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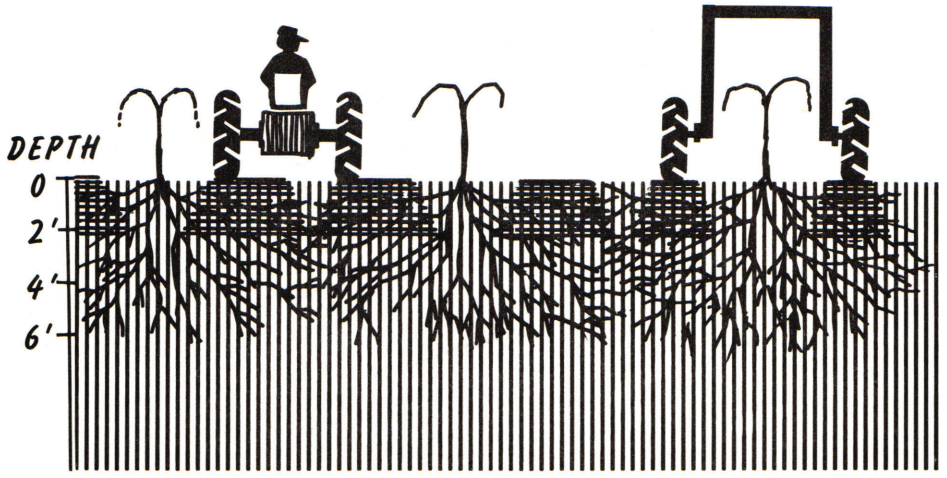
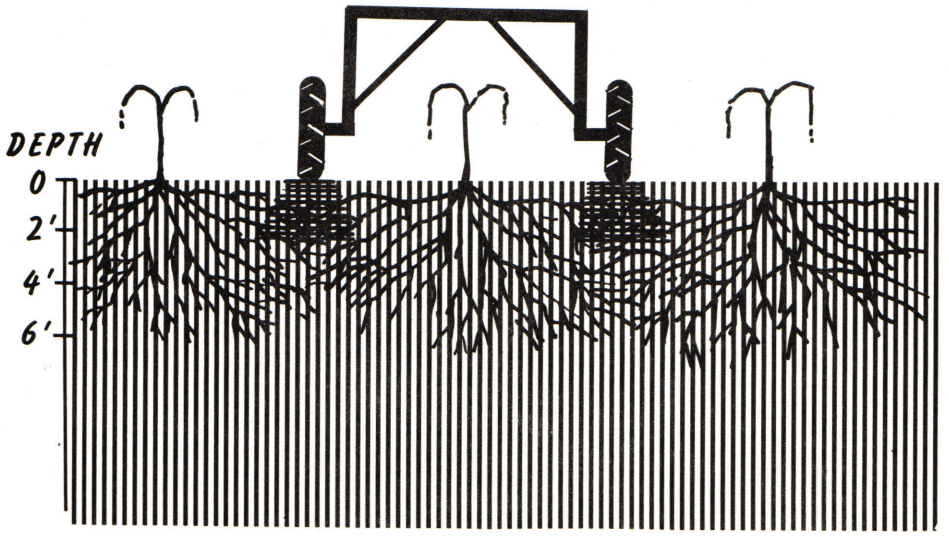


On left, a small tractor operating repeatedly in a vineyard may compact most of the soil between vine rows to a depth of as much as two feet. At right, a harvester used for all vineyard trips might not compact as close to the vine because of better control of pathway, but either tractor would lower water infiltration over a significant portion of the surface.



A straddle vehicle with a wheel spacing equal to the row spacing might be the answer to soil compaction in vineyards. See article on controlled traffic.

F. Aljibury, R. Ayers, R. Branson, E. Fereres, R. Hagan, A. Marsh, J. Meyer, R. Meyer, J. Quick, R. Rauschkolb, J. Rible, H. Schulbach, and W. Wildman.

Edited by George A. Pearson, Extension Soils Specialist, University of California, Davis.

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Controlling Traffic

"Controlled Traffic" is an expression that has crept into the agricultural literature in recent years and we are likely to hear more about it in the future. Now, we're not talking about policemen on busy street corners or dividers in the freeway. Traffic in this case refers to the sum total of all the wheel, track, and maybe even foot traffic that moves across a field, orchard, or vineyard year after year in order to plant, care for, and harvest a crop. Each pass does its bit toward compacting the soil and sealing the surface to the entry of water. Of course, some passes do more compacting than others. In general, the following statements may be made about soil compaction:

1. At a given vehicle weight and soil moisture content, the first pass over a loose soil does 90% or more of the compacting that can be done in that path. Subsequent passes in the same path probably do not increase average compaction much but may significantly increase sealing at the surface by reorienting soil particles and completing breakdown of structural units.

