# ALFALFA WATER-PRODUCTION FUNCTIONS UNDER CONDITIONS OF DEFICIT IRRIGATION WITH SALINE WATER

by

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entitled Alfalfa Water-Production Functions Under Conditions of Deficit Irrigation With Saline Water

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

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SIGNED Karrie Sellers Pennington

# DEDICATION

This work is dedicated with love to the memory of a courageous woman, Janet Charlotte Pennington, who gave life her best and me a wonderful husband.

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ABSTRACT

This experiment was designed to determine the shape of the yield response function relating crop yield to total amount of saline irrigation water applied. Such a function contains a built-in leaching fraction that is the inevitable consequence of the inability of the plant to extract 100 % of the water from a saline soil.

In order to define the production function and to determine the leaching fractions, alfalfa (Medicago sativa L. cv. 'Mesa Sirsa') was planted in soil columns in a greenhouse. Two experiments were run sequentially. These were irrigated with water of differing salinities. The first with an EC of 4 dS/m (1.4 bars) and the second with an EC of 8 dS/m (2.9 bars). Both solutions were prepared by adding equivalent amounts of sodium chloride and calcium chloride to distilled water. The treatment variables were amounts of irrigation water applied. The amounts in both experiments were 110%, 100%, 75%, 50% and 25% of the measured evapotranspiration (ET). Four crop harvests were made in each experiment. At the end of experiment 1, (approximately 120 days), one column from each treatment was destructively sampled for soil salinity and water content measurements. The remaining columns were similarly sampled at the end of experiment 2 (approximately 120 days).

The crop-saline water production functions for both experiments were linear. Leaching fractions in experiment 1 were 9, 9, 6, 5 and 5% for treatments 1-5 respectively. Experiment 2 leaching fractions for treatments 1-5 respectively were 23, 25, 18, 15 and 17%. The lowest rootzone soil water osmotic potentials achieved by the end of experiment 1 for treatments 1-5 were -19, -20, -18, -26 and -24 bars. Corresponding treatment values achieved by the end of experiment 2 were -18, -22, -28, -31 and -45 bars.

# CHAPTER 1

## INTRODUCTION

Agricultural use of water resources in many parts of the nations farmlands has become a controversial subject. Farmlands in the arid western United States use over 80% of the available water resource for irrigation (Vaux and Pruitt, 1983). Worldwide, about one-third of the potentially arable land has an insufficient water supply, and on most of the remaining land, yields are periodically reduced by water deficits resulting from drought. Plant water deficits affect every aspect of growth (Hsiao, 1973) and the worldwide losses in yield from water stress probably exceed the losses from all other sources combined (Kramer, 1980). The competition for water among agriculture, urban populations and non-agricultural industry, particularly in the United States, will increase as more people and more industries choose to move into traditionally agricultural areas. It is the obligation of all water users to make the most efficient use of their portion of the resource.

This increasing shortage of "good" quality water for irrigated agriculture, particularly in arid lands, creates a need to find and develop alternative water sources. Using waters with higher salinity levels is one possibility. To irrigate effectively with saline water, it is necessary to understand the effects of these higher salt loads on crop response, especially the yield response.

This experiment was designed to determine the shape of the yield response function relating crop yield to total amount of saline irrigation water applied. Such a function contains a built-in leaching fraction that is the inevitable consequence of the inability of the plant to extract 100 % of the water from a saline soil. The objectives of this work were to produce the production function and to determine the leaching fractions.

Stress studies involving water and salinity are usually not combined because it is currently not possible to distinguish between a plant responding to an osmotically induced water stress and one responding to a soil matric potential induced water stress. However, in a field environment, natural soil variability leads to a situtation where plants are subject to a combined and changing total soil water potential due to variations in osmotic and matric potentials.

# CHAPTER 2

## LITERATURE REVIEW

In arid regions, soil water and soil salinity must often be considered simultaneously, since the availability of water for plant use is influenced by both the matric and the osmotic potential of the soil water, and the effects of salinity are mediated by the soil water content.

When salinity is a hazard, the concept of plant water use is expanded to include an increment of water to meet the leaching requirement. A leaching requirement, the fraction of the irrigation water that must be leached through the root zone to control salinity (U.S. Salinity Laboratory Staff, 1954) must be added to the amount of water necessary to grow a crop.

Bower et al. (1969), investigated root zone salinity and alfalfa growth, and found that crop yield was linearly related to average root zone salinity regardless of leaching fraction. Yield did decrease with increased electrical conductivity (ECe) of the saturation extract.

Bernstein and Francois (1973), demonstrated a relationship between irrigation water salinity and alfalfa growth in a greenhouse lysimeter study. Alfalfa yields were not sensitive to drainage water salinity as long as the salt balance in the rooting zone was unchanged. Francois (1981), carried this principle further by showing that alfalfa yields were not significantly reduced under conditions of zero leaching until salt began to accumulate in the upper portion of the root zone. His work predicted that leaching fractions smaller than those previously recommended for alfalfa could be used.

Water application nonuniformity will occur with any practical irrigation system. Areas in a field can receive more or less water than the average applied to the field depending on the peculiarities of the irrigation system and the soil. Trying to maintain low leaching fractions can exaggerate the effects of salts accumulated in areas receiving less than the estimated field average of irrigation water.

The history of the development of crop-water production functions was very ably presented by Tanner and Sinclair (1983). They discuss the climatic, soil and plant characteristics that influence the plant water use-yield relationship, and include a through examination of how and why the resulting crop-water production functions work. Whether salinity of the irrigation water influences the yield response curve is not considered in their discussion. They conclude that while yield of crops may vary with growing conditions, dry matter is decreased by water deficits in proportion to the decrease in transpiration produced by those deficits. The general form of a yield response function is presented in Figure 1. ETmax is the maximum seasonal evapotranspiration, Ymax is the maximum yield at ETmax and AWmin is the minimum applied water necessary before getting any yield.

How salinity of the irrigation water influences the yield-water relationship must also be considered. Eaton (1941), demonstrated that plants use less water as the salinity of the soil water increases.

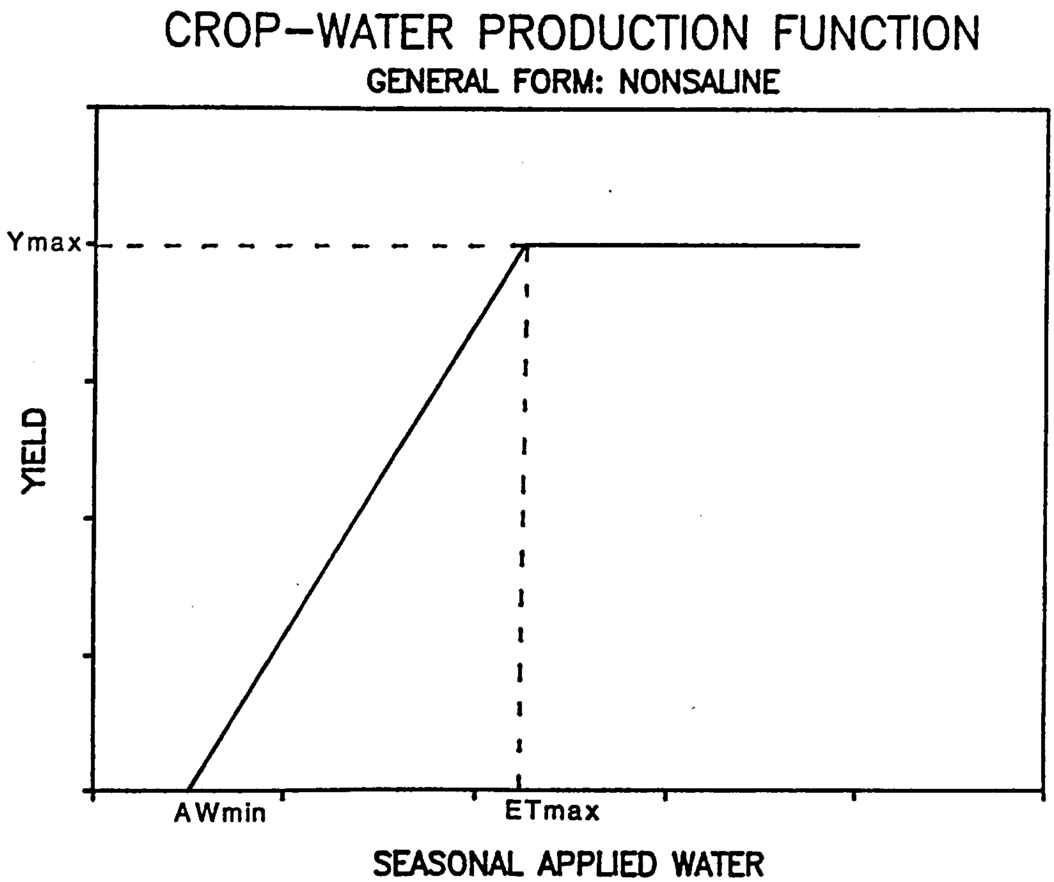


Fig. 1. The relationship between yield (Y) and seasonal applied nonsaline water. Symbols are described in the text.

Since that time, researchers have not clearly demonstrated whether a reduction in osmotic potential causes the same reduction in yield as a similar reduction in matric potential. Whether the reduction in growth with increased soil salinity is the cause of reduced water consumption or whether the reduced water consumption is the cause of the reduced growth due to salinity is also not known. Salts may reduce plant growth by decreasing the osmotic component of total water potential thus reducing net available water. Another possibility is that toxic effects reduce growth and decrease the total leaf area for transpiration. In either case, the end result is less water use.

Childs and Hanks (1975) showed that under variable salinity conditions, the relationship between relative transpiration and relative yield was the same whether water stress was induced by decreased osmotic potential or decreased matric potential. The production function from this analysis was described by Shalhevet (1984) as following the equation of Stewart et al. (1974):

$$Y/Ym = (1-b) + b(ET/ETm) \qquad (1)$$

The constant (b) appeared to be sensitive to evaporation and may or may not vary with salinity. The quality of the relationship is maintained when either water quantity or water salinity reduces water use. When evaporation is negligible, then b=1 (Childs and Hanks, 1975). This reduces equation 2 to that of Hanks (1974):

$$Y/Ymax = ET/ETmax \qquad (2)$$

Since salinity influences canopy development, salinity will have an effect on evaporation and on the function parameter b.

Shalhevet (1984) examined the field and greenhouse results of nine experiments (Hanks et al., 1978; Selassie and Wagenet, 1981; Stewart et al., 1976; Parra and Romero, 1980; Hoffman et al., 1978; Hoffman et al., 1979; Wadleigh et al., 1946; Meiri et al., 1982; Frenkel et al., 1982) and concluded that they offer convincing evidence for a unified linear relationship between yield and evapotranspiration regardless of whether changes in either yield or available water are caused by decreased osmotic or matric potential. This unified function was described by Hanks (1974) equation 2. Shalhevet further concludes that osmotic and matric stress are additive in their effects on yield and ET. He does stress that this does not mean that a unit change in osmotic potential is equivalent in its effect on growth and water use to a unit change in matric potential.

Warrick and Gardner (1983) address the problems of nonuniformity in relation to crop production. They state that conditions which are sub-optimal in terms of crop production will result in the same linear function as optimal conditions except that the yield maximum will be decreased. These authors also point out that average yield data for a nonuniform field does not represent a yield maximum and as a consequence, the slope of the yield-water line will be decreased from the optimal curve.

Attempts at simulating crop-water production functions when irrigating with saline waters have been made by Letey and Dinar (1986), Letey, Dinar and Knapp (1985), and Hanks (1984). The model proposed by Hanks (1984) could approximate the actual situation very closely. It is designed to take into account nonsteady soil water flow, nonuniform soil and water salinity, and variable applications of irrigation and rain. Possible limitations to this model involve obtaining correct estimations, computations or measurements of the input data required.

The Letey and Dinar (1986) model uses applied water as a basis for calculating the crop-saline water-yield functions. Actual plots are done using relative yield as a function of applied water divided by pan evaporation. This provides scaled values for both parameters which may make the functions applicable to a larger variety of areas, crops and conditions. This is the idea used by Arkley (1963), Stewart et al. (1972) and Hanks (1984) in making modifications of the de Wit equation.

The Letey and Dinar model calculates a yield decrement (YD) for different quantities of applied water such that the expected decrease in production using a given quality irrigation water can be determined. The Stewart (1972) model takes a similar approach. When applied water is greater than the amount that would result in zero yield but less than ETmax, the equation is:

$$100(YD)^2/B\ S(AW-AWt) + (YD)C' - (ECi(S)(AW))/2 \qquad (3)$$

$$-0.1\ ECi(S)(AW)\ln[(YD/(AW)S) + ((1-(YD/(AW)S))\exp(-5)] = 0$$

where YD is yield decrement, B is the slope of the yield- salinity curve at ECe values greater than C′ the threshold salinity, i.e. the ECe at which 100 % of the yield potential can be met, values for both B and C′ were taken from Mass and Hoffman (1977), S is the slope of the crop-water production function for nonsaline irrigation water, AW is applied water, AWt is the applied water resulting in zero yield and ECi is EC of the irrigation water.

When irrigating with saline waters, reductions in transpiration will occur as the osmotic potential of the soil solution decreases to some critical level where the plant can no longer extract water from the soil solution. The stomates close, transpiration is reduced and growth is reduced. At this point, the reduced growth will result in decreased water use. Some of the applied water is then available to leach the salts. In this way, an equilibrium of sorts is reached. The plants grow at some reduced rate, less water is transpired, some leaching occurs and a crop is produced. This is a "compromise yield" determined by the quality and quantity of available water. Letey and Dinar (1986) use a similar assumption in their report.

There was some very interesting work done by Hoffman et al. (1979), Jobes et al. (1981) and Hoffman and Jobes (1983). Their goal was to use continuous irrigation to maintain wet soils and low leaching fractions (LF = 0.02-0.20) and to compare relative yield to LF. They found that the LF-yield relationship paralleled the relative yield and ET relationship. Treatments with LF's of 0.02, 0.07 and 0.20 had mean soil water contents of 12%, 14.5% and 17.5% with soil averaged salinities of 36, 8 and 5 dS/m respectively. The lower LF did result in the highest soil salinity but, contrary to what the authors expected, it also had the lowest soil water content. This indicated that the plants were able to extract water in the low LF treatment despite the increased soil water salinity.

Hoffman and Van Genuchten (1983) proposed calculating a mean root zone salinity and using that to compute LR. Their method predicted measured leaching requirements from several studies more accurately than the general expression for LR. This suggests that soil water salinity in the rooting zone, not just the salinity of the irrigation and drainage waters, influenced the need for leaching. The fact that root zone salinity was a good predictor of leaching requirement could indicate plant involvement.

Vaux and Pruitt (1983) thoroughly review the available literature on plant responses to water deficits as they relate to crop-water production functions. They discuss adaptations in terms of morphological and physiological characteristics of the plants. They conclude that the morphological adaptations of primary importance are cell division and enlargement as they relate to leaf area development. The reduced leaf area that occurs with decreased cell enlargement is associated with a reduced water use which may help conserve water although at the expense of yield (Fischer and Kohn 1966; Ritchie and Burnett 1971 and Ritchie 1974). Reduced shoot growth increases the assimilates available for increased root growth and for osmotic adjustment (Begg, 1980).

