the velocity of these currents at 5,000 ft. is double that at the earth, and any storm or high area would be very quickly disintegrated by such action.

AUTUMN COLORING OF LEAVES.

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THE subject of this paper was suggested to me more than a year ago by some highly colored leaves of the common red currant that I noticed while rambling in the woods near Urbana.

I shall not take up my notes in the order in which they were made, or of their importance, but shall begin with the smallest.

In the leaves of several species of trees where a principal vein has been broken, the part toward the tip of the leaf has colored earlier and more highly than the rest. Not unfrequently, in lobed leaves, the lobe with the broken rib has been the only part of the leaf that showed any coloring. Leaves torn from the margin to the midrib were not changed as a result of the injury.

The species in which parts of leaves have been seen to color as a result of this injury are soft and hard maple, tulip, white, red and scarlet oak and cottonwood, and blackberry. Probably all plants that color at all would show the same thing.

Carrying the observation a little further, branches of many kinds of trees and shrubs that have been girdled or otherwise injured, have been found to color earlier and usually, though not always, much more highly above the injured or girdled part than below, or than other branches on the same tree that were not injured. As noticed before, the thing that first called my attention to this subject was finding a clump of the common red currant with the leaves on the tips of several twigs colored dark crimson. An examination showed that all the twigs with colored leaves had been girdled by some insect while none of those still green were. Girdled grape branches frequently have very highly colored leaves, but I have never seen them colored on branches that were not injured. Girdled or injured branches with highly colored leaves have been noticed on all our native maples, on cottonwood, elm, wild black cherry, oak, pear and plum.

A large branch on a hard maple on one of our streets used to attract my attention, and I sometimes wondered if its habit of early coloring could not be perpetuated by budding from it. It was finally broken off and was found to be eaten by borers and partly decayed. Branches on some of the hard maples round which wires have been tightly drawn have colored earlier than the rest of the trees. In a few cases where forked branches have split, the one nearest off has been found to be colored more than the other.

The next step would be to find the whole tree more highly colored than those around it on account of some injury to the trunk. Believing that a variety of trees might be produced and propagated that would color regularly every fall, I have watched for such as might offer a good chance to try the experiment. In the artificial forest belonging to the University is a plat of hard maple that has attracted my attention several times, but in looking at trees that were especially brilliant, it was found that all of them had some noticeable defect in the trunk; usually a place where the bark had been destroyed on one side of the tree and the wood left exposed so that it died. In a group of hard maples like these there will frequently be found in the fall all gradations of color from plain green to bright yellow or red, at the same time. There is an individuality in time, depth, and shade of color that is entirely independent of the condition of the tree itself.

Of four young soft maple trees near my house that were planted at about the same time, one has been allowed to get full of borers, and the trunk is so badly eaten that the tree will probably die before a great while, but last fall it was more highly colored than I had ever seen a soft maple before, and the leaves were all off of it before the others had fairly begun to turn. The brightest colored red oak yet seen had a barbed wire drawn tightly around it at about three feet from the ground, and the brightest Virginia creeper had had the bark knocked off in some way.

It is now only one more step to the roots of the trees. We have on the University farm a plat of two year old white oaks that have been grown for planting in the artificial forest. As a preparation for their removal, the top roots were cut last fall. The work was begun while the leaves were still green; when it was about half done, it was stopped and not completed until two weeks later. Within a week after the roots of the first had been cut, there was a very marked change in the foliage. The root pruned trees were all highly colored, while of those not pruned there was only occasionally one that had begun to color.

It is a matter of common observation that trees on hilly land color more deeply than those on level land, but it is not so frequently reported that they also color earlier, though the latter is just as much a fact as the former. Trees on thin land color earlier than the same species on rich land.

It is a common practice among nursery men to stop cultivation before the end of summer and allow the weeds and grass to grow, so that the trees will ripen up their wood earlier and more perfectly. Cultivated land holds moisture longer than uncultivated, and when the uncultivated land has a coat of weeds and grass, the loss of moisture is still more rapid.

It is a very common thing to see a clump of wheat or oats standing out at the edge of a field where it has things more to itself, that is much greener than the general field; or to see thick and thin spots in a field, and the thick always ripe earlier than the thin. Corn grown very thick ripens earlier than corn grown thin. A plat of corn on the Experiment Station grounds, that had no cultivation this past year, the weeds being allowed to grow at will, ripened earlier than cultivated plats of the same variety on each side of it. This shows that the time of ripening depends on other circumstances than the individual character of the plant.

It is not uncommon for our apple trees to shed many of their leaves during a season of severe drouth. If this is followed by heavy rains and warm weather, blossoms and new leaves are very apt to make their appearance. The age of a tree makes a difference in the length of time it uses to complete its season's growth. Young trees, under like conditions, grow longer than older ones, and this is not a matter of shade either, for it is seen more decidedly in nursery stock, as compared with older orchard trees, than in trees in the forest. Sprouts from the stump of a tree that has been cut down grow later than trees of the same species near then. Water-sprouts in apple and other trees grow later than the normal branches; in fact there is but little difference in this respect between the water-sprout and the nursery grown apple tree. Both may be seen until the early winter with tufts of unripened leaves still adhering to their tips.

This thought leads naturally to the subject of determinate and indeterminate growth of plants.

