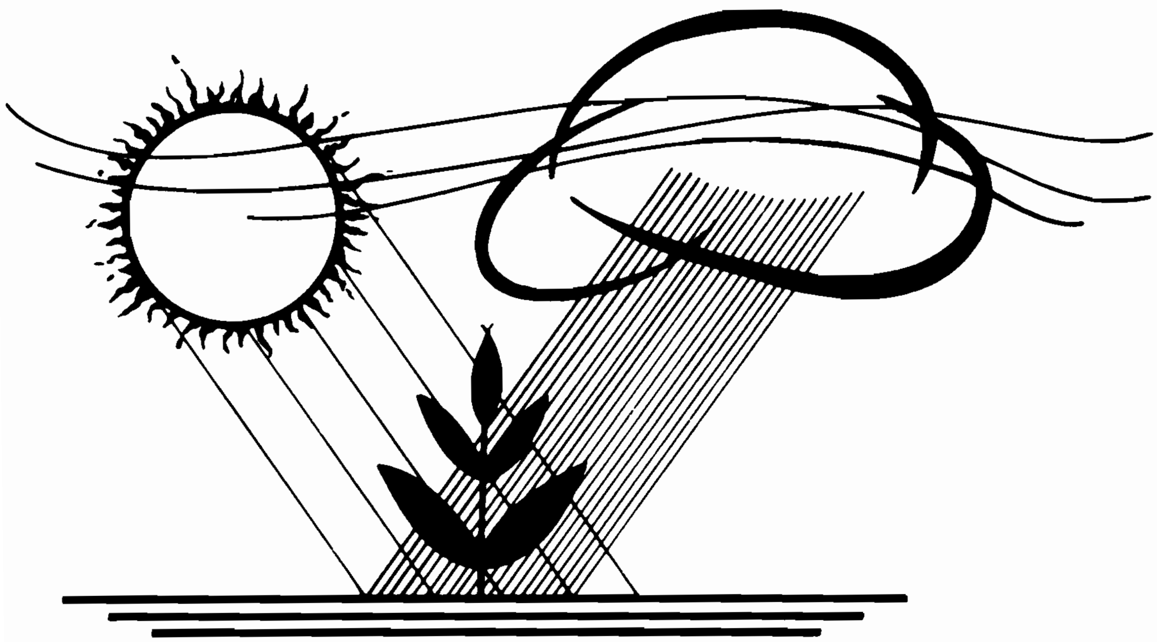
1980
CALIFORNIA PLANT
AND
SOIL CONFERENCE



January 30 - February 1, 1980

Sacramento Inn

Sacramento, California

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1972	Duane S. Mikkelsen
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1977	Henry A. Jones
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EFFECTS OF GASEOUS POLLUTANTS ON CROP GROWTH

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Air pollutants, primarily ozone (O_3) and sulfur dioxide (SO_2), now represent a serious threat to crop production in California. This has been recognized in the Los Angeles air basin for many years. Millecan reported in 1976 that 18 different crops could no longer be grown profitably in some areas of Southern California. In more recent years, substantial evidence has been produced by University of California workers that cotton yields are being reduced in the San Joaquin Valley.

With current technology, it is impossible to estimate with any accuracy the magnitude of losses to growers or to guess intelligently at future losses, even if one assumes certain concentrations of pollutants. Millecan (1976) estimated losses to California growers at $55 million, excluding losses in ornamentals, forests, and native vegetation. The EPA puts non health-related losses in the U.S. at from several hundred million dollars to as high as $1.7 billion (Glass, 1978). These estimates do not take into consideration chronic injury from low-level pollutant concentrations.

A more accurate estimate of gaseous pollutant effects would be of great value in setting realistic air quality standards (see Table 1 for current standards), and to government and private investors in making transportation, energy and land use decisions.

Visible Injury and Growth Responses

Pollutants are first absorbed by plants, then undergo biochemical reactions affecting a wide range of plant processes. These effects may or may not be visible, and visible effects are not necessarily correlated with other plant responses. Many publications are available documenting with photographs the visible effects for a large number of plant species (e.g. Jacobson and Hill, 1970). Relative sensitivity to ozone of several plant species is shown in Table 2.

Growth and yield responses are also well documented, though not as extensively as the visible symptoms. In the San Joaquin Valley, Brewer and workers (1979) have been growing cotton in open top chambers with carbon-filtered air since 1972. The main effect of filtering has been to increase boll number, hasten boll set and delay leaf senescence. Yield reductions due to ambient pollution have been demonstrated as follows:

Location	Yield Decrease
West side of valley	5%
Hanford	15-20%
Parlier and Strathmore	20-35%

These locations are ranked in increasing order of ambient oxidant level. Newer cotton varieties, such as SJ-5, have demonstrated greater resistance than earlier varieties, but even SJ-5 yields are lowered at sufficiently high levels of ozone.

Other workers in Southern California have documented yield losses in citrus when few or no visible symptoms are present (Thompson and Taylor, 1969).

Some species are extremely sensitive to ozone. For example, very obvious leaf damage appeared on pinto beans in New Jersey when ambient oxidants were less than 0.04 ppm for 6-7 hours (cf. Table 1) (Brennan and Rhoads, 1976). Meiners and Heggestad (1979) have published a list of 156 resistant, 65 intermediate, and 20 susceptible cultivars of snap beans, based on visible injury.

Median tolerances to SO_2 span a 10- to 20- fold range of doses and, as with O_3, effects depend on stage of plant development (Glass, 1978).

Current Research Directions

In spite of the voluminous literature documenting both visible and non-visible effects, substantial technical problems prevent extrapolation of these experimental results to crops growing in the real world. Many complications and interactions with other environmental and genetic factors have been reported. The major problems are listed here:

1. Dose-response relations

   It is not clear at all whether pollutant concentration or length of exposure is more important in determining injury. Bressan et al. (1978) reported that the rate of SO_2 absorption by cucumber varieties, and not the concentration to which they were exposed, accounted for the varietal differences in injury. Other researchers have reported that low-level chronic exposure produces more injury to plants than single high doses (e.g. Wilhour, 1979). Effects of length of exposure time are often confounded with changes in susceptibility as the plant develops.

2. Pollutant interactions

   Many researchers have demonstrated that when two or more pollutants are present, the effect on plant processes may be additive, more severe than additive (= synergistic), or less severe than additive (= antagonistic), depending on a large number of factors. The picture at this point is very confusing. Heagle and Johnston (1979) found that when soybeans were exposed to SO_2 and O_3, the effects were synergistic or additive unless the single-gas effect was severe, in which case the effect was antagonistic, but other researchers have not been able to sort out the effects as clearly.

3. Correlation of greenhouse and field responses

   Wind speed, light intensity, relative humidity, and temperature-both during the growth of plants and during the exposure period-have a very large effect on the magnitude and direction of response. One rather clear example is provided here (Table 3), but it should be kept in mind that even plants growing in open-top chambers can develop and respond quite differently from field grown plants, regardless of filtration (e.g. Musselman et al., 1978). Several researchers report that plants are more susceptible to pollutants at higher relative humidity, but Bennett (1979) found that spinach yield losses due to ozone were greater at 50% RH than at 80% RH, while lettuce losses followed the opposite, expected pattern.

4. Correlation of visible with non-visible effects

As noted previously, a correlation does not necessarily exist. Exposure to O_3 may produce leaf symptoms in tomatoes without reducing fruit set or yield. In contrast, citrus yields may be reduced without visible leaf injury. Vegetative growth of ryegrass may be reduced by long-term, low level exposure to SO_2 (Guderian, 1977), as shown in the following table:

Treatment	Growth	Visible Injury
Filtered control	100%	none
+ .07 ppm SO_2 for 6 months	48%	none

5. Pollutants may indirectly affect plant growth by affecting diseases and mycorrhizae

These indirect effects, particularly on mycorrhizae, have hardly been studied at all. McCool et al. (1979) at UC Riverside reported that acute doses of O_3 substantially reduced citrange seedling height and dry weight in mycorrhizal plants, but only a slight reduction occurred in non-mycorrhizal plants. Following weekly exposures to 0.90 ppm O_3, dry weight was reduced by 42% in mycorrhizal plants and 19% in non-mycorrhizal plants.

The relationship of pollutants to plant disease and insect pests is also very complex. Pathogenic organisms may induce O_3 resistance, and O_3 and SO_2 may either reduce, increase, or have no effect on susceptibility to invasion by disease organisms or nematodes, depending on species, stage of growth, level of pollutant and many other factors. An observation by Brewer (1979) illustrates the pitfalls of research. He reports that insects were drawn to the carbon filtered open top chambers: "Hundreds of times more worms and moths could be found in the filtered units than in outside or ambient air units."

CONCLUSIONS

1. Regional and national crop loss estimates are at best, educated guesses.
2. Experimental techniques and improved models are needed to more accurately predict the effect of ambient air pollutants on crops in the field. In particular, more information is needed on dose-response relations, the effects of two or more pollutants in combination, and the correlation of chamber and field results.

Table 1. Ambient air quality standards.

		Standard, ppm		
Pollutant	Averaging Time	California	U.S. Primary	U.S. Secondary
O_3	1 hr	0.10	0.12	0.08
SO_2	Annual	-	0.03	-
	24 hr	0.05	0.14	-
	3 hr	-	-	0.50
	1 hr	0.50	-	-

Notes

1. California standards are values that are not to be equaled or exceeded.
2. National standards, other than those based on annual averages or annual geometric means, are not to be exceeded more than once per year.
3. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health. Each state must attain the primary standards no later than three years after that state's implementation plan is approved by the Environmental Protection Agency (EPA).
4. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant. Each state must attain the secondary standards within a "reasonable time" after implementation plan is approved by the EPA.

Table 2. One-hour exposure to O_3 required to produce visible injury (Heck, 1968).

Sensitive (0.1 ppm)	Intermediate (0.2 ppm)	Resistant (0.35 ppm)
Spinach	Begonia	Zinnia
Radish	Onion	Beet
Muskmelon	Chrysanthemum	Radish
Oats	Dogwood	Poinsettia
Pinto bean	Sweetcorn	Black Walnut
White Pine	Wheat	Strawberry
Potato	Lima Beans	Carrot
Tomato		

Table 3. Response of bean plants to ozone. Exposure was to 0.20-0.30 ppm O_3 for 3-4 hours and in each test was identical for all plants (Lewis and Brennan, 1977).

Test	% Injury		
	Greenhouse (Medium Light)	Growth Chamber (Low Light)	Open-top Chamber (High Light)
1	80	-	0
2	84	-	10
3	67	-	0
4	45	12	1
5	82	36	3
6	83	47	24
Symptoms	fleck stipple bronzing	bleaching, some stipple	bronzing, some stipple

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PHYTOTOXICITY OF TRACE ELEMENTS

H. M. Reisenauer

Trace element toxicities are an ever present and increasingly probable hazard to agriculture. Excessive levels of these elements in soils arise in 4 main ways: (1) From natural geologic and biologic processes, (2) As a result of agricultural processes, (3) From waste disposal practices, and (4) From aerial inputs. Right now, growth of crops in many of our soils is restricted by the toxic actions of salts and of specific elements. Of equal concern is the deleterious effects of excessive levels of certain elements on the health and well being of the animals that consume plant tissues from affected soils. It is imperative that we improve our understanding of the processes involved if future generations are to be assured adequate supplies of quality food and fiber.

Excessive levels of many elements produce toxic reactions. Those occurring frequently at phytotoxic levels in agricultural soils include aluminum, boron, chlorine and manganese. Excesses of arsenic, beryllium, chromium, cobalt, copper, fluorine, iron, nickel and lead are known and must be guarded against. Soils supplying plant tissues containing levels of cadmium, fluorine, molybdenum, and selenium harmful to animals have been identified. The hazards from excesses of these elements are further complicated by possible synergistic effects of high levels of two or more elements, by the interactions between potentially toxic elements and soil characteristics (as acidity) that change with time, and by the fact that additions of these elements to soils are essentially permanent - they can be removed only very slowly and with great difficulty. On the other hand, the severity of a toxicity can in many cases be alleviated by shifting to a more tolerant crop, by modifying another soil characteristic, or by simply increasing the growth rate of the crop. Only in few instances have soils been made totally sterile.

The biochemical mechanisms of toxic actions are not understood. Phytotoxicities can be broadly grouped into those that inhibit plant processes through osmotic (high salt concentration) disturbances, and those that disrupt metabolism through specific inhibitory reactions. Plants in saline environments grow poorly, and display symptoms of water stress and salt burn (leaf-edge and leaf-tip necrosis). The stress varies little between species, and is generally independent of the nature of the salt; however, specific ion toxicities may be involved. In contrast toxic reactions from specific element effects occur over a range of concentrations of the casual element, influence different parts of the plant to different degrees, and produce a variety of visual symptoms. Tolerance to excesses of individual elements differs greatly among species and within cultivars of a species. The rapidity with which genetic resistance may be acquired suggests single gene control and highly specific effects.

Trace element toxicities once identified can be dealt with in a variety of ways. Only rarely would the control be as satisfactory or as productive as the condition existing before the toxicity developed. Any action or treatment likely to produce toxic effects should be approached cautiously and with complete understanding of the problems involved.

ABSTRACT

TRACE ELEMENTS IN COAL AND THEIR POTENTIAL FOR ENVIRONMENTAL POLLUTION

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The trace element composition of coal is site and source specific. It varies from location to location in a coal bed and from bed to bed within a coal rank. Regardless of its source, concentrations of trace elements in coal fall within the range comparable to those of other geologic deposits such as rocks and soils. However, on the average, Hg, Pb, Mo, As, Cd, Sb, and Se tend to be richer in coal than the average composition of the earth's crust. Upon combustion, trace elements originating from the source coal are redistributed among the various residue streams (bottom ash, boiler slag, fly ash, and flue-gas-desulfurization sludge). The concentrations of trace elements in the collected residues vary with particle size. In particular, those elements which are volatile at combustion temperatures (e.g., As, Be, Cd, F, Hg, Se, Sb, Mo, Pb, Zn) exhibit higher concentrations in fly ash than in coal. In modern coal-fired power plants, emission control devices are designed to collect more than 99% of the residues from coal combustion. The finer particles (<1 μm) escaping the emission control devices are enriched in certain trace elements. Even though the particles emitted from stacks are enriched

in trace elements, the amounts deposited onto soil and vegetation in the environs surrounding modern coal-fired power plants are small and do not substantially contribute to background levels. Collected residues capture the bulk of the trace elements mobilized by coal combustion. In situations where these materials are disposed or recycled onto land, excessive salinity and boron may adversely affect the growth of sensitive crops. Both Mo and Se in forage may accumulate to levels unsafe for animal consumption.

AGRICULTURAL USE OF TREATED DOMESTIC WASTEWATER

AND MAINTENANCE OF SOIL PRODUCTIVITY

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In California, domestic wastewater is too valuable a resource to utilize once and throw away. The importance is shown by the following calculation: California farm income $1 x 10^{10}, irrigated acreage 1 x 10^{7}; nonirrigated income $100 per acre; average water use of 3 acre feet/acre. An acre foot of water thus "produces" $300 of income. The continued productivity of our finite crop land acreage is also of critical importance. If treated wastewater is to be used as supplemental irrigation, then some difficult political-economic decisions must be made:

Basically, who pays for what?

How are the benefits apportioned?

Who is responsible for treatment to prevent pathogens from recycling in the food chain, or toxic metals from accumulating in either the soil or the ground water?

And what do we do with what's left over? Fortunately, in this paper we aren't concerned with the latter.

Here we are concerned with the utilization of domestic wastewater for irrigation purposes.

Water applied to cropland in arid and semiarid regions has an intrinsic economic benefit. In addition, wastewaters frequently have higher concentrations of plant nutrients than natural waters; especially phosphorus, nitrogen, metals (zinc, copper, etc.), sulfur and boron. And often the organic matter that produces the biologic oxygen demand can be considered as a beneficial additive--although most of this benefit is probably associated with the mineralization of the organic nitrogen, phosphorus, and sulfur to plant available forms.

The hazards of utilizing untreated wastewater can be listed as:

Human pathogens -- ranging from the various higher life forms that are parasitic on humans (tape, hook, trichinosis worms) through fungal and bacterial disease causing agents as well as viruses.

Many of the metals used in society -- zinc, copper, nickel, cadmium -- can cause phyto-toxic problems when added to cropland soil. Cadmium can accumulate in soil increasing cadmium in the crop and make it unacceptable or undesirable for human consumption.

Essential plant nutrients may also reduce crop yields when applied at the wrong time or at rates too high for the planned crop. -- nitrogen, boron, zinc.

The addition of high BOD loadings may also cause imbalances in nitrogen supply.

A major use of domestic water -- soil removal from clothing and/or persons -- also tends to increase the two major constituents considered in evaluation irrigation water quality -- sodium and total dissolved solids.

The utilization of untreated or minimally treated wastewater is associated with potential problems. If the source is a small, non-industrial community and if crop production on the receiving land is also limited to crops not directly edible by humans, then possibly the high cost of secondary treatment can be eliminated. However, this may also require dedication of the land to non-hazardous purposes if it becomes contaminated with metals.