A disadvantage of morphological adaptations that occur during growth and development of the crop is that they are largely irreversible. The decreased yield potential can not be recovered even if there is a return to more favorable conditions (Begg, 1980).

Physiological processes which influence crop productivity such as photosynthesis and partitioning of assimilates were considered the most pertinent to stress studies. The morphological change, decreased leaf area, decreases the amount of incident light that a plant can intercept. This can decrease total carbon dioxide assimilation, i.e. photosynthesis, calculated on a field basis.

Turner and Jones (1980) and Radin (1983) review work on turgor maintenance by osmotic adjustment. Since the fate of assimilates ultimately determines dry matter yield, this can be an important process. In both reviews, evidence of the occurrence of osmotic adjustment in response to water stress in a variety of different species and cultivars is presented. Turner and Jones (1980) stress that osmotic adjustment is unquestionably a mechanism of dehydration tolerance. It is particularly difficult to determine the overall value of osmotic adjustment because the plant has other methods of maintaining turgor. Tissues with highly elastic cell walls can reduce their volume to prevent wilt at lower relative water contents (RWC). Also, some tissues contain a larger portion of their water in a bound form rather than the free (osmotically active) form. This bound water takes longer to leave the cell in a deficit situation and may thereby, maintain turgor for a longer time (Radin, 1983).

Radin (1983) suggests that osmotic adjustment has been recognized as a mechanism for salinity tolerance for some time (Eaton, 1927; Bernstein, 1961; Slatyer, 1961). The restraints to water uptake imposed by excess salinity or water deficits are different. Plants grown under conditions where there is a ready source of inorganic solutes for osmotic adjustment will be able to implement osmotic adjustment more readily than those grown without the inorganic solutes. Water-stressed plants in nonsaline conditions must produce their own organic osmotica internally. Another important difference between salinity and water stress is that plants grown under saline conditions may require a reduced internal water potential just to be able to absorb water.

Crop response to the various aspects of salinity has been the subject of several excellent reviews (Lagerwerff 1969; Bernstein 1975; Jennings 1976; Greenway and Munns 1980). Since the net effect of excess soil water salinity is a water deficit, many of the symptoms of salinity stress are those of a water deficit stress. Bernstein (1975) discusses several of these symptoms.

Specific ion effects, although they can be significant, will not be discussed in this work. The decreased osmotic potential associated with soil water salinity is of primary importance to this study. In a normal saline field situation, concentrations of calcium and sodium salts are high. Plant response in this situation correlates well to the osmotic potential of the soil water (Bernstein 1964; 1975). This is the basis for many of the methods used to evaluate soil salinity and plant growth.

A major problem in determining the physiological effects of salinity on plant growth is a lack of specific information. We do not know if the primary effect of increased salinity consists of reductions in photosynthesis, in new cell growth, in translocation of assimilates or in some other factor. Vaux and Pruitt (1983) expressed the hope that a physiological approach, based on the chemistry and physics of crop response to the environment, in developing a crop-water production function would resolve the problems of current models.

CHAPTER 3

# MATERIALS AND METHODS

Alfalfa (Medicago sativa L. cv. 'Mesa Sirsa'), was grown for one year in 0.2 diameter by 1.2 m high soil columns in a greenhouse. Columns were irrigated sequentially with two solutions, the first with an ECi of 4 dS/m (1.4 bars), the second with an ECi of 8 dS/m (2.8 bars). Both solutions were prepared by adding equivalent amounts of sodium chloride and calcium chloride to distilled water.

## Soil

Ten columns 0.2 in diameter by 1.2 m high were filled with soil collected from the University of Arizona's Campus Agricultural Center in Tucson, Arizona. Soil was collected from the surface 15cm and sieved to remove particles larger than approximately 2 mm. The soil was classified as a coarse, loamy, mixed, thermic Typic Torrifluvent, Comoro sandy loam.

Columns were packed to a bulk density of 1.46 g/cc. A moisture release curve was determined by pressure plate analysis of core samples. Core samples were collected by two methods: 1. by plastic ring samples of loose soil, and 2. by using soil samples held in 4 by 6 brass rings. The samples in brass rings were wetted and pressurized overnight to stabilize the soil before the actual pressure plate analysis was done. Air dried soil moisture content was determined gravimetrically. All moisture values in this study were from gravimetric determinations.

The soil was chemically characterized by sodium saturation for cation exchange capacity (CEC), N:N ammonium acetate extraction for exchangeable cations, saturated paste extraction for soluble cations and electrical conductivity (ECe). (Results of the soil chemical and physical characterization are listed in Appendix A.)

## Columns and Measuring Devices

The columns were constructed of PVC pipe 22cm in diameter and 122cm high. Bottoms were sealed by gluing on a PVC cap. Holes were drilled in the column base cap for two high flow ceramic tipped tubes for drainage. Holes were drilled for mercury manometer tensiometers at 90, 60 and 30 cm in all columns. After the treatments were begun, it was necessary to drill holes for tensiometers in the dry treatments at 15 cm depths. (Note: These distances were measured so that the tensiometers would be the given distances from the soil surface). After filling, measurements of distances from the soil surface were confirmed. Mounts for the manometer tubing and scale were made of 1x4 boards cut 122 cm long and fitted with holders to guide the tubing and hold the mercury bottles. The wood mounts were water proofed with several coats of polyurethane.

Individual columns were held in carriers so that they could be transported to a platform balance for weighing. The carriers were constructed of angle iron and designed to hold the columns relatively stable during transport to the scales for weighing. The carriers were painted with white enamel to avoid rust and metal splinters. Column carriers were 23x23x60 cm. Transport was accomplished using a dolly. A ramp was constructed of plywood to facilitate placement onto the scale.

Holes were drilled in the side of each column at 15, 30, 45, 60 and 75 cm depths from the soil surface, to provide access to the soil to take soil samples for salinity and gravimetric water content measurements. These measurements were conducted using standard techniques for saturated paste extract electrical conductivity and gravimetric water determination, (U.S. Salinity Laboratory Staff 1954). Samples were not taken at a depth until the soil at that particular depth was wet enough not to run out of the hole when the stopper was removed. Soil samples were taken from the columns at harvests 1 (March 28, 1985), 2 (April 24, 1985), and 3 (May 16, 1985).

## Plant Stand Establishment

On October 19, 1984, all of the columns were watered with 600 ml of ECi 1 dS/m (0.3 bar) water to wet the top two cm of soil depth for seed germination. Alfalfa (Medicago sativa L. cv. 'Mesa sirsa' ) seeds were planted at a rate of 40-50 seeds per column on October 22nd. During stand establishment, water with an ECi of 1 dS/m (0.3 bar) was applied to all columns in 50, 100, or 200 ml amounts depending on estimated plant use. In January and February the plants in all columns were maturing very slowly, showing signs of insect stress and in general not doing well. Five one liter applications of the ECi 1 dS/m (0.3 bar) water and fertilizer were made to encourage healthy plant growth. Top growth from all columns was harvested March 7, 1985. Plant populations were thinned to 13 plants per column (all plant populations were thinned as closely as possible to stands of similar vigor). All columns were irrigated with one liter ECi = 1 dS/m (0.3 bar) water on March 8, 1985. Variable water treatments began March 15, 1985.

The study was divided into two experiments based on the salinity of the irrigation water. Experiment one covered harvest one through harvest four, March 28, 1985 to June 9, 1985. Irrigation water for all five treatments had an electrical conductivity (ECi) of 4.0 dS/m. Experiment two consisted of harvest five through harvest eight, July 8, 1985 to October 6, 1985. Irrigation water quality for all five treatments was changed to an ECi of 8.0 dS/m. All other methods, materials and measurements were the same for both experiments.

## Irrigation

All columns received irrigation water of the same salinity within an experiment. Water in experiment 1 was adjusted to an ECi of 4 dS/m (1.4 bars) by addition of sodium and calcium chloride salts in equivalent molar amounts to distilled water. Tables found in the Chemical Rubber Company Handbook of Chemistry and Physics were used to determine the necessary amounts of each salt to use. Water in experiment 2 was similarly adjusted to an ECi of 8 dS/m (2.8 bars). Actual measured ECi in both experiments was adjusted until readings of 4 and 8 dS/m respectively were achieved.

With each irrigation, a fertilizer solution, described by Bernstein and Francois (1973) was added to the irrigation water at the maximum rate of 0.5 ml of stock solution for each day since the last irrigation. Rates varied with treatments and expected yields to prevent increasing the salinity of the irrigation water. The fertilizer solution did not contribute significantly to the osmotic potential of the irrigation water. The goal was to maintain adequate nutrition in all treatments.

Experimental treatments consisted of varying the amounts of water applied. Irrigation of all treatments was done on the same day to simulate a field irrigation. Amounts of water to be applied were determined by weighing the columns to calculate actual water used. Water equivalent to 100% of the weight lost plus 10% for leaching was applied to the controls. The controls received enough water to meet 100% of the ET demand plus a leaching fraction. Subsequent treatments were 100% ET, 75%, 50% and 25% of the control. Treatments were duplicated. Irrigations were planned so that the plants in the control columns were not stressed, i.e. the tensiometers in the active root zone of the columns had readings less than 0.75 bars. The amount of water used by the controls was less than what was calculated to be available in the soil profile based on gravimetric soil samples and moisture release curve data. Approximate seven day irrigation intervals were chosen. Since there was no drainage from any column at an time during the two experiments, all water loss was assumed to be ET.

## Measurements of Plant Growth, Potential and Yield

Plant heights were measured daily during experiment 1 and on weekdays in experiment 2 with a cm ruler. Two plants of approximately equal vigor were chosen from each column. Marks were made in two places on the plant stem after each harvest when there was approximately three cm of regrowth. The marks were three cm apart unless there was not enough regrowth, then 2 cm were used. Distance increases between the marks indicated stem growth. Distance from the top mark to the top of the plant's terminal leaves was indicative of growth due to cell division and elongation.

Immediately prior to each harvest period, total leaf water potential was determined using a Scholander bomb. These measurements were made between 1000 and 1300 hours. Entire trifoliate leaves were used with leaf water potentials determined immediately after sampling.

A Wescor dew point microvoltmeter and chamber psychrometer were used to measure leaf osmotic potentials. Plant discs were taken with a paper punch, placed in an aluminum foil envelope and immediately frozen in liquid nitrogen. Samples were stored in a 0 C freezer until the analysis could be done. Triplicate samples were taken for two plants in each column.

At all harvests, plants were cut 8cm above the soil surface. The harvested alfalfa samples were weighed, dried and reweighed for total dry matter yield. Stems were counted and measured for length. Total numbers of flowers, trifoliates and leaf nodes were determined.

## Final Sampling

Immediately after the harvest on 6-09-85, and the harvest on 10-06-85, one column from each treatment was destructively sampled for an intensive evaluation of soil salinity and soil water content measurements. Columns were sectioned into 1 to 5 cm depths, 1 cm increments were used near the visible wetting front, and soil samples for moisture were quickly placed into tared aluminum cans. Samples for EC determination were collected in twist tie plastic bags. Columns were kept covered during sampling to minimize evaporation. A qualitative examination of root distribution and density was also done on these dates.

## Greenhouse

This experiment was designed to be conducted in a controlled greenhouse environment. Basically, the greenhouse served as a rain and wind shelter since it had inadequate cooling and little supplemental lighting. Actually, the holes in the glass roof also rendered it pretty ineffective as a rainout shelter. Clear polyethylene sheeting was nailed to the ceiling to catch the rain. Lighting was uniformly influenced by the plastic sheeting. Supplemental light in the form of fluorescent strips was used to encourage early growth in the winter months.

CHAPTER 4

# RESULTS AND DISCUSSION

## Water Yield Relationships

The water-yield relationship can be presented several ways. Yield (Y) as a function of total water applied (AW), total evapotranspiration (ET) or transpiration (T) alone are commonly used to produce a crop-water production function. Total water applied is perhaps the most applicable to production agriculture because it reflects a total cost of water input. Evaporation can be a significant portion of the total water loss, it is not water actually used by the crop. However, ET is a useful indicator of water use for the water-yield relationship of the crop because evaporation is directly influenced by differential ground cover.

Figure 2 is a plot of cumulative grams of dry matter yield (Y) as a function of cumulative cm of water used (ET) per treatment. A linear relationship between the alfalfa yield and ET is demonstrated for both experiments 1 and 2. The regression equations are:

exp. 1: $Y = 0.43\ T - 4.38$ $r^2 = .99$

exp. 2: $Y = 0.29\ T - 3.23$ $r^2 = .98.$

The linearity of this relationship is significant and complements the strong experimental evidence in the literature of a linear relationship between yield and ET for several crops under nonsaline

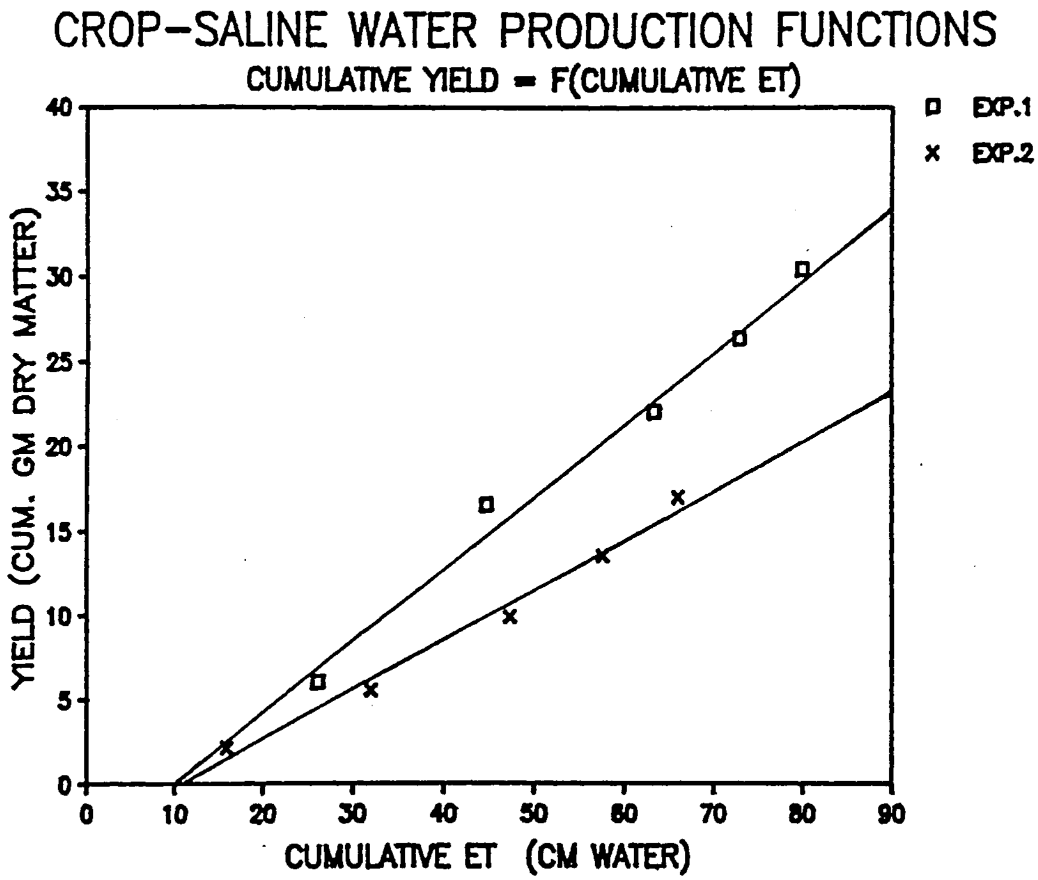


Fig. 2. The relationship between yield in cumulative grams dry matter per treatment and cumulative cm of water used (ET) for experiments 1 and 2.

nonsaline conditions. The data in Figure 2 demonstrate a similar relationship under saline conditions.

