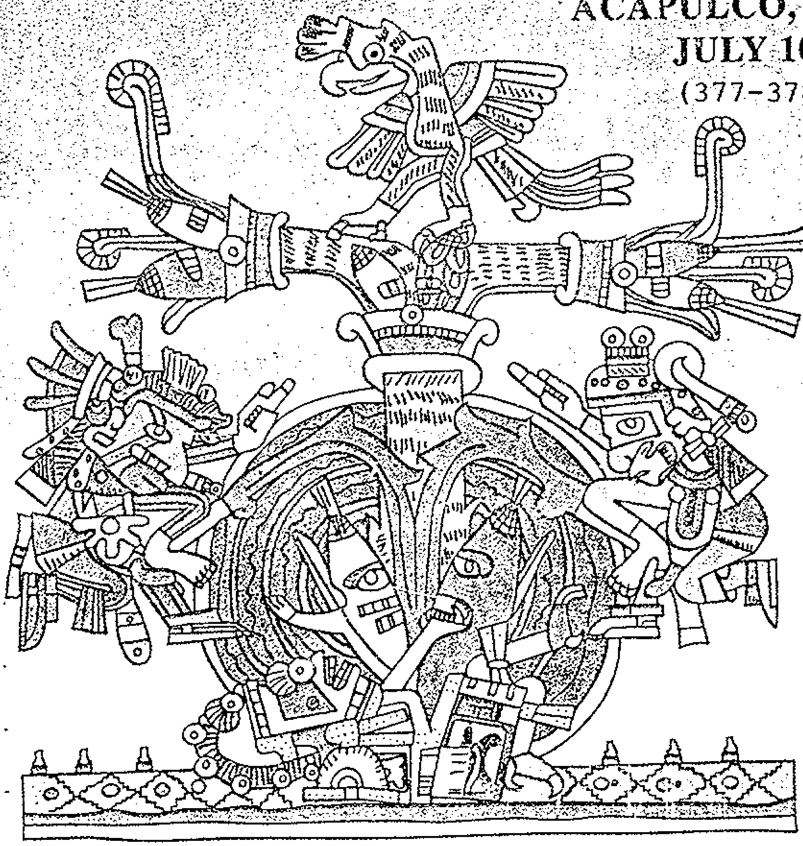
ACAPULCO, MEXICO
JULY 10-16, 1994
(377–378)



VOLUME 5b:
COMMISSION IV: POSTER SESSIONS

Transactions

15th World Congress of Soil Science
15 Bodenkundlicher Weltkongress
15ème Congrès Mondial de la Science du Sol
15° Congreso Mundial de la Ciencia del Suelo

Soil water content and P acquisition by sugar beet

N.Claassen*, and H.Schmid. *Institute of Plant Nutrition, TU München-Weihenstephan, 85350 Freising, Germany.*

Introduction. The acquisition of soil nutrients by plants may be affected by drought. In dry soils ion mobility is low (1) and root growth is reduced(2). Even so, it is seldom heard that in dry years plants would show P deficiency, and Kuchenbuch and Barber found, that in dry years root density in the upper soil decreased by a factor of 3 but the yield of maize on the unfertilized plot was not affected. Therefore P influx must have been as high or even higher in dry than in wet years.
The purpose of the present study was to investigate to which extent soil water content affects root growth, P influx and P uptake.

Materials and Methods. This experiment was carried out on a plot of low and a plot of high soil P, on a loamy soil in Bavaria, Germany. At low P level P soil solution concentration in the upper 15 cm was 2.7 μmol P/l, at high level 37.4 μmol P/l. There was no difference in soil solution concentration below 15 cm. 40 days after planting sugar beet a mobile plastic roof protected half of the plots against rain. When rain ceased the roof was removed. At five dates between the end of May and August plants were harvested and separated into leaves, beets and roots. Root length and several soil parameters as P soil solution concentration, water content or soil test values (Ca-Acetate-Lactate procedure) were determined at 6 depths, down to 120 cm.

Results and Discussion. Figure 1 shows that drought reduced the yield about 50%. There was no difference in yield between the high and low P level. Total root length was affected by drought. The higher root length on the watered plots was due to an increased root growth in the 0-15 cm layer and reflected the lower water content in this layer. Below 30 cm there were no differences in water content. The effect of drought on P uptake and influx was large. Average P influx was reduced by 40% on the low, and by 60% on the high P level.

