

SOIL and WATER

Winter 1971-No. 11



SOIL WATER REMOVAL - Through this experiment on the University Farm at Davis, water scientists are gaining understanding of the time and depth function of soil water removal from a nonirrigated corn crop. The experiment is aimed at development of a new approach to practical irrigation scheduling. The shear stress lysimeter shown above was essential for separating deep percolation amounts from actual ET in the field plots. See article on Page 1.

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SOIL WATER USE BY NONIRRIGATED CORN PLANTS

The following paper prepared by Ian Stewart reports the results of a time and depth study of soil water extraction by roots of nonirrigated corn plants at Davis. Others participating in this study were Dr. R. M. Hagan, John Prato, W. O. Pruitt, Paul Martin, Serge Von Ottingen, and Arturo Mendoza.

---L. J. Booher---

Winter 1971

UTILIZATION OF STORED SOIL WATER BY CORN AS A BASIS FOR IRRIGATION PLANNING

Research now well advanced in the Department of Water Science & Engineering at UC Davis is aimed in part at development of a new approach to practical irrigation scheduling. Data requirements for computation of optimal timing and amounts of irrigation water applications are minimal but complete. Factors considered by the method are crop type (as to patterns of both top and root growth): soil characteristics (primarily depth, texture as it affects field capacity and available water quantities, and structure as it may affect root elongation and/or proliferation): weather (evaporative conditions and rainfall): and finally management decisions such as maturity time for the chosen variety, planting date, rate and spacing, fertilization plans and other decisions as they may apply.

A key requirement is to gain understanding of the time and depth function of soil water removal by each given crop type when developing in accord with its genetic potential into a soil initially at field capacity (well drained so there is no water storage above FC even temporarily) which soil offers no structural or depth limitations. To meet the requirement it is further necessary there be no irrigation or rainfall of consequence after the season is underway, and that the storage and supplying capacity of the soil be great enough to prevent tissue damaging water deficiencies, i.e., very severe deficits which kill leaves already formed, or prevent pollination, etc., yet not great enough to fully supply the maximum

potential transpiration requirements of the plants at any time except germination and perhaps a short period thereafter.

These conditions were all satisfied, and such a function was developed for corn at Davis in the summer of 1970. This function is shown in chart form on page 4 and is followed by a table of actual nonirrigated corn water use with each soil layer shown separately, then totalled for the soil profile. The function represents attainment of one of several goals of a 2-year field experiment on corn growth and yield response to levels of irrigation and nitrogen carried out jointly by the Departments of Water Science and Engineering and Agronomy at UCD in the summers of 1969-70. The experiments were funded by a USBR grant administered by Dr. Alan Kleinman of Iowa State University.

EXPLANATION: Time and Depth Function
of Nonirrigated Corn Water Use

The left hand column of the chart shows soil depth in inches, while the far right column gives total season water extraction from each soil layer. The figures are solely for water used by the crop in transpiration, and exclude evaporation from the upper six inches of soil, hence the very small figure for water extraction from that layer. All water quantities on the chart are expressed as percentages of field capacity (%FC) which was the starting point at planting time. For example, the actual FC found for the 6-18 inch soil layer was 3.63 inches of water, i.e., 3.63 inch water was stored in that particular soil layer at planting time. Only a portion of stored water is available to plants; a rule of thumb says about 50%. The right hand column shows that in this instance exactly 50% (1.82 in.) was removed from this layer between planting time (May 22) and physiological maturity (Sep 16).

The other columns each represent the water removal over a short period within the season as seen in the dates given at the top, and corresponding to the crop growth stages shown by the arrows below. Each row of these figures adds up to the total season water use at the right, thus these figures show the amount of water extracted from each soil layer in each time period or at each growth stage. As an example it will be seen that 15% of FC was withdrawn from the 6-18 inch soil layer between June 30 and Jul 21. In actual figures this would be $.15 \times 3.63 = .55$ inch of water. The reason for using %FC instead of actual water quantities is to eliminate the effects of different FC values for the different soil layers (see the lower table). In this way we get to see the pattern of water extraction as influenced primarily by corn root growth habits rather than soil characteristics.

Figures in parentheses show the principal zone of water extraction within each time period, and this zone is seen to move continually downward as the season progresses, finally reaching bottom of 66-102 inches for the last two periods. However, there will still be some water obtained from all soil levels (6-66 in.) even in the last period, and a little water is obtained below 102 inches.

The black line shows at a glance where the "center of root activity" is at any given time or growth stage. This line has been drawn so that water extraction above it and that below it are approximately equal at any given time.

---J. Ian Stewart---

TIME AND DEPTH FUNCTION OF NONIRRIGATED CORN WATER USE

SOIL DEPTH (In.)	VEGETATIVE GROWTH				GRAIN PRODUCTION			SEASON H ₂ O USE FC=100
	May 22 — Jun 11	11- 19	Jun19 Jun30	Jun 30 — Jul 21	Jul 21— Aug 10	Aug10- Aug24	Aug 24 — Sep 16	
0 - 6	(1)	-	--	---	---	--	---	1
6 - 18	---	(6)	(16)	(15)	6	4	3	50
18-30	---	2	(16)	(35)	6	4	4	67
30-42	---	2	3	(48)	9	3	2	67
42-54	---	-	2	(40)	(15)	3	2	62
54-66	---	-	2	(18)	(32)	4	5	61
66-78	---	-	2	6	(40)	(8)	(6)	62
78-90	---	-	1	2	(28)	(19)	(8)	58
90-102	---	-	--	2	8	(11)	(7)	28
102-114	---	-	--	--	1	2	3	6

	↑	↑	↑	↑	↑	↑	↑
	PLANT	CANOPY	FIRST	POLLI-	MILK	S.D.	DENT MATURE
		CLOSED	TASSEL	NATE			
DAY NO:	0	40	55	66	75	89	103 117

ACTUAL FC and WATER USE by NONIRRIGATED CORN at UC DAVIS, 1970

Soil Depth (inches)	FC at Plant- ing (In/Layer)	Soil Water at Ma- turity (In/Layer)	Transpiration, Season Total (In/Layer)
0-6	1.82	0.45	0.03 (Evap.=1.34")
6-18	3.63	1.81	1.82
18-30	3.44	1.14	2.30
30-42	3.42	1.15	2.27
42-54	3.52	1.33	2.19
54-66	3.34	1.31	2.03
66-78	2.56	0.98	1.58
78-90	2.71	1.13	1.58
90-102	2.67	1.91	0.76
102-114	4.09	3.85	0.24

31.20 In.

15.06 In.

14.80 In.T + 1.34" E

WESTERN KERN RECLAMATION EXPERIMENT

Soils on the lower end of alluvial fans north and east of Lost Hills often contain fine textured clayey layers which are high in boron and sodium. Leaching these soils is not a simple process because the sodium saturated clay layers restrict water movement. The clay layers are usually interstratified with sand and silt layers. If the horizontal clay layers were broken up and mixed with the sand and silt layers, the chance for effective leaching would be greatly improved. Further enhancement of leaching might be gained by addition of organic waste materials and gypsum to the mixed soil profiles.