For the larger community that creates the usual California wastewater, secondary treatment and analysis of the treated effluent is necessary prior to its application to land. Primary treatment removes many of the pathogens and some of the BOD from the incoming waters. Secondary treatment removes most of the remaining BOD and pathogens, except for some viruses. Most of the metals are sequestered or adsorbed to the solids in the sludge. However, soluble salts, Mo and B, are left in the water and significant levels of other ions also may stay in solution.

The chemistry of most of the elements that remain in the wastewaters are reasonably well understood and their reactions in the soil can be predicted. Many of the transition and heavy metals (Zn, Cu, Cd, etc.) will adsorb strongly on soil surfaces if present in the treated water at concentrations higher than that in the solution phase of the receiving soil. Note that if the concentration of metal in the treated water is sufficiently low, no accumulation will occur in the receiving soil. The organic matter can produce soluble chelates of several of the metals (Fe, Zn, Cu, Ni) and lower the dissolved oxygen in the receiving soil causing reducing conditions. Iron and manganese, either in the water or pre-existing in the soil, can be reduced in valence thereby increasing their solubilities and phyto-toxicity.

Other elements (phosphate, arsenic) are also adsorbed in the soil. Although soils have large capacities for all sorts of adsorption, there is a finite limit for each soil and each element. If this limit is exceeded, contamination of ground-water can occur. Long before this, soil levels of arsenic could be sufficiently elevated to produce phytotoxicity.

Even chlorinating the secondary treated wastewater does not eliminate viral populations. Passing the water through a soil column removes them below detectable levels in a few meters, but only desiccation and exposure to UV light kills them.

Present levels suggested for safe land disposal are designed to protect underlying ground water and appear to be too high for long term application of wastewaters if soil productivity is to be maintained. The application of high concentrations of metals that are adsorbed on the soil will increase soil levels with the potential of producing phytotoxicity. The resulting loss of productivity would have long term effects and be nearly impossible to correct economically. Using current soil solution concentrations as effluent design goals will prevent accumulation in the soil. Breakdowns, malfunctions and spills are a problem, even with this as a treatment goal. If productive agricultural land is the design disposal area, where does the undertreated water go? Who has the responsibility for the long term contamination of the soil? Receivers must have not only assurance of, but also insurance against long term adverse effects.

ABSTRACT

OCTOBER 29, 1979

AN INTEGRATED MUNICIPAL-INDUSTRIAL LAND TREATMENT SYSTEM, WITH BENEFITS FOR THE FARMER

BY: J. L. SMITH, P.E. J. R. SIMPLOT COMPANY

A SERIES OF STUDIES OF WATER QUALITY MANAGEMENT ALTERNATIVES INDICATED THAT THE WASTEWATERS FROM A COMMERCIAL FERTILIZER COMPLEX AND A MUNICIPAL SEWAGE TREATMENT PLANT PREFERABLY SHOULD BE:

1. REMOVED, ESPECIALLY DURING THE SUMMER MONTHS, FROM THE SMALL RIVER INTO WHICH THEY FLOWED, AND
2. USED TO IRRIGATE AND FERTILIZE FARMLANDS IN THE AREA.

THIS APPROACH WAS DETERMINED TO BE TECHNICALLY FEASIBLE, COST-EFFECTIVE AND ENVIRONMENTALLY SOUND, AS COMPARED WITH OTHER TREATMENT OPTIONS AVAILABLE TO THE FERTILIZER COMPANY AND THE MUNICIPALITY. NECESSARY APPROVALS FROM LOCAL, STATE AND FEDERAL AGENCIES DEALING WITH LAND USE, SURFACE WATER PROTECTION, GROUNDWATER PROTECTION, WILDLIFE PROTECTION AND PROTECTION OF PUBLIC HEALTH WERE OBTAINED, ALONG WITH THE USUAL PERMITS REQUIRED FOR FACILITIES CONSTRUCTION.

TECHNICAL FACTORS CONSIDERED IN DESIGNING THE SYSTEM AND A RATIONAL OPERATING PLAN INCLUDED:

1. NUTRIENT AND WATER REQUIREMENTS OF CROPS GROWN BY USERS
2. LIMITS ESTABLISHED BY EPA FOR LONG-TERM (20 YEARS) APPLICATION OF VARIOUS NON-NUTRIENT CHEMICALS, SUCH AS FLUORIDES, IN CROP-PRODUCING LAND TREATMENT SYSTEMS
3. TIMELY DELIVERIES OF NUTRIENTS AND WATER IN APPROPRIATE AMOUNTS, FROM A SYSTEM HANDLING TWO DIFFERENT EFFLUENTS

4. OFF-SEASON STORAGE OF THE FERTILIZER PROCESSING EFFLUENT, SO AS TO MAINTAIN A ZERO DISCHARGE CONDITION
5. PROTECTION OF GROUNDWATER QUALITY IN THE DESIGN AND OPERATION OF THE OFF-SEASON IMPOUDMENT
6. MONITORING OF THE APPLICATION OF THE WASTEWATERS TO THE CROP-LANDS, AS WELL AS OF POTENTIAL ADVERSE IMPACTS ON CROPS, SOILS AND GROUNDWATER.

ECONOMIC FACTORS CONSIDERED INCLUDED:

1. PURCHASING OF FARMLAND, AS COMPARED TO CONTRACTING WITH FARMERS FOR WATER AND NUTRIENT PURCHASE
2. RECOVERY OF SOME SYSTEM OPERATING COSTS, WHILE STILL PROVIDING AN ATTRACTIVE OPTION TO THE FARMER.

METALS IN HUMAN FOODS - TERRESTRIAL INPUT

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The metals to be discussed are copper, zinc, nickel, arsenic, selenium, lead, mercury, and cadmium and the emphasis will be on accumulation in or on the edible product of levels of metals hazardous to the health of human consumers. Toxicity can be either acute or chronic. Acute toxicity is the short term exposure or intake causing detectable debility or death while chronic toxicity occurs after long exposures of months or years. Acute toxicity from metals in food (excluding processing inputs) is virtually impossible, whereas chronic effects have been observed.

Metals with low potentials for mammalian toxicity include copper, zinc and nickel. These metals as well as arsenic, mercury, and lead are generally inhibited from accumulating to hazardous levels in edible parts of plants growing on polluted soils either by root barriers or diminished translocation, or both. An exception to this is a report of threshold hazardous levels of lead accumulated in vegetables grown on soil highly contaminated by lead. It is sometimes stated that toxicity to plants of high levels of copper or zinc or nickel in soil will prevent growth or development of the plants before levels of the metals reach levels hazardous to consumers. Arsenic has accumulated in old "apple orchard soils" around the world from repetitive spray application of lead arsenate as an insecticide to the point where growth of many crop plants is still diminished even though the use of the arsenates virtually stopped in 1935 due to the switch to DDT. During the time of arsenate use, FDA laboratories analyzed the fruit for arsenic residues. There are no known reports of hazardous levels developing in edible plant products by soil to plant transfer in these contaminated areas.

Selenium is an essential nutrient for humans, but the range between threshold deficiency and threshold toxicity is narrow. Some soils of the north central United States cause elevated levels in wheat but it is generally considered that market mixing adequately alleviates any problem.

Mercury and cadmium are two elements for which there has been great interest from a toxicological standpoint over the past 20 years. Both elements have been released to the environment by industrial processes in Japan causing human suffering and premature death following consumption of food that acquired the metals through biological acquisition processes. In the case of mercury, the contaminated environment was marine and the toxic principle was methyl mercury formed from mercury by biological activity in bottom sediments and then transferred through food chains to fish that were caught and eaten by the local population. In the case of cadmium, mine waste was deposited during flooding of a river onto land used by peasants to grow rice and vegetables which acquired excessive amounts by root uptake and transfer to edible tissues.

A faulty analytical procedure giving spurious, high results led to speculation that the mercury-treatment of agricultural seeds was leading to excessive contamination of soils, and transfer into grains and vegetables at elevated dangerous levels. A very costly worldwide sampling and analysis program showed that such was not the case for terrestrial products and only older tuna and swordfish contained mercury in excess of tolerance levels.

Cadmium is also susceptible to analytical error. Cadmium uptake by plants ranges from virtual exclusion to extraordinary accumulation. The concentration of cadmium in plants is strongly affected by plant species, soil content, and plant anatomical organ. It is moderately affected by soil pH, soil chloride level, surface area of soil and competing metals such as zinc. Dietary impact is thus conditioned by diet selections as well as by all of the above. Tolerable threshold levels for cadmium in food have not been set in the U.S. (except for water). Cadmium levels in soils throughout the U.S. are not known although a recently initiated USDA study will answer this question. It can be shown that a gardener is probably at greatest hazard from soil contamination by cadmium in sewage sludges, particulate deposits from smelters or coal burning in metropolitan areas, or from other unregulated disposal processes. It can be shown that soil levels of approximately 5 ppm Cd growing three vegetables (50% of annual intake) could raise an average U.S. person's diet from 13 mg Cd/yr. to 26 mg Cd/yr. which is the maximum tolerable threshold recommended by a joint committee of the World Health Organization -- Food and Agriculture Organization. This would probably amount to no more than a 10-fold increase of normal, uncontaminated soil levels of cadmium.

From the above, and recognizing that all of these elements are present in normal soils at very low levels, significant contamination of soil is relatively easy. It is recommended that we exercise great care to prevent excessive and unnecessary contamination of soils.

RGB/smr

NITROSAMINES IN FOOD AND THE ENVIRONMENT

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SUMMARY

Effects

In all species tested in laboratory animal studies, approximately 70 percent of all N-nitroso compounds studied were found to be carcinogenic, with a wide range of potency. There is no direct evidence, however, that nitrosamines have caused cancer in humans, although a few cases of accidental, or occupational, exposure to dimethylnitrosamine are known to have resulted in liver damage. Nitroso compounds have been cited as a possible cause of high rates of cancer in rubber workers, but these workers are also exposed to other chemicals shown to produce cancer in animals. Metabolic studies *in vitro* using rat and human liver slices have shown that the pathways of biochemical changes in the two are similar to some degree. Epidemiological studies to date do not, however, show a direct relationship between exposure to nitroso compounds and cancer in man. It can be concluded, then, that in the few studies in which N-nitrosamines are cited as a possible cancer link the association is implied rather than tested. Thus, no causal relationship between human cancer and nitroso compounds has been established; however, there is no reason to assume that the human species should be immune in view of the available data from animal studies.

The toxic and carcinogenic properties of nitrosamines in experimental animals are well established, with the N-nitrosamines considered to be among the most potent and versatile of all chemical carcinogenic agents.

In laboratory studies, these compounds have produced cancer in over 20 species tested via all routes of exposure in essentially all vital organs. One compound, diethylnitrosamine, has exhibited a toxic effect in rat, mouse, hamster, guinea pig, pig, rabbit, dog, rainbow trout, aquarium fish, grass parakeet, and monkey. The nature of the toxic response apparently is related to the chemical characteristics of the compound administered. The site of activity appears to depend on the compound, the diet, age of animal, species, dosage

level, route of administration, and rate of exposure.

No experimental data are available on the effects in domestic animals of exposure to nitrosamines or their precursors. Nitrites, which are precursors, are formed in the gastrointestinal tract of animals and may be absorbed into the blood, producing methemoglobinemia, especially in ruminants and horses. However only one study reported cancer in domestic animals from the in vivo formation of nitrosamines from this and other precursors.

Physical Properties, Chemistry, and Metabolites

The simple aliphatic nitrosamines are yellow or yellow-green non-hygroscopic liquids that boil without decomposition at 150°C to 200°C. The compounds are partially soluble in organic solvents, with solubility in water varying inversely with molecualr weight. The simple aromatic nitrosamines are low-melting solids or yellowish oils that are insoluble in water and undergo decomposition at atmospheric pressure. The density of nitrosamines ranges from 0.9 to 1.2 g/cm^3, increasing with molecular weight.

The chemistry of nitrosamines relative to the problem of human exposure and biological effects is not well known. It is known, however, that nitrosamines are rapidly photolyzed in the presence of ultraviolet light and are rapidly metabolized in animals. Therefore, one would not expect a persistent buildup of this specific compound in the atmosphere or in the human body. Various studies have been made to assess the potential for the in vivo formation of nitrosamines, but the results are not yet conclusive. A large number of variables are involved in the biochemical processes, many of which have not been determined quantitatively in a biochemical system representative of the human environment. Nitrosation in the systems studied has been found to depend on the concentration of nitrite and secondary amines, the pH of the medium, the presence or absence of promoters or inhibitors (ascorbate has been shown to be an effective inhibitor), temperature, time of reaction, the basicity of the amines, and the presence of nitrosating organisms (nitrosation may occur in the intestine or in an infected urinary tract).

Early laboratory work demonstrated that nitrosamines are rapidly metabolized, so that even very large doses are removed within 24 hours. Further, the evidence indicates that dimethylnitrosamine is not accumulated in any one organ of the body. The general consensus is that the related carcinogenesis is caused by some active metabolite rather than by the nitrosamine itself. Alkylating agents, such as diazomethane or a carbonium ion, have been suggested as possible active metabolic products of nitrosamines; other suggested intermediates include the corresponding aldehyde, nitrous acid, a hydroxlamine derivative, and a hydrazine derivative (all known mutagens).

Concentrations and Human Exposure

The relative risk of nitroso-compound-induced cancer in humans can be discussed only in a qualitative sense, based on hypothetical reasoning. Given a reasonable qualitative estimate of relative exposure, it is still not possible to translate this to an effective biological burden; i.e., the dose-response relationship at the concentration to which the human population is exposed is not known. If relative exposure is defined simply in terms of total dose over time, then it might be divided into two components: (1) direct exposure to nitrosamines via inhalation, ingestion, and smoking; and (2) exposure to precursors (nitrogen compounds, including amines) via inhalation, ingestion, and smoking.

There are no reliable estimates of the average daily dietary intake of nitrosamines; however, based upon the available measurements, it is not likely to exceed a few micrograms per day. Various nitroso compounds, including N-dimethylnitrosamine, have been identified in a variety of vegetables, fruits, and meats. The concentrations reported vary widely (from non-detectable to mg/kg); however, the validity of the analytical methodology used in many cases is now under question. The long-established practice of using nitrates or nitrites for the curing and processing of meats, and for the control of Clostridium botulinum (the organism responsible for botulism), may contribute to the nitrosamine levels in these products; again, the concentrations vary widely and results are not always consistent. Further, the available information indicates that nitrite levels are being reduced in these food products.

The direct intake from drinking water from municipal water supplies probably would be much less than 1 μg per day. At present there are very limited data regarding the presence of nitrosamines in water, and results to date are not conclusive. Recent studies indicate the presence of N-nitroso derivatives of pesticides in some water samples. Analysis for nitrosamines in a few well-water supplies in the United States, characterized by high nitrate levels and coliform counts, revealed results of $\leq$ pg/g. Nitroso compounds, as well as nitrates and amines, are found in a variety of pharmaceutical products, constituting another potential for human exposure. Reported values of nitroso compounds in cigarettes range from 0 to 180 ng/cigarette. A one-pack-per-day smoker may then be exposed to a few micrograms per day. Nitrosamines in ambient air at levels up to 36 $\mu g/m^3$ have been reported near an emission source, while concentrations as high as 0.2 $\mu g/m^3$ have been reported in major population centers. Assuming 20 m^3 of air inhaled per day, exposure via inhalation again might be a few micrograms per day. It then seems reasonable to assume that direct exposure to nitrosamines via each of the primary routes may be of the same order of magnitude.

The second component of exposure, i.e., the exposure to precursors (nitrogen compounds, including amines) again may be via inhalation, ingestion, and smoking. In this case, the daily intake of both nitrates and amines via ingestion of food and water may be on the order of a few hundred milligrams per day. Nitrosamine precursors are commonly found in foodstuffs and water at much higher concentrations than the nitroso compounds themselves. Nitrite formation in human saliva particularly among smokers, has been estimated at about 6 to 10 mg/day. Human saliva in smokers also has been found to contain thiocyanate ion, which has been shown to catalyze the reaction of nitrite and secondary amines to form nitrosamines. Tobacco smoke contains several secondary amines and oxides of nitrogen. Nitrate intake via inhalation (ambient air) may be on the order of several hundred micrograms per day in some areas, such as near point sources of emissions. Data are not available on amine intake. Although the reaction between ingested amines and nitrites appears to produce nitrosamines in the digestive tract of animals, almost no studies have assessed the results of inhaling potential nitrosamine precursors. Since the reaction has been found to be enhanced in acidic media, it might be hypothezised that nitrosamine formation in the neutral environment of the lung would be less efficient than under the acidic conditions found in the stomach. Furthermore, preliminary estimates suggest that exposure to precursor amines and nitrogen oxides from food, water, and smoking is probably greater than that through inhalation. Thus, until further evidence is available, risks from inhaled nitrosamine precursors can be viewed as theoretically possible but likely to be of lower order than those from direct nitrosamine inhalation.