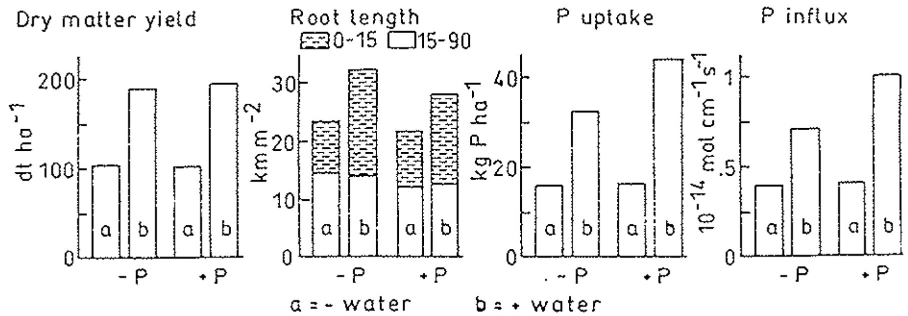


Fig. 1. Final yield (leaves + beets) and P uptake of sugar beet on a soil low (-P) and high (+P) in P at low and high water supply. Root length for the soil layers of 0-15 and 15-90 cm and the P influx were average values for mid June through the end of August.

These results are as expected from the laws of diffusion, which is the main mechanism of P transport to roots (4). The equation shows that the flux by diffusion, F_D (mol cm^{-2} s^{-1}) can be described as follows

$$F_D = D_L \Theta f (dC_L/dr)$$

Where D_L is the diffusion coefficient in water (cm^2 s^{-1}), Θ the volumetric soil water content (cm cm^{-3}), f the impedance or tortuosity factor which increases with Θ (1). C_L is the soil solution concentration (mol cm^{-3}) and r (cm) is the distance to the root. The equation shows that the flux to the root surface and thereby the influx depends on the diffusion path characteristics given by the soil water content and the tortuosity of that path.

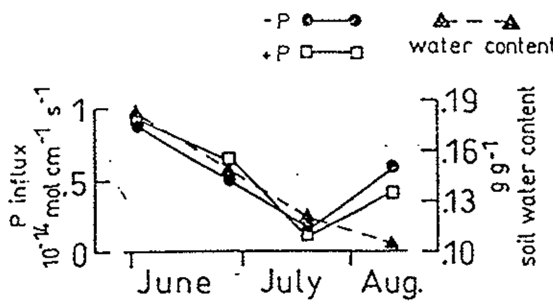


Fig.2. Phosphorus influx of sugar beet roots on a low P (-P) and a fertilized plot (+P) at changing water content of the plow layer (0-30 cm depth) on the dry (unwatered) plot.

Figure 2 shows for the low and high P plot, that a decrease of the soil water content from 18.5% to 12.1% reduced P influx by about a factor of 6.5. But in July and August, even though soil water content continued to decrease to 10.2 %, P influx increased in both plots by about 400%.

These results are unexplained, because there is no doubt that soil water content does affect ion mobility in soil, and should therefore affect the influx. It seemed that plants have developed mechanisms to change the conditions in the rhizosphere which overcome the impairments of soil dryness. This may be the explanation why P deficiency is not observed in dry years. In further experiments we will try to elucidate those mechanisms.

Literature Cited.

(1) Barraclough, P.B., Tinker, P.B. 1981. The determination of ionic diffusion coefficients in field soils. I. Diffusion coefficients in sieved soils in relation to water content and bulk density. J.Soil Sci. 32, 225-236.

(2) Hallmark, W.B., Barber, S.A. 1981. Root growth and morphology, nutrient uptake and nutrient status of soybeans as affected by soil bulk density. Agron.J. 73, 779-782.

(3) Kuchenbuch, R., Barber, S.A. 1987. Yearly variation of root distribution with depth in relation to nutrient uptake and corn yield. Comm. Soil Sci. Plant Anal. 18, 225-263.

(4) Barber, S.A. 1962. A diffusion and mass-flow concept of soil nutrient availability. Soil Sci. 93, 39-49.