1 determination per composite sample per field rep.

Table 7. Color of husk and kernels at harvest of sweet corn, Experiment 47C, 1999.

Fertilization Treatment	*Husk Color [1]* L*	*Husk Color [1]* Chroma	*Kernel Color [1]* L*	*Kernel Color [1]* Chroma
4	67.2	34.2	71.7	18.7
3	65.3	34.4	69.2	17.2
2	67.7	34.5	72.0	19.1
1	66.2	35.0	70.4	17.7
Average	66.6	34.5	70.8	18.2
$LSD_{(0.05)}$	ns	ns	1.7	1.0

[1]L represents lightness or darkness (0=black, 100=white) and chroma represents the intensity of the green or yellow color, the higher the value the brighter the color appears.

Table 8. Postharvest quality of sweet corn, Experiment 47C stored at 41°F (5°C) for 0, 6 and 12 days, 1999.

Fertilization Treatment	*Days at 5°C (41°F)*	*Visual[1] Quality Husk*	*Visual[1] Quality Ear*	*Visual[1] Quality Silks*	*Decay[2] on Silks*	*% Dry Weight*	*% Soluble[3] Solids*	*L* Color Value*	*Chroma Color Value*
4	0	9.0	9.0	9.0	1.0	18.2	12.1	67.2	34.2
3	0	9.0	9.0	9.0	1.0	17.9	11.3	65.3	34.4
2	0	9.0	9.0	9.0	1.0	18.4	11.6	67.7	34.5
1	0	9.0	9.0	9.0	1.0	17.4	9.3	66.2	35.0
Average		9.0	9.0	9.0	1.0	18.0	11.1	66.6	34.5
4	6	7.0	7.6	6.5	2.5	18.2	10.7	67.3	33.7
3	6	6.2	7.0	5.9	2.7	17.9	10.5	65.6	34.3
2	6	5.9	7.6	6.0	2.8	18.4	10.6	66.0	32.9
1	6	6.7	7.0	6.8	2.2	17.4	9.2	66.9	33.0
Average		6.4	7.3	6.3	2.6	18.0	10.2	66.4	33.5
4	12	5.3	7.4	5.1	3.1	17.4	9.6	67.8	32.8
3	12	5.8	7.2	5.1	3.1	18.1	9.6	67.1	33.9
2	12	5.4	6.9	4.7	3.2	17.6	9.6	69.2	33.3
1	12	5.6	7.9	5.6	2.7	17.2	8.9	69.4	33.0
Average		5.5	7.4	5.1	3.0	17.6	9.4	68.4	33.2
$LSD_{(0.05)}$		0.6	0.8	0.8	0.4	ns	1.1	2.3	1.1

[1]Visual quality of intact ear in husk, silks and husked ear was scored on a scale of 9 to 1, where 9=excellent, 7=good, 5=fair, 3=poor and 1=unusable; a score of 6 is the limit of salability

[2]Decay on silks was scored on a 1 to 5 scale, where 1=none, 2=slight, 3=moderate, 4=moderately severe, and 5=severe.

[3]Soluble solids were determined on 1 composite cleared juice sample per field rep on a temperature compensated refractometer.

Interaction Of Cotton Nitrogen Fertility Practices And Cotton Aphid Population Dynamics In California Cotton

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INTRODUCTION

During the last 10 years, the cotton aphid (*Aphis gossypii*) has developed from a non-pest to one of the most significant insect pests of California cotton. This insect pest has joined lygus bugs, spider mites, silverleaf whitefly, and beet armyworms as the key arthropod pests of California cotton. The most significant cotton aphid outbreaks occurred in 1997; an estimated 3.5% yield loss occurred which was nearly $34 million in crop loss and an additional $38 million in control costs were incurred to "manage" this one insect pest. Cotton aphid infestations damage the cotton crop in several ways. On vegetative stage cotton, aphid feeding stunts the plant growth. However, only the highest, most prolonged early-season infestations result in yield reductions or delays in crop maturity. During the mid-season (July to mid-August), cotton aphids reduce cotton lint yields because the aphids act as a significant sink and compete with the bolls for the limited energy. The late-season infestations (mid-Aug. to Sept.) are problematic because the aphids deposit honeydew on the exposed cotton lint, which reduces the lint value and marketability. Reasons for the intensification in pest status of cotton aphid are unclear; however, one of the most noticeable changes in cotton production over the last 10-15 years is the use of a plant growth regulator instead of irrigation and N deficits to limit early-season cotton vegetative growth. This has allowed cotton production practices in the San Joaquin Valley to evolve to higher N fertilization and irrigation inputs. Host plant conditions including high N and adequate moisture are generally optimal for aphid population growth and development. Insecticide use patterns (some of which directly or indirectly aphid populations), cotton varieties, the crop mosaic in the SJV, and other factors may also be acting upon aphid populations. Several species of insects have been shown to respond positively to higher levels of N, and similarly, small plot studies have shown more cotton aphids in highly N-fertilized cotton plots compared with low fertility areas. The idea of balancing the amount of N needed for optimal cotton yield with the level required to mitigate cotton aphid population build-up is the goal of this project. Utilizing cultural control measures such as N management could play an important role in cotton aphid management. Biological control of mid- and late-season aphid outbreaks is only moderately effective. Relying on insecticides for aphid control adds undesirable production costs and also promotes the development of insecticide resistance in this aphid pest. Therefore, additional non-chemical control measures, such as cultural control, would fill an important void.

OBJECTIVES

1. Study the influence of cotton N fertilization practices on cotton aphid population dynamics and seasonal buildup in cotton.
2. Identify specific crop carbohydrate and N status associated with higher aphid densities during specific crop growth stages.

DESCRIPTION

Replicated field studies with differential N levels, set up by the Cotton Agronomist and Cotton Farm Advisors in grower fields, were largely utilized for Objective 1. The treatments were set up in strips, generally 8 rows wide x the field length (up to 1/4 mile long) x 4 blocks (smaller plot sizes were used at the research centers). Target N rates in these studies were 50, 100, 150, and 200 lb N/acre; the lowest rate utilized the residual soil N and therefore varied across locations. The three highest rates were the residual plus the appropriate amount of applied N generally in June. Field sites were located in Tulare Co., Fresno Co./West Side Research and Extension Center (REC), Kings Co., Merced Co., Madera Co., and Kern Co. (Shafter Research and Extension Center [2 locations] and in a grower field). Planting dates varied across locations but were generally in mid-late April in 1999. Cotton aphid populations were sampled at weekly intervals from each plot from July to September. A twenty-leaf sample, fifth main stem node leaf from the top, was used. Aphids were counted in the laboratory with the aid of 50X magnification. For Objective 2, treatments of 0 (=20 lb residual in soil), 50, 100, 150, 200, and 250 lb N/acre (as ammonium sulfate) were applied to small plots. There was also a treatment of 200 lb N/acre split in 4 applications (applied every two weeks), a treatment with an alternate source of N (200 lb /acre of urea), and a "balanced" fertilization (200 lb N/acre + 100 lb K_2O/acre). Cotton aphids from a laboratory colony were placed on to five plants in each plot on July 16. These aphids were enclosed in single-leaf cages (to minimize the effects of predator insects feeding on them) and were monitored for their survival, fecundity, and generation time daily over the next month. Three compete aphid generations (new-borne to adult) were completed.

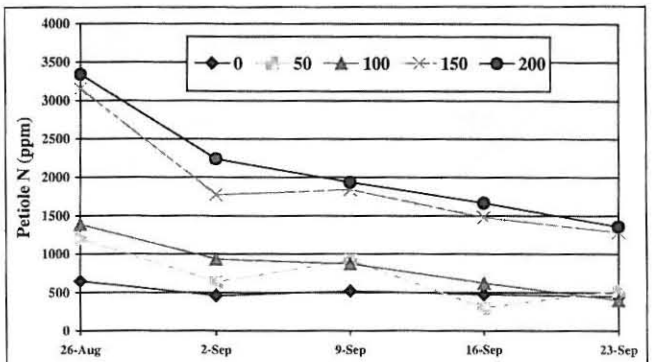

Figure 1. Petiole N levels vs. applied N treatments (1lb /A) simultaneous with aphid build-up.

RESULTS AND CONCLUSIONS

Cotton aphid populations were generally low in 1999, but levels responded to the N regime. Populations generally built-up late in the season and at that time the N levels had likely largely equilibrated or at least were greatly altered compared with the treatment regimes. In the strip tests (grower fields and RECs), aphid populations developed in six of the eight sites (see Table). The highest aphid density was ~33 per leaf. However, at all the six sites with aphids, there was a trend with more aphids at the higher N levels; a 3-4X range was commonly seen from the 50 to 200 lb/acre treatments. Similarly, the percentage of leaves with aphids also responded positively to N level.

The highest densities of aphids were found in the Shafter REC field 2 site. Populations were present in early August and started to increase noticeably in late August. At this time, petiole N levels were much lower then earlier in the year, but there were still distinct differences among the treatments (Figure 1). Across the treatments, petiole values ranged from high to low in terms of normal cotton growth and development.

Results from detailed studies on the effects of N on cotton aphid levels showed that, for the first generation of aphids exposed to the conditions, the aphids from high N plots, especially the ones reared on plants fertilized with ammonium sulfate only, produced significantly more offspring and had shorter generation times, i.e., the time needed to go from a new-borne aphid to an adult, than the aphids from low N

Table 1. Response of cotton aphid populations, at the time of the peak, to applied nitrogen levels in cotton in the San Joaquin Valley, 1999.

Location/Nitrogen Treatment (lb/acre) [1]	*Aphids per leaf*	*Location/Nitrogen Treatment (lb/acre)* [1]	*Aphids per leaf*
Shafter REC (field 1) - 50	0.7	Tulare County - 60	1.8
100	1.3	100	3.2
150	1.7	150	7.9
200	3.3	200	9.0
Kern County - 50	0.05	West Side REC - 50	0.7
100	0.05	100	1.0
150	0.05	150	1.1
200	0.08	200	2.2
Kings County - 50	0.3	Shafter REC (field 2) - 0	12.3
100	0.9	50	17.9
150	1.4	100	18.9
200	1.2	150	27.9
		200	32.8

[1] Date of peak: Shafter REC (field 1) - 3 September; Kern County - 12 August; Kings County, Tulare County, Shafter REC (field 2) - 2 September; West Side REC - 15 September.

plots (Figures 2, 3). Generation times ranged from 12.3 days (0 lb N/acre) to 9.3 days (250 lb N/acre). Similarly, the number of offspring per adult averaged 1.7 and 5.3 with the low and high N regimes, respectively. Conversely, potassium seemed to have a detrimental effect on the aphid processes. Thus, aphids from the treatment that had the "balanced" fertilization (200 lb N /acre + 100 lb /acre K2O) had a lower fecundity and longer generation time than individuals from the two highest N treatments (200 and 250 lb /acre of ammonium sulfate). This negative effect of potassium on aphid fitness has been observed in other systems with other herbivore species. The split application and urea form of N did not alter the results compared with the "standard" 200 lb N treatment. No differences in aphid survival were found among treatments; however, the overall survival was low (about 33%). In the second generation, there was a trend of higher offspring production and shorter generation time with aphids from the highest N plots; however, the differences among treatments were not as distinct (Figures 2, 3).

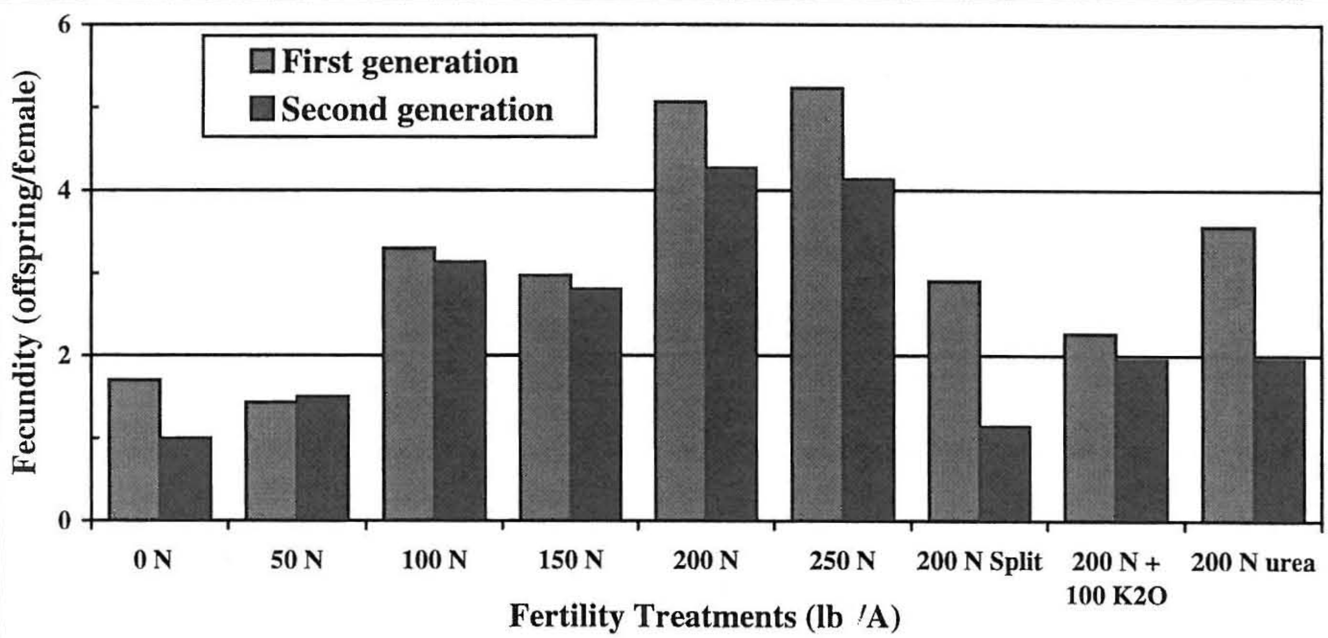

Figure 2. Number of cotton aphid offspring produced with various fertility regimes on cotton.

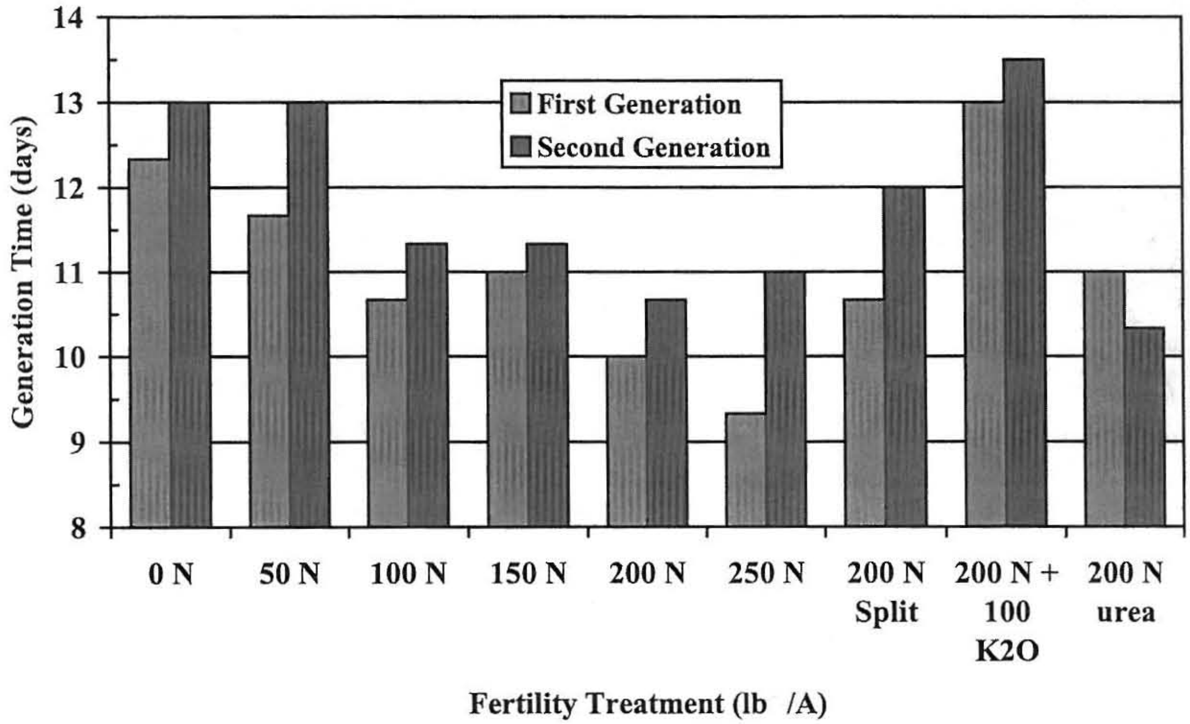

Figure 3. Length of cotton aphid generation time with various fertility regimes on cotton.

Potassium Responses In California Rice Fields As Affected By Straw Management Practices

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OBJECTIVES

1. Re-evaluate the effect of K fertilization response of rice yield and its interaction with N.
2. Determine on how adequate level of available K affects the occurrence of rice diseases.
3. Reassess the accuracy of the soil K test on predicting plants available K.

INTRODUCTION

California legislation (AB 1378) leads to a phase down of rice straw burning over a 10-year period which will change the way farmers manage rice straw. Although various options are available, it is likely that the incorporation of rice straw; i.e., on-site disposal, will remain a major option for rice straw disposal. The average concentration of K in rice straw is around 1.4 % but its range can be as low as 0.6 % or as high as 1.8 %. The amount of straw removed by baling for off-site use is approximately 6 tons/acre and hence the amount of K removed in the straw after harvest in Californian rice fields can exceed 90 lb/acre. When straw is continually removed, available K levels in the soil will be profoundly affected. Some preliminary data gathered from the long-term straw rotation studies at the Rice Experiment Station showed that the extractable K levels in the soil in the top 6 inches declined significantly to less than 60 ppm when straw was baled for 3 years. The current fertility guideline for rice is that about 87 ppm of extractable K should be present at time of seeding; otherwise K fertilization is recommended.

DESCRIPTION

As part of the first field season activities of this three-year field study, a field at Mathew Farm near Marysville, CA which has historically shown a potassium (K) deficiency was selected. From half of the selected area (about 7 acres), the rice straw was removed whereas for the other half of the field, the rice straw was incorporated in the fall of 1998. The same location will be used for the next three years and straw will be removed or incorporated for the duration of the experiment.

In the spring of 1999, 15 soil samples were collected from the site where straw was removed or where straw was incorporated. After one year of straw removal, a significant difference in plant available K concentration was detected: 59 ppm when the straw was removed versus 88 ppm soil in the straw-incorporated plot. In the spring of 1999, an N by K rate trial was established on both straw management treatments. A split plot factorial design replicated 4 times with 5

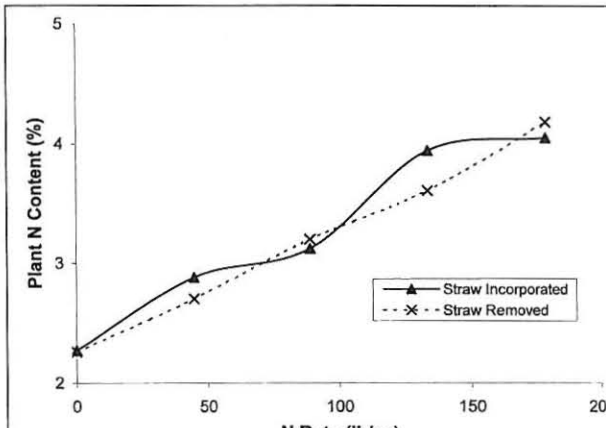

Figure 1. Midseason leaf N concentration as affected by N fertilization.