With these objectives in mind, an experiment was initiated in the fall of 1969 to attempt to establish some principles regarding the leaching of sodium and boron from these soils. We intentionally chose a piece of land which would be difficult and expensive to reclaim, thinking that knowledge gained from this trial could be economically applied to reclaiming soils with lesser problems throughout the west side. Our tillage and amendment treatments covered the range from practical to grossly uneconomical, in order to find out all we could about how much it takes to reclaim these soils.

The treatments were:

1. Check - one light discing over plots
2. Moldboard plowing, 3 feet deep
3. Disc plowing, 18 inches deep
4. Disc plowing, 18 inches deep followed by slip plowing 6 feet deep on 10 foot centers
5. Same as 3, but with 25% by volume of manure incorporated
6. Same as 4, but with 25% by volume of manure incorporated

These six treatments were repeated four times each without added gypsum, and four times each with addition of 25 tons per acre of actual gypsum, for a total of 48 individual plots. The large number of plots was necessary because of the high variability of the soils.

A solid set sprinkler irrigation system applied water continuously to the experimental plots at a rate of about .08 inches per hour, or 2 inches per day. After the first 10 feet of water, applied from May to July, 1970, plots were allowed to dry for three weeks and soil samples were taken. An additional 10 feet of water was applied from August to October, and again soil samples were taken. Tensiometers were installed to measure moisture content throughout the profile and visual evaluation was made of water runoff, ponding, weed growth, etc.

The following table shows the percentages of the original salt and boron contents removed from the entire five foot profile by the first 10 feet of water applied. Lab analyses are not yet completed for the soil sampling after 20 feet of water.

In all deep tillage treatments salt was reduced to a low level throughout the five foot profile, and boron was reduced to an acceptable level in the top two feet of soil. Gypsum additions enhanced salt and especially boron removal in all treatments. Eighteen inch disc plowing was apparently just as effective as 36 inch moldboard plowing in allowing more water to pass through the profile for salt and boron removal. Slip plowing did not increase removal of salt or boron in the sampling area between slip channels. Slip channels themselves may have been reclaimed faster, but this possibility remains to be checked. The effect of manure in

increasing water percolation, as indicated by increased boron removal, was most pronounced in the non-gypsum treatment. Addition of gypsum to the manure treatment did not result in a further increase in salt or boron removal.

TABLE 1

Treatment	Salt %* Removed	Boron %** Removed
Check	69	24
Check - gypsum	79	47
Moldboard plow	86	60
Moldboard plow-gypsum	92	75
Disc plow	90	58
Disc plow-gypsum	95	72
Manure, disc plowed	89	76
Manure, disc plowed-gypsum	92	78

*Based on the excess salt above 4 mmho conductivity in a saturation extract.

**Based on total boron content in a saturation extract of the soil.

Planting of crops on the plots was not attempted in 1970 because the original levels of salt and boron were too high for tolerant crops. However, the various stages and depths of reclamation represented in the plots and intermediate untilled areas after the 1970 leaching afford an opportunity to gain valuable information on boron sensitivity of crops in 1971. A variety of shallow and deep rooted crops will be planted across the plots. Both sensitive and tolerant

varieties will be included. Crop symptoms and tissue analyses will be correlated with rooting depth and soil boron levels. Laboratory work on boron chemistry will complement the field observations.

Results in 1970 and 1971 will be the basis for further leaching trials in 1972. Information gained in 1970 confirmed that disc plowing was as effective as more expensive tillage and amendment treatments. Further refinement of disc plowing, gypsum addition, and irrigation scheduling should enable more efficient boron removal with less water than was used in the 1970 trials.

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WATER PENETRANTS AND ELECTROLYTES TESTED

The following summaries are based on data obtained from a series of four studies conducted by Mr. Gary Foster, consultant for Progressive Farms, Inc., Bakersfield, California. Several materials were evaluated, all of which are sold on the basis of improving water infiltration rates in soils and subsequently crop yields.

The test crop was White Rose Potatoes and the materials were evaluated versus untreated controls by the use of replicated observations.

Investigation I

A water penetrant (surfactant) at 1, 2, and 4 gallons of material per acre were compared with untreated canal water of low electrolyte content (less than 50 parts per million total dissolved salts). Plots were 46 by 650 feet and treatments replicated six times. Harvest was on April 25 by hand from two locations in a plot each consisting of one bed and five feet of row.

There was no difference in yields per plot due to treatment at the 95 percent confidence level. There was also no effect on storage ability due to treatment.

Investigation II

Treatments consisted of a blend of two-thirds canal water (40 parts per million total dissolved salts, ppm tds) and one-third well water (685 ppm tds) averaging 250 ppm tds, the 2/3-1/3 blend plus sulfurous acid to reduce the pH to 6.2, the 2/3-1/3 blend plus CO₂ gas, and a blend of 1/3 canal water and 2/3 well water averaging 470 ppm tds or greater. Plot size was 50 by 650 feet and treatments were replicated four times. Harvest was conducted on

April 18 in the same manner as in Investigation I.

There was no significant effect on yield due to treatment at the 95 percent confidence level. It was pointed out by the investigator that the value of 250 ppm tds has been quoted in the literature as approximating the threshold concentration at which no further improvement of infiltration can be expected due to increased electrolyte concentration. There was no treatment effect on storage ability.

Investigation III

Gypsum (99 percent pure) was added to canal water (less than 50 ppm tds) in sufficient quantities to approximate 100, 200, and 400 ppm tds. These treatments were compared with a control of untreated canal water. Plots were 46 by 650 feet and each treatment was replicated six times. Five applications of the treatment were made. Yield data were obtained on April 28 in the same manner as in Investigations I and II.

There was no significant effect on yield due to treatment at the 95 percent confidence level. Storage ability was not affected by treatment.

Investigation IV

Farm Builder's Bio-Chem was compared with untreated canal water. Plots were 46 x 650 feet and treatments were replicated six times. There were a total of twenty applications of Farm Builder material during the season.

The plots were harvested for yield data on May 9 in the same manner as in the previous investigations.

There was no significant effect on

yield due to treatment at the 95 percent confidence level. Storage ability was not affected by treatment.

It is interesting to note the results of these investigations of an independent consultant corroborate other existing scientifically obtained data related to these materials.

---R. S. Rauschkolb---

AVAILABLE WATER CONTENT VALUES

Recent studies have shown that the available water capacity (AWC) of some soils as determined by older procedures has resulted in values which are in error. These studies have also indicated that the accepted values for AWC for the textural classes are in need of revision.

Accurate values for AWC of a soil or of soil textural classes are necessary in planning irrigation systems and projects. Inaccurate values may result in excessive or inadequate water application, poor delivery schedules and improper capacities of delivery systems.

The available water content is the difference between the field capacity (FC) and the permanent wilting point (PWP). The most accurate method of obtaining these values are those determined in the field. However, field methods are expensive and time consuming, and therefore laboratory and greenhouse methods have been developed.

More accurately, the PWP is the percent of moisture remaining in the soil when dwarf sunflower plants wilt and fail to recover turgidity when transferred into a high humidity chamber. More recently, the 15 Bar moisture retention value has been substituted for the PWP. The 15 Bar values are still acceptable for practical usage in that little variation is found between disturbed and undisturbed samples.

The 15 Bar values have shown a high correlation with the clay content (.97). The clay content is also highly correlated with the saturation percentage. On the other hand, there is a very poor correlation between the AWC and the clay content.

