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REUSE OF DRAINAGE WATER PROJECT

Some aspects of crop salt tolerance and water management

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C O N T E N T S

1. INTRODUCTION

Irrigation is necessary for intensive crop production in arid and semi-arid areas and may be used to supplement rainfall in temperate and tropical areas.

During and immediately following periods of rainfall or irrigation water moves downwards through the soil to the water table. At other times water losses through evapotranspiration may reverse the direction of flow in the soil, so that water moves up from the watertable by capillary rise. Evapotranspiration removes pure water from the soil leaving salts behind. Since salt uptake by plants is negligible, salts accumulate in the rootzone. A more or less favourable salt balance in the rootzone can be maintained by leaching applying irrigation water in excess of plant needs.

The only agronomically significant criterion for establishing salt tolerance is the commercial field crop. Crop salt tolerance has usually been expressed as the yield decrease ecpexted for a given level of soluble salts in the rootmedium as compared with yields under non-saline conditions.

However, salt tolerance is a relative value based upon agricultural conditions under which the crop was grown. Although the effects of salinity on crop growth seem to be related with the osmotic potential of the soil solution this relationship is, obviously invalid under conditions in which specific ion effects are significant. Accordingly, corrections must be made for the additional detrimental effects. Absolute tolerances that reflect predictable inherent physiological responses by plants cannot be given because many interactions among plant, soil, water and environmental factors influence plant's ability to tolerate salts.

The purpose of this paper is to develop an evaluation system for the integrated effects of water management, water quality, soiltype and climate on crop production.

2. SALT TOLERANCE AND OTHER GROWTH CONSTRAINTS

Perhaps the most difficult task in assessing crop salt tolerance is accounting for the many factors that may influence plant's response to salinity.

Apparant salt tolerance may vary with soil fertility. Crops grown on infertile soils, generally have abnormally high apparent salt tolerance as, compared with crops grown on fertile soils, because yields on non saline soils are severly limited by inadequate fertility. Because salinity is not the limiting variable governing growth, the data are of limited value. Obviously, proper fertilization would increase absolute yields even though the apparent relative salt tolerance is decreased. Salt tolerance data may be desired for suboptimal conditions, however, where fertilizers are either uneconomical or unavailable.

Similar results have been obtained under different soil management conditions, as related to waterlogging and as a consequence conditions of poor aeration in the plant's rootzone.

Evaluation of water quality criteria for irrigation purposes must take into account the interactive effects of water, soil, plants and climate, but also the influence of management practices.

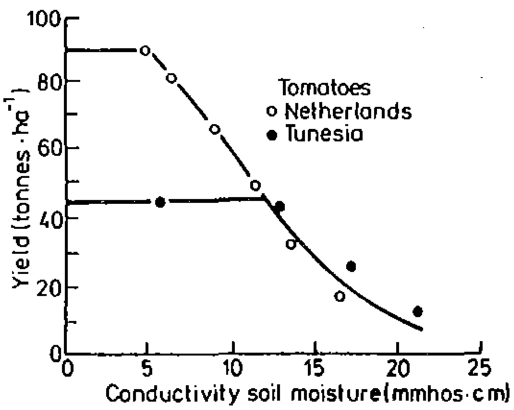

Fig. 1. Relationship between the mean conductivity in the root zone at field capacity and the productions of tomatoes in the Netherlands and Tunesia (RIJTEMA, 1981)

Figure 1 (RIJTEMA, 1981b) shows for instance the relation between production of tomatoes and soil salinity in Tunesia and in greenhouses in the Netherlands. Although the exposure-effect relationship for both regions coincide the salt tolerance in the Netherlands is much lower than in Tunesia, but the level of maximum production differs about a factor two due to other production constraints in Tunesia. So plants vary in their tolerance to soil salinity on other constraints for growth.

The recommendation of a single set of criteria for irrigation water is impossible because of the large variation in salt sensitivity, as well as variation in culture management. Climate will significantly influence plant response to salinity. Temperature, atmospheric humidity and radiation have markedly influenced salt tolerance. Many crops seem less salt tolerance when grown under hot dry conditions than under cool humid ones. Since not all crops are equally affected, these environmental factors must be considered, when assessing salt tolerance.