Note that both regression lines in Figure 2 have non-zero intercepts on the X-axis. The x-intercept in cm of water is an estimate of evaporation. This value is only an estimate and should not be considered anything else. The cm of water evaporated were subtracted from the cm total ET to get water transpired (T). The water budget for experiments 1 and 2 (Table 1) includes these calculations of both E and T. Ratios of E/T (Table 2) calculated per experiment, with both E and T in cm of water, ranged from 15 to 227 % for treatments 110 % and 25 % ET respectively in both experiments. Estimated evaporation accounted for 12 to 57 % of the total water budget of the columns. The necessity for taking evaporation into consideration in this experiment is obvious. In the driest treatment, where water applied was 25% ET, apparent evaporation exceeded T. This can be attributed to the lack of ground cover in this treatment due in part to slow recovery after a harvest and to an overall decrease in growth.

The amount of water leached (Table 1) was estimated as the difference between total water available and total water used. Table 3 contains the numbers used for this calculation. Water data for individual irrigations are listed in Appendix B. The column labeled LFs is a leaching fraction calculated as ECi divided by ECsw averaged over the sampling depths at the end of experiments one and two. Soil profile salinity data by depth taken at the end of experiments one and

Table 1. Water budget.

EXPERIMENT 1

| | ------CM | WATER------ | | | | | |
|---|---|---|---|---|---|---|---|
| %ET | APPLIED | ANTEC.* | TOTAL | ET | LEACHED | EVAP. | TRANS. |
| 110 | 83.23 | 5.01 | 88.24 | 79.91 | 8.33 | 10.20 | 69.70 |
| 100 | 75.36 | 4.50 | 79.87 | 72.84 | 7.03 | 10.20 | 62.63 |
| 75 | 63.21 | 4.15 | 67.36 | 63.25 | 4.11 | 10.20 | 53.05 |
| 50 | 43.14 | 3.67 | 46.81 | 44.69 | 2.12 | 10.20 | 34.49 |
| 25 | 23.13 | 4.38 | 27.51 | 26.10 | 1.41 | 10.20 | 15.90 |

EXPERIMENT 2

| | ------CM | WATER------ | | | | | |
|---|---|---|---|---|---|---|---|
| %ET | APPLIED | ANTEC.* | TOTAL | ET | LEACHED | EVAP. | TRANS. |
| 110 | 76.94 | 8.33 | 85.27 | 65.90 | 19.37 | 10.96 | 54.94 |
| 100 | 70.03 | 7.03 | 77.06 | 57.48 | 19.58 | 10.96 | 46.52 |
| 75 | 53.59 | 4.11 | 57.70 | 47.24 | 10.46 | 10.96 | 36.28 |
| 50 | 35.40 | 2.12 | 37.52 | 31.88 | 5.63 | 10.96 | 20.93 |
| 25 | 17.73 | 1.41 | 19.14 | 15.79 | 3.35 | 10.96 | 4.83 |

* Antecedent water was applied to the columns during stand establishment in experiment 1. Antecedent water in experiment 2 was applied during experiment 1.

Table 2. Ratio of yield to water transpired, evaporation to transpiration and percent of total water used that was leached, evaporated to transpired.

EXPERIMENT 1

| TREATMENT | | | % OF TOTAL | | |
|---|---|---|---|---|---|
| % ET | G/KG | E/T | LEACHED | EVAP. | TRANS. |
| 110 | 1.34 | .15 | .09 | .12 | .79 |
| 100 | 1.30 | .16 | .09 | .13 | .78 |
| 75 | 1.28 | .19 | .06 | .15 | .79 |
| 50 | 1.48 | .30 | .05 | .22 | .74 |
| 25 | 1.17 | .64 | .05 | .37 | .58 |

EXPERIMENT 2

| TREATMENT | | | % OF TOTAL | | |
|---|---|---|---|---|---|
| % ET | G/KG | E/T | LEACHED | EVAP. | TRANS. |
| 110 | .95 | .20 | .23 | .13 | .64 |
| 100 | .90 | .24 | .25 | .14 | .60 |
| 75 | .84 | .30 | .18 | .19 | .63 |
| 50 | .82 | .52 | .15 | .29 | .56 |
| 25 | 1.37 | 2.27 | .17 | .57 | .25 |

two are listed in Appendix D. Although the estimates are similar, the salt method, overall, tends to predict a slightly larger leaching fraction in experiment 1 and a slightly lower LF in experiment 2 than the water budget method.

A graphic representation of how the plants partitioned the water in the columns during experiment 1 and experiment 2 is presented in Figure 3. The major differences were in LF in all treatments and in T especially in the lower treatments.

When trying to predict a yield response function, it is important to know if the expected Ymax is reasonable for the conditions of the test since it is a basic part of the function. The ratio of yield to transpiration reported in Hanks and Retta (1980) is about 1.22 g dry matter per kg of water. A similar analysis of data from this study (Table 2) indicates that the value of the ratio for the control treatment in experiment 1 is 1.34 g dry matter per kg of water transpired. The experiment 2 control value is 0.95 g dry matter / kg water. The maximum yields in both experiments are reasonable. The experiment 2 maximum is some what low and reflects the influence of the increased salinity of the irrigation water. Actual yields per harvest for experiments 1 and 2 are given in Table 4.

Normalized production functions have been plotted to see if some unified function can be applied to all situations. This method is presented in Figure 4 for yield as a function of water transpired. Although it is obvious that the relative yield per unit of water transpired is less in experiment 2 than in experiment 1, this method of data presentation results in the coalescing of the data from the

Table 3. Leaching fraction estimates from water use (LFw) and salt balance (LFs).

EXPERIMENT 1

| | CM WATER | | | | | | |
|---|---|---|---|---|---|---|---|
| %ET | APPLIED | ANTEC.* | TOTAL | ET | % USED | LFw | LFs |
| 110 | 83.23 | 5.01 | 88.24 | 79.91 | .91 | .09 | .11 |
| 100 | 75.36 | 4.50 | 79.87 | 72.84 | .91 | .09 | .08 |
| 75 | 63.21 | 4.15 | 67.36 | 63.25 | .94 | .06 | .07 |
| 50 | 43.14 | 3.67 | 46.81 | 44.69 | .95 | .05 | .06 |
| 25 | 23.13 | 4.38 | 27.51 | 26.10 | .95 | .05 | .06 |

EXPERIMENT 2

| | CM WATER | | | | | | |
|---|---|---|---|---|---|---|---|
| %ET | APPLIED | ANTEC.* | TOTAL | ET | % USED | LFw | LFs |
| 110 | 76.94 | 8.33 | 85.27 | 65.90 | .77 | .23 | .25 |
| 100 | 70.03 | 7.03 | 77.06 | 57.48 | .74 | .26 | .21 |
| 75 | 53.59 | 4.11 | 57.70 | 47.24 | .82 | .18 | .15 |
| 50 | 35.40 | 2.12 | 37.52 | 31.88 | .85 | .15 | .14 |
| 25 | 17.73 | 1.41 | 19.14 | 15.79 | .83 | .17 | .13 |

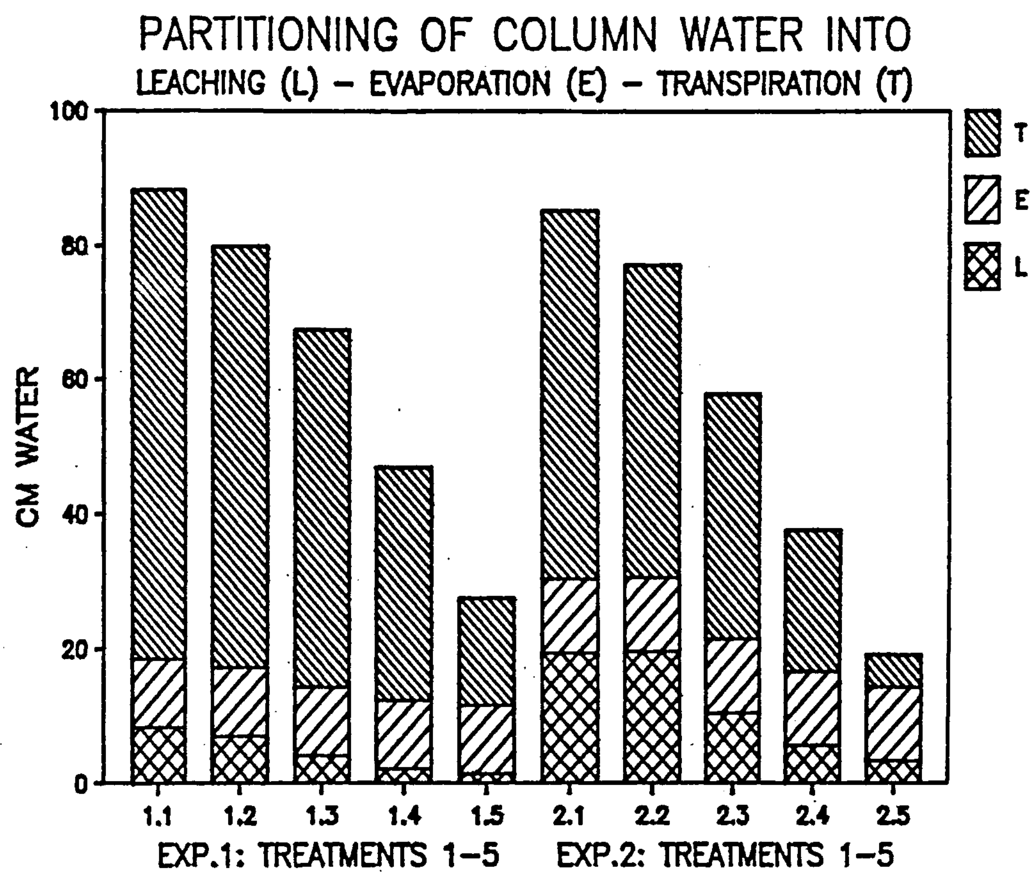


Fig. 3. Water partitioning between leaching, evaporation and transpiration in Experiments 1 and 2. Symbols on the x-axis represent experiment 1, treatment 1 (1.1), experiment 2, treatment 1 (2.1), etc.

Table 4. Plant dry matter yields per experiment by harvest.

Experiment 1 includes Harvests 1-4. Experiment 2 includes Harvests 5-8.

| | HARVEST # | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | TONS PER HECTARE | | | | | | | |
| % ET | | | | | | | | |
| 110 | 2.52 | 3.03 | 2.22 | 1.60 | 2.05 | 1.46 | 1.05 | .67 |
| 100 | 2.31 | 2.75 | 1.82 | 1.24 | 1.71 | 1.10 | .76 | .60 |
| 75 | 2.10 | 2.23 | 1.53 | .92 | 1.31 | .89 | .51 | .34 |
| 50 | 1.89 | 1.60 | 1.00 | .61 | .90 | .47 | .28 | .06 |
| 25 | 1.20 | .25 | .24 | .17 | .47 | .14 | .04 | .01 |

| | HARVEST # | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | GM PER COLUMN | | | | | | | |
| % ET | | | | | | | | |
| 110 | 8.16 | 9.82 | 7.22 | 5.20 | 6.66 | 4.73 | 3.41 | 2.16 |
| 100 | 7.49 | 8.91 | 5.90 | 4.03 | 5.54 | 3.57 | 2.47 | 1.93 |
| 75 | 6.80 | 7.23 | 4.97 | 2.99 | 4.25 | 2.90 | 1.64 | 1.10 |
| 50 | 6.12 | 5.19 | 3.25 | 1.98 | 2.92 | 1.52 | .91 | .20 |
| 25 | 3.89 | .82 | .78 | .55 | 1.53 | .46 | .12 | .03 |

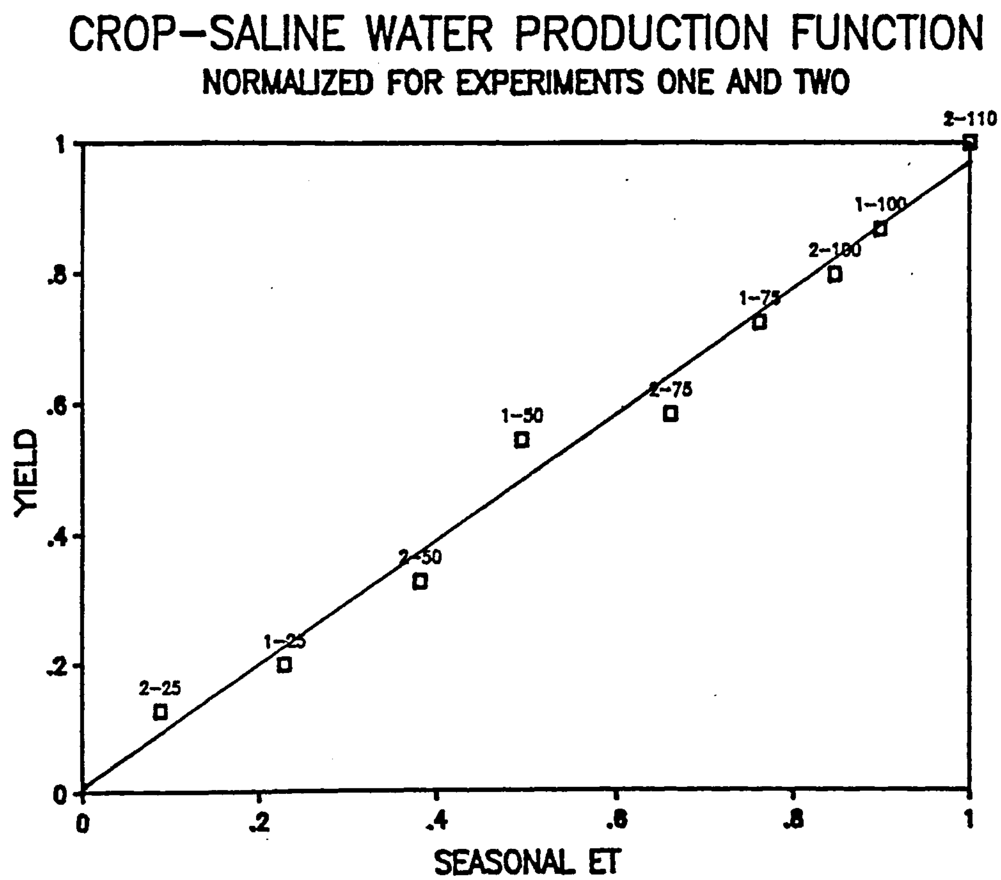


Fig. 4. Normalized crop saline-water production function for Experiments 1 and 2.

two experiments into one straight line. The equation of the line is as follows:

$$Y = (0.99\ T) + .009 \qquad r^2 = 0.98 \tag{4}$$

This line approaches a 1:1 line with an intercept of zero.

