plants not irrigated for 30 days as compared with those irrigated 10 days before harvest.

The loss in root tonnage was largely due to dehydration, but dry matter was also reduced — that is, less sugar and other cell constituents accumulated in the roots of the more severely stressed plants. The net effect was a gradual decrease in sugar produced—about 13 pounds per acre for each additional day of water stress. The value of this lost production would probably be more than compensated for by reduced costs of irrigation, harvesting and hauling. It appears, therefore, that stressing sugar beets for water just prior to harvest, to the extent experienced in this trial, will not result in a net loss of income.

George V. Ferry is Farm Advisor, Kern County; F. J. Hills is Extension Agronomist, and R. S. Loomis is Associate Professor of Agronomy, University of California, Davis. D. W. Henderson, Associate Professor of Irrigation and the late John Stockton of the Department of Irrigation, University of California, Davis, assisted in planning and conducting this experiment.

CREDIT CORRECTION

It has been called to our attention that the article, "Aspects of Citrus Fruit Growth Studied in Tissue Cultures" (*California Agriculture:* Vol. 14, No. 4, pp. 10–11) included a photograph (without acknowledgment) that had been previously published in the article, "Proliferation of Excised Juice Vesicles of Lemon in Vitro" (*Science* 129: pp. 779–780), by Herbert A. Kordan.

CALIFORNIA AGRICULTURE

Progress Reports of Agricultural Research, published monthly by the University of California Division of Agricultural Sciences.

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MICROBES Affect Physical Properties of Soil

J. P. MARTIN · S. J. RICHARDS

These studies indicate that some of the microbial polysaccharides are relatively resistant to decomposition by soil organisms and, therefore, may well be contributing influences to the favorable effects of organic residues on soil physical properties.

Organic residues in the form of manure, composts, plant roots, or cover crops often exert a favorable influence on soil physical properties by promoting water-stable granulation or aggregation. The favorable effects generally depend upon decomposition of the residues by soil microbes. During rapid decomposition, microbial filaments may bind soil particles together, but more often the binding of soil into aggregates is brought about by organic substances synthesized by the soil microbes, or formed as decomposition waste products.

Most soil organisms synthesize polysaccharides. These consist of sugar or related molecules which are polymerized or chemically joined to form very large molecules. Starch and cellulose are common plant polysaccharides. The microbial polysaccharides, in comparison with other natural organic substances, are relatively effective in binding soil particles. The aggregating action of these substances, however, is believed to be of short duration because most of them are presumed to decompose readily in the soil. Nevertheless, polysaccharides constitute a substantial portion (10 to 20%) of the more stable soil humus—indicating that some may be relatively resistant to attack by soil microbes or may become resistant by combining with other soil constituents.

INFLUENCE OF TWO BACTERIAL POLYSACCHARIDES AND THEIR IRON AND COPPER SALTS AND OF THE SOIL CONDITIONER VAMA (KRILIUM) ON AGGREGATION AND HYDRAULIC CONDUCTIVITY OF RAMONA SANDY LOAM

Treatment	Concentration in soil	Aggregation of silt, clay particles	Hydraulic conductivity
	%	%	cm/hr.
None	...	13	0.2
C. violaceum polysaccharide	0.02	35	1.3
	0.05	53	2.2
Iron salt of C. violaceum polysaccharide	0.05	19	0.4
Copper salt of C. violaceum polysaccharide	0.05	40	1.4
A. indicus polysaccharide	0.02	25	0.1
	0.05	37	0.1
Iron salt of A. indicus polysaccharide	0.05	15	0.2
Copper salt of A. indicus polysaccharide	0.05	43	0.2
VAMA (Krilium)	0.02	43	2.0

In studies at Riverside, a number of microbial polysaccharides were prepared by growing specific soil organisms on appropriate media, separating out the polysaccharides, and adding them to soils to evaluate their effects on physical properties. In some cases, relatively small amounts resulted in marked effects on soil aggregation and on hydraulic conductivity or water transport by soil. In order to establish the duration of some of the measured effects, rates of decomposition of the materials were measured and compared with certain plant polysaccharides and complex organic residues. Typical results are indicated in the graph.

The rates of decomposition of the polysaccharides varied greatly. *Azotobacter indicus* polysaccharide was more resistant to decomposition than almond shells and two additional bacterial polysaccharides as shown by the lower curve in the figure. Other data, not shown, indicate that its decomposition was also slower than for Rhodes grass, bean straw, orange leaves, and seven different plant polysaccharides. *Chromobacterium violaceum* polysaccharide was more resistant to decomposition than corn stalks. On the other hand, several bacterial polysaccharides decomposed almost as quickly as glucose.

All the bacterial products were highly effective in promoting soil granulation. At 0.05% concentration (dry weight basis), the *A. indicus* and *C. violaceum* products increased aggregation of the silt and clay particles of Ramona sandy loam from about 13% for the control to 53%, as shown in the table. The soil binding action of the polysaccharides, however, did not always correlate with hydraulic conductivity effects. A concentration of 0.05% of the *C. violaceum* polysaccharide increased hydraulic conductivity of moist compacted soil by about 11-fold, whereas the *A. indicus* product did not improve water permeability. The attraction for water and subsequent swelling of the *A. indicus* polysaccharide probably reduced the effective space for water movement through the soil even though granulation was improved.

