COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

SOIL and WATER

Summer 1981 - No. 48



No Fertilizer With Seed
(Photos - Stuart Pettygrove)



16-20-0 With Seed (64 lb N/A)



Urea With Seed
(64 lb N/A)

AMMONIA TOXICITY FROM STARTER FERTILIZER

The danger of ammonia toxicity from placement of ammoniacal or ammonia forming starter fertilizers too close to the seed is well known. The photos of Yecora Rojo wheat at the left taken on June 5 are from a trial being conducted near Adin, California by Daniel Marcum, Shasta County Farm Advisor. The increased growth due to 16-20-0 is largely a response to nitrogen or the interaction of a higher nitrogen to phosphorus ratio. Lack of a growth response on plots receiving 0-45-0 fertilizer and slight response to 12-40-0 (not pictured) is evidence that soil is adequately supplying phosphorus to the plants in this location. Plant height and green color appeared to be directly related to the rate of nitrogen applied in the starter fertilizer placed in direct contact with the seed, except that the high rate of urea (64 lbs N/acre) caused a reduction in stand density and slower growth. Indicated in the table are average plant counts for the control and urea treatments taken on May 15. Note that the detrimental effect is much greater for Yecora Rojo wheat than Steptoe barley. Although more sparse and shorter, wheat on the high urea plots was well tillered and dark green in color compared to wheat which received lower rates of N in other fertilizer treatments. We won't know until harvest time whether the extra tillering compensates for the initial stand loss. We were moderately surprised that such a high rate of 16-20-0 fertilizer (400 lbs/acre) did not reduce the stand in the same fashion as the urea. Labor and economics even more than fear of ammonia toxicity probably prevents most growers from

(continued on p. 2)

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SOIL AND WATER is the quarterly newsletter of U.C. Cooperative Extension Specialists in Soils, Water, and Biometeorology. You may receive it free of charge by sending your name and address to Department of Land, Air, and Water Resources, Soils Extension, Hoagland Hall, University of California, Davis, CA 95616.

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IN THIS ISSUE

	Page
Ammonia Toxicity From Starter Fertilizer	Cover
U.C. Davis Initiates Soil Database Development Laboratory	2
A New Fertilizer: Urea-Sulfuric Acid	4
Up to Date on 208	7
New Publication on "Non-Traditional "Soil and Plant Amendments"	9
REAL PEOPLE.....in Soil and Water Research	10
Evaluating Drip Hoses	13
Recent Climate Data for California	16

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IRRIGATION PROJECT MAP OF CALIFORNIA

A newly revised map showing irrigation projects and canals throughout the state is now available from the Western Water Education Foundation, 1107 9th Street, Suite 618, Sacramento, CA 95814, (916)444-6240.

The map is in color and can be purchased for $5.00 each which includes tax and postage.

It is a very useful aid in discussing the complex irrigation problems in the state with less informed visitors.

- Gylan L. Dickey

(cont'd. from cover)

applying such a high rate. But in this trial, 400 lbs of 16-20-0 has produced substantially more growth than half that rate. This experiment is also being conducted on plots of Steptoe barley with similar results.

(Plots were seeded at 130 lbs/acre on April 9 into good moisture. Fertilizer materials were applied in direct contact with the seed. No other nitrogen was applied until May 15 when all plots received either 60 or 120 lbs N/acre as urea broadcast on the surface. When photographs were taken (June 5), effects of the broadcast urea were not yet visible, and control plots receiving either no fertilizer or, 0-45-0 still appeared quite nitrogen deficient.)

-Stuart Pettygrove, Dan Marcum, Roland Meyer, Lee Jackson (Agron. Ext.), and Harry Carlson (Agron. Ext.).

Fertilizer and Rate	Plants, no. per 3-20 1/2" lengths per plot for 3 reps			
	Wheat		Barley	
	Ave.	S.D.	Ave.	S.D.
Control	19.8	5.14	21.8	3.35
Urea, 16 lbs N/A	20.1	4.65	21.7	4.92
Urea, 64 lbs N/A	9.2	5.49	17.0	3.74

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U.C. Davis Initiates Soil Database Development Laboratory

The Department of Land, Air and Water, UCD, in cooperation with the California State Department of Conservation, has initiated a pilot project to investigate the feasibility of developing a soil and land use interpretive database for California. Our new group is called the UCD Soil Database Development Laboratory (SDDL).

The primary objective is to develop a working, computerized soil catalog based on the most current soils information available. The soil maps will be digitized into a computer file and all soil map units (polygons) would have a set of soil properties and suitabilities files. These files could be accessed through the Department of Conservation and ultimately through local terminals. The files would provide many products for county and regional planners, city and local officials, and private individuals.

The products could include soil maps at any selected scale or intensity (limited by the basic information available), special interpretative maps, acreages, locations of particular or unique soils, extent of any soil feature or combination of features, or many other specialized interpretations made by combining any of the data in the files, such as those concerned with zoning. The information available would not go beyond

that in the basic, standard soil surveys, but manipulation is made easier with the computer as is data storage. Ultimately, the data could be interfaced with other resource databases to facilitate special conflict or special purpose studies.

We are currently evaluating methods for producing the database and techniques for digitizing the soil maps. Parts of Santa Cruz County and Monterey County are being tested as pilot areas. Information from the respective soil surveys will be used to form a set of files for producing interpretative maps and other products. Ultimately, the State Departments of Conservation and Water Resources will use this system in conjunction with the California Automated Resource Inventory (CARI) system to interface with other resource databases.

Similar projects have been investigated by a number of states and federal agencies. Currently, the states of Missouri, Ohio and Minnesota have viable, working systems that are well adapted to their needs. We want to make the California program useful to county planners, farm advisors, state and local officials, landowners, and all other potential users in the state. This requires input from all interested parties as to what they need or would like to see in the program. We solicit suggestions for products that would be useful to your programs or needs. If you have comments or suggestions, please write Eugene Begg or Jim Wardlaw, Dept. of Land, Air and Water Resources, Soil Data Base Development Laboratory, 139 Hoagland Hall, University of California, Davis, Calif. 95616.

-Eugene Begg and James Wardlaw

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INTRODUCTION: DAVE GOLDHAMER

Welcome to our new Area Soils and Water Specialist, David A. Goldhamer. Dave grew up in Upland, California and then moved to Davis where he stayed long enough to earn three degrees. His M.S. is in Water Science, and his Ph.D. (1980) is in Soil Science. For his doctoral research, he studied the effects of organic matter and infiltration rate on the fate of ammonium sulfate nitrogen in flooded soils. Dave also has done consulting work in environmental engineering and just before joining Cooperative Extension in March of this year worked for a retail agricultural chemical company in Bakersfield.

Dave's extension responsibilities include both irrigation and soil management problems in southern and central parts of the San Joaquin Valley. He is located at the San Joaquin Valley Agricultural Research and Extension Center, 9240 South Riverbend Avenue, Parlier, CA 93648. Phone (209) 646-2794.

A NEW FERTILIZER: UREA-SULFURIC ACID

Introduction

Recently, a new nitrogen fertilizer has been introduced in California. It is an acid-based product manufactured using concentrated sulfuric acid and urea as raw materials. The chemical bonding of these compounds results in a fertilizer with unexpected properties, and it may offer the grower a tool that can be used as an acidulating amendment as well as a nitrogen fertilizer.