2. At a given vehicle weight, a moist soil will compact more than a dry soil. The more moist a soil is the weaker the bonds that hold soil particles together in aggregates. Soil strength becomes lower with increasing moisture content.

3. At a given wheel pressure on the soil, the heavier the vehicle, the deeper the soil compacting effect. To illustrate, if you put larger tires on all four wheels of your tractor to double the area of soil contact, and then double the weight of the tractor, you have the same soil pressure as before, and the surface soil will compact to the same density. However, the compacting force will go more deeply than before because of overlapping vectors over the larger area of surface contact.

The concept of controlled traffic was developed to minimize or eliminate soil compaction in the root zone of the crop. It is an attempt to designate certain permanent pathways for all traffic required to grow a crop, and leave the major portion of the field free from the compacting influence. Several studies have shown that soil will remain at a lowered density for one to several years after loosening if it is not subject to traffic after the loosening. But to be effective, the traffic control must begin immediately after the soil

is loosened by plowing, subsoiling, rototilling, etc. In row crop production you cannot expect to achieve much benefit from controlled traffic if, after plowing or subsoiling, you disc several times, land plane, bed up or list, and then determine where your controlled traffic paths are going to be.

To apply controlled traffic after the initial soil loosening, the tractor pulling the disc needs to run in the same paths that will later be used for all cultural operations on the row crop. This means no cross discing and no land planing except using the same paths. This obviously is not going to be acceptable for most growers using surface irrigations. What are the alternatives?

1. Subsoil, plow, disc, land plane in conventional manner and hope that you get some benefit from controlling traffic after rows are established.

2. Subsoil, plow, disc, and land plane, then retill the surface 6 - 12 inches of soil as you make your beds and furrows for controlled traffic.

3. Develop a whole new system of land preparation compatible with controlled traffic.

One additional advantage to controlled traffic in row crops: You may be able to use the same beds next year with no further primary tillage, and just a small amount of residue incorporation and bed reshaping. Whether you can do this depends on the crop and its pest and disease problems, but if you can, you can save considerable energy and labor.

Sprinkler irrigated row crops and field crops should be easier to adapt to controlled traffic, since land planing is not required. For example, after plowing a field prior to alfalfa planting, discing and dragging can be done with tractor wheels running in the same tracks that will eventually be used for mowing, raking, and baling. This, of course, depends on the wheel spacing of all the alfalfa equipment being the same and tracking in the same track each time. A lot of bother maybe, but it might more than pay for itself in increased yields and stand longevity.

Permanent crops, such as vineyards and orchards, offer considerable challenge to the grower interested in controlled traffic. The problem is threefold:

1. Much of the soil area between vine and tree rows is compacted in the processes required to manage and harvest the crop.

2. It is difficult to loosen the compacted soil effectively because the trees and vines are in the way of operating large equipment.

3. That loosening which can be accomplished damages roots in the loosened area.

In the vineyard situation, repeated trips for dusting may compact up to 75% of the area between vine rows (See cover illustrations). Some growers have used grape harvesters for other cultural operations and this may be an improvement if the resulting wheel tracks cover a smaller width (because of less chance of wandering back and forth across the interrow) and remain further away from the vine. But either of these tractors can compact a significant amount of soil between vine rows. The problem is most serious in soils with restricting layers which result in root zones only 2 - 3 feet deep, since roots are confined to a small soil volume near the vine.

If a harvester's wheels could be spaced the same distance apart as the width between rows (cover, bottom figure), the least amount of soil would be compacted, since there would only be one narrow track in the center of each interrow. Even in vineyards that are not mechanically harvested, a light weight straddle tractor could be developed to do most of the vineyard jobs.

Orchards present another challenge. In fact, I'm going to reserve a discussion of orchard controlled traffic for the next issue of SOIL and WATER, and provide some illustrations of how at least a certain measure of traffic control in an orchard might be accomplished.

-- Bill Wildman

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New Publication on Soil Compaction

Dr. William Chancellor, of the UCD Department of Agricultural Engineering, has written a very comprehensive and readable bulletin on soil compaction, its measurement, causes, effects on plant growth, and means of removing or offsetting its effects. (SOIL and WATER printed the summary to the bulletin in an earlier issue).

The 53 page bulletin is entitled "Compaction of Soil by Agricultural Equipment" and is listed as Bulletin 1881, Division of Agricultural Sciences, University of California, October 1976. Single copies may be obtained free of charge from the UC Cooperative Extension Office in each county, or by writing to:

Public Service
4415 Chemistry Annex
University of California
Davis, CA 95616

-- Bill Wildman

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New Irrigation and Surface Water Specialist

Dr. Elias Fereres, the new Irrigation and Surface Water Specialist, was born in Spain and received a degree in Agronomy and Engineering from the Polytechnical University of Madrid. His graduate studies conducted in Water Sciences and Engineering, UCD (1973-1976), led to an M. S. degree in Irrigation and a Ph.D. degree in Ecology. His thesis was entitled "Growth, Development and Yield of Sorghum in the Field Under Variable Water Supply".