Conclusions

In spite of the wide gaps in knowledge of nitroso compounds in the environment and of their impact on human health, a few conclusions appear valid at this time:

* N-nitroso compounds or their metabolites are carcinogenic and mutagenic in a wide range of animal species. Tumors can be induced in essentially all vital organs. N-nitroso compounds are one of the most potent groups of carcinogens, but potency varies over a wide range and depends upon chemical characteristics. These compounds are carcinogenic in experimental animals via all routes of administration and generally act systemically, although some have produced tumors at the site of injection. The tumors induced depend on the route of administration, level of dose, and frequency and length of treatment. Optimum effectiveness in tumor inducement appears to be in small doses given over long periods of time. Administration to experimental animals by inhalation has produced tumors in the nasal cavity and in other organs.
* There is no direct evidence that nitrosamines have produced cancer in humans
* Nitroso compounds are readily metabolized by animals.
* Nitroso compounds can be formed by the reacion of secondary, and some tertiary, amines and nitrites. The reaction, under suitable conditions, may occur in air, water, soil, food, animal stomach or intestines, or in the urinary tract (where it occurs through microbial action).
* Nitroso compounds, or their precursors, are widespread in all media of the environment as the result of contributions of both natural and man-made sources.
* The human population may be continuously exposed to nitroso compounds or their precursors. The consequence of this exposure in terms of human cancer is unknown.
* Although detailed emission inventories have not been prepared, it appears that man-made sources contribute to the environmental loading of nitroso compounds and their precursors and hence may pose a potential health hazard. The extent of man-made contributions is unknown; prudence dictates that adequate control be exercised consistent with economic and social constraints.

Pesticides and Food Quality Maintenance

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Pesticides* are used to conserve and enhance food quality. They are used to prevent direct damage to edible parts of plants, and to prevent contamination of food. They are also used to help establish uniform plant stands, maintain plant vigor, and promote and accelerate ripening. Without pesticides, quality and yield of many crops would be much lower than they are today. And postharvest crop losses would be greater than they are today.

Most pesticide uses do not have adverse effects on food quality. When an experienced applicator uses a good-quality pesticide in accordance with label directions and other regulatory restrictions, the use is generally safe if it has been adequately tested beforehand. It is safe because of premarket testing of pesticides, pesticide quality control, and regulation of pesticide applicators, and in some cases because of crop buyers' pesticide control programs:

1. Pesticide manufacturers are required by law and by product liability considerations to test each candidate pesticide thoroughly, to show how it can be used effectively and safely. Use patterns which might jeopardize quality and yield of crops are carefully excluded from directions for use on the pesticide label.

2. Regulations and liability considerations also require pesticide manufacturers to maintain strict control over quality of their products. Pesticide production establishments, books, and records are subject to inspection by regulatory authorities. Pesticide products must meet stringent standards of strength and purity.

3. People who apply pesticides must meet standards of competence, and are subject to penalties for misuse of pesticides. In most States, any person who applies pesticides for hire must be licensed. Any person who applies pesticides which are classified for restricted use under the Federal Insecticide, Fungicide, and Rodenticide Act must be certified. And Federal laws and some State laws prohibit application of any pesticide in a manner inconsistent with its labeling. Penalties of up to $25,000 and one year in prison are provided for violators of these laws.

4. Many crop buyers insist on proper use of pesticides, and prohibit uses which are known to endanger food quality. For more than 20 years, members of the National Food Processors Association have maintained a Protective Screen Program intended to assure that the use of pesticides on processing crops will not have adverse effects on quality. Briefly, the program consists of grower education on proper use of pesticides, and contractual limits on pesticide use by growers. Growers are provided with lists of acceptable pesticide uses, with limits on residues, dosages, and timing of application. Certain uses which are acceptable to regulatory agencies, and recommended on pesticide labels, are excluded from the lists because of potential adverse effects on crop quality.

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* Pesticides are the active and inert ingredients in antimicrobial agents, attractants, defoliants, desiccants, fungicides, herbicides, insecticides, nematocides, plant regulators, rodenticides, and slimicides, and in preparations for poisoning or repelling amphibians, reptiles, birds, fish, mammals, and invertebrate animals.

Many crop buyers keep detailed records of pesticide applications to growers' crops, and scrutinize the records to be certain that pesticide label directions and other contractual limits have been observed. Instances of non-compliance are investigated and, if necessary, buyers refuse to accept mistreated crops.

In spite of all these precautions, pesticide use can sometimes result in significant adverse effects on food quality and yield. Most obvious are phytotoxic effects such as fruit spotting, leaf burning, and death of the plant. Less obvious effects include off-flavors, delayed maturity, and contamination with excessive residues. These adverse effects may occur if the applicator is careless, if the pesticide quality is poor, if label directions and other regulatory (and contractual) limits are not observed, and if the use has not been adequately tested beforehand. For example, crop damage or contamination may occur if the applicator inadvertently uses the wrong pesticide, or allows substantial drift to a non-target crop. Crops may be damaged or contaminated by pesticide products which contain traces of other pesticides produced in the same factory, or traces of pesticide manufacturing byproducts. Crop damage or contamination can also result from failure to follow label directions specifying dosage, spray concentration, and timing of application. And many problems can arise when a pesticide is used without adequate testing beforehand. It is risky to assume that a pesticide use shown to be safe for one variety of a crop in one season and one area will be just as safe or effective for other varieties and in other seasons and areas.

To prevent food quality problems which can be caused by pesticides, pesticide misuse must be avoided. Errors in pesticide formulation and use must be avoided. New use patterns for pesticides must be tested carefully. And food quality problems which require the use of pesticides must be minimized, to reduce the overall risk of pesticide use. Toward these goals, pest management components should be integrated in each crop research program involving potential changes in crop varieties, growing seasons, or production areas. In variety development, increases in susceptibility to pests should not be tolerated as trade-offs for small gains in other attributes. And, in view of increasing regulatory restrictions on pesticide use, cropping systems should be designed so that they are not totally reliant on the use of pesticides.

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POTENTIAL OF AMARANTHS AS HUMAN AND ANIMAL FOOD

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Several species of the genus *Amaranthus* are widely grown in Asia, Africa, the highlands of Central America and Mexico, and the Andean region of South America for both grain and vegetable uses. Grain amaranths most probably originated in the New World and certainly early American peoples had recognized their food value. Several recent studies have drawn much attention to them as a source of protein as well as for their high productivity in marginal environments. A National Science Foundation study (1) found it to be one of the most promising 20 new crops in the U.S., "singled out for closer economic and feasibility" studies. The International Board of Plant Genetic Resources placed a high priority on the collection and study of both leafy and grain types because of their "very high actual or potential nutritional importance, and a low present level of research" (2). Amaranths represent a fascinating crop genus, having close associations with the early history of domestication and civilization, worldwide potential as a high quality food, and now offering many challenges to the crop scientists working to improve it (3). This paper surveys some current developments of nutritional, agronomic, adaptational, and genetic aspects of this new crop.

Nutritional value: Amranth grain, used as a popped cereal or flour, provides a valuable source of protein, calories and minerals. Table 1 summarizes data on the main food constituents in amaranth and other seed crops. The discovery of as high as 6% lysine in Amaranthus edulis (4) heightened the nutritional interest in this crop. Elias (5) reported the aminogram scores as a measure of protein quality. Compared to egg protein scores as 100, amaranth, maize, and wheat scored were 75-87, 44, and 57 respectively. Furthermore, the main limiting essential aminoacid for amaranth is leucine, making it a good candidate for complementation with plant proteins from various sources.

Data on the nutritional value of vegetable amaranths are summarized in Tables 2 and 3. Grubben (6) emphasized the value of amaranth used as leafy vegetable in the diet of people in the tropics as an excellent source of vitamins A and C. Thus, both grain and leafy amaranths have a great deal to offer as human food. High oxalate and nitrate levels are of some concern in relation to the use of amaranth as a vegetable, also characteristic of other leafy vegetables. Several studies have shown, however, that usual food preparation by boiling and the level of consumption at 100 gm or less per day should cause no dietary problems, and that oxalate and nitrate concentrations are comparable to those of spinach and other traditional leafy vegetables (7). Although forage use has not been specifically studied, several feeding trials using laboratory animals showed amaranth leaves and seed to have high palatability and high digestibility. Lexander et al. (8) found amaranth leaf protein to be the most highly digestible of 25 crop and wild plants studied for their potential in the production of leaf protein concentrate.

Agronomic aspects: Grain amaranths are summer annuals with an unbranched main stalk that reaches a height of 1 to 3 meters, large elliptic leaves, and a terminal panicle type inflorescence. All species are monoecious, and have a deep taproot system. Amaranths are commonly grown for grain in India, Nepal, Mexico, Guatemala and Andean South America, usually in mixtures with other crops but occasionally in pure stands. Interplants almost always involve a cereal, usually corn, or millet (e.g. finger millet). The ubiquitous pattern of cereal-amaranth mixtures suggests an ecological relationship tht should be studied for the possibility of its exploitation. Seed yields in the few trials reported so far range from 1 to 3 MT/ha, the highest reported seed yield being 6100 kg/ha (3).

At present, amaranth cultivation in Davis has been as a row crop, on a 37 cm row spacing, 12 cm between plants in a row (about 250,000 plants/ha), and can be planted from April to mid-June. Seed yields in Davis average about 2,000 kg/ha. No problems have been encountered with insect or disease pests. Growth rates are high and weeds are soon overshadowed by the crop. Preliminary experiments in Davis have shown little or no difference between plots irrigated every 3 weeks and those receiving no water after 2 initial irrigations, a week apart.

Remaining agronomic problems pertain chiefly to shattering and harvest techniques. The shattering problem may be solved by the introduction of non-dehiscent types, presumably the result of introgression with weedy species, recently found in the South American germplasm (9). Harvest is now done by hand, because of shattering and late senescence problems.

However, if a non-shattering type can be developed, agronomic techniques can be refined to machine harvest amaranth, either after a windrowing step, or without windrowing through earlier planting dates.

Vegetable amaranth yields have been reported as high as 40 MT/ha with outstanding prospects for protein concentrate uses. Grubben (6) reported a series of extensive studies in Dahomey and reviewed work from other parts of the world in which several crops taken at four and six week intervals with heavy organic manuring and intensive management provided as high as 2.7 to 3.5 MT/ha/yr dry matter production (equivalent to 6-7 $gm/m^2/day$).

Adaptability: Several studies have shown amaranths to be adaptable to a wide range of climatic and soil conditions. They are often found in humid, tropical lowland environments; however, although amaranths, like maize, are C_4 plants, adaptation to temperate regions as well is evident in the cultivars of highland areas. Amaranth is found cultivated in areas that range from xerophytic to mesophytic categories. Grubben (6) reported a series of experiments on the response of amaranth cultivars to variations in temperature, light intensity, and drought. Water use efficiency was noted and high temperature and intense light requirements were important for optimal plant growth. Our studies on photoperiod response have shown various available accessions to be short day responsive to neutral, with wide variation within and among populations.

Genetics and breeding research: Researchers at OGFRC, Rodale Press, have developed a series of selections with high yield and short stature. Some of their breeding objectives in grain amaranths are related to wider adaptability, higher yield, and mechanization. The health food industry, in particular breakfast cereal industry planning to mix amaranth seed in granola, would standardize food quality criteria as part of variety selection programs. Although several growers have anecdotally reported a wide scope for selection based on intrapopulation variation, no systematic collection and evaluation of germplasm collections have yet been undertaken; in fact, no more than 100 to 300 different accessions were available two years ago. Following Sauer's painstaking studies on the geography, taxonomy, and agricultural history of amaranth (10), we have begun to assemble germplasm from India (11) and the New world centers of diversity (9). Table 4 lists our objectives in germplasm research. Rodale researchers and the USDA scientists are also interested in a worldwide collection with suitable data banks. Under the auspices of the International Board of Plant Genetic Resources, Dr. G. J. H. Grubben has initiated a plan to assemble both grain and vegetable types. Selected entires from our collections are now being studied for biosystematic and agronomic traits. Genetic and physiological studies are planned for a broad evaluation of both crop and weedy forms and a search for evolutionary relationships among the Old and New World accessions.

Feine et al. ( ) concluded that "amaranth has a long way to go to make a significant contribution to the world food base, but interest is high and progress is rapid." We might add that a very promising new crop is at hand, biologically speaking, but the politics and sociology of such new crops are uncertain.

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Table 1.
Food Composition Tables for Comparative Nutrient Composition of Amaranth Seeds

Composition of Foods, 100 grams, Edible Portion

	Food Energy	Moisture	Protein	Fat	Carbohydrate, Total (incl. fiber)	Fiber	Ash	Calcium	Phosphorus	Iron	Sodium	Potassium	β-carotene equivalent	Thiamine	Riboflavin	Niacin	Ascorbic Acid
	Calories	Percent	Grams	Grams	Grams	Grams	Grams	Milli-grams	Milli-grams	Milli-grams	Milli-grams	Milli-grams	Micro-grams	Milli-grams	Milli-grams	Milli-grams	Milli-grams
Cereals	343.5	11.6	11.0	2.7	73.0	2.1	1.7	29.8	334.8	3.4	—	369.3	22.5	.46	.13	3.9	0
Legumes low oil	344.1	10.6	22.9	1.9	61.1	4.7	3.5	122.1	401.0	7.1	20	964.8	23.0	.53	.21	2.2	--
Legumes high oil	483.5	7.8	30.1	32.6	26.1	3.7	3.5	147.5	477.5	5.3	5	1175.5	48.0	1.12	.22	9.7	—
Nuts	648	4.1	15.1	64.3	14.2	2.4	2.4	98.8	468.0	3.7	2	582.3	66.0	.49	.12	1.0	1
Amaranthus spp.-seeds	382.8	11.3	14.5	7.5	60.4	7.5	2.9	368.5	477.5	3.4	--	--	0	.14	.32	1.0	3
Chenopodium spp.-seeds	347	11.4	14.8	5.2	63.7	94.0	4.2	136.5	405.0	12.2	--	--	--	.69	.68	1.3	1.3

Table 2.
Composition of the leaves of amaranth and some other leaf vegetables.

	Values for 100 grams of dry matter													
	% dry Matter	kcal	proteins g	lipids g	carbohydrates g	fiber g	minerals total g	calcium mg	iron mg	β-carotene μg	thiamine mg	riboflavin mg	niacin mg	ascorbic acid mg
Amaranthus spp. (Platt 1965)	15.0	320	33.0	4.7	33.0	10.0	-	1,667	26.7	12,000	0.7	2.0	10.0	667
Amaranthus sp. (Wu Leung et al. 1968a)	16.0	263	28.8	1.3	51.9	11.3	18	2,563	56.0	35,725	0.31	2.6	7.5	400
Amaranthus gangeticus (Gopalan 1971)	14.3	315	28.0	3.5	43.0	7.0	18	2,776	178.0	38,601	0.2	2.1	8.4	693
Brassica (Platt 1965)	7.0	329	21.0	2.9	57.0	11.4	-	571	7.1	257	0.7	0.7	4.3	571
Lactuca sativa lettuce (Platt 1965)	6.0	317	23.0		50.0	8.3	-	583	16.7	3,000	1.7	1.7	6.7	250
Spinacia oleracea (Anon. 1975)	8.0	162	25.0	3.8	6.3	-	-	1,625	37.5	62,500	0.8	2.5	7.5	313

2: 1 kcal. = 4.186 Joule; 1 I.U. pro-vitamin A = 0.6 g -carotene; = negligible quantity.

Table 3.
Amount and % daily dietary requirements of man (65 kg) provided by 100 g. amaranth leaves (15% dry matter)

	Protein*	Ca	Fe	-carotene	thiamine	riboflavin	niacin	ascorbic acid
Amount	5 g	250 mg	4 mg	1800 m	0.1 mg	0.3 mg	1.5 mg	100 mg
% daily requirement	7	50	44	42	8	17	7	333

*Biological value 60% of the reference proteins.

Table 4.
Research on Germplasm Collections.

A. Immediate-High Priority

1. Field evaluation under several regimes, with emphasis on adaptation (planting date, density, water/N)

2. Genetic variation (use family data) for both seed/biomass yield and quality criteria.

3. Hybridization and composite gene pools generate recombination/variation.

4. Mass and recurrent selection (using selfing series)

5. Standardization of highly promising stocks.

B. Long Term-Medium Priority

1. Biosystematics

2. Heritability and character associations.

3. Crop-weed gene exchange.

4. Historical origins and evolution of diversity.

5. Conservation through seed storage; periodic regeneration; gene pools.

THE COSTS OF QUALITY IN PLANT PRODUCTION

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Concepts of quality in agricultural products lead to a wide array of definitions. Some like color and taste are largely subjective while others such as digestibility and protein content can be given rigid quantitative description. Whether based on biochemical composition or morphology, quality attributes represent the end state of plant metabolism and growth and development processes. Thus they are subject to manipulation through crop management or genetic means.

To be efficient in the manipulation of quality factors, we need understanding of the mechanisms which control them. Our progress towards developing such understanding has been slow, particularly in the critical areas of growth and development. While knowledge of metabolism has advanced greatly, a large gap remains between knowing about a metabolic pathway and interpreting quality variations in the field. We need progress also in what might be called "whole-plant" or "environmental" biochemistry. My intent today is to outline an aspect of that subject -- assessment of the costs of biosyntheses of chemical compounds which contribute to quality.