The formulation of a urea-sulfuric acid mixture may alleviate some problems associated with the singular use of each material.

Urea and urea-containing fertilizers (UN-32) are high in analysis and relatively easy to transport, store and handle. After soil application, however, zones of high pH can develop in the vicinity of the applied fertilizer (during the transformation of urea to ammonium carbonate), due to net consumption of hydrogen ions in the reaction. This alkaline zone can promote ammonia toxicity and ammonia volatilization losses and can interfere with the phosphorus nutrition of plants.

Sulfuric acid has been widely used to improve water penetration in sodic soils. Sulfuric acid application increases the soluble calcium levels by dissolving lime already present in the soil. Additionally, sulfuric acid may be added to irrigation water to lower bicarbonate levels. While the benefits of sulfuric acid use in appropriate cases are clearly documented, it is an extremely dangerous material to handle -- both to personnel and equipment. Many growers recognize the advantages of using sulfuric acid as a soil or water amendment but avoid it because of its highly corrosive properties.

Production and Properties of Urea-Sulfuric Acid Fertilizers

Mixing concentrated sulfuric acid with urea produces excessive heat. If not controlled, this heat will destroy the urea and sulfuric acid molecules and result in the production of ammonium sulfamate which has herbicidal properties. However, when proper amounts of each ingredient are used, and the heat of reaction is adequately dissipated, the urea and sulfuric acid molecules bind together to form a clear solution with a pH of approximately one. Sulfuric acid at this pH would be highly destructive to human tissue, but the nature of the chemical bond between the acid and urea molecules renders the solution only slightly irritating to the skin, even after prolonged contact. It will, however, cause burning in an open cut or in the eyes.

At present, urea-sulfuric acid fertilizers are being manufactured and marketed by at least two companies in California. Both firms produce a formulation that is 28% nitrogen and 27% sulfuric acid by weight. One of these firms also offers formulations with less nitrogen and more sulfuric acid (Table 1).

Plastic or stainless steel tanks and handling equipment are recommended, although one manufacturer indicates that mild steel can be used due to the inclusion of corrosion inhibitors in their solutions. Fittings used in storage or application systems should be stainless steel or PVC. The material will attack nylon and leather. Urea-sulfuric acid formulations are compatible with phosphoric acid, but should never be added to UN-32 or sulfuric acid -- the latter results in an explosive reaction.

Table 1. Urea-sulfuric acid fertilizer materials.

Nitrogen (% by weight)	Nitrogen (lbs. N/gal)	Sulfuric acid (% by weight)	Material Weight [1/] (lbs./gal.)
28	3.3	27	11.9
17	2.2	49	12.8
10	1.2	55	12.8

1/ at 20° C.

Agronomic Applications

Only a small number of field trials have been conducted with urea-sulfuric acid fertilizers, usually by the manufacturer with cooperative product users. Proper statistical design and replication are lacking in many of these trials. Moreover, evaluations have been made based mainly on yield response with little or no soil or tissue data, so performance appraisal is somewhat difficult. However, certain trends seem to have emerged that indicate strengths and weaknesses of the material.

Urea-sulfuric acid has been compared to ammonia, aqua ammonia, and UN-32 as a sidedressing on row crops -- mainly cotton. Preplant application for wheat has also been evaluated against anhydrous ammonia. While the results of these experiments with respect to yield vary considerably, a rather disturbing observation occurs with some regularity. Early in the growing season, the urea-sulfuric acid treated blocks appear yellow compared to those treated with conventional nitrogen fertilizers. Nitrogen content is lower in the plants from treated plots. Toward the end of the season, however, visual and nitrogen tissue concentration differences narrow or dissappear. Possibly the lowered pH in the zone of application retards nitrification or growth of roots near the fertilizer.

Injection into drip irrigation systems may be a more rewarding usage. Drip systems offer a convenient and efficient method of applying nitrogen fertilizers, but the uniformity of application is dependent upon having a system that is free of emitter clogging. Irrigation waters high in calcium and bicarbonates are susceptible to the deposition of lime at the emitter orifice, which can build up with time. While the emitter is operating, the rate of discharge may be significantly lowered due to partial clogging. Sulfuric acid is sometimes recommended to lower the pH of the water in order to dissolve precipitated calcium salts as well as to treat the system continuously thereby lowering bicarbonate levels to maintain good water quality. Many growers, however, have reservations concerning the use of sulfuric acid due to its previously mentioned hazardous nature. Owing to the relatively safe handling characteristics of urea-sulfuric type fertilizers, they appear to be a viable alternative to sulfuric acid as an acidulating

agent. Moreover, nitrogen is supplied at the same time that the quality of the water is being improved.

In order to better understand the usage of these acid-based products in drip systems, the following case of a hypothetical almond orchard using rather poor quality irrigation water is considered.

Assumptions:

1) 80 lbs. N/acre required.
2) Fertilizer should be applied as early in the season as possible.
3) Irrigation season runs from April to December.
4) 0.4 acre-feet per acre of irrigation water needed between April 1 and May 15.
5) 2.4 acre-feet per acre of irrigation water needed between May 15 and December.
6) 100 ppm bicarbonate in irrigation water.

From Table 2, 61 gallons per acre feet of water of urea-sulfuric formulation 28-0-0-27 is required to neutralize 90% of the bicarbonate in the water. Between April 1 and May 15, 0.4 acre feet of water is applied and, therefore, the nitrogen addition under continuous injection is:

0.4 ac. ft. x 61 gal. 28-0-0-27/ac. ft.= 24.4 gal. 28-0-0-27

24.4 gal. 28-0-0-27 x 3.3 lbs. N/gal.= 73.2 N applied.

The remainder of the nitrogen requirement would be 6.8 lbs/acre.

It would not be feasible to continuously inject fertilizer because the nitrogen requirement of the plant would be grossly exceeded, even with the lowest nitrogen analysis formulation (10-0-0-55). Using this material at the rate recommended to dissipate 90% of the bicarbonate (29 gal./ac. ft.) would allow approximately 0.2 acre feet of treated water to be applied for the remainder of the irrigation season to meet the remaining nitrogen requirement (29 gals./ac. ft. x 0.2

Table 2. Quantities of acidulating material required to neutralize 90% of the bicarbonate in irrigation water.

Bicarbonate Content (ppm)	Solution Required per Acre Foot of Water			
	H_2SO_4 1/ (ppm)	H_2SO_4 1/ (gals)	28-0-0-27 (gals)	10-0-0-55 (gals)
50	38	7	31	14
100	76	13	61	28
200	152	27	122	56
400	304	55	244	112

1/ 95% sulfuric acid.

ac. ft. x 1.3 lbs. N/gal. $\cong$ 8 lbs. N). If 2.4 acre feet of water remains to be applied, the 10-0-0-55 material can be injected during only 8% of the time the drip system is operating. It's logical to assume that most of the precipitation of lime in the system occurs if and when poor (high bicarbonate) water remains in the lines during off use times. Assuming that the drip system is operated for ten hours each time it is activated, the best management practice would be to inject fertilizer (10-0-0-55) during only the last hour of drip system operation. This should result in low bicarbonate residual water in the drip system during shut down, and hopefully preclude any precipitate buildup at the emitters.