Before coming to the U. S. he worked in Spain for 3 years designing irrigation systems, mainly sprinkler and drip irrigation, and also had professional experience involving irrigation and water management in France, the Netherlands, and Israel. He is a co-author on several research papers.

His areas of special interest and expertise include agricultural water management, irrigation engineering, irrigation with limited water supply and soil-plant-water relations.

Dr. Fereres' office is located in Veihmeyer Hall, Room 133 and his phone number is (916) 752-1130.

The following article expresses some of his thoughts on a timely subject.

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Irrigation Under Limited Water Supply

Until very recently, most of the research on water use and crop production has been directed towards maximizing crop yields and little, in comparison, towards the optimization of water use through attaining maximum water productivity. (Water productivity, also known as water use efficiency, is expressed as the ratio between harvestable yield of crop and amount of water used during

the season). With this limited research we do not now have all the answers to questions being raised on how to obtain acceptable crop yields when irrigation water is in short supply. Nevertheless, the recent research developments to date provide a basis for cautious optimism that it is possible to develop the information required to optimize water use by crops.

Among annual crops, yield response to a reduced water supply appears to be very much dependent upon the crop to be grown. For instance, the crop yield per unit of water used for corn at Davis developed by Dr. J. I. Stewart, indicates that there is a linear relationship between grain yields and soil water depletion. Also, recent unpublished research findings by J. I. Stewart, R. M. Hagan and W. O. Pruitt suggest that an excellent strategy to irrigate corn with limited water supply is to start the season with the soil fully wet to the expected depth of rooting, then to apply the remaining available water at intervals regularly spaced over the entire growing season. In other research, Dr. Grimes, working with cotton in the San Joaquin Valley, has shown that maximum lint yields are attained at somewhat less than maximum water use (the crop is stressed for water).

Field studies performed at Davis during the past four years by D. W. Henderson, T. C. Hsiao and E. Fereres have pointed out the capability of some crop plants to adjust to a short water supply. At Davis, corn and grain sorghum plants were able to adjust to the short water supply and had maximum rates of leaf expansion around midday when evaporative demand was near its peak. In terms of photosynthesis, water stress is known to induce stomatal closure thus reducing the rate of CO_2 assimilation. In these studies, though, the adapted plants maintained fully opened stomata at plant water stress levels more severe than expected from previous research in controlled environments. An important factor in the adaptation process appears to be the continuous root exploration and water extraction from the wet subsoil that enabled plants to keep up with the evaporative demand so that water stress developed very slowly. Yield responses at Davis were strikingly different between corn and sorghum. Corn, starting out with the soil filled to field capacity but unirrigated during the season produced 50 to 60% of the grain yield of a frequently irrigated treatment, while grain sorghum unirrigated after germination produced an 80 to 100% yield. While more research is going on to determine the nature of the adaptive mechanisms related to the responses to a short water supply their practical significance has yet to be explored. It is possible that, for "adapted" crops, withholding water at certain periods may condition the crop or aid it to adjust to the reduction in water supply and thereby produce "more crop per drop". In this respect, the report submitted by D. E. Miller (USDA-ARS Prosser, Washington) to the last ASA meeting at Houston is encouraging. Deficit high-frequency irrigation of winter wheat resulted in sustained grain yields and increased water productivity. Daily applications by sprinkling using 50% of estimated evapotranspiration (ET) until flowering followed by 75% ET resulted in 18 inches (46 cm) of water applied as compared to 24 inches (61 cm) supplying 100% of ET. The water productivity increased from 32 pounds of grain/inch of water used (37 kg/cm) in the 100% ET treatment to 46 pounds/inch (53 kg/cm) for the drier treatment. Here again, the crop was started on a soil initially wet to field capacity.

It appears that field research is urgently needed to assess the production potential with less than a full water supply and to develop management techniques best suited for irrigating with short water supplies while still maintaining adequate crop yields.

-- Elias Fereres

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Furrow Irrigation for Row Crops

When you are thinking of what you can do to improve your irrigation by more even distribution of water and reducing the amount of water waste, it is appropriate to think of sprinkler irrigation and drip irrigation. It is also appropriate to think of what you can do to improve your furrow irrigation. All irrigation methods waste some water and fail to deliver the required amount of water to 100 percent of the irrigated area. Evaporation wastes considerable water in sprinkler irrigation and for both sprinkler and drip irrigation extra water has to be applied to compensate for imperfect uniformity of water distribution.