FC is the upper limit of available soil moisture and in the laboratory it has been determined as the moisture equivalent, and by 1/10 Bar and 1/3 Bar pressure plate values on sieved, clod and core samples.

The moisture equivalent is now seldom used. The 1/10 Bar and 1/3 Bar values obtained on sieved samples appear to result in erroneous values. Because of some erroneous values obtained on sieved samples, properly taken clod and core samples are now preferred. However, proper sampling and laboratory techniques are still necessary. Sampling requires accurate determination for bulk density (BD), or field volume of soil.

The search continues for an accurate laboratory procedure for determining field capacity (FC). Eventually it is hoped that soil texture can be correlated to FC. The accumulation of accurate data would eventually allow the establishment of AWC for the various textural classes.

The objection to determining the 1/10 Bar and 1/3 Bar values on sieved samples is that the natural structure of the soil is not preserved and instead additional voids and pore spaces are created which increase moisture retention. In some cases values of disturbed samples may be double that of undisturbed samples. Moisture retention values for clods and cores are more meaningful but are more difficult to obtain. The using of sieved samples for the determination of FC should be avoided. For some sandy textured samples it is difficult to obtain cores or clods as the soils are not cohesive.

Some researchers have suggested that a sliding scale for the upper limit of available moisture may resolve some of the problems. The sliding scale would be in the approximate range of 1/10 Bar to 1/3 Bar. This would require a soil textural analysis before the proper soil moisture tensions were selected for the upper limit determination. This however would create some operational problems in the laboratory. Soils would have to be grouped for pressure plate analysis according to their requirements, or they would have to be grouped for pressure plate analysis according to their requirements, or they would require individual pressure cells. There are other factors, such as OM, soil structure, bulk density, stones, salinity, etc., which makes accurate determination of field capacity in the laboratory more difficult.

Several studies have shown that the available water-holding capacity is highly correlated with silt and with silt plus very fine sand. The following tables and graphs have been developed from one of these studies.

Graph #1 shows the relationship between silt and clay percentage and the available water content in inches per foot of soil textures which have been arranged in order of increasing silt content.

Graph #2 shows the relationship between silt and clay percentage and the available water content in inches per foot of soil textures which have been arranged in order of increasing clay content.

Table 1 gives approximate AWC for some soil textures based on values presented to the Soil Moisture Committee by the SCS in 1963. Table 1 would indicate that

some of the clay soil textures may have much lower AWC than previously acknowledged. Therefore, some clay soils may require irrigation frequencies and rates similar to those of drouthy, sandy soils. While the above AWC may vary as new data is acquired, one may find it useful in evaluating soil-water problems on more difficult soils, particularly for soils which are compact, have poor structure, or where structure has been destroyed.

TABLE 1

	<u>AWC</u> <u>inches/ft. depth of soil</u>
Sand	1.0
Clay	1.0 - 1.5
Clay loam	1.4
Loam	1.7
Silty clay	1.7
Silty clay loam	2.0
Silt loam	2.3
Silt	2.9

Table 1 shows values for clay textures which are approximately 50% of many accepted values. However, these values have been developed for general textural groups. Where local information and experience has developed more acceptable values they would be preferred. The values in Table 1 are useful in that they do show that clays can have very low values and these values should be considered when working with problem soils.

Of interest in understanding soil moisture relations is that the 15 Bar percent, total water content, the saturation percentage, the wilting point, liquid limit are correlated to the clay content. The FC is correlated to the silt content, or silt plus very fine sand, and organic matter. FC is affected by a number of other factors such as structure, nature of particles, cementation, etc.

Since soil moisture is held in the pores or capillaries, the size of pores associated with water held at low tensions are those that are associated with silt and very fine sand particles. Since soils are a mixture of various size particles it becomes more difficult to evaluate the pore sizes. In general, much of the available moisture held in the pore sizes associated with sands are held at tensions of less than .5 Bars, in silts less than 1 Bar, and in clays only a small percentage of the available water is held at tensions of less than 1 Bar. In very heavy clays most of the water would be held at tensions approaching 15 Bars.

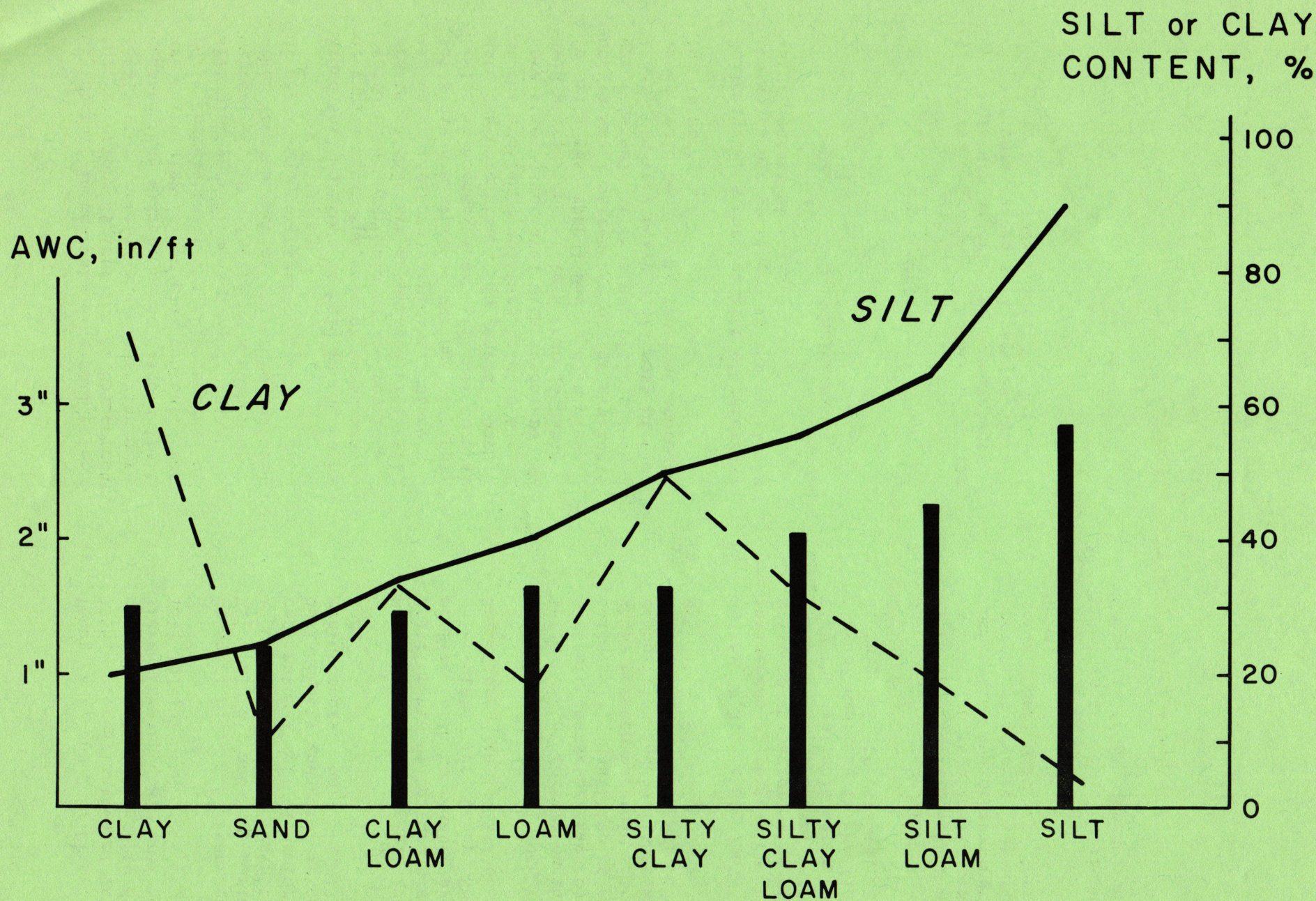
Following is a partial list of references which are pertinent to the available water content of soils.