To date, little work has been done to quantitatively evaluate urea-sulfuric type fertilizer injection in drip systems. It seems clear, however, that it holds promise as a substitute for sulfuric acid when acidulation of irrigation water is desired. Recommendations for injection rates are relatively easily made using titration curves or stoichiometric expressions for bicarbonate reaction. However, injection timing rates and schedules must reconcile the acidulation effects with the amount of nitrogen also being added. This task is made easier because there are three formulations - each with different nitrogen/acid ratios. Proper injection scheduling will be determined through research now being conducted to determine the optimum timing and rates of nitrogen fertilization of permanent crops under drip irrigation.

Summary

Urea-sulfuric acid fertilizers allow the application of a highly acidic nitrogen solution that is relatively safe to handle. Its properties offer the potential for the benefits that both urea and sulfuric acid offer individually, but alleviate some of the problems associated with their use. Research needs to be continued in order to assess the agronomic situations that are best addressed by the use of this type of material.

- Dave Goldhamer

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UP TO DATE ON 208

Central Valley Regional Water Quality Control Board

Acid mine drainage and heavy metals from inactive and abandoned mines have severly degraded water quality in receiving stream segments within the Central Valley Region. More than 40 problem mines have been identified and ranked according to their impacts on beneficial uses of receiving waters. Current discharges from mines typically include high concentrations of copper, zinc, and other metals and are highly acidic (pH of 2-3 is not uncommon). These characteristics often produce essentially sterile conditions downstream from the mine.

The overall objectives of the Regional Board mining program continues to be:

- reduce water quality impacts of inactive and abandoned mines.
- coordinate related research and development programs.
- continue regulatory and related support activities.

The first effort of this proposed program is to initiate actions which will lead to pollution abatement for priority problem mines in the vicinity of Lake Shasta (an area where there is widespread documented water quality

impacts from mine drainage). The Regional Board intends to complete feasability studies on these priority problem mines as quickly as funds become available to them.

Agricultural chemicals in irrigation return flows from rice fields have been a concern of the Regional Board for many years. At a recent meeting, the Board accepted the 208 water quality management study reports dealing with agricultural chemical useage in rice and their effect on fish. This action led to a resolution which recommends that following agricultural chemical label instructions for application of chemicals to rice be designated a Best Management Practice (BMP).

State Water Resources Control Board

Because the groundwater basins in California are such important contributors to our water supplies, the State Board is actively engaged in an assessment of groundwater quality conditions. Already a number of problems are known which affect this valuable resource, but the Board is aware that others are becoming evident as more data are gathered through monitoring programs. These include:

- increasing nitrate concentrations, due to diverse sources.
- the continuing overdraft of groundwaters resulting in mineralization due to recirculation or percolation of used water, induced connate water migration, and seawater intrusion in several coastal basins ("connate water" is saline water entrapped in the geologic past when the land was covered by seawater).
- the lack of hazardous waste dump sites and consequent illegal dumping leading to percolation of toxic materials.
- industrial and military percolation ponds not designed for disposal of the types of wastes present.
- crop dusting operations--a source of many pesticides which have the potential to reach usable groundwaters.

The Board feels that in order to establish waste discharge requirements, monitoring wells must be constructed and data then collected over a long enough time to detect problems.

On October 29, 1980, the State Board adopted the Lake Tahoe Basin Water Quality Plan. The plan establishes a program of development restrictions and remedial erosion control projects needed to protect Lake Tahoe water quality. In February of this year, the EPA offered the State Board a Federal Clean Lakes grant of approximately $950,000 to be matched by state funds making a total of $1.9 million for the project. The State share funds would come from the Proposition 2 State Assistance bond funds, of which $10 million has been set aside for Lake Tahoe projects.

- Stephen P. Carlson

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NEW PUBLICATION ON "NON-TRADITIONAL" SOIL AND PLANT AMENDMENTS

Growers and home gardeners alike face a bewildering array of "elixirs" in the agricultural chemicals market. "Elixir" is defined in the dictionary as a cure-all, and many non-conventional products - it is claimed - cure a wide variety of agricultural ills.

Published information on such products is hard to come by. A new publication is available entitled Compendium of Research Reports on Use of Non-Traditional Materials for Crop Production which contains information on over 50 products. This compendium was prepared by extension and experiment station personnel in the North Central Region which includes most of the Corn Belt states and Alaska. It is available for $10.00 from: Publication Distribution, 112 Printing and Publications Bldg., Iowa State University, Ames, Iowa 50011.

Following is a list of some of the products discussed:

Biological Inoculants and Activators

Agra-Life
Agrispon
Agriserum
Bioact
Genesis II
Medina
Phosphobacterin
Planterra
Radiant Blend
Soil-A-Zyme
Super Natent
Symbex

Growth Stimulants and Regulators

AgroPlus
Burst
Culbac
Dinoseb (premerge, Spark)
Ergostim
Sea Born Plus and Sea Born Plus F
Agriblend

Mineral Nutrient Sources (Low Volume/ Low Analysis)

Bayfolan
H-Plus
Hybrotite
NaChurs
Plen-T-4
Shur-Gro
Eco-Gro
Trazco

Soil Conditioners

Agri-Sc
Fertilaid
Leonardite
Miagra
Microlite
Planters Soil Conditioner
Supergro
Western Soil Conditioner
Wonderlife
Humate

Other

ACA
Extend
Promesol
SRC-101
Enagizer

Wetting Agents

Amway Spray Adjuvant
Basic H
Formula 7040
Saturall
Sol-Ez
Trazco
Wex

- Stuart Pettygrove

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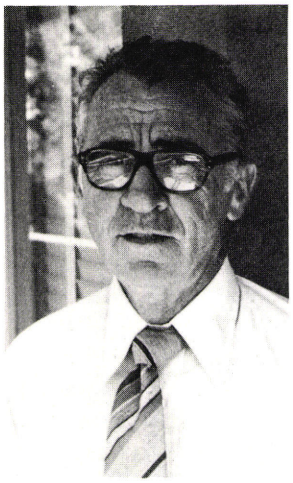
REAL PEOPLE.....in soil and water research.



MICHAEL REISENAUER, Professor of Soil Science, UCD, Dept. of Land, Air and Water Resources. H.M. Reisenauer is almost a household name among extension advisors and commercial laboratory workers due to the widespread distribution of some of his publications. Mike has edited Soil and Plant-Tissue Testing in California (Bulletin 1879) and served as first author for a chapter in Soil Testing and Plant Analysis (Walsh and Beaton, eds.) entitled "Testing soils for sulfur, boron, molybdenum, and chlorine". He also wrote the soil and tissue testing chapter in the Western Fertilizer Handbook. Mike's research in soil fertility and plant nutrition spans more than 30 years. He earned his M.S. in Soil Science at the University of Idaho and a Ph.D. in Soil Science at North Carolina State College. For 13 years he was a professor of soil science at Washington State University in Pullman. In 1962 he joined the Kearney Foundation of Soil Science at UCD and in 1973 the Dept. of Soils and Plant Nutrition (now Land, Air and Water Resources). He teaches Soil Fertility at UCD, and is actively involved with the graduate program in Soil Science. His researches have dealt with N, Co, Mo, Mn, and Cr uptake by plants. His current interests include the role of the amide-amine pool in plants, the plant uptake of chromium, and the fate of phosphorus in the soil when applied at high rates.