Furrow irrigation tends to waste more than sprinkling or drip irrigation because soil at the upper end of the field is exposed to water in the furrow for more time than soil in the middle of the field or at the lower end and also because, for practical purposes, it is often necessary to allow some water to run out of the field to prevent excessive accumulation of water and flooding at the lower end.

Furrow irrigation can often be made more efficient in its use of water by improving the grading of the land and by more skillful application of the water. Skillful application of water in furrow irrigation consists largely of regulating the rate of flow of the water into the furrow, deciding when to change the rate of flow, and deciding when to turn off the water. An effective procedure is to start with the highest rate of flow that the furrow will carry without excessive washing or flooding and as water approaches the lower end, reduce the rate of flow so that little or no water runs out of the furrow at the lower end. This minimizes the difference in time of exposure to water from one end of the field to the other and minimizes the amount of water wasted by penetration below the root zone of the crop. It also minimizes the amount of area in the lower half of the field that does not get enough water if this procedure is not followed. If the furrows are too long or if the slope is not uniform from one end of the field to the other, the most skillful application of water will fail to prevent objectionable waste of water, parts of the field not getting enough water, or both.

Irrigation is a complex subject that needs to be studied by farmers and taught by them to irrigators. One of the first things to be learned about irrigation is that water moves through soil slowly and that the amount of vertical and horizontal penetration required will be accomplished only if time is allowed for water to move these distances. Movement of water, both vertical and horizontal, stops soon after water disappears from the bottom of the furrow leaving soil beyond the point of penetration as dry as it was before irrigation. The rate at which water moves through soil tends to be a permanent characteristic of the soil although it will be somewhat faster following deep tillage. Farmers and irrigators soon learn how fast water moves through the soils they irrigate. It is good practice

to use a soil tube or a simple probe to monitor penetration as irrigation proceeds. Information from this monitoring will not only help for the irrigation going on but will provide experience that will improve judgment for future irrigations.

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"Water and Soil" is a miniature textbook on the subject of irrigation revised in 1973 which Robert Brendler, Farm Advisor for Ventura County, will be glad to send you for your own use. He believes that many of today's irrigators could improve their skills by reading this publication.

Editor's note: This artical was originally written by Robert Brendler for the newsletter ROW CROPS. It was submitted to the SOIL AND WATER Newsletter by A. W. Marsh.

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Update on Center Pivot Irrigation Systems

Since the article on center pivot irrigation systems was written for "Soil and Water Newsletter", #26, additional center pivot systems have been installed in California. These have been mostly Valmont, made by Valley Irrigation, now featuring several changes.

The drive is electric with rubber wheels. A special extension has been added at the end of the straight irrigation line. It is folded at 90° to the main line when the main line can reach the side of the field. As the main line approaches the corner of the field the extension gradually unfolds to a maximum position only 18° from the main line. As the line passes the corner the extension gradually folds back to the 90° position. By reaching the corners with this extension, the system irrigates about 150 acres out of a quarter section compared to 130 acres with the standard center pivot.

When the extension is in the 90° folded position, none of its sprinklers operate. As it starts to unfold, the sprinklers on the extension start to operate, one by one, until, when fully extended, they all operate.

The guide for the unfolding and retraction is a metal tape buried in the ground. A sensing device on the extension follows it and communicates through electronic controls to the drive motors on the tower wheels. They operate from this signal in a way to keep the sensor always above the tape. The same communication system turns the extension sprinklers on and off as needed. If the perimeter of the field to be irrigated has an irregular shape the sprinkler system can be made to follow it by burying the tape in the desired position.

On some systems the usual impact drive rotating sprinklers have been replaced by fixed jet spray nozzles covering 180° or half circles similar to those used on the edge of lawns. One reason for this change was to avoid wetting ground ahead of the drive wheels. The desire is to avoid bogging down of the drive wheels that has caused serious soil and mechanical problems with some center pivot systems. Between towers the sprinklers alternately face forward and are mounted on the main pipe. On each side of every tower the nearest three sprinklers are extended several feet away from the main pipe on booms and all face to the rear. The water from them reaches the ground behind the tower wheels.

Another reason advanced for trying the fixed jet heads was to produce a

spray of finer drops that would infiltrate the soil better than the larger drops from a rotating head. We were unable to evaluate the general effectiveness of this feature. The only operating system studied was west of Lodi on a fine-textured, dark-colored, Stockton clay that has a strong structure and surprisingly high infiltration rate. As the sprinkler line passed, water collected in the field furrows but disappeared a few minutes after the sprinkler line moved out of reach.

An analysis of the operation showed a total of 0.53 acre-inches per acre was applied in one sweep. The main line took about 20 minutes to pass a spot near the perimeter and 36 hours to complete the circle, meaning that the average application rate at the perimeter was 1.56 in./hr. This is a high application rate for most California soils.

