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EFFECT OF POTASH FERTILIZATION ON THE SALT TOLERANCE OF MAIZE, IRRIGATED WITH SALINE WATER

C.C. WEIR
Faculty of Agriculture
U.W.I., Jamaica.

SUMMARY

The effect of applying high levels of Potash fertilizer, on the salt tolerance of maize, was investigated under greenhouse experimental conditions.

It was found that high levels of applied K significantly reduced the uptake of Na, and resulted in approximately 20% greater dry matter yield compared to the control (K_0) treatments. The K/Na ratio in the maize tops, was shown go be a good index of salt injury. Ratios of K/Na less than 10 were associated with poor yields.

The effect of high salinity and Potash applications on the uptake of other nutrients was also ivestigated. High levels of Potash consistently decreased Magnesium and Nitrogen uptake, but somehow slightly increased Phosphate uptake.

The practical implications of using Potash applications to offset salinity injuries, caused by using saline irrigation water, are discussed, within the context of a nutrient balance for maize.

INTRODUCTION

Plant species differ widely in their tolerance to salinity. Some like mangroves, grow with their roots in sea water which is approximately 0.5 M NaCl, plus other salts, and has an electrical conductivity (EC) reading of about 55 mmhos/cm (35,000 mg/l).

However the yields of the most salt tolerant commercial crops are affected adversely by irrigation waters which exceed 5 to 10 mmhos per cm. The yields of sensitive ones are affected by waters exeeding 1 mmhos/cm. Thus even modest increases in the tolerance of crops, sufficient to permit economic crop production with moderately saline water, would be a tremendous accomplishment. But in looking for plants with high salt tolerance, we must recognize that tolerance is not necessarily a constant plant property, as it can be modified by other environmental conditions.

Many factors can affect the salt tolerance of plants. The stage of growth of the plant and many climatic factors such as atmospheric humidity, light intensity and oxygen tension can affect salt tolerance. Fertilizer application too can also be of importance in salt tolerance.

The fertilizer element of most significance in salt tolerance is Potassium. This investigation is concerned with studying the effect of Potash applications as a means of increasing the salt tolerance of corn, when irrigating with saline water.

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MATERIALS AND METHODS

a. Experimental Design

The statistical design of the experiment consisted of a randomized block design with 15 treatments; 5 salt levels x 3 Potash levels; and three replications. The salt levels ranged from non – saline irrigation water to highly saline water, while the 3 Potash levels consisted of zero, moderate and high applications of Potassium Chloride.

b. Soil used in Study – Application of K fertilizer

The soil used in this experiment was a non-saline alluvial soil, classified as Marverly loam – (No. 22) in the Jamaican Soil Classification System. Some chemical and physical properties of this soil are given in table 1.

Table 1. Some Chemical and Physical Properties of Soil used in Study – (Maverly Loam)

Soil depth	pH	% O.M.	p.p.m. availl. (1) P_2O_5	Exchangeable cations (2) K	Mg	Ca	Mechanical Analyses % Sand	% Silt	% Clay
0 – 15 cm	6.5	2.3	35	0.24	1.2	8.1	44	41	15
15 – 30 cm	6.7	1.6	28	0.20	1.0	7.3	46	42	12

(1) Truog's available phosphate
(2) Data in Me/100 gm

The 3 levels of K applied were as follows: (i) None, (ii) 0.3 Milliequivalent K per 100 gm. soil or approx. 200g KCl per hectare, (iii) 0.6 Me K per 100 gm. or approx. 400 kg KCl per hectare, (iii) 0.6 Me K per 100 gm. or approx. 400 kg KCl per hectare. The Potash applications were made before sowing of the maize seeds. Likewise, basal applications of Nitrogen (Ammonium Sulphate) and Phosphate, at rates of 200 and 100 kg, of N and P_2O_5 respectively were given to all pots.

c. Growth of Maize Seedlings

Maize seedlings (cv "Pioneer X-304") were grown in 25 cm plastic pots, containing approx. 10 kg. of a saline alluvial soil. Seedlings were produced by sowing six seeds directly in the pots, at a depth of about 2 cm. After germination, seedlings were progressively thinned out to 2 plants per pot.

d. Preparation of Saline Solutions and Description of Experiment

The saline solution used for irrigating were prepared from stock solutions, which were made by mixing calculated weights of appropriate chemicals. Relevant data on the 5 irrigation waters are given in table 2.