JILL SLATER, a graduate student, UCD, Dept. of Land, Air and Water Resources. Jill is completing a 3 year study of the behavior of the soluble forms of chromium (Cr) in soil and plants. Chromium, the 24th element, is required in our diets but is also an industrial pollutant. In high enough concentrations it can be toxic to plants. Chromium is found in sewage sludges, tannery wastes, photographic chemicals, stainless steel, and many other industrial chemicals. It is also a natural constituent of serpentine soils. Jill - under the supervision of Mike Reisenauer - is one of a small number of workers in the U.S. studying the effect of soluble forms of chromium on plant growth and microbial respiration. She has also studied the translocation of Cr from root to shoots in wheat seedlings.

Jill grew up on an almond ranch in Manteca, California, has a B.A. in chemistry from Occidental College and an M.S. in soils science from UCD. She will be completing her Ph.D. work soon and hopes to continue working as a soils researcher.

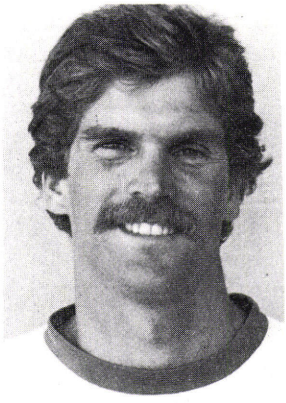
Jill's first love is clogging - a form of folk dancing which is hard to keep secret. She is president of the Camellia City Cloggers and has given clogging exhibitions at the state fair.

REAL PEOPLE.....in soil and water research.



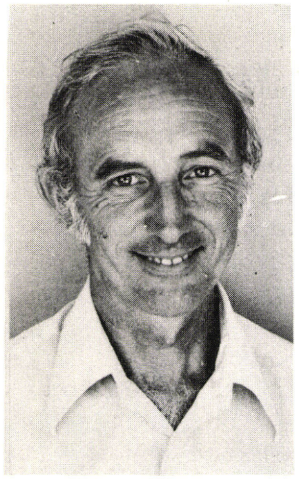
VERNE SCOTT, Professor of Water Science and Civil Engineering, UCD. Verne is obviously fascinated with water. For 33 years at UCD (with time out to earn a Ph.D. in civil engineering at Colorado State University), he has studied groundwater and its development, use, recharge and pollution. During this time he has written or helped to write over 60 technical papers and articles with such titles as: "Modelling movement of contaminants in groundwater systems" and "Energy and efficiency in wells and pumps." Verne co-authored the widely distributed Bulletin 1889, "Water wells and pumps: their design, construction, and maintenance." One of his current interests is groundwater in upland areas.

Verne teaches courses in water science and civil engineering and has worked with students in "experiential learning" programs - learning through non-classroom experience. Verne is well known in Davis for his swimming prowess and a level of physical conditioning uncharacteristic of a university professor.



WALTER BRICKER worked for a consulting firm in Colorado in the area of water resources. Now he has returned to his native California to study--aptly enough--groundwater resources in mountainous areas. Question: How would you begin to study such an important resource in a highly variable, rocky environment? Answer: Very carefully. Walter will be working closely this summer with his major professor, Verne Scott to determine the direction of his research. Walter grew up in Visalia, earned a B.S. in civil engineering (1976) at UC Berkeley and is now an M.S. student in civil engineering at UCD. Like his major prof he stays close to the pool. He played water polo at UC Berkeley and now swims daily in the Davis Aquatic Master's program.

REAL PEOPLE.....in soil and water research.



DONALD MUNNS, Professor of Soil Science, UCD, Dept. of Land, Air and Water Resources. Don is a native of Sydney, Australia and appeared to be headed towards a career as a plant and soil scientist in Australia but then earned his Ph.D. degree at the University of California, Berkeley in soil science and married a Californian. That seems to have sealed his fate, and he is still in California. Don is now supervising an energetic group of graduate students who call themselves "Munnsoids". Don's research career has been devoted to understanding the mineral nutrition and nodulation of legumes. He has done research on reactions of phosphorus and cations in tropical soils. His more recent work has focused on soil factors which effect nodulation and N_2 fixation, such as low pH, aluminum, manganese, calcium, phosphate and salt. Recently he and his graduate students have worked to screen large populations of cowpeas and other beans for tolerance to acid conditions and also to select rhizobial strains which tolerate acid conditions. Don is also active in the teaching program and is a co-author on the lab exercise manual in the beginning soil science course.



JULIA HOHENBERG, graduate student in Land, Air and Water Resources, UCD. Julia is one of the "Munnsoids" working under the direction of Don Munns on acid tolerance of cowpeas. She and her co-workers are screening 60 cultivars grown either in symbiosis with Rhizobium spp. or with synthetic nitrogen fertilizer. This work is being done both in soil and solution. One question Julia is trying to answer is, what reduces growth and nodulation under acid conditions -- is it low available calcium, toxic levels of aluminum, or low pH per se? This research is related to her M.S. degree project (also at UCD) in which she studied the effectiveness of rhizobial strains adapted to one host (common bean) on a second host (Scarlet Runner bean).

Julia comes from Santa Barbara. Upon completion of her Ph.D. work, she would like to do research in a tropical country. When asked what she does in her spare time, Julia replied "bicycling" -- not a particularly distinctive hobby in Davis -- but we learned that she is also pretty good at ceramics and glazing.

EVALUATING DRIP HOSES

Bob Brendler, farm advisor in Ventura County, is a statistics "nut" and has evaluated several types of irrigation systems for water application uniformity. His latest progress reports on line source emitters will be of interest to those working with drip irrigation. With Bob's permission I've summarized some of his results. For further information please contact him directly at the Ventura County office.

Four types of commercial drip hose are included in these latest reports: Chapin Tri-Wall low flow, Chapin Tri-Wall high flow, Reed Bi-wall, and T-tape. The Reed Bi-wall has a hole spacing of 12 inches; holes in the other three are spaced at 8 inches. By placing collectors under each hole along 100 feet of hose, Bob measured flow rates (gpm per 100 ft.) as a function of operating pressure (psi). Statistical treatment of the data allowed estimation of variability and calculation of extra water factors (E.W.F.). This factor times the irrigation water requirement gives the amount of water to apply so that 90% of the irrigated area receives at least the required amount.

Bob also calculated a measurement that was new to me: the number of hours required to apply one inch of water to a 100-foot strip two feet wide. It's a fairly straightforward calculation from the measured flow rate in gallons per minute (gpm) per 100 feet of hose. Simply divide gpm into 2.078, or, take the reciprocal of gpm x .4812: No. of hours = $1/(\text{gpm} \times .4812) = 2.078/\text{gpm}$. This could have important consequences for irrigation scheduling with drip systems. A simple calculation would extend this concept to one-foot or three-foot strips.