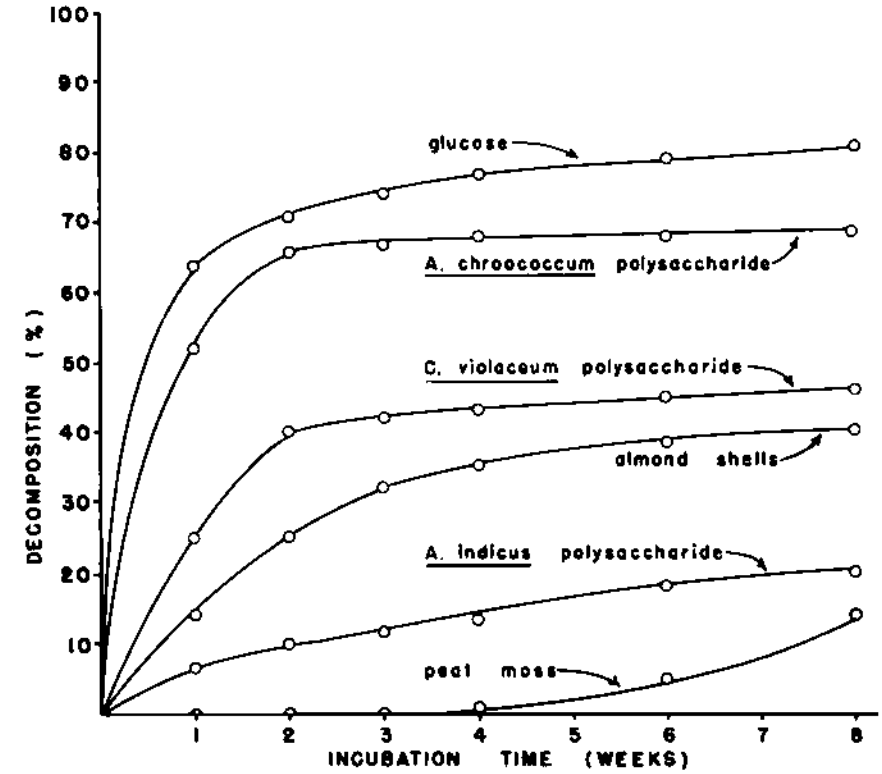
Metal combinations

Polysaccharides containing organic acid groups or certain other structural properties may form salts or complexes with metal cations. Studies now in progress indicate that combination with metals, such as iron, copper, zinc, and aluminum may greatly influence the rate of decomposition of polysaccharides in soil and their influence on soil physical properties. As noted in the table, the iron salt of *C. violaceum* polysaccharide was much less effective in promoting soil aggregation and hydraulic conductivity than the original material, while copper exerted little influence on its effectiveness. Iron likewise reduced the binding action of the *A. indicus* polysaccharide while copper enhanced its aggregating action.

Some of the polysaccharides were used as a food source in media for growing soil bacteria, actinomycetes, and fungi. The numbers of bacteria and actinomycetes capable of developing on *Bacillus subtilis*, *C. violaceum* and *A. indicus* polysaccharide media were sharply reduced. Polysaccharide from *Azotobacter chroococcum*, on the other hand, supported good growth of the bacteria and actinomycetes. *B. subtilis* polysaccharide supported good growth of fungi but the *C. violaceum* and *A. indicus* products did not.

These studies indicate that some of the microbial polysaccharides are relatively resistant to decomposition by soil organisms and, therefore, may well contribute to the relatively more stable soil aggregation.

DECOMPOSITION RATE OF THREE BACTERIAL POLYSACCHARIDES, PEAT MOSS, ALMOND SHELLS, AND GLUCOSE IN SIERRA LOAM (pH 7.0)*



*Organic substances were added at 0.5% concentrations.

James P. Martin is Professor of Soil Science; and Sterling J. Richards is Professor of Soil Physics, Department of Soils and Plant Nutrition, University of California, Riverside.

DATA CORRECTION SUDANGRASS GREENCHOP

TABLE 1 in the article, "Pasture and Greenchop Performance Comparisons . . . Piper Sudangrass and Sudan Hybrids Under Irrigation," page 14, Volume 19, Number 5, May, 1965, *California Agriculture* was in error through transposition of figures. The greenchop section of the table should have been as follows:

GREENCHOP
Harvested when Piper reached 50% late boot

	Season D.M.	Total green weight	% Ave. moisture	Ave. plant height (in.)
	(tons per acre)			
Piper	12.06	58.36	79.34	54.7
SX-11	11.58	77.46	85.06	50.3
Suhi-1	10.75	69.31	84.49	47.6
LSD (.05)	0.49	4.45		
(.01)	0.67	6.13		

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