3. SALINITY AND CROP PRODUCTION

Literature reviews (BERNSTEIN, 1974; MAAS and HOFFMAN, 1977) show that a large number of experimental procedures have been used for determining salt tolerance. Experiments have been conducted in soil, sand and water cultures. But also in fields, small plots, greenhouses and growth chambers, and under nearly every conceivable environmental condition.

Many of the data concerning plant tolerance for salinity have been obtained from experimental field plots that were managed by means of high leaching fractions to obtain a nearly uniform salt distribution throughout the rootzone. Experience of several years confirms that such data are reproducible and reliable (VAN DEN BERG, 1962; BIERHUIZEN and PLOEGMAN, 1967; PLOEGMAN and BIERHUIZEN, 1970; HELLINGS, 1973; AYERS and WESTCOT, 1976).

Salt tolerance lists published by the U.S. Salinity Laboratory (ALLISON, 1964; BERNSTEIN, 1974) represent relative tolerances when crops are grown under conditions simulating recommended cultural and management practices for commercial production.

Evaluating the data available for various crops MAAS and HOFFMAN (1977) concluded that in general, yield was not decreased significantly untill a threshold salinity level was exceeded. Beyond this level yield decreases approximately linearly as salinity increased (Fig. 2). For some crops like bean, onion, clover and pepper yield approached zero asymptotically. These deviations from linearity are of little concern, however, because they occur only in the lower part of the curve where yieldsare economically unacceptable.

Tables showing crop tolerances to salinity as given by AYERS (1977) are presented for field crops in Table 1, for fruit crops in Table 2, for vegetable crops in Table 3 and for forage crops in Table 4. The tables give the threshold values and the expected yield decrements at 10, 25 and 50% level. The soil salinity values (EC_e) tolerated by a crop are the basic data on which the tables are based. EC_e is the expected average salinity at saturation to which the crop will be exposed. These tables can be used to help select crops to match either the quality of the available water supply (EC_w) or the EC_e in the soil.

As part of the tolerances, a minimum leaching requirement (LR) is

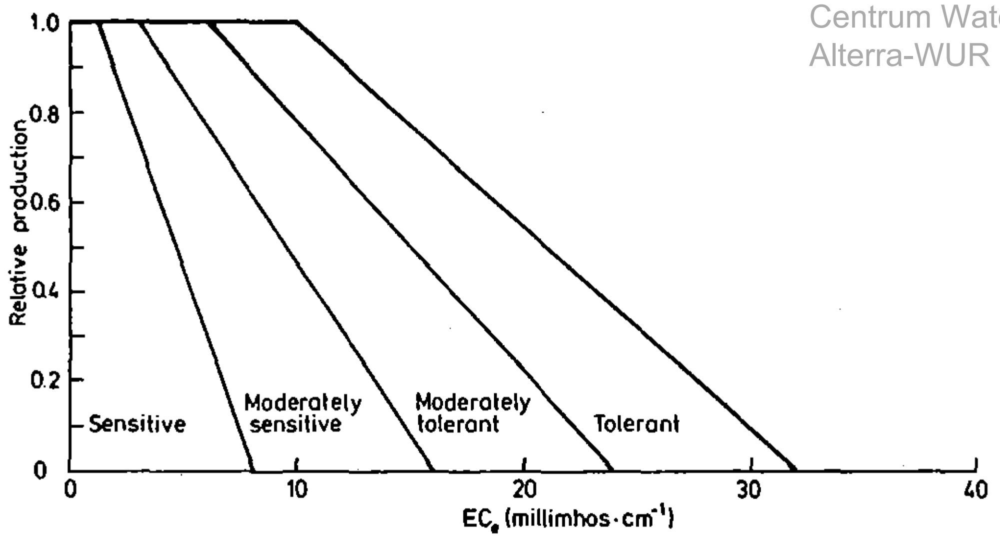

Fig. 2. Divisions for classifying crop tolerances to salinity (MAAS and HOFFMAN, 1977)

given based on the quality of the irrigation water used, according to the usual equation LR = EC_w/EC_{dw}, in which EC_{dw} is the electrical conductivity of the drainage water. This leaching requirement represents the minimum leaching fraction, that can be expected to keep salts under control for the specific crop and the quality of irrigation water used.

It is assumed that the leaching fraction corresponds to a moisture extraction of 40%, 30%, 20% and 10% of the consequentive layers of the root zone. The crop is presumed to integrate all the factors affecting water availability and it is believed to respond to the weighted average salinity of the soil water in the root zone.