Tables 1 and 2 are derived from Bob's data and emphasize the differences he found in the performance of these four hoses. The graphs of flow rate vs. pressure are taken directly from his reports, but I have included his range of flow rates for 95% of the holes (the vertical lines at each data point).

For further evaluation of drip hoses, Bob uses a theoretical relationship, $V_2/V_1 = (P_2/P_1)^{1/2}$, where P_2 and P_1 are the pressures in pounds per square inch corresponding to flow rates V_2 and V_1 in gallons per minute per 100 feet. That is, doubling the pressure should increase the flow rate by a factor of $\sqrt{2}$, or 1.41. Inspection of the figure indicates that both the Chapin low flow and the Reed hoses approach this relationship quite closely in contrast to T-tape and Chapin high flow.

I hope this makes you believe even more in pressure control and regulation to attain high water application efficiencies.

- John M. Rible

(Figures and Tables 1 and 2 on the following pages)

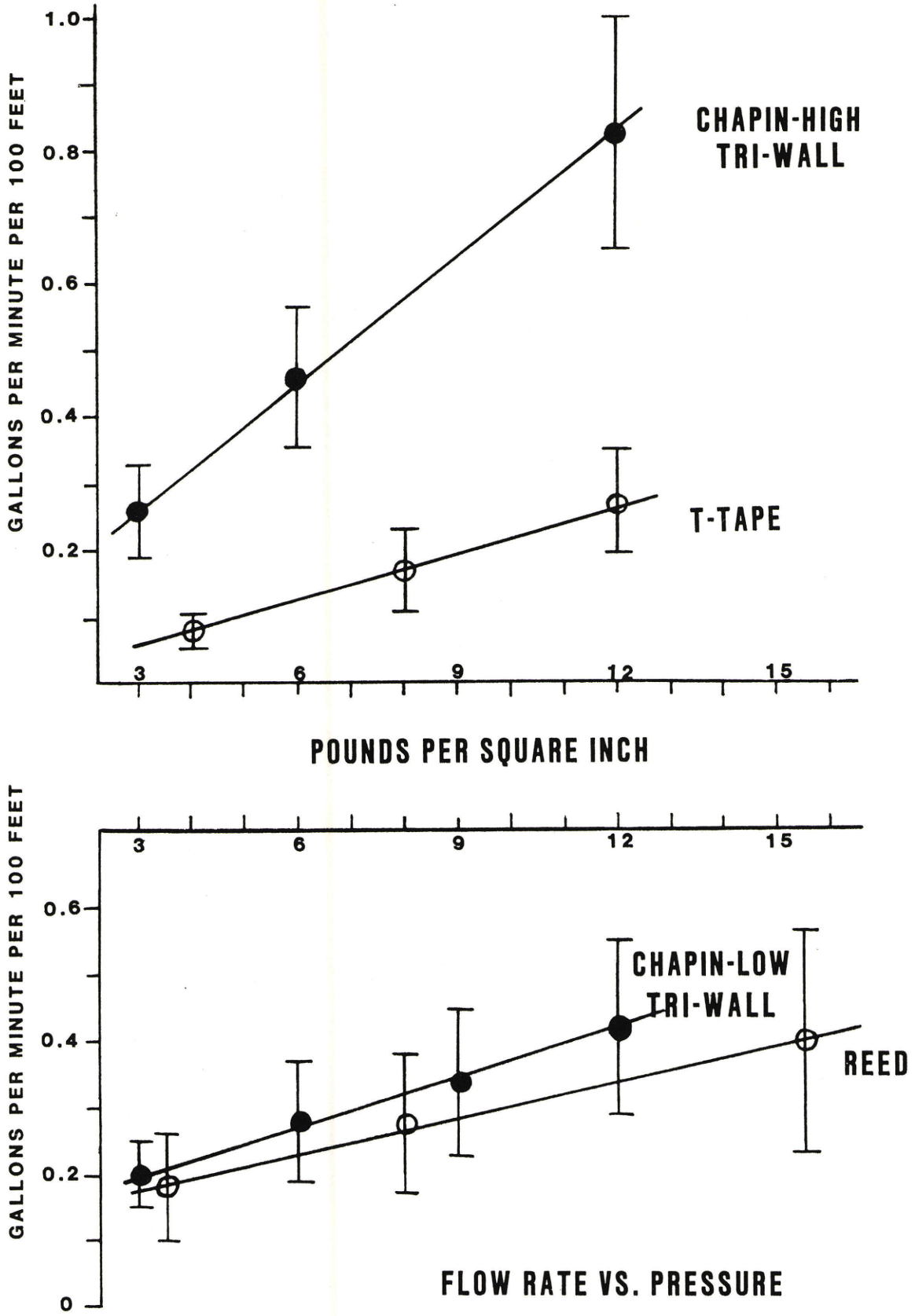

GALLONS PER MINUTE PER 100 FEET
1.0
0.8
0.6
0.4
0.2
CHAPIN-HIGH
TRI-WALL
T-TAPE
3
6
9
12
15
POUNDS PER SQUARE INCH
GALLONS PER MINUTE PER 100 FEET
0.6
0.4
0.2
0
CHAPIN-LOW
TRI-WALL
REED
FLOW RATE VS. PRESSURE

Table 1. Hose tubing comparisons at highest pressures used[1]

	psi	Ave. gpm per 100 ft.	95% Range Low	High	E.W.F.
T-Tape	12	.273	.198	.349	1.22
Reed Bi-Wall	15.5	.400	.233	.567	1.38
Chapin-Low Flo	12	.423	.288	.557	1.26
Chapin-High Flo	12	.825	.654	.996	1.16

[1]Pressures used: Chapin-Low Flo 3, 6, 9 and 12 psi; Chapin-High Flo 3, 6, and 12 psi; Reed Bi-Wall 3 1/2, 8 and 15 1/2 psi; T-Tape 4, 8 and 12 psi.

Table 2. Estimated number of hours to apply one inch of water to strip 2' x 100'

psi	T-Tape	Reed	Chapin Low	Chapin High
3	35.0	11.9	10.1	8.0
6	16.0	9.0	7.4	4.5
9	10.6	7.2	6.1	3.2
12	7.6	6.1	4.9	2.5

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RECENT CLIMATE DATA FOR CALIFORNIA

Introduction

Periodically the National Climatic Center (NCC) in Asheville, N.C., a subsidiary of the National Oceanic and Atmospheric Administration (NOAA), produces a publication comparing the climate data of weather stations across the United States. Recently the latest edition of "Comparative Climatic Data for the United States through 1978" was received by the Soil and Water Unit of Cooperative Extension. Data from that publication for California stations are presented for your information.

Explanation of Terms

Record maximum and minimum temperatures for each month are for the period of record of each station as are the mean number of days with a minimum temperature of 32°F or lower, mean number of days with precipitation 0.01 inch or more, snowfall, average wind speed and maximum wind speed. Average relative humidities are given for selected morning and afternoon observations.

Climatological normals are computed over a 30-year period from 1941-1970 in this publication. These normals will be updated to 1951-1980 in the near future. Heating and cooling degree days are used to estimate energy requirements to maintain comfortable indoor temperatures in the cool and warm seasons, respectively. They are calculated using statistical techniques by the NCC.

