HOW PLANTS FIGHT DROUGHT*

DROUGHT is ugly. It produces immediate ugliness and it begets a further ugliness that may, as man measures time, last forever. Even the word is ugly. Look at the printed word "drought". Try to pronounce it slowly. You immediately become conscious of the snarl in that gutteral "gh", the snarl that one feels in the dry winds when the sky becomes brazen and the leaves begin to curl. It is the snarl of a hidden menace, of a challenge to a fight that is not a combat, for, during a drought, life does not fight an opponent, it fights itself; it fights its own prodigal tendencies; it fights to make itself use what it has sparingly, to make itself endure yet one more day.

In this fight for life, plants are the shock troops. Indeed, it is impossible to define drought except in terms of its effects on plants. It can not be defined in terms of rainfall.

For instance, the eastern part of the State of Washington receives practically no rain during the summer months, but the farmers there do not call this drought. They would receive no sympathy if they did, for they raise about twice as much wheat per acre as do the farmers in western Kansas, whose soil is just as fertile, who get about the same amount of rain per year and who get it well distributed during the growing season. No, drought can not be defined in terms of rainfall.

Suppose we say, "A drought is a period during which plants suffer for lack of water."

That sounds complete, but is it ?

Would you say there was a drought if you observed plants in your garden that lacked water ? You know you would not.

Perhaps the biggest question-mark that emerges from this definition is, "What *kind* of plant?" For plants are neither simple nor alike. They are complicated enterprises that have been slowly developing for thousands and thousands of years. Because they have developed under different conditions, perfecting different ways of meeting competition and the innumerable difficulties presented by a constantly changing world, they have produced so many combinations of differences in behavior and appearance that no man can hope to call more than an insignificant fraction of them by name. That these countless differences, though subtle, are yet, decisive, we learn when we try to grow them. What is intolerable drought to a tough-looking plant like English ivy suits a snapdragon so well that it produces its delicate-looking flowers in abundance.

You see, drought-resistance can not always be judged by appearances. Different plants meet the problem of drought in different ways, yet the basic problem is common to them all.

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* By Howard E. Pulling, Professor of Botany, Wellesley College, in *The Scientific Monthly*, August, 1935.

All green plants are manufacturing establishments and obtain their raw materials from their surroundings. From these raw materials they make many things, among them food. Every living thing requires food —food from which to obtain the energy for keeping alive, still more energy for growing, more still for working, and yet more to store for their future and that of their offspring. This food is made chiefly from two substances: water, obtained from the soil, and carbon dioxide, from the air.

Now, this is only one of the many uses of water. Another important one is that of inflating all the cells in the soft parts of the plant, so that, like inflated tires, they can support loads placed upon them. If the amount of water in the plant falls too low, the cells become flaccid and the leaf or young stem wilts.

Thus the manufacturing plant faces a dilemma in building its factory. On the one hand, it must always hold enough water for the mechanical requirements of support and growth. On the other hand, if it can not obtain enough carbon dioxide, it can not store food for the future, or, lacking more, it can not build new tissue, and if it lacks too much it can not even remain alive. Herein lies the dilemma: wherever carbon dioxide can enter, water can leave. The drought-resistance of a plant depends upon the effectiveness with which this dilemma is met.

The common plants with which we are familiar form a more or less waterproof covering over the older parts of the roots, over the stem and, except for microscopic pores, over the leaves. Thus the roots may absorb water through their tips, and the leaves absorb carbon dioxide through the pores. If the plant is like some of the willows and has no mechanism by which these pores open and close according to conditions, it must live where it is never difficult to obtain plenty of water. It can not withstand the mildest of droughts.

At the other extreme are plants like the cactus and the Austrian pine. When conditions are such that the factory must close, when no food-manufacturing is possible, they really close the factory. They close it so completely and effectively that they are as safe as seeds.

That is unemployment insurance carried to the limit. The food-manufacturing cell that works for a cactus or an Austrian pine has apparently been guaranteed for its entire life against loss of its job because of shutdowns.

Not so those that work for coleus plants. Let a coleus become suddenly startled by dryness about its roots and it will discharge every food-manufacturing worker so promptly that morning finds the plant a bare pole with leaves in a heap at its base.

Other types of manufacturing plants do not lose their courage so quickly. The courage of some, like the touch-me-not or the pumpkin, is but blind, hopeful courage. They are not resourceful; they operate as long as they can and go bankrupt when they must. But others do have resources. Some, like the snapdragon, concentrate their cell-sap so that less water will evaporate when the pores are open. What changes this

may make in the way the cells live, no man can say, but there must be changes, for this concentrated sap becomes more and more poisonous the more concentrated it becomes. For many kinds of plants this program would be fatal. Perhaps that is what happens to the fesque grasses. Many a lawn of fesques has looked well after a dry summer, but died before spring. Perhaps the owner attributed this to cold, but the damage was really done before, and the plants died in the latent condition.