For the LR calculation the tolerance of the crop is represented by EC_{dw} and is taken as the maximum salinity that can develop in soil water due to crop removal of water from the soil. At this salinity the crop cannot longer extract water and so this maximum EC_{dw} would represent a theoretical 100% loss in yield.

If this minimum leaching requirement (LR) is achieved, it is believed that salinity in the rootzone can be controlled within tolerance of the crop at near 85-100% of the given production level.

The accuracy and reliability of these evaluations are no better than the data used to make them and they can only be refined by further observations. The published lists of salt tolerances are based on data obtained under optimum fertility for non-saline conditions.

Table 1. Salt tolerances of field crops (AYERS, 1977)

Crop	Expected yield reduction at EC_w indicated and minimum LR								Maximum EC_{dw}
	0%		10%		25%		50%		
	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	
Barley (Hordeum vulgare)	5.3	10	6.7	12	8.7	15	12.0	21	56
Cotton (Gossipium hirsutum)	5.1	10	6.4	12	8.3	15	12.0	21	54
Sugarbeet (Beta vulgaris)	4.7	10	5.8	12	7.5	16	10.0	21	48
Wheat (Triticum aestivum)	4.0	10	4.9	12	6.4	16	8.7	22	40
Safflower (Carthamus tinctorius	3.5	12	4.1	14	5.0	17	6.6	23	29
Soybean (Glycine max)	3.3	17	3.7	18	4.2	21	5.0	25	20
Sorghum (Sorghum bicolor)	2.7	7	3.4	9	4.8	13	7.2	20	36
Groundnut (Arachis hypogaea)	2.1	16	2.4	18	2.7	21	3.3	25	13
Rice (paddy) (Oryza sativa)	2.0	9	2.6	11	3.4	15	4.8	21	23
Sesbania (Sesbania macrocarpa)	1.5	6	2.5	8	3.9	12	6.3	19	33
Corn (grain) (Zea mays)	1.1	6	1.7	8	2.5	13	3.9	20	20
Flax (Linum usitatissimuhm)	1.1	6	1.7	8	2.5	13	3.9	20	20
Broadbean (Vicia faba)	1.1	4	1.8	7	2.0	12	4.5	19	24
Cowpea (Vigna simensis)	0.9	5	1.3	8	2.1	12	3.2	19	17
Beans (field) (Phaseolus vulgaris)	0.7	5	1.0	8	1.5	12	2.4	19	13

Table 2. Salt tolerances of fruit crops (AYERS, 1977)

Crop	Expected yield reduction at EC_w indicated and minimum LR								Maximum EC_{dw}
	0%		10%		25%		50%		
	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	
Date palm (Phoenix dactylifera)	2.7	4	4.5	7	7.3	11	12.0	19	64
Fig (Ficus Carica)	2.7	4	2.6	9	3.7	13	5.6	20	28
Olive (Olea Europaea)	1.8	6	2.6	9	3.7	13	5.6	20	28
Pomegranate (Puncia granatum)	1.8	6	2.6	9	3.7	13	5.6	20	28
Grapefruit (citrus paradisi)	1.2	8	1.6	10	2.2	14	3.3	21	16
Orange (Citrus sinensis	1.1	7	1.6	10	2.2	14	3.2	20	16
Lemon (Citrus Limonea)	1.1	7	1.6	10	2.2	14	3.2	20	16
Apple (Pyrus malus)	1.0	6	1.6	10	2.2	14	3.2	20	16
Pear (Pyrus Communis)	1.0	6	1.6	10	2.2	14	3.2	20	16
Walnut (Juglans regia)	1.1	7	1.6	10	2.2	14	3.2	20	16
Peach (Prunus persica)	1.1	9	1.4	11	1.9	15	2.7	21	13
Apricot (Pyrus armeniaca)	1.1	9	1.3	11	1.8	15	2.5	20	12
Grape (Vitis app.)	1.0	4	1.7	7	2.7	11	4.5	19	24
Almond (Prunus amygdalus)	1.0	7	1.4	10	1.9	13	2.7	20	14
Plum (Prunus domestica)	1.0	7	1.4	10	1.9	14	2.8	20	14
Blackberry (Rubus spp.)	1.0	8	1.3	11	1.8	15	2.5	21	12
Boysenberry (Rubus spp.)	1.0	8	1.3	11	1.8	15	2.5	21	12
Avocado (Persea americana)	0.9	7	1.2	10	1.7	15	2.4	20	12
Raspberry (Rubus idaeus)	0.7	6	1.0	9	1.4	13	2.1	19	11
Strawberry (Fragaria chiloens)	0.7	8	0.9	10	1.2	15	1.7	21	8

