A COMPARISON OF THE TRANSPIRATION RATES OF CORN AND CERTAIN COMMON WEEDS

HELEN A. MCGINNIS AND W. B. MCDOUGALL,
UNIVERSITY OF ILLINOIS

That the presence of weeds in a corn field is detrimental to the intake of moisture, the reception of light and the manufacture of food by the corn plant has been demonstrated by experiment (15). Such experiments, however, do not show either the amount or the rate of removal of water from the soil by the weed invaders. It is the purpose of the present paper to present data concerning the relative rates of water loss by transpiration from the leaves of corn and of corn field weeds growing under the same environmental conditions.

The study of transpiration from the leaves of growing plants is by no means new. Trelease and Livingston (19), for example, measured the relative transpiring power of a number of plants. These authors were interested, however, in the diurnal fluctuations of this transpiring power rather than with the differences between different plants. Bakke (1) also measured the index of transpiring power of various plants and the same might be said of several other authors. A fairly complete bibliography of the subject is given by Kiesselbach (10). No historical resumé of the literature will be attempted here but it may be pointed out that most of the writers have been concerned with the relative transpiring power of plants as compared with evaporation from a free water surface, the latter, rather than any living plant, being the standard for comparison.

In the experiments described in the present paper the corn plant, rather than a free water surface, is the standard for comparison. The data presented do not give quantitative information as to the rate of water loss but they do show comparative rates of transpiration from a given area of corn leaf and equal areas of weed leaves, thus demonstrating which transpires more rapidly area for area. The experimental work was carried on by Miss McGinnis mostly in the botanical greenhouses at the

University of Illinois, Urbana, Illinois, between February sixth and April tenth, 1920. Only a few measurements were taken out of doors because it was necessary to finish the work before the end of the college year. This is regretted by the authors because they believe implicitly that ecological work should be done in the field. However, since the objective was comparative and not quantitative results it is believed that the data in this case are as valuable as though obtained in the field, for the differences between greenhouse and field environmental conditions should affect all plants used comparably.

MATERIALS AND METHODS

The corn used in this experiment was of the variety known as Reed's Yellow Dent, the seed being purchased from Vaughan's Seed Store, Chicago, Illinois. The weeds used were Polygonum pennsylvanicum, Sida spinosa and Setaria glauca, the seed of which was collected from cornfields near Urbana, and Ambrosia artemisiifolia and Abutilon Theophrasti, the seed of which was kindly supplied by the Agricultural Experiment Station of the University of Illinois.

These five kinds of weeds were grown in the greenhouse side by side with corn in such a way as to insure practically identical environmental conditions for all. The well known cobalt chloride paper of Stahl (18) as described by Livingston (12) and more recently improved by Livingston and Shreve (13) was used for making the tests, care being taken to use the same leaves each day, or, if not the same, those having the same relative position on the stem. This latter precaution was taken because of the fact pointed out by Bakke and Livingston (3) that leaves of different ages and occupying different positions on the stem may vary markedly in their transpiring power. The lateral leakage of moisture which undoubtedly takes place, as stated by Shive and Martin, when tripartite cobalt paper slips such as used by Livingston and Shreve are employed may be disregarded in this experiment since any such leakage that occurred must have affected readings from all plants used to the same extent.

In every case transpiration readings were taken from both the upper and lower surfaces of the leaves used and the average of the two was taken as the result to be recorded. Also, whenever possible, readings were repeated one or more times and all readings taken were averaged for each plant. The data given in the following table, therefore, consist of averages rather than the results of single readings.

RESULTS

The results are given in tabular form below. The figures in columns A, B, C, D, E, and F give the number of seconds required to change the color of the cobalt paper by the transpiration of the plant named at the head of the column. The columns headed A-B, A-C, etc. are difference columns and show the number of seconds more or less that were required to change the color of the cobalt paper on the foliar surfaces of the weeds than on that of the corn. A plus sign in these columns indicates that the number of seconds required for the color change was more in the case of the corn than in that of the weed while a minus sign indicates a greater number of seconds for the weed than for the corn.

TABLE 1.