---H. Schulbach---

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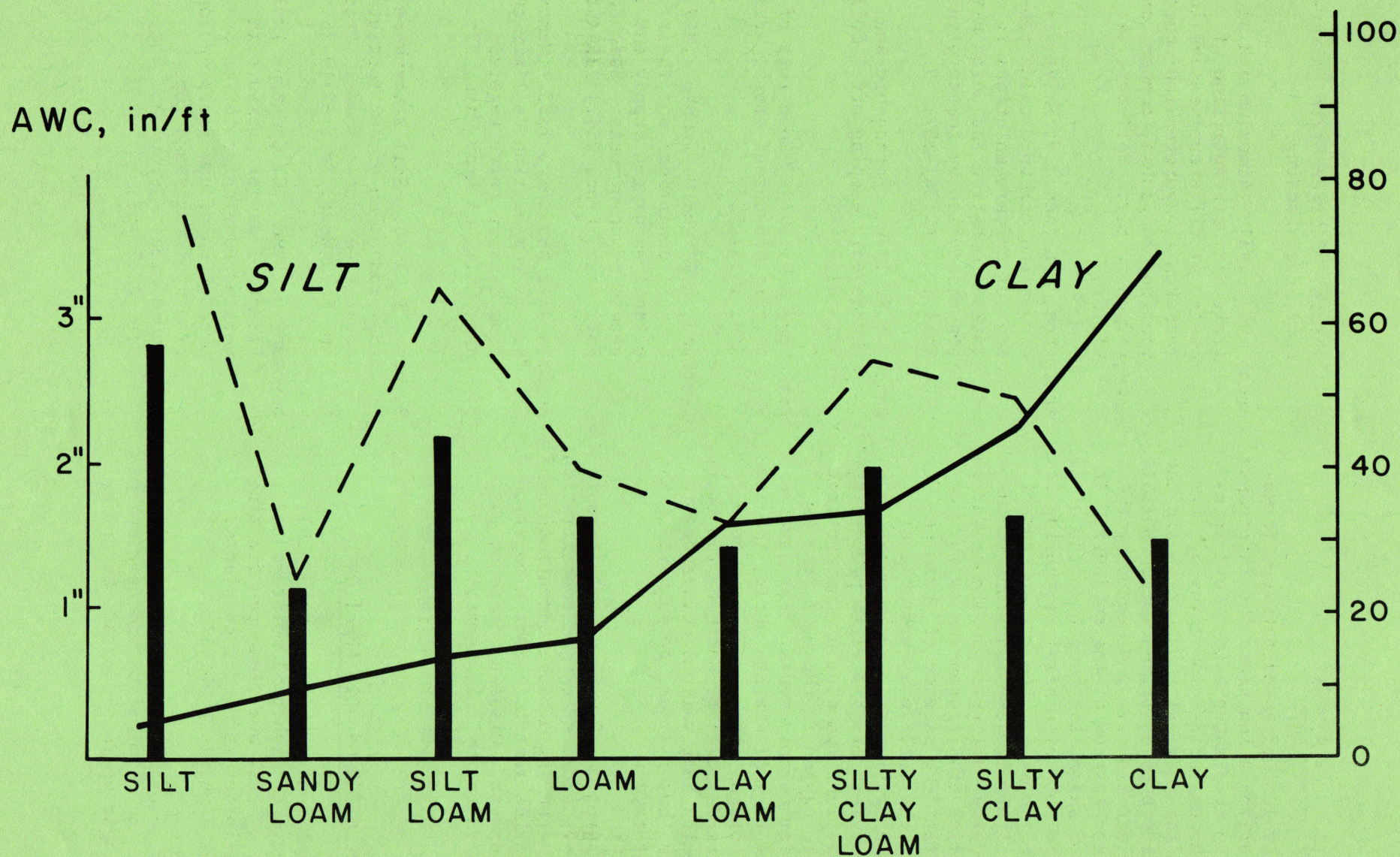
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Graph 1. Available water capacity (AWC, solid bars) of different soil textural classes arranged (l. to r.) in order of increasing silt content (solid line; dashed line shows clay content of each textural class).

SILT or CLAY
CONTENT, %



Graph 2. Available water capacity (AWC, solid bars) of different soil textural classes arranged (l. to r.) in order of increasing clay content (solid line; dashed line shows silt content of each textural class).

SOIL AERATION - - SUMMARY

The large volume of quantitative information on soil aeration shows the importance of aeration to plant growth. Soil aeration influences plant growth through its effect on the chemical composition and the biological processes of the soil. Soluble manganese and iron are influenced by the oxygen concentration of the soil air. In a similar fashion, the concentration of CO₂ affects the rate of mineral weathering of calcium in the soil. The oxygen content of the soil air is very important to the soil biological activities. The oxidation and reduction of nitrogen and sulfur compounds affect the balance of these nutrients in the soil in a favorable or toxic concentration to plant growth. Aerobic respiration is a vital process for all living plant roots; thus the presence of adequate oxygen in the root zone is required for normal growth. For species indigenous to well drained soils, the low levels of oxygen in the root zone result in restricted growth or death of the roots. Plant species have various tolerances to low oxygen, but all fail to survive in the absence of oxygen.

Active absorption of water by plant roots is also influenced by oxygen concentration. Lack of oxygen and a high concentration of carbon dioxide restricts root elongation and development. Disease incidence is greatly affected by soil aeration.

---F. K. Aljibury---

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MANGANESE TOXICITY IN MUSTARD PLANTS
INDUCED BY USE OF PHYSIOLOGICALLY
ACID FERTILIZERS

In courses in Plant Nutrition and in numerous textbooks students are informed that soils can become acidic through the continued use of acid fertilizers. A striking example of this development of physiological acidity was found on a farm on Bay Farm Island - not far from the Oakland airport.

The encroachment of subdivisions on the farm land is continuing and many farms are now surrounded by tract homes. The close proximity of urban populations to the farm proper has caused a change in farm management in regards to fertilizer use. In previous years fertilizer was added in the form of animal manures. Protests by urban residents to the Health Department as a result of odors and a marked increase in the fly population have resulted in the discontinuance of animal products and the substitution of mineral fertilizers, chiefly ammonium salts of sulphate and phosphate with some potassium sulphate used.

Continued use of the ammonium fertilizers has resulted in soils with pH values of 4.3 to 4.7. The truck crops

grown for market use in this area are radishes, turnips, mustard greens, cabbage, chard, and parsley. Of these plants only the mustard greens developed a disease whose visual symptom is a yellow border surrounding the leaf margin. Plants when bunched for sale appeared to be old and unappetizing.

