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The Effect of Leaching the Fertilizer Band on Nutrient Uptake and Growth of Sweet Corn[1]

Band placement of fertilizer for annual row crops usually results in markedly better growth and nutrient uptake than when the fertilizer is broadcast and incorporated. Periodically, experiments carried out in western Washington were complicated by a lack of a positive response to banded fertilizer. This occurred only when there was little or no natural rainfall for a period of three to four weeks following planting. Generally, soil moisture was high enough to prevent noticeable salt damage or moisture stress, and supplemental water was not applied.

Using laboratory and growth chamber studies Blanchar and Caldwell (1966a, 1966b) found that plant roots could not survive entry into the area strongly influenced by the fertilizer until after it was leached sufficiently to dilute the salts. This appeared to explain our anomalous field results. Because of its importance to efficient fertilizer utilization it was decided that a field investigation of this concept should be conducted.

Methods

A seed bed was prepared on three blocks of a Sultan silt loam in early May of 1971 in anticipation of initiating an irrigation study. Table 1 indicates that there were only minor differences in chemical and physical soil properties among the three blocks. The conditions required for initiation were that the soil be at or near field capacity with a weather outlook of an extended high pressure period. Weather conditions during May, June, and early July were wet, cool, and overcast. The soil was worked periodically for weed control during short breaks in the rain pattern. On July 12 five rows of sweet corn, *Zea mays saccharata,* var. Golden Jubilee, were planted in each block using a three-ft row spacing. The seed was placed one inch deep, and 500 pounds per acre of 10-20-10 fertilizer were placed in a band two inches below and two inches to the side of the seed. The fertilizer was a blend of 28, 15.5, 40, and 16.5 percent of concentrated superphosphate, 11-48-0 (technical ammonium phosphate), $(NH_4)_2SO_4$, and KCl, respectively.

On July 20, 0.5 in of water was applied to one block (termed limited). Another block (termed high) received 1.5 and 1.0 in of water on July 20 and August 9, respectively. The third block (termed nil) was not irrigated. Overhead sprinklers were used for irrigation during periods of minimal wind velocity, and the blocks were well separated to prevent any drift effect.

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Plant and soil samples were taken from each of the central three rows of each block starting July 28 and at seven-day intervals thereafter. There was no measurable natural rainfall until August 22, four days after the last sampling, when there was .47 in of rainfall. There was sufficient rainfall thereafter to prevent a moisture deficit during the remainder of the growing season.

Soil cores, 0.75 in in diameter, were taken from the 2.5 to 3.5 in layer at two in to the fertilized side of the row. The fertilizer band was thus included in the sample. The samples were placed in tared weighing cans, weighed, oven-dried at 105°C, and reweighed to determine the moisture content. Each plant sample consisted of the above-ground portion of 20 plants. These were oven-dried at 65°C, weighed, and ground to pass a 20-mesh screen. A fifth sampling of plants, consisting of the above-ground portions of 10 plants, was taken after the first killing frost. These were oven-dried at 65°C and weighed to obtain a relative measure of yield potential since no edible ears developed.

TABLE 1. Chemical and physical tests on the soil of each irrigation treatment.

Irrigation treatment	pH	Extractable nutrients Ca	Mg	K	P	Organic matter	Sand	Silt	Clay	Moisture equiv-alent-
		meq/100g			ppm	%				
Nil	5.64	6.58	1.34	.115	3.7	4.5	33.9	51.6	14.5	27.1
Limited	5.69	6.40	1.28	.115	3.0	4.6	29.9	54.7	15.4	29.8
High	5.70	6.50	1.28	.129	3.2	4.4	33.9	52.2	13.9	26.7

The analyses of soil samples taken previous to planting (Table 1) were run as follows: The pH, Morgan's solution extractable bases and P, and organic matter were determined by the Washington State University soil testing laboratory. Soil separates were determined by the pipette method after saturation with Na, oxidation of organic matter with H_2O_2, and dispersion in boiling Na_2CO_3. The moisture equivalent point was determined by centrifugation of water-saturated soil at 1000 G for 20 min.