This coalescing of the function data lends support to the proposal that there is a unified function, suggested by Hanks (1984) and Shalhevet (1984) of the following form:

$$Y / Ymax = T / Max \tag{5}$$

that adequately describes the yield-water relationship for any set of environmental factors, including increased soil and water salinity. The coalescing of the experimental functions into one line indicates that a unit decrease in transpiration whether induced by the decreased osmotic or matric potential of the soil water will produce a unit decrease in yield. This does not indicate how a plant can continue to transpire at increased water stress levels, only that if it does, it will grow at a predictable rate.

## Soil Profile Salinity and Water Content

Soil salinity and volumetric water content (Wv) were measured on samples taken from the columns at each harvest during experiment 1. On June 9, 1985 immediately following the fourth harvest, a single column from each treatment was destructively sampled for salinity and Wv measurements. This sampling marked the end of experiment 1. The procedure was repeated for experiment 2 on October 6, 1985 immediately following the eighth harvest. This was the end of experiment 2 and the experimental portion of the study. The data from these two sampling periods represent the condition of the soils in the different treatments at the ends of the two experiments.

Since volumetric water content and salinity varied during the experimental periods, an average Wv for each treatment and corresponding average salinity values (ECsw) was calculated for the two experiments to provide some idea as to how the soil Wv and salinity varied in the different treatments in a general way from day to day (Table 5). To calculate these average values for experiment 1, the data from the four harvest periods were used. For experiment 2, the column average Wv (Table 8) along with a column average EC of a measured 1:1 soil solution extract were used. These are average values from different sample times and as such represent an approximate salinity and water content for any one time period. The values should be valid approximations of the actual soil conditions during the two experimental periods and are those refered to in the following text as average Wv and average ECsw.

The last harvest and destructive sampling for experiment one was done ten days after the last irrigation. The soil profile volumetric water contents (Wv) were drier than the calculated average Wv for the treatments during the experiment (Table 5). The final soil profile water contents in volume percent for the five treatments in experiment 1 are presented in Figure 5 for the 0-60 cm depths. An examination of moisture release curve data shows that a volumetric water content less than 9 % indicates a matric potential less than or equal to -15 bars, the value usually called the permanent wilting point. Treatments 1-5 contained greater than 9 % water in most of the rooting depth.

Table 5. Soil profile water and salinity measured or calculated as the average for the end of an experimental period or for the period following an irrigation when infiltration had ceased.

| % ET | Rooting Depth cm | Wv % | ECsw dS/m | Soil Matric | Potentials (Bars) Osmotic | Total |
|---|---|---|---|---|---|---|
| End of Exp. 1 | | | | | | |
| 110 | 60 | .13 | 34.4 | -.9 | -13.9 | -14.8 |
| 100 | 60 | .14 | 36.7 | -.8 | -14.9 | -15.7 |
| 75 | 45 | .12 | 35.1 | -1.3 | -14.2 | -15.5 |
| 50 | 45 | .12 | 50.5 | -1.3 | -20.9 | -22.2 |
| 25 | 40 | .09 | 45.4 | -11.0 | -18.7 | -29.7 |
| End of Exp. 2 | | | | | | |
| 110 | 60 | .23 | 32.4 | -.3 | -13.0 | -13.4 |
| 100 | 60 | .25 | 38.2 | -.3 | -15.5 | -15.8 |
| 75 | 45 | .20 | 58.6 | -.4 | -24.5 | -25.0 |
| 50 | 45 | .17 | 59.6 | -.6 | -25.0 | -25.5 |
| 25 | 40 | .10 | 83.2 | -2.8 | -35.6 | -38.4 |
| Calculated Profile Average Values for Exp. 1 Period | | | | | | |
| 110 | 60 | .16 | 29.5 | -.6 | -11.8 | -12.4 |
| 100 | 60 | .16 | 35.1 | -.6 | -14.2 | -14.8 |
| 75 | 45 | .15 | 30.8 | -.7 | -12.4 | -13.1 |
| 50 | 45 | .13 | 46.8 | -.9 | -19.3 | -20.2 |
| 25 | 40 | .11 | 38.3 | -2.1 | -15.6 | -17.7 |
| Calculated Profile Average Values for Exp. 2 Period | | | | | | |
| 110 | 60 | .15 | 58.3 | -.7 | -24.4 | -25.1 |
| 100 | 60 | .17 | 49.9 | -.6 | -20.6 | -21.2 |
| 75 | 45 | .14 | 73.2 | -.8 | -31.1 | -31.9 |
| 50 | 45 | .14 | 69.0 | -.8 | -29.2 | -30.0 |
| 25 | 40 | .12 | 71.6 | -1.3 | -30.3 | -31.6 |

Table 5. (Continued)

| % ET | Rooting Depth cm | Wv % | ECsw dS/m | Soil Potentials (Bars) Matric | Osmotic | Total |
|---|---|---|---|---|---|---|
| Calculated Profile Averages Exp. 1 When Wet | | | | | | |
| 110 | 60 | .25 | 18.5 | -.3 | -7.2 | -7.5 |
| 100 | 60 | .25 | 21.8 | -.3 | -8.6 | -8.8 |
| 75 | 45 | .23 | 19.4 | -.3 | -7.5 | -7.9 |
| 50 | 45 | .20 | 30.1 | -.4 | -12.0 | -12.4 |
| 25 | 40 | .14 | 28.6 | -.8 | -11.4 | -12.2 |
| Calculated Profile Averages Exp. 2 When Wet | | | | | | |
| 110 | 60 | .25 | 29.5 | -.3 | -11.8 | -12.1 |
| 100 | 60 | .28 | 33.1 | -.2 | -13.4 | -13.6 |
| 75 | 45 | .23 | 49.0 | -.3 | -20.3 | -20.6 |
| 50 | 45 | .20 | 50.8 | -.4 | -21.1 | -21.5 |
| 25 | 40 | .14 | 59.0 | -.8 | -24.7 | -25.5 |

Soil samples were taken at all harvests during experiment 1. The information in Table 6 was calculated from these data. Note that although Wv increases with depth, the total soil water potential decreases. It seems clear that water in the top 30 cm of soil is less saline and therefore more plant available than water at 45 cm. Potentials become lower than -15 bars in the deeper soil due to the decreased osmotic potential of the soil water.

Total depth of wetting and column average volumetric water contents for the total depth wetted are listed in Table 7 for experiment 1. Wv in this table was calculated based on the amount of water added, the amount of water used, the Wv when irrigated and the total volume wetted for each treatment. The average depth of soil wetted for all irrigations ranges from 76 cm in treatment 1 to only 15 cm in treatment 5. Average Wv range from 16 % in treatment 1 to 12 % for in treatment 5. The Wv for a treatment that would occur immediately after an irrigation, the wettest period for all treatments, was estimated using calculations based on the volume of water added and the calculated maximum depth of wetting for the column (Table 7). These values show that at the soil matric potential, in the depth of soil wetted, alone was not limiting plant growth.

Actual soil salinity values (ECsw) are dependent upon soil water content. The 1:1 soil-water extract reading is corrected for water content by dividing the 1:1 value by the reciprocal of the Wv. A plot of electrical conductivity of the soil water (ECsw in dS/m) for each of the five treatments at the end of experiment 1 is shown in Figure 6. These lines reflect soil water content as well as soil salt content.

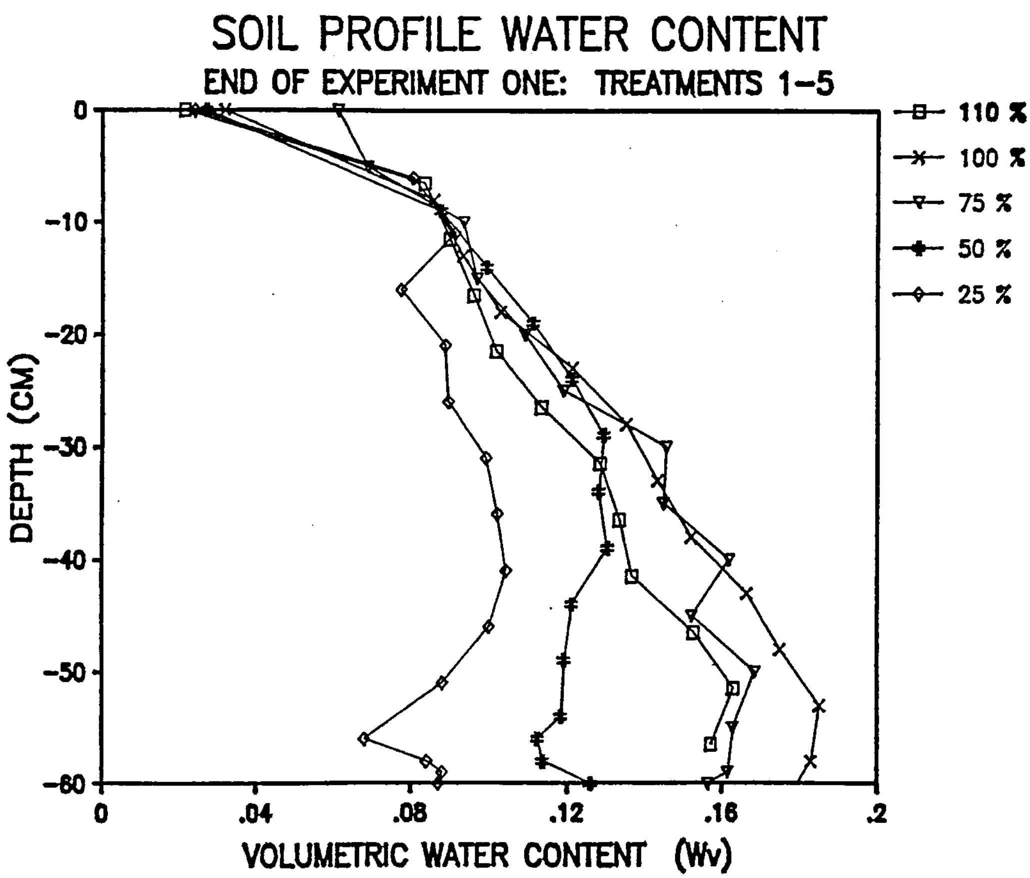


Fig. 5. Soil profile volumetric water content (Wv) by depth per treatment at the end of experiment 1.

Table 6. Measured soil water (Wv) and salinity (ECsw) during Experiment 1 at three depths.

| % ET | Sample Depth cm | Wv % | ECsw dS/m | Soil Potentials (Bars) Matric | Osmotic | Total |
|---|---|---|---|---|---|---|
| Measured Profile Average Values for Exp. 1 Period (15cm) | | | | | | |
| 110 | 15 | .13 | 19.9 | -1.6 | -7.8 | -9.4 |
| 100 | 15 | .12 | 23.5 | -1.7 | -9.3 | -11.0 |
| 75 | 15 | .13 | 25.8 | -1.4 | -10.2 | -11.7 |
| 50 | 15 | .11 | 32.5 | -2.2 | -13.1 | -15.3 |
| 25 | 15 | .10 | 37.3 | -5.8 | -15.2 | -21.0 |
| Measured Profile Average Values for Exp. 1 Period (30cm) | | | | | | |
| 110 | 30 | .16 | 28.4 | -.7 | -11.4 | -12.0 |
| 100 | 30 | .17 | 35.6 | -.6 | -14.4 | -15.0 |
| 75 | 30 | .18 | 38.4 | -.6 | -15.6 | -16.2 |
| 50 | 30 | .14 | 57.5 | -1.0 | -24.0 | -25.0 |
| 25 | 30 | .10 | 50.9 | -2.7 | -21.1 | -23.8 |
| Measured Profile Average Values for Exp. 1 Period (45cm) | | | | | | |
| 110 | 45 | .18 | 38.6 | -.6 | -15.7 | -16.3 |
| 100 | 45 | .18 | 45.6 | -.5 | -18.8 | -19.3 |
| 75 | 45 | .16 | 57.0 | -.7 | -23.8 | -24.5 |
| 50 | 45 | .10 | 81.9 | -3.6 | -35.1 | -38.6 |
| 25 | 45 | .11 | 68.2 | -2.4 | -28.8 | -31.3 |

Table 7. Depth of soil wetted at an irrigation during Experiment 1. Volumetric water content (Wv) calculated for the period at the end of an irrigation and when irrigated.

| | | | | | | |
|---|---|---|---|---|---|---|
| | CM SOIL WETTED | | | | | |
| | IRRIGATION NUMBER | | | | | |
| % ET | 1 | 2 | 3 | 4 | 5 | 6 |
| 100 | 38.5 | 67.9 | 71.3 | 78.2 | 88.1 | 82.3 |
| 110 | 35.8 | 60.0 | 62.8 | 66.2 | 74.8 | 76.0 |
| 75 | 33.5 | 48.8 | 49.5 | 50.5 | 61.1 | 49.5 |
| 50 | 30.9 | 29.3 | 28.6 | 25.6 | 31.7 | 30.9 |
| 25 | 35.4 | 18.6 | 15.6 | 11.9 | 12.5 | 12.8 |
| | Wv PRIOR TO NEXT IRRIGATION | | | | | |
| % ET | | | | | | |
| 100 | .17 | .18 | .15 | .17 | .18 | .16 |
| 110 | .16 | .16 | .15 | .16 | .18 | .16 |
| 75 | .16 | .15 | .14 | .14 | .18 | .14 |
| 50 | .15 | .14 | .12 | .11 | .13 | .13 |
| 25 | .16 | .17 | .13 | .09 | .10 | .11 |
| | Wv WHEN IRRIGATED | | | | | |
| % ET | | | | | | |
| 110 | .22 | .28 | .26 | .27 | .28 | .24 |
| 100 | .22 | .26 | .26 | .26 | .28 | .25 |
| 75 | .22 | .24 | .24 | .24 | .25 | .23 |
| 50 | .21 | .20 | .19 | .18 | .20 | .20 |
| 25 | .22 | .19 | .16 | .13 | .14 | .14 |

Table 7. (Continued).

| % ET | CM SOIL WETTED — IRRIGATION NUMBER 7 | 8 | 9 | 10 | 11 | 12 | AVG. |
|---|---|---|---|---|---|---|---|
| 100 | 76.4 | 69.6 | 91.4 | 92.4 | 73.0 | 79.7 | 75.7 |
| 110 | 68.7 | 61.9 | 76.9 | 77.2 | 68.2 | 70.4 | 66.6 |
| 75 | 50.0 | 48.4 | 65.2 | 53.9 | 46.6 | 49.1 | 50.5 |
| 50 | 31.1 | 31.2 | 38.1 | 33.2 | 29.8 | 30.5 | 30.9 |
| 25 | 13.0 | 12.6 | 12.9 | 12.8 | 12.4 | 12.8 | 15.3 |

Wv PRIOR TO NEXT IRRIGATION

| %ET | | | | | | | AVG. |
|---|---|---|---|---|---|---|---|
| 100 | .15 | .14 | .17 | .17 | .15 | .16 | .16 |
| 110 | .15 | .14 | .16 | .16 | .15 | .15 | .16 |
| 75 | .14 | .14 | .17 | .15 | .13 | .14 | .15 |
| 50 | .13 | .13 | .15 | .14 | .13 | .13 | .13 |
| 25 | .11 | .10 | .11 | .11 | .10 | .10 | .12 |

Wv WHEN IRRIGATED

| % ET | | | | | | | AVG. |
|---|---|---|---|---|---|---|---|
| 110 | .24 | .23 | .26 | .25 | .23 | .24 | .25 |
| 100 | .24 | .23 | .25 | .25 | .24 | .24 | .25 |
| 75 | .23 | .23 | .26 | .23 | .22 | .22 | .23 |
| 50 | .20 | .20 | .22 | .21 | .20 | .20 | .20 |
| 25 | .14 | .14 | .14 | .14 | .14 | .14 | .15 |

The lower the water content at the time of sampling, the higher the salt content. The three wettest treatments had an almost constant ECsw centering at about 35-45 dS/m (14-18 bars) in the 30 to 80 cm depths. Treatment 4 (50 % ET) shows a similar trend but with a maximum ECsw of about 55 dS/m (23 bars). Interestingly, the driest treatment (treatment 5) has a maximum ECsw of 55 dS/m (23 bars) at about 15 cm which decreases to 45 dS/m (18 bars) between 20 to 45 cm. A natural consequence of receiving lower amounts of irrigation water is to also receive lower total amounts of salt. Amounts of salt applied during each harvest period for both experiments are listed in Table 8.