Interest in the "trophic efficiency" of microorganisms and animals is very old. Basically, that takes the form of establishing how much new biomass, or metabolic product, can be formed from a given amount of substrate. Over 100 years ago, Pasteur was able to have yeast produce 48.4 kg of ethanol for each 100 kg of glucose fed, an efficiency yet to be exceeded. We can now calculate that his yield was so close to theoretical value of 52.5 kg that further progress will be insignificant. Similar research was focused on the amount of bacterial biomass and on the amounts of milk and butter fat from dairy cows which could be obtained from a given feedstuff. In contrast, plant scientists gave almost exclusive attention to the efficiency of photosynthesis rather than to efficiency in the use of photosynthate. The work of F. W. T. Penning de Vries and his associates of Wageningen, The Netherlands, was an exception. They analyzed the biochemical pathways for the costs of formation of all major biochemical constituents of higher plants including their assemblage in polymers such as cellulose and protein. The work is summarized in J. Theoret. Biol. 45:339-77, 1974, while Neth. J. Agr. Sci. 22:40-44, 1974, provides a simple overview. More recently, D. K. McDermitt (unpublished) has developed an accurate short-cut method for this purpose using empirical chemical formulae.

Briefly, the transformation of simple photosynthetic products such as sugar to elaborate end products involves oxidation or reduction of the carbon and associated elements such as nitrogen and sulfur. Generally, reduction dominates. Energy is conserved but carbon tends to be lost as CO_2 (i.e. respiration). By adding up the biochemical pathways one can total the number of carbons as well as the amount of energy (ATP) and reductant (e.g. NADH) needed. Since the ATP and reductant also can be derived from sugar, those requirements as well as the carbon skeleton needs can all be expressed in glucose equivalents. In the end, one can state that X grams of photosynthate will yield Y grams of product with specific associated exchanges of energy, O_2 and CO_2 (respiration). Y/X then is the "product value" (PV) or yield. Representative examples are given in Table 1.

One can use such tables to compare the material costs for producing different kinds of biomass. For 100 kg of wheat grain composed of 13 kg protein and 87 kg starch and cellulose, the original glucose requirement using nitrate is:

$$\text{Cost} = \frac{13}{0.45} + \frac{87}{0.86} = 130.1 \text{ kg glucose; PV} = \frac{100}{130.1} = 0.77$$

For an oil seed with 40% oil, 40% protein and 20% cellulose:

$$\text{Cost} = \frac{40}{0.36} + \frac{40}{0.45} + \frac{20}{0.86} = 223.2 \text{ kg glucose; PV} = \frac{100}{223.2} = 0.45$$

Thus from the same original amount of photosynthate, an oil crop will produce only 0.45/0.77 or 58% as much yield by weight.

Table 1. Product values of biochemical constituents of plants beginning with glucose.

Product (N source)	Product
	g/g glucose
Threonine (NH_4)	0.86
Lysine (NH_4)	0.66
Protein (NH_4)	0.67
(NO_3)	0.45
Cellulose or starch	0.86
Lipid	0.36
Lanosterol	0.34

This approach fully explains the inverse relationship between yield and protein content (P) generally observed for legumes and cereal grains. And it shows that as an obligate relation, PV = 0.86-0.0063 P, as starch and cellulose are diluted by protein, P. And high-lysine grain is shown to be much more expensive and thus lower yielding than normal grain. It also can be used to show the M. Calvin's claim that 50 barrels of sterol oil (8400 kg) can be produced per hectare each year in the California deserts corresponds to a claim of 88 mt/ha of biomass formation (39 tons/acre) -- a thermodynamically impossible feat with 100 or 200 mm of rainfall.

If 100 mm of water were to flow through the plant in transpiration with a reasonable water use efficiency of 3 mg photosynthate per g water, only 3 mt/ha could be produced. (Actual achieved yeilds with that rainfall seldom exceed 2 mt/ha.) The oil can be related to starch as an alternative product -- PV of starch (0.86) and sterol oil (0.34) are used: 8400 (.85/.35) = 21 mt/ha of starch. Calvin's suggestion is shown to be preposterous.

In more general terms, the formation of exotic biochemicals can be expensive of photosynthate and thus deleterious to yield. Protein is particularly expensive because of the costs of nitrate reduction or nitrogen fixation. An exception occurs with organic acids where PV may be > 1.0 because they carry more oxygen per carbon (more oxidized) than glucose. Flavor and color factors present in small amounts can be ignored. But waxes and oils, lignin and complex secondary products are expensive and will be negatively associated with yield when present in significant amounts.

LAND USE POLICY

William W. Wood, Jr.
University of California

Food and fiber production, housing, energy production, aesthetic and environmental quality improvement, community development, and recreation all place pressure on our land mass. Perhaps more critical than any of these, since these pressures can be converted to market demand, is the pressure of ownership--those components of the land tenure system which encompass subjective value. Ownership and the associated property rights are at the source of most conflicts over land use policy.

Among the major concerns expressed over the availability and use of land are:

Food Supply - feeding an expanding domestic and world population. Questions pertain to technological developments, climatic changes, ability to buy or trade, consumer choice, energy availability, local food self-sufficiency and present vs. future needs.

Quality of Life - farming as the backbone of communities, agriculture as providing open space, opportunities to live in a rural setting and extensive rather than intensive production systems.

Housing - the expanding need, due to both population expansion and affluence, for more residential units. Particularly critical in temperate climates.

Taxes and Economic Activity - even with proposition 13, a heavy reliance upon property taxation for public revenue as well as industrialization at the local level to increase economic well being.

Level of Government - federal and state interests in land use policy as an infringement on local government. With different quantities and qualities of land mass among local jurisdictions, individual interests are not clear. General eroding of local government, i.e. proposition 13, water policy, education, etc.

Private-Public Land - sage brush rebellion activities. California interest may relate more to water rights.

Compatibility - As generations are further removed from farming they find agricultural production practices less agreeable next to residential areas.

Windfalls-Wipeouts - distribution of who benefits and who loses from property transfers.

California and most of the west is semi-arid. Land and water policy go hand in hand.

NUCLEAR ENERGY AND THE "SOFT" TECHNOLOGIES

John D. Kemper
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ABSTRACT

The major source of energy in the United States is oil, but domestic production is declining, and world supplies have encountered political interference. The U.S. has an enormous amount of coal, and will have no choice but to utilize it. Nuclear energy will figure only modestly in our energy future, but is still too important to reject. Nuclear power is potentially dangerous. An extremely serious accident could cause the death of thousands, if the plant is located near a large city; the consequences of an accident could be reduced by a factor of 100 by placing plants in remote locations.

Coal, though abundant, can be even more dangerous than nuclear power. In fact, all sources of energy have risks associated with them, including solar energy. Perhaps the most dangerous source of power of all is hydroelectric power, because of the possibility of dam failures. Since we need energy, we should do all we can to reduce the risks of all sources of energy, while rejecting none.

The "soft" technologies include solar, wind, biomass, gasohol, geothermal, hydropower, and conservation. Solar power as presently employed is not economic, with pay-back of investment ranging from 9 to 22 years, depending upon the area of the country and the cost of comparison fuels. However, solar energy could become extemely important in the future because of prospective cost breakthroughs. Wind power is costly and would require millions of units, covering tens of thousands of square miles, to provide even a fifth of our energy needs. Biomass (mostly, meaning wood) will provide some of our energy, but will quickly come into short supply. Gasohol presently does not offer a net energy pay-back. Geothermal is important in the west, especially in northern California. Hydropower provides only a small portion of our energy, and encounters strong environmental resistance. Conservation is our most effective short-term strategy. Europeans use half as much energy as Americans, but have similar standards of living. They have had to practice conservation for decades, because energy has been expensive. They drive smaller cars, insulate more, have smaller living quarters, and have more efficient industry. In the U.S., important strides have been made in energy conservation by the industrial sector.

AGRICULTURAL WATER CONSERVATION POTENTIALS: ISSUES AND POLICY

Robert M. Hagan, Professor of Water Science and Extension Water Specialist

and

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Types of water losses in irrigated agriculture and potentials for water conservation are outlined. Recoverable water "losses" (seepage, leakage, and spillage during storage and conveyance, and surface runoff and deep percolation during irrigation) and irrecoverable losses (evaporation from water and soil surfaces, transpiration from plants, and losses to saline sinks) are described and illustrated. Differences between on-farm irrigation efficiency and area-wide efficiency are discussed. The applicability of agricultural water-conservation technologies are summarized and their effects on-farm and off-farm tabulated. Reduction in irrecoverable losses, especially evapotranspiration, technically provide the greatest potential for water savings but may have some undesirable impacts. The advantages and disadvantages of reducing recoverable and irrecoverable water losses are described, including possible side effects on groundwater recharge, salt balance, wildlife , and instream uses. Such information should be useful in clarifying the extent to which agricultural water conservation can reduce water demand and provide a sounder basis for determining water policy and for selecting and implementing appropriate water conservation programs where potentials for realistic water savings may be shown to exist.

WATER AND LABOR CONSERVATION - "LEVEL-BASIN IRRIGATION" 1/

Mr. Leonard J. Erie and Dr. Allen R. Dedrick 2/

SUMMARY

Level-basin irrigation, a gravity method of irrigation by which water is applied to level soil surfaces over a short period of time, is assuming increased importance at a time of increasing irrigation needs and concern over energy, water supplies, and high labor costs. This method, as practiced in the Southwestern United States, provides farmers with a reliable means of controlling irrigation water.

This practice can result in high efficiency of irrigation water application, uniform distribution of irrigation water, conservation of fertilizer, elimination of tail water, and reduced labor requirements. High application efficiencies and uniform distribution of water result in an overall reduction in amount of water used and a more favorable moisture level for plant growth, thus increased yields and profits.

The commercial availability of laser-controlled land leveling equipment has made it possible to conveniently level to very precise requirements.

The level-basin system is widely applicable and easily automated. Farmers and consultants in developing farmlands for irrigation may find this system more efficient and less costly than others and worth considering.

1/ Contribution from the U.S. Dept. of Agriculture, Science and Education Administration-Agricultural Research, U. S. Water Conservation Laboratory, Phoenix, Arizona 85040.

2/ Agricultural Engineers

Subject: Role of the Private Consultant in the 1980's
Soil - Water and Crop Management Services
By - Sarkis V. Sarabian

Some comments are in order before I get into what I see for soil, water and crop management consulting in the 1980's. Some of the basic facts that will have an effect on consultants are:

Farm policy will be more political in the future than it has been in the past. We will be moving more from the use of petroleum to the use of resources that are renewable, most of which will be grown by farmers. We are going to be looking at technology which only several years ago we had shelved, but because of the economics today they may be viable. We will be called upon to create new procedures and technics which heretofore have not been heard of.

We will see an increasing interdependence of world economics. Predictions are for a 140 million ton food deficit by the year 2000. Mexico has approximately 50 million population now and by the year 2000 it will be about 120 million. The United States and Mexico will need to cooperate which in the long run will benefit both countries.

The food crisis coming ahead is real and the only solution that is going to solve the problem is going to have to come from a vigorous agricultural developement in the countries that are in need of the food. In order to do this they need technology, equipment and guidance. Right now it is estimated that 750 million individuals need nutritional upgrading in the world. How are we as consultants going to bring these needed changes about?

In soils, I see an increasing use of infrared photography, satalites, scanning technics using computers, the use of radioactive materials for testing procedures and laboratory technics that are becoming more finite as each day passes.

Several years ago we were using parts per million as a testing criteria, today we have parts per trillion. What is this going to do for us as consultants. We are going to start looking for answers in our crop problems that we have heretofore not recognized or have attributed to other broad grouping of soil or water problems. We are going to be looking at more sophisticated soil mapping on a more rapid basis. We have to take into consideration soil manipilation. For example, soils that were classified as class two or class three may thru the use of tile drains, ripping, trenching to mix various soil stratas together will now act more like a class one or two soil.

We will be looking at soils which were considered as uneconomical to farm. This is going to happen for several reasons. They are not making any more land is a very old and tried cliche, but still true. We are going to be farming the shallower soils utilizing drip irrigation which has made it possible today to farm soils under conditions that a few years back we would consider only as having a minimal value from a cropping standpoint. Today, these soils are being actively considered for climatologly suited crops. As cost of the better agricultural land is increased rapidly, poor or less expensive land is being sought after to replace or expand farming operations. I think from a soil standpoint we need to take a more aggressive stance in our agricultural counties as far as zoning is concerned.

This next category really falls in the combination of soil and water. Where we are using furrow and border irrigations the recent development and now the widespread use of precision leveling equipment using laserbeam is becoming very commonplace. Many growers are going to an absolute zero grade and using larger heads of water to make the most efficient use of furrow or border irrigation systems. We are getting higher yields per acre by doing this as well as conserving on water and maximum utilization of our soil Lasers are also used to precision lay tile drains where they are necessary.

Water to is very basic. The farmers attitude that "Ican drill a new well if I'm short of water" is probably going to be something of the past. There is more and more pressure from our urban neighbors and legislators to make sure that those of us in farming will conserve every drop of water that is available. We are causing many problems by over irrigating and wasting water. The high cost of energy certainly behooves every operator to conserve water just from an economical standpoint as well as a conservation standpoint. New water use technology is certainly being rapidly developed. The use of drip irrigation which was mentioned earlier is probably the most dramatic inovation that has come along in water circles in many years. And it is widely accepted and widely used on a world wide basis.

Center pivot irrigation systems is another concept that is catching on primarily thru the Mid West and South West. Lower pressure sprinkler heads are being developed that do not require the high horsepower to boost pressures, rather heads are now being designed that can operate effeciently and economicly at lower pressure and still give very adequate pattern.

The use of soil penetrating agents with irrigation water on soil that has very low permeability or poor infiltration rates have shown good results and has reduced water use as much as one quarter to one third. There is research in progress using these penetrating agents in the area of helping reclaim alkali saline soils more rapidly. We find that some of these agents are also working as a very effective anticrustant.

Large scale water development by the Federal Government appears to be slowed down to a crawl. We have more special interest groups which will severely limit or eliminate water development possibilities so therefore we will probably be relegated to the basic amount of water that we are utilizing today. Through water conservation, we will be able to increase our acreage and production without increased water use. Certain products are being developed help reduce the transpiration of plants thus to help conserve water use. Plastic mulches have been used for this and weed control purposes for many years.

There are several forces that will be driving the farmer and you as consultants. Economic gain and the economic pressures will be with us in the 80's. We must be able to grow more from every given acre with every drop of water and at the same time we may see slimmer profit margins and we will need to produce more from that same acre to compensate. The number of farm operators will decrease, there will be a higher dependence on crop management experti e. There will be a need for consultants to work as farm manager for absentee land owners, which may be from one to many individuals, partnership or a farming syndication. The economics of these operations are often complex and require intensive management skills.

One of the important areas in the 80's will not be just the growing of the crop, but in the marketing of the crop. Housewives are becoming more and more quality conscious. Those who will produce a quality product are going to be in a much better market situtation. We are going to see more future contracting of crops. Today a farmer does not dare plant sugarbeets without a contract from a sugar refinery, the same is true for other crops. Future contracting has advantages and disadvantages. The disadvantages are that you are tied in at a minimum base price in most cases for a long period of time and are not able to take advantage of the spot market opportunities that may occur from year to year. However, on the other hand it does insure a permanent home for the products that you raise and it sets a minimum financial base for your crop.

One of the management service problems is going to be the ability to get adequate farm financing at rates that are reasonable. We are going to be facing a period of time which will be very challanging and will be changing practically on a weekly basis until the monetary system has a chance to settle down.

With the advent of high cost of farming, the risk is certainly going to be higher and individual operators and as a result they will be looking to crop consultants to make sure that everything that they are doing is right, that they are taking advantage of all the latest technology and information available, this includes timing, marketing, cultural operations.

I see increased use of crop management services to the agri-industry. I find myself being utilized more and more by firms who are planning to enter a market which they do not have adequate expertise. This may be a product or a service. They are increasingly looking for professional advice. There has been an infusion of foreign investors in agriculture and here is another opportunity for the crop management.

In my experience most of these organizations look to establishing management services on a local basis. The extent of foreign investors is somewhat dependent on the laws that they now can operate under.

I provide for some of my clients a management consulting service in the agricultural field. I monitor the farming operations on a regular basis, submit a written report as to my observations, and review the billings before they are paid. I sit in a position of an overviewer to look at the total picture, to find areas of weakness and encourage areas of strength. I am the go-between the farm manager and the farm owner. I feel that this area of consulting is going to be increasing quite rapidly.

I think we have to be prepared to meet the challanges that are inherent in this type of consulting. You must know your crops, not only the technical aspect but you have to be able to prepare budgets, help with marketing, etc.

This has been a general overview of the soil, water and crop management service as I see them developing in the 1980's.

CROP GROWTH AND PROTECTION PRODUCT EVALUATION

by W. B. Jordan, AgriDevelopment Company

I appreciate the opportunity of presenting to you some of the programs that we in Agri-Development Corporation carry out in our various functions for agriculture and related interests.

By design, our functions cover a wide scope of activities, from studies that can be adequately carried out in a greenhouse to major multi-million dollar programs of long duration and involving a diversity of agronomic, legal and economic considerations.

