PHYSICAL AND CHEMICAL CHARACTERISTIC, OF LOBLOLLY PINE SEEDLINGS ASSOCIATED WITH DROUGHT RESISTANCE[1/]

by

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Much has been said and written concerning genetics; but little has been said about the bows and whys of genetics, that is, the physiology of the plant as controlled by inheritance.

The purpose of this report is to point out some differences in the external and internal makeup of two groups of plants known to differ genets in drought resistance. As stated in the title, these differences have been divided into two categories, namely, physical characteristics and chemical characteristics.

First, let us define the term, drought resistance. It means the ability of a seedling to survive and become established when outplanted under droughty conditions.

Loblolly pine (Pinus taeda)seedlings were furnished by the Texas Forest Service. The seedlings came from mother trees at a number of geographic sources. Previously, progeny of the same mother trees had been tested for ability to survive when outplanted under adverse conditions. On the basis of these source tests, later substantiated by tests in the greenhouse, the seedlings were separated into two groups designated more drought resistant and less drought resistant.

Physical Characteristics

Representative sample seedlings from each group were planted in cans filled with sand and kept in a greenhouse. Minimum daily temperature never exceeded 75° F., and maximum daily temperature sometimes exceeded 100° F. After the seedlings became established, water loss by transpiration was measured daily. The soil was sealed so that no evaporation occurred, and the entire mass was weighed to determine the water loss. On the basis of the finding of Tiren[2/] that Scotch pine needle area was directly proportional to dry weight, water loss by the seedlings under study was expressed as daily transpiration per gram of needle, oven dry weight,

Figure 1 shows the average daily transpiration per gm. of needle when

[1/] A preliminary report of progress on Regional Project 3-23.

[2/] Tiren, L. 1927. Ueber die grosse der Nadelfache einiger Kiefernbest and Statens Skogsforsoksanst (Sweden), Meddel, 23i 295-336.

moisture content of the soil was high. it shows that more moisture of needle was lost by the less drought resistant seedlings than by the more drought resistant seedlings, If the average total weight of needles per seedling for each group, 1.55 gm. and 2.86 gm. for the less and the more drought resistant seedlings, respectively, is taken into account, it can be seend that the more drought resistant seedlings extracted more moisture from the soil than the less drought resistant seedlings. The moisture loss by transpiration at a low soil moisture content is also indicated on figure 1. These curves show that at a low soil moisture content the more drought resistant plants lost only half as much moisture per gm. of needle as the less drought resistant plants during the few days that transpiration was measured.

Figure 2 brings out more vividly the picture of water loss. When the two groups of seedlings are compared on the basis of accumulative loss of moisture by transpiration, it is at once noticeable that the less drought resistant seedlings lost more moistue per gram of needle at both the high and the low soils moisture content.

Chemical Characteristics

There is abundant evidence that genetic differences between varieties of cultivated plants include constitutional differences that affect mineral composition, even when the plants are grown under similar conditions.

Sample seedlings from each group were divided into three parts; roots, stems, and needles. All portions of the plants were dried in an oven and sub-samples taken for chemical analysis.

Table 1.--Average carbohydrate content of two groups of loblolly pine seedlings, expressed as per cent, O.D. weight

Plant Part	Less drought resistant				More drought resistant			
	CHO 1/	Reducing sugars	Sucrose	Starch	CHO 1/	Reducing sugars	Sucrose	Starch
Roots	11.7	0.9	0.4	10.4	14.0	1.1	0.3	12.6
Stems	7.0	1.0	0.3	5.7	8.9	2.0	0.4	6.5
Needles	5.0	0.6	0.2	4.2	5.1	1.2	0.4	3.5

1/ Total carbohydrates.

Differences in carbohydrate content of various parts of seedlings in the two groups are apparent from Table 1. The stems and needles of the more drought resistant plants contain *nearly* twice the concentration of reducing sugars as the stems and needles of the less drought resistant plants. The sucrose content of the two groups is about the *same.* When the total carbohydrate content is examined, it is apparent that the amount that accumulates in the roots is much smaller in the less drought resistant seedlings than in

Figure 1.--Average daily transpiration per gram of needle (O.D. weight) for less drought resistant and more drcuth resistant loblolly pine seedlings grown under conditions of high and low soil moisture conditions.