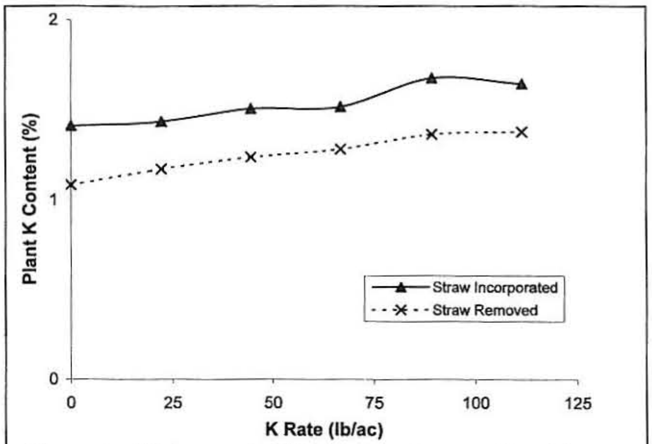

Figure 2. Midseason leaf K concentration as affected by K fertilization.

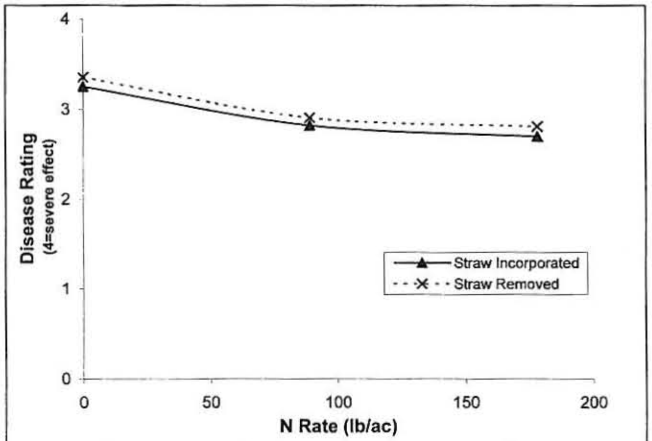

Figure 3. Aggregate sheath spot occurrence as affected by N fertilization.

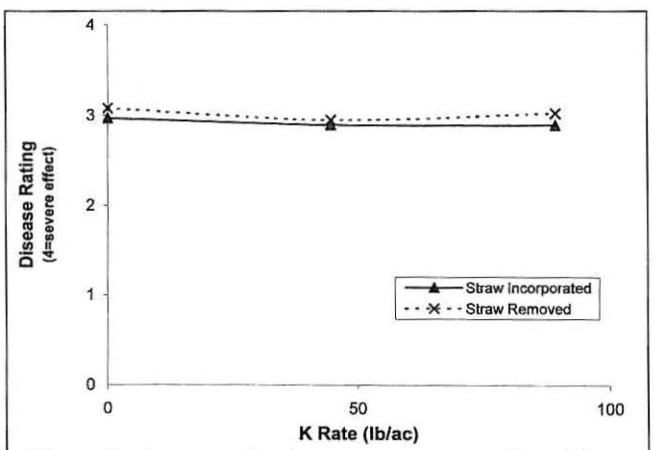

Figure 4. Aggregate sheath spot occurrence as affected by K fertilization.

rates of N (0, 45, 90, 135, 180 lb/acre) as ammonium sulfate and 6 rates of K (0, 22, 44, 66, 88, 110 lb/acre) as KCl for each straw management treatment (total of 240 plots) was used. Midseason concentration of N and K in the leaves was conducted for all treatments. A disease rating was carried out a few weeks prior to harvest for the following rates: 0, 45 and 90 lb N/acre. Straw and grain yield were determined and both plant components were analyzed for total N.

RESULTS AND CONCLUSIONS

Midseason N and K

During the summer, the concentration of N and K in the youngest expanded leaf increased significantly following N and K application, respectively (Figs. 1 and 2). However, the concentrations of K in the leaves increased when straw was incorporated under all rates of K application compared to straw removal. The difference in K concentration in the leaves when straw was removed or incorporated remained similar across all K levels. This is a surprising result for which no clear explanation is presently available. If the incorporation of straw led to an increase in plant available K, this response would become most apparent when no K was applied and would disappear at higher rates of K fertilization. This would suggest that the increase in the concentration of K in the leaves when straw is incorporated is not induced by an increase in plant available K. An argument could be made that the growth stage of rice was different when where straw was incorporated or removed, leading to a so-called dilution effect. Such a dilution effect is unlikely as the concentration of N in the leaves was not different when straw was removed or incorporated (Fig. 2). A small increase in the cation exchange capacity when straw is incorporated might also account for more plant available K by preventing leaching and runoff losses.

As anticipated, an increase in the rate of N fertilizer led to an increase in leaf issue N (Fig. 2). High rates of N doubled the concentration of N and leveled off at about 4%. There was no impact on straw removal or incorporation on tissue N, suggesting that straw did not immobilize or increase plant available N.

Diseases

Leaf diseases and the occurrence of aggregate sheath spot and rice stem rot was assessed at the end of the growing season. Only aggregate sheath spot was observed and rated for severity. Aggregate sheath spot, rated on a scale between 1 and 4, was prominent in all treatments and an overall rating of 3 was observed across all treatments whether straw was incorporated or removed. The severity of aggregate sheath spot declined slightly with higher rates of N fertilization for both straw management practices (Fig. 3) but was unaffected by the application of K (Fig. 4). Straw management practices had no significant impact on aggregate sheath spot.

It is likely that incorporating straw for one growing season may not yet show the severity of aggregate sheath spot occurrence. How aggregate sheath spot severity will be affected over time following several years of residue incorporation will be assessed during the duration of this project.

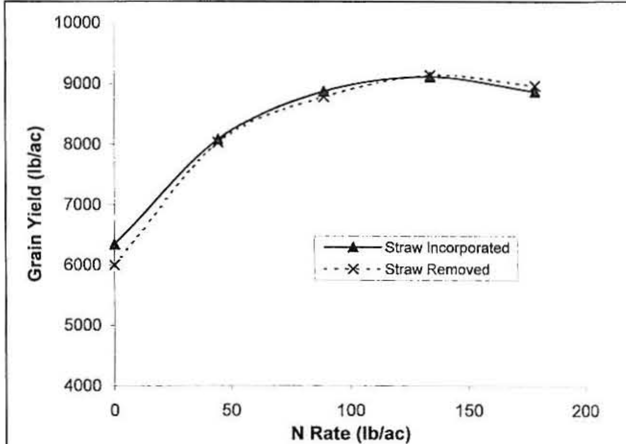

Figure 5. Grain yield as affected by N fertilization.

Straw and Grain Yield

Rice yield was affected by rate of N application (Fig. 5). Whereas unfertilized rice achieved an average yield of 5500 lb/acre, increasing the rate of N fertilizer increased the grain yield to 9100 lb/acre. However, the removal or incorporating of the straw did not significantly affect the yield. In addition, applications of N above 90 lb/acre did not further increase the grain yield, whether residue was incorporated or removed. The often observed N benefit on grain yield following residue incorporation did not occur. The most likely explanation is that the duration of residue incorporation has been too short to show any significant impact on the overall N supply power of the soil and therefore an effect on total grain yield was not observed.

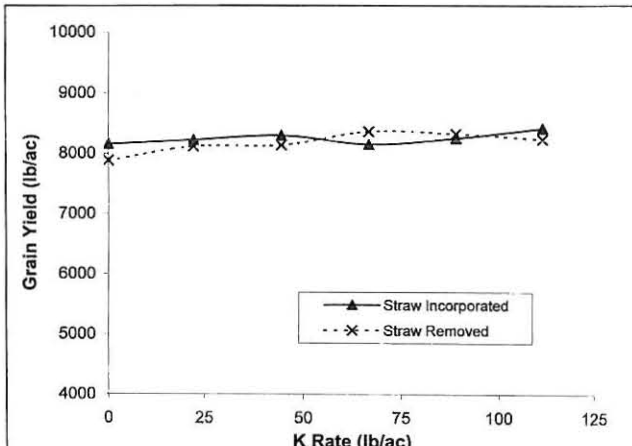

Figure 6. Grain yield as affected by K fertilization.

Medium rates of K fertilization had a small but significant effect on total grain yield when straw was removed but not when straw was incorporated (Fig. 6). Evidently, the amount of K removed in the straw was sufficient to induce a K deficiency. It is of interest to note that just one year of straw removal led already to such a significant increase in grain yield. It is anticipated that a stronger K response on yield will manifest itself in years 2 and 3 of the experiment.

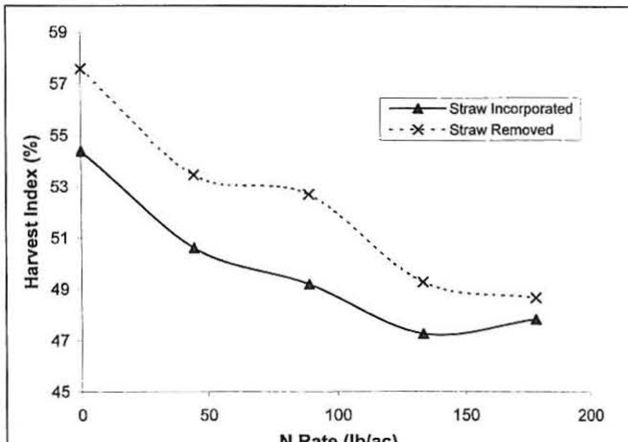

Figure 7. Harvest index as affected by N fertilization.

The total amount of rice straw residue produced, however, was not only affected by N rate application but also by straw management (Fig. 7). There was no effect of K application on straw yield. Incorporation of straw led to higher straw production and because yield was not affected, to a lower harvest index (Fig. 8). Harvest index is here defined as the total amount of grain yield divided by the total amount of aboveground biomass produced multiplied by 100. The increase in straw production without an increase in grain production would suggest that the additional nutrients that became available following the incorporation of straw were not used by the crop to produce additional grain. Or in other words, the crop became less efficient in its nutrient use (in particular N) once the N was taken up in the production

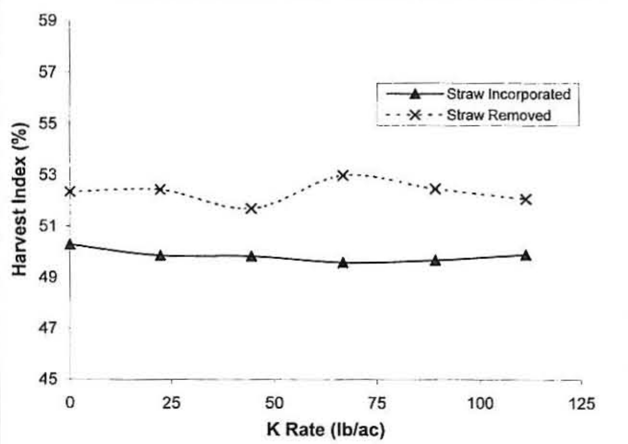

Figure 8. Harvest index as affected by K fertilization.

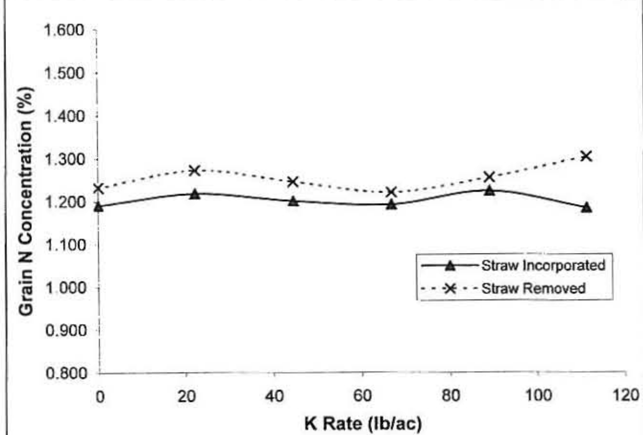

Figure 9. Grain N concentration as affected by K fertilization.

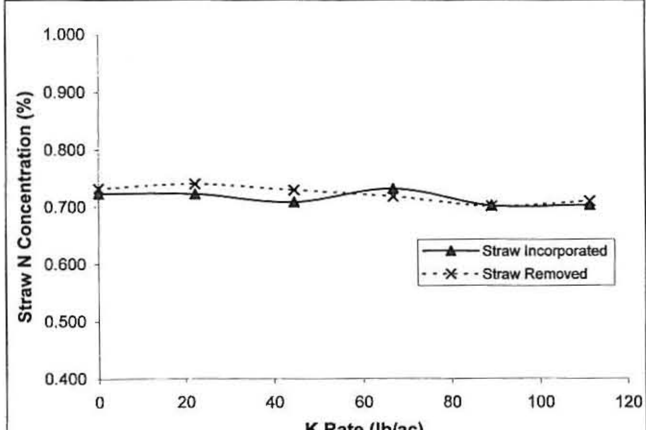

Figure 10. Straw N concentration as affected by K fertilization.

of grain following straw incorporation. As K rate had no effect on straw production and the harvest index, the production of straw and subsequently the lower harvest index appears to be mainly controlled by N which becomes accentuated following the incorporating the residue. Of interest would be to determine how to manage the rice straw differently and whether an increase in nutrients leads to an increase in grain rather than in straw production.

Nitrogen Use Efficiency

For the 1999 season, the concentration of N in the grain at final harvest showed that removing straw led to an increase in the concentration of N in the grain at all levels of N applications (Fig. 9). The K fertilizer had no effect on N concentration in the straw (Fig. 10). As anticipated, the concentration of N in the grain increased with increasing rates of N application and the increase was more pronounced when straw was removed. The application of N fertilizer increased the concentration of N in the straw but neither straw management nor K fertilization had a significant impact on the concentration of N. The increase in the concentration of N in the seed when straw is removed compared to straw incorporation can be explained by a principle of plant physiology. Stressed plants are known to show higher concentrations of nutrients in their seed, a phenomenon that may have occurred in this study.

The N requirement (amount of N in lb/acre to produce a ton of grain), increased significantly under higher rates of N (Fig. 11). Higher rates of K application had no effect on the N requirement (Fig. 12). However, the N requirement for rice under low N and K rates of fertilizers improved when straw was incorporated: i.e., less N was needed to produce a ton of grain (Figs. 11 and 12).

Although increased levels of N application decreased the recovery of the applied fertilizer-N (N-use efficiency or NFUE) and the lowest N recoveries occurred when straw was incorporated (Fig. 13), the decline was not significant. The impact of K fertilization on N fertilizer use efficiency remains unclear and is non-significant (Fig. 14).

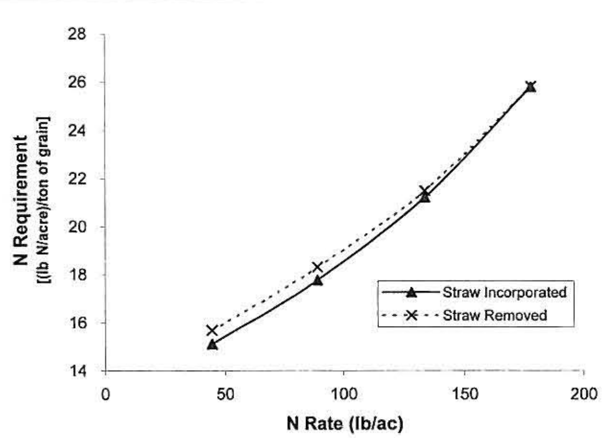

Figure 11. N requirement as affected by N fertilization.

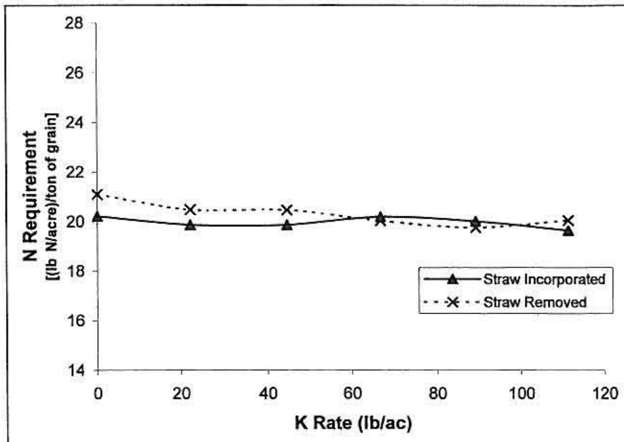

Figure 12. N requirement as affected by K fertilization.

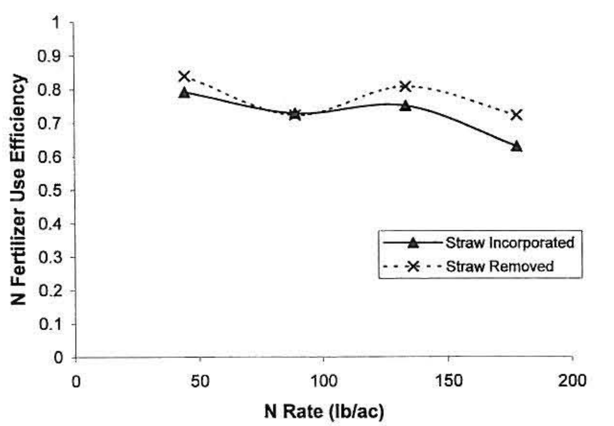

Figure 13. N fertilizer use efficiency as affected by N fertilization.

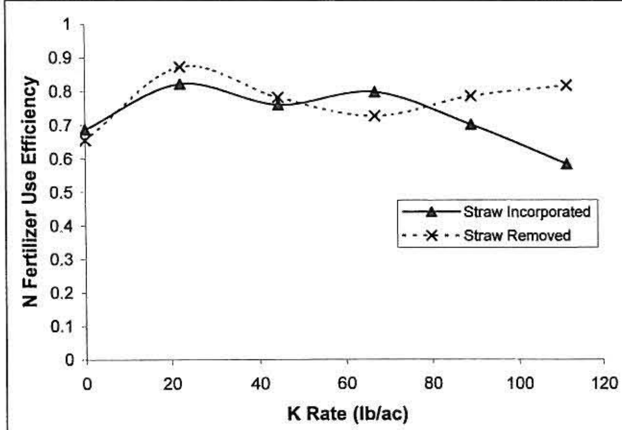

Figure 14. N fertilizer use efficiency as affected by K fertilization.

Nitrogen Budget In California Cotton Cropping Systems

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INTRODUCTION

When applied fertilizer is labeled with a tracer, i.e., ^{15}N, the flow and the fate of the N can be followed in a cropping system. A portion of the labeled fertilizer will be accumulated by the crop and from the ^{15}N-enrichment, the fertilizer use efficiency can be determined. Not all the ^{15}N-fertilizer will be accumulated by the crop and a portion of the applied N will be incorporated into the soil organic matter pool where it can be recovered from the various fractions, each with its own rate of turn-over. Initially, the ^{15}N that is recovered from the soil organic-N pool is predominately present in the labile, microbial biomass fraction. Following die-off and decomposition of the microbes, the ^{15}N becomes available again for plant uptake. However, a portion of the ^{15}N in the various soil organic matter fractions is derived from ^{15}N-labeled plant residues; i.e., roots, stems and leaves. During the mineralization process, a portion of this organic ^{15}N is converted into NH_4 and subsequently converted into NO_3. The remaining ^{15}N that is not converted rapidly into mineral N becomes part of the more stable soil organic matter pool and becomes slowly available for plant uptake over a number of years following decomposition.

Although reported values for fertilizer use efficiencies often do not exceed 50%, i.e., 50% of the applied fertilizer is recovered in the aboveground biomass, this does not imply that the unaccounted portion of the applied N is lost from the field. As discussed earlier, part of the ^{15}N is still present in the soil as mineral N, in the microbial biomass or in the roots. Therefore, some of the N-fertilizer that was applied will not be used by the crop during the first growing season but rather in subsequent growing seasons. In addition, N present in aboveground crop residues that are not removed from the field will also become a source of N for subsequent crops.

In summary, the N component of this study should result in a rethinking of fertilizer application practices in California cotton production. New cultural practices will likely include preplant soil analyses to establish a baseline N level, early application as called for by soil analysis, and additional applications on an as needed basis. Detailed analysis of mineralization of organic residues will permit inclusion of the contributions of this fraction to the availability of soil N and increase the precision of the fertilization of the cotton system. It is anticipated that this overhaul in N fertilization practices will result in a significant reduction in N use in cotton production systems and address environmental concerns of the potential movement of excess N into groundwaters.