Accordingly, our personnel staff must be well qualified not only with excellent training as specialists in the agronomic field but they also must have years of qualified experience in dealing with many and varied complexities of the agricultural industry. Also, with these experiences, actual farm operation pays excellent dividends.

On this occasion, I will discuss just one phase of our consulting and advisory program; the development of new agricultural chemicals and the development of new uses for currently registered chemicals. A successful agricultural chemical has its first practical series of tests in greenhouse and in field development studies.

The following nine (9) are among the more important considerations that are evaluated in our field development programs:

1) Methods, rates and timing of applications

2) Phytotoxicity studies

3) Growth responses

4) Biocidal action

5) Comparison with reference compounds

6) Effects on environment and animal toxicity ratings

7) Effects on yield

8) Summarization of data and reporting

9) Production and market feasibility studies

Once a chemical has sucessfully made these hurdles, then the long and tedious road of qualifying for Federal and State registrations is started and followed through to label acceptance. Totally, this is a long-term program and one that must be evaluated along each step of the way to make sure that the current and total expenditures can be justified.

Working with previously registered chemicals for new uses and/or modification of present uses is much simpler and the total time for expanding the registration is usually much less than with the introduction of a new chemical.

More recently, most of our assignments have dealt with extending the uses of chemicals previously registered. This is partially due to an outgrowth of the high costs and the time factor involved in the development of new chemicals up to and through registration. Thus, the registration of new chemicals for agriculture over the past decade has greatly diminished.

Applying the nine (9) development steps for evaluating a new chemical as mentioned above, the speaker has developed several agricultural chemicals of economic importance. The first two that we will discuss today are classified as Soil Fungicides and were the fore-runners in bringing forth this relatively new field of soil fungicides in crop protection. These two chemicals were developed while I was National Manager for Olin's Chemical Development Department and while serving as Olin's Western Manager in their Crop Protection Division.

The first, Pentachloronitrobenzene, was trade-marked Terraclor, with it's chief claim to fame as being the foremost control for Rhizoctonia, and is commonly used in laboratories, in field trials and as a reference compound where Rhizoctonia is being isolated and identified. Totally, this compound controls five soil fungi of economic importance and is sold in most of the agricultural areas of the world. The second soil fungicide is 5 Ethoxy-3-(Trichloromethyl)-1,2,4 Thiadiazole and is trade-marked, Terrazole. This chemical is an excellent water mold control and is most used for its control of Pythium and Phytophthora in field, nursery and tree crops. These diseases are called water molds because their mobility and their existence depend on the presence of moisture. One of the most important uses for Terrazole in California is for the control of Avocado root rot, Phytophthora cinnamomi, which heretofore was not controlled. This disease is of wide economic importance wherever avocados are grown.

Currently, I am working with new uses for an old chemical, Formaldehyde, in combination with urea, and sold as a fertilizer known as Agramine. Agramine is a product of Reichhold Chemical Corporation of Tacoma, Washington and was first developed for use in the plywood industry. Because of the 54% formaldehyde content, Agramine has certain protective qualities that prevent plants from being attacked by soil organisms. Although Agramine is not sold for, nor any claims made for, the biocidal action, the secondary effect of this fertilizer is to ward off possible attacks by soil pathogens.

The field of soil fungicides is a complicated one because of the changing environment and because of the many soil inhabitants, both parasitic and beneficial. To establish a practical soil biocide without upsetting the soil microflora balance is quite a feat, yet one that is necessary in establishing a long range tool to control certain parasitic organisms.

To better understand some of the soil action by soil fungi and their harmful effects on plants of economic importance, I will now present a 10-minute movie developed by the University of California at Riverside with Olin's financial aid. This film is entitled "The Morphology of Certain Soil Fungi" and reveals quite well what may hurt you without your knowledge.

At this time, I would like to present to you my suggestion of a concept for more adequately serving the farming community in the '80s.

Present day agriculture is fast becoming more complex and much more involved with new cultural practices, new equipment, new techniques, new chemicals, new and more State and Federal regulations and with much higher cost factors, to mention a few. It is no longer feasible for today's farmer to attain profitable production on the same concepts and operating basis that were successful a decade ago. Just a few years back, farmers were not only recognized as rugged individualists, but men who worked out their own problems. Today, we certainly have the rugged individual, but this individual is very keen on keeping abreast of the latest farming information and is more prone to call for outside aid in solving problems and for help in perfecting his overall practices. In this vein, I present a suggestion for those of us in the business of agricultural consulting that we may be more useful to the agricultural community in the '80s.

This idea could not only help the grower in his day-to-day operations for solving specific problems, but also it could help to originate and expand new ideas and concepts, to make advances in cultural practices, to improve pest control, to work out more profitable marketing plans, to aid in financial planning, and in general, to make farming a more profitable venture. To carry out such a program, it is highly probably that an AGRICULTURAL INFORMATION AND REFERENCE CENTER could play an important role. Such centers would be located in the larger and more important valleys, such as the San Joaquin, where there is a wide diversity of important crops involving many cultural and economic practices.

The availability of expert consultants who have been highly-trained and who have had several years of experience in many phases of farming and in aid to farmers could make up a group that could cooperate in carrying out this grower-consultant plan. Members of the consultant group would be available by individual appointment or for group discussions and seminars. Of course, a well-supplied library would be available. Outside guest speakers would be called in from time to time to bring new ideas and concepts. The consultant group could be financially sponsored by a relatively large number of growers and agriculturally related organizations for a nominal fee. The Center could be grower owned and controlled and might become a function of Farm Bureau.

This activity would not take away from the efforts of the University and/or the Extension Service, but would extend and individualize the services for each grower and cover a wider range of activities than commonly offered by these State services.

Further in-depth studies would be made to determine if this idea is a practical one.

W. B. JORDAN

AMERICAN SOCIETY OF AGRONOMY

CALIFORNIA PLANT & SOIL CONFERENCE: JANUARY 31, 1980

AGRICULTURAL DAMAGE CLAIMS INVESTIGATIONS

A review of the degree of legal and/or financial exposure by the agricultural consultant; consider: public opinion, economy of agriculture, etc.

Factors influencing the potential for complaints.

1. Poor farming practices by client.
2. Economic pressures by commodity: market glut, strikes, etc.
3. Influence of weather, soil characteristics, natural competition, cultural practices, etc.
4. Poor practices by the consultant: any manner of fault(s).

Have a firm plan of (re-)action if/when a complaint is received.

1. Listen to the complaint courteously and understand the grower's points.
2. Alert a supervisor; don't "wait and see" if the bomb will really blow.
3. Evaluate the essence of the complaint and call for an impartial investigation soon; i.e. don't wait.

4. Take photographs and appropriate samples. Consider those natural factors which may have played a part in the expression of crop symptoms. Consider also the adjacent spray and/or cultural practices which may have coincidentally influenced the symptoms.
5. Don't admit anything!!

For those involved in any way, especially with pest management, if you have a firm recommendation for action - chemically or culturally - give it in writing even if you know the grower will not follow it. This act puts the consultant on record so that any deterioration of crop condition will not implicate your judgement. Make further reference to all potential hazards adjacent to the target area; this should include sensitive crops as well as school bus stops, one horse corrals, etc. Follow the chemical label without trying to re-write it.

Do not underestimate the value of IPM (Integrated Pest Management), but by all means do not overestimate it either. This philosophy demands an even greater understanding of the crop environment and crop economy. Do not just "practice" IPM; apply it professionally and realistically...or not at all. Both qualities require a full knowledge of 1) the chemicals,

2) the pests and secondary pests, 3) the limits of the application techniques, and 4) the crop, agronomically and economically; i.e. the consultant must know the standards under which the grower must sell his crop.

Agricultural consulting in the 1980's will not be any easier than it was in the 1970's; the field in fact will be more difficult. However because of this, the opportunities for qualified consultants will be greater.

AGRICULTURAL LAND AND ENTERPRISE APPRAISAL IN THE 1980'S

Allan Thode, M.A.I., A.R.A.
January 1980

I am an independent appraiser in Stockton. I have operated my own office there for 14 years. Before that I was with the Corps of Engineers, a federal agency, as an appraiser here in Sacramento. And, going "way back", I was employed in this area as an appraiser by the Mortgage Loan Department of Prudential Insurance Company. I give you this background information to illustrate the three different areas of the business world in which appraisers work and perform functions important to the agricultural industry.

The institutional appraiser estimates land and improvement values for long term loan purposes and sets the parameters for crop budgets necessary in short term financing. The governmental appraiser works in areas that affect the real estate taxes you pay each year, the taxes eventually paid by your estate and estimates market values for real property to be acquired for public projects. If the project is on other people's land, it is usually to your benefit; if its on your land, it is usually to your detriment.

The independent appraiser does work in both of the above categories when hired by governmental agencies, banks or insurance companies. He additionally becomes involved in estimating market values for the following purposes, with private individuals, partnerships or corporations as his clients:

Purchase of agricultural property;

Sale of agricultural property by absentee owners;

Formation or dissolution of partnerships (including divorces);

Sale to or out of a corporation;

Estate planning and formation of trusts;

Special use valuations for estates;

Damage claims;

Litigation involving any of the reasons for which an appraisal is made.

The last stated item is probably the main reason for the independent appraiser's existence. As a part of the daily process in the flow and productivity of business, he isn't important. He becomes a part of the process only when a problem develops. His expertise helps to arrive at a solution through negotiation, compromise or court ruling.

Now to the purpose of the talk. How are the activities of the three types of appraisers, their work product and the yardstick by which most operate -- that of market value -- going to operate in the 1980's? I would like to discuss this in terms of the organization units that will perform the work, the work requirements that will be demanded of them for the purposes stated, and the behavior of the real estate market in which they will be working.

Let's tackle the real estate market first. This commentary, by request, has been prepared in advance. In this fast moving age of world political and economic events, what I say here may have entirely been superseded. We may be at war, we may have world-wide economic collapse or it may be plain old business as usual with only 14±% annual inflation to worry about.

The appraiser's job is to estimate market value. The increasing frequency of shifts in economic events, such as Federal Reserve policies, OPEC price fixings and the behavior of the billions of excess U. S. dollars floating around the world has made "market value" in terms of dollars less meaningful. He has historically relied on past human behavior in the market place to predict the future. He is today faced with determining the influence of so many more events exterior to the property itself. His conclusion is good only for today.

My general observation is that market values of agricultural land will continue to increase in terms of dollars and that the increase will not be related to productivity or net income but more to the behavior of the dollar. Land has some of the characteristics of gold. It's tangible but unfortunately taxable on an annual basis. As a mathematical exercise, $3,000 per acre row crop land compounded at only 10% per year will have a value in terms of dollars of only $7,750 per acre in 1990. This seems like a lot of money, but a parallel in the 70's can be found in the Salinas Valley.

The role of the appraiser in governmental agencies will decrease. Assessor's full cash values are set at 1975 levels plus an automatic 2% per year increase or are based on the sale price if a property is sold. Williamson Act values are set by following a legislated procedure. Less appraisal work and more paper work will be required. Our major public utility has acquired no significantly additional rights of way in the past 10 years due to environmental limitations. Our freeway system is essentially complete, with current state transportation policy opposed to finishing what remains undone. No new reservoirs are in the land acquisition stage and we can't fill what has recently been built. There may be some increased activity resulting from public acquisitions for wildlife refuges and state parks and inverse condemnation actions resulting from Coastal Commission policies and planning actions of other public bodies.

The institutional appraiser will become more specialized and will have more information with which to work. The average dollar amount involved in a productive agricultural operation is rapidly increasing. The complexity and diversity of these enterprises will cause a narrowing and concentration on particular categories of operations with an increasing burden of proper decision making each time an appraisal is made.

Computer technology will become a common operating tool. Complete record keeping demanded by the increasing size of the typical operation will be of benefit as will adaptation of methods of analysis by the lending institutions.

The institutional appraiser's expertise, in addition to being more specialized, will trend toward the overall business concept. The value of all the components as a going business will become important. Not just the land or the buildings or the equipment. However, as agricultural enterprises grow in size but decrease in overall number, the number of appraisers required to serve this phase of the profession will decrease.

As for the independent appraiser, I foresee for him business about as usual. He will have to contend with a greater number of influences that go into his analysis. But, somehow he will come up with a conclusion. The "worry" factors are inflation and the increasing amount of regulatory control reflecting highest and best use of properties. He, too, will become more involved in overall business or enterprise valuation as opposed to what an acre of land is worth.

Most independent appraisers are "mom and pop" type operations consisting of the appraiser with some professional qualifications, a research assistant, a secretary and possibly a part-time draftsperson. It is this way because a personal service is rendered. There are few large independent appraisal organizations serving agriculture. However, due to the increasing costs of operation, I see a partial trend in this direction in the 1980's. This will be to better take advantage of the economics of data gathering and storage, report processing and common use of personnel while at the same time still being able to provide independent personal service. I do not see the independent appraisal business as a growth situation, but one of consolidation and improvement in professional capabilities in the 1980's.

In conclusion, I foresee for the 1980's a less perfect market in which to operate, more governmental regulations affecting values, better communication and availability of data between apppraisers and appraisers and clients, lower staffing in numbers of people performing the function and substantial increases in market values in terms of dollars. We don't have control over inflation and "they aren't making much new land". The agricultural industry in general will benefit from the appraiser's role in the 1980's through decisions arrived at by better availability of working data and more professional techniques applied to problem solving. It will be business as usual (almost) in the 1980's.

Presented by: John P. Stanley, President of Agribusiness Investment Management Servic

Topic: Agriculture Investment and Management Services

(Preceded by Introduction)

This is not a stock broker business with ticker tape and flashing lights,---but there is a similarity in selecting, managing and selling. The development of these services are only beginning to emerge from traditional farm ownership services. Rarely will a farm operator seek services in investment management, ~~services~~. Perhaps that is due in part to the failure of those of us in the business to sell our wares. But I suspect it is related to the farmer's distrust of any outsider poking around in his internal affairs and also, a belief that he does not need any help.

Investment and management is really inseparable; a good investment with poor management will almost always fail and good management operating a poor investment will have a very rough time. While technologies in agriculture are generally supported by complex chemistry and engineering that is beyond the scope of many farm operators, this is not the assessment of his investment and management problems. Most all of the people in agriculture do not believe that any outsider could help him, -- simply on the basis that he is just as smart and more knowledgeable about his farm. To do otherwise, he would have to admit that his ego is shattered. How would he ever admit defeat when he goes to his wife and neighbors that he has called in a consultant? The fact is that to even raise the question of possible improvements is more touchy than family matters. To attest to this fact, I recently made a mailing to 5000 California farmers, asking them to check off on an enclosed card, this item---"I request a no obligation appointment with one of your senior partners to discuss how you may help in an income improvement strategy for our farm." How many replies to do you think I received? Five!

To be effective as an A.I.M. (Agricultural Investment Management) consultant, a very slow introduction and personal rapport must be completed. This is where I fail a number of times. My nature is to get on with the job,--a lot needs to be done. We have a mind to work with,not just an investment management plan.

The need for such services can be documented by every farm lender in this country. Some bankers believe they are the ones to guide their client, but his attorney, the realtor and accountant also think so. I state categorically that any professional that has a conflict of interest in behalf of his client can not do the job. With all of this competition that already has the investor farmer in a squeeze much of the time, it makes the job of the professional very difficult indeed.

The large investor employs the professional because he knows how to use him. He wants a person or firm that has a track record helping others. He wants someone that has been there. He does not want an academician without on-ground experience.

They do not expect you to be an encyclopedia. They expect you to research the tasks they give you, not to carry them all in your head. They look to all of the help you can give in the reference and time frame given. They expect your report to improve earnings, by new projects or the omission of others. Divestiture might be the right course.

Like most consultants, assignments are sought from client prospects where the services rendered have a clear potential to make profits from your work.

Let me blow my horn a bit. I submit that the decisions made in the investment and management processes will make or break an operation more than any technology in engineering, chemistry, pathology or entomology. This is where all practices enter the judgement arena.

Let us start with the fact that agriculture and related businesses, is the largest user of resources throughout the world, including labor. It is necessary for our very survival. Point number two, management decisions (including investment) are regarded as the most critical in the whole process. Point number three, logically there can be no other conclusions than the services I render are the most marketable of any other throughout the world!! Can anyone dispute this?

Be that as it may, I can not approach a prospective client with a head-on statement that there are only three reasons for his rejecting my services.--- 1/ he is not convinced I can teach him something, regardless of my training and experience; 2/he is not convinced there are other options for him to consider (not yet in the frame of mind for a possible change); 3/ he does not have enough available resources to spend $300 per day for my services even though many times that amount might be generated by following a different plan.

As to point number one, I have never seen a farm operation that I could not make a contribution to. Likewise, I have never seen a farm operation that I could not learn something from. This is the advantage of a consultant, accumulating data and information for application elsewhere (with confidential treatment absolute).

For the 1980's. Agribusiness in all of its facets will continue to be under pressure for improvement in investment and management decisions and practices. The small entrepreneur will need more help than ever. Will he let himself loose to employ minds other than his own?

