Proceedings of the Iowa Academy of Science

Volume 37 | Annual Issue Article 21

1930

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W. F. Loehwing
State University of Iowa

THE EFFECT OF LIGHT INTENSITY ON TISSUE FLUIDS IN WHEAT

W. F. LOEHWING

Foliar chlorosis was observed to occur frequently during periods of strong insolation in grain plants growing humus soils to which lime had been added to correct acidity. An experiment was undertaken to determine the reasons for the increasing prevalence of chlorosis during periods of clear, sunny weather.

Marquis wheat was grown on two soils, an unproductive, strongly acid humus low in mineral matter, and a fertile but acid loam. The soil acidity in a portion of each soil was corrected by addition of indicated amounts of powdered calcium carbonate. When the plants were five weeks of age, a thin muslin screen was placed over approximately half of the plants on each of the treated and untreated soils. The remaining plants remained exposed to full daylight.

Tissue analyses begun at this time included a study of the expressed sap. The procedure involved harvesting of entire tops, immediate freezing of tissues, expression of sap from 30 gram samples at uniform pressure and the duplicate potentiometric determination of the hydrion concentration. The expressed fluids were clear and liquid.

It will be observed (table I) that the acid level of the sap from plants on the untreated soils was much higher than that of plants

Table I — Hydrion Concentration (pH) of Sap Expressed from Six Week Old Wheat Plants

Hour Cut	Type of Illumination	Humus Soil		Loam Soil	
		Unlimed	Limed	Unlimed	Limed
6 A.M	Shaded	5.47	6.22	5.67	6.20
	Full	5.47	6.22	5.67	6.20
10 A.M.	Shaded	5.51	6.28	5.68	6.42
	Full	5.57	6.42	5.68	6.42
2 P.M.	Shaded	5.55	6.30	5.69	6.44
	Full	5.62	6.51	5.70	6.46
6 P.M.	Shaded	5.59	6.38	5.70	6.46
	Full	5.69	6.63	5.74	6.51
10 P.M.	Shaded	5.55	6.40	5.69	6.45
	Full	5.64	6.62	5.71	6.51
6 A.M	Shaded	5.49	6.18	5.64	6.17
	Full	5.50	6.18	5.65	6.22

from the limed soil. This clearly disclosed the efficacy of lime in altering the free acidity of the tissue fluids. In addition, a definite diurnal acid periodicity was observable, the free acidity of the sap falling in daylight in all plants and rising again at night. The magnitude of the daily sap hydrion fluctuation varied with the intensity of the illumination and the type of soil. Plants on the humus soil were more sensitive to light than those on the loam, and plants on limed soils were more sensitive than those on unlimed soils if variations in sap acidity be taken as criteria. These facts suggested that sap in plants on limed soils was not as effectively buffered as in plants on untreated soils. To test this possibility, uniform amounts of standard alkali were added to aliquot samples of expressed sap and the resulting pH was measured. In general, a given amount of alkali produced a greater change in the hydrion level in the sap of treated as opposed to the unlimed plants, indicating a lower titratable acid reserve and lower alkali tolerance.

When foliar chlorosis had become very marked in the limed plants during a period of bright, warm weather, sap was again expressed from entire tops of eight week old plants in search of a possible cause of the injury noted. The daily acid fluctuation was still apparent in all plants but the general acid level of limed plants was considerably lower than that in the unlimed plants. The period of darkness was apparently insufficient for complete acid recovery in the chlorotic plants on the limed humus, as these plants displayed a progressive fall in hydrion concentration during strong insolation. Chlorosis was not marked in these plants.

Microchemical inspection of sections from normal and chlorotic plants disclosed the absence of iron in the injured tissues. This observation was confirmed by chemical analyses of the ash from normal and chlorotic tops. The ash of roots of chlorotic plants was higher in iron than that from green plants. Iron appeared to be massed in the roots of chlorotic plants. The conclusion follows that the injury is an iron chlorosis attributable to impaired iron mobility in the nearly neutral tissue fluids.

Chlorosis was not severe among plants on the untreated soils or among the plants which had been shaded. The diurnal fall in acidity in these instances is apparently insufficient to interfere with iron mobility.

Reversals in slope of the diurnal acidity gradient are not coincident with the hour of maximal light intensity, a fact which suggests that the thermal factor in insolation may not be as important as its light effect. Though no attempt was made to measure foliar temperature, spectral composition or thermal energy of the light, it is certain that the thermal maxima of the plants were reached much earlier in the afternoons than the maximum pH of the sap. Other investigations have shown that sap hydrion concentration in wheat rises with the temperature. Thermal and light stimuli thus appear to exert opposite effects on the acidity of tissue fluids in wheat. The fact that sap pH increased in light despite the probable concomitant rise in leaf temperature further suggests the predominance of the photo-effect. It remains a matter for further investigation, however, to determine what portion of the diurnal hydrion variation herein reported is due to the increased temperature of the tissues and what fraction to the light.

During the tenth week, it was found that mature leaves of fully illuminated, chlorotic plants on the limed humus gradually began to lose their turgor and turn brown. Many of the oldest leaves wilted and died. Acidity tests made on these plants during the incipient stages of browning (table II) disclosed that the sap hydrion concentration had risen considerably above that found in the eight week old plants of the same series.

Table II — Sap Hydrion Concentration of Fully Illuminated, Chlorotic Plants (Ten Weeks Old) On Limed Humus

Hour	pH
6 A.M.	5.57
10 A.M.	5.55
2 P.M.	5.59
6 P.M.	5.59
10 P.M.	5.62
6 A.M.	5.58
10 A.M.	5.55
2 P.M.	5.55
6 P.M.	5.58

Moisture content had also fallen about five percent. Diurnal acid periodicity could no longer be detected and the hydrion level approximated that of plants growing on the untreated acid humus. This latent increase in the acidity of initially low-acid chlorotic plants appears to be due to the accumulation of acid catabolic products and to partial dehydration of the tissues. Thus the persistent extremes of high and low soil acidity eventually culminate in sap hyperacidity. Changes in soil acidity and light intensity produced the smallest changes in sap hydrion concentration in the plants grown on the loam soil. These plants were also more nearly normal in appearance. The higher mineral content of this soil appears to buffer tissue fluids more effectively than the low mineral humus.

The foregoing data show that both soil reaction and light influence sap acidity. When their effects are cumulative the change in metabolism is sufficient to cause marked alteration in the appearance of the plants.

INDEX CROSS REFERENCES:

STATE UNIVERSITY OF IOWA,
IOWA CITY, IOWA.