Table 3. Salt tolerance of vegetable crops (AYERS, 1977)

Crop	Expected yield reduction at EC_w indicated and minimum LR								Maximum EC_{dw}
	0%		10%		25%		50%		
	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	
Beets (Beta vulgaris)	2.7	9	3.4	11	4.5	15	6.4	21	30
Broccoli (Brassica italica)	1.9	7	2.6	10	3.7	14	5.5	20	27
Tomato (Lycopersicum esculentum)	1.7	7	2.3	9	3.4	13	5.0	20	25
Cucumber (Cucumis sativus)	1.7	8	2.2	11	2.9	15	4.2	21	20
Cantaloupe (Cucumis melo)	1.5	5	2.4	7	3.8	12	6.1	19	32
Spinach (Spinacia oleracea)	1.3	4	2.2	7	3.5	12	5.7	19	30
Cabbage (Brassica oleracea capitata)	1.2	5	1.9	8	2.9	12	4.6	19	24
Potato (Solanum tuberosum)	1.1	6	1.7	8	2.5	13	3.9	20	20
Sweetcorn (Zea mays)	1.1	6	1.7	8	2.5	13	3.9	20	20
Sweet potato (Ipomea batatas)	1.0	5	1.6	8	2.5	12	4.0	19	21
Pepper (Capsicum frutescens)	1.0	6	1.5	9	2.2	13	3.4	20	17
Lettuce (Lactuca sativa)	0.9	5	1.4	8	2.1	12	3.4	19	18
Radish (Raphanus sativas)	0.8	4	1.3	7	2.1	12	3.4	19	18
Onion (Allium cepa)	0.8	5	1.2	8	1.8	12	2.9	19	15
Carrot (Daucus carota)	0.7	4	1.1	7	1.9	12	3.1	19	16
Beans (Phareolus vulgaris)	0.7	6	1.0	8	1.5	12	2.4	19	125

Table 4. Salt tolerance of forage crops (AYERS, 1977)

Crop	Expected yield reduction at EC_w indicated and minimum LR								Maximum EC_{dw}
	0%		10%		25%		50%		
	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	EC_w	LR(%)	
Wheat grass (Agropyron elongatum)	5.0	11	6.0	14	7.4	17	9.8	22	44
Bermuda grass (Conydon dactylon)	4.6	10	5.7	13	7.2	16	9.8	22	45
Barley hay (Hordeum vulgare)	4.0	10	4.9	11	6.3	16	8.7	22	40
Perennial ryegrass (Lolium perenne)	3.7	10	4.6	12	5.9	16	8.1	21	38
Trefoil birdsfoot, narrow leaf (Lotus corniculatus tennifolius)	3.3	11	4.0	13	5.0	17	6.7	22	30
Harding grass (Phalaris tuberosa)	3.1	9	3.9	11	5.3	15	7.4	21	36
Tall fescue (Festula elatior)	2.6	6	3.9	8	5.7	12	8.9	19	46
Crested wheat grass (Agropyron desertorum)	2.3	4	4.0	7	6.5	11	11.0	19	57
Vetch (vicia sativa)	2.0	8	2.6	11	3.5	15	5.0	21	24
Sudan grass (Sorghum sudanese)	1.9	4	3.4	7	5.7	11	9.6	18	52
Wildrye, beardless (Elymus triticoides)	1.8	5	2.9	7	4.6	12	7.4	19	39
Trefoil, big (Lotus uliginosis)	1.5	10	1.9	13	2.4	16	3.3	22	15
Alfalfa (Medicago sativa)	1.3	4	2.2	7	3.6	12	5.9	19	31
Lovegrass (Eragrostis spp.)	1.3	5	2.1	8	3.3	12	5.3	19	28
Corn (forage) (Zea mays)	1.2	4	2.1	7	3.5	11	5.7	18	31
Clover, berseem (Tritolium alexandrinum)	1.0	3	2.2	6	3.9	10	6.8	18	38
Orchard grass (Dactylis glomerata)	1.0	3	2.1	6	3.7	11	6.4	18	35
Meadow Foxtail (Alopecurus pratensis)	1.0	4	1.7	7	2.7	11	4.5	19	24

4. THE CRITICAL LEAF WATER POTENTIAL

Evapotranspiration from a crop dependson prevailing meteorological conditions, availability of soil moisture and physiological properties of the crop. For exellent crop growth non-stress conditions are required, so an approach has to be given to determine non-stress conditions.