The symptoms were similar to those previously observed on lettuce leaves grown at fairly high Mn levels. Analysis of leaf material from mustard plants showing the symptoms gave Mn values of 1600 to 2500 ppm in the old leaf tissue. As a result of this analysis and field observation, it was suggested that the farmer lime his fields with 2 tons of dolomitic lime.

Soil from the field was placed in pots and seeded to mustard in the greenhouse. Following a month of growth, plants were harvested and pH values were obtained for soil treatments. Values obtained are as follows:

<u>Fertilizer treatment</u>	<u>plus lime</u>	<u>minus lime</u>	<u>plus lime</u>	<u>minus lime</u>
	<u>Soil pH</u>		<u>Yield in grams DW</u>	
Ca(NO ₃) ₂	6.2	5.3	3.03	2.31
NH ₄ NO ₃	5.5	4.9	3.13	2.82
(NH ₄) ₂ SO ₄	4.8	4.3	2.73	2.06

In the absence of lime, mustard leaves showed yellow margins regardless of fertilizer, ranging from trace to strong as pH decreased. In the presence of lime, only the (NH₄)₂SO₄ treatment showed any yellow borders.

Application of lime in the field has completely eliminated the disease. Further work is being carried on in soils and culture solutions in the greenhouse to

study the Mn nutrition of radish, turnips and mustard.

---D. E. Williams and
J. Vlamis---

NITRATE PROFILES UNDER CROPS

Soil suction probes have been used on an exploratory basis to extract soil solution at selected depths under several crops. These soil solutions have been analyzed for the usual chemical constituents.

Nitrate nitrogen is reported here as being of interest. We are not implying that these reported results are typical or even representative of other than the single location sampled.

The profiles presented are from what might be termed grab samples taken to determine (1) if the method is of interest in exploring leaching losses particularly of nitrogen and (2) to get a rough idea of the magnitude of nitrates moving downward through the soil under several cropping systems.

Of the profiles sampled, the potato profile from the San Joaquin Delta exhibited lowest nitrogen (1 to 6 ppm NO₃-N) and the potato profile from west Kern County was the highest (45-280 ppm NO₃-N). Increasing quantities of nitrates were found from the lowest delta potatoes on peat (1-6) through alfalfa (2.8-14.0), citrus (1.0-15.5), strawberries (27-36), delta potatoes on peaty muck (4-60), grapes (8-125), to the highest in Kern fall potatoes (45-280).

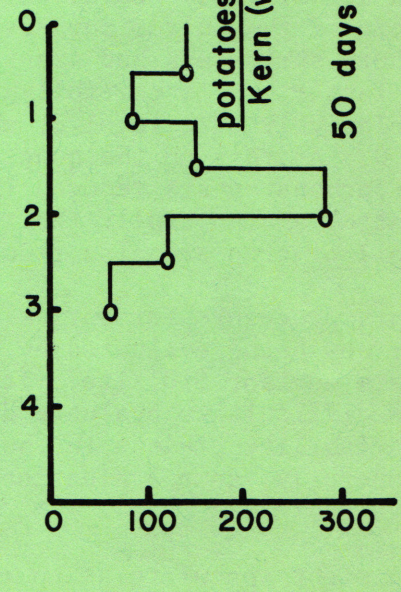
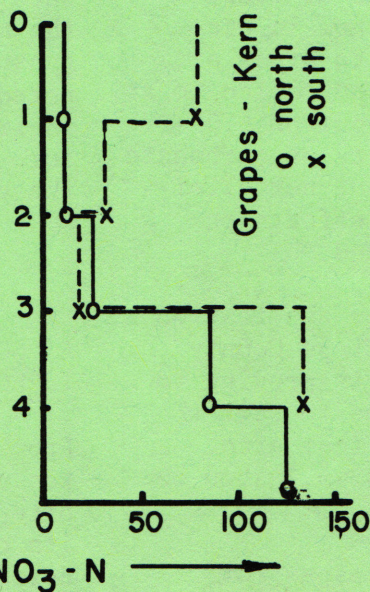
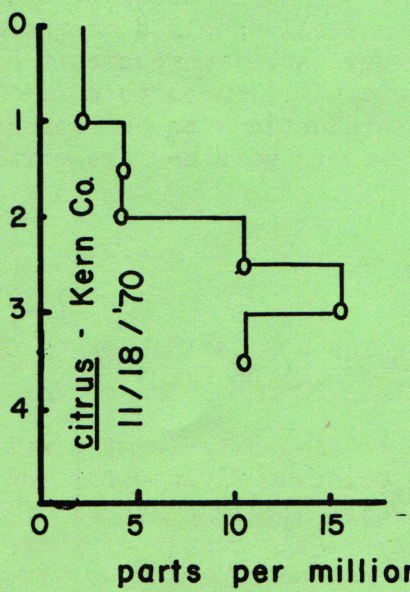
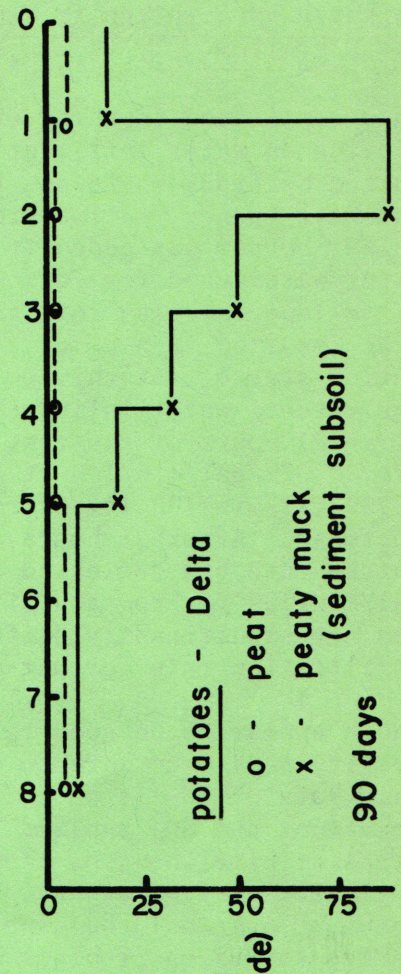
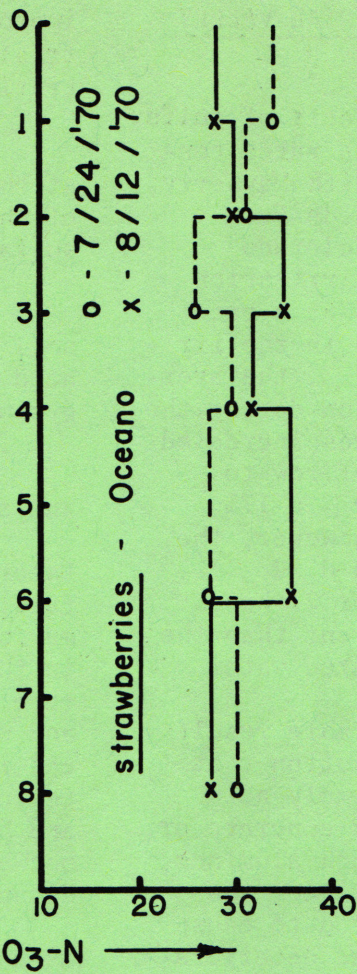
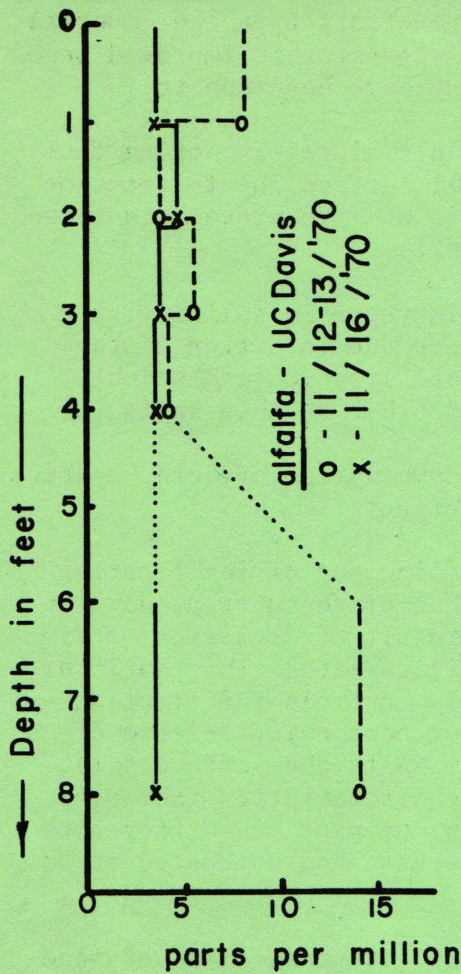
It is hoped this may be a suitable approach to determining leaching losses related to fertilizer rates and water management.