Please inform us when any installations appear in your county.

-- Albert W. Marsh
and
-- Jewell L. Meyer

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Water Rights - Ground Water Users

A new bill, SB 1927 Ayala, permits ground water users to retain their rights when imported water allows cessation or reduction in ground water use. Previously, this credit was only given to users in the southern nine counties of the State. The Water Code Sections are 1005.1, 1005.2, and 1005.4. ELIGIBLE WATER USERS, WHO WISH TO CLAIM A CREDIT FOR PREVIOUS YEARS, MUST FILE A STATEMENT PRIOR TO APRIL 1, 1977.

The purpose of the new program is to encourage conjunctive use of ground and surface water. The typical conjunctive user will pump from wells during dry years, but substitute surface water during wet years. If the ground water user switches to imported (canal) water he will maintain his water right as if the substituted surface water had been pumped from wells. Without this water right protection, pumpers of ground water in depleted and overdrawn basins are reluctant to substitute imported water or water released from reservoirs for fear of losing their ground water rights.

Paperwork required to claim the credit will be kept to a minimum. A map locating the wells is required with the first filing. Additional information is limited to quantities of water used from each source during each year. After the initial filing, yearly statements by the user are required to claim the credit. There is no cost to the water user.

Statement forms are available from the offices of the Division of Water Rights located in Sacramento and Los Angeles, offices of the Regional Water Quality Control Boards, and offices of the Department of Water Resources.

An engineer from the Division of Water Rights is available to answer questions at (916) 445-1294.

-- Robert S. Ayers

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"Soil Taxonomy", a 754 page book on the Seventh Approximation of soil survey, is available from the Superintendent of Documents, Washington, D. C. as Handbook No. 436 for $17.50.

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Foliar Fertilization of Bean Crops

Although foliar fertilization of micronutrients is extensive on many crops, application of large quantities of macro- and secondary nutrients is rarely used. Severe leaf burning and perhaps other physiological effects have usually resulted in slight to significant yield reductions. During the past several years experiments have been conducted on soybeans using rather large quantities of nitrogen, phosphorus, potassium and sulfur. Varying yield responses have been reported ranging from small decreases to rather large increases. Perhaps the highest increase was reported by Ramon Garcia and John J. Hanway in Iowa where they reported a 50% increase above a very respectable 3,000 pound per acre yield. Apparently the reason for some potentially large yield increases can be attributed to several physiological occurrences in the bean plant. At the time the initiation of pods and bean filling occurs most of the photosynthate is moving to the beans, rather than to supply the roots with the necessary energy for nutrient uptake and nitrogen fixation by Rhizobia. It was postulated that if additional supplies of nutrients in shortest supply could be applied in sufficient amounts on the foliage that these nutrients would be available for filling the beans that might develop rather than abort. Perhaps previous foliar fertilization trials have resulted in a decrease in the number of potential pods. The large increase in soybean yield was recorded when applications began as the beans were beginning to develop at one of the four uppermost nodes. That is, they could be felt when the pod was squeezed (Growth stage R5). To achieve addition of sufficient quantities of nutrients, up to four applications at approximately weekly intervals were made.

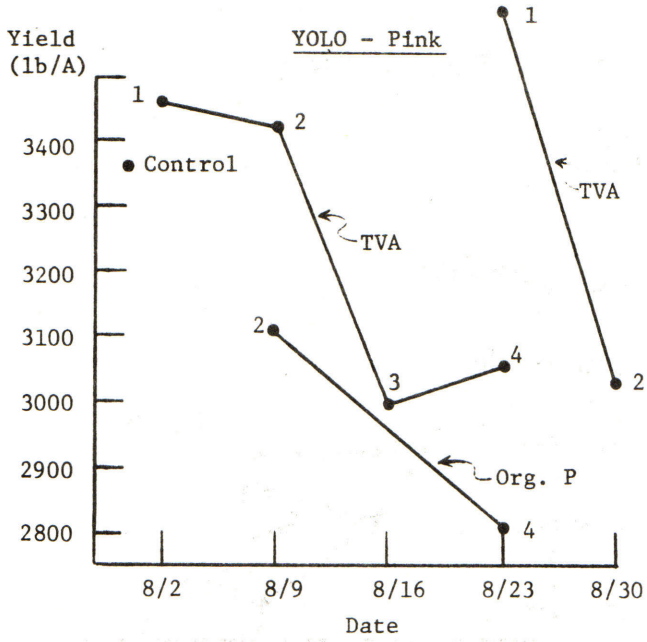
Another ingredient in the current foliar fertilization research has been the use of several fertilizer materials which have less adverse effect on plant foliage. It has been demonstrated in citrus and other crop fertilization that foliar application of low biuret urea result in less leaf damage than several other sources.