Precipitation includes the liquid equivalent of snowfall.

Explanation of Symbols

* frequency of occurrence is greater than zero, but smaller than one half.

no data available.

For more information, the cited publication and other weather climate data, including information on cost of unpublished data, can be obtained from the National Climate Center, Federal Building, Asheville, North Carolina 28801 (704) 258-2850, extension 683.

- Richard L. Snyder

(Tables on the following pages)

Stuart Pettygrove
Editor

Bakersfield

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	78	85	92	98	107	114	115	112	112	103	91	82
Record Minimum Temperature (°F)	20	26	31	35	40	45	53	52	45	29	28	21
Mean Number of Days Below 32°F	4	1	*	0	0	0	0	0	0	*	*	4
Mean Number of Days with Precipitation ≥0.01 in.	6	6	6	4	2	*	*	*	1	2	3	5
Average Snowfall (inches)	T	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
Average Windspeed (mph)	5.2	5.8	6.6	7.2	8.0	8.0	7.2	6.8	6.3	5.6	5.1	5.0
Maximum Windspeed (mph)	35	44	38	40	38	41	25	30	35	31	30	46
Average Morning Relative Humidity (%)	75	66	55	46	37	34	32	36	41	46	63	75
Average Afternoon Relative Humidity (%)	61	50	40	32	24	23	20	23	27	33	49	61
Normal Maximum Temperature (°F)	57.5	63.3	68.6	75.5	83.6	91.5	99.1	96.5	91.1	80.5	67.8	57.4
Normal Minimum Temperature (°F)	37.4	41.4	44.5	49.9	56.0	62.3	68.7	66.6	62.1	53.3	44.2	38.4
Normal Mean Temperature (°F)	47.5	52.4	56.6	62.7	69.7	69.8	76.9	83.9	81.6	76.6	66.9	56.0
Normal Heating Degree Days	543	353	266	140	22	0	0	0	0	90	345	596
Normal Cooling Degree Days	0	0	6	71	171	362	586	515	348	114	6	0
Normal Precipitation (inches)	0.96	1.03	0.83	0.85	0.19	0.06	0.02	0.01	0.08	0.26	0.69	0.74

Bishop

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	77	78	87	92	101	109	109	107	106	95	84	78
Record Minimum Temperature (°F)	-7	-2	9	15	25	29	40	37	26	16	5	-4
Mean Number of Days Below 32°F	29	24	21	8	1	*	0	0	*	6	23	29
Mean Number of Days with Precipitation ≥0.01 in.	4	3	3	3	3	2	2	2	2	2	2	3
Average Snowfall (inches)	3.7	2.0	0.7	0.4	0.1	0.0	0.0	0.0	T	0.1	0.2	1.2
Average Windspeed (mph)	#	#	#	#	#	#	#	#	#	#	#	#
Maximum Windspeed (mph)	47	52	59	58	53	60	46	75	52	52	56	66
Average Morning Relative Humidity (%)	49	40	29	22	21	18	19	20	22	24	34	43
Average Afternoon Relative Humidity (%)	35	27	20	17	16	13	14	13	14	18	26	33
Normal Maximum Temperature (°F)	53.6	57.9	63.7	71.9	80.7	89.7	97.5	95.3	88.7	77.2	63.8	55.4
Normal Minimum Temperature (°F)	20.5	25.3	28.8	36.8	43.6	49.7	55.7	52.8	46.2	37.2	27.5	22.3
Normal Mean Temperature (°F)	37.1	41.6	46.3	54.4	62.2	69.7	76.6	74.1	67.5	57.2	45.7	38.9
Normal Heating Degree Days	865	655	580	337	145	38	0	5	44	256	579	809
Normal Cooling Degree Days	0	0	0	19	58	179	360	287	119	15	0	0
Normal Precipitation (inches)	1.20	1.06	0.43	0.41	0.27	0.09	0.17	0.10	0.10	0.26	0.58	1.05

Blue Canyon

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	71	73	72	78	86	92	95	97	93	85	78	75
Record Minimum Temperature (°F)	5	6	9	17	21	28	40	35	27	17	13	3
Mean Number of Days Below 32°F	19	17	19	12	5	*	0	0	*	3	10	16
Mean Number of Days with Precipitation ≥0.01 in.	12	12	13	10	7	3	1	1	2	5	10	12
Average Snowfall (inches)	47.3	41.4	48.2	29.1	7.7	0.5	0.0	0.0	0.4	2.1	22.5	39.4
Average Windspeed (mph)	9.7	9.4	9.1	7.7	7.7	7.5	6.9	6.8	7.3	8.1	8.2	7.9
Maximum Windspeed (mph)	67	76	67	50	37	49	32	30	49	70	54	51
Average Morning Relative Humidity (%)	59	58	60	52	47	41	32	32	35	42	51	54
Average Afternoon Relative Humidity (%)	55	60	56	51	44	34	29	35	45	37	47	48
Normal Maximum Temperature (°F)	42.9	44.2	45.0	51.7	59.8	67.8	77.5	76.4	72.7	62.6	51.7	45.6
Normal Minimum Temperature (°F)	29.8	30.5	30.9	36.1	42.7	50.4	58.7	57.1	53.1	45.3	37.3	32.6
Normal Mean Temperature (°F)	36.4	37.4	38.0	43.9	51.3	59.1	68.1	66.8	62.9	54.0	44.5	39.1
Normal Heating Degree Days	887	773	837	633	425	197	27	58	108	341	615	803
Normal Cooling Degree Days	0	0	0	0	0	20	123	114	45	0	0	0
Normal Precipitation (inches)	13.66	9.42	8.55	5.47	3.14	0.99	0.10	0.27	0.52	4.14	9.04	12.28

Eureka

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	75	85	78	79	84	85	76	82	85	82	77	77
Record Minimum Temperature (°F)	25	27	29	32	36	41	45	44	41	32	29	21
Mean Number of Days Below 32°F	2	1	*	*	0	0	0	0	0	*	*	1
Mean Number of Days with Precipitation ≥0.01 in.	16	14	15	12	8	5	2	3	5	9	13	15
Average Snowfall (inches)	0.2	T	T	T	0.0	0.0	0.0	0.0	0.0	0.0	T	T
Average Windspeed (mph)	6.9	7.2	7.6	8.0	7.9	7.4	6.8	5.8	5.5	5.6	6.0	6.4
Maximum Windspeed (mph)	54	48	48	49	40	39	35	34	44	56	43	56
Average Morning Relative Humidity (%)	#	#	#	#	#	#	#	#	#	#	#	#
Average Afternoon Relative Humidity (%)	#	#	#	#	#	#	#	#	#	#	#	#
Normal Maximum Temperature (°F)	53.5	54.4	54.1	54.9	57.2	59.6	60.4	61.2	61.9	60.4	57.9	54.6
Normal Minimum Temperature (°F)	41.1	42.3	42.5	44.4	47.8	50.7	52.1	52.7	51.2	48.4	45.5	42.6
Normal Mean Temperature (°F)	43.7	48.4	48.3	49.7	52.5	55.2	56.3	57.0	56.6	54.4	51.7	48.6
Normal Heating Degree Days	549	465	518	459	388	294	270	248	252	329	399	508
Normal Cooling Degree Days	0	0	0	0	0	0	0	0	0	0	0	0
Normal Precipitation (inches)	7.42	5.15	4.83	2.95	2.11	0.66	0.14	0.27	0.65	3.23	5.77	6.58