	Corn A	Ambrosia B	Polygonum C	Setaria D	Abutilon E	Sida F	A-B	A-C	A-D	A-E	A-F
Feb. 6	87.3	63.7	56.5	178.7	167.4	.....	+23.6	+30.8	—91.4	—80.1	.....
12	89.8	38.5	30.4	116.7	45.7	47.7	+51.3	+59.4	—26.9	+44.1	+42.1
13	128.3	54.2	83.3	119.7	100.7	89.9	+74.1	+45.0	+8.6	+27.6	+38.4
14	222.2	68.3	43.9	89.0	233.2	76.9	+153.9	+178.3	+133.2	—11.0	+145.3
16	112.3	47.7	47.3	.....	111.5	54.8	+64.6	+65.0	.....	+0.8	+57.5
18	153.9	41.0	52.2	183.1	66.0	93.0	+112.9	+101.7	—29.2	+87.9	+60.9
23	220.6	41.4	96.3	.....	231.6	.....	+179.2	+124.3	.....	—11.0	.....
25	371.1	64.5	97.8	150.7	180.1	125.0	+306.6	+273.3	+220.4	+191.0	+246.1
27	164.9	44.5	68.0	230.7	93.2	57.9	+120.4	+96.9	—65.8	+71.7	+107.0
Mar. 3	99.3	24.6	45.2	156.2	95.1	61.0	+74.7	+54.1	—56.9	+4.2	+38.3
5	106.0	56.3	49.8	200.5	50.7	57.2	+49.7	+56.2	—94.5	+55.3	+48.5
13	88.0	33.7	21.0	153.8	92.0	24.9	+54.3	+67.0	—65.8	—4.4	+63.1
15	146.4	21.4	30.9	114.8	.....	.....	+125.0	+115.5	+31.6	.....	.....
18	183.2	38.3	18.7	126.2	127.6	64.6	+144.9	+164.5	+57.0	+55.0	+118.6
20	51.4	8.2	26.9	14.4	10.9	25.2	+43.2	+24.5	+37.0	+39.0	+26.2
22	86.1	19.4	20.6	74.3	15.1	24.5	+66.7	+65.5	+11.8	+71.0	+61.6
25	92.2	24.0	22.8	58.3	30.2	27.0	+68.2	+69.4	+33.9	+62.0	+65.2
26	91.6	21.6	20.5	65.1	28.7	22.4	+70.0	+71.1	+26.5	+62.9	+69.2
29	158.9	11.5	11.6	44.6	20.6	28.1	+147.4	+147.3	+114.3	+138.3	+130.8
Apr. 3	84.1	21.0	20.3	55.4	21.8	19.1	+63.1	+63.8	+28.7	+62.3	+65.0
7	63.7	17.5	17.8	61.4	27.1	54.2	+46.2	+45.9	+2.3	+36.3	+9.5
10	46.7	11.4	12.6	54.1	35.6	21.7	+35.3	+34.1	—7.4	+11.1	+25.0
Average	129.9	35.1	40.6	112.3	84.9	51.3	+94.8	+89.3	+17.6	+45.0	+78.6

DISCUSSION

In order to interpret the above data correctly it is necessary to keep in mind the fact that the figures in columns 2 to 7 represent in each case the number of seconds required for the color change in the cobalt paper to take place. A large number therefore indicates a low transpiration rate while a small number indicates a high transpiration rate. Likewise a plus in the difference columns indicates a high transpiration of the weed as compared with corn, while a minus shows that the rate in the case of the weed was low as compared to corn. With these facts in mind it is seen readily from the averages at the end of the table that all of the weeds used have higher transpiration rates, per unit area, than corn. Setaria, which is a grass and therefore closely related to corn, has a transpiration rate only slightly higher than corn since the average difference (column A-D) is only 17.6 seconds. The four dicotyledonous weeds, however, all have rates considerably higher than that of corn, the average differences varying from 45 seconds in the case of Abutilon to 94.8 seconds in the case of Ambrosia.

As seen from the table, the plants used, when arranged in the order of decreasing transpiration rate, stand as follows: Ambrosia, Polygonum, Sida, Abutilon, Setaria and corn. This order is fairly consistent with the number of stomata per unit area on the leaves of these plants. Corn and Setaria have approximately equal numbers of stomata per unit area and they are about evenly distributed on the upper and lower leaf surfaces. The numbers are very small, however, as compared to those found on any one of the dicotyledonous weeds, though the latter have many more stomata on the lower than on the upper surfaces.

