The Drought Myth

An Absence of Water is Not the Problem

by William A. Albrecht, Ph.D.

When we keep breaking heat records, and when droughts are being classified as national emergencies, it seems appropriate to make some observations on the crop disasters under what is commonly called "drought." We may well study some of the factors concerned beside the weather records and the meteorological parameters. In place of using these extended rain-free periods as the alibi, perhaps a more complete analysis of the situation will exhibit the soil as a contributing factor. Perhaps through it there may be some means of mitigating the disastrous effects associated with what is commonly called "drought."

Some geographic characters of the droughts suggest that they are highly continental. Within larger land bodies, the unexpected weather comes more often. That is another way of saying that the weather records for certain short periods may vary widely from the climate, or from the average figures for extended times. As an illustration, Columbia, Missouri, had an annual rainfall in 1953 of only 25.12 inches in place of 39.33 inches, or what was the average of over more than a half century, and what was considered "the normal." The rainfall of the year 1953 was 36.1 percent below normal (assuming that "the normal" hasn't gone lower, too). Accordingly, we may expect rainfall to go above normal by that figure some of these days. This, then, tells us that the continental effect may amount to that much above or that much below "the normal." It may be a variation totaling 72.2 percent of "the normal." Thus, we have had in 1953 what amounts to a continental effect of 72.2 percent or a new record of continentality as well as a new record of low rainfall.

The variations in temperatures from the mean, and the long periods without rainfall or the drought, must be put into that category of continentality along with the variation in inches of annual precipitation. Droughts, then, which involve both high temperatures and extended rain-free periods, become disasters because (a) longer periods between rainfalls represent soils dried to greater depths, (b) soils have less and less water evaporating from them directly and from the vegetation growing on them to spend the sun's heat in vaporizing it, and (c) the atmospheric temperature rises high enough thereby to injure the plant tissues because of the record heat wave.

Sanborn Field with its shallow but fertile surface soil over the infertile clay subsoil, which characterizes the Putnam silt loam, illustrated well the drying of the soil to great depths of its profile. Water exhaustion of the soil to near the permanent wilting point of the crop went deeper and deeper as the corn roots, for example, were marching downward like an army for more water. On their leaving the fertile surface soil exhausted of water, and on entering the infertile subsoil for the stored water there, the lower leaves of the corn plants were "fired." This yellowing of those older leaves represents a case of robbing them of their nutrients for the survival of the younger, growing top leaves. It reports the decided shortage in delivery of fertility brought on by the transition of the roots from one fertile soil horizon to the other less fertile. But the growing leaves at the top of the plants did not necessarily wilt.

That fact tells us that the "firing" is not due to a water shortage. It is the wilting of the growing tip of a plant that tells us when a plant needs water, as every woman keeping house plants knows very well.

Data from the Soil Conservation Research project at McCredie during the summer drought of 1953 showed the corn crop exhausting the soil moisture to a depth of 3.5 feet under the fertilized soils. The equivalent of only 1.04 inches of water was left in that entire depth. Where the soil was not fertilized, the crop dried out the soil to a lesser depth. It left the equivalent of 4.5 inches of water in the upper 3.5 feet. On the unfertilized corn, which took 14 inches of water from the soil, the yield was only 18 bushels per acre. It required 26,000 gallons of water to make a bushel of corn. On the fertilized soil with a yield of 79 bushels, only 5,600 gallons of water per bushel were required. The drought was a case of plant hunger rather than thirst.

This was a clear demonstration that the soil is a factor in the drought, not through differences in the stored water in this case, but rather as it represents fertility by the management of which the specific supply of rainwater can be made to yield so much more in crop returns. It suggests the possibility of more fertility to greater depths of the soil as the way to use stored water more efficiently. We need not only to store water to greater depths but to store fertility to such depths also. The drought drying the soil down to 42 inches and spending 16 inches of stored soil water to give 79 bushels of corn certainly would be considered much less of a "disaster" or of an "agricultural emergency" than the drying of it to only about 36 inches and spending 14 inches of soil water but getting only 18 bushels for that cost in water. Unfortunately, the rainfalls after the drought of the summer of 1953 and before the summer of 1954 were not sufficient to restore the moisture in the soil to those depths of its previous drying.

During the drought of 1954 the different levels of soil fertility represented by the plots on Sanborn Field suggested forcefully that the drought may be injurious to plant processes because of high temperatures. It suggested also a more severe injury to plant tissues according as the higher soil fertility represented more actively growing plants.

Where corn has been grown continuously since 1888 with crop removal and no soil treatment, the plants remained greenest of all corn plots on the entire field. Only the lower two leaves on the stalks were "fired." The other eight leaves, though much rolled, showed no irregularities. The stalks were tassled but were without shoots. One would say it was about the customary "short" crop which that plot has been growing for many years.

On the adjoining plot where 6 tons of manure per acre have been used annually, the much taller and heavier stalks had the lower five leaves badly "fired." The remaining six leaves were rolled. But they were not visibly injured. The stalks were well tasseled. The plants were without shoots, suggesting no grain production.