However, not every kind of plant forces the food-manufacturing cells to take such risks as these, while the cells in the roots that should be finding water sit day after day with their feet in the same place. No, indeed. The first thing done by them is to put the fear of the future into those root-cells and get those feet into motion. Many of the drought-hardy members of the grass family try this as one scheme to save the business.

This is apparently the reason that in eastern Washington wheat grows better with practically no rain during the growing season than it does in western Kansas, where the rainfall appears to be well distributed. In Washington the rain falls during cool, cloudy weather. But little evaporates. The rest is stored in the soil. When spring wheat is planted in April or even in May, the young plants find moisture near the surface. As the summer advances and becomes drier and drier, the roots grow deeper and deeper, finding water all the time.

Unfortunately, when the acquisitive instinct is aroused in a living creature, it is likely to exercise none of its faculties except those helping it to get what it starts after. Roots are no exceptions. In Kansas, hot, dry, windy weather alternates with the rains. Much water evaporates. The rest is near the surface. The eager, go-getter roots, dominated by the single purpose of obtaining water, grow towards that surface and — a dry period kills them.

We lawn-owners should remember this, for the roots of our grass will do the same thing. Water that penetrates dry soil does not distribute itself evenly. It travels downward for a distance that is determined by the amount of water applied. Within that distance the soil is very moist. Below it, and the line is sharp, it is dry. So if you can not apply enough water to wet the soil to a depth of several inches, it is better not to water at all.

No plant has devised a perfect method—neither orthodox methods like these that have enabled plants to survive everywhere throughout great areas of country, nor the little, tricky schemes that work only under some special set of conditions. But we must leave this plant question-mark, for others also appeared when our definition exploded.

Such another one is the drought question-mark. We have just seen that there are different kinds of droughts: in Kansas the drought is generally below ground, whereas in Washington it is above ground. In most northern dwellings, there is an above-ground drought in the winter, but it is a dark drought, not a drought full of bright sunshine, as in Washington.

Also, there may be cold droughts as well as hot droughts. When a Northerner talks of plants being winter-killed, he generally thinks that they die of cold. This is rarely true for any but tropical plants. For instance, those evergreens transplanted this fall have damaged roots. Unless they are given extra amounts of water just as long as the ground can absorb it, they may enter the winter without enough to last them until spring. When what Chaucer called the "drought of March" arrives, with its bright sun and high winds, the last of their inadequate store will vanish into the air, and, almost overnight, they will turn brown and then probably die.

Wind and sun—what a terrible combination for a plant with too little water. With sun to warm the air and enable it to hold more water, and with wind to move water-vapor away, to remove it from every pocket and crevice of the surface soil and from every pore of the plant, to bend and twist the leaves until every particle is literally wrung from them, how can a plant make food if the soil is too cold or too dry ?

Tests by the Forest Service show that windbreaks in Kansas and Nebraska reduce evaporation in their lee by as much as 70 per cent. Though this effect decreases with distance, yet it was measurable about twenty times as far from the windbreak as the windbreak was high.

That is one of the reasons for that huge series of windbreaks that are to be built from North Dakota to Texas. Built of trees, some evergreen and some deciduous, trees that will establish themselves as permanent residents, that have proved that they can build up reserves that will tide them over the hot droughts and the cold droughts, these windbreaks of the big shelter-belt can offer protection to the little high-speed, quick-production factors that the farmers want to plant.

That Kansas wheat and the other plants that we hope will soon be growing near it will have a better chance against the water-robbing wind every year. And in the drought years, the little plants can last longer, something can be salvaged by the farmer, but above all the soil will be left.

For this is that further ugliness that the drought can beget, the ugliness that can last beyond the traditions of rain. When the plants have dried or been harvested, when their roots no longer hold the soil together, and their tops no longer break the force of the wind near the surface, the soil begins to move. The lighter particles swirl upward into the air, to be carried, as in dust-storms of last November and May, thousands of miles away. The coarse particles slide over each other and, in the bad drought years, the surface soil travels like the dunes of the seashore, leaving desolation behind, a desolation that does not always end when the drought ends, for when the fertile top-soil is gone it can

not be renewed by man. Only the slow time-for-getting processes of nature may some day, far in the future, produce again the prairies that many betrayed.

These trees can not conquer drought, they can endure it. But by enduring it, by merely remaining in place and living, they can temper the droughts of the future and prevent some of their consequences.

If man will then but do his part.

If he will make his methods of cultivation fit the country and the emergencies of the country. If he will remember that this soil remained through all the storms and droughts of the centuries before his ancestors found it, because, and only because, the prairie plants kept the wind from it. If he will remember this and refrain from cultivating those parts of this vast domain that should be in grass—his days and the days of his children will be long in the land the prairie grass gave him.