OBJECTIVES

1. Determine the rate of mineralization of organic matter and release of N from the pool of labile soil N in cotton systems
2. Determine the contribution of the labile pool of N to the subsequent cotton crop and determine the N supplying power of the soil at selected sites.

DESCRIPTION

Plots were established at two sites in the San Joaquin Valley, Wisecarver Ranch, Kings County and Westside Field Station, Fresno County. These two sites have been used for the ^{15}N studies for three seasons ^{15}N enriched urea was used to label micro plots which were established within the fertilizer trials and a number of measurements were made over the 1998,1999 and 2000 seasons. These measurements included: lint yield, leaf dry wt., stem dry wt., boll dry wt., total dry wt., leaf area, specific leaf area, plant height, total nodes, node at first square, leaf, stem and boll N and atom% excess ^{15}N. Three levels of N were used as treatments (0,56,168 kg/ha). Tissue was sampled at specified times and subsamples were analyzed for atom% excess of ^{15}N. Results presented below represent sampling and analyses for both the 1998 and 1999 season. The importance of the various soil organic N pools as sinks of applied fertilizer-N were determined. Soil samples were taken to a depth of 8 feet, the first 4 feet in 1' increments and from 5-8 feet at 2' increments at the end of the growing season from the center of the ^{15}N micro plots. Three soil samples per plot were taken and combined prior to analysis. The soil microbial biomass in the top 10 inch and the soil organic matter in the entire soil profile was determined.

The amount of ^{15}N that is released from the soil organic matter pool and the cotton residue was determined using incubation/mineralization studies. Soil samples from the field plots were collected as described above. These samples were incubated under controlled conditions. The production of inorganic ^{15}N is determined by analyzing the NO_3 content of the soil solution and the rate of organic decomposition determined by losses of C through evolution of CO_2 In addition the rate of organic matter decomposition can be estimated by determining the soil microbial biomass. Partial results are reported below. To determine the contribution of the previous season's organic matter to the N pool for the next crop, cotton residue was collected from the labeled plots, weighed and incorporated into this year's plots. The break down of organic matter and the distribution of ^{15}N will provide information on the cycling of N and organic matter in the system.

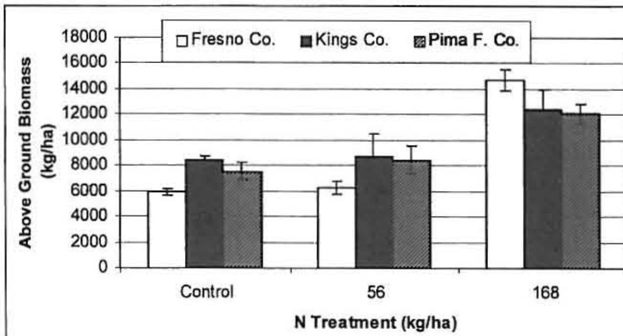

Figure 1. Above-ground biomass of Pima and Acala cotton as a function of N treatments for the 1999 season. For the control treatment no N was added. The biomass was measured after defoliation and represents the standing crop which will be incorporated into the soil.

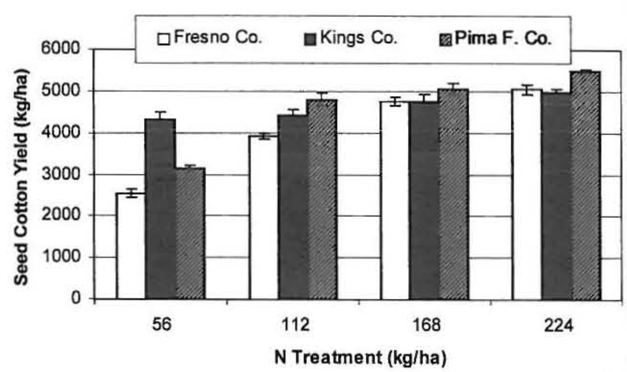

Figure 2. Seed cotton yield of the 1999 Pima and Acala cotton crop as a function of N treatments.

RESULTS AND CONCLUSIONS

Figure 1 illustrates the data from the two sites that were labeled with ^{15}N. The above ground biomass of both Acala and Pima type cotton was determined in response to N fertilizer levels. At both locations there was little response of biomass to N levels of 0 and 56 kg/ha. At 168 kg/ha the total biomass was greater with a much greater response of Acala cotton at the Fresno site. Seed cotton yields in response to N are shown in Figure 2. There was no significant yield response by Acala to applied N at the Kings County site, however, both Acala and Pima showed a response between 56 and 112 kg/ha at the Fresno site with no response above 112 kg/ha. Above 168 kg/ha N yield leveled off at both sites.

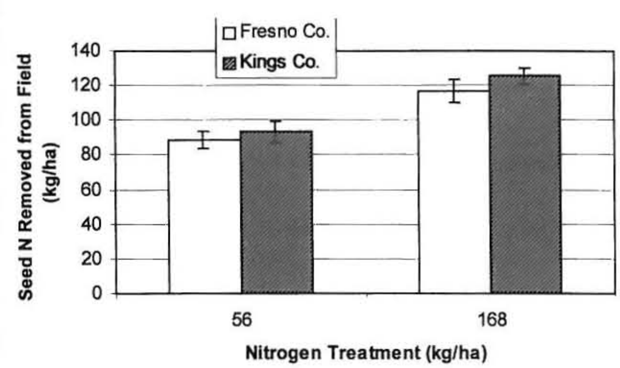

Figure 3. The amount of seed nitrogen removed from the field of the 1998 cotton crop as a function of N treatments.

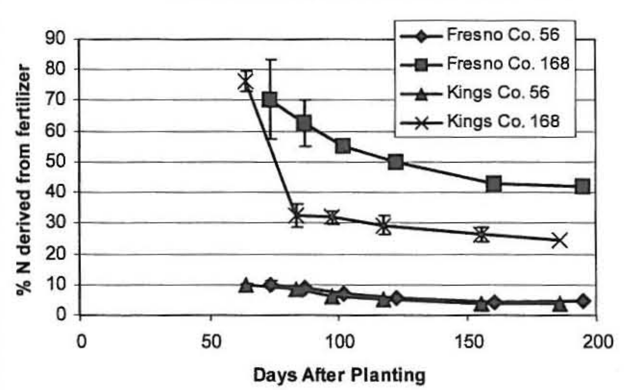

Figure 4. The % N derived from fertilizers by cotton treated with two levels of ¹⁵N labeled fertilizers as a function of time.

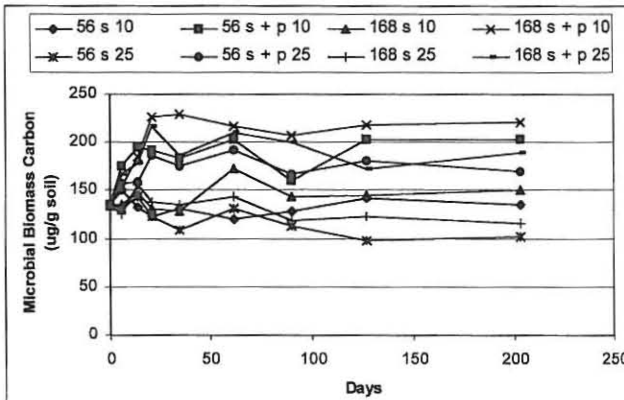

Figure 5. Microbial biomass from soils from the Fresno County site as a function of time. The biomass is calculated from the CO_2 evolved from incubated soils (see last report).

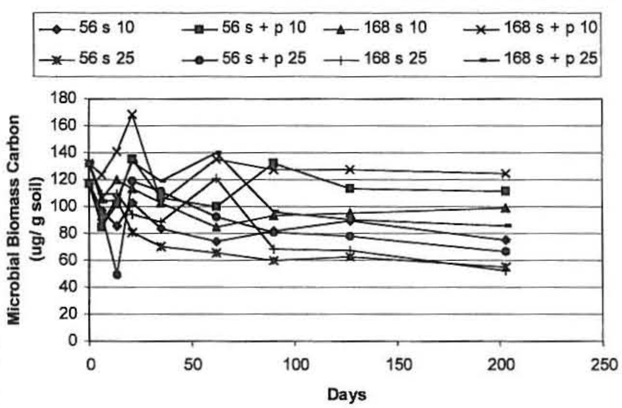

Figure 6. Microbial biomass from soils from the Kings County site as a function of time (see figure 5 for details).

Figure 3 is follow up data from 1998 and shows that at 56 and 168 kg/ha N there was no difference in the amount of N removed in Acala seed at harvest even though the cotton seed yields at the two sites were significantly different. This would suggest that there was efficient redistribution of N from the vegetative parts to the seed and that lint yield is not a stand alone indicator of N level or distribution in cotton.

The ^{15}N labeled fertilizer data are shown on Figure 4. These data provide information on the sources of N from the soil. At both sites the amount of N derived from fertilizer was greater at 168 kg/ha of applied N fertilizer than at 56 kg/ha. Also more N was obtained from fertilizer at the Fresno site at the higher level of applied N than at the Kings County site. At both sites and both levels of applied N, the % N derived from fertilizer N declined over the season. These data suggest that when N is low and/or limiting the plant becomes more dependent on soil N sources. In the 56 kg/ha N treatment the N derived from fertilizer did not exceed 10% and by the end of the season was less than 5%. Even at the 168 kg/ha treatment the N derived from fertilizer decreased from 75% to 20%. This suggest that when N is relatively high and available the plant acquires N from those sources but as the level of N decreases a greater amount comes from less available sources such as soil organic matter. This means that we need a more accurate assessment of the "supplying power" of soil if we are to obtain a N budget, a parameter necessary to effectively manage soil N.

Figures 5 and 6 provide some information on the role of microbial decomposition in providing N for a developing crop is required to develop a N budget. Figure 5 shows microbial biomass from soils from the Fresno County location. Figure 6 represents microbial biomass from the soils from the Kings County location. Both soils show a fairly constant level of microbial biomass over the season. There appears to be overall a greater amount of microbial biomass at the Fresno County location than at the Kings County location. It is expected that the greater the microbial biomass, the greater the rate of decomposition of organic matter. These data will be compared with organic matter decomposition rates as determined by CO_2 evolution of incubated soils and the seasonal levels of soil organic matter content. This information will be used to relate cause and effect if possible.

The project is progressing as designed in the initial proposal. Data for the 2000 season is being collected on the processes involved in N cycling and these data will be used to develop both an accounting of N in the cotton system and the management approaches to improve N-use efficiency in this system. If justified revised recommendations on N fertilization of cotton will be made available to growers.

Precision Agriculture In California: Developing Analytical Methods To Assess Underlying Cause And Effect Of Within-field Yield Variability

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INTRODUCTION

Precision farming or soil-specific management (SSM) is not a new concept. Yet, recent technological advancements in multiple disciplines are revolutionizing the potential for the application of SSM concepts in large scale, industrialized agriculture. This new potential for more efficient and environmentally-friendly agriculture has revitalized many of the traditional agricultural sciences by posing the new challenges of describing, understanding, and predicting spatial agro-ecological patterns with high resolution at landscape scales.

The challenge, however, will not be on how to collect and transfer the data into maps that reflect the spatial patterns of features of interest but on how to interpret the data and make predictions on the impact of variable management practices across a farmer's field. This cannot be achieved without a thorough understanding of the underlying mechanism that causes the variability of key processes across the field to occur in the first place.

This project aims at integrating state-of-the-art tools for collecting, georeferencing and mapping spatial data with thorough characterization and modeling of the fundamental processes causing spatial variability. This project, dealing with field-scale variability, is part of a larger, multi-scale research effort dealing with spatial variability in Californian rice agroecosystems.

OBJECTIVES

1. Initiate a case study to quantify the underlying mechanisms that control the spatial variability of grain yield in rice fields.
2. Determine how the efficiency of collecting information across a farmer's field can be optimized using state-of-the-art geostatistical techniques.
3. Develop a predictive model for yield and perform sensitivity analysis to assess the main factors controlling its spatial variability.
4. Test the economic feasibility of SSM by varying treatments across the field.

DESCRIPTION

As part of the first-season activities of a three-year study, a rice field was selected at Josiassen Farm, near Oroville, California. The field has been under cultivation with rice for the last five years, and rice straw has been incorporated in winter during that time. Within the field, four transects of 1200 feet each were randomly selected for our study. Two of those transects were selected to be left unfertilized, in order to quantify natural variability of soil fertility.

In the spring of 2000, 50 soil samples (40 with a spacing of 30 feet, 10 random) were collected for each transect, yielding a total of 200 samples. Samples were dried and stored using standard methodology, and are currently being analyzed for P-Olsen, total N, total C, ^{15}N natural abundance, ^{13}C natural abundance, cations and texture. In addition, an extraction with sodium tetraphenyl boron will be carried out to determine available K for the crop.

The field was planted on May 25th. Two of the transects, 30 feet wide, were left unfertilized. The rest of the field was fertilized with aqua ammonia. At plant establishment and a month later, infrared images were taken. Plant samples were collected on July 20th, and will be analyzed for mid-season nutrient status.

At harvest, whole plant samples (including roots) will be collected from all locations. In addition, the number of weeds will be quantified. Harvest maps across the transect will be made using a yield monitor calibrated using hand-harvested plots across the transects.

After completion of the analyses, a preliminary assessment of functional relationships within the field can be carried out. Using geostastistical techniques (kriging, co-kriging, simulation), spatial variability and possible co-variability will be analyzed. This will allow us to fine-tune our sampling scheme for the next growing season. In addition, multivariate regression will be used to link the measured variables to grain yield, above-ground and below-ground biomass.

Site-Specific Farming Information Systems in a Tomato-based Rotation in the Sacramento Valley

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OBJECTIVES

1. Measure variability of yield within fields in a processing tomato-based rotation.
2. Determine relationship of crop yield to soil and plant characteristics and color infrared aerial imagery.
3. Assess the potential for site-specific farming in irrigated row crop rotation and communicate with growers and allied businesses.

DESCRIPTION

Yield variability within a field and its inter-annual correlation is one of the main concerns today in precision agriculture. Data were analyzed from two 378-acre commercial four-crop-rotation fields in Sacramento Valley, California. One of the fields had a wheat-tomato-bean-sunflower rotation from 1996 to 1999, the other had a wheat-tomato-sunflower-corn rotation during the same period. After georeferencing, interpolation and correction of monitored-yield data, correlation was measured between the years using 20 x 20m cells. Six two-year comparisons were performed in each field to estimate the congruence of inter-annual variation in defining yield patterns within the fields.

RESULTS AND CONCLUSIONS

Very low correlation values were found using this approach, but after standardizing and adding the yields, a larger spatial correlation resulted. This indicates that areas with the same average performance tend to be clustered together. To further the study from another perspective we constructed clusters using standardized yield data. This provided a different spatial configuration of clusters but also a high level of spatial autocorrelation. Preliminary relations with soil characteristics were developed through Classification and Regression Trees (CART) and regression analysis, using soil sample data from a 60-m square grid. Some relatively stable to very stable soil traits such as textural components and organic matter content were found to be important in explaining the average yield over the four-year period.

Because soil properties affect irrigation and drainage, as well as supply of nutrients to crop plants, farmers should define monitoring or management zones based on soil texture. In one of the test fields, soil texture (0-15 cm depth) was mapped by analysis of sand, silt, and clay content. Samples were collected from 86 sites on a 220 feet square grid. A second sampling was conducted to determine values between adjacent sites that differed in clay content in the initial sampling by more than a threshold value. The combined data set covered 120 sample locations (Fig. 1a.). The cost of such an intensive survey would make it impractical to most farmers. A more affordable survey based on 18 samples collected on a 400-ft square grid produced a map of clay content that was similar to the more intensive sampling (Fig. 1b). With the coarser sampling, areas of ~1 ha (2-3 acres) may be misclassified. However, a map of the difference between clay content interpolated from the coarse and intensive sampling shows that absolute differences of clay content >2.5% occur only in a few small areas of the field (Fig. 2).

Another approach would be to adjust sample locations based on soil color determined by bare-soil aerial photography. This will improve the resolution of the farm field-scale texture map while minimizing the sampling and analysis cost.A separate study was conducted by Alvaro Roel and Jorge Perez to determine the applicability of the USDA-NRCS soil survey geographic database (SSURGO) to precision agriculture. They concluded that the SSURGO data were as good as the soil core data for defining three management zones which coincided with wheat yield zones.

In summary, there are three approaches to producing a farm field-scale soil texture map: (1) Soil sampling with one sample per 0.5 to perhaps 4 acres; (2) Use of NRCS soil databases – essentially county soil survey information; (3) Soil sampling and/or soil database information in combination with remote imagery such as aerial photographs.

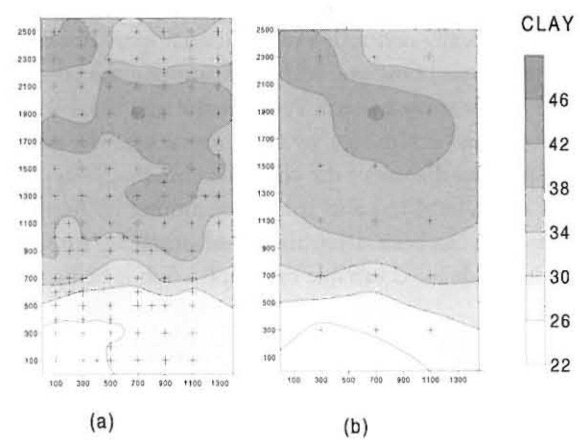

Figure 1. (a)Two-stage sampling: 86 grid samples plus 34 additional samples collected where clay content change is large. (b) Single-stage sampling of 18 grid samples on a 400-ft spacing = 1 sample/4.33 acres.

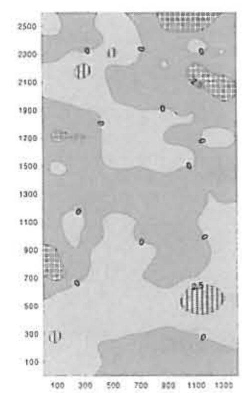

Figure 2. Clay content difference between intensive sampling and sparse sampling as shown in Figure 1. Only a few small areas (hachures) show an absolute difference >2.5% clay

Development And Testing Of Application Systems For Precision Variable Rate Fertilization

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INTRODUCTION

Precision or "site-specific" management of agricultural production requires application of fertilizer, pesticides, water and other inputs on spatial scales much smaller than previously used. The concept is simple; by using accurate navigation and positioning to guide collection, sensors for crop yield, soil properties and other conditions can be used to develop maps or databases of crop response and geographic variation. From the collected information and an understanding of crop development, the inputs supplied to the crop and the management practices used can be refined on small areas. The overall economic return can be increased while environmental effects can be reduced. Significant research is underway to determine how to adapt this tool to California agriculture.

This project is working on one essential machine for precision farming, namely, a fast system for varying the application rate of liquid and gaseous fertilizer. This is complicated by the real-world problems of fast ground speeds, a wide range of rate control, and the ever-present demands of simplicity and high reliability during busy seasons. When a fertilizer applicator is traveling at 8 mph, 3 feet are covered in approximately 0.25 seconds. If fertilizer rate changes are desired in, for example, a 6-foot distance, the application system must respond in 0.5 seconds. Most application equipment, even that with electronic rate control, cannot respond quickly enough. Even when it is fast, a typical rate controller has a limited range and resolution.

A unique spray control system has been developed and patented at University of California, Davis that can control pesticide application rates over an 8:1 range and respond within 0.3 seconds and often within 0.1 second. The system uses electronically-controlled valves at each spray nozzle to meter the desired flowrate, without disrupting the spray droplet size or spray pattern. Performance and durability of the system has been proven by commercial use. The project is investigating the use of the control technique for application of liquid fertilizers and anhydrous ammonia. Accuracy of the system has been determined and suitability for GPS- or manually-directed variable rate application is being investigated.