Studies on water uptake by crops (GARDNER, 1960; RIJTEMA, 1965, 1969; ENDRÖDI and RIJTEMA, 1969) show that the relation between leaf water potential, transpiration and soil physical conditions can be given by the general expression:

$$- \Psi_{\ell} = + E(r_{p\ell} + b/k) - \Psi_s \qquad (1)$$

where: Ψ_{ℓ} = leaf water potential in bar
E = evapotranspiration in $mm.day^{-1}$
$r_{p\ell}$ = crop resistance for liquid flow from root surface to sub-stomatal cavities in $bar.day.mm^{-1}$
b = geometry factor of the root system in bar
Ψ_s = mean soil water potential in the rootzone in bar
k = capillary conductivity in $mm.day^{-1}$, as function of the soil water potential Ψ_s

Non-stress conditions for plant growth can be defined as those conditions under which the water use of the crop is not controlled by stomatal reaction. Data, as presented for some crops in Table 5 concern the critical leaf water potential at which transpiration starts to reduce. RIJTEMA and ABOUKHALED (1975), derived a relation between the critical leaf water potential ($\Psi_{\ell c}$) and the soil moisture content in the rootzone of the crop for different crops and soil types, resulting in a crop and soil dependent reduction factor for evapotranspiration which has been used succesfully in studies on irrigation water management.

Only a few data of critical leaf water potentials for crops are available. However, if effects of salinity on crop production mainly operate through the osmotic potential a relation can be expected between the value of $\Psi_{\ell c}$ and the maximum EC_{dw} a crop can withstand. The available data are given in Fig. 3, showing a linear relation between $\Psi_{\ell c}$ and EC_{dw}. This relation can be used to derive from the Table 1-4 also values of $\Psi_{\ell c}$ for different crops. It must be concluded from Fig. 3

Table 5. Critical leafwater potentials ($\Psi_{\ell c}$) of some crops at which transpiration starts to reduce

Crop	$\Psi_{\ell c}$ (bars)	Reference
Cotton	- 13	EHLIG and GARDNER, 1964
Birdsfoot trefoil	- 10	EHLIG and GARDNER, 1964
Grass	- 10	RIJTEMA, 1965
Wheat	- 10	RIJTEMA and RYHINER, 1968
Sunflower	- 7.5	EHLIG and GARDNER, 1964
Pepper	- 3.5	EHLIG and GARDNER, 1964
Potatoes	- 3.5	ENDRÖDI and RIJTEMA, 1969

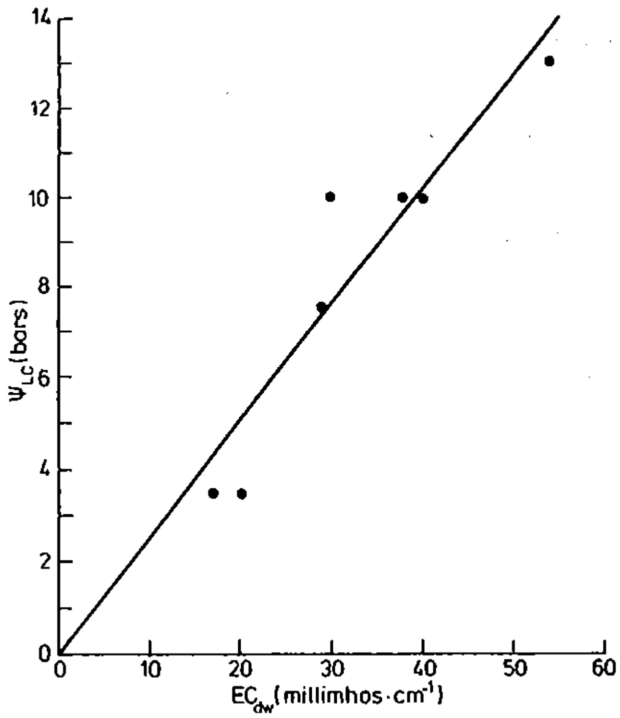

Fig. 3. Relation between EC_{dw} and $\Psi_{\ell c}$ for some crops

that a remarkable coincidence appears to exist between drought sensitivity and the salt sensitivity of a crop.

