INFLUENCE OF WATER EXCESS OR DEFICIENCY ON LEAF NUTRIENT CONTENT AND PLANT GROWTH IN SUGARCANE AND OTHER CROPS[1]

Farmers growing crops are often faced with varied moisture conditions ranging from water deficiency (drought) to excess (flooding). Extreme water stress may take place in many parts of the Tropics during the growth of a single crop. Time of planting may be when soil moisture levels are optimum, but several months of heavy rainfall with poor drainage, causing a water excess, may be followed by a period of dry weather causing a water deficiency. Nutrient availability and distribution under abnormal water stress becomes a matter of concern when plant and soil analyses are to be interpreted for fertilizer application recommendations.

To evaluate the influence of water deficiency and excess on leaf nutrient content and growth, water regimes, 1 deficiency, 2 normal, and 3 flooding were established in the greenhouse for sugarcane, corn, tobacco, tomatoes, and taniers (*Xanthosoma sp.*). The crops were grown in 2-gallon glazed containers, in a Toa silty clay (Mollisol) soil of pH 6.1. Each treatment was replicated 3 times in a randomized-block design. The plants were grown in the pots receiving a normal water supply until flowering for corn and tomatoes, age 4 months for sugarcane and tanier and 6 weeks for tobacco before beginning the water treatments. The water-deficient treatment plants received no additional water except for 100 ml. every fifth day, and the normal-water treatment plants 500 ml. of water per day. The excess-water treatment was achieved by fitting a rubber stopper in the drainage outlet and filling the container with water. Plants were kept standing in 1 inch of water, except for sugarcane where the water level was 3 to 4 inches above the soil surface. Tap water was used throughout. Some water was added daily to compensate for transpiration and evaporation losses. The treatments were maintained 14 days for sugarcane, 19 for corn, 7 for tobacco, 19 for tomatoes and 28 for taniers. Plant growth was assessed by weight of plant. Due to insufficient plant material, the 3 replicates of each treatment were combined for chemical analyses.

For sugarcane, both water deficiency or excess resulted in reduction of growth which was more pronounced under the water-deficiency treatment (table 1). Leaf-sheath moisture, leaf N and K values declined to levels below those considered acceptable for normal cane growth.[2] Water-deficient and water-excess treatments were similar in their influence on moisture

[1] Manuscript submitted to the Editorial Board August 12, 1971.

[2] Alexander, G., Samuels, G., and Spain, G., Physiology of sugarcane under water stress: Invertase, ATP-ase and amylase behavior in plants experiencing water deficiency, night flooding and continuous flooding, J. Agr. Univ. P.R. (Submitted for publication.)

TABLE 1.—*The relative percentage change in weight, moisture and nutrient content of various crops subjected to water deficiency and excess as compared to normal water treatment*

Item	Water treatment	Percent change from normal water treatment					
		Sugarcane	Corn	Tobacco	Tomato	Tanier	
						L[3]	P[3]
Weight	D[1]	−56**	−65**	−33**[2]	−59*	−80**	−69**
	E[1]	−22*	−77**	−36*	−55**	−47*	−23*
% H_2O[4]	D	−6*	−8**	−4**	−8*	−36**	+1
	E	−5*	−17**	−6*	−6*	−8*	−2
% N leaf[5]	D	−33	+53	−28	+11	−17	+129
	E	−29	+22	−45	−4	−4	+63
% P leaf	D	+3	+44	−19	+23	−37	−29
	E	0	+21	−33	+9	−28	−21
% K leaf	D	−24	+37	+29	+24	+10	+77
	E	−11	0	+63	−11	+15	+33
% Ca leaf	D	+6	+61	+1	−5	+10	+47
	E	+28	+13	−22	+31	−29	−40
% Mg leaf	D	+38	+58	−6	−8	−1	+176
	E	+31	−17	−4	+11	−43	−28
% Mn leaf	D		−16		−10		
	E		+59		+37		

[1] D-deficient (dry), E-excess (flooded).
[2] * Significantly different at 5-percent level, ** significantly different at 1-percent level, as compared to normal water treatment.
[3] L-leaf, P-petiole.
[4] For entire plant except sugarcane where leaf sheath was used.
[5] Percent nutrient contents on dry-weight basis.

and N. A separate experiment in sand culture rather than soil showed that leaf moisture and growth were reduced similarly for either excess-water or deficient-water treatments.[2] The various water levels did not cause change in leaf P, but leaf Ca and Mg values were higher than normal under water stress.

Growth in corn was reduced quite drastically when the plants received deficient or excess water (table 1). Plant weight and moisture level decreased less under flooding that under water deficiency. Unlike sugarcane, the corn leaves had a higher N content with both the deficient and the excess-water treatments than with the normal water regime. This trend also was apparent for leaf P and Ca. Water deficiency gave higher leaf K and Mg levels than either normal or water-excess treated plants. Soil flooding caused a marked increase in the Mn content of the corn leaves compared to normal and water deficient treatments.