OBJECTIVES

One goal of this project is to determine if desired rate changes can actually be achieved with existing application equipment and improved metering systems. Another goal is to address the question, "Can uniformity and accuracy of fertilizer application rates be improved with the pulsing valve flow rate control approach?" The specific objectives are:

1. Determine if the control valves are suitable for use with typical fertilizer liquids at typical application flow rates and supply pressures.
2. Install the control system on a liquid fertilizer applicator and document accuracy and uniformity in application rate and speed of response to changes in application rates in a field setting.
3. Determine if the control system can be modified for use with anhydrous ammonia in order to improve uniformity of application, reduce vapor formation in supply lines and allow a wide range of rate control.

DESCRIPTION

The work on first objective was described in the 1999 CDFA/FREP Conference Proceedings. Two common liquid fertilizers (UN 20 and UN 32) were tested with three common nozzles (8008, 11015 and TF-10) and liquid supply pressures of 10-30 psi. The system was found to be very predictable and provide a 10:1 range of rate control. No excessive wetted part wear or corrosion was observed.

Work on Objective 2 has used two commercial application systems. Preliminary work, reported in the 1999 CDFDA/FREP proceedings, used a 500 gal trailer with 30 feet liquid boom. This work established that the system could provide a wide range of application rate control while maintaining consistent nozzle pressure for good pattern and droplet control. This year, work expanded to a self-propelled 700 gal, 75 feet boom vehicle. The vehicle was installed with a Case Tyler Ag Navigator GPS system, Mid-tech TASC rate controller and the AIM Command commercial version of the University of California, Davis rate flow control system. The Case vehicle was used to demonstrate and investigate using the pulsed valves with a true GPS-directed application map in a test field.

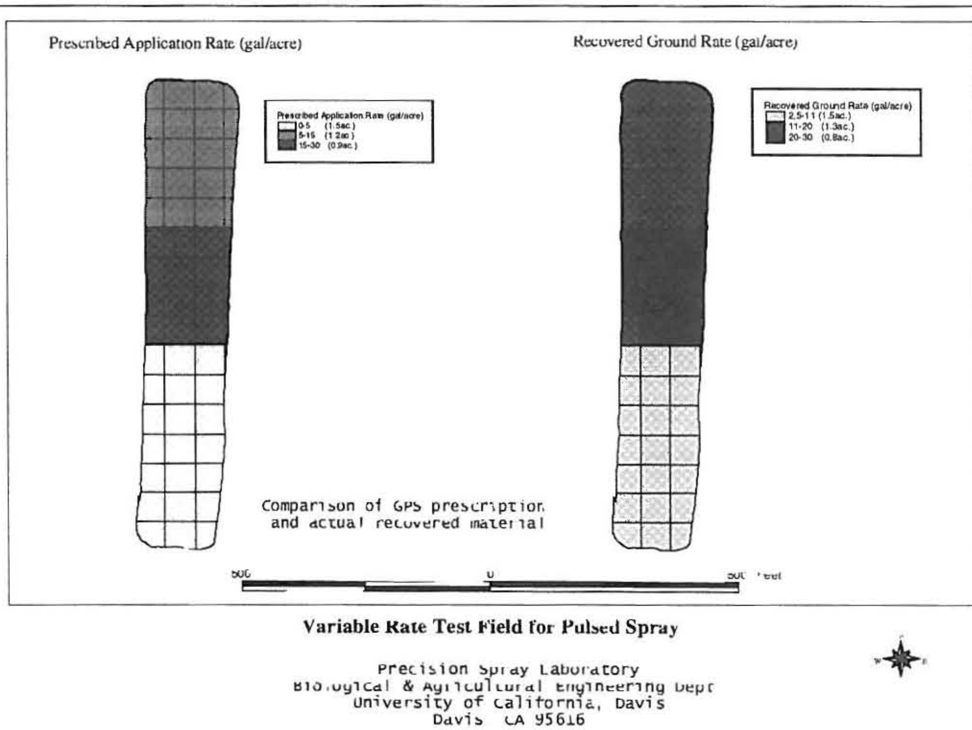
The third objective was investigated in cooperation with an equipment manufacturer, Kansas State University and a California application company. Preliminary data have shown that the pulsed valve system can improve uniformity of anhydrous ammonia distribution across a manifold, reduce the formation of vapor and allow a wider range of application control. A test system was placed in the field in California during the fall of 1999 and spring of 2000.

RESULTS AND CONCLUSIONS

The installed system on the self-propelled sprayer was used to generally evaluate the integration of the pulsed flow system into a commercial system including a GPS navigation and variable rate system, a commercial rate controller with conventional electronics and commercial software for creating a variable rate application map. The pulsing nozzles were interfaced to the existing rate controller using a commercial control module. Otherwise, the GPS system and variable rate map creation software was used without any modification. A series of application tests, at different ground speeds and application rates, was conducted. The system generally performed well and the pulsed spray technique worked well with the commercial equipment. These results indicate that the technique is compatible with existing commercial equipment.

Additionally, comparisons were made to test the actual deposition of liquid on the soil surface with the prescription that was loaded into the GPS system. An example test was successfully run where the liquid was varied over a 6:1 range

Comparison maps of prescribed and actual liquid distribution in a test field using pulsed spray technology.



from 5 to 30 gal/acre (see figure). As the vehicle traveled from south to north, the rate prescription instantly changed from 5 to 30, then 30 to 15 gal/acre. Deposit on the soil was determined by adding a fertilizer (zinc) tracer to the sprayer liquid, placing collector surfaces at surveyed locations in the field and then chemically analyzing the collectors. This technique provided a true measure of the actual performance. The recovered rate at the locations was then used to create the map of actual deposit. Comparisons of the maps show good results.

Work on the final objective is still underway but the general approach has been to install the pulsing valves downstream of the ammonia distribution manifold. This allows the manifold to be kept at a sufficiently high pressure to prevent vapor formation in the lines and to keep a uniform distribution of flow through the manifold. The pulsing valves are then used to modulate flow using the same technique as with the liquid controller. The prototype system deployed in the field in 1999-2000 used a conventional electronic rate controller but added the pulse valves for actual rate control. This allowed the system to operate over a wider range of tank pressures, ground speeds and ambient temperatures. The cooperating application and grower reported improved productivity (treated acres/day) through use of the system.

Agricultural Baseline Monitoring And BMP Implementation: Steps Toward Meeting TMDL Compliance Deadlines Within The Newport Bay/San Diego Creek Watershed

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INTRODUCTION

Agricultural production in the Newport Bay Watershed in southern California is considered one of several sources of nutrient loading to San Diego Creek, the main tributary for the Newport Bay. Due to the ecological importance of the Newport Bay, San Diego Creek was placed on the state's 303(d) list for impaired waterbodies, a listing that requires the development of a Total Maximum Daily Load (TMDL). The goal of the TMDL is to return the waters to a condition where its beneficial uses are no longer impacted by the identified pollutant(s). The process to reach this goal is both costly and time-consuming. A TMDL developed without adequate funds and time comprises the goal of ultimately improving the quality of the waterbody.

The development of a sediment and nutrient TMDL for the Newport Bay Watershed proceeded rapidly in response to litigation. As a result, the Santa Ana Regional Water Quality Control Board (SARWQCB) was forced to estimate N and P loads in agricultural surface runoff. Agricultural baseline flow and nutrient data were limited to that collected by three large wholesale nurseries to meet their waste discharge requirements. The timeline required for TMDL development was not sufficient for baseline monitoring of surface runoff from agricultural fields. In order to address this problem, SARWQCB utilized a phased approach that allows for incremental reductions in loads over several years as well as the opportunity to revisit loads previously set when new information becomes available. Currently load reductions have been established for the end of 2002, 2007, and 2012. The final goal is to reduce total N and P loading by 50% in 2012.

Agricultural producers in the Newport Bay Watershed, in order to meet the goal of a 50% reduction by 2012, will need to implement additional Best Management Practices (BMPs) that specifically address the movement of N and P compounds in surface runoff. This project seeks to establish baseline loads of N and P in surface runoff from agricultural fields. The data will then be used to evaluate the effectiveness of implementing BMPs that aim to improve the quality of surface runoff from both row crops and nurseries.

OBJECTIVES

1. Establish a water quality monitoring program for several representative agriculture sites in the Newport Bay Watershed in order to determine the baseline loads of N and P compounds in surface runoff.
2. Develop and conduct meetings that focus on current TMDL development and provide an opportunity for agricultural producers, nursery operators, and consultants to interact with SARWQCB and UC Cooperative Extension staff in an informal setting.
3. Develop and conduct a series of management workshops that provide hands-on demonstrations and seminars that focus on new technologies and cultural practices that will assist agricultural producers, nursery operators, and consultants in minimizing nutrient movement in surface runoff.

DESCRIPTION

The initial phase of the project involved the selection of agricultural sites that accurately represent the various types of production occurring in the Newport Bay Watershed. Other selection criteria included the following: the accessibility of site; the ability to install flow monitoring and water sampling equipment without drastic changes in a grower's existing drainage design; and the willingness of a grower to implement BMPs following the collection of baseline data.

Each site consists of two plots, a control plot and a treated plot. A monitoring program was initiated on both plots to collect both baseline flow data and nutrient concentrations. The monitoring program will continue through the end of 2000. The implementation of BMPs on treated plots will begin in 2001 following an evaluation of the baseline flow and nutrient data.

The baseline-monitoring program consists of the placement of automatic water samplers in the field once a week to sample surface runoff for a 24-hour period. Surface runoff flow is measured continuously with an area-velocity flow meter thus allowing for the estimation of N and P loads. Conditions when monitoring equipment cannot be utilized such as during field preparation, monitoring is replaced with grab samples if surface runoff is present. Water quality parameters consist of pH, electrical conductivity (EC), (NO_2 + NO_3)-N, NH_4-N, TKN, PO_4-P, and total-P. All nutrient analyses are being conducted by Irvine Ranch Water District's EPA approved water testing laboratory while EC and pH measurements are completed in the field.

The educational component of this project is composed of a series of forums and workshops. A forum will consist of an informal meeting between agriculture operators, nursery growers, UCCE project staff, and representatives from the SARWQCB. The meetings will provide the opportunity for updates on this project as well as interaction between the agency developing TMDLs and those that are directly affected it.

Workshops will focus on management strategies that are useful to both agriculture and nursery operators in reducing nutrient loads in surface runoff. The meetings will be held twice a year focusing on specific topics such as nutrient and irrigation management. New technologies will be demonstrated in an effort to expose growers to equipment available to assist them in making sound nutrient management decisions.

RESULTS AND CONCLUSIONS

Specific characteristics of the sites included in the baseline-monitoring program are described in detail in Table 1. Unforeseen changes in land use, however, resulted in the loss of the original site C after two months of monitoring. Flow and nutrient monitoring were resumed following relocation to another site. Due to the lack of measurable surface runoff as well as access difficulties, Site D required relocation from an orchard production site to row crop. Control and treated plots were chosen based on similar acreage and drainage patterns when possible. The ability to collect baseline data provides information on the differences in flow and nutrient movement between the plots prior to BMP implementation.

Because a significant amount of baseline data is already available for site E, a vegetation filter strip was installed in a concrete-lined channel with flow measurements and water sampling occurring upstream and downstream of the strip. The vegetation strip acts both a biological active filtration system as well as a source for plant material. Three sediment basins (an upper, middle, and lower) were created in the channel to remove as much sediment as possible and to slow the velocity of the water prior to entering the vegetation strip. The vegetation filter consists of 215 plastic mesh bas-

Table 1. Specific characteristics of the sites included in the baseline-monitoring program.

Site	Plot	Crop(s)[1]	Flow[2]	Sampling	BMP Implementation
A	R-1 (control)	S	March-July	Weekly if present	None
	R-2	S	March-July	Weekly if present	Initiate January 2001
B	R-3 (control)	S	March-May	Weekly if present	None
	R-4	S	April-May	Weekly if present	Initiate January 2001
C[3]	R-5 (control)	C, B, S	Feb-June	Weekly if present	None
	R-6	C, B, S	Feb-June	Weekly if present	Initiate January 2001
D[4]	R-7 (control)	S	New site	Weekly if present	None
	R-8	S	New site	Weekly if present	Initiate January 2001
E	N-1 (upstream)	CN	May-current	Weekly if present	None
	N-2 (downstream)	CN	July-current	Weekly if present	Vegetative filter

[1]Crop letter codes: B=Bean, C=Celery, CN=Container Nursery, and S=strawberry
[2]Flow is monitored at sites under production when surface runoff is present.
[3]Site was relocated in March (following celery harvest) to a field used for bean and strawberry production.
[4]Site was relocated from an orchard where surface runoff was absent to a field slated for strawberry production.

Table 2. Details of the average monthly flow from each plot at various sites.

Site	Plot	Monthly Flow Totals (m³)					
		February	March	April	May	June	July
A	R-1	N/A	275.4	119.3	2.5	0.9	0.0
	R-2	N/A	99.5	104.5	7.6	0.0	0.0
B	R-3	46.7	0.0	0.0	0.0	N/A	N/A
	R-4	N/A	N/A	51.9	0.2	N/A	N/A
C	R-5	35.6	0.13	3.9	57.9	12.3	N/A
	R-6	68.5	0.0	2.3	1.2	15.1	N/A
D	R-7	N/A	N/A	N/A	N/A	N/A	N/A
	R-8	N/A	N/A	N/A	N/A	N/A	N/A
E	N-1	N/A	N/A	N/A	3771.1	8209.9	15541.5
	N-2	N/A	N/A	N/A	N/A	N/A	9399.2

Table 3. Nitrogen content of surface runoff from a row crop and a nursery site.

Sampling Date	Plot	NH_3 (kg-N/day)	$NO_3 + NO_2$ (kg-N/day)	TKN (kg-N/day)	TN[1] (kg-N/day)
April 17, 2000	R-1	0.2	3.1	2.2	5.5
	R-2	0.2	1.8	2.0	4.0
April 18, 2000	R-1	0.1	1.0	1.0	2.1
	R-2	0.0	0.4	0.6	1.0
June 6, 2000	N-1	9.5	21.0	7.0	37.5
June 29, 2000	N-1	8.4	21.7	11.5	41.6
July 12, 2000	N-1	0.1	1.9	1.7	3.7
July 25, 2000	N-1	22.7	32.6	24.4	79.7

[1]TN=(NH_3) + ($NO_3 + NO_2$) +(TKN)

kets with two to three Canna lily plants (tubers) per basket. The baskets were set into the lower basin on 0.3 m centers covering 108 m2. Tubers will be harvested on an eight-week cycle. The data collected will be used to look at differences between the quality of influent and effluent as well as compared to baseline data collected by the nursery over the last two years.

The average monthly flow from each plot at each site is detailed in Table 2. A large percentage of surface runoff detected from sites A, B, and C in February, March, and April can be attributed to storm events. Irrigation events in April, May and June produced minimal or no surface runoff from row crops. Surface runoff, however, was detected occasionally and could be attributed to system leaks, long irrigation events, and the flushing of filters. The absence of significant rain events in May, June and July resulted in a decrease in flow from plots located at sites A, B, and C. Flow through the vegetation strip (site E) is continuous with peak flows occurring between 6:00 am and 4:00 pm.

Table 3 contains examples of the N content of surface runoff from a row crop and a nursery site. Sampling points R-1 and R-2 monitor surface runoff from four acre plots. The surface runoff analyzed from the row crop plots was the result of two storm events. Precipitation totaled 22.3 mm on April 17 and 5.6 mm on April 18. The nursery sampling point (N-1) monitors the surface runoff from approximately 95 acres of container-plant production. The low N loads on July 12 from N-1 can be attributed to an inoperable fertilizer injector compared to June 6, 29, and July 25. Fertilizer injection, in combination with overhead irrigation, results in higher N loads in surface runoff. The effects of the installation of a vegetation filter strip on the quality of this surface runoff will be characterized by the downstream sampling site that was recently installed. Nutrient data for plot N-2 is not yet available.

Evaluating And Demonstrating The Effectiveness Of In-field Nitrate Testing In Drip And Sprinkler Irrigated Vegetables

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INTRODUCTION

Vegetable production, including lettuce, celery, baby greens, peppers, sweet corn, tomatoes and onions, is an important sector of the agricultural economy in the Upper Pajaro River Watershed region which includes the Southern Santa Clara Valley. However, recent studies suggest that nitrate levels in the surface waters and the various aquifer zones of this basin often exceed the Maximum Contaminant Level (MCL) of 45 ug/mL due to excessive loading from residential septic systems, agricultural fertilization, animal enclosures, and other non-point and point sources. Concurrently the Water Quality Control Board Region 3 has indicated that it will develop a Total Maximum Daily Load Plan (TMDL) for nutrients (including nitrate) for Llagas Creek within the next few years. The high value of vegetable crops along with market demands for quality, make growers reluctant to increase economic risk by reducing N and/or irrigation inputs. To date recognition and adoption of in-field soil and plant monitoring as a simple and effective N management decision-making tool in this region has been limited due to the lack of a significant research and education effort in this region.

OBJECTIVES

The primary objective of this project is to assist a few key Santa Clara County growers in evaluating and adopting the use of in-field nitrate testing and N management planning to improve fertilizer use efficiency and profitability, while potentially reducing nitrate loading to ground- and surface water. Routine field monitoring and comparative trials utilizing in-field soil and petiole testing is being used to:

1. Confirm the utility of in-field soil nitrate testing in this region for pre-plant and sidedress N scheduling on cool season crops like lettuce whether on sprinkler or drip irrigation,
2. Evaluate whether and how effectively in-field quick soil and petiole testing will work for crops on drip and buried drip systems for a long, warm season crop like peppers (green and red bell types and Jalapeno types) which have not had as much attention as the cool season crops, (e.g. lettuce).
3. Use the data, grower observations and comments to demonstrate to a larger group of growers in outreach events that these tools actually work and are cost-effective under their regional conditions e.g. climate, crop types and irrigation technologies.

RESULTS AND CONCLUSIONS

Project activities began in January 2000 with presentations at two of the Water district's grower workshops. Beginning in early March, weekly and bi-weekly monitoring of lettuce, pepper, and celery fields is being used to document soil nitrate dynamics and identify key decision times for cooperating growers. In a number of these fields, we are using weekly soil nitrate date to suggest if elimination or reduction of preplant or sidedress N might be practical. We are also utilizing small in-field plots or strips to assess the outcome of this change in N fertilization practice, monitoring soil and crop productivity. In all field trials we plan to develop a simple N budget for each grower's fields which includes estimates of nitrate input from all sources, including irrigation water. The Water district has provided invaluable assistance by providing a number of complete well water tests for participating growers. To date we have completed two lettuce trials where one application of sidedress N was eliminated. Currently we have two bell pepper fields where reduced N plots/strips have been established. We have had early success in assisting two of our grower cooperators in modifying their fertilization programs prior to harvest. We also continue to monitor a number of pepper fields in the Valley through fall harvest.

This project has been enhanced by collaboration with the District's Mobile Irrigation Lab Program. Power Hydrodynamics has provided irrigation system evaluations for each grower and field that we have trials or monitoring programs in place. In addition Mobile Lab technicians collect irrigation water samples for routine confirmation of nitrate content as well as tailwater/runoff estimates and samples for nitrate analysis where appropriate.

Additional Activities for 2000 Season

At the end of the 2000 season, we will meet with all participating growers to review the field data, identify specific field trial objectives for the 2001 season, and provide more detailed training on in-field monitoring. The Project Leader will present results at grower workshops, which will also provide general and new crop specific information concerning nutrient and water management for crop production. Additionally an annual technical sheet will be developed which provides similar information in English and Spanish. We are also planning to provide a presentation in spring 2001 for students at the Live Oak High School Agricultural Academy in Morgan Hill, as well as participating in any other special meetings by Santa Clara County Cooperative Extension and the Farm Bureau.

Development Of Fertilizer And Irrigation Practices For Commercial Nurseries

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OBJECTIVES

1. Determine water use of eight tree species grown in 5-gallon containers. The species were chosen to include both deciduous and evergreen trees that are widely used in California. These are white alder (*Alnus rhombifolia*), southern magnolia (*Magnolia grandiflora*), Chinese pistache (*Pistacia chinensis*), California sycamore (*Platanus racemosa*), hollyleaf cherry (*Prunus ilicifolia*), coast live oak (*Quercus agrifolia*), valley oak (*Quercus lobata*), and coast redwood (*Sequoia sempervirens*).
2. Determine N uptake and leaching losses for these trees and compare N use efficiency of three methods of fertilizer application (liquid feeding with NO_3-N, liquid feeding with polymethylene urea, and pre-mix application of controlled release fertilizer).
3. Determine dry weight gain of trees.