Electrical conductivity is directly related to the concentration of soluble salts in the soil solution and within limits to the osmotic potential as given by RICHARDS (1954) with the expression:

$$\Psi_o = - 0.36\ EC \tag{2}$$

Combination of the equations (1) and (2), assuming a linear decrease of the osmotic potential with the decrease of the soil moisture fraction and taking osmotic potential at field capacity as reference level yields the expression:

$$- \Psi_{\ell} = + E(r_{p\ell} + b/k) - \Psi_s - \Psi_o(\theta_{fc}/\theta_t) \qquad (3)$$

where: θ_{fc} = moisture fraction at field capacity
θ_t = moisture fraction at time t in rootzone

In a recent study ABDEL KHALIK et al (1986) extended the method described by RIJTEMA and ABOUKHALED (1975) for saline conditions introducing the weighted mean osmotic potential of the rootzone in the equation used to calculate the critical moisture content for non-stress conditions as a function of maximum evaporative demand, crop type, soil type and soil salinity. Following the procedure described by RIJTEMA and ABOUKHALED (1975) for the calculation of actual evapotranspiration under saline conditions gives the effect of soil salinity on crop water use. It appeared that the main effect of salinity on crop production can be explained by osmotic effects, so there should be a similar effect on crop water use.

5. SALT TOLERANCE AND WATER MANAGEMENT

The effects of salinity and different water management strategies on crop water use can be calculated with the method described by ABDEL KHALIK et al (1986). It will be valuable to investigate whether differences in crop water use under different conditions can be used as indicators for the response of crop yield to these conditions, or not. Calculations have been performed for the four main crops: berseem, wheat, maize and cotton under the prevailing climatological and irrigation conditions in Egypt. It is assumed that steady state salinity conditions are present in the crop's rootzone to assume a direct relation with the salt tolerance tables given by AYERS (1977). In fact these tables are based on steady state conditions, using a minimum leaching requirement (LR), depending on the quality of the irrigation water used. Calculations have been based on the assumption of 40% crop water uptake, coming from the upper quarter of the rootzone, 30% coming from the next quarter, 20% from the third quarter and 10% coming from the lower quarter of the rootzone. The salt concentration at field capacity in each layer can be calculated for steady state salinity conditions using the equation:

$$C(n) = \frac{1 + LF}{1 - \sum_{n=1}^{n} a(n) + LF} * C_{irr} \qquad (4)$$

where: $C(n)$ = concentration in layer n

C_{irr} = concentration of irrigation water

LF = leaching fraction

$a(n)$ = fraction of moisture extraction in layer (n)

The weighted mean salinity in the rootzone is calculated as:

$$\bar{C} = \sum_{n=1}^{n} a(n) * C(n) \qquad (5)$$

From this weighted mean salinity in the rootzone the mean osmotic pressure is calculated, that is used in the evapotranspiration calculations. Based on the climatological conditions in Egypt, using normal irrigation intervals and taking irrigation with Nile water, with minimum leaching as standard (RIJTEMA, 1981) gives the following results (TABLE 6).

Table 6. The relation between irrigation water quality, leaching fraction, osmotic pressure in the rootzone and crop water use for different crops

Crop		Relative production				
		100%	100%	90%	75%	50%
Berseem	- EC_w	0.5	1.0	2.2	3.9	6.8
	LF	0.02	0.03	0.06	0.10	0.18
	Ψ_o (bars)	1.52	2.38	3.66	5.13	6.96
	E^o (mm)	702	672	654	625	500
Wheat	- EC_w	0.5	4.0	4.9	6.4	8.7
	LF	0.02	0.10	0.12	0.16	0.22
	Ψ_o (bars)	1.52	5.26	5.95	6.88	8.19
	E^o (mm)	485	449	441	363	291
Maize	- EC_w	0.5	1.2	2.1	3.5	5.7
	LF	0.02	0.04	0.07	0.11	0.18
	Ψ_o (bars)	1.52	2.44	3.25	4.42	5.83
	E^o (mm)	617	599	548	443	230
Cotton	- EC_w	0.5	5.1	6.4	8.3	12.0
	LF	0.02	0.10	0.12	0.15	0.21
	Ψ_o (bars)	1.52	6.71	7.77	9.16	11.52
	E^o (mm)	961	883	865	772	503

The data of relative production and relative transpiration have been plotted in Fig. 4. For wheat, cotton and maize relative transpiration appears to be a reasonable indicator for the reduction in production due to salinity.