The work described in this paper proves that corn transpires more slowly area for area than the weeds with which it was compared. Whether or not this fact is an economically important one under any conditions has not been demonstrated. Kiesselbach (10) showed conclusively that weeds do rob corn of some needed moisture, but other factors such as food supply, light relations, etc., have usually been considered of more im-

portance. It is logical to suppose, however, that in case the moisture content of a soil were low, the withdrawal of even a small portion of this water by weeds might prove very serious to the life of the corn and, in this case, the rate at which weeds take water from the soil and transpire it into the atmosphere would be a factor of great practical importance.

SUMMARY

1. The relative rate of transpiration of Zea Mays, as indicated by cobalt paper, is lower per unit area than that of Polygonum pennsylvanicum, Sida spinosa, Ambrosia artemisiifolia, Abutilon Theophrasti and Setaria glauca.

2. Of the weeds compared with Zea Mays, Ambrosia artemisiifolia has the highest rate of water loss.

3. The transpiration rates of Zea Mays and Setaria glauca are more nearly similar than those of the corn and any of the dicotyledonous weeds studied.

BIBLIOGRAPHY.

1. Bakke, A. L., Studies on the Transpiring Power of Plants as Indicated by the Method of Standardized Hygrometric Paper. Jour. of Ecology. 2:145-173, 1914.
2. Bakke, A. L., Index of Foliar Transpiring Power as an Indicator of Permanent Wilting in Plants. Bot. Gaz. 60:314-319, 1915.
3. Bakke, A. L. and Livingston, B. E., Further Studies on Foliar Transpiring Power in Plants. Physiol. Res. 2:51-71, 1916.
4. Briggs, Lyman J. and Shantz, H. L., Transpiration During the Normal Growth Period and its Correlation with the Weather. Jour. Agr. Research 7: 155-212, 1916.
5. Briggs, Lyman J. and Shantz, H. L., Hourly Transpiration Rate on Clear Days as Determined by Cyclic Environmental Factors. Jour. Agr. Research 5: 583-649, 1916.
6. Cannon, W. A., A New Method of Measuring the Transpiration of Plants in Place. Torrey Botanical Club Bull., 32:515-529, 1905.
7. Cox, H. R., Weeds: How to Control Them. U. S. Dept. of Agr. Farmer's Bull. No. 660. 1915.
8. Cribbs, James E., Ecology of Tilia Americana: I—Comparative Studies of the Foliar Transpiring Power. Bot. Gaz. 68:262-286, 1910.
9. Freeman, G. A., A Method for the Quantitative Determination of Transpiration in Plants. Bot. Gaz. 46:118-129, 1908.
10. Kiesselbach, T. A., Transpiration as a Factor in Crop Production. Bull. (Research) No. 6. Nebraska Agr. Expt. Station, 1916.
11. Livingston, B. E., Light Intensity and Transpiration. Bot. Gaz. 52:417-438, 1911.
12. Livingston, B. E., The Resistance offered by Leaves to Transpirational Water Loss. Plant World 16:1-38, 1916.

13. Livingston, B. E. and Shreve, Edith B., Improvement in the Method for Determining the Transpiring Power of Plant Surfaces by Hygrometric Paper. Plant World 19:287-307, 1916.

14. Miller, E. C. and Coffman, W. B., Comparative Transpiration of Corn and the Sorghums. Jour. Agr. Research 13:579-604, 1918.

15. Mosier, J. G. and Gustafson, A. F., Soil Moisture and Tillage for Corn. Bull. No. 181. Ill. Agr. Expt. Station, 1915.

16 Shive, J. W. and Martin, W. H., The Effect of Surface Films of Bordeaux Mixture on the Foliar Transpiring Power in Tomato Plants. Plant World 20:67-86, 1917.

17. Shreve, Edith B., The Daily March of Transpiration in a Desert Perennial. Carnegie Inst. Wash. Publ. 194. Washington, 1914.

18. Stahl, E., Einige Versuche über Transpiration und Assimilation. Bot. Zeit. 52:117-146, 1894.

19. Trelease, Sam F. and Livingston, B. E., The Daily March of Transpiring Power as Indicated by the Porometer and by Standardized Hygrometric Paper. Jour. of Ecology 4:1-14, 1916.