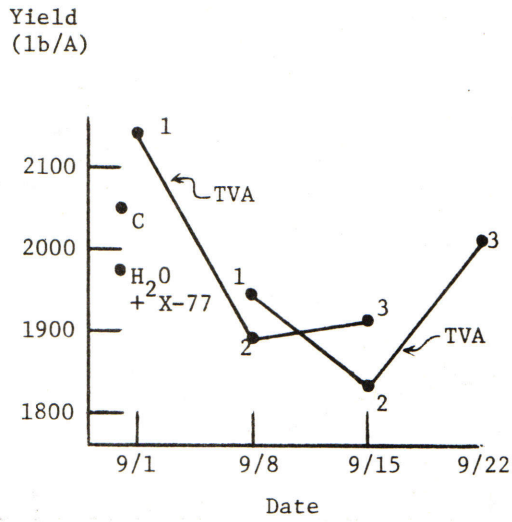
The preliminary results with soybeans being somewhat encouraging served as motivation to investigate foliar applications on several bean crops grown in California. Our primary objective was to determine the effect of frequency and timing of the nutrient ratio 25-6-9-1.5 (N-P_2O_5-K_2O-S) found to give the highest yield with soybeans. In addition, an organic phosphate material and micronutrients copper and zinc were included at several locations. Nearly all solutions were applied with 0.1% X-77 surfactant.

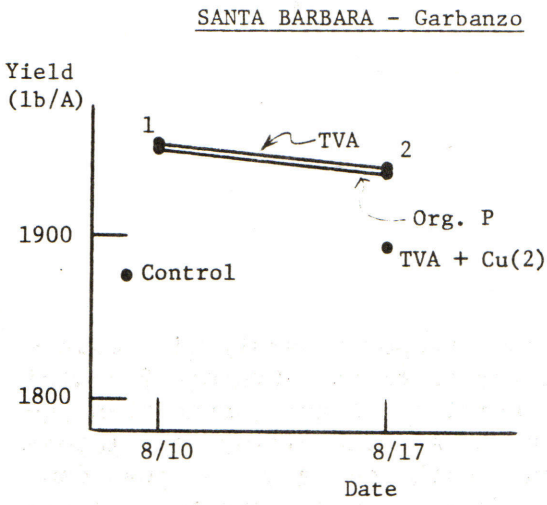
Results for the 1976 experiments at several locations with different beans are shown in the following figures. Each figure shows the mean of each treatment. The number near the yield point indicates the number of fertilizer applications on a given plot.

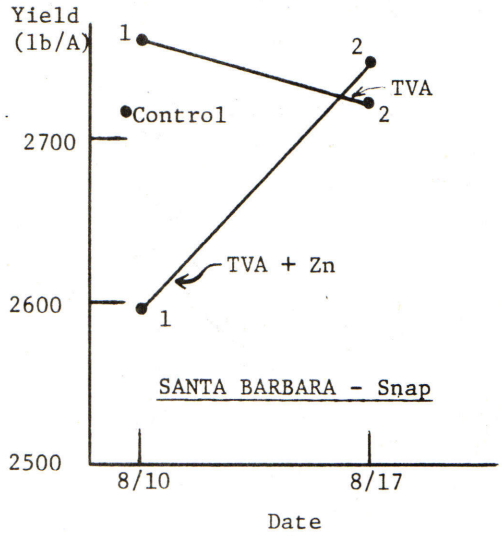
It is evident from the figures that foliar treatments did not increase yields. At the majority of locations the control had the highest yield and only for the Garbanzo in Santa Barbara County were the treatment yields larger than the control.

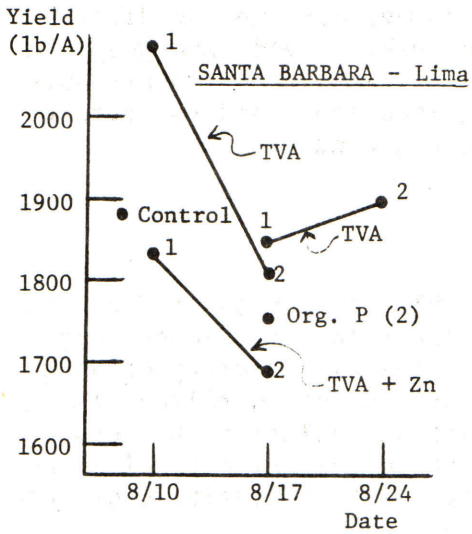
There are some other general results which arose out of the study. The more material applied to the leaves the greater the decrease in yield, leaf burn, however, was not strongly associated with the yield decrease. At Davis (Yolo) it appeared that the initial treatment caused the most severe burning. Leaf burn did not