---R. S. Ayers
C. F. Krauter---

SOIL SUCTION PROBES

Nitrate Profiles

Dec. 1970



SULFUR BURNER TESTED AT IMPERIAL VALLEY
FIELD STATION

In a replicated test for effects of sulfur dioxide on water infiltration rates conducted by Frank Robinson, Keith Mayberry, and Dave Cudney, sulfur dioxide from a sulfur burner was added to Colorado River water used for furrow irrigation of an Imperial clay soil and at a rate that resulted in a pH of 2.3 in the irrigation stream. At this pH 2.3, the average rate of water infiltration during the first 21 hours of the test was increased from 0.677 gal/min/100 ft. of row to 0.792 gal/min/100 ft. of row - a 17% increase. After 21 hours, however, the intake rate had decreased to 0.32 gal/min/100 ft. row and after 21 hours was not significantly different than the infiltration rate for untreated water.

These appear to be good reliable results but it seems necessary to caution that this rate of SO₂ is an extremely acid treatment and SO₂ applied in concrete or transite pipelines, or through aluminum sprinkler systems at any pH lower than about pH 6.0 would be expected to cause severe corrosion problems and deterioration of the irrigation system.

In actual field operation of at least some of the sulfur burners now in use where sprinklers and transite pipes are a factor, pH is carefully controlled to a relatively safe level of about pH 6.0 - 7.0. At this pH the quantity of carbonate bicarbonates are reduced (but not eliminated) and hopefully their effects on soil or crop are also reduced.

This procedure for sprinkler application is now being evaluated by Kings County farm advisor Sid Kite. It is proving to be difficult to evaluate due to soil variability present in the test area. Hopefully, some evaluations will soon be available.

We might speculate as to reasons for

improved penetration in the Imperial trial and suggest this improved penetration may have been due to:

1. Initial release of calcium at the soil surface due to reaction of the acid on lime present in these surface soils.
2. Increase in salinity at soil surface due to action of the acid on soil lime to form soluble gypsum and other soluble salts, or
3. Combination of both, calcium and salt effects.

Later leveling out of infiltration rate to that of the untreated water may be a result of depletion of lime in the soil surface. This soil surface really controls infiltration and without continuing release of calcium or salts the surface soil textural characteristics take over and become dominant and differences between treated and untreated areas disappear.

As a general comment, improved penetration may or may not result from an application of an acid amendment such as the SO₂ as reported or from the more generally applied amendment-gypsum. Where some improvements are noted, growers will need to make their own evaluations to be reasonably sure the results obtained are worth the cost.

---R. S. Ayers---

A "GOOD" WATER FOR IRRIGATION OF
TURFGRASS IF MANAGED RIGHT

From time to time articles are written about Colorado River water and often they are highly critical of its quality. As a result of these derogatory comments, Colorado River

water had developed a reputation in turfgrass circles as being a highly saline water quite hazardous to use for irrigation. Let's examine the facts, and I think you will conclude that this valuable water resource in southern California has been unjustly slandered. One of the best ways to get an accurate picture of the quality of Colorado River water is to look at the results of those who use it. Growers of a wide range of crops in southern California depend on this source of water for their livelihood. Their experiences show that it can be used very successfully for irrigation of even the most salt-sensitive of plants. Examples of such plants are strawberries and avocados, both of which are much more sensitive to soil salinity than are turfgrasses. Even the most sensitive turfgrasses, Kentucky bluegrass and Highland bent, can tolerate double the soil salinity that strawberries and avocados are able to withstand.

Citrus has a salt tolerance more like that of the sensitive turfgrasses. Is there great concern about the salinity hazard of Colorado River water for irrigation of citrus? Not really. Many orchards are irrigated with it without any bad effects. We should expect to get as good or better results when this source of water is used on turfgrass. The reason we might expect to get even better results on turfgrass is that many kinds of turfgrass grown in southern California have a salt tolerance considerably greater than does citrus, almost 100% greater in the case of *alta fescue*, for example, and several hundred percent greater in the case of the bermudas.

If Colorado River water is all this good, then why all the slanderous remarks to the contrary---remarks which are not consistent with grower experience? Most of these remarks can probably be traced to the USDA system in common use for classification of irrigation waters. This system tends to downgrade the quality of Colorado River water more than is

justified based on experiences mentioned above. According to this system, Colorado River water is classified as follows:

"High salinity water. Cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected."

Recently the University of California Agricultural Extension Service modified the USDA system of water quality classification to bring it more in line with grower experience. The table below shows the modified system now in use by the Agricultural Extension Service.

<u>Salt in Water</u> <u>(Millimhos)</u>	<u>Salinity Hazard</u>
Below 0.75	Low
0.75 - 1.5	Medium
1.5 - 3.0	High
Above 3.0	Very High

According to the classification system of the Extension Service, Colorado River water, whose electrical conductivity is approximately 1 millimho (or about 700 parts per million), would fall at the lower end of the medium salinity category. Thus, the modified classification system changes the salt hazard of Colorado River water from high to medium. This means that if Colorado River water is used with average management skill and on soils with reasonably good drainage, one can expect not to have a salinity problem in growing turfgrass of any variety---even the most salt sensitive. If a salinity problem does develop in using this water, it indicates that water management and/or soil conditions

are not up to par and as a result insufficient water is moving through the soil past the root zone. To eliminate a problem of this nature, the cause of the inadequate leaching should be determined and corrected. First, look into the quantity of water used. If this appears normal, then check for thatch and/or compaction which can cause excessive runoff and thereby increase the possibility of salinity developing.

Despite good intentions, it may not always be possible to correct soil conditions which cause salt accumulation. Difficult soils or limited budgets may make it necessary to live with some salt build-up. Fortunately, this can be done with turfgrasses far more easily than with many other types of plants. If the soil becomes too saline for one kind of turfgrass, others of higher salt tolerance may be planted. Turfgrasses are rather unique in the plant world in having such a wide range of salt tolerance thereby providing many choices for difficult situations.