I look to financial institutions to provide some form of investment management service, on a fee basis to their borrowing customers. Some banks are planning such departments, contracting with outside consultant firms, in some cases. The cooperative Agricultural Extension Service in California does not now provide on-farm, farm management service and will not do so under future plans.

This business will be continuing with the large investors. Contract management will be an expanding service in addition to fee consulting. The financial and economic aspects of governmental intervention will be researched and analyzed as never before. Credit controls, taxes, estate penalties, labor and pesticide regulations, land use, water use and market influences are some of these issues.

It is impossible to expect other consultants to assess the feasibility of their recommendations in the science area, excepting in a general way. One must be versed in the objectives of the investor and manager and be able to balance up the judgement on many factors. Preparing an investment management plan takes a lot of experience looking at many varied operations. It must be tailored to a particular investor and manager and on specific property.

How many of you have seen such a written plan? Do they keep it updated? Do they have a meaningful performance measurement system?

I must leave it here. I hope I have given a better idea of the outlook and problems of those in this specialty of the consulting business. To complete this subject I submit for your investment of $15.50 in a copy of my book, entitled "Farming by Design".

STALK ROT OF CORN: INFLUENCE OF FUSARIUM MONILIFORME ON PLANT-SOIL WATER RELATIONSHIPS

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Stalk rot of corn, caused by *Fusarium moniliforme*, is a serious disease in California and other parts of the world (2). Symptoms, which include internal rotting of the stalk and lodging, are not apparent until the plant nears maturity. However, the fungus can be recovered from the basal portions of the stalk long before the onset of symptoms. *F. moniliforme* also causes ear rot of corn although the two diseases apparently are not related.

Observations by growers and researchers indicated that water stress imposed early in the season predisposes corn plants to infection even though symptoms may not be apparent for several months. This study concerns the effects of predisposing water stress on infection and subsequent plant-soil water relationships.

The inclusion of such parameters as root density, rates of soil water extraction, and root colonization required the use of a soil of uniform texture and infestation throughout the rooting profile. This was accomplished by incorporating ground barley straw infested with *F. moniliforme* into a field soil which was then used to fill large cylindrical tanks (5 ft. in diameter by 5 ft. high) made from corrugated steel pipe. The tanks were lined with polyethylene and placed over a bed of gravel covered with fine nylon mesh to facilitate drainage. Soil was then added to a depth of 4.5 feet leaving a 6 inch rim for flood irrigation. Ten plants were grown in a circular pattern in each tank to give an equivalent population of 22,000 plants per acre. The experiment was conducted in Davis, California, in 1978 and 1979.

Treatments consisted of infested and noninfested soil with plants either not stressed or stressed for water beginning one month after planting. Water potential of stressed plants was about 2 bars lower than controls at the termination of the treatment period. Plant water potential and diffusive resistance were measured with a Scholander pressure chamber and commercially made porometer, respectively. Relative water content of leaves was determined by standard procedures. These three measurements were made periodically from predawn until after sunset on three days during the drying cycle following relief of water stress. Additional determinations were made two days after the drying cycle was terminated. Root density was determined in soil cores of known volume by the line intersect method, and root colonization by *F. moniliforme* was assessed with a surface sterilization and agar plating technique. Soil water content was measured periodically with a neutron meter, the instrument having been calibrated in the soil tanks.

Water potential of previously stressed plants at midday in infested soil became progressively more negative than both noninfested controls and nonstressed plants in infested soil with readings of 2 to 4 bars more negative than the other three treatments at 21 days after irrigation. At this time the nonstressed plants grown in infested soil also had midday water potentials of 1 to 2 bars lower than noninfested controls. However, after the next irrigation plant water potential at midday in both infested treatments was significantly more negative than the noninfested controls.

There were appreciable differences in diurnal cycling patters of diffusive resistance among treatments. At three days after irrigation there was a significant midday closure of stomates in previously stressed infested treatments beginning at 10:00 am and lasting until 1:30 p.m. No such closure was observed in the other treatments on this day. At 8 days after irrigation midday closures were apparent in all treatments but amplitudes and duration in the infested treatments were much greater. There was a second closing cycle of about 1.5 hours duration in both infested treatments just prior to sunset. At 21 days after irrigation there were essentially no differences in stomatal cycling among treatments. Three days after the next irrigation the diurnal water potential and diffusive resistance characteristics in both infested treatments were identical with much greater amplitude than either of the noninfested treatments.

There were no detectable differences among treatments in the relationships between leaf water potential and relative water content and only slight deviations among the relationships between plant water potential and diffusive resistance. Thus, differences in diurnal cyclings of plant water potential and diffusive resistance, particularly the midday closures, were probably not caused by differences in leaf water characteristics. A more likely explanation is that resistance to water uptake is increased in roots infected by F. moniliforme. This conclusion supports a currently accepted mechanism for stomatal cycling (1). Under conditions of high evaporative demand when the rate of decline of leaf water potential far exceeds the water absorption capability of the root system, a feedback mechanism operates to increase diffusive resistance, i.e. close stomates. This results in a decreased rate of transpiration and arrests the precipitous decline in plant water potential. Under extreme conditions the feedback loop overcompensates by closing stomates to such an extent that photosynthetic productivity is impaired. Such overcompensation is usually caused by increased resistance in the liquid water transport system, primarily the roots (1). Because there were no differences in root density or leaf area index between infested and noninfested treatments under identical irrigation regimes, I conclude that the progressively increasing duration and amplitude of the midday closures in the infested treatments during the drying cycle were caused by greater resistance to water flow through infected roots. Laboratory studies are needed to test this hypothesis.

Rates of soil water extraction during the drying period provided additional evidence for the altered plant-soil water relationships caused by F. moniliforme. At the 25 cm depth, abrupt decreases in rates of water extraction occurred at about -2.0 bars and -0.65 bars for the infested previously stressed and all other treatments, respectively.

Rate of root colonization and proportion of roots with systemic infection was several-fold higher in previously stressed than in nonstressed plants. However, the differences were much smaller after termination of the drying cycle. While stalk rot did not occur in this experiment, the fungus was recovered from 93% and 43% of the basal internodes of plants previously stressed or not stressed, respectively.

Several conclusions can be drawn from this research regarding symptom development and disease management. It has long been known that various types of stress, including nutritional, temperature, and water, predispose corn plants to infection and stalk rot development (2). This study showed that water stress imposed early in the season increases the rate of root colonization by F. moniliforme, which results in corn plants less able to cope with conditions of high evaporative demand later in the season. As leaf area increases, these plants spend a greater proportion of the daylight hours under stress conditions during which photosynthesis may be greatly impaired. During periods of reproductive growth, corn plants compensate for reduced photosynthetic productivity by mobilizing stored carbohydrate reserves in the stalk and translocating them to the developing seed (3). The net effect is to reduce stalk strength and pith density, which is more conducive to invasion by F. moniliforme.

Considering that F. moniliforme was present in a nonstressed treatment in which plant-soil water relationships were indistinguishable from noninfested treatments early in the drying cycle, it should be possible to control this disease by careful water management early in the season. This would be difficult because the relatively mild stress imposed in this study did not manifest itself in classical water stress symptoms. Thus, absolute criteria in the form of plant water potential thresholds for various physiological stages of development would have to be established above which predisposition does not occur. Unless set irrigation schedules were used, this would mean that plant water status would have to be continually monitored. The use of remote sensing of leaf surface temperature by thermal infrared thermometry might be helpful in this regard.

Irrigation management in semi-arid conditions may not suffice in preventing predisposition by water stress. Under California's Central Valley conditions, transpirational demand simply cannot be satisfied by the limited capacity of the corn plant to absorb water. Thus, plants may ge into stress even though the soil is at field capacity. In this situation, the use of antitranspirants or reflectants may alleviate stress conditions. The use of drought resistant varieties and the development of varieties which do not sacrifice stored carbohydrate reserves in the stalk also could be explored.

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ROLE OF RHIZOBACTERIA IN INCREASING PLANT GROWTH AND CROP YIELD

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There are many reports claiming that specific bacteria, when inoculated onto plant parts such as seed, cause significant increases in plant growth and yield. Scientists in general have been skeptical about the reports of increased yield because, frequently, replicated plots were not used nor were data evaluated by statistical analysis.

Our experiments with specific strains of plant growth promoting rhizobacteria (PGPR) have conclusively shown that stimulation of plant growth by bacteria is a real and valuable phenomenon. A total of 33 replicated field plots, each testing 3-6 different PGPR for ability to increase growth and yield of potato, radish, and sugar beet have been made since 1975. Statistically significant increases with potatoes have ranged from 5 to 33% in 7 of 11 field plots in California and Idaho. Yield increases by treating sugar beet seed with PGPR ranged from 4.4 to 8.4 tons per hectare with increases of total sucrose yield from 20.7 to 26.9 cwt per hectare ($P = 0.05$ or 0.01) in four out of six plots. Field tests with radish resulted in increases ranging from 60 to 144% in seven of seven trials ($P = 0.01$).

Specific strains of PGPR were initially selected from several hundred root colonizing bacteria isolated from excised roots of field grown plants. Most of the strains which have growth promoting capacity produce a wide spectrum antibiotic. However, the vast majority of bacteria that exhibit antibiosis towards fungi and bacteria do not stimulate plant growth in greenhouse or field trials.

PGPR resistant to the antibiotics rifampicin and nalidixic acid were used to examine their root colonizing capacity and persistence in the field. With potato, PGPR from inoculated seed pieces rapidly colonized emerging roots with populations up to 1 x 10^6 cfu/cm root two weeks after emergence in field tests. Populations averaged 10^3 cfu/cm root throughout the season, but declined to about 10^2 cfu/cm at harvest time. The bacteria colonized the entire root of treated plants, including developing daughter tubers and the apical roots of adjacent non-treated plants. The mechanism of action appears to be related to interactions of PGPR with other microflora. When radish was grown under sterile conditions, there was no significant difference in weight between radish plants in PGPR treated and non-treated flasks indicating that effects of PGPR are not caused by the elaboration of hormones or growth factors.

In experiments with potato, mutants of PGPR which no longer produced an antibiotic were obtained by mutagenesis with nitrosoguanidine, ethyl methane sulphonate and ultraviolet light. These antibiosis negative strains did not affect growth of plants in contrast to the parent strains. The mutants had growth rates similar to parent strains, and still retained the capacity to colonize plant roots.

Experimentation has shown that inoculation of plants with PGPR results in a change of the microflora around roots. Populations of fungi were reduced from 23 to 60% on roots colonized by various PGPR in comparison to controls. Most of the fungi that were displaced were saprophytes, including Penicillium spp., Aspergillus spp., and saprophytic Fusarium spp.

The occurrence of gram positive bacteria on roots of potato colonized with PGPR were reduced up to 93% compared to controls. Mutant PGPR that no longer produced an antibiotic had no effect on reducing populations of either gram positive bacteria or fungi that colonized roots.

The greatest problem in using PGPR in field experimentation concerned the viability and stability of inocula. Initial experiments were done with aqueous suspensions of bacteria, but this was not satisfactory as the bacteria did not survive long in water suspensions and were difficult to handle under field conditions. After several years' work, a technique utilizing various gums to preserve bacteria was developed. The gum-bacterial suspensions were then incorporated into talc and dried. Bacteria in this state have survived up to one year with no appreciable loss in viability. This formulation proved successful in field tests and inoculum could be applied to seeds or potato seed pieces as a dust.

SOIL MICROORGANISMS IN RELATION TO PLANT GROWTH (ASA MEETING)

COMMERCIAL UTILIZATION OF VESICULAR-ARBUSCULAR MYCORRHIZAL FUNGI TO INCREASE CROP GROWTH

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Mycorrhizal fungi of the vesicular-arbuscular (VA) type are very common beneficial fungi associated with the roots of most crop plants. Mycorrhizal fungi are beneficial because they enhance plant absorption of mineral nutrients such as phosphorus, zinc, copper, sulfur and probably other elements.

Mycorrhizal fungi are very sensitive to fumigation with some soil fumigants, particularly methyl bromide. They are killed when subjected to doses of 12,000 ppm methyl bromide for 7 hrs or longer. Most commercial fumigations with methyl bromide surpass this level, at least in the top 18 inches of soil where most mycorrhizal spores are concentrated. Mycorrhizal fungi are more sensitive to methyl bromide than most soil-borne plant pathogenic fungi. Therefore it is not realistic to avoid destruction of mycorrhizal fungi by reducing fumigation doses of methyl bromide. The elimination of soil-borne pathogens is the prime motive for soil fumigation and if doses of methyl bromide are reduced to levels which will allow mycorrhizal fungi to survive, pathogens will survive also. In most field fumigations, the mycorrhizal fungi quickly reinvade the fumigated soil. However, in some situations reinvasion does not occur rapidly and stunting of plants results. Such situations frequently occur in nurseries or greenhouses where repeated fumigations prevent the build-up of mycorrhizal populations. Other soil fumigants which have caused stunting-following-fumigation under expermental conditions include chloropicrin, carbon disulfide, dazomet, 1,3-D, vapam and vorlex. Steam sterilizing or autoclaving soil will also destroy mycorrhizal fungi. Extended flooding used to leach salt from the soil may also result in a severe reduction in the mycorrhizal fungi population.

In fumigated soil or in soil where mycorrhizal fungi have been killed, inoculation with mycorrhizal fungi is capable of stimulating growth of many crop plants. Growth of citrus may be increased by 20-1600%, avocado 200%, corn 259%, soybeans 122%, cotton 100%, grape 4900%, and tomatoes 17-395%, by mycorrhizal fungi in fumigated or sterilized soils. Therefore, inoculation with mycorrhizal fungi may be the answer to the stunting-following-fumigation problem. Many nursery and greenhouse operations have attempted to avoid the stunting-following-fumigation problem with heavy fertilization programs which are often costly. In one trial, citrus seedlings inoculated with mycorrhizal fungi were equal in size to nonmycorrhizal citrus seedlings fertilized with 100-500 lbs of phosphorus/acre. At the current cost of triple superhosphate, mycorrhizal inoculation could result in savings of $45 - 226/acre in the cost of phosphorus fertilization of citrus in fumigated nursery soil. Mycorrhizal fungi also reduce the need for zinc and copper fertilization. Futhermore, they are capable of reducing salt-damage because they cause a reduction in the uptake of sodium and magnesium salts.

Mycorrhizal fungi are obligate symbionts which means they cannot be grown axenically. However, large amounts of pathogen-free mycorrhizal inoculum can be economically produced under greenhouse conditions. Mycorrhizal inoculum is currently being commercially produced at least on an experimental basis by several companies.

Field inoculation with mycorrhizal fungi can be done by coating seeds, layering, and banding with mycorrhizal inoculum. Mycorrhizal inoculum can be applied with standard fertilization or seeding machinery.

Mycorrhizal fungi do not provide growth responses to plants in all soils. Normal healthy plants can be grown in very fertile soils without mycorrhizal fungi. Predictive equations have been devised to indicate which soils require inoculation with mycorrhizal fungi following fumigation. For citrus, fumigated soils with less than 34 ppm phosphorus (bicarbonate), 12 ppm zinc, 27 ppm manganese, or 3% organic matter should be inoculated with mycorrhizal fungi before planting.

Some species and strains of mycorrhizal fungi are more efficient symbionts than others. Recent experimentation indicates that some of these superior strains can stimulate plant growth even in non-sterile soil when in competition with indigenous mycorrhizal fungi.

Parasites of mycorrhizal fungi have been isolated and identified. Some of these parasites can destroy mycorrhizal fungi and result in stunted growth of plants. Although these parasites of mycorrhizal fungi do not attack plants, they can be considered plant pathogens.

Vesicular-arbuscular mycorrhizal fungi can provide some resistance to specific root pathogens. Non-compatible mycorrhizal fungi may provide the best resistance.

SECTION: Soil Microorganism in Relation to Plant Growth (ASA Meeting)

GENETIC ENGINEERING OF ROOT NODULE BACTERIA OF LEGUMINOUS PLANTS

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The *Rhizobium*-legume symbiosis is the single most important contributor of available (fixed) nitrogen to the biosphere. Genetic engineering of root nodule bacteria is the application of genetics for improving these crucial symbiotic organisms. For example, root nodules of soybeans (*Glycine max*) inoculated with most strains of *Rhizobium japonicum* have been found to release considerable amounts of hydrogen whereas nodules from a minority of strains evolve little if any H_2. Physiological, biochemical and genetic studies have shown that a significant portion of the energy consumed during symbiotic nitrogen fixation is apparently wasted during nitrogenase-mediated H_2 evolution.

A number of studies have pointed toward a significant benefit of the H_2 uptake system to overall plant productivity since energy limitation is one of the major factors in nitrogen fixation in soybeans and other legumes. A comparison of soybean productivity in experiments conducted with Hup^+ (strains with an active H_2 uptake system) and Hup^- (strains which lack an active H_2 uptake system) strains of *Rhizobium japonicum* have shown that the Hup^+ strains are more efficient symbionts. Also, a comparison of plants (grown in the greenhouse and growth chamber) inoculated with isogenic Hup^- mutants (derived from Hup^+ parents) yielded significantly less nitrogen reduced yields than the parent Hup^+ strain which synthesize the hydrogenase system. Thus, *Rhizobium* strains used as commercial inoculants should have the capacity to synthesize the hydrogenase or H_2 uptake system as one of their desirable characteristics.