Plant samples were analyzed as follows: Ammoniacal-N was determined by a macro-Kjeldahl method. K and P were extracted from the plant samples with 2 percent HOAc. The K was determined by flame emission spectrophotometry and the P by the method of Baker (1971). The K determined by this method is equal to the total plant K, and the 2 percent HOAc extractable P is an index of the total plant P. For Cl analysis, plant tissue treated with 1 percent Na_2CO_3 was dried, ashed at 550°C, the ash dissolved in HNO_3, and the Cl titrated by the method of Caldwell and Moyer (1935).

Results and Discussion

The moisture percentage of the fertilized soil zone remained higher where no or only limited supplemental water was applied (Table 2). Two explanations for this appear possible. One is that, through a hygroscopic effect or reduced vapor pressure, the fertilizer salts absorbed water from the surrounding soil to maintain a higher water content in the fertilized zone. A supplemental laboratory experiment indicated that this effect was unimportant under the conditions of the field experiment. Thus, a second explanation is more plausible; that is, that the water content of the unleached

TABLE 2. The effect of irrigation and date of sampling on moisture in the fertilizer zone and plant weight.

Irrigation treatment	Sampling date 7/28	8/4	8/11	8/18	10/11
	Soil moisture in the 2.5- to 3.5-in layer—%				
Nil	28.8 ± 0.3[1]	28.4 ± 0.7	26.1 ± 1.1	22.9 ± 1.0	
Limited[2]	27.0 ± 0.3	26.7 ± 0.8	25.4 ± 0.6	21.6 ± 0.9	
High[3]	22.1 ± 1.4	22.8 ± 0.8	26.7 ± 1.0	21.4 ± 0.3	
	Oven-dry weight per plant—g				
Nil	.230 ± .015	1.298 ± .134	7.70 ± .49	19.8 ± 3.5	293 ± 29
Limited	.213 ± .010	1.296 ± .161	7.29 ± .60	22.2 ± 1.1	311 ± 35
High	.223 ± .016	1.345 ± .103	8.49 ± .11	26.8 ± 3.7	430 ± 21

[1] Numbers that follow the ± sign are the standard deviations.
[2] 0.5 in of water applied on 7/20 which was eight days after planting.
[3] 1.5 and 1.0 in of water applied on 7/20 and 8/9 respectively.

or partially leached fertilized zone remained high because of the failure of roots to exploit the moisture stored in the zones of high salt content.

As expected, the moisture level was up on August 11 in the block that received an inch of water two days previously. On August 18 there was between 24 and 26 percent soil moisture at the six- to seven-in depth below the corn rows on the block that received no supplemental water, and natural precipitation was plentiful thereafter. It is thus improbable that the plants ever suffered a moisture stress.

Plant growth was not greatly influenced by irrigation at the first two sampling dates (Table 2). By the third and fourth sampling dates, plants growing in the block that received the highest level of irrigation were noticeably taller than in the other two irrigation treatments. This was confirmed by plant weight differences. Plant weights measured on October 11 indicated that strong leaching of the fertilizer band in the early stages of growth markedly affected later growth despite the lack of any appreciable moisture stress throughout the growth period.

The explanation for this may be found in differences in the early exploitation of the fertilizer. The K concentration in plants (Table 3) and uptake (Table 4) of K was markedly and consistently increased by leaching of the fertilizer band.

Although there was a trend toward higher concentrations of P and N (Table 3) in the plant tissue on some sampling dates with increased band leaching, this was not as marked or as consistent as with K. The uptake data (Table 4), which should be more indicative of fertilizer usage, showed a more consistent improvement of P and N fertilizer utilization with band leaching on the last three sampling dates. This is especially true in comparing the high irrigation with the other two treatments.

Leaching of the fertilizer band can be expected to modify fertilizer availability in two ways. It results in greater dispersion of fertilizer salts so that they contact a greater portion of the root system. It will also reduce the salt concentration and acidity of the band, making it a more suitable medium for root penetration (Blanchar and Caldwell, 1966b).