DESCRIPTION

Large container-grown trees (5-gallon container and larger) have become an important nursery commodity in California, but there are no reliable guidelines for their fertilizer and irrigation management. This research was undertaken to characterize the water use and N demand of ornamental trees commonly produced in California nurseries, and to compare methods of providing N fertilizer during nursery production.

The trees were transplanted from liners into 5-gallon containers on June 1, 2000 and placed in the UC, Davis Environmental Horticulture experimental nursery. Each fertilizer treatment group is irrigated through a separate irrigation system, each controlled by a solenoid valve and timer. One supplies tap water to plants fertilized with controlled release fertilizer; one uses a Smith injector to introduce methylene urea and potassium sulfate into tap water at a final N and K concentration of 100 mg/L; one uses a Smith injector to introduce calcium nitrate, potassium nitrate, and ammonium nitrate at a final N and K concentration of 100 mg/L (25% of N supplied as ammonium). Controlled release fertilizer was incorporated into the appropriate treatment at the recommended rate.

RESULTS AND CONCLUSION

During the first two months after planting, cumulative water use (the volume difference between applied water and water leached) among the eight tree species ranged from 32.5 L for Platanus to 11.3 L for Prunus (Figure 1). The difference in water use among species was statistically significant ($P = 0.07$), but there was substantial variability among the individual trees. After two months of growth, there was a five-fold difference in average daily water use among the species (see Table). Basing evapotranspiration on the surface area of each tree container, cumulative water use during the eighth week of the experiment ranged from 33% to 273% of reference evapotranspiration (see Table). The differences due to species and to variability among individual trees introduce a problem for the nursery, since it will be difficult to predict water use and, in any event, it is impractical to establish separate irrigation systems for each species. As a result, it may be difficult for nurseries to control leaching losses. For example, despite close monitoring of both application and leaching of irrigation water, we have been unable to achieve consistent leaching fractions (ratio of volume of water leached to the volume applied), and the average leaching fraction for most species has been over 0.35 (see Table).

Nitrogen leaching losses during the first two months were significantly greater from the standard liquid feeding than from the controlled release treatment (Figure 2). Due to problems with the injector for the methylene urea treatment, data for that treatment are not included in the cumulative N leached; however, current data indicate that leaching losses of N (as nitrate, ammonium, urea, and methylene urea) from the liquid feeding of methylene urea are similar to the N losses from the standard liquid feeding treatment. Tree species imparted no significant effect on N leaching. It is worth noting that the average N concentration in the leachate from the standard liquid feed has been less than 40 mg/L, which is substantially less than the applied rate of 100 mg/L. Tree demand for N is therefore diminishing the concentration of N in the irrigation water; thus, if the volume of leachate could be reduced through better control of the leaching fraction, the total leaching losses from the liquid feed treatment might be diminished considerably. Leaching losses from the controlled release fertilizer treatment have been very small, even during the first weeks of the experiment, when plant demand for N was low. Nitrogen leaching losses from that treatment at the end of July, after about two months of tree growth, were only about 6 mg per week. It is too soon to tell whether the N release rate in the controlled release fertilizer treatment is sufficient to meet plant demand; however, there have been no visual symptoms of N deficiency.

Initial results from this study indicate that liquid feeding of trees in large containers may result in substantial leaching losses of N because of widely variable rates of water use among species and individual trees. Use of controlled release fertilizer can reduce N leaching losses.

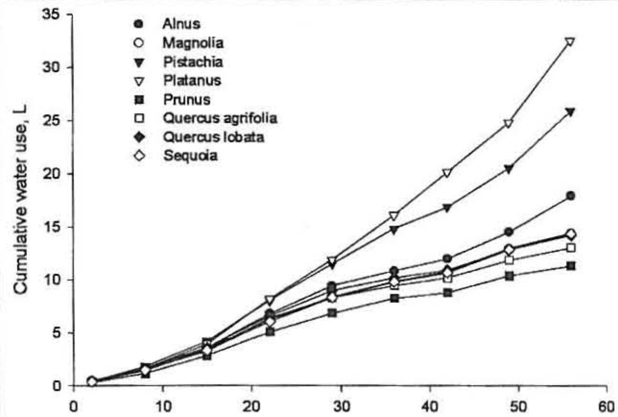

Figure 1. Cumulative water use by eight tree species in 5-gallon containers during June and July 2000. Water use was calculated from the volume difference between applied and leached water.

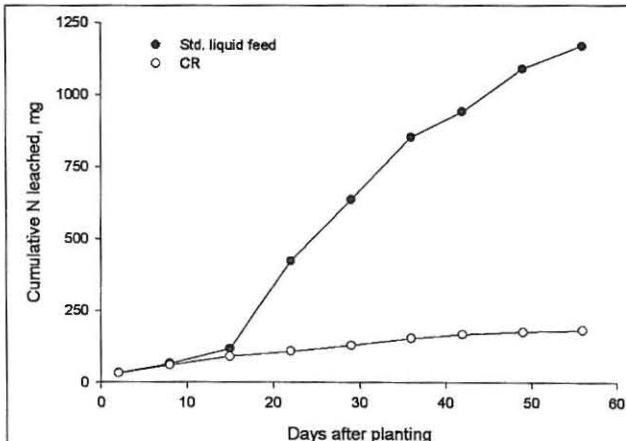

Figure 2. Cumulative N leached from eight tree species in 5-gallon containers during June and July 2000. Trees were fertilized with a standard liquid feed or controlled release fertilizer (CR), as described in the text.

Average daily water use and leaching fractions for trees after two months of growth.

Species	*Average Daily Water Use* *mL*	*Leaching Fraction*	K_c *
Alnus rhombifolia	427	0.36	1.21
Magnolia grandiflora	261	0.39	0.52
Pistacia chinensis	648	0.34	1.91
Platanus racemosa	886	0.15	2.73
Prunus ilicifolia	180	0.61	0.33
Quercus agrifolia	208	0.50	0.43
Quercus lobata	236	0.43	0.49
Sequoia sempervirens	266	0.38	0.54

* Fraction of reference evapotranspiration, based on the surface area of each tree container.

Development Of Irrigation And Nitrogen Fertilization Programs For Turfgrass

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INTRODUCTION

Urban landscapes, including areas planted with turfgrass, offer numerous functional, recreational, and aesthetic benefits. Several functional benefits include excellent soil erosion and dust stabilization; improved recharge and quality protection of groundwater, enhanced entrapment and biodegradation of synthetic organic compounds, heat dissipation and temperature modification, reduced noise, glare, and visual pollution problems, and lowered fire hazard via open green-turfed firebreaks. The 1997 estimate of $2.1 billion spent annually on turfgrass maintenance in California also is a significant benefit to the state's economy. This estimate is based on a published figure for 1982 and corrected for inflation (multiplier=1.54) and for population increase (multiplier=1.34).

Although the establishment and maintenance of quality, functional turfgrass is justifiable, developing and implementing best management practices (BMPs) also is important for the responsible use and protection of natural resources. Currently, there is considerable interest in developing and implementing turfgrass BMPs for addressing following points:

- Water conservation and its efficient utilization.
- The potential contamination of runoff water and groundwater with applied nutrients, especially NO_3-N, and pesticides
- The potential contamination of surface water with sediment and nutrients during turfgrass construction.
- The potential development of pest populations with increasing resistance to chemical control.
- The potentially negative impacts of chemical management on beneficial soil and nontarget organisms.
- The potentially toxic effects of applied chemicals to non-target plants and animals.
- The potential loss or degradation of native habitat during construction and turfgrass maintenance.
- The reduction of landscape waste, including grass clippings, that are deposited in landfills.

Considering the number of issues listed above, there are probably numerous research and education opportunities for developing and implementing turfgrass BMPs in California. Though each environmental issue is individually important for turfgrass management, the use (conservation) of irrigation water on urban landscapes, including turfgrass, is the most general driving force in California. Considering the importance of crop-water management and fertilizer-use efficiency, we developed a research and education project concerning BMPs for efficient use of irrigation water and N fertility on tall fescue which is currently the most widely planted turfgrass species in California. Our rationale in developing the specific protocols of the project are founded on three assumptions listed below:

1. Future landscape water-use budgets will most likely range from 80% reference evapotranspiration (ET_o) per landscape area (AB325, 1990) to 100% ET_o per landscape area.
2. Fertilization of turfgrasses, according to established cultural strategies, presents a negligible potential for nutrient elements to pass through the root zone and into groundwater or be transported by runoff water into surface waters. This has been confirmed by a number of earlier

studies and reviews. However, turfgrass managers will need to give special attention to fertilization practices when 1) there is a potential for heavy rainfall, 2) the turfgrass is immature and the soil is disturbed, such as during establishment, and 3) root absorption of nutrients is low because of plant dormancy or stress.

3. Although excessive application rates of water-soluble N fertilizers on turfgrass followed by over-watering on sandy soils has been shown to cause NO_3-N leaching, this situation would be less likely to occur during the implementation of annual landscape water-use budgets at 80% and 100% ET_o per landscape area.

In light of these assumptions regarding the management of tall fescue, water management/N-fertility use efficiency research would involve the development of a balanced irrigation and N-fertility program. This research will takes into consideration the landscape water-use budgets and optimal annual N rates for tall fescue performance in terms of visual turfgrass quality and drought stress tolerance, growth, and N uptake.

OBJECTIVES

1. Test irrigating tall fescue at a defined annual amount (80% historical ET_o plus rain) with increased irrigation during the warm season to improve turfgrass performance, and then proportionally adjusting the cool-season irrigation amount downward to make up for the additional warm-season irrigation. These treatments are compared to irrigating tall fescue at a constant rate of 1) 80% historical ET_o plus rain and 2) 80% ET_o (real-time) plus rain.
2. In conjunction with irrigation treatments, test the influence of the annual N-fertility rate on tall fescue performance.
3. Quantify the effects of irrigation and N-fertility treatments on visual turfgrass quality and drought stress tolerance, growth (clipping yield), and N uptake, along with treatment effects on soil water content and soil N status.
4. Develop BMPs for tall fescue relating to turfgrass water conservation and N-fertilizer use efficiency, which provide optimal performance in terms of visual turfgrass quality and drought stress tolerance, growth (clipping yields), and N uptake.
5. Conduct outreach activities, including trade journal publications and oral presentations, emphasizing the importance of turfgrass BMPs, and how to properly carry out these practices for turfgrass irrigation and N fertilization.

DESCRIPTION

This project involves the study and development of best management practices (BMPs) for landscape water conservation and N-fertility efficiency on tall fescue, currently the most widely-planted turfgrass species in California. This 3-year field study investigates irrigation treatments that are designed to test irrigating tall fescue at a defined annual amount (80% historical ET_o plus rain), with increased irrigation during the warm season to improve grass performance. Later on it will proportionally adjust the cool-season irrigation amount downward to make up for the additional warm-season irrigation. These treatments are being compared to irrigating tall fescue at a constant rate of 80% historical ET_o plus rain; and 80% ET_o (real time) plus rain. In conjunction with the irrigation treatments, this study investigates N-fertilizer treatments designed to test optimal annual N rates for tall fescue performance in terms of visual turfgrass quality and drought stress tolerance, growth (clipping yields), and N uptake. We are also determining the influence of irrigation and N-fertilizer treatments on soil water content and soil N status. A detailed description of treatment, measurement, and plot-maintenance protocols was provided in the 1999 CDFA/FREP Conference Proceedings.

In the course of the study, we are also conducting outreach activities, including trade journal publications and oral presentations, reflecting both the ongoing research and the importance of turfgrass BMPs in general. The presentations will evolve with the ongoing research and from audience evaluations. This will include an assessment of the current turfgrass management practices of the target audience, so that these practices can be modified in order to meet the requirements of generally accepted BMPs for turfgrass irrigation and N fertilization. Upon completion of this project, we hope to provide the necessary information for maintaining acceptable tall fescue, complying with landscape water-use budgets, and efficiently applying N fertilizers. Considering that water use is the top environmental issue in California, and that tall fescue is currently the most widely planted turfgrass in the state, there is a high potential that BMPs developed from this project will have immediate and widespread adoption by professional turfgrass managers, personnel involved in the fertilizer industries, educators, consultants, as well as home-lawn owners.

RESULTS AND CONCLUSIONS

A discussion concerning the field research was provided in the 1999 FREP Conference Proceedings. This year, the results from an outreach activity will be discussed.

Surveys were handed out at the 1998 and 1999 University of California, Riverside Turfgrass Research Conference and Field Day. A total of 381 surveys were collected from the participants of these conferences. These surveys were designed to determine the specific fertilization and irrigation practices that were consistently performed by the respondents.

Fertilization Practices

The majority of respondents (61%) indicated that they consistently apply appropriate amounts of N specific for turfgrass species and requirements of turfgrass use. Other (59%) apply N based on seasonal growth patterns and need. Some respondents (53%) apply different combinations of slow- and fast-release nitrogen sources according to seasonal growth and expected rainfall. More than a third (37%) of the respondents also indicated that they conduct soil fertility tests every 1 to 2 years. The least common practices were applying P_2O and K_2O relative to annual N applied (26%) and avoiding fertilization prior to rain (12%).

Irrigation Practices

The vast majority of respondents (86%) indicated that they consistently check irrigation systems for proper function. Approximately two-thirds also indicated that they consistently adjust irrigation clocks at least every 3 months (68%) and size nozzles for balanced precipitation on rotor systems (62%). About half of the respondents consistently cycle irrigation on slopes to prevent runoff (55%) and irrigate according to weather station or soil moisture sensor data (49%). Only 41% of the respondents indicated they consistently check system operating pressures.

Outcome of Survey

Advisors vs. Managers

Very little statistical difference was observed between the advisory and management categories, except for mowing program development and protecting non-target plants, animals and humans from chemicals.

- Only 53% of advisors considered mowing program development to be highly important as compared to 82% of managers. Advisors were also 28% less likely to be frequently implementing mowing programs and 29% less likely to continue or start the practice. Both advisors and managers, however, agreed developing mowing programs is not particularly difficult (only 31% of advisors and 23% of managers considered this practice to be highly difficult).
- Advisors (69%) were less likely to consider protecting non-target plants, animals and humans from chemicals to be highly important than were managers (84%). Similarly, only about half of advisors as opposed to about three-quarters of managers were likely to be frequently implementing the BMP or were likely to continue or start implementing the practice. Both advisors and managers, however, agreed that protecting non-target plants, animals and humans from chemicals is not particularly difficulty (only 28% of advisors and 31% of managers considered this practice to be highly difficult).

General vs. Sports Turf Managers

- General and sports turf managers, overall, considered the BMPs listed to be highly important (averaging 76% to 81%, respectively). The only statistical differences between the two groups were for fertility program development and protecting native habitats during construction/maintenance, both of which sports turf managers considered to be more highly important than general turf managers (differing by 22% and 15%, respectively).
- Sports turf managers were more likely to be frequently implementing the listed BMPs than general turf managers. This was particularly true for fertility program development (48% to 76% for general and sports turf managers, respectively); integrated pest management (41% to 65% for general and sports turf managers, respectively); and protecting water sources from chemicals (48% to 76% for general and sports turf managers, respectively).
- Sports turf managers were more likely to continue or to start implementing the BMPs than general turf managers. This was particularly true for fertility program development (59% to 79% for general and sports turf managers, respectively); integrated pest management (52% to 69% for general and sports turf managers, respectively); and protecting water sources from chemicals (50% to 67% for general and sports turf managers, respectively).
- Both general and sports turf managers, overall, were not statistically different in terms of how they rated the difficulty level for the BMPs listed (less than a third of both general and sports turf managers considered the BMPs to be highly difficult). Moderately more sports turf managers (43%) than general turf managers (30%) considered turfgrass selection to be highly difficult. The same trend held for protecting native habitats during construction/maintenance (40% of sports turf managers and 26% of general turf managers considered the practice to be highly difficult).

Uniformity of Chemigation in Microirrigated Permanent Crops

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OBJECTIVES

1. Develop information on the water and chemical travel times and on application uniformity of both readily soluble products (e.g. liquid nitrogen fertilizers) and of low solubility materials (e.g. potassium sulfate) injected via solutionizer machines.
2. Develop recommendations in the form of best management practices for chemigation in order to attain uniform application of chemicals.
3. Conduct a series of workshops on chemigation of micro-irrigation systems.

DESCRIPTION

Chemigation, the injection of chemicals through an irrigation system, is becoming common among permanent crop growers (tree and vine) using microirrigation systems. Advantages to chemigation include: (1) flexibility in timing fertilizer applications, (2) reducing the labor required for applying chemicals, and (3) the potential increase in the efficiency of chemical use, thus reducing the cost of chemical use. Some chemicals (e.g. chlorine) and some fertilizers (e.g. numerous nitrogen sources) readily dissolve in water and are injected via venturi or positive displacement pump injectors. Other chemicals seeing recent chemigation use (e.g. gypsum, potassium sulfate), are not readily soluble and are being injected using "solutionizer" machines.

RESULTS AND CONCLUSIONS

Six commercial orchards and vineyards were evaluated for chemigation uniformity. Evaluations included determining water/chemical travel times through drip irrigation system mainlines/submains and through drip lateral lines. Chemical application uniformity was also determined. Drip irrigation systems travel times were measured by injecting chlorine (calcium hypochlorite) and monitoring its passage through the drip irrigation system using a pool / spa chlorine test kit. Chemical application uniformity was determined by injecting potassium chloride and collecting all the discharge from drip emitters at key locations in the drip irrigation system. The collected samples were then analyzed for K content at the UC DANR Analytical Laboratory.

The travel times through the drip irrigation systems for the commercial vineyards and orchards was evaluated and is presented in Table 1. Note that there is a wide range of water/chemical travel times in both the mainline/submain and in the drip lateral line portions of the irrigation system. As the drip irrigation system designs vary from site to site, so do the water/chemical travel times through the irrigation system. No general recommendations on injection time periods to achieve high chemical application uniformity is appropriate for all drip irrigation systems. A one-time, field determination of water/chemical travel times is necessary for each drip irrigation system.

Additional work was done on a single drip lateral line to evaluate the impact of chemical application uniformity of varying the injection times and the post-injection irrigation times. The results of some of these evaluations are shown in Table 2. The lateral line evaluated was a 500-foot drip lateral (16 mm polyethylene tubing) with a 1 gallon per hour (gph), pressure compensating, drip emitters installed every 5 feet. It was determined through field evaluation that the travel time for water/chemicals passing through the lateral line was 25 minutes.

Note that excellent chemical application uniformity was achieved when: (1) the injection period was equal to or greater than the water/chemical travel time to the end of the drip lateral (25 minutes in this case), and (2) the post-injection irrigation time was equal to or greater than the lateral line's water/chemical travel time. The results in Table 2 also show that there are two injection strategies to avoid. First, avoid injection periods, which are less than the drip system's water/chemical travel times to the end (hydraulically) of the

Table 1. Water/chemical travel times through the pipelines and drip lateral lines for the vineyard and orchard field sites evaluated.

Site	Mainline and Submain Travel Time (min.)	Mainline / Submain Length (ft)	Lateral Line Travel Time (min.)	Lateral Line Length (ft)
1	22	1000	10	175
2	30	1500	10	340
3	65	5000	10	340
4	15	1400	23	630
5	8	700	23	625
6	17	820	28	600

Table 2. Chemigation uniformity in a drip lateral (500-feet long with 1-gallon per hour drip emitters installed at 5-foot intervals) for various injection time periods and various post-injection clean water irrigations.