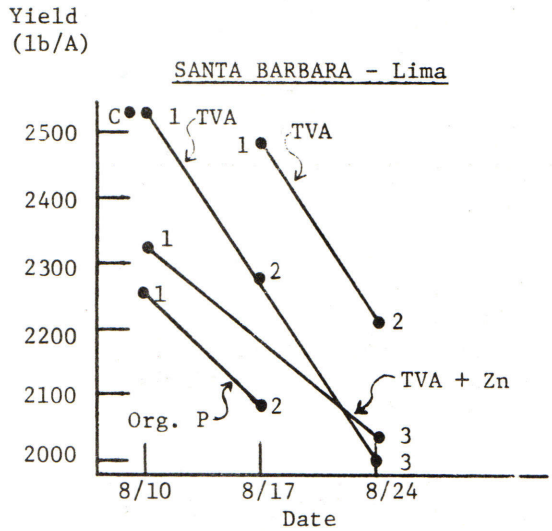

YOLO - Pink
Yield (lb/A)
3400
3300
3200
3100
3000
2900
2800
Control
TVA
TVA
Org. P
8/2
8/9
8/16
8/23
8/30
Date

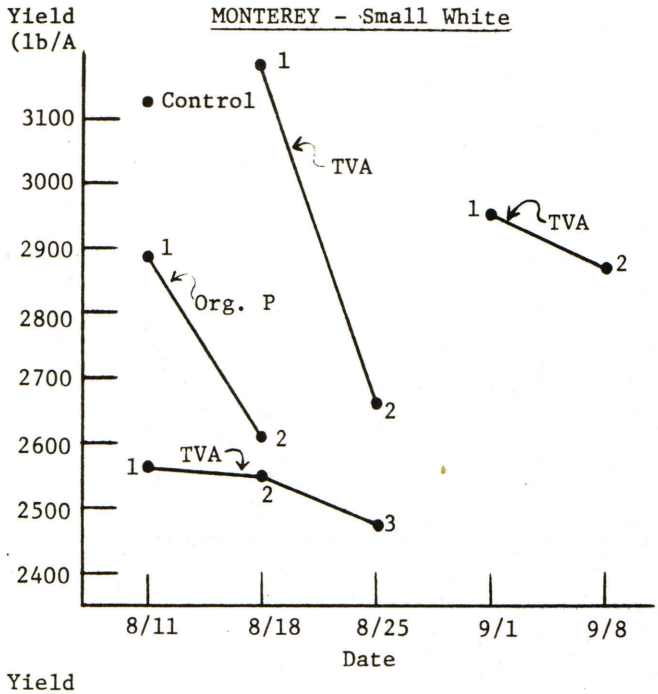

BUTTE - Kidney
Yield (lb/A)
2100
2000
1900
1800
TVA
C
H_2O + X-77
TVA
9/1
9/8
9/15
9/22
Date

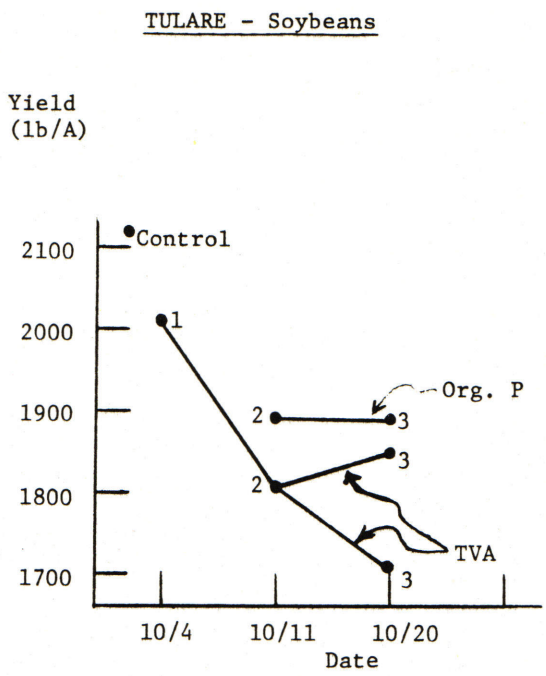

SANTA BARBARA - Garbanzo
Yield (lb/A)
1900
1800
TVA
Org. P
TVA + Cu(2)
Control
8/10
8/17
Date