Fresno

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	75	79	90	95	104	110	111	109	105	100	89	76
Record Minimum Temperature (°F)	19	25	26	32	36	44	50	49	37	27	26	21
Mean Number of Days Below 32°F	9	4	1	*	0	0	0	0	0	*	3	10
Mean Number of Days with Precipitation ≥0.01 in.	8	7	6	5	2	1	*	*	1	2	5	7
Average Snowfall (inches)	0.1	T	T	0.0	0.0	0.0	0.0	0.0	0.0	T	0.0	T
Average Windspeed (mph)	5.4	5.7	6.7	7.2	7.9	8.1	7.2	6.7	5.9	5.2	4.7	5.0
Maximum Windspeed (mph)	32	38	41	36	38	34	25	31	29	40	29	43
Average Morning Relative Humidity (%)	85	77	64	52	42	40	38	42	46	52	73	85
Average Afternoon Relative Humidity (%)	68	56	45	35	25	24	23	26	29	34	56	70
Normal Maximum Temperature (°F)	54.8	60.8	66.6	74.3	82.9	90.3	98.2	96.0	91.0	79.8	66.1	54.6
Normal Minimum Temperature (°F)	35.8	39.0	41.2	46.2	51.9	57.5	62.9	60.6	56.5	48.6	40.8	36.9
Normal Mean Temperature (°F)	45.3	49.9	53.9	60.3	67.4	73.9	80.6	78.3	73.8	64.2	53.5	45.8
Normal Heating Degree Days	611	423	344	182	51	9	0	0	0	90	345	596
Normal Cooling Degree Days	0	0	0	41	125	276	484	412	267	66	0	0
Normal Precipitation (inches)	1.84	1.72	1.62	1.24	0.32	0.06	0.00	0.02	0.07	0.42	1.22	1.71

Los Angeles International Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	88	92	93	95	97	100	97	98	110	106	101	94
Record Minimum Temperature (°F)	23	32	34	39	43	48	49	51	47	41	34	32
Mean Number of Days Below 32°F	*	0	0	0	0	0	0	0	0	0	0	*
Mean Number of Days with Precipitation ≥0.01 in.	6	6	5	3	1	1	1	*	1	2	3	5
Average Snowfall (inches)	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
Average Windspeed (mph)	6.6	7.3	8.0	8.4	8.2	7.9	7.6	7.6	7.2	6.8	6.5	6.4
Maximum Windspeed (mph)	48	57	62	59	45	32	31	33	29	46	55	49
Average Morning Relative Humidity (%)	55	59	61	61	66	70	69	69	66	60	58	55
Average Afternoon Relative Humidity (%)	60	63	65	64	66	68	69	69	67	65	63	61
Normal Maximum Temperature (°F)	63.5	64.1	64.3	65.9	68.4	70.3	74.8	75.8	75.7	72.9	69.6	66.5
Normal Minimum Temperature (°F)	45.4	47.0	48.6	51.7	55.3	58.6	62.1	63.2	61.6	57.5	51.3	47.3
Normal Mean Temperature (°F)	54.5	55.6	56.5	58.8	61.9	64.5	68.5	69.5	68.7	65.2	60.5	56.9
Normal Heating Degree Days	331	270	267	195	114	71	19	15	23	77	158	267
Normal Cooling Degree Days	5	7	0	9	17	56	127	154	134	83	23	0
Normal Precipitation (inches)	2.52	2.32	1.71	1.10	0.08	0.03	0.01	0.02	0.07	0.22	1.76	1.75

Mount Shasta

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	65	71	80	84	91	96	100	103	103	92	80	72
Record Minimum Temperature (°F)	- 2	1	11	14	21	25	31	34	25	19	9	- 5
Mean Number of Days Below 32°F	26	22	21	13	4	*	*	0	1	6	18	26
Mean Number of Days with Precipitation ≥0.01 in.	12	11	12	9	7	5	2	2	3	6	10	12
Average Snowfall (inches)	32.1	17.0	17.1	9.7	1.0	T	0.0	0.0	0.0	0.4	9.3	21.7
Average Windspeed (mph)	#	#	#	#	#	#	#	#	#	#	#	#
Maximum Windspeed (mph)	#	#	#	#	#	#	#	#	#	#	#	#
Average Morning Relative Humidity (%)	74	69	62	54	50	48	39	40	44	53	69	74
Average Afternoon Relative Humidity (%)	68	60	52	43	41	37	29	29	33	46	63	68
Normal Maximum Temperature (°F)	41.8	47.3	51.0	58.5	66.6	74.0	84.9	83.4	77.8	64.9	51.6	43.7
Normal Minimum Temperature (°F)	25.4	28.3	29.8	34.0	40.0	46.0	50.6	48.6	44.5	37.9	31.7	27.3
Normal Mean Temperature (°F)	33.6	37.8	40.4	46.3	53.3	60.0	67.8	66.0	61.2	51.4	41.7	35.5
Normal Heating Degree Days	973	762	763	561	371	178	37	64	145	422	699	915
Normal Cooling Degree Days	0	0	0	0	8	28	124	95	31	0	0	0
Normal Precipitation (inches)	6.65	5.61	4.03	3.05	1.87	1.08	0.32	0.31	0.69	2.54	5.09	6.25

Red Bluff

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	79	85	92	98	108	114	119	119	114	104	93	81
Record Minimum Temperature (°F)	20	23	26	31	35	42	52	52	42	32	26	20
Mean Number of Days Below 32°F	10	3	1	*	0	0	0	0	0	*	1	7
Mean Number of Days with Precipitation ≥0.01 in.	11	9	9	7	4	3	1	1	2	5	8	10
Average Snowfall (inches)	1.3	0.1	0.2	T	0.0	0.0	0.0	0.0	0.0	T	0.1	0.7
Average Windspeed (mph)	9.0	9.2	9.8	9.6	9.3	9.3	8.0	7.6	7.9	8.3	8.4	8.3
Maximum Windspeed (mph)	59	61	63	50	46	38	38	30	50	68	56	60
Average Morning Relative Humidity (%)	73	66	57	46	40	35	30	33	34	44	61	72
Average Afternoon Relative Humidity (%)	59	51	44	35	28	23	18	20	22	31	50	60
Normal Maximum Temperature (°F)	53.6	59.5	63.8	71.6	80.6	89.3	98.0	95.7	90.6	78.3	64.0	54.7
Normal Minimum Temperature (°F)	36.7	40.4	42.5	47.3	54.2	61.7	66.6	64.1	60.0	51.7	43.3	38.1
Normal Mean Temperature (°F)	45.2	50.0	53.2	59.5	67.4	75.5	82.3	79.9	75.3	65.0	53.7	46.4
Normal Heating Degree Days	614	420	366	218	64	8	0	0	0	82	339	577
Normal Cooling Degree Days	0	0	0	53	139	323	536	462	309	82	0	0
Normal Precipitation (inches)	4.48	3.17	2.51	1.79	0.98	0.47	0.04	0.18	0.31	1.17	3.05	3.91