Injection Time (min)	Post-Injection Irrigation Time (min)	Relative Uniformity
50	50	100
50	25	98
50	0	25
25	50	90
25	25	95
25	0	11
13	25	81
13	0	7

The water/chemical travel time to reach the end of the drip lateral was 25 minutes.

system. Secondly, an injection should always be followed by a period of "clean" water irrigation. This post-injection irrigation period should be at least as long as the water / chemical travel time to the end of the drip irrigation system. The worst chemigation uniformities would result from a too short (less than the end-of-system travel time) injection period followed by drip system shutdown.

To aid in visually observing what was occurring during an injection, an experimental setup simulating the last two drip emitter intervals at the tail end of a drip lateral was developed. Clear tubing of the same diameter as drip tubing was used with 2, 1-gph drip emitters installed — one 5 feet from the inlet and the other 10 feet from the inlet. With the system operating, colored dye was injected into the water and the time since injection began recorded along with the dye movement along the tube. Once the dye reached the end of the tube, the dye injection was stopped and a record was kept of time vs. dye clearing from the tube. Professional photographs of this event were taken and have been digitized. They are available upon request from the authors.

Additionally, a University of California DANR leaflet — "Uniform Chemigation in Tree and Vine Microirrigation Systems" — is in production and should be available by the end of 2000. This publication will be available both through CDFA/FREP and University of California Communication Services.

RECOMMENDATIONS

As a result of our field evaluations, the following drip irrigation chemigation practice is recommended:

One-time field determination of water/chemical travel times through the drip system should be done. Of particular importance is the determination of the time it takes for injected chemical to travel from the injection point to the hydraulic end of the drip irrigation system. Travel times can be readily determined by injecting chlorine and timing its movement through the drip system by testing for chlorine in the irrigation water using a pool / spa chlorine test kit.

Once the water/chemical travel time to the hydraulic end of the drip system is determined, the injection strategy to achieve high chemigation uniformity should consist of the following steps:

Step 1: Allow the drip system to fill and come up to full pressure.

Step 2: The injection period should be at least as long as the water/chemical travel time to the hydraulic end of the drip irrigation system. A longer injection period is even better.

Step 3: The post-injection irrigation time should again be at least as long as the travel time to the hydraulic end of the drip irrigation system. A longer post-injection irrigation period is better.

Nitrogen Mineralization Rate of Biosolids and Biosolids Compost

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INTRODUCTION

The disposal of biosolids is one of California's vexing environmental problems. Application on agricultural land represents the most beneficial use of this N rich material. However, without a sound understanding of N mineralization behavior of the common biosolids products (dewatered, air-dried or composted) it is impossible to determine appropriate field application rate to supply the desired agronomic benefit without creating a nitrate pollution hazard. Information on N mineralization from biosolids under central California field conditions is extremely limited. This project proposes to develop short- and long-term N mineralization estimates for representative biosolids products and, through field studies and laboratory assays, to examine the effects of soil type, cropping system, and loading rate on N mineralization dynamics. Furthermore, the ability of laboratory analytical procedures or short-term incubation assays to predict N mineralization behavior will also be investigated.

OBJECTIVES

1. Determine the short- and long-term N mineralization rates of locally produced dewatered, air-dried or composted biosolids.
2. Determine if short-term incubation assays, or laboratory analytical procedures, are predictive of field mineralization rates.

DESCRIPTION

A total of 100 microplots were established at University of California, Davis in early summer, 2000. These microplots were amended with various biosolids materials collected from waste treatment plants in several metropolitan areas of California. Over the course of a 3-year study the effects of the following variables on the N mineralization behavior of biosolids will be evaluated:

3. Soil texture (sandy loam vs. clay loam)
4. Cropping system (summer production of sudangrass vs. overwinter production of wheat)
5. Types of biosolids materials (dewatered, air-dried, and composted)

A parallel laboratory study will be conducted in which net N mineralization will be estimated from aerobic incubation of biosolids-amended soil under constant temperature and moisture. Several laboratory indices of N mineralization potential (autoclaving, or extraction in hot KCl) will be evaluated for correlation with measured N mineralization from the field and controlled environment incubation studies.

RESULTS AND CONCLUSIONS

The first biosolids application was made in June, 2000. Application rate was equivalent to 8 dry tons / acre for the air-dried and dewatered biosolids, and 16 dry tons / acre for the composts. To date the only data collected have been the composition of the original biosolids materials, and the biomass production of sudangrass after approximately 8 weeks of growth (see Table).

The relatively small dry weight differences among treatments do not reflect the magnitude of the difference in available N.

Sudan grass biomass accumulation in biosolids-amended microplots.

Biosolids sample	*Type of material (dry g/microplot)*	*% N*	*Sudan grass biomass*
A	air-dried	5.7	283
B	air-dried	4.6	340
C	dewatered	3.9	360
D	dewatered	4.8	365
E	composted	2.2	323
F	composted	0.9	266
unamended soil	–	–	284

* Note: Support for this project is provided to CDFA/FREP by the Sacramento Regional County Sanitation District.

The air-dried and dewatered biomass treatments had much darker green foliage, indicative of higher N content. Sudangrass growing in the unamended soil, and in microplots amended with biosolids sample F (a low-N compost), were distinctly yellow.

The sudangrass will be allowed to continue growth, and will be harvested again in October. Wheat microplots will be planted in late September, and the crop harvested in June, 2001. The experiment will be continued through 3 cropping seasons for the sudangrass and 2 cropping seasons for the wheat.

Funding for this project comes from the Sacramento Regional Wastewater Treatment Facility.

Development Of An Educational Handbook On Fertigation For Grape Growers

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OBJECTIVES

1. Develop an easy-to-read, well illustrated printed guide on fertigation for wine grape growers, that includes the following:
   - Nutritional needs of grapevines and how to determine nutrient statutes in grapevines and soil.
   - Equipment needed for fertigation, and instructions on how to design and install it (including backflow prevention).
   - Water quality issues, and cautions to prevent system clogging.
   - Strategies for applying materials.
   - Fertilizer materials and their suitability for drip irrigation.
   - Charts and tables to assist growers in determining concentrations and application amounts.
   - Environmental cautions on the storage and use of fertilizers, especially concentrated materials.
   - Monitoring to measure the effectiveness of fertilizer applications and system performance.
2. Prepare materials for camera-ready publication.

DESCRIPTION

An illustrated handbook will be written for grape growers to assist them in developing environmentally safe and effective fertigation programs for their vineyards. The primary focus of the book will be on utilizing drip irrigation systems to deliver fertilizers to their vines. Included in the publication will be information on how to assess the need for fertilizing vines, equipment for applying materials, and the materials that work well in fertigation; evaluation of water and potential plugging and clogging problems, and how to chemically condition the system to avoid these problems; calibration and monitoring of injection equipment during fertigation; and strategies to provide adequate nutrition and balanced vines.

The publication will be clear and concise, targeted to wine grape growers in California. Upon completion of this project, a camera-ready publication will be submitted to DANR publications or other suitable publisher.

Irrigation And Nutrient Management Conference And Trade Fair And Field Days

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INTRODUCTION

Water availability and quality continue to be important problems on the Central Coast. Eighty percent of all water use is attributed to agriculture. Although agriculture is a $2.4 billion contributor to the economy, it is blamed for contaminating the groundwater of the Salinas Valley and Santa Cruz County coastal areas. It is imperative that growers modify their irrigation and fertilizing practices to improve the water situation and to negate any need for a regulatory approach.

Nitrate leaching is a major documented problem that occurs in this area. As in the case of seawater intrusion, the California State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Board (RWQCB) deem agriculture responsible for contaminating the groundwater.

Through the Salinas Valley Water Project Plan (SVWPP), extension of information has been identified as a very weak link in the remediation efforts. Clearly there is a need for continuing research, but the existing body of proved, effective practices and methods of irrigation and fertilization needs to be more widely used to impact water quality/quantity. Therefore, the focus of this project has been educational.

OBJECTIVES

1. Present the latest fertility and irrigation management findings and techniques, using a variety of educational settings.
2. Present options and sources of suppliers.
3. Promote adoption of new techniques.
4. Provide a non-regulatory approach to protecting the groundwater.
5. Survey growers for unique, successful practices.

DESCRIPTION

A conference was held in conjunction with a vendor trade show in February 2000, in Salinas. The trade show portion was conducted by a separate entity. The two events (educational workshops and vendor displays) were held concurrently to maximize participation for both events.

The full-day conference consisted of presentations from noted experts and grower panels. Approximately 250 – 300 people attended the entire event, while 208 folders containing information about irrigation and nutrient management were distributed to the people who actually signed in. Three months after the conference, 73 participants were contacted for a follow-up survey. Seventeen survey questionnaires were completed.

A field day, the second component of this project, was held in July. About 65 people were in attendance.

RESULTS AND CONCLUSIONS

One grower-participant who said, "I want an invention I can just stick in the ground to tell me what nutrients I need" best describes grower sentiment. Simplicity and ease of use will be essential to increasing adoption of new fertilization and irrigation efficiency tools and techniques.

Contrary to the popular notion that expense is grower's primary obstacle, the surveys indicate that more time and personal demonstration or explanation is what growers feel they need to try new methods. Along with that idea, growers would much rather learn in small workshops and on-farm demonstrations. The trade show and large conference formats are among their least favored venues for learning. The grower panels, while popular, require careful preparation to insure that the presenting grower gives factual information.

The telephone survey revealed that farmer perceptions differ from practice. They don't perceive themselves to be innovative when, in fact, they are using a variety of newer practices or products. Their most common solution to minimizing nitrate leaching is "good management practices".

While almost every possible topic was listed by at least one grower, the more frequent requests for additional information were: TMDL's, using injections with drip systems, increasing irrigation uniformity, irrigation scheduling and timing, the "basics", nutrient management in organics, well-water nitrates and new "devices".

RECOMMENDATIONS

- Omnipresent guides clearly explaining "best management practices."
- Clear explanation of time needed, or time saved, as related to best management practices.
- Easy-to-use tools that require minimal amounts of time, and which perform as many calculations as possible for the farmer.
- Small, focused demonstration workshops or classes.
- A "open farm" day, where people can chose, based on an area map where farmers can chose to go observe innovative processes are being used.

A final caveat for any information, in order to be utilized, is that it has to show, as one grower requested "How to make money in the business of agriculture."

PAJARO VALLEY NUTRIENT/WATER MANAGEMENT EDUCATION AND OUTREACH PROJECT

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INTRODUCTION

As a pilot project, the primary focus area is the Pajaro Valley which covers the same area and boundary of the Pajaro Valley Water Management Agency (PVWMA) which includes the southern part of Santa Cruz County and the northern portion of Monterey County. Agriculture is the most significant land use, occupying 31,000 acres of irrigated farmlands within the Pajaro Valley. In 1998, the County of Santa Cruz reported that nitrate in 25% of the wells exceeded the drinking water standard of 45 mg/L. Nitrate in some wells in Springfield and the coastal area reached nearly 400 mg/L Some individuals and mutual water companies lost their potable water supplies to nitrate contamination. The State Water Resources Control Board (SWRCB) has identified the Pajaro River and several tributary streams as priority watershed due to significant water quality impairments. In 1999, the Pajaro River Watershed Management Plan (PRWMP) indicated the most likely sources of nitrates from fertilizer and irrigation runoff during the growing season.

OBJECTIVES

1. Disseminate information on nutrient management alternatives including BMPs
2. Expose growers to alternative nutrient management approaches at seminars/workshops
3. Convince growers of the effectiveness of nutrient management alternatives through field demonstrations
4. Provide on-farm technical assistance to those who are interested to try.

DESCRIPTION

A hands-on workshop on irrigation and fertilization was completed in January 2000. However, the project was formally launched with a "Hands-on Nitrate Quick Test" event in April. Originally, the project was scheduled to implement many programs during the growing season. At the advice of community leaders, in response to the market and on-farm priorities with the local growers, mostly the small farmers, the programs have been rescheduled to the early fall and winter.

Upcoming Activities

October 17, 2000: Pajaro Valley Water Quality Awareness Faire & Agricultural Expo '2000, a one-day educational fair. It will be held at the Art Building at Watsonville - County Fairgrounds. This event will be an annual event in the Monterey Bay region. The event will be filled with educational information for the growers, students and the general public alike, as well as with food and fun to enjoy. During the FAIRE day, new technologies, products and services will be introduced to the growers (as an attraction) while Best Management Practices will be exposed to the growers by public and non-profit organizations.

October 27, 2000: Pajaro Valley Nutrient Management Workshop, an afternoon event. Growers are encouraged to bring in their water and soil sample to make nitrate quick test on their won with the assistance provided by local technicians. There will be a series of presentation on nutrient management and precision farming.

November 27, 2000: Nutrient Management Seminar, an all-day event. Local irrigation consultants, farm advisors, extension agents, experts from University of California and Cal State University will discuss research findings on nutrient management and precision farming. Special guests from the private industry will participate.

December 12, 2000: Nitrate Accumulations in the Plantbeds, a field demonstration. This is a research project collaborated by Soil Control Lab of Watsonville, Pajaro Valley. Frank Shields of Soil Control Lab, leads the research. This research has already begun since February 2000, and data collection will be completed by October 2000. Due to the need for conducting comprehensive lab analysis of a large number (hundreds) of soil samples over a long period, growers cannot afford to investigate such an undertaking. We believe that knowledge gained from this research will directly benefit growers as well as aid the research communities by providing the following in-depth analysis of the soil at the research site(s). Each month, soil samples from ten zones of each plant-bed have been collected and analyzed for the rate of release of fertilizers movement, accumulation of specific ions in the N cycle, pH changes, reasons for changes toxic bands, formation root development, ongoing fertilizer application, salt distribution and accumulation, and carbonate accumulation. The research sites are selected from both strawberry (spatially dominating crop in the area) and lettuce plant-beds. The goal of this research is to work with local growers to come up with a plan to reduce waste of water and nutrients, and maintain quality production.

January 9, 2001: Irrigation Scheduling Workshop, a half-day training. It is limited to 20 attendees. Registration is required. It will be held at a Computer Lab, possibly at CSUMB-SIVA.

January 18, 2001: Nutrient Management Seminar, an all-day event. Local irrigation consultants, farm advisors, extension agents, experts from University of California and Cal State University will discuss research findings on nutrient management and precision farming. Special guests from the private industry will participate.

It is anticipated that the on-farm assistance to growers for nitrate quick testing will resume during February and March of 2001. Details of the above-mentioned programs can be found at www.nutrient-winners.com.

Nitrogen Budgeting Workshops

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INTRODUCTION

Efficient fertilizer management is vital to the production and profitability of almonds in California. Almond growers statewide are seeking information and guidance on the optimum timing and quantity of N to maximize their crop. Nitrogen budgeting is a tool that growers can use to maximize fertilizer use efficiency and minimize fertilizer unintentionally released into the environment. This project proposes to conduct N budgeting workshops in three almond-producing counties in the Central Valley of California.

Note: The proposed workshops will take place in the fall/winter of 2000 after harvest.

OBJECTIVES

1. The primary objective is to hold workshops in three counties using the Nitrogen Budgeting Worksheet as a tool to evaluate fertilization practices. The workshops will provide a forum for participants to discuss innovative management techniques being used by growers. The events are an opportunity for interaction between farmers, farm advisors, and independent farm consultants with experience in optimizing N fertilizer applications.
2. Distribute the Nitrogen Budgeting Worksheet. Calculation of an N budget can help optimize fertilizer use efficiency and minimize excessive nitrate fertilizer released into the environment. The Nitrogen Budgeting Worksheet provides growers with an independent resource for the evaluation of annual N applications. Growers attending workshops will receive the worksheet, and it will also be available from the World Wide Web.

DESCRIPTION

In order to assist almond and walnut growers with formulating an N budget, CAFF's Biologically Integrated Orchard Systems Program (BIOS) developed a Nitrogen Budgeting Worksheet based on an earlier worksheet developed for peaches. Values for the N contribution from cover crops and compost were added at this time. The BIOS staff scientist further refined the worksheet in 1998 in consultation with University of California researchers, crop consultants, PCA's and farmers. The current worksheet has been tested by over 40 farmers and their comments have been integrated.

Following harvest in the year 2000, the Community Alliance with Family Farmers will hold Nitrogen Budgeting Workshops in Madera, Merced, and Yolo/Solano counties.

Workshops will focus on the methods and calculations used to determine N needs for almond and walnut trees as well as the best timing for N fertilization. In less than two hours, growers will learn how to modify their N fertilization programs to meet their orchard's needs using data from soil, water, and leaf tissue analysis, and other measurements.

During the workshops an instructor will explain the Nitrogen Budgeting Worksheet and introduce to growers the process of formulating their own N budget calculations. The workshops will inform growers about inefficiency of post-harvest fertilization and the best time to make N applications. The worksheet offers an assessment of the N available from manure, compost and cover crops in relation to the accumulation of N currently in the water and soil. The calculation allows the growers to effectively make fertilization rate decisions based on the total number of pounds of N gathered from all sources.

The workshops will also give us an opportunity to promote another project funded by the California Department of Food and Agriculture's Fertilizer Research and Education Program. This project is a computerized spreadsheet version of the Nitrogen Budgeting Worksheet developed by Patrick Brown and his lab at the University of California, Davis. BIOS (Biologically Integrated Orchard Systems) is a cooperator on this project and has assisted in the development and testing of the spreadsheet version of the Nitrogen Budgeting Worksheet.

RESULTS AND CONCLUSIONS

Results and conclusions will be provided after the final workshop has been held and evaluations have been completed.

Air Quality And Fertilization Practices: An Inventory Of Fertilizer Application Practices For Agriculture In The San Joaquin Valley

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OBJECTIVES

1. Compile a monthly calendar of N fertilizer application timing for major crops in California's San Joaquin Valley.
2. Identify circumstances where it would be possible to predict with a high level of precision the time and location of a given type of N fertilizer application.

DESCRIPTION

Nitrogen contained in fertilizers applied to agricultural lands can be lost to the atmosphere in the form of ammonia and nitrogen oxide. Nitrogenous gases released to the atmosphere can lead to the production of ozone and cause air pollution problems in the San Joaquin Valley. Ozone concentrations in the San Joaquin Valley often exceed state and federal ambient air quality standards especially during the winter months. An improved understanding of the causes of these excesses will require the development of inventories of nitrogen oxide and ammonia emissions from all potentially significant sources in the San Joaquin Valley, including N fertilizer application.

This project will generate a calendar of N fertilizer applications for the major crops in the San Joaquin Valley. The report will describe factors that will account for differences in the timing of N fertilizer use between farms and crop years. A cropping regions map of the San Joaquin Valley will be developed to help explain any differences in N fertilizer applications that may be found to exist among regions of the San Joaquin Valley. This project will also identify and describe circumstances that make it feasible to predict, within a comparatively precise time frame, instances of strongly expressed pulses of N fertilizer application to agricultural lands.

Industry, extension, research and university sources are contributing to the development of this calendar. However, the primary source of information for the N fertilizer application calendar is interviews with farmers.

In the eight counties of the San Joaquin Valley, various crops were identified as major, target crops for this study. Field crops and vegetables selected were: lettuce, potatoes, tomatoes, melons, barley, corn, oats, rice, safflower, wheat, alfalfa, dryland grain and hay, cotton, dry beans/peas, sugar beets irrigate pasture. Nut and fruit trees included almonds, apples, apricots, citrus, cherries, grapes, olives, peaches, pistachios, plums, strawberries, walnuts and grapevines. Most of these crops are target crops in more than one county. When farmers are interviewed they are asked to give information on all of the crops that they grow. Consequently, information on N fertilizer application timing is being gathered on minor crops as well as the major, targeted crops.

To date interviewing has been concentrated in the southern part of the San Joaquin Valley. The timing of seasonal N fertilizer applications has been found to be variable within those seasons for both annual and perennial crops. The timing of spring N fertilizer applications is the most variable. Methods of application are also variable. Nitrogen sources are generally predictable on the basis of price. The only precise time indicator that has been identified to date is the obvious one of soil moisture in late winter and early spring. NASA/ Ames Research Center is developing a cropping regions map for the San Joaquin Valley based on growing degree-days. This work is focusing on the late winter and early spring months where the highest levels of variability in the timing of N fertilizer applications exist.