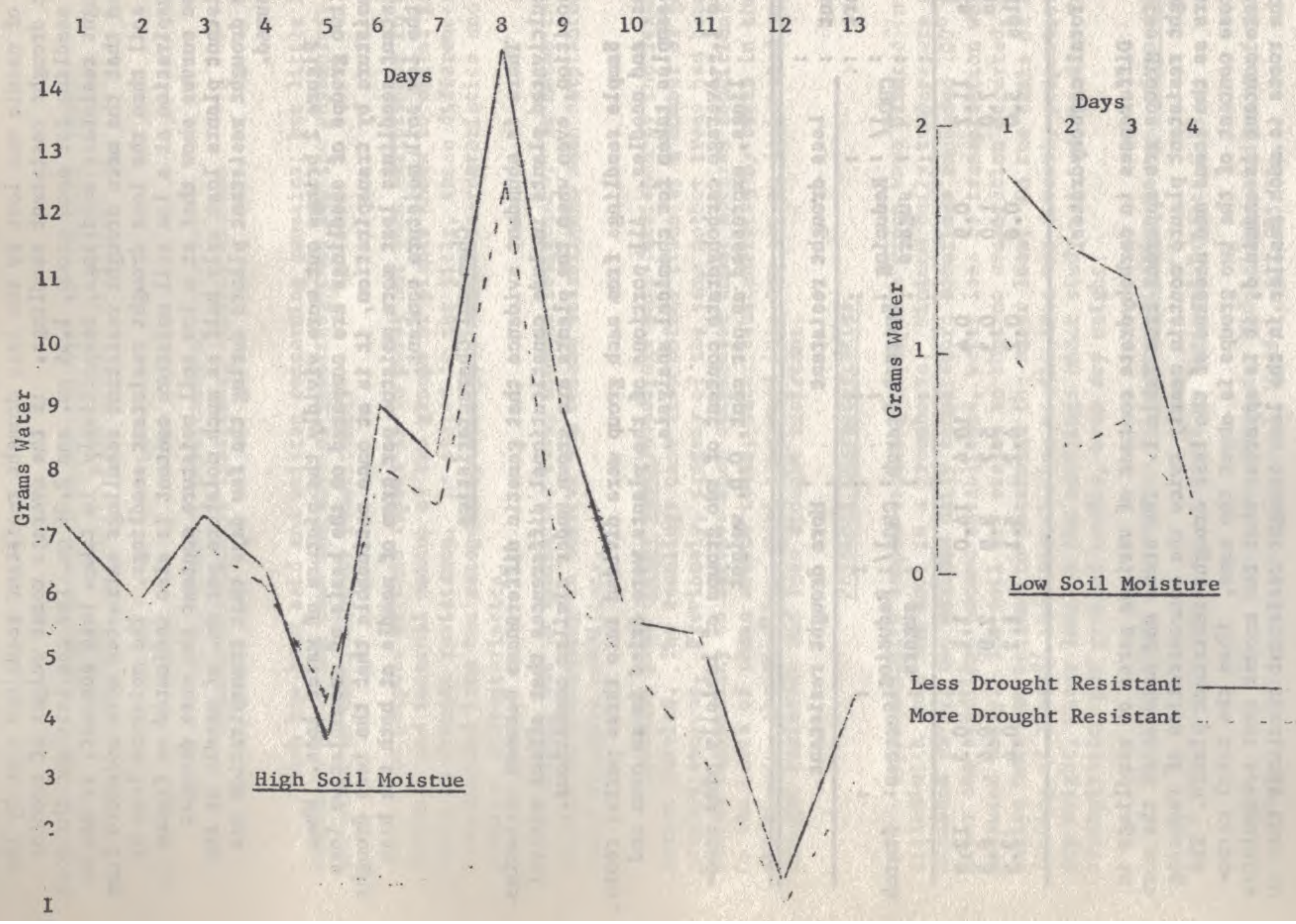
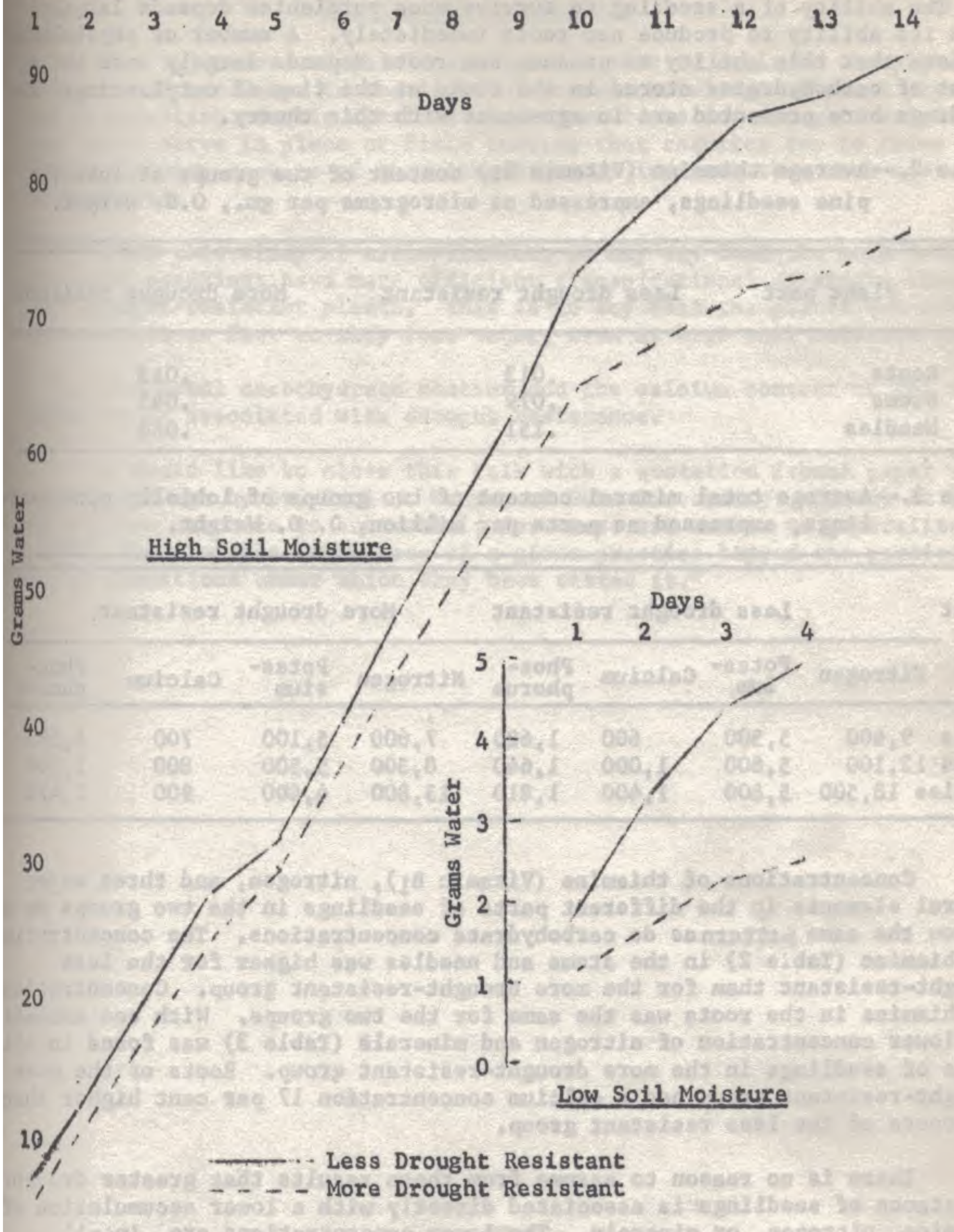