Table 2. Characterization of Saline Solutions used for Irrigation

Classification for Waters	Elec. Cond. Mmhos/cm	Salts P.P.M.	E.S.P.	Rating
1. Non-saline	0.8	480	55	Good
2. Moderately saline	2.1	1260	70	Fair
3. Saline	3.8	2280	82	Doubtful
4. Very saline	5.7	3420	90	Unsuitable
5. Very highly saline	7.7	4620	95	Highly unsuitable

Irrigation with the saline solutions was started one week after germination, and all pots were irrigated with the appropiate solution on alternate days.

In order to keep the salt concentration of the soil solution in the root zone as close to that of the irrigation water as possible, the soil in the pots was prevented from drying out and thus concentrating the salt in the root zone.

e. Harvesting and Tissue Analyses

The tops of the maize plants were harvested after six weeks growth in the greenhouse, and weighed after drying at 80^{o}C for 24 hours.

The dried samples were ground in a micro-hammer mill and then analysed for total Nitrogen, Phoshporus, Potassium, Sodium, Calcium and Magnesium.

Total Nitrogen was determined by a Micro Kjeldahl Procedure. Phosphorus analyses were carried out by the standard Molybdenum Blue method, Sodium and Potassium by flame photometry and Calcium and Magnesium by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

The yield of maize tops and the major nutrient conteng of the oven dried tissues are given in table 3.

EFFECT OF K AND NA ON YIELDS

The depressing effect of increasing salinity on yields and Potassium uptake are at once evident in table 3.

Table 3. Yield and Nutrient content of Maize tops

Treatmant		Yield of tops (g)	% K	% Na	% N	% P	% Ca	% Mg
1. NS	K_2	68.3	5.3	.068	1.65	0.20	1.0	0.40
2. NS	K_1	70.0	5.0	.069	2.21	0.19	1.2	0.51
3. NS	K_0	62.1	2.0	.055	2.37	0.17	1.2	0.75
4. MS	K_2	63.7	5.0	.21	1.70	0.21	1.0	0.42
5. MS	K_1	60.0	4.7	.22	2.31	0.20	1.0	0.49
6. MS	K_0	53.4	2.0	.26	2.53	0.17	0.9	0.70
7. Sal.	K_2	55.0	4.6	.50	2.25	0.19	0.95	0.31
8. Sal.	K_1	52.2	4.3	.52	2.60	0.20	0.83	0.35
9. Sal.	K_0	44.5	2.1	.63	2.10	0.14	0.83	0.51
10. V.S.	K_2	48.0	4.0	.65	2.25	0.16	0.83	0.33
11. V.S.	K_1	44.3	3.6	.68	2.10	0.14	0.95	0.39
12. V.S.	K_0	34.1	1.8	.79	2.15	0.13	1.0	0.49
13. V.H.S.	K_2	40.7	3.5	.74	2.53	0.14	0.83	0.30
14. V.H.S.	K_1	37.3	3.2	.90	2.53	0.13	0.70	0.35
15. V.H.S.	K_0	31.0	1.3	1.40	2.48	0.11	0.83	0.40
L.S.D. (P = 0.05)		± 7.1	ND	ND	ND	ND	ND	ND

NS = Non-saline; MS = Moderately saline; Sal = Saline;
VS very saline; VHS = Very highly saline.

Also obvious is the effect of using very saline irrigation water on the Sodium content of the maize tops.

The effects of Potash applications on (a) increasing yields and (b) reducing Sodium absorption are quite striking. Potash additions at the highest levels (K_2) decreased Sodium uptake over the controls (Ko), from 19 to 47%. Likewise, Potash applications at the highest levels, increased yields over controls, by an average of approx. 15%. Similar results on wheat, were reported by Schleiff (1975) who found that when using irrigation water, made saline with $MgCl_2$, a 20% yield increase was obtained by application of Potash.