It was noted that farmers are increasingly making use of animal and poultry manure in their cropping programs. These commodities function primarily as soil amendments but farmers are also taking them into account as a source of N fertilizer. It was also observed that farmers are taking groundwater N into account as a source of N. A discussion of these sources of fertilizer N will also be presented to the extent possible in the final report.

Long-term Nitrate Leaching Below The Rootzone In California Tree Fruit Orchards

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OBJECTIVES

Nitrate-N is the most widespread contaminant in groundwater, causing as much as ten times as many well closures in California as all other industrial contamination combined. While a large amount of research has focused on N cycling in the root zone of California tree fruit orchards (0-6 feet depth), little is known about the fate of N between the root zone and the groundwater table. Unlike other agricultural regions of the United States, groundwater levels in many areas of Central and Southern California are from 30 feet to over 100 feet deep. Therefore, the deep vadose zone is a critical link between agricultural sources and groundwater. Few studies have surveyed N levels or denitrification rates at such depths or monitored leaching of N to a deep water table. Field-scale spatial variability of nitrate levels due to natural variability of soils and vadose zone sediments also remains unaccounted for in most work on groundwater quality impacts of agricultural N management. The objectives of the proposed research are:

1. Investigate the fate of N throughout the entire deep vadose zone at a well-controlled, long-term research orchard with a stratigraphy typical of many areas on the east side of the San Joaquin Valley and Southern California, and with management practices representative of orchards and vineyards.

2. Develop and validate an appropriate modeling tool to assess the fate of N in deep, heterogeneous vadose zones.

DESCRIPTION

During 1997-98, we drilled and characterized approximately 3000 feet of geologic material from 60 cores drilled to groundwater at 52 feet depth. Eighteen cores were sampled at each of three subplots in the orchard, The subplots had been subjected to a 12-year fertilization trial with different rates of fertilization: The annual fertilization rates had been less than 5 lb /acre in the first subplot (0 lb /acre treatment), 100 lb/acre in the second subplot, and 325 lb /ac in the third subplot. Drilling and field analysis during the initial months of the project provided a detailed characterization of the geologic architecture that makes up the vadose zone underneath the orchard.

The focus of the first project year 1998-99 was the distribution of water and nitrate in the vadose zone underneath the three subplots; and initiation of other hydraulic and chemical laboratory analysis. During the past year (1999-2000), we continued both chemical and hydraulic laboratory analyses. Chemical analysis focused on microbial carbon and total carbon distribution as indicators for denitrification. Hydraulic analysis focused on completion of multistep outflow experiments that are designed to determine the transmissive and water storage properties of soil samples at various moisture levels. During the coming year we will complete the geochemical and hydraulic characterization of the core samples and implement vadose zone modeling. Our work will provide the geologic framework, the hydraulic framework associated with the geologic framework, and the geochemical process framework, all of which affect the fate of nitrate in the vadose zone. The "snapshot" of the nitrate distribution that we obtained from the cores is the result of the geologic-hydraulic-geochemical architecture.

RESULTS

Geochemical Characterization

Analysis of soil extracts from all the core depths for microbial carbon, nitrate and ammonium is almost complete. As expected, microbial carbon generally declines with depth but also varies according to soil texture. Similar results have been seen for nitrate. We are currently analyzing the data to see if there is a correlation among the microbial and inorganic N data. Also, bromide was applied to selected plots of the orchard one year prior to drilling. We are currently analyzing the core extracts for bromide content. These data will be correlated to the nitrate data to better estimate nitrate leaching rates and turnover times. Lastly, we are beginning to analyze the soil core data for the nitrate ^{15}N and ^{18}O content. These data will provide insight into denitrification processes occurring throughout the soil core depths. All of the above data will be used to understand the movement of N fertilizers in the vadose zone of the orchard. We expect to get a more thorough understanding of the biological and abiotic factors affecting the fate of N in these stratified sediments characteristic of this region.

Hydraulic Characterization

The multistep outflow experiments were implemented on over 100 undisturbed cores representing 9 major textural classes identified in the field cores: sand, loamy sand, sandy loam and silty loam to sandy loam, Hanford fine sandy loam (surface soil), loam, clay loam, clay, hardpan, deep paleosol. The undisturbed soil cores were taken during the original drilling in 1997. They are approximately 2 inches long and 1.5 inches in diameter. After developing the experimental protocol for the multistep outflow experiments in 1998/1999, the experiments were implemented in sets of ten cores at a time. Each set takes approximately two to three weeks for setup and implementation. In principle, the experiment is a step-wise, controlled drying experiment: After saturating the core with water, air pressure is applied to one end of the core, thereby "driving out" water at the other end. The core is forced to dry out in multiple steps by stepwise increasing the pressure. We monitor how quickly the soil moisture inside the core changes in response to each pressure step; and we monitor how much water leaks out of the core as a result. Soil moisture and outflow are recorded automatically with sensoring equipment connected to a computer. After completion of each experiment, the measurement data are cleaned up and converted into meaningful units utilizing laboratory-derived calibration curves.

Water drainage from the soil core is a unique function of the hydraulic properties of the soil material. To compute the hydraulic properties of the soil core, the experiment is repeated in computer simulations. The hydraulic parameters of the computer model are adjusted until results from the computer simulation match the measurements from the outflow experiment. This process is referred to as "inverse modeling" or "parameter estimation". We expect to complete the parameter estimation of each of the over 100 experiments and a statistical analysis of the results by late fall 2000. The large set of hydraulic parameters will be critical in assessing and understanding the transport pattern of N through thick unsaturated material of alluvial origin. These types of unsaturated zones are the most common buffer between California's intensively cropped agricultural regions and their groundwater resources.

California Certified Crop Adviser Management Project

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INTRODUCTION

California's economic vitality, quality of life, diversity of land and people, and environmental well being is linked inextricably to the states agricultural industries. Field, vegetable, turf, ornamental, tree and vine and other crops are produced in great abundance by a relatively small percentage of people throughout California. There is a heavy reliance on fertilizers, agri-chemicals and other synthetic and natural inputs in the production of many of these crops. These inputs are required in a delicate balance, which is an in-exact science practiced by professional crop advisers. There is little margin for error in prescribing these chemicals and the effects of mismanagement can be severe, long lasting and extend far beyond the individual farm fields and well into all segments of California society.

The potential for non-point source pollution, as a result of mismanagement of fertilizers, is an example of the need for industry to support stewardship programs, such as the Certified Crop Advisor (CCA) program. These voluntary programs work jointly with regulatory programs to insure that industry correctly manages agri-chemicals including fertilizers when producing a crop in California. Regulatory bodies such as the United States Environmental Protection Agency (USEPA), and regional water boards in California require growers to provide soil and water management plans that have been approved or developed by certified professionals.

The CCA program was established through the joint efforts of professional societies, government and industry to establish standards of expertise for advisers and consultants involved in preparing nutrient management plans. In California, the Board is composed of members from a variety of government and private interests including the California Department of Food and Agriculture, University of California, State Water Resources Control Board, Natural Resource Conservation Service, California Fertilizer Association as well as others. California's program is strongly supported by the American Society of Agronomy. The Board is committed to providing a high quality certification program that raises the knowledge base and standards of excellence for those individuals making input recommendations to California growers. The impact of the program will be an agricultural production system that effectively and efficiently meters its inputs in ways that maximize the returns for growers and minimizes the opportunity for the degradation of California soils, water and air.

OBJECTIVES

1. To administer the CCA Program including management of testing, continuing education and member tracking and coordination with the International CCA program.
2. To aggressively market the CCA Program within the California agricultural sector including field and horticultural crops, livestock (for waste management programs), turf and ornamental industries.
3. To develop and implement a strategic and tactical plan for a self funded CCA program.

SUMMARY

In 1992, the Certified Crop Adviser Program was introduced in California and fully implemented by August 1994. The program is intended to respond to growing concerns at local, state and national levels that the improper use of fertilizer and related agricultural products was contributing to a variety of environmental problems including non-point source pollution. The Certified Crop Adviser Program in California is designed to help raise the awareness and professional standards of individuals making recommendations for the use of agricultural fertilizers, pesticides and related products by providing a certification program which includes testing and education requirements of the highest levels. The initial certification of an individual requires a minimum level of education combined with experience in a relevant agricultural discipline as well as passing both State and International exams. The exams cover four competency areas including: 1) nutrient management, 2) soil and water management, 3) crop management and 4) integrated pest management. Maintaining certification requires that participating individuals accumulate a minimum of 40 hours of continuing education every two years.

Since the implementation of the CCA program in California, over 500 individuals have obtained Certification. These individuals have now been involved in the program for several years and form the core membership on which to build a broader program. In the last several years, the CCA program in California has focused on developing a management system that provides for testing, continuing education and tracking of individual crop advisers certifications (CEU's accumulated, tests, status etc). In addition in the last year the California CCA (CACCA) office has focused on service to its member base by providing advance course certification, regular newsletters and quick professional response to member inquiries and concerns. This solid management provides the basis for the expansion of the program and the strategic movement towards a self-run program. In addition in the last year the CA CCA Office has focused on service to its member base by providing advance course certification, regular newsletters and quick professional response to its member inquiries and concerns.

The California Certified Crop Adviser Program offers information about the program on its web site: (http://www.cacca.org). For more information about becoming a CCA, contact Cheyanne Cook at the number above.

Evaluation Of Slow Release Fertilizers For Cool Season Vegetable Production In The Salinas Valley

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Nitrate pollution of groundwater in the Salinas Valley is recognized as a serious environmental issue that has the potential to adversely impact the commercial production of vegetables. High rates of nitrogen fertilizer are frequently used to produce cool season vegetables such as lettuce, broccoli, cauliflower, and celery in order to achieve the high quality demanded by the market. In addition, cool season vegetable production in the Salinas Valley is intensive with two or more crops produced annually. As a result, nitrate levels can buildup in the soil at the end of the growing season, just at the time when the leaching rains of winter come to the valley. Growers are interested in techniques that can reduce the risk of nitrate leaching, but that safeguard yield and quality. Potential solutions to the nitrate leaching issue include various best management practices such as the presidedress soil nitrate tests (PSNT) developed by Dr. Tim Hartz, as well as the use of cereal cover crops grown in the winter. Slow release fertilizers also may have a role as a best management practice that growers can utilize to reduce nitrate leaching from vegetables that are produced over the winter during the time of highest rainfall and greatest potential for leaching. The problem to this point with slow release fertilizers has been 1) uncertainty regarding the release pattern of the slow release materials and how they mesh with the uptake demand of cool season vegetables and 2) the additional cost of slow release materials.

This project proposes to evaluate the release characteristics of slow release fertilizers under controlled incubation conditions, as well as evaluations of a limited number of materials in field trials with winter broccoli. Evaluations will be made various rates of slow release materials on the yield, quality and economics of the applications. Broccoli is selected as the test crop because it is extensively planted (53,880 acres in 1999) and winter-grown broccoli is produced during the rainiest time of the year when the potential for leaching is highest. The results of this research will be made widely available to growers, fertilizer companies and allied industry representatives through field meetings, newsletter articles and publications.

Field Evaluations And Refinement Of New Nitrogen Management Guidelines For Upland Cotton: Plant Mapping, Soil And Plant Tissue Tests

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Fertilization of cotton, as with most crops, is conducted primarily with yield and quality objectives in mind. For CA cotton production, objectives often are directed toward optimizing lint yield while maintaining excellent fiber quality. Available information from crop N use estimates, estimated soil test N, and within-season application (additional soil-applied N) are all part of the system used to promote good yield performance through maintenance of adequate plant nutrient status to support economic yields. Field experiments evaluating nitrogen management options and responses of CA crops have been numerous over the years, and there is experimental evidence form many of these studies indicating that crop fertilization can be managed so that agronomic, economic, and environmental efficiencies can be significantly improved simultaneously.

Growers typically express significant interest in evaluating viable approaches to reduce production costs, but despite evidence of potential for improvement in any of these areas of efficiency, they frequently reject recommendations that involve reductions in applied N rates. Reasons for this general response are undoubtedly many, but include concern for unreasonable economic risks. Grower concerns can be that direct savings can be relatively small when compared with potential revenue losses associated with inadequate available N to sustain high yields. More grower awareness is needed for the fact that while direct savings resulting from more judicious N applications may be small, excess N applications can also result in other management problems (more difficult balance of vegetative: reproductive growth defoliation). The level of concern and difficulties in convincing growers to change practices in part must reflect the lack of grower confidence in the adequacy or accuracy of soil N tests, and in the N management recommendations developed by the University and others.

A field-based research and demonstration project is proposed to provide further evaluation of the potential to integrate rapid laboratory tests for better estimates of mineralizable N. The project's goals are to improve grower appreciation of an integrated N management system still based upon soil and plant N status measurements, but incorporating: (1) estimates of crop growth and yield potential; (2) lower initial N applications to reduce potential for leaching losses; and (3) use of split soil N applications and/or foliar applications to supplement supplies when plant sampling indicates good enough yield potential to warrant additional N supply.

Seasonal Patterns Of Nutrient Uptake And Partitioning As A Function Of Crop Load Of The 'Hass' Avocado And Rate Of Fertilization

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For the 'Hass' avocado (Persea americana L.) industry of California, optimal rates and times for soil fertilization have been or currently are being determined for only nitrogen, iron and zinc. For all other nutrients, fertilization rates and optimal ranges by leaf analysis were borrowed from citrus. The avocado differs distinctly from citrus; avocado fruit are especially high in N (removing ~ 150 lb N/acre), P, K, and Ca. Competition from Mexico and Chile requires the California avocado industry to increase production per acre to remain profitable. Optimizing fertilization is essential to achieve this goal. The seasonal pattern of nutrient uptake is key to matching fertilizer application times and rates with periods of high nutrient demand to maximize yield, increase nutrient-use efficiency, and reduce the potential for groundwater pollution. Developing best management practices for perennial tree crops requires repeated excavation of mature trees. Thus, few best management practices have been developed for tree crops.

Rosecrance recently completed an assessment of N, P, and K uptake and partitioning in mature alternate-bearing pistachio. Pistachio trees were not luxury users, sink demand regulated the uptake and distribution of N, P and K. Thus, the quantity and time that fertilizer should be applied was determined by crop load and storage pools. His research showed that the amount and timing of fertilizer that should be applied was determined by crop load and storage pools. The same approach will be used to determine the seasonal pattern of nutrient uptake and partitioning in alternate-bearing 'Hass' avocado tree. The collaborative project will be conducted at levels of fertilization, optimal (avocado industry standard as currently prescribed by the California Avocado Commission) and two times the optimal rate for N, P, K, B, Ca, and Zn. By excavating and dissecting the entire tree and quantifying nutrient uptake and allocation. The project will be a success when we provide fertilizer guidelines (amount and time of application) to California's 6,000 avocado growers for N and additional nutrients for which no experimental data presently exist. If the results demonstrate that avocado trees are not luxury users, a significant reduction in the amount of fertilizer applied annually should result.

Location Of Potassium-fixing Soils In The San Joaquin Valley And A New, Practical Soil K Test Procedure

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In 1997, the UC published a bulletin describing methods for diagnosis of K deficiency in soils and cotton plants and recommending K fertilization rates. The publication included recommendation to apply very high rates of K fertilizer – 400 lb K_2O/acre or more – where soils have a very high K-fixation capacity. The economic consequences to cotton growers of applying such high K rates where they are not needed or of failing to meet soil fixation capacity where K is needed are severe. High soil K fixation capacity in soils with micaceous/vermiculitic mineralogy has been documented in San Joaquin Valley soils derived from granitic alluvium.

This project proposes to produce a map of the San Joaquin Valley in digital and paper format that identifies those lands used for cotton production that have soil with potentially high-K fixation capacity. We will use two USDA soils databases that are in GIS format.

We also will test soils collected from the San Joaquin Valley a recently published laboratory method for estimating plant-available K over a wide range of K fixation capacity – the modified sodium tetraphenyl boron method. The 1997 UC bulletin does not recommend a method for estimating K fixation capacity, but there are at least two methods currently available through commercial agricultural laboratories. Unfortunately both these methods – the "Cassman K release method" and the "UNOCAL test" – are labor intensive and involve a one-week incubation. These tests are relatively expensive and are after the standard exchangeable K test shows a low level of available K.

The relative accuracy of the sodium tetraphenyl boron method compared to existing methods for predicting K response will be determined in on-farm cotton fertilizer experiments. Results of this project and a recommendation for soil testing will be made available to agricultural laboratories, crop advisers, fertilizer suppliers, and cotton growers in the San Joaquin Valley.

Minimizing Nitrogen Runoff And Improving Nitrogen Use Efficiency In Containerized Woody Ornamentals Through Management Of Nitrate And Ammonium-nitrogen

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Horticulture is a 2.2 billion-dollar industry in California. Over 70% of ornamental production is located in the coastal regions of Southern California, an area of the state where urban communities, agricultural developments and protected wetlands are in close proximity to each other. Due to these geographical constraints, along with the high use of fertilizer and water by the industry, nitrate (NO_3-) leaching from agricultural lands continues to threaten local drinking water supplies and the neighboring ecosystems. In an effort to prevent nitrogen (N) contamination from non-point sources of pollution, the Total Maximum Daily Loads (TMDL) process has been enforced by local agencies, reducing the maximum allowable NO_3- levels from 10 mg N/L to 1.0 mg N/L. Unless fertilization and cultural practices are restructured, many nurseries will be unable to comply with the new water quality control programs that have been implemented in recent years.

The main objectives of this research are to develop fertilization and irrigation guidelines for woody ornamental crop production that will minimize NO_3- runoff and improve nitrogen use efficiency (NUE). Two experiments will be done to characterize the dynamics of N cycling in the plants and the media.

University of California – Davis. A hydroponics study will be conducted at Davis. By monitoring the rates of N and water depletion from nutrient solution, the researchers will characterize the dynamics of N and water demand for several ornamental crops, as affected by physiological (stage of plant development) and environmental conditions (time of year).

University of California – Riverside. The study conducted at Riverside will investigate the fate of different controlled-release fertilizers (CRF) and liquid fertilizers (LF) as affected by acid pH (5.0) and neutral pH (7.0) media. The dynamics of N cycling in the planting media and N uptake into the plants will be determined by measuring (NO_3-) ammonium (NH_4+) and total N in leachates (weekly), and in planting media and plants (monthly). Plant response to fertilizers will be determined by monthly growth measurements.

Based on these efforts, new information will be learned regarding the dynamics of N cycling in media and plants. This information is necessary to develop fertilizer and irrigation protocols for the nursery industry, which will reduce NO_3- leaching and improve NUE. These guidelines will be actively communicated with growers, CE advisors, consultants, the fertilizer industry, teachers and students through extension programs, workshops, seminars, and publications (newsletters, trade magazines and journals).

Site-specific Variable Rate Fertilizer Application In Rice And Sugar Beets

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A previous research project by the first two investigators, supported by the California Department of Food and Agriculture Fertilizer Research and Education Program initiated the university research on site-specific crop management for adoption by growers. These are: (1) that sufficient variability exist in field properties or environment to cause significant spatial variability in economic yield, 2) that these properties are capable of being identified and measures, and (3) that management actions are possible that respond to this variability to increase economic yield. The initial research focused on establishing the first two of these criteria. This project will focus on the third aspect by establishing site-specific fertilizer management strategies through the use of variable-rate application technology.

In this research project we will focus on nitrogen management. To maximize its economic utility and prospects for rapid adoption and impact, an initial variable-rate nitrogen management research program should focus on systems for which a substantial economic advantage accrues to the use of site-specific management. Maximum economic payoff is obtained in those crops for which there is a relatively large economic penalty for both under- and over-fertilization and a relatively narrow range of optimal fertilizer rates we have selected as two such crops: specialty rice (*Koshihikari* and *Akitakomashi*) and sugar beets. For both of these crops, the primary economic penalty associated with over-fertilization is in quality reduction. In the case of specialty rice, increases in nitrogen levels have been identified with increased protein content, which in turn has been associated with poor flavor. In the case of sugar beets high levels of soil nitrate area associated with reduced sugar concentration. In both crops the factor causing a reduction in quality is readily quantifiable and therefore subject to rigorous experimental analysis.