The H_2 uptake system (Hup) in *Rhizobium japonicum* can now be monitored qualitatively and quantitatively by a variety of assays including whole plants or detached nodules, through H_2 evolution or uptake or through correlative studies isolated colonies in free-living cultures induced for hydrogenase activity measured chromatographically or amperometrically or by the tritium-exchange assay. The last mentioned assay is the preferred assay in view of its specificity as it is a measure of the activity of hydrogenase itself while the first two assays measure the H_2 uptake system. In addition there is a strong correlation between hydrogenase activity in free-living cultures and that obtained with whole nodules. Nevertheless, it is important to keep in mind that the conditions developed for hydrogenase induction in *Rhizobium japonicum* may not apply to other nodulation groups and that exception among *Rhizobium* spp. may be observed. As such it may be necessary to also monitor nitrogenase activity in free-living cultures as an additional index of inducibility of the system since it has been observed that both hydrogenase and nitrogenase may be under the same regulatory control.

In this paper data on the percentage of Hup^+ strains in several commercial inoculants will be presented. The majority (68%) of the strains found in these samples are Hup^-. Similarly, a survey of the soybean nodules in the major soybean production regions will be presented. The majority of the nodules formed by *Rhizobium japonicum* strains in the USA are also inefficient with respect to H_2 utilization. The major defect in this case lies with the microsymbiont since *Rhizobium japonicum* harbors the *hup* genes. It might be possible by genetic engineering in the future to introduce a small plasmid containing the *hup* genes into strains that currently lack them, increasing energy efficiency without significantly reducing the strain's ability to compete in its original environment. Progress on *hup* plasmids will be discussed.

N Fixation in the Rhizosphere and its "Importance"

The continuing escalation in the cost of nitrogen fertilizer has prompted considerable research into the area of nitrogen fixation during the last decade. Aside from the well-established contributions of N fixation by legumes, questions still remain about the so called "importance" of asymbiotic or more particularly "associative" N fixation in the rhizosphere. Repeated experimentation with temperate grasses has failed to establish fixation rates higher than 5 kg N $\cdot$ $ha^{-1} \cdot yr^{-1}$, and in many cases, the rates are much lower. Calculations derived from estimates of bacterial growth rates, maintenance energy, N conversion efficiency, and plant productivity would confirm that N fixation in temperate grasses is insignificant. Moreover, the rates of fixation derived from macerated root tissue of tropical plants in vitro bear little resemblance to what probably occurs in nature. Nevertheless, the nitrogen balance of tropical grasses produces a dilemna since removal rates amounting to 100-200 kg ha in unfertilized tropical soils does not appear to cause any dimunition in the N content of the soil.

Central to the understanding of N fixation in nature is that the process is inhibited by a plentiful supply of NH_4^+ and requires a labile energy source. Thermodynamically, this makes "sense" to the bacterium since it is cheaper to make an amino acid by transaminating NH_4^+ with a keto acid, thereby conserving the supply of carbonaceous substrate that would otherwise be combusted to produce the energy required in converting N_2 to NH_4^+. Thus, there are elaborate control mechanisms in bacteria that "shut off" nitrogen fixation when NH_4^+ is present.

In N-deficient soils, effective nodulated plants obtain N through fixation by the bacterium and in turn supply the necessary carbohydrate for energy.

There is no indication that this occurs to any great extent outside the plant in the rhizosphere; from an ecological point, this is not unexpected for the simple reason that available carbon is the most limiting factor governing the growth of microorganisms in soil and competition for it is very keen. Thus many better competitors which do not fix N may deprive N fixers from the supply of carbohydrates. Moreover, the rhizosphere ecology of soil bacteria in temperate climates has generally been shown to be selective towards amino acid utilizing bacteria since amino acids--not carbohydrates--are the primary excrement from plant roots.

The futility of soil inoculation in unsterilized soil has generally been recognized by soil microbiologists for 80 years. This futility is also applicable to the introduction of *Azotobacter* or any other symbiotic N fixer for the simple reasons that these organisms are already indigenous to the soil and that their ability or inability to maintain a given population level is solely dependent upon how well they compete with other microflora for an extremely restricted supply of available carbonaceous substrate. Furthermore, any N fixed by *Azotobacter* is not necessarily released to the plant. The relatively small fraction of *Azotobacter* present in soil (about 0.01% of the heterotrophic bacterial population) makes their significance questionable. Massive inoculation of soil *in vitro* with *Azotobacter* rarely increases the rate of N fixation. Only when a labile substrate is added to soil is there a significant (ten to one thousand fold) increase in N fixation, as measured by acetylene reduction. Since there is generally no difference in the higher rate in the presence or absence of *Azotobacter* this clearly indicates the importance of available substrate, and raises the question whether Azotobacter or other more abundant N fixing bacteria, such as Alcaligenes, are the responsible agents.

Manipulation of environmental conditions which favor the growth of beneficial bacteria is the most practical management procedure which is likely to be successful. The addition of plant residues to the soil or the excrement of organics by roots both add available carbonaceous substrates to the soil. Green manuring or crop residue incorporation has generally been avoided because such practices may immobilize mineral N because of the high C/N ratio. Yet, there is mounting evidence to suggest that in the long run, the addition of such residues may add more N to the soil as a result of assymbiotic N fixation. What is not clear is how much N is fixed, and how much is immobilized by N-poor fractions of plant material such as polysaccharides. By analogy, the rapid and prolific growth of tropical grasses such as Digitaria decumbens conceivably could add more carbohydrates to the rhizosphere than what is normally found in temperate plants. Thus, the dilemna concerning the "thermodynamic impossibilities" of asymbiotic N fixation determined from temperate agronomic conditions may be inapplicable to tropical crops.

Finally, the dynamics of the N cycle in the rhizosphere are much greater than in non-rhizosphere soil. It is well-established that the processes of ammonification, nitrification, and denitrification are higher in the rhizosphere, so it would follow that N fixation should also be higher. The recent discovery that many species of Rhizobium and Azospirillum are simultaneously both N fixers and denitrifiers may imply that the cycling of N vis a vis the atmosphere and soil is more rapid than presently envisioned when N balances are calculated by a "black box" approach.

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ALGAE AND PHOTOSYNTHESIS

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Photosynthesis in the soil is carried out by diverse types of eukaryotic algae, prokaryotic algae (cyanobacteria) and photosynthetic bacteria. Of these microorganisms, the algae are by far the most important from the standpoint of the earth's photosynthesis budget. The prokaryotic algae, in addition, contribute significantly to nitrogen fixation in the soil.

Until recently, one of the poorly understood features of the different types of algae and other photosynthetic organisms is the means by which photosynthesis is regulated. Recent work in our laboratory has been designed to answer this question. For technical reasons, most of our experiments have been done with chloroplasts isolated from higher (C_3) plants. Cell-free preparations from algae, used in certain experiments, show a similar regulatory pattern. Corresponding experiments have not been performed for plants showing C_4 photosynthesis.

Our experiments have led to the discovery of a new system of enzyme regulation. In this mechanism, photoreduced ferredoxin--an iron-sulfur protein that functions as an acceptor in photosynthetic electron transport--activates key regulatory enzymes of chloroplasts. In the light, electrons from chlorophyll are transferred to ferredoxin and then via the enzyme ferredoxin-thioredoxin reductase to thioredoxin, a small protein present universally in living cells. Reduced thioredoxin, in turn, reduces and thereby activates a number of enzymes of chloroplasts, some of which are indicated in Fig. 1. Four of these enzymes (fructose 1,6-bisphosphatase, sedoheptulose 1,7-bisphosphatase, NADP-glyceraldehyde 3-phosphate dehydrogenase, phosphoribulokinase) are key enzymes of the reductive pentose phosphate cycle--the light-driven mechanism

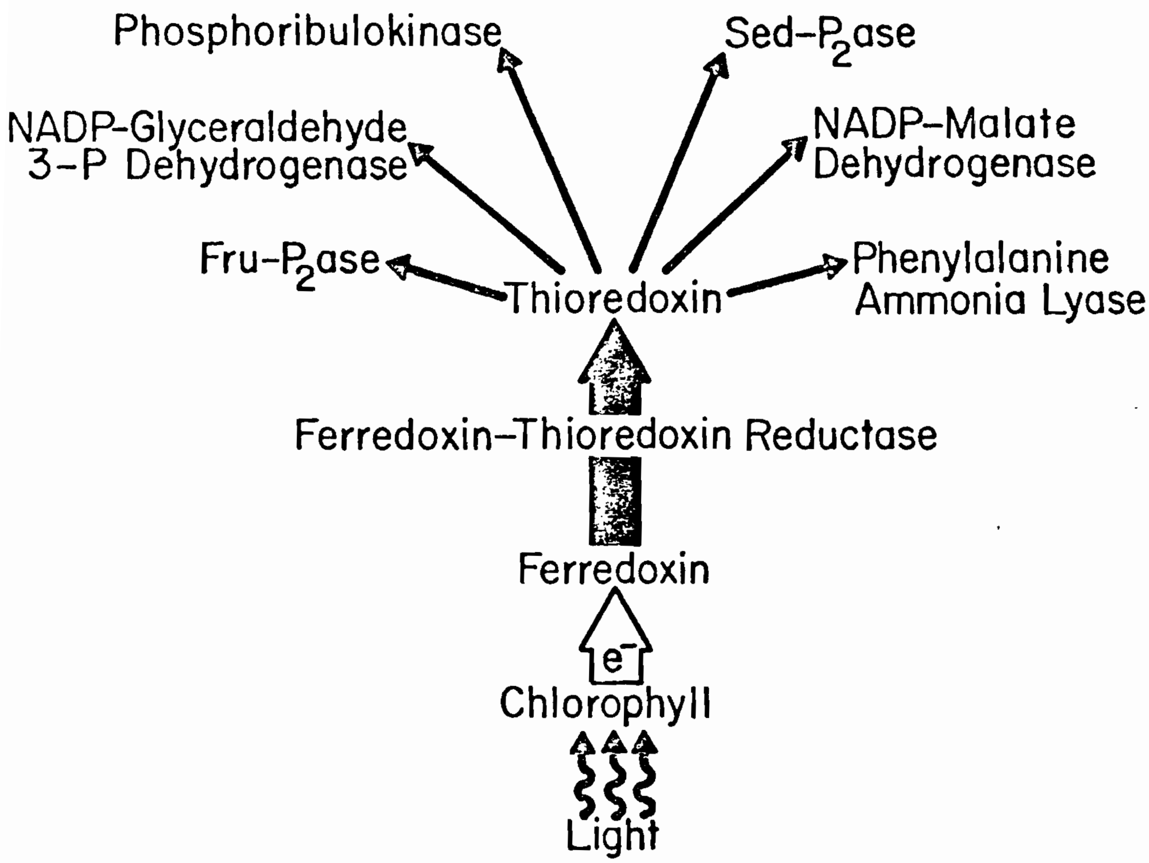


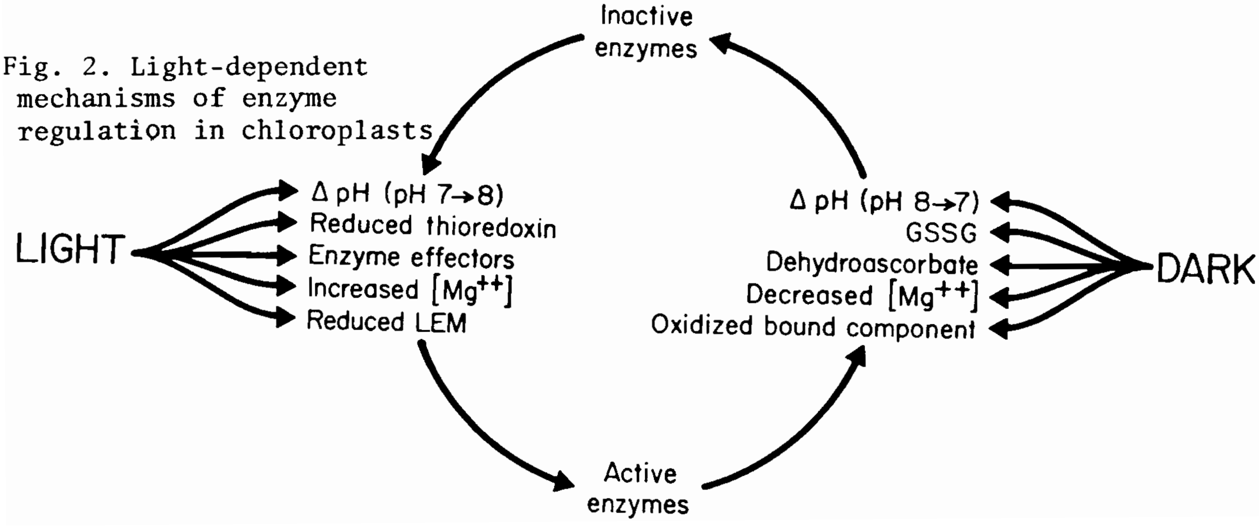
Fig. 1. Role of thioredoxin in the light-dependent activation of chloroplast enzymes. Fru-P_2ase = fructose 1,6-bisphosphatase; Sed-P_2ase = sedoheptulose 1,7-bisphosphatase.

whereby algae and higher plants convert carbon dioxide to carbohydrates and other cell components. The regulatory role of thioredoxin has recently been extended to different algae and to photosynthetic and fermentative bacteria. Certain of these enzymes may be rate-limiting in particular biosynthetic processes. There is a growing body of evidence that one of the thioredoxin-linked enzymes is rate-limiting in photosynthesis, at least in algae and C_3 plants.

The ferredoxin/thioredoxin system brings about a conversion of the light signal, via chlorophyll and the associated photosynthetic apparatus, to a reductant signal (reduced ferredoxin). The reductant signal is transmitted via ferredoxin-thioredoxin reductase to thioredoxin and then to key enzymes of biosynthetic and perhaps degradative processes as well. Thioredoxin thus may be visualized as a regulatory messenger between light and the enzymes of processes that utilize the products formed by light, i.e., ATP and NADPH. In this capacity, thioredoxin 'alerts' key enzymes of diverse biosynthetic processes that the light is turned on and that biosynthesis is to proceed. It currently seems that the ferredoxin/thioredoxin system functions jointly with other light-actuated regulatory systems in chloroplasts (Fig. 2). These mechanisms include light-generated (i) enzyme effectors such as ATP and NADPH; (ii) shifts in pH and Mg^{++} concentrations; and (iii) membrane-bound oxidants and reductants (LEM).

In summary, evidence now at hand shows that, in addition to supplying assimilatory power (ATP and NADPH), light plays a major role in enzyme regulation in photosynthesis. Evidence obtained from a variety of experimental approaches has revealed that, in contrast to previous notions, the carbon reduction phase of photosynthesis in both algae and higher plants requires light for the activation of a number of specific enzymes that are either sluggishly active or totally inactive in the dark. In achieving these different regulatory effects, light has been found to act through several chemically sophisticated mechanisms that utilize the photosynthetic apparatus to produce agents that alterthe activity of selected enzymes. Certain of these enzymes catalyze reactions that could potentially be limiting in photosynthesis. The work may thus be relevant to the understanding of the factors that limit the growth and productivity of algae and higher plants.

Fig. 2. Light-dependent mechanisms of enzyme regulation in chloroplasts



PETROLEUM PLANTS FOR FUEL AND MATERIALS

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The possibility for the development of an economically useful solar energy and materials system is an outgrowth of, and in a sense, a return to, an older system: We can use the best existing solar energy-capturing device we know, the green plant, by selecting and modifying it to produce the materials we want, namely, hydrocarbons of suitable molecular weight and structure. We have yet to choose the particular plants with which to begin such a large-scale development, although information is currently at hand that will make such a decision feasible in the near future.

The choice of plant(s) will depend on growth rates and habits, hydrocarbon productivity and harvest adaptability, as well as process development. Our experiments, and those of others, have indicated the economic feasibility of the production of oil from hydrocarbon-producing plants, particularly species of _Euphorbia_ and _Asclepias_. With the continued increase in cost of petroleum from fossilized photosynthetic residues and the continued decrease of its availability, the development of this alternate energy source becomes absolutely necessary.

From: Calvin, Melvin. 1979. Petroleum plantations for fuel and materials. Bio Science 29:533-538.

The Role of Genetics in Integrated Pest Management

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The role of genetics in Integrated Pest Management is both intimate and comprehensive. Major areas of interplay include: 1) inheritance of host resistance to pests, 2) variability in pest populations, 3) co-evolution of host-pest populations, and 4) strategies for use of host resistance in conjunction with other control procedures, viz., cultural manipulations, pesticides, etc.

Plant breeders became intensely aware of the potential of host resistance soon after the rediscovery of Mendel and resistant varieties have played a major role in the stabilization of agricultural production. The future use of pest resistance as a potential replacement for or minimization of the extensive use of pesticides should be emphasized. The present awareness of the possible adverse impact of pesticides on non-target organisms, including those functioning as components of natural pest control, mandates an increased effort in discovery of new sources of resistance and an evaluation of the strategies for their use and deployment. This view is supported by the fact that resistance in pests to many of the newer "single-site" mode of action pesticides is becoming an increasing problem. By enlightened integration of the use of pesticides with resistant hosts it should be possible to reduce our dependence on pesticides and extend the life span of both specific sources of resistance and pesticides.