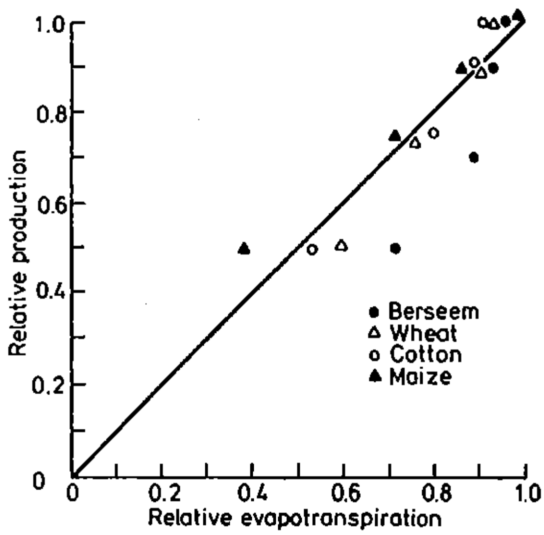

Fig. 4. Relation between relative production and relative evapotranspiration for 4 major crops in Egypt

Berseem appears to deviate. Two reasons can be present for this deviation:

- the relative yields given in the international tables might be based on fresh weight yield. This also explains the deviating salinity yield response curve;
- under Egyptian conditions berseem is irrigated rather frequently, compared with the evapotranspiration rate, which prevents the soil from drying too much between two successive irrigations.

Taking relative evapotranspiration as indicator for relative production enables to calculate the effect of different conditions on crop production. As example calculations have been performed for the total yield of maize for different conditions of water quality, leaching fractions, irrigation intervals and for conditions of low soil fertility. Fig. 5 shows the relation between the relative production and the osmotic pressure in the rootzone. The line in the figure is derived from the data given by AYERS (1977), whereas the points were calculated on basis of evapotranspiration using the method of ABDEL KHALIK and al (1986) for different water qualities and leaching fractions.

A reasonable agreement appears to be present between both methods, although the evaporation method tends to give a some what higher reduction compared with the salinity tables.

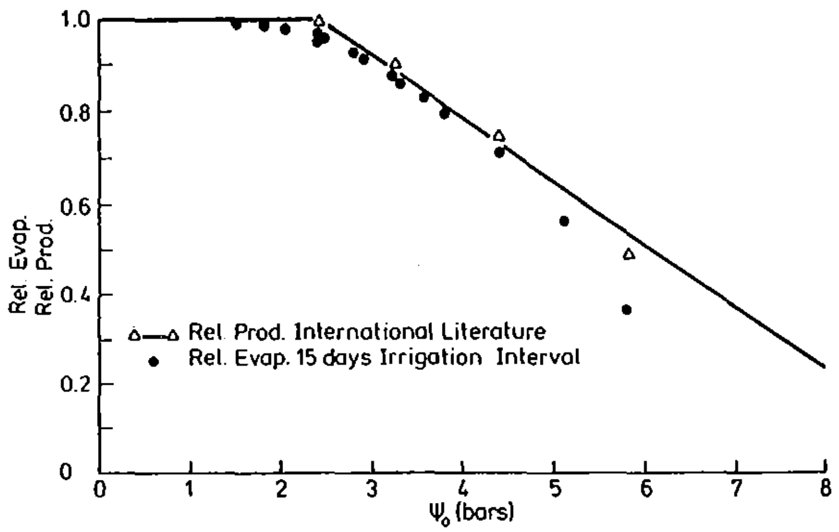

Fig. 5. Relation between relative production, relative evaporation and the osmotic pressure in the rootzone of maize

Calculations have also been performed for different irrigation intervals using 10, 15 and 21 days intervals. Normal practice in Egypt is a 15 days interval. The 100% level is assumed to be obtained with Nile water irrigation (EC_w = 0.5) and minimum leaching. The results of the calculations are given in Fig. 6. In this same figure the results of assumed restricted crop development, due to low fertility in its relation to evapotranspiration and salinity are presented.

The results indicate that at short irrigation intervals the possible production will be about 10% higher than under standard conditions, but salt tolerance seems to decrease. With the irrigation interval of 21 days maximum crop production is about 95% of the standard, with some increased salt tolerance. When due to low fertility the maximum rate reduces as effect of poor crop development, salt tolerance increases considerably, which is in agreement with data from literature.