Ayers and Wescot (1985) suggest a maximum ECe, the ECe at which a 100% yield decrement will occur if the entire root zone is at that salinity, of 16 dS/m (6 bars) for alfalfa. A corresponding ECsw at 9 and 24% Wv, permanent wilting point and field capacity for the study soil, can be estimated using ratios, these are 62 and 23 dS/m (26-9 bars) respectively. By the end of experiment 1, the ECsw values in all treatments were between these values at depths below 20 cm (figure 6).

Total soil water potential was calculated by adding matric potential, taken from the moisture release curve using the measured volumetric water contents, and osmotic potential, calculated as [0.321 * (ECsw (in dS/m)$^{1.065}$)] (Campbell, Bower and Richards 1949). The total soil water potential values at the end of experiment 1 for the five treatments were plotted as a function of depth (Figure 7). The three wettest treatments exhibit the same pattern of total soil potentials and are not easily separable. The drier treatments show similar patterns to those in the treatments 1-3 in the top 10-30 cm but have much decreased

Table 8. Salt added during experiments 1 and 2.

EXPERIMENT 1

| % ET | ADDED (MEQ) | ANTECEDENT* (MEQ) | TOTAL (MEQ) |
|---|---|---|---|
| 110 | 1079.6 | 150.8 | 1230.4 |
| 100 | 977.6 | 150.8 | 1128.4 |
| 75 | 820.0 | 150.8 | 970.8 |
| 50 | 559.6 | 150.8 | 710.4 |
| 25 | 300.0 | 150.8 | 450.8 |

EXPERIMENT 2

| % ET | ADDED (MEQ) | ANTECEDENT* (MEQ) | TOTAL (MEQ) |
|---|---|---|---|
| 110 | 1996.0 | 1230.4 | 3226.4 |
| 100 | 1816.8 | 1128.4 | 2945.2 |
| 75 | 1390.4 | 970.8 | 2361.2 |
| 50 | 918.4 | 710.4 | 1628.8 |
| 25 | 460.0 | 450.8 | 910.8 |

*Antecedent salt was added to experiment 1 prior to the initiation of variable water treatments. Antecedent salt added to experiment 2 was all salt added in experiment 1.

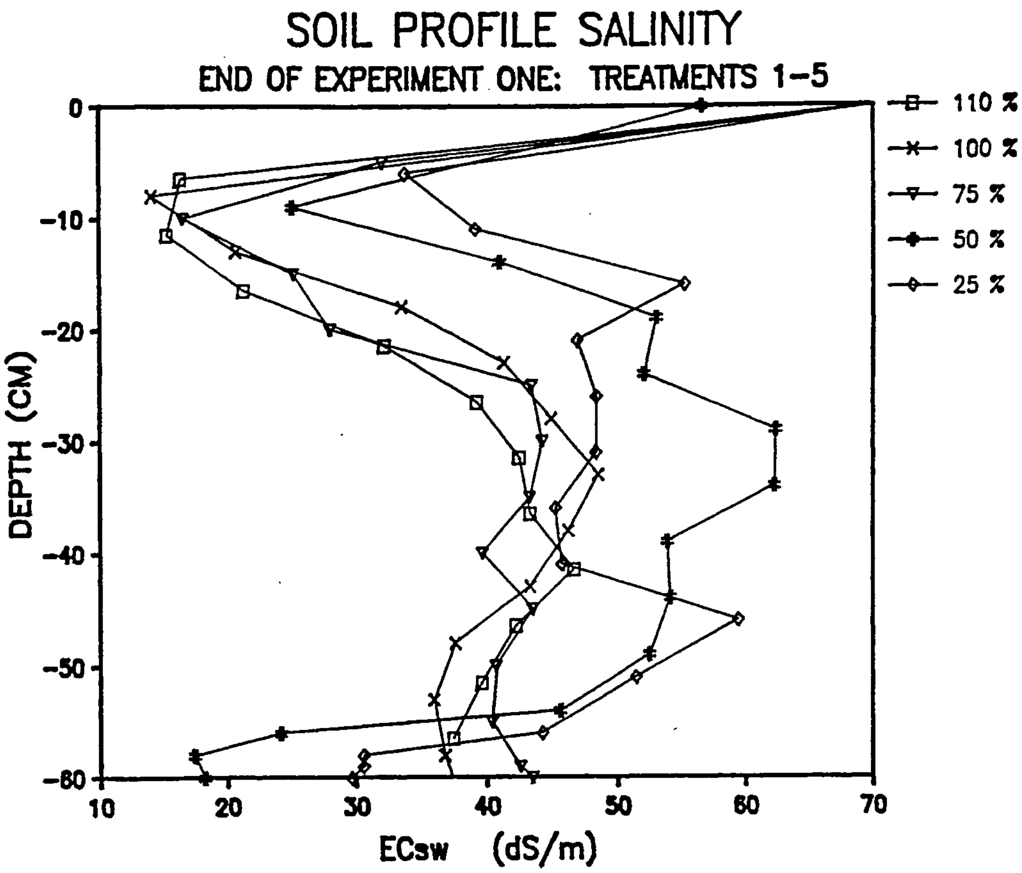


Fig. 6. Soil profile electrical conductivity of the soil water (ECsw in dS/m) by depth per treatment at the end of Experiment 1.

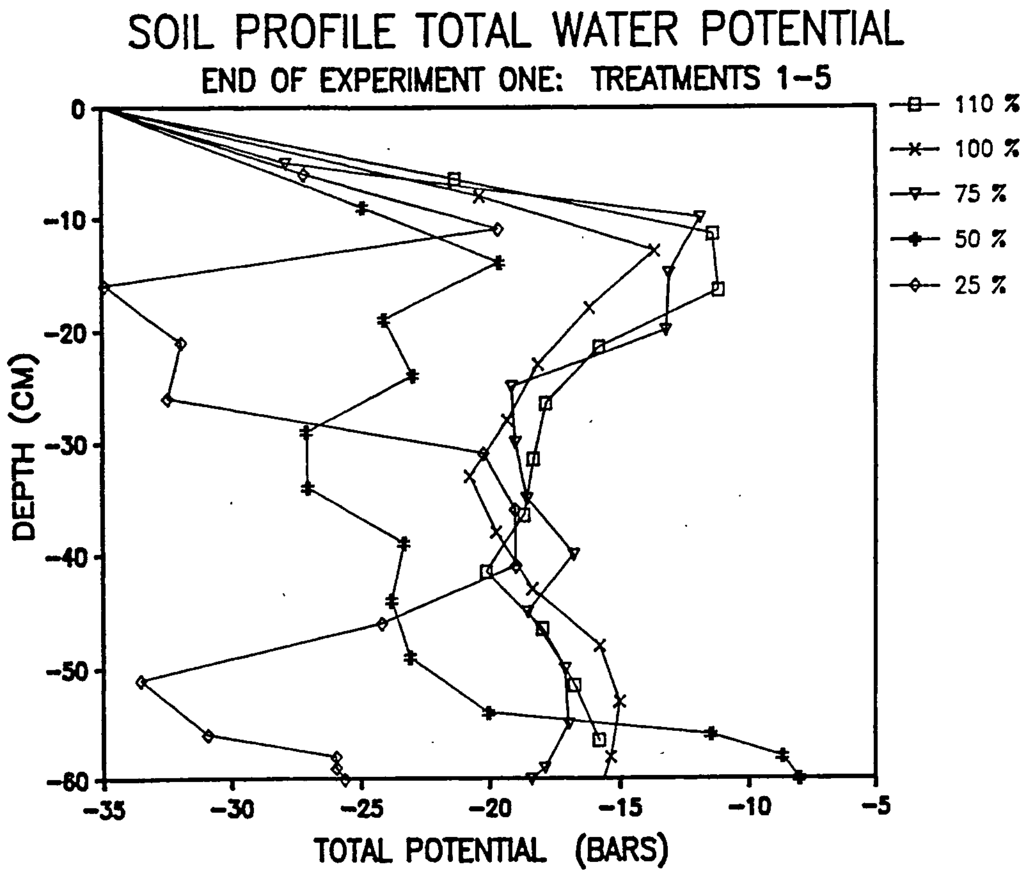


Fig. 7. Soil profile total soil potential by depth per treatment at the end of experiment 1.

potentials that increase between 30-60 cm and 30-50 cm in treatments 4 and 5 respectively.

The remaining columns were harvested October 6, 1985 and immediately thereafter were destructively sampled for Wv and salinity measurements. Experiment 2 was harvested four days after the last irrigation. The soil Wv for all treatments was wetter than the calculated average for the experimental period (Table 5). Soil volumetric water content profiles for the end of experiment 2 (Figure 8) indicate that all treatments were wetter than the experiment 1 profiles (Figure 6). Treatments 1 and 2 volumetric water contents are about 25 % throughout most of the profile. Treatment 3, 4 and 5 Wv are progressively drier. All of the treatments have water contents greater than 9 % which correspond to soil matric potentials less than -15 bars.

Depths of wetting for each irrigation and the corresponding average water contents for the treatments at that irrigation for experiment 2 are listed in Table 8. The average depth of wetting during all of experiment 2 for treatments 1 and 5 were 61.5 and 7.25 cm respectively with matching average water contents of 16 and 12%. The estimated water contents just after an irrigation, like those in experiment 1 indicate that matric potential was not limiting plant growth when the treatments had just been watered.

ECsw measured for the treatments in experiment 2 (Figure 9) clearly indicate that in experiment 2 soil salinity was greater than in experiment 1 (Figure 6) in treatments 3, 4 and 5 at all depths. Treatments 1 and 2 show an increase in salinity shallower in the profile than the corresponding experiment one treatments.

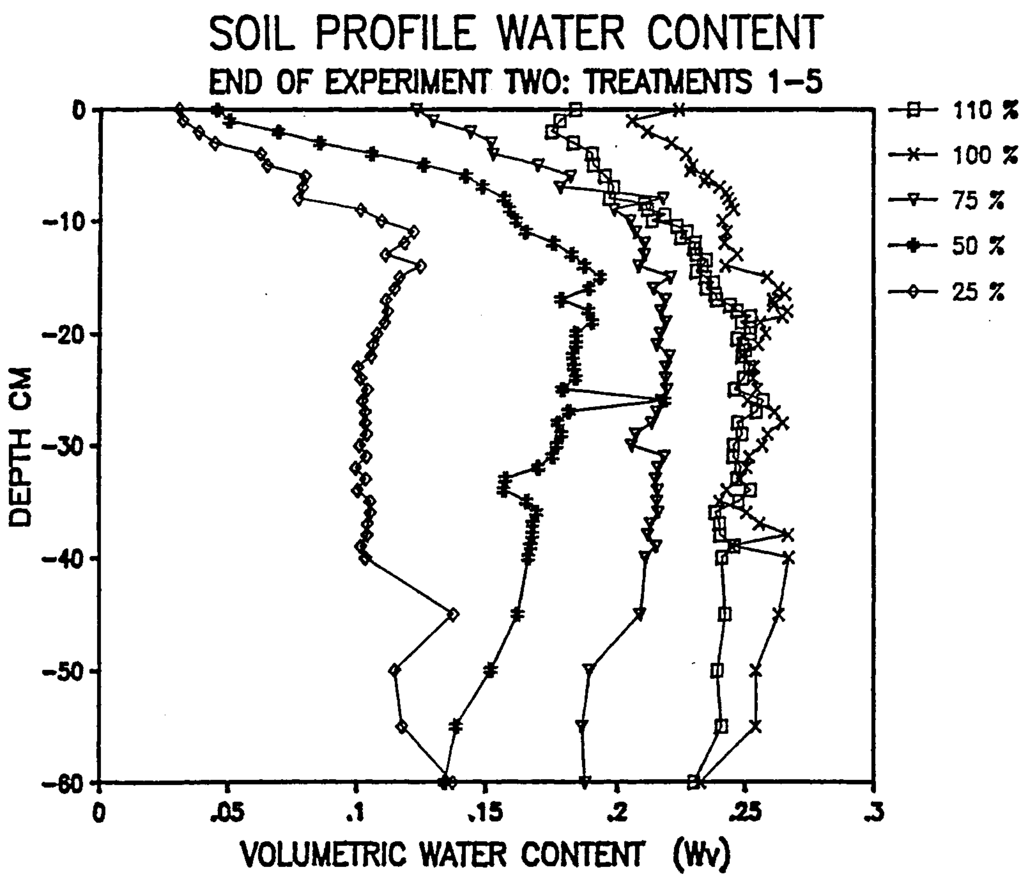


Fig. 8. Soil profile volumetric water content by depth per treatment at the end of experiment 2.

Table 9. Depth of soil wetted at an irrigation during Experiment 2. Calculated Wv before the next irrigation and when irrigated.

| | CM SOIL WETTED | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | IRRIGATION NUMBER | | | | | | | | |
| % ET | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 110 | 50.8 | 29.7 | 35.5 | 55.2 | 85.5 | 38.5 | 41.6 | 58.9 | 95.1 |
| 100 | 51.9 | 29.2 | 34.7 | 58.7 | 83.7 | 44.7 | 45.1 | 66.1 | 82.5 |
| 75 | 31.4 | 19.5 | 22.9 | 34.4 | 38.4 | 22.0 | 26.4 | 31.2 | 41.5 |
| 50 | 20.1 | 12.6 | 15.0 | 21.8 | 20.9 | 13.8 | 15.4 | 19.6 | 20.4 |
| 25 | 10.4 | 6.6 | 7.6 | 11.0 | 9.1 | 6.0 | 6.8 | 8.2 | 7.8 |
| | Wv PRIOR TO NEXT IRRIGATION | | | | | | | | |
| % ET | | | | | | | | | |
| 110 | .10 | .10 | .09 | .10 | .17 | .15 | .14 | .15 | .20 |
| 100 | .11 | .10 | .10 | .12 | .18 | .17 | .16 | .17 | .21 |
| 75 | .08 | .09 | .08 | .08 | .13 | .14 | .14 | .13 | .17 |
| 50 | .08 | .10 | .10 | .09 | .12 | .15 | .14 | .13 | .16 |
| 25 | .09 | .10 | .10 | .09 | .09 | .13 | .11 | .11 | .12 |
| | Wv WHEN IRRIGATED | | | | | | | | |
| % ET | | | | | | | | | |
| 110 | .22 | .21 | .21 | .24 | .24 | .25 | .25 | .26 | .25 |
| 100 | .23 | .23 | .23 | .27 | .27 | .27 | .28 | .29 | .28 |
| 75 | .21 | .19 | .20 | .23 | .23 | .22 | .22 | .24 | .23 |
| 50 | .20 | .17 | .18 | .20 | .20 | .18 | .19 | .21 | .21 |
| 25 | .14 | .12 | .13 | .14 | .13 | .12 | .13 | .14 | .14 |

Table 9. (Continued).