An elucidation of the genetics of host factors conferring resistance is essential in attempts to develop varieties resistant to a complex of pests. Through this approach genes conferring resistance or tolerance to pests can be incorporated systemicatically into varieties without adversely affecting or losing agronomic characters that contribute to pest control.

Future studies on the genetics of parasitism and pesticide resistance in pest populations will play a major role in determining long-term success of control programs. Such studies will provide the basis for management decisions regarding deployment of resistant host germplasm as well as selection of appropriate pesticides.

Many pests can and will be controlled in the future through development of resistant varieties or those that allow the host to escape the impact of pests. Early maturity plant type and modifications of cultural practices, when considered in relationship to pest life cycles need to be further exploited. Our understanding of the co-evolution of host-parasite systems on a population basis regarding the influences of the host on shifts of biotypes and races in the pest and deployment of host germplasm is still infant in practice.

Recent advances in genetic enginnering and manipulation should greatly facilitate the incorporation of useful germplasm from exotic sources into useful agronomic varieties. Thus the role of genetics, although extensive in the past, can be expected to be even greater in future pest control programs.

Guayule--A Rubber Crop for the United States in the 1980's

by George P. Hanson and Staff
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In addition to food needs, a major challenge for the 1980's will be to find new energy sources or more efficient ways of utilizing existing energy sources. For the energy dependent United States, any crop which will reduce our dependence upon imported petroleum and simultaneously reduce other imports will be a welcome addition. Such a crop is guayule. It provides natural rubber equivalent in quality to the imported Hevea product, the demand for which may soon exceed the supply according to world economists. In addition, a plentiful supply of natural rubber in this country may reduce the demand for synthetic rubber and thus reduce demand for its precurser--petroleum.

Guayule, Parthenium argentatum Gray, is a perennial desert shrub native to Northeastern Mexico and Western Texas from which natural rubber can be obtained in commercially viable quantities. Although the plant has been sporadically harvested in a commercial manner from wild populations for nearly a century and over 30,000 acres of cultivated crop has been grown in Southwestern United States it has never been domesticated. In order for guayule to become an important crop for the United States it is necessary that plant breeders and other agriculturalists make increased yields possible and significantly reduce stand establishment costs. Plant breeders have set a goal of 1,000 pounds of rubber per acre per year as achievable within 5-10 years and economists agree that such a yield would allow growers to obtain a reasonable return from their investment.

The high rubber-bearing guayule plant is unusual in that it is up to 95% apomictic. This makes hybridizing and selection difficult but does provide for preservation of desirable gene combinations once they have been obtained. Guayule has a number of relatives which hybridize freely with it and which can contribute a number of useful attributes, however, they bear no rubber. Guayule is a prolific seed producer so that once obtained, a desirable genotype can be rapidly propagated. Although difficult to root from cuttings, guayule is a perennial that produces retonos (adventitious shoots from underground roots). This trait can be encouraged genetically and culturally. It is possible to stimulate rubber accumulation in guayule by spraying the plant with a bioregulator a few weeks before harvest. The ability to respond to bioregulators is under genetic control. The bioregulator seems to encourage the plant to develop to its genetic potential but different genotypes have different potentials.

The plant has need for the typical types of genetic improvement associated with other crops: yield (quantity and quality of rubber); disease, drought, salt, cold, and herbicide tolerance; wider ecological adaptation and more efficient water utilization. The plant as harvested contains a number of by-products which need a technology developed to efficiently utilize the leaves, wood pulp, waxes, and resins. Data will be presented to illustrate the progress to date and to suggest the rate of progress expected in the future.

This work has been supported by grants from the National Science Foundation and from the State of California Department of Food and Agriculture.

THE FUTURE OF VEGETABLE AND FLOWER VARIETY DEVELOPMENT

David J. Thompson

(Summary of talk presented at CALIFORNIA PLANT AND SOIL CONFERENCE, CALIFORNIA CHAPTER, AMERICAN SOCIETY OF AGRONOMY, 1 February 1980)

Predicting the future is a risky business, attested to by the persiflage directed at the efforts of such professionals as weather forecasters, astrologers, and football coaches. Nevertheless, horticultural plant breeders are engaged - on an almost daily basis - in predicting the future and in planning for it. The predictive ability of plant breeders is tremendously important because of the direct responsibility they have in the overall task of feeding the world. It is pertinent, therefore, to consider how we got where we are, where we might be going, and how we might get there with respect to vegetable and flower variety development.

Basic food sources, plants and animals, were the same for primitive man as for modern man. Manipulation of these sources, on a conscious and directed basis, probably took place when human tribes abandoned roving and elected to live in one area. Our modern technology has failed to introduce many important new food crops into agriculture; the ancient origin of many of our cultivated plants bears witness to the efficacy of primitive man and his practice of simple forms of plant breeding. Modern plant breeders, particularly since the advent of the science of genetics, have vastly improved primitive genotypes. The plant breeding aspect of modern agricultural technology may, however, have also set the stage for catastrophe on a huge scale by encouraging monoculture of varieties with a narrow genetic base. The "genetic vulnerability" resulting therefrom cannot be over-emphasized.

Future trends in variety development include more hybrids. Economics of the agricultural marketplace are of themselves potent enough factors to assure an accelerating trend towards hybrid varieties. More and more new varieties will have multiple disease and insect resistance. Environmental concerns coupled with human health considerations are, and will continue to be, major motivating factors. We can also expect to see increased efforts in the area of breeding for nutritional value. When people are faced with starvation, they tend to become less critical concerning what they eat. Vegetable plant breeders would do well to address themselves on a larger scale to this issue. Added breeding emphasis can be expected earlier maturity in the future, allowing for increased multiple cropping of land. Last, but not least, varieties of the future may well be resistant to various environmental stresses and will be selected to be productive under lower energy outputs.

It is expected that most varieties of the immediate future will be developed by convential plant breeding techniques. Some varieties, however, will be totally unique types resulting from the economic application of plant cell and organ culture techniques. It is important to recognize that a great deal of basic research needs to be done before genetic engineering through plant cell techniques can be applied to the improvement of plants fo the future on a wide scale. It is equally important to recognize that the potential is there, and that these techniques offer an apparently limitless future.

January 1980

1980 Plant & Soil Conference
Sacramento, California

1980 President
California Agricultural Production Consultants' Association

The role of the private consultants in the 1980's will be professionalism and continued expertise on the part of the pest control advisor. In my presentation, I will cover areas of Professional Responsibilities, Considerations for Crop Treatment Evaluation, Utilization of Integrated Pest Management:

Professional Responsibilities:

1. The farmer must have a marketable product - this is primary consideration for a Pest Control Advisor;
2. Use of I.P.M. to its utmost potential;
3. Avoid large multiple combinations of insecticides when possible;
4. Adjust acreage responsibilities to season to enable more frequent checks during "pressure periods";
5. Keep pertinent information per field up to date regarding changes in crop use, days to harvest, daily weather forcasts, irrigation and fertilization schedules;
6. Use any and all expertise available on special problems. Never assume an answer to an obvious problem. There are no obvious problems.

Consideration for Crop Treatment Evaluation:

1. Use of Crop - (insect parts and residue standards)
   a. Frozen - no insect parts tolerated - check Canner's Guide for residue tolerances;
   b. Fresh - no less critical on insect parts generally - check label for residue tolerances.
2. Stage of Growth of Crop - (insect pressures vary with ability of crop to out-grow populations)
   a. Seedling - very vulnerable to medium to heavy populations of aphids and lepidoptera and some coleoptera;
   b. Accelerated Growth Period - vulnerability limited by type of crop (ex. cornear worm on lettuce is a serious problem during this time and must be prevented once presence is determined vs cabbage looper on broccoli or cauliflower which can be monitored and chemical applications timed properly;
   c. Marketable Product Present - very vulnerable stage as must be clean within 3-5 days before harvest.
3. Type of Crop - (physiology and product placement on plant has definite persuasion on management approach)
   a. Leafy - lettuce families or marketable leafy products present reasons for stricter management practives;
   b. Head - cole crops, corn and head lettuce present varying pressures depending upon season of rotation and natural enemies present;
   c. Fruit - cucumbers and melons can have early insect problems such as

Consideration for Crop Treatment Evaluation:

3. Type of Crop - (continued)
   c. Fruit - (continued) ...aphids, lepidoptera and mites that will effect plant vigor and fruit set as well as heavy pressure during growth period from cucumber beetles therefore close monitoring is necessary for proper timing of chemicals;
   d. Tubers - because little has been agreed upon concerning the time and rate of infestation of crops that are grown below the soil surface a preventive program is used for the major pests during the time of economic pest pressure.
4. Proper Identification of Insects Present - (numbers/plant per counted plot)
   a. Pests - establish economic importance, and numbers of various stages present;
   b. Parasites and Predators - must be in proportional balance to pressure observed considering crop type, pest number and days to harvest;
   c. Type of Feeders - considering both pests and beneficials must evaluate crop stage, weather, insect stage, and use of crop in addition to whether the pest is an internal or external feeder.
5. Season of Rotation - (insect life cycle vs weather)
   a. Seasonal varieties - consider growth rate and insect life cycles;
   b. Chemical selection - consider performance dependence upon certain temperatures by some shorter residual type formulations vs longer residual non-temperature dependent chemicals with better timing.
6. Days to Harvest vs Market Price - (a definite interrelationship when USE is a consideration)
   a. Chemical choice - certain chemicals automatically eliminated b/c of closeness to harvest;
   b. Treatment elimination - some treatments eliminated b/c of closeness to harvest (ex. no usual clean-up treatment on FRESH broccoli or cauliflower with a low population of cabbage aphid or looper on outside leaves during warm weather b/c additional treatment would cause farmer to lose money on field where crop us just meeting its own cost (must have previous experience with processing sheds policies on acceptance and know areas insect habits)
   c. Politics - in some instances market drops and processor overloaded so will dump crops regardless of state of crop, therefore know processor and how grading is going.
7. Mobility of Insect - (alternate hosts and feeding sites)
   a. Crop Plant - awareness of insects ability to move on and within plant and/or in a field as well as to adjacent fields containing other vulnerable crops;
   b. Weed hosts - use as monitoring agents for population increases when in field with alternate crops hosts (ex mallow-green peach aphid-cole crop cycle-can monitor GPA presence, numbers, possible parasitization and movement using mallow) *

*Elaine Hale, Hale Agricultural Consultation Service, Santa Maria, California, (reprinted and quoted by permission)

Utilization of Integrated Pest Management:

Alternate Control Measures - (including rotation, tillage, fallow, and time change in planting and harvesting)

A. Sugar Beets:

1. Russian thistle (common name Tumble weed) is controlled along fence rows and railroad right-of-way; tumble weed is a host to leafhopper which transmit curlytop virus in sugarbeets;
2. Aphid control to prevent virus yellows; aphid is controlled by mechanical means;
3. Host-free period. During this time sugar beets cannot be growing. This is enforced by the Agricultural Commissioners' Office;
4. Chemical Weed Control. Herbicides are banded over seed line instead of broadcast rates, thus reducing the amount of chemical applied per acre. An example would be: recommended rate: 4#/acre broadcast, grower request two 8" bands over seed line, or 16"/40" = 40% of acreage or 1.6# instead of 4#/acre (bedtop and shoulders are cultivated).

B. Lettuce:
1. Chemical control for weeds: Broadcast rate is 4#/acre. By using two 5" bands (10"/40") the chemical applied is reduced 75%. Again, using I.P.M. by reduced chemical material and cultivation, weed control is maintained.
2. The P.C.A. works with his respective growers on not using sprinklers on lettuce because of potential incitement of anthracnose or downey mildew which could destroy a crop if a fingicide were not applied. By using this I.P.M. technique, we can reduce the amount of fungicides applied.
3. Control of Sclerotinia (Lettuce Drop); the P.C.A. recommends high beds to keep moisture away from senescent leaves (older leaves) because pathogens thrive on the older leaves. Should a fungicide treatment be necessary, the application is made to the base of the plant to treat soil by band application. Application is only made if history of soil has sclerotinia or a crop rotation was similiar. Irrigation is done low in the furrow and only the seed line is wet, keeping moisture away from older leaves lying on the ground - very important later in crop maturity;
4. Insect I.P.M. in lettuce: Yes, we allow the lacewing and the big-eyed bug to prey on the green peach ahpid. But once the head of the lettuce starts to form, a chemical application is made to keep the aphid or worm out of the growing point of the lettuce plant. Once the economic injury level is reached, the aphid is predator ratio is not balanced and it then requires a chemical treatment;
5. Area where biological control cannot effectively work; early cabbage looper or alfalfa looper infestation in lettuce, as we experienced last season, and will probably expect again this year, requires immediate chemical application to protect the growing point of that crop. Economic injury levels were, and are now, being reached prior to thinning stage. This type of infestation does not allow for biological control. Lygus control: Biological control here is not effective. The adult pierces the midribs of the lettuce causing discoloration. Again, chemical treatment is required. However, we do control weeds on headlands where lygus populations appear to keep infestations under control. Or, if the field is downwind from alfalfa, we may talk to the alfalfa grower about treating his field for lygus populations.

Last year we had both lygus and looper attacking lettuce (Fall). With the

Utilization of Integrated Pest Management:

B. Lettuce (cont)

frequency of lygus flights I used biological materials, Pyrenone, to control lygus and the Bacillus thuringenis to control the looper. This worked effectively and safely but was costly to the grower.

C. Celery IPM:

1. Herbicides used and applied on planted areas on a band basis, rather than broadcast, thus reducing amount of chemical applied and cost to grower.
2. Pink rot control: P.C.A.s and growers recommend not transplanting the plants too deep to avoid direct contact with soil, thus avoiding unnecessary fungicide applications. If the base of the celery plant comes in constant contact with the moist soil, pink rot could develop. In the fall plantings, where wet weather is expected, fungicide applications are made, but on only selected field-by-field basis and banded to the base of the plant, again not broadcast.
3. Late blight of Celery : IPM The P.C.A. works with the growers on suggestions to avoid spread of this seed-borne disease - no overhead sprinkling is done after initial setting of plants. The sprinkling incites the organism. Also, close monitoring of equipment, together with thorough cleaning after each field use, assists in controlling the disease.
4. Insect control in celery: I.P.M. is difficult to use in celery except for weed control on headlands and monitoring of adjacent crops for insects. Pest control in celery is very definately a challange. Leafminor and worms are a major problem. BTB works occasionally. The main problem is that the density of foliage does not allow the material to be properly placed, thus worms will not feed on treated areas reducing effective control.
5. Plow-down dates are enforced by the Agricultural Commissioner's office with total cooperation by growers to control spread of virus yellows in the County of Monterey.

D. Cauliflower and Broccoli: I.P.M.

1. The P.C.A. recommends to his growers that he does not use sprinkler irrigation since this may cause water spot, thus reducing any unnecessary fungicide applications;
2. Systemic insecticides used at side-dress have decreased. Many P.C.A.s have found that injury levels are not reached at this stage in the crop - thus systemic sidedress applications have been reduced;
3. Aphid: The aphid can be controlled by careful monitoring and timed application at a later stage. There is a parasitic wasp which parasitices the cabbage aphid, but the ratio of parasites to aphid does not allow biological control to be effective. If the plant is at a stage where the infestation has not reached the injury level, I will allow the aphid to remain while being parasiticed, but once the plant head starts to form, a chemical application will be made to control aphid.

I might add here that the parasiticed aphid (mummies), even though they are dead, are still "insect parts." Whether they are biologically controlled or chemically controlled, the crop would not meet standardization laws due to insect parts. One year a cannery was complaining about ladybugs on spinach that had been harvested. We need to look at these standardization and cannery requirements.

Two years ago a shipper requested I contact one of his broccoli growers. The grower was having difficulty with aphid in his field. I investigated the problem. The 'seasoned' P.C.A. was not properly monitoring the field and was not timing his pllication accordingly. As a result this P.C.A. has retired. Times are changing. This P.C.A. was spraying 4-5 times while other P.C.A.s, both independent and commercial, had sprayed 1-2 times, or none at all, and still were maintaining control. The control was - proper monitoring, timing and use of I.P.M.

The examples of Integrated Pest Management are practices that each Pest Control Advisor takes into consideration as an alternative pest control tool before his final decision is made.

IN CONCLUSION: Agricultural Production for the 1980s

Any and all cultural and biological methods should be considered and applied if and when feasible and not economically devastating to the farmer and/or consumer. (Explanation: a philosophical point of view to some but none the less valid -- cultural and biological control of insect, disease and rodent problems take more time than chemical control; however, if the farmer can afford for any reason whatsoever to follow a cultural method he should be encouraged. But if that cultural method means a loss of the availability of the crop at an affordable price as well as a possible decrease in employment on the ranch in the midst of a cultural control program, the social impact must be weighed as heavily as whatever chemical impact there is presumed.*

*Elaine Hale, Hale Agricultural Consultation Service, Santa Maria, California, (reprinted and quoted by permission)