Figure 2.--Average daily accumulative transpiration per gram of needle (O.D. weight) for less drought resistant and more drought resistant loblolly pine seedlings grown under conditions of high and low soil moisture conditions.



the more drought resistant plants.

The ability of a seedling to survive when outplanted depends largely upon its ability to produce new roots immediately. A number of physiologists believe that this ability to produce new roots depends largely upon the amount of carbohydrates stored in the roots at the time of outplanting. The findings here presented are in agreement with this theory.

Table 2.--Average thiamine (Vitamin B1) content of two groups of loblolly pine seedlings, expressed as micrograms per gm., O.D. weight.

Plant part	Less drought resistant	More drought resistant
Roots	.013	.013
Stems	.079	.045
Needles	.151	.068

Table 3.»-Average total mineral content of two groups of loblolly pine seedlings, expressed as parts per million, O. D. Weight.

Plant	Less drought resistant				More drought resistant			
Part	Nitrogen	K+	Calcium	Phosph.	Nitrogen	K+	Calcium	Phosph.
Roots	9,600	5,500	600	1,620	7,600	5,100	700	1,590
Stems	12,100	5,800	1,000	1,640	8,300	5,500	800	1,600
Needles	18,500	5,800	1,400	1,810	13,800	4,400	900	1,470

Concentrations of thiamine (Vitamin B1), nitrogen, and three major mineral elements in the different parts of seedlings in the two groups do not follow the same concern as do carbohydrate concentrations. The concentration of thiamine (Table 2) in the stems and needles was higher for the less drought-resistant than for the more drought-resistant group. Concentration of thiamine in the roots was the same for the two groups. With one exception, the lower concentration of nitrogen and minerals (Table 3) was found in. all parts of seedlings in the more drought-resistant group. Roots of the more drought-resistant group had a calcium concentration 17 per cent higher than did roots of the less resistant group.

There is no reason to assume from these results that greater drought resistance of seedlings is associated directly with a lower accumulation of vitamins, nitrogen, or minerals. The lower concentrations are, in all probability, merely a result of the dilution effect of the more rapid growth of the seedlings with greater drought resistance. On the other hand, the higher concentration of calcium in the roots of the larger, more drought-resistant seedlings must indicate a higher accumulation of that element. It seems possible that calcium accumulation in the roots is significantly, associated with drought resistance.

Summary and Conclusions

The objectives of this investigation were to evaluate the physiological processes of seedlings in the light of present knowledge of plant physiology and to establish certain specific short-term tests for drought resistance that could serve in place of field testing that requires two to three years. The preliminary results of this investigation indicate that such tests might be developed.

From this study of transpiration, we may say that the more drought-resistant seedlings have more efficient transpirational apparatus than the less drought-resistant plants. This is to say that the plants can absorb water almost as fast as they lose water, even at high soil moisture stress.

The total carbohydrate content and the calcium content of the roots appear to be associated with drought resistance.

I would like to close this talk with a quotation from'a paper wtitten a few years ago by Dr. Paul J. Kramer of Duke University: "Until it is known why a given practice is successful, foresters are unable to generalize concerning the probable usefulness of a given practice beyond the particular set of conditions under which they have tested it."