Effect Of Different Rates Of N And K On Drip Irrigated Beauregard Sweet Potatoes

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Drip irrigation acreage used for sweet potato production in California has increased tremendously in the last few years, and it is one of the factors that has lead to substantial yield increases in the past 20 years. However, a fertilizer rate trial has not been performed by UC Cooperative Extension in drip irrigated sweet potatoes. Current fertilizer recommendations are based on trials performed in the 1960's and 70's with furrow irrigation. Growers using drip irrigation use much higher fertilizer rates, which may or may not be necessary and may lead to high residual nitrate and potassium soil.

Because of this, the objectives of this trial are 1) to determine optimal rates of nitrogen and potassium for best economic yield and quality in drip irrigated sweet potatoes; 2) to evaluate fertilizer rate effects on moisture loss in storage; 3) re-evaluate current fertilizer application and tissue analysis guidelines; and 4) to determine if drip irrigation reduces the potential for nitrate leaching, even at high nitrogen fertilizer rates. Four rates of nitrogen and potash will be applied using a randomized block split-plot design. Early and end of season deep soil cores (to 3 feet) will be taken to determine the seasonal location of these nutrients in the soil profile. Leaf and petiole samples taken during the growing season will be compared to published sufficiency ranges.

Following yield and grade determination at harvest, potatoes will be periodically weighed to determine if the treatments have an effect on storage losses over the winter. Results will be published in the Sweet Potato Tips bulletin and presented at the annual winter meeting. The target audiences for this information are commercial sweet potato growers, drip irrigation supply companies, agricultural chemical dealers, and extension personnel. Results may also be applicable to government regulatory agencies forming nutrient management strategies in Groundwater Protection Areas.

Improving The Diagnostic Capabilities For Detecting Molybdenum Deficiency In Alfalfa And Avoiding Toxic Concentrations In Animals

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During the mid 1980's molybdenum deficiency in alfalfa was identified in several intermountain valleys of Northern California by plant tissue analysis and the generally recommended pound of sodium or ammonium molybdate per acre (0.4 lbs Mo/acre) based on some research in Washington gave adequate growth and high yields of alfalfa. Since the mid 1990's numerous samples of alfalfa coming from the same areas have shown lower levels of molybdenum (<0.5 ppm). Over the past 10-15 years many laboratories have changed a number of analytical procedures and instruments which do not provide reliable analyses of molybdenum at concentrations in the range of 0.1-2 ppm. Several surveys of alfalfa and other forage species as well as animal blood samples have indicated that copper concentrations are minimally adequate to deficient in many of the same locations where molybdenum were made, even at the low rate of just 1 lb/acre sodium molybdate (0.4 lb Mo/acre) the higher molybdenum would cause severe animal nutrition problems.

The objectives of proposed project are to:

- Characterize the relationship between plant tissue molybdenum and copper concentrations and alfalfa yield response where molybdenum is applied at several rates,
- Develop a broader diagnostic capability by assessing plant tissue molybdenum concentration at different stages of alfalfa growth,
- Provide standard forage samples for distribution to analytical laboratories by collecting large quantities (20-50 lb) of two alfalfa samples having molybdenum concentrations in the range 0.1-0.3 ppm and 0.5-0.7 ppm.

Three field experiments in Burney Basin, Big Valley and Scott or Butte Valley will include at least 6 rates of Mo/acre along with a lime treatment. Plant tissue samples at several growth stages will be analyzed for molybdenum and copper. Alfalfa yields will be measured and forage quality (ADF and nutrient content) determined. Alfalfa hay producers, Certified Crop Advisors, PCA's, fertilizer dealers and sales personnel and laboratories that the agricultural clientele will participate and utilize project findings. Since few if any field experiments have been conducted to obtain alfalfa yield response and diagnostic plant tissue data where molybdenum applications have been made it is desirable to make this contribution to science and California agriculture.

Precision Horticulture: Technology Development And Research And Management Applications

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Recent studies have determined that yield is the primary determinant of nutrient demand and uptake efficiency and therefore, fertilizer needs. In tree, crops however, yields vary dramatically from tree to tree within an impossible. Given this fundamental limitation it has been impossible to develop truly efficient orchard fertilizer management system or to conduct nutritional research experiments properly.

The ability to map yields in an orchard and to use that information to optimize inputs would revolutionize tree crop industries and directly contribute to improved resource use efficiency. The benefits to in-field experimentation would be equally significant. The most direct benefit of this information would be the ability to optimize fertilization strategies on a site-specific basis. This is the key to improving nutrient use efficiency.

This project aims to develop the means to rapidly harvest and map pistachio tree yields in commercial orchards on a tree long term basis by integrating Global Positioning System (GPS) and yield monitors into the harvesting machinery. This will be followed by development of statistical and visual computaional methodology to analyze and map results. Subsequent ground truthing (soil and plant testing etc.) will be used to determine the cause of the yield variability and experimental manipulations will be used to determine the cause of the yield variability will be conducted to optimize yield and management efficacy. The first year of this project will establish a demonstration orchard for field demonstrations management and will provide the means to dramatically improve our ability to conduct field research. The lessons learned in this project will then be extended to all tree crops in California.

The ability to optimize production systems benefits everyone from producer to consumer. It will allow researchers to conduct better research programs which will directly benefit research funding agencies and improve our ability to protect the environment.

Fertilization Technologies For Conservation Tillage Production Systems In California

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Conservation tillage production row crop systems have a number of potential advantages that may be desirable to California producers including reduced production costs, maintenance of soil organic matter, and water conservation. Evaluation of this potential has been an increasingly important focus of the University of California Division of Agriculture and Natural Resources Conservation Tillage Workgroup in recent years. To date, however, no systematic studies have been conducted California to evaluate optimal fertilization strategies for these reduced tillage systems. The selection of fertilizer rates, materials, and application methods will likely require management decisions in conservation tillage systems that differ from those used in conventionally-tilled systems. This project addresses two of FREP's key research and education priorities by developing new information of fertilization practices and crop nutrient uptake in minimum disturbance agro-ecosystems and by providing this information in educational functions such as field day demonstrations that will be readily accessible to producers, consultants and resource managers.

Reducing Fertilizer Needs Of Potato With New Varieties And New Clonal Strains Of Existing Varieties

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Potatoes are one of the important vegetable crops grown in California. Potato is also one of the heaviest fertilized crops in California. An average of approximately 300 lbs of N per acre is applied, with rates varying from 200 to over 400 lbs/acre. The most widely grown variety (Russet Norkotah) has a weak vine and is susceptible to early dying diseases. To compensate for these variety deficiencies, growers have increased the amount and duration of nitrogen fertilization in an effort to keep the vines healthier and alive longer. Several new clonal selections of Russet Norkotah have stronger vines and later maturity. Preliminary indications are that nitrogen fertilizer needs are lower than the standard Russet Norkotah. New varieties are also being developed and grown that may also have lower nitrogen requirement than the previous or current standard varieties.

The objectives of this project are to determine 1) the responses to standard and new potato varieties to fertilization rates, 2) if the new Russet Norkotah strains are more efficient in applied nutrient utilization and thus require lower fertilization rates, and 3) if other new potential potato varieties are more efficient use than existing standard varieties.

We will establish nitrogen, and if adequate funding is available – potassium and /or phosphorous, rate x variety experiments at 3 locations of varying soil types for two additional years; include 8-12 new and standard varieties or clones; monitor plant N, P and K content, determine N, P, and K uptake; assess yield and quality; and determine utilization efficiency and profitability. Information will be disseminated to primary users – potato growers and crop consultants – through various methods; other broader based audiences, such as CDFA/FREP conference attendees, UC vegetable specialists and advisors, and professional potato researchers in the U.S. will also be recipients of information.

On-Farm Monitoring And Management Practice Tracking For Central Coast Watershed Working Groups

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The Coalition of Central Coast County Farm Bureaus (CCCCFB) proposes to deliver presently available information regarding agricultural management practices and self-monitoring tools to address nonpoint source pollution prevention through industry-led local watershed specific agricultural water quality management plans. The plans will identify water quality improvement projects and will track management practice improvements on a sub-watershed level. Watershed working group participants will be trained in methods of self-monitoring and tracking of management practices. Equipment will be housed at County Farm Bureau Offices and available for participants to perform self-assessments to guide management practices. CCCCFB will coordinate with the local Resource Conservation Districts (RCD), water authorities, and University of California Cooperative Extension (UCCE) for technical assistance to ensure equipment is used properly and that the monitoring tools offered to producers through watershed working group activities are consistent with UCCE short courses and mobile irrigation lab assessments.

From The Ground Up: A Step-by-step Guide To Growing A School Garden

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While the diminishing connection between agriculture and Californians is complex, the benefits of programs targeted at youth are clear. The California Fertilizer Foundation (CFF) School Garden Program's goal is to increase awareness and understanding of agriculture through the hands-on learning experience of school gardens. By providing funding to California elementary, middle and high schools for implementation and/ or continuation of school gardens, the program helps improve a child's agricultural literacy.

Incorporating school garden programs in California schools provides a unique opportunity for raising agricultural awareness and literacy. Students, teachers, faculty and parents have an opportunity to not only learn more about food production, but to learn about their connection to agriculture through hands-on experience.

A critical component of agricultural literacy is nutrient management. Educating students, teachers and parents about proper fertilization, soil preparation, planting and other aspects of gardening is an important lesson. By having first-hand experiences of the complexities of growing food and fiber, educators and students improve their understanding of agriculture and all its complexities including nutrient management.

The California Fertilizer Foundation will address these issues in the following ways: 1) develop, produce, promote and distribute instructional video for teachers and students that focuses on soil sampling, amending, proper nutrient and plant management, and environmentally-sound handling of fertilizer; 2) distribute the video to 1,000 school teachers with garden programs throughout California; 3) develop and promote the video through existing training and in-service days, as well as printed newsletters, and 4) conduct follow-up surveys to determine the effectiveness and usefulness of the video for both teachers and their students.

Teach The Teachers: Garden-based Education About Fertility And Fertilizers

Project Leader:
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The Department of Horticulture/Plant and Soil Science within the College of Agriculture at California Poly Pomona University was designated a Regional Support Center for A Garden in Every School by the State Department of Education starting in 1999. Our charge is to work with the regional teachers and schools to support the development of garden-based education including technical gardening information and curriculum integration. As an RSC, we held the first annual conference on School Garden s in March 2000 and have planned workshop series throughout the year. We will also serve as a clearinghouse for information and opportunities for teachers through the development of a newsletter and a website. Funding from FREP will allow us to enhance our emphasis on soils, fertilizers, soil/water management and related topics with presentations and demonstrations at our conferences, in our workshop series, and in our other communications.

In addition, CDFA/Cal Poly Pomona will soon begin construction of the first phase of AGRIscapes, a 42-acre education and demonstration center for food, agriculture and the urban environment. We will hold our teacher training workshops here, as well as host school tours on appropriate topics. As part of this, we plan to develop field experiment sites where students can see and touch for themselves aspects of soil science, plant nutrition experiments, and studies of soil/water relations. These field sites will be tied to curricular materials that can be used in the classroom for support and reinforcement. CDFA funding will allow us to begin the research and development of these stations prior to the opening of AGRIscapes (slated for Fall 2001).

Completed Projects

The following is a list of FREP projects completed prior to October 2000. Summaries of many of these projects appear in the 1999 FREP Conference Proceedings; final reports are available by calling FREP or ordering through FREP's Resource Guide. The summaries of the completed projects are also available at our web site (www.cdfa.ca.gov/inspection/frep).

FRUIT/NUT AND VINE CROPS

Development of Nitrogen Fertilizer Recommendation Model for California Almond Orchards
Patrick Brown and Steven A. Weinbaum

Development of Diagnostic Measures of Tree Nitrogen Status to Optimize Nitrogen Fertilizer Use
Patrick Brown

Citrus Growers Can Reduce Nitrate Ground Water Pollution and Increase Profits by Using Foliar Urea Fertilization
Carol J. Lovatt

Crop Management for Efficient Potassium Use and Optimum Winegrape Quality
Mark A. Matthews

Potential Nitrate Movement below the Root Zone in Drip Irrigated Almonds
Roland D. Meyer

Field Evaluation of Water and Nitrate Flux through the Root Zone in a Drip/Trickle Irrigated Vineyard
Donald W. Grimes

Influence of Irrigation Management on Nitrogen Use Efficiency, Nitrate Movement, and Ground Water Quality in a Peach Orchard
R. Scott Johnson

Using High Rates of Foliar Urea to Replace Soil-Applied Fertilizers in Early Maturing Peaches
R. Scott Johnson and Richard Rosecrance

Nitrogen Efficiency in Drip Irrigated Almonds
Robert J. Zasoski

Effects of Four Levels of Applied Nitrogen on Three Fungal Diseases of Almond Trees
Beth Teviotdale

Nitrogen Fertilizer Management to Reduce Groundwater Degradation
Steve Weinbaum

Avocado Growers can Reduce Soil Nitrate Groundwater Pollution and Increase Yield and Profit
Carol Lovatt

Relationship Between Nitrogen Fertilization and Bacterial Canker Disease in French Prune
Steven Southwick, Bruce Kirkpatrick, and Becky Westerdahl

VEGETABLE CROPS

Determining Nitrogen Best Management Practices for Broccoli Production in the San Joaquin Valley
Michelle LeStrange, Jeffrey Mitchell and Louise Jackson

Effects of Irrigation Non-Uniformity on Nitrogen and Water Use Efficiencies in Shallow-Rooted Vegetable Cropping Systems
Blake Sanden/Jeffrey Mitchell/Laosheng Wu

Demonstration of Presidedress Soil Nitrate Testing as an Nitrogen Management Tool
Timothy K. Hartz

Drip Irrigation and Fertigation Scheduling for Celery Production
Timothy K. Hartz

Diagnostic Tools for Efficient Nitrogen management of Vegetables Produced in the Low Desert
Charles Sanchez

Evaluation of Controlled Release Fertilizers and fertigation in Strawberries and Vegetables
Warren Bendixen

Optimizing Drip Irrigation Management for Improved Water and Nitrogen Use Efficiency
Timothy K. Hartz

Improvement of Nitrogen Management in Vegetable Cropping Systems in the Salinas Valley and Adjacent Areas
Stuart Pettygrove

Nitrogen Management through Intensive On-Farm Monitoring
Timothy K. Hartz

Development and Promotion of Nitrogen Quick Tests for Determining Nitrogen Fertilizer Needs of Vegetables
Kurt Schulbach and Richard Smith

On-Farm Demonstration and Education to Improve Fertilizer Management
Danyal Kasapligil, Eric Overeem and Dale Handley

FIELD CROPS

Management of Nitrogen Fertilization in Sudangrass for Optimum Production, Forage Quality and Environmental Protection
Dan Putnam

Impact of Microbial Processes on Crop Use of Fertilizers from Organic and Mineral Sources
Kate M. Scow

Effects of Various Phosphorus Placements on No-Till Barley Production
Michael J. Smith

Establishing Updated Guidelines for Cotton Nutrition
Bill Weir and Robert Travis

EDUCATIONAL/MISCELLANEOUS

Improving the Fertilization Practices of Southeast Asians in Fresno and Tulare Counties
Richard Molinar and Manuel Jiminiz

Western States Agricultural laboratory Proficiency Testing Program
Janice Kotuby-Amacher and Robert O. Miller

Agriculture and Fertilizer Education for K-12
Pamela Emery and Richard Engel

Use of Ion Exchange Resin Bags to Monitor Soil Nitrate in Tomato Cropping Systems
Robert O. Miller and Diana Friedman

Education through Radio
Patrick Cavanaugh

Integrating Agriculture and Fertilizer Education into California's Science Framework Curriculum
Mark Linder and Pamela Emery

The Use of Composts to Increase Nutrient Utilization Efficiency in Agricultural Systems and Reduce Pollution from Agricultural Activities
Mark Van Horn

Nitrogen Management for Improved Wheat Yields, Grain Protein and the Reduction of Excess Nitrogen
Bonnie Fernandez

Determination of Soil Nitrogen Content In-Situ
Shrini K. Updahyaya

Extending Information on Fertilizer Best Management Practices and Recent Research Findings for Crops in Tulare County
Carol Frate

Educating California's Small and Ethnic Minority Farmers: Ways to Improve Fertilizer Use Efficiency Through the Use of Best Management Practices (BMPs)
Ronald Voss

Survey of Changes in Irrigation Methods and Fertilizer Management Practices in California
John Letey, Jr.

Practical Irrigation Management and Equipment Maintenance Workshops
Danyal Kasapligil, Charles Burt and Eric Zilbert

Irrigation and Nutrient Management Conference and Trade Fair
Danyal Kasapligil

EDUCATIONAL VIDEOS

Best Management Practices (BMPs) for Nitrogen and Water Use in Irrigated Agriculture: A Video
Larry Klaas and Thomas Doerge

Drip Irrigation and Nitrogen Fertigation Management for California Vegetable Growers Videotape
Timothy K. Hartz

Nutrient Recommendation Training in Urban Markets: A Video
Wendy Jenks and Larry Klaas

Best Management Practices for Tree Fruit and Nut Production: A Video
Thomas Doerge and Lawrence J. Klaas

Peer-reviewed Publications Resulting From CDFA/FREP-sponsored Projects

Tim Hartz, UC Davis, Department of Vegetable Crops

Hartz, T.K. 1994. A quick test procedure for soil nitrate-nitrogen. Communication Soil Science and Plant Analysis 25:511-515.

Hartz, T.K. 1996. Water management in drip-irrigated vegetable production. HortTechnology 6:165-167.

Hartz, T.K., W.E. Bendixen and L. Wierdsma. 2000. The value of presidedress soil nitrate testing as a nitrogen management tool in irrigated vegetable production. HortScience 35:651-656.

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Robert Green, UC Riverside, Department of Botany and Plant Sciences

Green,R., G. Klein, J. Hartin, W. Richie and V. Gibeault. 1999. Best management practices for tall fescue irrigation and nutrition in southern California. Turf Tales Magazine 6:6-7.

R. Scott Johnson, UC Davis, Department of Pomology

Rosecrance,R.C., R.S. Johnson and S.A. Weinbaum. 1998. The effect of timing of post-harvest foliar urea sprays on nitrogen absorption and partitioning in peach and nectarine trees. Journal of Horticultural Science and Biotechnology 73:856-861.

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Dillon, J., S. Edinger-Marshall and John Letey. 1999. Farmers adopt new irrigation and fertilizer techniques. California Agriculture 53:24-28.

Carol J. Lovatt, UC Riverside, Department of Botany and Plant Sciences

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Pettgrove, G.S., S.K. Upadhyaya, M.G. Pelletier, T.K. Hatz, P.E. Plant and R.F. Denison. 1999. Tomato yield – color infrared photograph relationships, pp. 1483-1491. In: P.C. Robert, R.H. Rust and W.E. Larson (eds.). Proceedings of the Fourth International Conference in Precision Agriculture, 19-22 July, 1998, St. Paul Minnesota. American Society of Agronomy, Madison, WI.

Pettygrove, G.S., S.K. Upadhyaya, J.A. Young, G.M. Miyao and M.G. Pelletier. 1999. Tomato yield variability related to soil texture and inadequate phosphorus supply. Better Crops with Plant Food. No. 2, pp. 7-9. Potash and Phosphorus Institute, Norcross, GA.

Miller, R.O., G.S. Pettgrove, R.F. Denison, L.F. Jackson, M.D. Cahn, R.E. Plant and T.E. Kearney. 1999. Site specific relationships between flag leaf nitrogen, SPAD meter values, and grain protein in irrigated wheat, pp. 113-122. In: P.C. Robert, R.H. Rust and W.E. Larson (eds.). Proceedings of the Fourth International Conference in Precision Agriculture, 19-22 July, 1998, St. Paul Minnesota. American Society of Agronomy, Madison, WI.

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Robert Travis , UC Davis, Department of Agronomy and Range Science

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