Where salinity is marginal and cannot be eliminated, another helpful practice is more frequent irrigation. This keeps the soil solution less concentrated than it would be if irrigation were less frequent.

So far, this discussion of salts has dealt with the mixture of various kinds of salts normally present in irrigation water and soil, i.e. calcium, magnesium, sodium, chloride, sulfate, etc. In some irrigation waters the sodium needs to be considered separately for excess sodium can cause a special problem with soils. It causes the aggregates of fine particles to disintegrate. This clogs soil pores making it difficult for water and oxygen to get into the soil in sufficient amounts. Addition of gypsum is the common corrective treatment. Natural Colorado River water has a very low sodium hazard. No sodium problem is at all likely to occur from use of this water because it contains among its dissolved

salts an appreciable amount of gypsum. Some irrigation waters in California have a gypsum requirement to reduce the sodium hazard. Colorado River water on the other hand already contains the gypsum necessary for prevention of a sodium problem.

Some Colorado River water distributed in southern California is softened at the facilities of the Metropolitan Water District (MWD). To make the water more suitable for domestic and industrial use, the softening treatment removes or reduces the dissolved substances which make water hard, causing the formation of boiler scale, deposits in pipes, soap curds, "tattletale gray", and the familiar "ring around the tub". The softening process removes some calcium and magnesium and substitutes sodium in their place. If carried to extreme (as occurs in home water softeners), this process can produce water with a high sodium hazard. Stringent controls in the MWD's softening operation prevent this from happening. Therefore, MWD-softened Colorado River water has a sodium hazard low enough to be satisfactory for irrigating turfgrasses without having to resort to any corrective treatment.

Concerning the future, all indications are that the salt content of Colorado River water will gradually increase. Eventually, it may become a high-salt-hazard water, but presently it is not. Until it deserves a bad reputation, shouldn't we criticize it less and appreciate it more?

---R. W. Branson---

RESEARCH UNDER THE MIDNIGHT SUN

The Tundra Research Project, a part of the International Projects, took Drs. Arkley and Gersper and four graduate students; Brian Viani,

Alex Simons, Josephine Challinor and Karen Fuller to Point Barrow, Alaska last summer. The six of us represented the soil nutrient study group of a larger team from various universities who were examining various aspects of the ecology of the Tundra. The other groups studied plant production, plant species and nutrients, meteorology, insects, small mammals and birds, microorganisms, soil respiration, and aquatic (pond) organisms and nutrients. Operations were based at the Naval Arctic Research Lab (NARL) near Barrow on the Arctic Ocean, and which contains excellent laboratory and living facilities and a large support staff, all of which were made available to us by the Office of Naval Research. The project was funded primarily by NSF and directed by Jerry Brown, a soil scientist from the Cold Regions Research Lab of the Army.

The funds did not become available until very late, but after madly ordering equipment and supplies and shipping them off to Barrow, we departed for Alaska about the middle of June. A number of plots were selected and staked out in 10 x 10 M. squares including six untreated controls and treatments with NPK fertilizer, disturbance by rototiller, covered by fiber glass "greenhouse", heated by underground tubing, spraying with crude oil. Control plots were then sampled in duplicate at ten-day intervals, and the remainder generally at the beginning, middle and end of the growing season, which occurred early in September.

The weather was favorable, with only a few short periods of subfreezing temperatures with blowing light snow or rain. The 24-hour daylight period which extended well into August made it possible to work long hours both indoors and out so that by working extremely hard our group was able to collect 350 samples from the plots, most of which were analyzed for soluble plant nutrients in the lab at Barrow. The remainder were shipped to Berkeley and analyses are mainly completed.

Also, a number of other cores were taken with a power auger which penetrated well into the permafrost, and analyses of these for particle size, C. N, exchangeable cations, etc. are complete. An immense amount of data has been developed and is being prepared for multivariate statistical study by computer on our CDC6400.

Judging from the comments of various people and comparing our results with others, our group was certainly the most effective one in Barrow, thanks particularly to the hard work of the graduate student crew. The project will continue next summer; graduate students who are interested in participating should contact Dr. Gersper.

---R. J. Arkley---

SOIL SURVEY CONFERENCE

Dr. Arkley attended the Technical Work Planning Conference of the National Cooperative Soil Survey at Charleston, N.C. during the past week, and reported on activities of the Western Regional Soil Survey Work Group from the Land Grant Colleges. Also representing the west was Dr. Al Southard from Utah State University. This meeting was important for soil scientists everywhere in that it dealt with possible changes in standards, terminology, and definitions for describing soil profiles and pedons. Dr. Marlin Cline from Cornell is editor-in-charge of preparing a new Soil Survey Manual, and a number of the 14 committee reports were aimed at providing information to be contained in the Manual.

A highlight of the Conference was a banquet in honor of Dr. Charles Kellogg and Dr. Guy Smith, two of the most

influential pedologists in the world, who both announced their retirement during 1971 from the USDA.

---R. J. Arkley---

UCB GRAD STUDENT RESEARCH EFFORTS

Students at the UCB Department of Soils and Plant Nutrition are involved in a variety of research projects. I thought the following brief statements would be of interest to SOIL AND WATER readers. My thanks to Professor Harvey Doner, Editor of the Department news sheet "Ceres", for permission to use them.

---W. E. Wildman---

THE EFFECTS OF MECHANICAL DISTURBANCE UPON THE TUNDRA

I am attempting to assess the effect of vehicle disturbance upon the Tundra, within the bounds of the soil-plant ecosystem. Areas within a weasel track crossing Low Tundra were monitored throughout the summer for soil physical and morphological changes. Plant production and plant nutrient content have now been determined, and presently the soil nutrient state is being analyzed.

Results to date indicate that following soil compression, erosion, and increased water content, soil fertility and plant production increases to an optimum level, which when passed allows these same factors to dominate and destroy the balance of the system. It appears, therefore, that strictly controlled disturbance of the Tundra top soil layers could increase fertility and stimulate productivity.

---Josephine Challinor---

ECOLOGY OF NITRIFYING BACTERIA IN SOIL

I am presently studying growth kinetics of the nitrifying bacteria in relation to their rate of nitrification in a Less-Quartal soil perfusion apparatus. My present objective is to determine how the rate of growth of the nitrifying bacteria are affected by continuously perfusing a column of soil while periodically changing the perfusate to add a fresh solution of substrate (ammonium sulfate solution). Two different genera of bacteria transform ammonia (NH_4^+ ion) into (NO_2^-) and finally (NO_3^-) nitrate, Nitrosomonas ($\text{NH}_4 \longrightarrow \text{NO}_2^-$) and Nitrobacter ($\text{NO}_2 \longrightarrow \text{NO}_3^-$). My present study is with Nitrobacter.

---E. L. Dinkins---

VOLZ'S VETCH

At present I am studying ion uptake by excised Vetch roots. My primary purpose is to investigate the significance and role of Ca^{2+} in the metabolism and ion uptake behavior of vetch. Current difficulties are being encountered regarding simultaneous quantitative determination of Ca^{2+} , K^+ , and Cl^- contents on individual samples. It is hoped a good qualitative and quantitative comparison can be made regarding ion uptake behavior between legumes as a group and a monocot like barley.