Finally the effect of different leaching fractions and water qualities on relative evapotranspiration have been calculated. The relation between leaching fraction and relative evaporation for three different irrigation water qualities are given in Fig. 7. The curves show that at high leaching fractions a lot of water is required for a slight increase in relative production. It appears from the given examples, using relative evapotranspiration as an indicator for crop production that different combinations of irrigation applications,water quality and leaching can be evaluated in terms of relative production taking expected yield at standard irrigation with Nile water as reference yield.

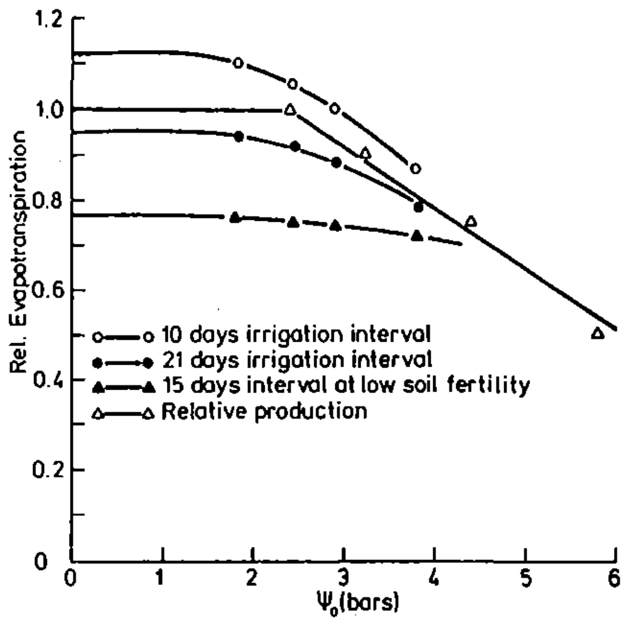

Fig. 6. Relation between relative evapotranspiration and osmotic pressure (Ψ_o) in the rootzone of maize

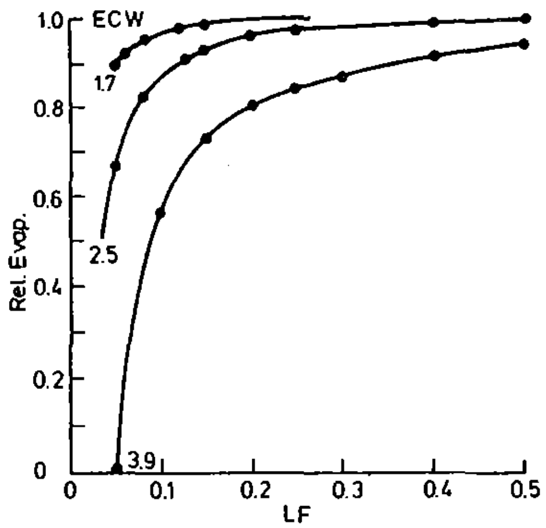

Fig. 7. Relation between relative evaporation (RELE) (relative production) of maize and the leaching fraction LF for 3 different qualities of irrigation water

Steady state salinity conditions are generally not present in field situations. Early in the growing season sufficient good quality water is available whereas during top water use also drainage water will be reused. A combination of the salt distribution model (in preparation 1986) and the evapotranspiration model (ABDEL KHALIK et al, 1986) enables to calculate the time integrated effect of salinity on crop water use. Taking crop water use when irrigating with Nile water as reference base, then relative evapotranspiration for different crops will give a good indicator for relative production under optimum fertilization conditions.

6. SUMMARY

A discussion has been given of salt tolerance of crops as presented in the international literature, using the salt tolerance tables presented by AYERS (1977). It appears from literature that osmotic effects are responsible for the main effect of salinity on crop growth, excluding some specific toxic ion effects.

A linear relation appeared to exist between critical leaf water potential and the maximum salt concentration (EC_{dw}) a plant can with stand. This indicates a good relation between drought sensitivity and salt sensitivity of crops.

A good relation was presented between relative production and relative transpiration of crops using irrigation water with different salinities.

Some examples have been given using relative transpiration as an indicator for productivity of the effects of different management conditions on productivity. Using a combination of a salt distribution model and a transpiration model is expected to give the time integrated effects of salinity on production

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