Sacramento

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	70	76	86	92	104	115	114	108	108	101	87	72
Record Minimum Temperature (°F)	23	26	26	32	36	41	49	49	43	36	26	20
Mean Number of Days Below 32°F	7	1	1	*	0	0	0	0	0	0	1	6
Mean Number of Days with Precipitation ≥0.01 in.	10	9	8	6	3	1	*	*	1	3	7	9
Average Snowfall (inches)	T	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
Average Windspeed (mph)	7.7	7.8	9.0	9.0	9.4	10.0	9.2	8.7	7.8	6.7	6.3	7.0
Maximum Windspeed (mph)	60	51	66	45	35	47	36	38	42	68	70	70
Average Morning Relative Humidity (%)	85	79	68	58	51	47	47	49	51	57	75	84
Average Afternoon Relative Humidity (%)	70	61	51	43	36	31	28	29	31	39	59	70
Normal Maximum Temperature (°F)	53	59.1	64.1	71.3	78.8	86.4	92.9	91.3	87.7	77.1	63.6	53.3
Normal Minimum Temperature (°F)	37.1	40.4	41.9	45.3	49.8	54.6	57.5	56.9	55.3	49.5	42.4	38.3
Normal Mean Temperature (°F)	45.1	49.8	53.0	58.3	64.3	70.5	75.2	74.1	71.5	63.3	53.0	45.8
Normal Heating Degree Days	617	426	372	227	120	20	0	0	5	101	360	595
Normal Cooling Degree Days	0	0	0	26	98	185	316	286	200	48	0	0
Normal Precipitation (inches)	3.73	2.68	2.17	1.54	0.51	0.10	0.05	0.19	0.19	0.99	2.13	3.12

San Diego

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	88	88	93	92	96	97	93	98	111	107	97	88
Record Minimum Temperature (°F)	29	36	39	41	48	51	55	57	51	43	38	34
Mean Number of Days Below 32°F	*	0	0	0	0	0	0	0	0	0	0	0
Mean Number of Days with Precipitation ≥0.01 in.	7	6	7	5	2	1	*	*	1	2	5	6
Average Snowfall (inches)	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
Average Windspeed (mph)	5.6	6.3	7.2	7.7	7.6	7.5	7.1	7.0	6.8	6.3	5.7	5.4
Maximum Windspeed (mph)	39	35	46	37	30	26	23	23	31	31	51	34
Average Morning Relative Humidity (%)	54	57	59	58	64	69	69	67	65	60	57	55
Average Afternoon Relative Humidity (%)	55	58	58	59	63	67	66	66	64	62	62	58
Normal Maximum Temperature (°F)	64.6	65.6	66.0	67.6	69.4	71.1	75.3	77.3	76.5	73.8	70.1	66.1
Normal Minimum Temperature (°F)	45.8	47.8	50.1	53.8	57.2	59.9	63.9	65.4	63.2	58.4	51.5	47.2
Normal Mean Temperature (°F)	55.2	56.7	58.1	60.7	63.3	65.5	69.6	71.4	69.9	66.1	60.8	56.7
Normal Heating Degree Days	314	237	219	144	79	52	6	0	16	43	140	257
Normal Cooling Degree Days	10	0	0	15	26	67	149	201	163	77	14	0
Normal Precipitation (inches)	1.88	1.48	1.55	0.81	0.15	0.05	0.01	0.07	0.13	0.34	1.25	1.73

San Francisco International Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	72	78	85	88	96	106	104	98	103	95	85	75
Record Minimum Temperature (°F)	24	25	30	31	36	41	43	42	38	34	25	20
Mean Number of Days Below 32°F	2	0	*	0	0	0	0	0	0	0	0	1
Mean Number of Days with Precipitation ≥0.01 in.	11	10	9	6	3	1	*	1	1	4	7	10
Average Snowfall (inches)	T	T	T	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	T
Average Windspeed (mph)	7.1	8.5	10.3	12.1	13.2	13.9	13.5	12.8	11.0	9.3	7.2	6.8
Maximum Windspeed (mph)	58	52	40	46	41	44	38	36	38	44	47	47
Average Morning Relative Humidity (%)	79	75	69	65	64	64	66	67	65	67	74	78
Average Afternoon Relative Humidity (%)	66	65	62	60	60	60	60	62	59	59	64	68
Normal Maximum Temperature (°F)	55.3	58.6	61.0	63.5	66.6	70.2	70.9	71.6	73.6	70.3	63.3	56.5
Normal Minimum Temperature (°F)	41.2	43.8	44.9	47.0	49.9	53.0	54.0	54.3	54.5	51.6	47.2	42.9
Normal Mean Temperature (°F)	48.3	51.2	53.0	55.3	58.3	61.6	62.5	63.0	64.1	61.0	55.3	49.7
Normal Heating Degree Days	518	386	372	291	210	120	93	84	66	137	291	474
Normal Cooling Degree Days	0	0	0	0	0	18	16	22	39	13	0	0
Normal Precipitation (inches)	4.37	3.04	2.54	1.59	0.41	0.13	0.01	0.03	0.16	0.98	2.29	3.98

Sandberg

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record Maximum Temperature (°F)	71	72	80	85	94	99	102	102	98	89	80	74
Record Minimum Temperature (°F)	3	13	15	22	26	30	40	40	35	21	21	11
Mean Number of Days Below 32°F	13	11	11	6	2	*	0	0	0	1	5	11
Mean Number of Days with Precipitation ≥0.01 in.	6	6	6	4	2	*	*	1	1	2	4	6
Average Snowfall (inches)	9.0	4.5	4.8	3.2	0.4	0.0	0.0	0.0	T	0.1	1.4	5.1
Average Windspeed (mph)	17.0	16.4	16.7	16.4	15.9	15.1	12.8	12.6	12.9	14.9	16.1	16.4
Maximum Windspeed (mph)	64	77	74	64	59	64	46	40	45	53	62	53
Average Morning Relative Humidity (%)	56	56	57	51	46	36	26	27	30	39	46	54
Average Afternoon Relative Humidity (%)	52	49	51	49	47	37	28	30	36	40	47	55
Normal Maximum Temperature (°F)	46.4	49.1	51.5	58.3	65.8	75.0	85.1	84.2	79.2	67.8	55.4	48.0
Normal Minimum Temperature (°F)	33.9	35.3	35.7	40.1	45.6	53.0	62.9	61.8	58.5	49.8	41.1	35.8
Normal Mean Temperature (°F)	40.2	42.2	43.6	49.2	55.7	64.0	74.0	73.0	68.9	58.8	48.3	41.9
Normal Heating Degree Days	769	638	663	474	288	116	7	10	33	212	501	716
Normal Cooling Degree Days	0	0	0	0	0	86	286	258	150	20	0	0
Normal Precipitation (inches)	2.15	2.45	1.33	1.12	0.25	0.03	0.03	0.06	0.21	0.34	2.05	1.95

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