K/NA RATIOS

In computing the K/Na ratios, the % values for each element was first converted to milliequivalents per 100 gm plant material as follows:

$$\text{Milliequivalent K or Na/100g} = \frac{\text{K or Na} \times 1000}{\text{Atomic weight}}$$

The following conclusions can be drawn

- above a K/Na ratio of about 15 – 20, there is vertually little or no change in Maize yields.
- below a K/Na ratio of about 10, Maize yields decreased sharply.
- for reasonable growth, the K/Na ratio must be maintained above 10.

It is interesting to compare the yields at a low K supply and 2.1 mmhos irrigation water, with that of 3.8 mmhos water and high K application.
Similar yields of about 76% of maximum were obtained with a lower K supply, when the water was of fair quality; as well as with poor quality water (3.8 mmhos), when the supply of K was high (K_2). Thus the increased use of Potash, was able to eliminate partly the damage caused by salinity.

NITROGEN AND PHOSPHATE CONTENTS OF MAIZE

The effects of the increasing salinity, as well as the K levels, on N and P uptake, was also investigated. Data in table 3, clearly show the depressing effect of salinity on P content of maize tops. On the other hand, Potash applications tend to increase P uptake.

Some workers (Bernstein, 1964; Nieman & Clark, 1976) have also shown that salinity can cause a deficiency of P in crops. However, a few have shown that salinity can sometimes result in an accumulation of P in plant tissues (Bernstein, 1974). But the injurious effects of salinity depends on the concentration of P in the root medium — at low concentration of P, salinity can cause a deficiency in P. These effects on the concentration of Phosphate in plant tissues seem unique, since salinity does not cause comparable changes in concentration of other essential ions (Bernstein, 1974).

Careful study of table 3, will reveal that there is little or no effect of salinity per se on N uptake. The differences in N content are really due to Potassium. At low salinities (NS, MS) there is a definite reduction in N (about 30%), due to K applications.
This trend is not apparent at higher salinities, because of the depressing effect of Na on K content. Thus, because of low K uptake, the N content in the very highly saline treatments were much higher than in the non-saline pots - 2.5% N vs 2.1% N.

SALINITY AND POTASH EFFECTS ON Ca AND Mg UPTAKE

Table 3 shows that neither high salt levels or Potash applications had any significant effect on Calcium uptake. This is not surprising. On the other hand, both salinity and Potash applications had marked depressing effects on Magnesium uptake. On the average, the nonsaline treatments had 40% higher Magnesium content, than the very saline pots. Similarly, the K_2 treatments had approximately 38% higher Magnesium than the K_o treatments. Leaf symptoms of Magnesium deficiency were detected in some of the K_2 and K_1 treatments.

These results are of great importance, as they indicate some of the nutritional problems that will have to be overcome, in any attempt at using high Potash applications to counteract saline conditions, caused by irrigating with saline water.

CONCLUDING REMARKS

The cation content of the leaves of salt tolerant plants, such as Spinach and Beet, often contain as much as 400 - 500 Meq cations per 100 gm, compared to about 100 - 150 Meq for non-tolerant plants. Many salt sensitive plants such as maize are able to absorb K selectively in large amounts. In this investigation, it has been shown that when K is taken up in large amounts, the salt tolerance of maize was increased.
However, it is believed that if higher tissue contents of K were achieved, more salt tolerance

could have been obtained, particularly in the very saline treatments.

In this greenhouse investigation, the criteria used for assessing salt tolerance, was growth and dry matter yield of maize – rather than grain production. It is recognised that salt tolerance is a function of plant growth stage, i.e. the plant may be more sensitive to salt at certain growth stages, and more tolerant at others. Because of this one cannot assume that the various treatments used in this investigation, would have similar effects on grain yields. However, research by the U.S.D.A. Soil Salinity Division (U.S.D.A. Handbook 60, 1953), have shown that using irrigation water of 8 mmhos, resulted in a 50% reduction in grain yield of maize. These results approximate quite closely the values obtained in this investigation.

The possibility of using K application to offset salinity injuries is not without drawbacks. In the first case, increasing uptake of K consistently results in decreased uptake of Mg and N. In addition, there is the accompanying depressing effect of high salinity on Mg, N and P. This means that if high levels of K are used to offset salinity injuries, then additional amounts of N, P and Mg, will be needed to obtain proper nutrient balance. It is quite possible that higher yields would have been obtained in the very saline treatments if extra N, Mg and P were applied. Subsequent research will explore the implications of these observations.

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