Some species, as the oaks and ashes, will start out a shoot in the spring that reaches its full length in a short time, and the leaves expand and the wood hardens after-

ward. The whole plant is then apparently at a standstill for a time, but when it has matured its buds it starts out again and makes another growth just like the first, though not usually so long. In this way the tree may make two, three, or more distinct growths the same year, depending on the age of the tree, and other conditions. Trees that make their growth continuously stretch out most rapidly at first, becoming slower and slower until growth ceases. The number of buds, leaves or joints which such a branch will form depends on circumstances; its position on the tree, the character of the season, etc. Terminal branches not only grow longer, in both senses, than lateral ones, but produce more buds. Water-sprouts grow longer and produce more buds than either. If a branch is cut off so that all the growth is forced into what would have made a short lateral, it then takes the nature of a terminal branch, and what would otherwise have made a bud for next year's growth, is developed right along into this year's branch, which grows more rapidly, makes more leaves in the same length of time, and also ripens later in the season.

While no notes have been kept, it has seemed to me that our trees growing in a deep rich soil have colored more after a dry season than after a wet one. There can be no question that there is a great difference in the intensity of the color which the same tree will take on in different seasons.

We have in the experimental orchard two kinds of plums, of which some are growing on their own roots, and the rest on the roots of peach trees. The plum trees on peach roots color from ten days to two weeks earlier than those on plum roots, and they also drop that much earlier. In the fall of 1892 the plum on peach roots colored more highly than that on its own roots, but the past fall there was little or no difference in the intensity of color.

The leaves on the outer branches of our dense growing trees color and drop off while the inner ones are still on and green. This is very noticeable in the hard maple and may be seen in the elm and ash to some extent. I have frequently seen hard maples with the naked twigs sticking out two or three feet all round, while the middle of the tree was still green and had dropped scarcely a leaf.

There is a difference in the time of coloring of leaves on trees of the same species, even when they are in perfect health and are under the same conditions. The difference in the time of leafing is frequently spoken of, but I do not remember anyone having noticed that there is a corresponding difference in the season of dropping the leaves in many species. Leaves that color first also drop first; but there does not seem to be any definite relation between the time of leafing and the time of shedding leaves.

There is not only a difference in the season of coloring, but also a difference in the color of individual trees. This difference is very marked in some species, and in others is scarcely noticeable. The ash, elm and walnut each has a characteristic yellow that is comparatively uniform, but other species vary considerably. The hard maple, plum, blackberry, etc., may be seen varying from a pale yellow or orange to a very bright scarlet. The same individuals take the same color, though to the same degree, year after year, just as a variety of apples does, and there is no doubt but that a characteristic season and color could be propagated in the leaf of the maple just as in the fruit of the apple or pear.

It is a practice, not uncommon among some grape growers, to girdle the vines to make the fruit ripen earlier. This makes a difference of something like a week in the season, and the fruit is larger though not so good in quality. Our own plum trees on plum roots have so far borne no fruit, but plum growers inform me that the Wild Goose and some other varieties when grown on peach roots ripen and are gone before those on plum roots have begun to ripen.

The play song beginning, "The higher up in the cherry tree the riper grows the cherry," expresses a familiar fact that is seen not only in the cherry but more or less in all our tree fruits. Those most fully exposed to the light not only ripen more thoroughly, but ripen earlier and color more highly than those in the shade. Apples that grow in the middle of a dense growing tree never do as well nor attain as high a quality as those exposed to the full light, on the outer branches. Whether it is the light or the place where the apple happens to grow that makes the difference, I do not know; grapes color as well and the quality is as good when grown in bags as when fully exposed. Apples grown on hilly or comparatively thin land, where there is little vegetable matter, are more highly colored and are of better quality than those grown on deep rich soils.

There is a correlation in some species between the color of the ripe fruit and the autumn leaves. Generally the blackberry is a very brilliant autumn plant, but the varieties bearing fruits that are white when ripe have pale yellow autumn leaves. Both the black and red raspberry groups have reddish colored autumn leaves, but there are in both these a few varieties with yellow fruits, and the autumn leaves on these are yellow. The yellow fruited plums also have yellow leaves in the fall, and the varieties that have most red in the fruit also have most red in their autumn leaves. Corresponding differences are also seen in the bark of the young wood. I suspect this is an albinism of plants which is related to the albinism of animals.

The fruit is a modified branch and its leaves, and so we have the fruits and leaves corresponding in these ways:

Fruits vary in their time of ripening; leaves in their time of coloring or ripening and falling.

Fruits in the top of some kinds of trees ripen earlier and more perfectly than those in the body of the tree; leaves on the outer branches of some trees color or ripen and fall earlier than those in the middle.

There is an individuality in and a correlation between the color of the ripe fruit and the autumn leaves.

The girdled grape-vine ripens its fruit earlier than those not; leaves on girdled or otherwise injured twigs, branches, or trees color or ripen earlier than those on sound branches or trees, though they do not always fall earlier. The colored leaves may hang on until the frost takes all off together.

Both leaves and fruits color more highly on hilly than on level land; but color in fruit is an indication of maturity.

We have, then, a relation and a regular gradation: The broken leaf, the girdled branch which colors its leaves or ripens its fruit earlier, the brighter color of the injured tree or vine, the earlier ripening and coloring of the fruit and leaves of the plum tree on peach roots, the earlier and higher coloring of both fruits and leaves on broken land, and the earlier and more complete ripening of both leaves and fruits on the outer branches. Probably the leaves on trees in deep rich soils never would color as highly as on those on the rougher land, but the probability is that if we had a longer season for ripening we would have more color.

Is there in the high leaf coloring an indication not of maturity alone, but of an unnatural maturity that would not be found in trees growing in soil and with conditions best suited to their wants?