-------------------CM SOIL WETTED--------------------

IRRIGATION NUMBER

| % ET | 21 | 22 | 23 | 24 | 25 | 26 | 27 | AVG. | % ET |
|---|---|---|---|---|---|---|---|---|---|
| 110 | 45.6 | 58.5 | 84.5 | 62.1 | 69.7 | 71.8 | 101.5 | 61.5 | |
| 100 | 47.2 | 66.7 | 101.0 | 46.6 | 51.6 | 55.6 | 102.4 | 60.5 | |
| 75 | 20.9 | 38.8 | 36.2 | 26.6 | 30.8 | 31.8 | 55.1 | 31.7 | |
| 50 | 11.4 | 20.6 | 18.6 | 14.6 | 16.0 | 16.0 | 21.0 | 17.4 | |
| 25 | 4.7 | 7.2 | 7.3 | 5.1 | 5.8 | 6.0 | 6.6 | 7.2 | |

-------------Wv PRIOR TO NEXT IRRIGATION-------------

| % ET | | | | | | | | AVG. |
|---|---|---|---|---|---|---|---|---|
| 110 | .18 | .17 | .20 | .20 | .20 | .20 | .23 | .16 |
| 100 | .19 | .18 | .21 | .19 | .19 | .19 | .21 | .17 |
| 75 | .15 | .16 | .17 | .18 | .18 | .18 | .21 | .14 |
| 50 | .14 | .17 | .17 | .18 | .18 | .17 | .19 | .14 |
| 25 | .11 | .13 | .14 | .14 | .14 | .14 | .14 | .12 |

----------------Wv WHEN IRRIGATED-------------------

| % ET | | | | | | | | AVG. |
|---|---|---|---|---|---|---|---|---|
| 110 | .26 | .27 | .26 | .26 | .27 | .27 | .27 | .25 |
| 100 | .29 | .30 | .30 | .30 | .31 | .31 | .32 | .28 |
| 75 | .23 | .25 | .24 | .24 | .24 | .24 | .25 | .23 |
| 50 | .20 | .20 | .21 | .20 | .21 | .21 | .22 | .20 |
| 25 | .13 | .13 | .14 | .14 | .15 | .15 | .15 | .14 |

ECsw values for all of the treatments in experiment 2 exceeded the maximum average profile ECsw of 23 to 62 dS/m (9-26 bars) for maximum yield decrement (Figure 9), calculated from the ECe of 16 dS/m (6 bars) suggested by Ayers and Wescot (1976, 1985). The interesting point here is that the plants in all treatments did not die. Under the conditions in this study, alfalfa was able to continue to grow at higher salinity levels than had been previously proposed. Yields were down and decreasing but there was some growth in all treatments. Plants in treatment 5 were, for all practical purposes, dead at the end of experiment 2.

Total soil water potential for the end of experiment 2 (Figure 10) shows the decrease in soil potential with each drier treatment. Unlike the experiment 1 pattern (Figure 7), treatment 3 has a lower total soil water potential than treatments 1 and 2. These data seem to pair with treatments 1 and 2 and 3 and 4 being similar in pattern and values. Calculated average treatment values for total soil water potential for the experimental period are listed in Table 5. These values show that calculated as an average of the treatments day to day water and salt status, soil matric potentials for the corresponding treatments in experiments 1 and 2 were very similar but that osmotic and therefore, total potentials for experiment 2 were higher than in experiment 1.

Figures 11 and 12 are graphic representations of total soil water potential and soil water osmotic potential calculated as profile averages for the treatments in the two experiments. The columns marked "END" are the actual values from measured data at the ends of

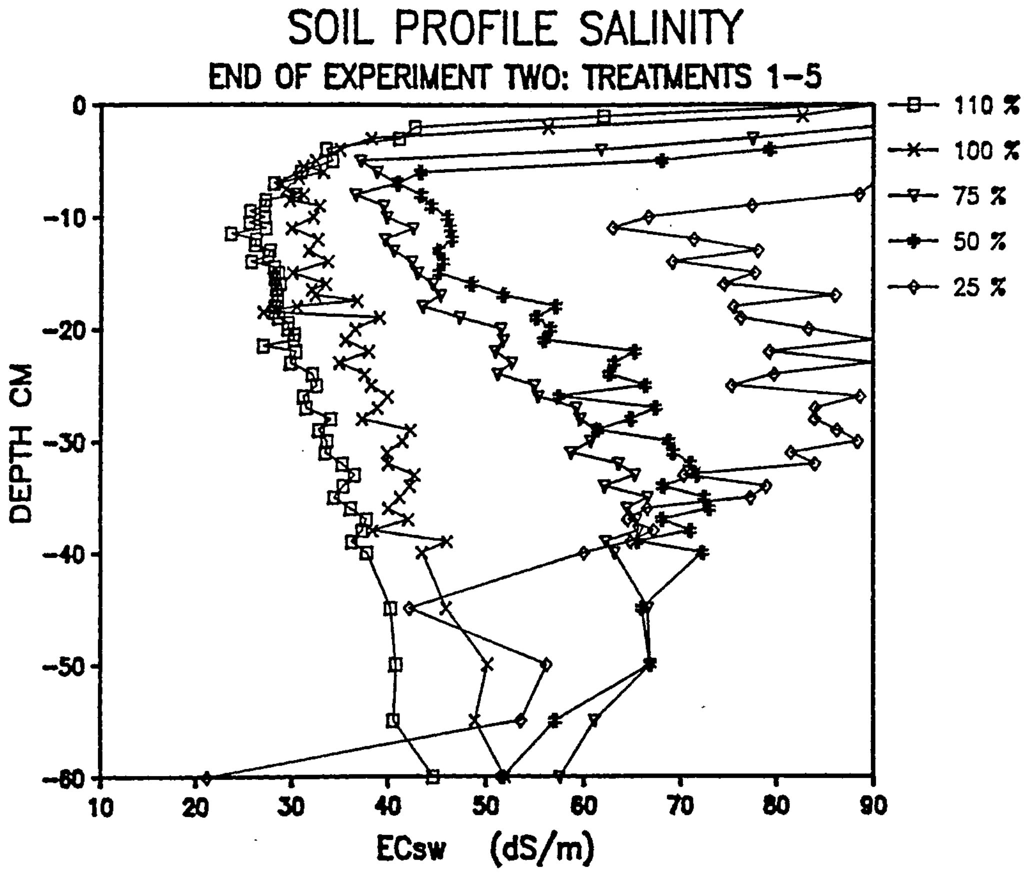


Fig. 9. Soil profile electrical conductivity of the soil water (ECsw) by depth at the end of experiment 2.

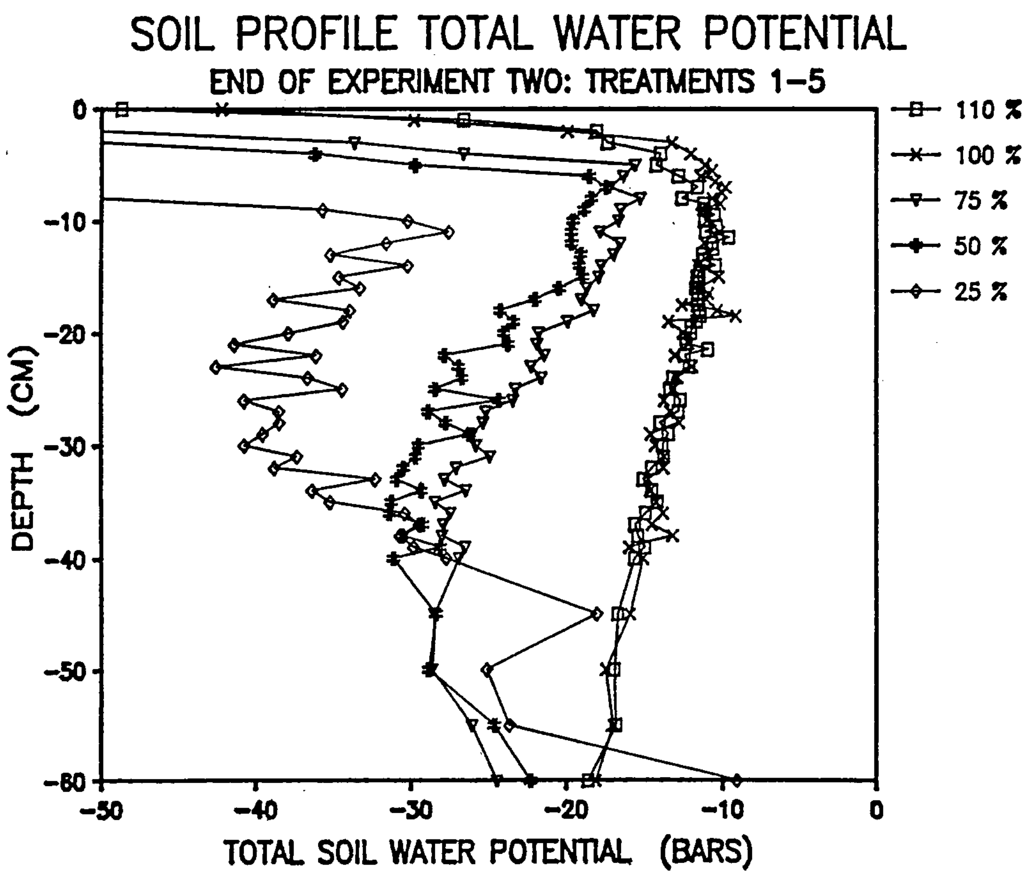


Fig. 10. Soil profile total soil water potential by depth per treatment at the end of experiment 2.

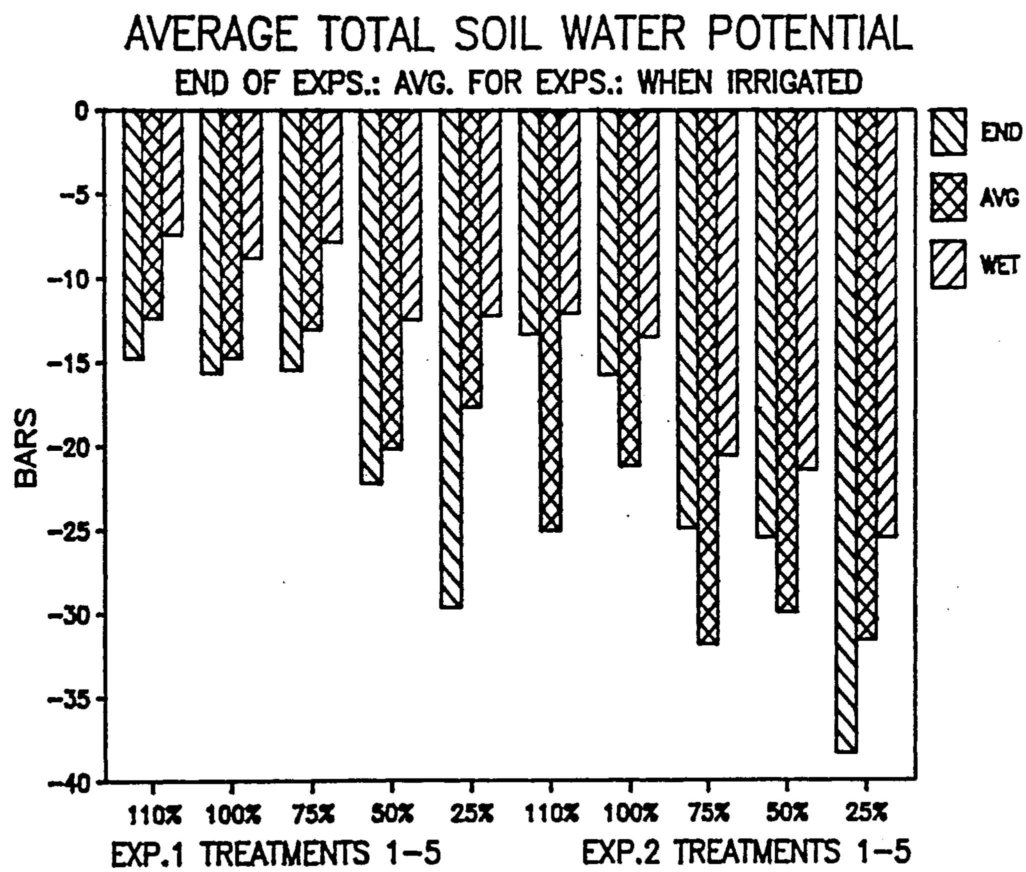


Fig. 11. Total soil water potentials during experiments 1 and 2. Symbols are explained in the text.