On the nearby plot where heavy crop residues were turned under and the soil given

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full fertilizer treatment — including nitrogen — only a single lower leaf was "fired." The other 13 or more leaves were closely bunched on the shortened stalk. The tassel had not emerged. There were no shoots or signs of ears. More significant, however, was the observation that the leaves were badly bleached from their tips back to almost their mid-length. This part of the leaf tissue was dead. Save for its widely different appearance, the damage took a pattern suggesting the same leaf area involved when the plant suffers from nitrogen deficiencies in the soil. It suggested death in the area where the extra nitrogen was involved in growth rather than where there was a deficiency.

When the more vigorous plant growth for seed production involves more physiological functions, it seems reasonable that high temperatures might be more disturbing to the living processes centered in the expectably higher protein content of the cells than to those in plants growing less vigorously and doing little more than making the minimum of carbohydrates, like starch and cellulose. Processes of growth and life are activated by enzymes, compounds resembling proteins in some respects. They are decidedly thermolabile, or are killed by temperatures going above 45 C or 113 F. The proteins of vigorously growing plants may not be so widely different in their responses to high temperatures than are fertile eggs under incubation. Eggs give a good hatch when the temperature is held at 100 F. But a few hours of 10 F above that temperature will ruin the hatch even if the egg protein is not coagulated or even coddled. No visible signs of injury are recognized until the egg really dies and processes of change or decomposition have had time to give their evidence. The death of the corn leaf under the high temperature of heat wave suggests a close similarity, and time is required for the disturbed plant metabolism to indicate itself as may be suggested by accumulation of nitrates to the danger point as poison for animals consuming the green fodder. One may well be reminded that crops growing in the tropical heat are not high producers of protein.

Droughts are disasters to crops because they are more than shortages of water per se. They are disasters because they are (a) shortages of soil fertility and (b) excesses of temperature. When they are the latter they represent little that we can do to offset the damage. As the former, or shortages of fertility, their disasters are not necessarily mitigated if we merely apply water. Soils made both deeper in structure required for water storage, and more fertile also to that depth, will lessen the damage in the drought years but will also give bigger yields in years of no drought. When once we appreciate the soil as a factor in the drought, then we can use the years of no such damage to build the soil fertility for less of disaster from the drought when it occurs. Fertility is the major means of managing soil to mitigate drought damage, and to give bigger crop returns when there is no drought.

The heat wave of 1954 was disastrous to animals in Missouri as well as to plants, according to the reported deaths of poultry and rabbits from the excessive temperatures. The mounting temperatures correlated with increasing numbers of deaths of experimental rabbits on grain coupled with hay grown on soil of different treatments suggested that the nutrition of the animal and not the high temperature per se is the factor in the fatalities associated with the heat.

Seven lots of nine rabbits each, separated from the larger original stock, were fed on wheat of a single lot and on timothy hays grown on soil given different treatments: (1) Full fertilizer treatment; (2) this supplemented by copper; (3) by boron; (4) by cobalt; (5) by manganese; (6) by zinc; and (7) by all these trace elements.

With the mounting temperatures of the drought and heat wave, many of the experimental rabbits died and replacements were made from the remaining original lot (which had suffered no heat fatalities) at the weighing date after a fortnight. Those in the original lot were fed on the same wheat as the experimental lots, but the roughage of the former was green grass growing on soil fertilized with rabbit manure. During the period June 11 to July 17, 1954, a total of 57 rabbits died on the timothy-wheat ration, while in the same room there were no deaths of the original lot remaining on their wheat-grass ration and tolerating the same heat wave. This represented maxima ranging from 88 to 113 F and a mean maximum of 99.4 degrees during the fortnight closing with July 17. On that date the wheat-timothy hay ration was supplemented with 10 gm. per rabbit per day of commercial dried milk powder. No more deaths occurred during the extension of the experiment for nine more days. Maximum daily temperatures ranged from 89 to 111 F. with a mean maximum of 98.2 F.

A repeat of this test was started July 26 using corn, oats, and wheat in equal parts by weight along with the same timothy hay. This trial exhibited again the fatalities with the high temperatures until August 23, when the feeding of the timothy hay was discontinued and replaced by red clover hay. No deaths occurred during the extension of the test with red clover hay from August 23 to September 6, during which the maxima of temperatures ranged from 79 to 102 F with a mean maximum of 97.6 F for those 14 days. For the fortnight preceding the date of change to red clover, the maxima ranged from 70 to 98 F, with a mean maximum of 82.5 F. With the close of this test there were still eight rabbits left of the original lot kept on the wheat-grass ration during the entire summer, among which no fatalities occurred as a result of the record-breaking heat wave. These disasters, ascribed to drought as mainly a water shortage in the soil allowing the increasing insulation to raise the temperature to excessive degrees, represent differing fatalities according to nutrition of either plant or animal. They suggest hope in our efforts for their mitigation in some degree, when viewed less as rainfall shortage and heat waves beyond our control and more as nutrition via the soil.