---Michael Volz---

SOIL SOLUTION RESEARCH

An accurate interpretation of the chemical properties of soil solutions requires an evaluation of the extent of ion-pair formation (complexing)

in these solutions. This is particularly important with respect to phosphates as the relevant dissociation constants would indicate that a large proportion of the total phosphate is actually present as ion-pairs. The work that I am currently undertaking is an attempt to evaluate the degree of ion-pair formation between the cation (Ca, Mg, K, and Na) and the anions (SO_4 , H_2PO_4 , PO_4 , HCO_3 , and CO_3). After correcting for ion-pairs, an attempt will be made to interpret the elemental concentrations of the soil solution in terms of solid phases governing these concentrations.

---G. M. Marion---

PLANT DEPENDENT PHOTOREACTIVATION

I am studying the plant dependent photo-reactivation (PR) of Tobacco Mosaic Virus Ribonuclei Acid (TMU-RNA). TMU-RNA, irradiated in aqueous solution by ultra violet light (UV) is repaired by plant leaves using blue light. I am investigating whether TMU-RNA, irradiated dry, results in a greater or lesser extent of P.R. than the aqueous case. By analogy to DNA, different photochemical products are expected from the dry state irradiation.

I equilibrate dry films of TMU-RNA at specific relative humidities. These films are next irradiated with UV, resuspended in solution and inoculated onto bean leaves. Control inoculations are done and the increased survival of TMU-RNA on leaves left under 366 nm blue lights (PR) is noted. An analysis of the expected dry-irradiation photoproducts will be made and compared to the aqueous irradiation photoproducts. A comparison of the extent of PR for the two conditions will establish the type of photochemical damage which is repaired.

---Jim Kirwan---

PHOSPHATE INTERACTIONS WITH POTASSIUM UPTAKE IN EXCISED BARLEY ROOTS

As perhaps might be expected, Phosphate exerts anomalous effects on K^+ uptake in excised barley roots. K^+ uptake rates from KH_2PO_4 are nearly as rapid as from KCl of equal strength even though the H_2PO_4^- uptake rate is much less than Cl^- (Rate Cl^- uptake is approximately equal to rate of K^+ uptake at pH 5). When compared to K_2SO_4 solutions K^+ uptake is about 50% more rapid in KH_2PO_4 of the same concentration even though anion uptake rates are not greatly different.

Furthermore, additions of small concentrations of KH_2PO_4 to KCl or K_2SO_4 solutions, maintaining constant K^+ concentration result in appreciable increases in K^+ uptake. Even more surprisingly this effect occurs even while there is a net loss of P from the roots. At the concentrations used, (1 meq/l total salt) P losses occur below H_2PO_4^- concentrations of 0.15 meq/l. Above this there is a net uptake of P. The presence of the H_2PO_4^- at 0.1 meq/l also causes a small but significant decrease of Cl^- uptake.

I hope to arrive at some explanation of the above behavior and am looking at the effects of H_2PO_4^- on organic acid levels in the root, rates of respiration and losses of Ca from the roots.

---Brian Cooper---

SELENIUM IN PLANTS

The will-o'-the-wisp that I have been chasing for so long involves a very short segment of the metabolic pathway of selenium in higher plants;

specifically, that portion of selenium metabolism leading to its release as a volatile compound by "normal" plants. Part of the difficulty in working with this element arises from the fact that some of the Se compounds needed for gas chromatography and in vitro experiments must be synthesized in our lab, since only a few are available commercially. Also, selenium is taken up in relatively small amounts by most plants before toxicity occurs, which makes it difficult to obtain Se compounds from the plant in quantities convenient to work with. However, the end is in sight, and it appears that selenium parallels the metabolism of sulfur, at least with respect to its production as a volatile compound from cabbage. (Se occurs below S in the same group of the Periodic Table but it does not always behave like S.)

---Barbara-Ann G. Lewis---

CALCIUM AND THE SUGARBEET

In culture solution, sugarbeet plants suffer calcium deficiency symptoms while the initially added calcium is depleted by about 50%. This occurs at low levels of calcium. WHY? On the culture solution side, the question of calcium availability was tested. (Calcium-selective electrode was used to confirm a new modified equation for the ionic strength involving the use of electric conductivity.) The data on calcium activity show that calcium is still available. On the plant side, it was found that the percentage deficient leaves increased with the increase in beet diameter. A hypothesis to that effect is currently being tested with the use of ^{45}Ca . The different parts of the plant will be analyzed for the possible forms of calcium; soluble, exchangeable, inorganic-bound and organic-bound, in order to correlate the decrease/increase in calcium form (s) with the appearance of deficiency symptoms. The shoot: root ratio could be a factor too.

An S/R high enough might lead to calcium deficiency because calcium consumption is higher than calcium supply by the root uptake. The question of mechanism of calcium absorption (whether mechanism I or II) is also taken into consideration.

---Mohamed Mostafa---

ADSORPTION OF WATER BY SOIL

I am studying the mechanisms by which soils take up and hold water. ("Because they are dry" is not a sufficient answer.) My experimental technique is to perform adsorption isotherms on soils in vacuum with closely regulated temperatures and precisely determined vapor pressures of water. With the data I obtain I can compute the differential enthalpy and entropy of water adsorption. Also I can screen various adsorption theories to see if they fit my data. Since an adsorption theory hopefully presumes a mechanism of uptake, an equation that fits my data should give me a mechanism. The mechanism should also be consistent with my thermodynamic calculations. At the moment I am working on a new adsorption apparatus and I am investigating a theory which, if valid, would predict my adsorption data and also the cation exchange capacity of non-montmorillonitic soils.

---Terry O'Neal---

THE INFLUENCE OF WIND-BORN MATERIAL ON SOIL FORMATION IN THE DESERT

The purpose of this study is to investigate the influence of desert playas as a salt source on the soils in the surrounding region. Analysis of dust samples gave very high total salt content and high content of specific ions; namely Sodium, Boron, Chloride,

Carbonate and Bicarbonate. These salt amounts are substantially higher than salts in the surface soil, an indication that they probably came from a source of more concentrated salt - the nearest and most likely is a playa.

---El Tag Fadlalia---

STUDY OF GROWTH PROCESSES IN BUDS

Dormancy or rest period in buds is a physiological condition occurring in many plants for survival in a detrimental environment. Generally, the rest period occurs in anticipation of winter cold, but it can be in response to lack of water, light variations, as well as presence of growth inhibiting chemicals.

A better knowledge of the nature of the rest period and its relation to temperature and other factors might well lead to a basic contribution in the field of growth. Our most comprehensive study is with Hardy pea tree vegetative buds. Through controlled variations of intensity and duration of temperature treatment we are making observations on activity within the buds. Our study indicates the physiological and morphological changes from active to rest are essentially a change of growth rate induced by the environment. Understanding dormancy lies not only in factors that control growth rate, but also in factors concerned in differentiation. It is our objective to learn more about these factors in the apical meristem and leaf primordia.

We have undertaken the chemical analysis of active and inactive buds in conjunction with electron microscopic studies using radioactive nucleosides. It appears from our results that a phospho-protein - DNA complex is involved in rest. It is proposed that the break of rest occurs when protein synthesis is reactivated in the buds.

---Lucy Young---