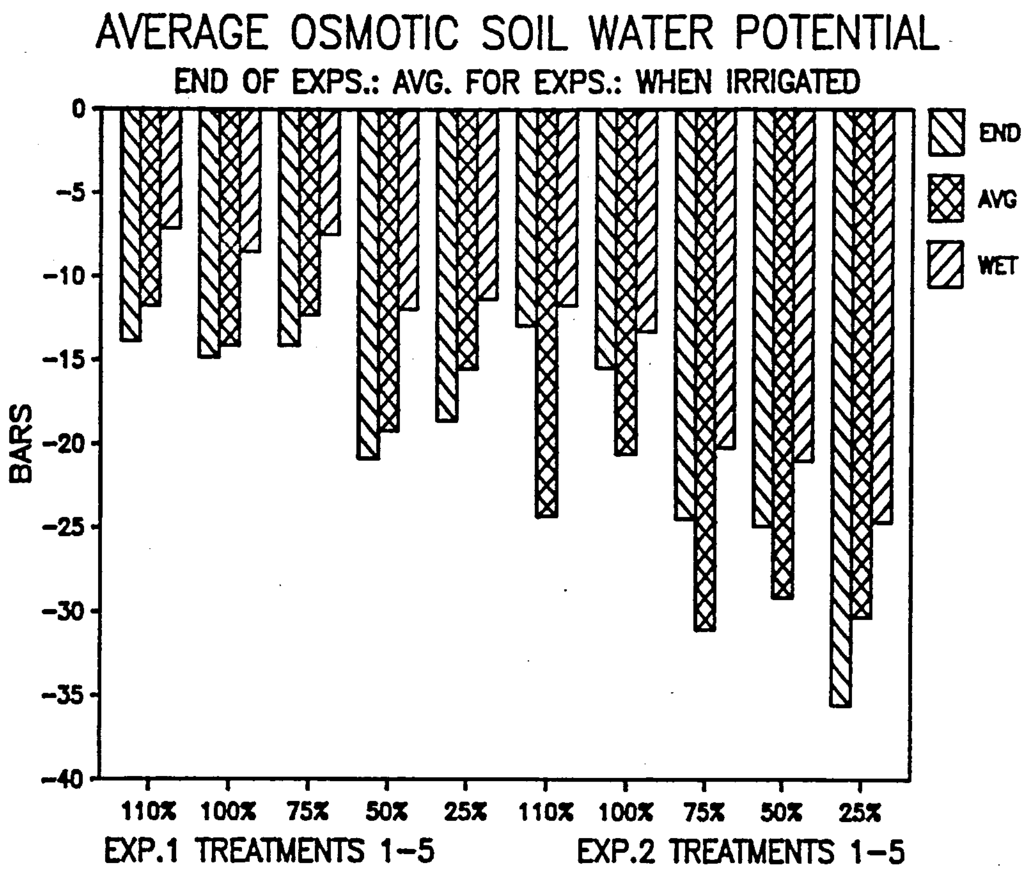


Fig. 12. Soil osmotic potential during experiments 1 and 2. Symbols are explained in the text.

experiments 1 and 2, 6-09-85 and 10-06-85 respectively. "AVG" indicates the average values for the experimental periods based on the estimates for average daily soil water and salinity content calculated from the empirical data. "WET" is based on the calculated estimate for soil salinity and water content when the column was irrigated. These findings indicate that yield decreases for all treatments in experiment 2 were most probably due to a decreased total soil water potential which was caused by a decreased osmotic potential. The soil water developed a total potential too low for the plants to be able to adjust and extract water. The stomates closed, transpiration slowed and growth was decreased. This results in the reduced yields found in experiment 2.

## Plant Response

An examination of the alfalfa growth patterns in the different treatments in experiments 1 and 2 provides some insight into the growth-yield-water relationship. In all treatments of both experiments, depth of available water, defined as water with a total potential between -0.1 to -15 bars, decreased with time due to plant water uptake and increased salt concentration in the upper profile. (Note soil profile water data in Appendix D, also Figures 7 and 10 in this text.) As the available water became limited to shallower depths, the top 10-30 cm in most cases, major growth spurts could only occur soon after an irrigation at which time, soil water content was relatively high and soil water salinity was relatively low. Actual measurements of cm of growth for both experiments are in Appendix C.

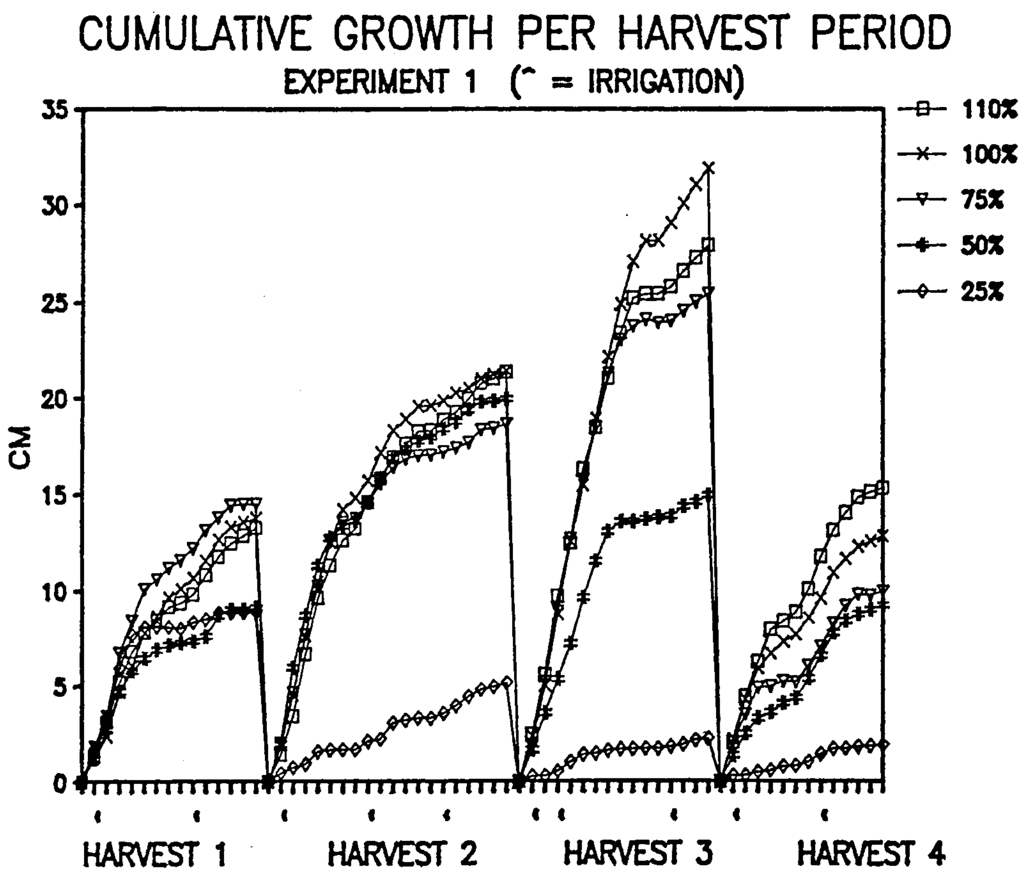


Fig. 13. Plant growth patterns by treatment for the four harvests in Experiment 1.

In experiment 1 (Figure 13) the growth responses in all of the treatments generally show a response to irrigation. Tick marks on figures 13 and 14 represent the day an actual measurement was made. The plants measured in treatment 2 were larger than in treatment 1. This is more likely an artifact of sampling rather than any treatment effect. For all treatments during experiment 2 (Figure 14), growth, measured as stem and top elogation, increased for 1-2 days after an irrigation and then stopped until the next irrigation. By harvest 8, growth in treatments 3, 4 and 5 was minimal. The average length of the plants in a treatment was determined at each harvest (Figure 15). Eight plants from each column were measured for this average.

Some consideration needs to be given to the yield declines in sequential harvests. The reduced yields were due to the treatment differences (amount of water) but were influenced by uncontrolled factors such as aging of the plants, temperature fluctuations, and light availability. The maximum yield for a particular harvest occurred with all uncontrolled factors acting equally on all treatments. Therefore, if yields are calculated as a percentage of this maximum yield, i.e. as a relative yield, the outside influences are the same for all treatments and the differences in growth or yield could reasonably be attributed to treatment differences. Relative yield percentages calculated, for all treatments in both experiments, as a percentage of the maximum grams dry matter produced in treatment 1 of the appropriate experiment (Table 10), indicate that there were clear treatment effects as well as differences between experiments 1 and 2 in treatments 2 through 5.

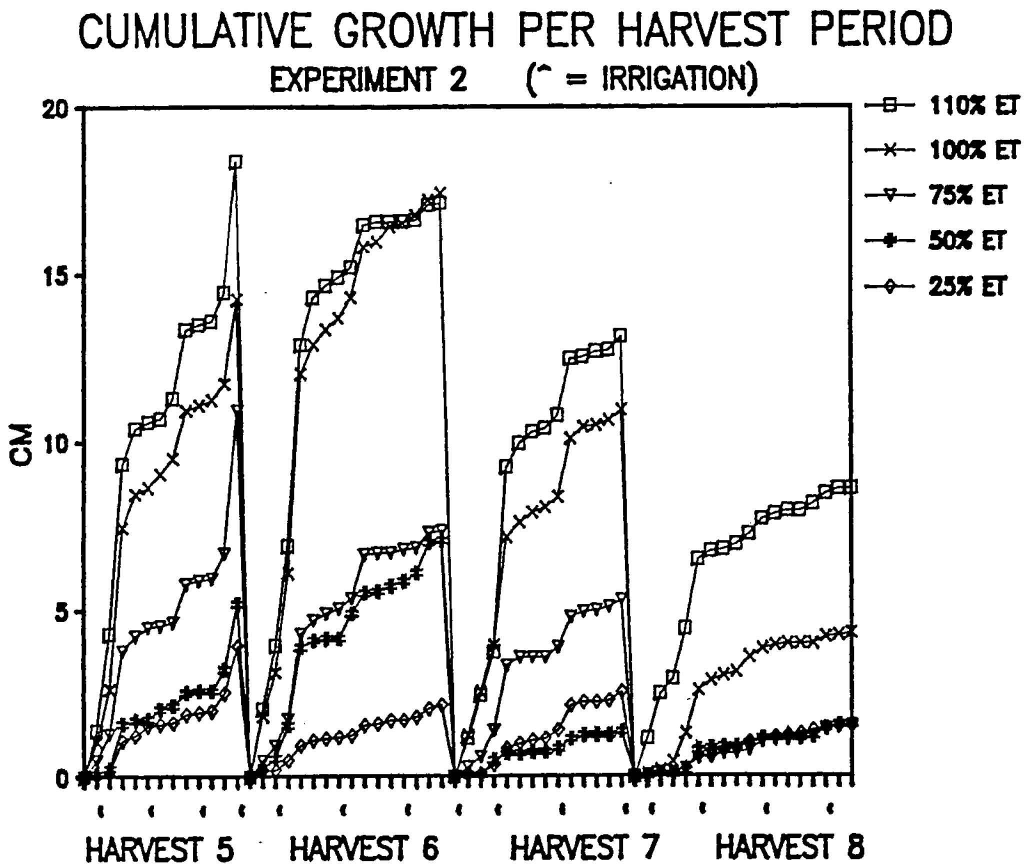


Fig. 14. Plant growth patterns by treatment for the four harvests in Experiment 2.

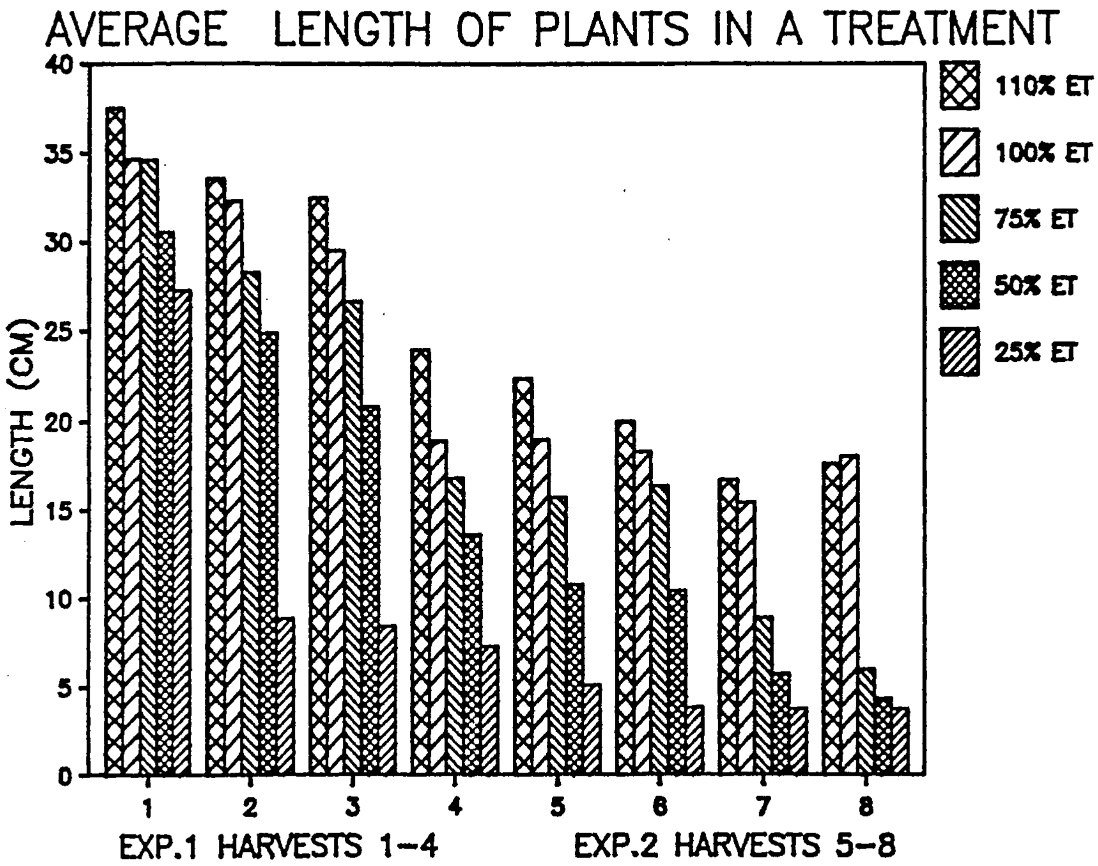


Fig. 15. Average length of plants per treatment for each harvest in Experiments 1 and 2.

Table 10. Percent of maximum yield per harvest.

Yield was measured as grams of dry matter per column.

| | HARVEST # | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| % ET | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 110 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 100 | .92 | .91 | .82 | .77 | .83 | .75 | .72 | .89 |
| 75 | .83 | .74 | .69 | .58 | .64 | .61 | .48 | .51 |
| 50 | .75 | .53 | .45 | .38 | .44 | .32 | .27 | .09 |
| 25 | .48 | .08 | .11 | .10 | .23 | .10 | .04 | .01 |

## Plant and Soil Water Potential

The data for this section are limited to experiment 1. Necessary measurements of plant water potentials were not made during experiment two. Soil and plant sampling were limited because there were not enough columns or enough plants to permit the intensive daily sampling required to make a detailed analysis of plant adjustment to the imposed treatments. What these data show is plant adjustment to the treatments on a particular date.

Plant water potential components were measured on the alfalfa samples collected during harvests 1-4. May 31, 1985 and June 1, 1985 were also chosen so that the potentials could be measured on the day before and the day after an irrigation.