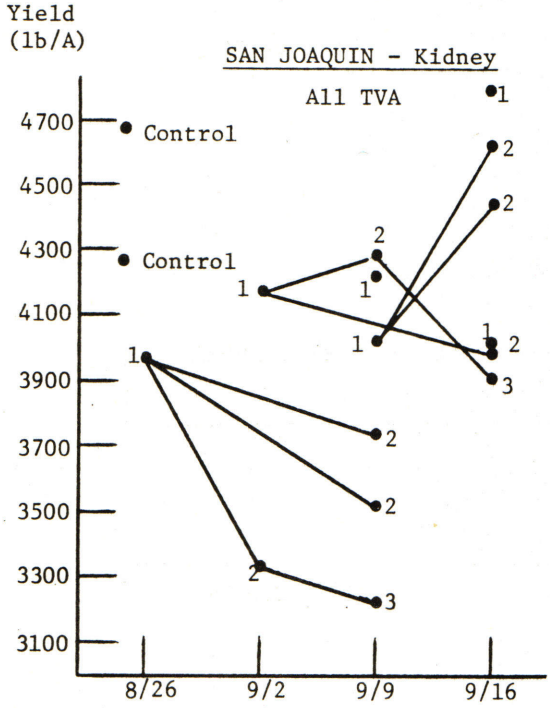

Yield (lb/A)
2700
2600
2500
Control
TVA
TVA + Zn
SANTA BARBARA - Snap
8/10
8/17
Date


Yield (lb/A)
SANTA BARBARA - Lima
2000
1900
1800
1700
1600
TVA
Control
TVA
Org. P (2)
TVA + Zn
8/10
8/17
8/24
Date


Yield (lb/A)
SANTA BARBARA - Lima
2500
2400
2300
2200
2100
2000
C
TVA
TVA
TVA + Zn
Org. P
8/10
8/17
8/24
Date







increase proportionately with subsequent applications. Organic P caused more burning of the leaves than the TVA material but yields were inconsistent with the amount of leaf damage. This would suggest that physical leaf damage may not be directly associated with yield changes. Zn and Cu were applied as micronutrients at several locations and the results were not consistent.

● = yield point
C = Control
1 = one foliar application
2 = two " applications
3 = three " "
4 = four " "
Date = number of applications and application dates

It is possible that results from foliar fertilization are inconsistent because of the wide variety of beans and the lack of standardized timing of application relative to growth stage. Future experiments will include more detailed analysis of the

effect of growth stage and amount of fertilizer applied at a particular stage of growth. This will possibly result in a more precise evaluation of foliar fertilization for beans in California.

-- R. D. Meyer
J. L. Hatfield
W. E. Bendixen
W. D. McClellan
T. Prichard
D. Ririe
J. D. Smith

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The January 13th issue of Orchard Topics, Colusa County by Tom Aldrich was devoted to the subject of Drought. Although written with orchardists in mind, many of the ideas presented have application to agriculture in general. With permission, the following thoughts and suggestions are presented here.

If water is available, irrigate now. Use sufficient water to fill the soil profile to the depth of rooting for the crop intended for that particular field. This may take several irrigations. Water deep in the soil profile is not subject to loss by evaporation. Eliminate weeds, they remove water the same as a cash crop. If water is short next year, irrigate deep rooted crops in alternate rows. Twice as much water in alternate rows will wet the soil twice as deep. In this way only half the soil surface will lose water to the atmosphere leaving more water in the soil for the roots.

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Salt Tolerance of Ornamental Trees Under Study

The scope of the U. S. Salinity Laboratory's studies on the salt tolerance of ornamentals has been expanded from shrubs and ground covers (results reported earlier in USSL publications and this newsletter) to ornamental trees. In May 1975, a field-plot experiment was initiated under the direction of L. E. Francois to determine the salt tolerance of eight species of trees, listed below, commonly used in Southwestern landscaping.

SPECIES	NURSERY SIZE TREE PLANTED
Prunus cerasifera "Krauter vesuvius" (Red leaf Plum)*	1 gal.
Liquidambar styraciflua (American Sweet Gum)	1 gal.
Magnolia grandiflora (Southern Magnolia)	5 gal.
Pyrus kawakami (Tree type) (Evergreen Pear)	5 gal.
Lagerstroemia indica "Durant Red" (Crape Myrtle)	1 gal.
Liriodendron tulipifera (Tulip Tree)	1 gal.
Bauhinia purpurea (Orchid Tree)	5 gal.
Pinus pinea (Italian Stone Pine)	1 gal.

*Replacement for Acacia latifolia (Bush Acacia) which did not survive well in plots.

Treatments will be imposed in the spring of this year, after having allowed the trees to become established for two years. Expected soil salinity levels are 1, 3-4, and 6-8 millimhos, to be attained by addition of salts to the irrigation water.

Effects of treatments will be determined over a period of at least three years. Observations of the trees' response to treatments during the first growing season will be included in a progress report in this newsletter.

Information of this nature is much needed to assist landscape architects, contractors and nurserymen, who are becoming increasingly involved in landscaping of areas with salinity problems in this country and overseas.

-- Roy L. Branson

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George A. Pearson
Extension Soils Specialist

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