It appears that KCl was leached from the band to a greater extent than the other nutrient sources. Plant Cl was determined to ascertain whether it followed the same uptake pattern as K. Tables 3 and 4 show that it was not until the second sampling that Cl differences began to appear and not until the third and fourth sampling that they tended to parallel K in the magnitude of differences due to irrigation. The lag

TABLE 3. The effect of irrigation and sampling date on the concentration of K, Cl, N, and P in the oven-dry plant tissue.

Irrigation treatment	Sampling date 7/28	8/4	8/11	8/18
		K—%		
Nil	2.45 ± .01	2.86 ± .09	2.09 ± .15	1.47 ± .07
Limited	3.11 ± .12	3.53 ± .06	2.81 ± .06	1.97 ± .01
High	3.81 ± .07	4.09 ± .08	3.74 ± .05	2.88 ± .13
		Cl—%		
Nil	1.61 ± .11	1.29 ± .07	0.76 ± .11	.43 ± .03
Limited	1.62 ± .07	1.34 ± .07	0.98 ± .09	.61 ± .11
High	1.52 ± .15	1.31 ± .07	1.01 ± .07	.91 ± .04
		P—%		
Nil	.291 ± .011	.423 ± .013	.314 ± .028	.242 ± .012
Limited	.271 ± .010	.450 ± .010	.321 ± .011	.247 ± .019
High	.307 ± .003	.497 ± .018	.443 ± .025	.246 ± .022
		N—%		
Nil	5.65 ± .10	5.42 ± .04	4.36 ± .11	3.45 ± .03
Limited	5.54 ± .02	5.50 ± .05	4.54 ± .02	3.57 ± .09
High	5.63 ± .10	5.52 ± .09	4.22 ± .05	3.51 ± .07

TABLE 4. The effect of irrigation and sampling date on the uptake of K, Cl, N, and P.

Irrigation treatment	Sampling date 7/28	8/4	8/11	8/18
		K uptake—mg per plant		
Nil	5.65 ± .35	37.2 ± 4.2	160 ± 2	291 ± 59
Limited	6.61 ± .28	45.8 ± 5.5	205 ± 14	438 ± 23
High	8.48 ± .46	55.0 ± 3.9	318 ± 5	770 ± 91
		Cl uptake—mg per plant		
Nil	3.71 ± .35	16.9 ± 2.5	58.1 ± 7.5	86 ± 19
Limited	3.44 ± .25	17.3 ± 1.3	71.4 ± 3.1	135 ± 16
High	3.38 ± .28	17.6 ± 2.0	83.8 ± 9.0	245 ± 44
		P uptake—mg per plant		
Nil	.672 ± .023	5.51 ± .69	24.0 ± 1.3	47.7 ± 8.2
Limited	.575 ± .008	5.84 ± .82	23.4 ± 2.4	54.8 ± 1.5
High	.684 ± .049	6.70 ± .67	37.7 ± 2.5	65.2 ± 2.9
		N uptake—mg per plant		
Nil	13.0 ± .6	70.4 ± 7.5	336 ± 15	682 ± 127
Limited	11.8 ± .6	71.3 ± 8.1	331 ± 27	793 ± 26
High	12.5 ± .7	74.2 ± 4.6	359 ± 2	941 ± 129

in Cl uptake may be related to the fact that plant roots expend considerable energy to absorb K while Cl is taken up passively.

The reasons for variations in both the magnitude of difference in uptake and date at which differences occurred for the four fertilizer constituents can only be speculative at this time. Nevertheless, the uptake of all four elements was markedly increased at the fourth sampling due to previous band leaching.

Conclusions

The results indicate that even when soil moisture appeared adequate for maximum plant growth, it was expedient to apply supplemental water when natural precipitation did not follow planting. Leaching and dilution of the fertilizer salts resulted in greater exploitation of the banded fertilizer.

Later leaching of the fertilizer bands by natural precipitation, beginning 41 days after planting, did not result in sufficient stimulation of plants growing in the previously nonirrigated block or in the block receiving limited irrigaton for them to approach the growth of plants on the well-irrigated block.

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