A 7-day exposure to water deficiency and excess caused similar reduction in growth of tobacco (table 1). Although leaf moisture, N and P dropped for both water-stress treatments, the decline was somewhat greater in the excess-water than in the deficient-water treatments. The decrease in leaf N obtained in the flooding treatment was more severe in tobacco than any of the other crops tested. Excess-water treatments resulted in higher leaf K than normal or deficient treatments. Ca levels in the leaf showed small variations for all treatments except for a reduction in the excess-water treatment.

Plant growth in tomato was greatly reduced in both water-stress treatments (table 1). Leaf-moisture levels dropped for water-deficiency and excess treatments. Despite the severe reduction in plant growth due to the various moisture stresses, the nutrient levels in the tomato leaves showed small variation. Leaf NPK values were somewhat higher under water deficiency than under other water regimes, whereas leaf Ca and Mg yielded higher levels under excess water than under other treatments. As for corn, leaf Mn values were highest for the flooding treatment while the water-deficiency treatment gave leaf Mn values lower than normal. The increase in leaf-Mn values can be attributed to the increase in soluble Mn in the soil due to the flooding treatment.

As for the other crops, marked reduction in growth for taniers resulted from water deficiency or excess, with poorest growth in the water-deficiency treatment (table 1). Because the tanier plant has a large fleshy petiole which often outweighs the leaf, moisture and nutrient analyses are presented for both portions of the leaf. Although the moisture content of the leaf was lowest under a water deficiency, the petiole showed minimal variation for any of the water level treatments. Nitrogen decreased moderately in the leaf under both water-stress treatments; yet, in the petiole, the N content increased greatly, especially in the water-deficiency treatment. Leaf P values decreased in both leaf and petiole for the two water-stress treatments. Although K increased in both leaf and petiole with water excess and deficiency, the K increases were much higher in the petiole especially under water-deficiency treatment. Ca increased in the petiole more so than in the leaf under a water deficiency, but there was a decrease when the soil was flooded. There was a large accumulation of petiole Mg under the water-deficiency treatment, but leaf and petiole Mg decreased when there was an excess of water.

Extreme water regimes, whether deficiency or excess, present a medium unsuitable for proper root development and uptake of water and nutrients from the soil. The ensuing shortage of moisture in the plant prevents proper translocation of nutrients, causing a reduction in growth and moisture content of the plant for each of the crops studied. Typical drought symptoms developed whether growing under a water-deficiency treatment or flooded soil.

Despite the similarity in growth behavior by the five crops when exposed to extreme water regimes, the changes in the levels of nutrient contents in their leaves were not similar. Leaf N values decreased sharply for water-stress treatments, as might have been expected from the low sugarcane sheath moisture contents. Corrections for leaf N values, due to variation in plant moisture measured by sheath moisture, have been used by Clements[3] and Samuels[4] for proper interpretation of the nitrogen needs of sugarcane. However, decreasing leaf N values were associated with decreasing leaf moistures only with sugarcane, tobacco, and taniers (leaf). Corn and tomatoes showed higher nitrogen values with decreasing moisture in the leaf.

It has been shown that changes in sheath moisture directly influence the K content of the sugarcane leaf.[3] Because K in plant tissues appears to be entirely soluble in the cell sap, Clements reasoned it may be better to report K on a tissue-moisture basis rather than on a dry-weight basis.[5] This concept enabled one to adjust leaf K values for large variations in plant moisture, ranging from dry to wet weather, when making potash recommendations for sugarcane. Unfortunately, such a relationship does not appear to exist for any of the other crops tested.

Either water deficiency or excess can bring about marked changes in plants. For sugarcane, these variations in moisture caused by water stress may be used to correct the nutrient (NPK) levels for proper interpretation of fertilizer recommendations. However, this relationship between leaf moisture and nutrient content does not appear to be similar for all crops, or at least not for the five crops evaluated in this study. Thus, variations in nutrient levels brought about by any changes in the moisture levels of the plant may not be necessarily the same for different crops, and interpretations of these relationships will require study for each crop.

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[3] Clements, H., Crop logging of sugarcane: The standard nitrogen index and the normal nitrogen index, Hawiian Agr. Exp. Sta. Bull. 35, 1-56, 1957.

[4] Samuels G., Foliar diagnosis for sugarcane, Agr. Res. Pub., Río Piedras, P. R., 1969.

[5] Clements, H., Recent developments in the crop-logging of sugarcane, Proc. 10th Congr. Int. Soc. Sugar Cane Technol. 10: 522-8, 1959.