Table 11 is a compliation of measured and calculated plant potential components and soil total potentials at two depths, 15 and 30 cm. The total soil water potentials were calculated by adding the measured and or calculated soil matric and osmotic potentials. Total soil potential generally followed a pattern of decreasing with the drier water treatments. Total leaf potential varied more between harvests than soil potential but again was generally decreased in the drier treatments. Since water moves from a high potential to a lower one, the plants must maintain a lower total water potential than at least some portion of the soil profile in order to obtain water. Plants in all treatments were able to accomplish this in harvests 1-3. At harvest 4, ten days after the last irrigation, plants in all treatments, except treatment one, were showing signs of wilting. Comparison of

Table 11. Experiment 1 plant potential components and total soil potential at two depths.

| | PLANT POTENTIALS | | | SOIL POTENTIALS | |
|---|---|---|---|---|---|
| | TOTAL | OSMOTIC | TURGOR | 15 CM | 30 CM |
| % ET | HARVEST 1 | | | | |
| 110 | -13.2 | -26.6 | 13.5 | -7.9 | -7.6 |
| 100 | -12.1 | -33.6 | 21.6 | -9.0 | -13.0 |
| 75 | -12.0 | -35.0 | 23.0 | -9.7 | -12.5 |
| 50 | -16.6 | -44.2 | 27.6 | -14.9 | -20.2 |
| 25 | -18.0 | -61.2 | 43.3 | -18.2 | -17.0 |
| | HARVEST 2 | | | | |
| 110 | -18.2 | -40.4 | 22.1 | -9.2 | -11.7 |
| 100 | -17.3 | -45.9 | 28.6 | -11.6 | -13.0 |
| 75 | -17.0 | -50.0 | 33.0 | -12.6 | -15.6 |
| 50 | -21.8 | -47.7 | 25.8 | -12.4 | -22.5 |
| 25 | -21.9 | -46.0 | 24.2 | -14.5 | -22.2 |
| | HARVEST 3 | | | | |
| 110 | -13.3 | -29.8 | 16.5 | -7.9 | -9.7 |
| 100 | -14.9 | -32.8 | 17.9 | -7.3 | -10.4 |
| 75 | -13.8 | -31.0 | 17.2 | -8.7 | -14.3 |
| 50 | -17.8 | -34.8 | 17.0 | -11.5 | -20.0 |
| 25 | -16.6 | -40.6 | 24.0 | -16.6 | -21.5 |
| | HARVEST 4 | | | | |
| 110 | -21.5 | -65.7 | 44.2 | -22.0 | -16.2 |
| 100 | -15.2 | -60.4 | 45.2* | -22.0 | -17.0 |
| 75 | -18.9 | -71.9 | 53.0* | -24.0 | -16.7 |
| 50 | -23.3 | -64.5 | 41.2* | -25.0 | -23.0 |
| 25 | -20.2 | -63.5 | 43.3* | -34.0 | -32.0 |

Table 11. (Continued).

| | | | | | |
|---|---|---|---|---|---|
| 5.31.85 | | | | | |
| 110 | -23.2 | -39.2 | 16.0 | -9.2 | -20.2 |
| 100 | -21.4 | -47.8 | 26.4 | -8.8 | -24.1 |
| 75 | -21.8 | -53.0 | 31.2* | -10.4 | -29.3 |
| 50 | -25.3 | -56.3 | 31.0* | -14.7 | -25.0 |
| 25 | -19.5 | -52.2 | 32.7* | -19.8 | -34.0 |
| 6.01.85 | | | | | |
| 110 | -15.0 | -33.1 | 18.0 | -9.2 | -11.0 |
| 100 | -15.3 | -33.4 | 18.2 | -8.8 | -17.0 |
| 75 | -15.1 | -32.0 | 16.9 | -10.4 | -30.0 |
| 50 | -13.5 | -32.1 | 18.6 | -14.7 | -26.0 |
| 25 | -19.9 | -32.6 | 12.7 | -19.8 | -33.0 |

* Since these plants showed visual symptoms of wilting, osmotic potential should equal total potential and the turgor potential should be zero. Possible sources of error are discussed in the text.

plant and soil total potentials indicate that the plants in these treatments were not able to extract water from the soil at 15 or 30 cm.

Data from 5-31-85 indicate that by the end of this irrigation cycle, plants in treatments 3, 4 and 5 were wilted. Potential comparisons indicate that treatments 3 and 4 could obtain water at 15 cm but apparently not enough to meet the transpiration demand. Total plant potentials for treatments 1-4 were increased on 6-09-85 indicating recovery after the irrigation. Soil potentials for treatment four do not reflect a recovery. Treatment 5 plants and soil showed no change. Although no potential measurements were made, treatment 2-5 showed visual recovery from stress by 6-02-85.

Turner and Jones (1980) state that the degree of osmotic adjustment should be measured as the change in osmotic potential at some reference potential or water content, usually full or zero turgor. The osmotic potential of the alfalfa in the 110% treatment at harvest one was about -27 bars. This was a fully turgid plant and other treatment water potentials can be compared to it to determine the amount of osmotic adjustment. The maximum adjustment was an additional -39 bars in treatment 1 at harvest 4. The range of osmotic adjustment was from -3 bars to -39 bars.

Osmotic potential should equal total potential in wilted leaves resulting in a turgor near zero. The numbers reported in table 11 are actual measurement values, note the treatments where turgor values are marked with an asterisk. The discrepancies in the calculated turgor potential values at Harvest 4 and on 5-31-86 could be due to errors in either the total potential measurements, the osmotic potential measurements or both. At this time, it is not possible to say where the error was. Total potential measurements were taken as closely as possible to noon. Since it was not possible to do all of the samples at the same time, some error could result. Osmotic potentials at Harvest 4 were extremely low. It is not possible to measure total potentials in that range with a pressure bomb. Future work would require an examination and improvement of these methods.

Munns, et al. (1979) found that osmotic potential of the apex and leaves of wheat fell from -12 to -40 bars during a thirteen day period of water stress. This would be a -28 bar adjustment and was the maximum found reported in the literature available for examination.

Comparisons in amount of osmotic adjustment from the literature were all for nonsaline environments under conditions of noncontinuous stress. During the present study, treatments 3, 4, and 5 were stressed for a large portion of the experiment. The prolonged period in which osmotic adjustment could have occurred may have allowed for more osmotic adjustment than has been usually reported. The osmotic potential measurements in this study reflect the long term adjustment to a prolonged combined osmotic and matric stress. Plant potential components averaged over the Experiment 1 period and total soil potentials at 15 and 30 cm for the same period are illustrated in figure 16. Total plant potential was maintained low enough to extract water from the soil in treatments 1-4 at either 15 or 30 cm. Treatment 5 total plant potential adjustment was not sufficient for water extraction. These are average values. Obviously, there were periods when plants in all of the treatments were able to get at least some water.

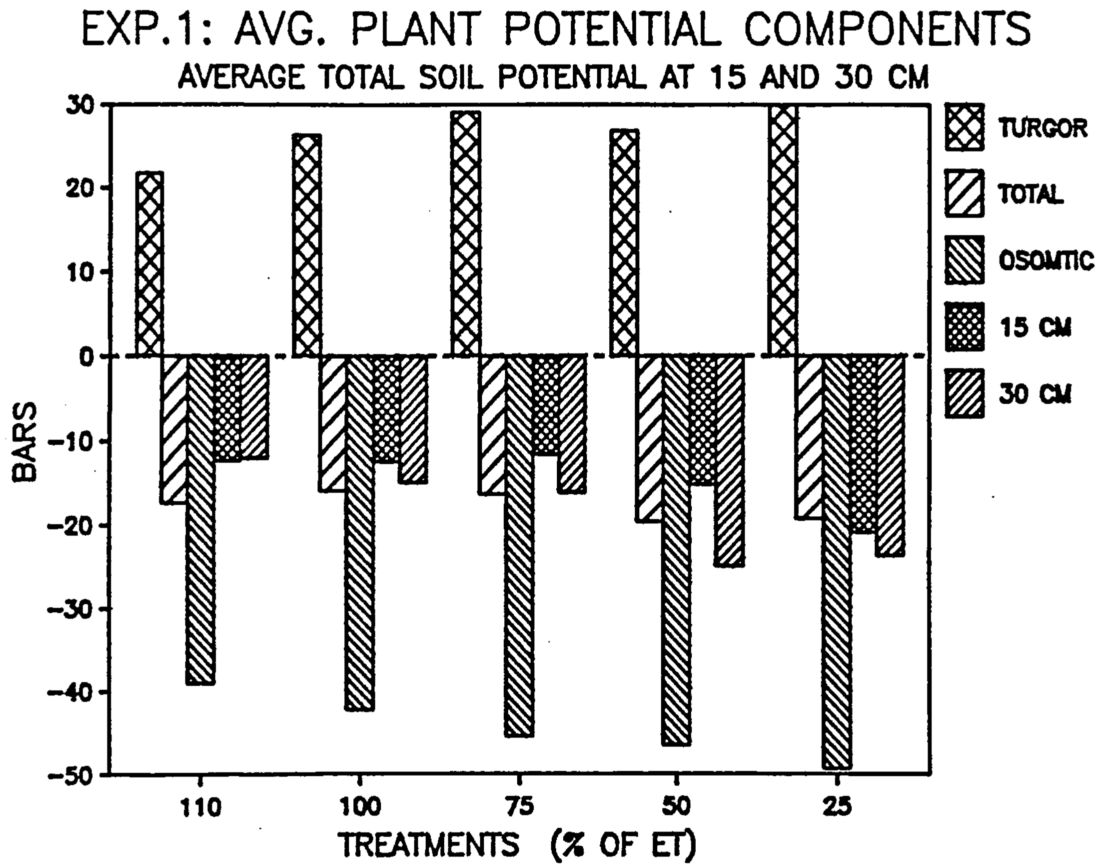


Fig. 16. Plant potential components averaged for the experiment 1 period. Total soil water potential at 15 and 30 cm during the experiment 1 period.

## Conclusions

1. The yield response function relating crop yield to total amount of irrigation applied is linear. This function can be used to determine an expected yield for a given amount of applied saline irrigation water applied.

2. The leaching fractions resulting from the crop's inability to use 100 % of the saline irrigation water were 9, 9, 6, 5 and 5 % for treatments 1-5 in experiment 1. Corresponding leaching fractions for experiment 2, treatments 1-5 were 25, 26, 18, 16, 17%. In both experiments, treatment 1 had a planned leaching fraction of 10%, no additional irrigation water for leaching was applied in treatments 2-5. The leaching fraction in these treatments was a plant determined parameter.

3. The lowest rootzone soil water osmotic potentials achieved by the end of experiment 1 for treatments 1-5 were -19, -20, -18, -26 and -24 bars. Corresponding treatment values achieved by the end of experiment 2 were -18, -22, -28, -31 and -45 bars. Plants in treatments 1 and 2 were exposed to levels of osmotic stress which were similar, within 1-2 bars of each other. Plants in experiment 2, treatment 3-5 were experiencing osmotic potentials 5-21 bars less than the corresponding experiment 1 plants.

4. The yield in grams of dry matter per kg of water transpired was 1.34, 1.30, 1.28, 1.48 and 1.17 for experiment 1, treatments 1-5 respectively. Corresponding treatment values for experiment 2 were 0.95, 0.90, 0.84, 0.82 and 1.37. These values represent yields which when compared to experimental yields from other studies are reasonable.

5. The amount of water used for evapotranspiration in experiment 1 was greater for all treatments than in experiment 2. This reflects the inability of the plants to use saline water.

6. Osmotic adjustment, measured only in experiment 1, ranged from -3 to -39 bars for all treatments over the approximately 120 day period. These values contain some measurement errors, but indicate that this variety of alfalfa was able to osmotically adjust in order to extract water from the salinized soil profile.

APPPENDIX A

SOIL CHARACTERIZATION

Classification...............................
coarse, loamy, mixed, thermic Typic Torrifluvent,
Comoro sandy loam

| | |
|---|---|
| Saturated Paste EC (dS/m)................. | 5.5 |
| Saturation Percent (%).................... | 36 |
| Air Dry Percent Water (%)................. | 1.8 |
| Column Bulk Density (g/cm cubed)......... | 1.46 |

Exchangeable Cations (meq/100g)

| | |
|---|---|
| Calcium............................. | 33.84 |
| Sodium.............................. | 0.22 |
| Potassium........................... | 2.85 |
| Magnesium........................... | 2.25 |

| | |
|---|---|
| Sodium Saturation for<br>Cation Exchange Capacity (meq/100g)....... | 14.21 |
| Exchageable Sodium Percent................ | 1.54 |

Moisture Release Curve:

| POTENTIAL (BARS) | % WATER (Wv) |
|---|---|
| 0.1 | 36 |
| 0.2 | 28 |
| 0.3 | 24.8 |
| 0.4 | 21 |
| 0.5 | 18 |
| 0.8 | 14 |
| 1.0 | 12.5 |
| 2.0 | 11.1 |
| 3.0 | 9.8 |
| 5.0 | 9.3 |
| 15.0 | 8.99 |

# APPENDIX B

# WATER DATA

Experiment 1: Liters of Water Used per Irrigation

........................DATE............................

3.08 3.15 3.22 3.28 4.05 4.12 4.18 4.26

...................IRRIGATION NUMBER....................

1 2 3 4 5 6 7

| % ET | LITERS | | | | | | |
|---|---|---|---|---|---|---|---|
| 110 | .95 | 2.23 | 1.95 | 1.45 | 2.57 | 2.41 | 2.51 |
| 110 | 1.00 | 2.09 | 1.98 | 1.70 | 2.57 | 2.60 | 2.67 |
| 100 | 1.18 | 2.01 | 1.85 | 1.40 | 2.10 | 2.36 | 2.20 |
| 100 | 1.11 | 1.97 | 1.92 | 1.59 | 2.11 | 2.38 | 2.43 |
| 75 | 1.18 | 1.84 | 1.73 | 1.16 | 2.22 | 1.78 | 1.87 |
| 75 | 1.15 | 1.89 | 1.96 | 1.14 | 1.93 | 1.97 | 1.84 |
| 50 | 1.15 | 1.49 | 1.56 | .86 | 1.23 | 1.30 | 1.32 |
| 50 | 1.20 | 1.41 | 1.44 | .73 | 1.25 | 1.19 | 1.19 |
| 25 | 1.02 | 1.14 | 1.26 | .46 | .53 | .56 | .69 |
| 25 | .97 | 1.13 | 1.19 | .44 | .57 | .62 | .56 |

........................DATE............................

| | 5.03 | 5.12 | 5.20 | 5.31 | 6.09 | |
|---|---|---|---|---|---|---|
| | IRRIGATION NUMBER | | | | | |
| | 8 | 9 | 10 | 11 | 12 | |
| % ET | LITERS | | | | | TOTAL USED |
| 110 | 1.56 | 2.78 | 2.70 | 2.42 | 2.90 | 26.43 |
| 110 | 1.53 | 2.33 | 2.96 | 2.21 | 3.07 | 26.71 |
| 100 | 1.47 | 2.21 | 2.78 | 2.06 | 2.67 | 24.28 |
| 100 | 1.60 | 2.12 | 2.41 | 2.13 | 2.49 | 24.25 |
| 75 | 1.14 | 2.18 | 2.08 | 1.73 | 2.02 | 20.92 |
| 75 | 1.26 | 2.12 | 2.02 | 1.85 | 1.99 | 21.11 |
| 50 | .91 | 1.31 | 1.28 | 1.20 | 1.36 | 14.98 |
| 50 | .84 | 1.44 | 1.26 | 1.21 | 1.28 | 14.45 |
| 25 | .53 | .63 | .62 | .60 | .60 | 8.64 |
| 25 | .50 | .64 | .69 | .58 | .62 | 8.51 |

Experiment 1: Liters of Water Applied per Irrigation

| DATE | 3.08 | 3.15 | 3.22 | 3.28 | 4.05 | 4.12 | 4.18 |
|---|---|---|---|---|---|---|---|
| IRRIGATION NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| % ET | LITERS | | | | | | |
| 110 | 1.00 | 2.01 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 |
| 110 | 1.00 | 2.01 | 2.40 | 2.40 | 2.40 | 2.40 | 2.40 |
| 100 | 1.00 | 1.83 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 |
| 100 | 1.00 | 1.83 | 2.16 | 2.16 | 2.16 | 2.16 | 2.16 |
| 75 | 1.00 | 1.51 | 1.80 | 1.80 | 1.80 | 1.80 | 1.80 |
| 75 | 1.00 | 1.51 | 1.80 | 1.80 | 1.80 | 1.80 | 1.80 |
| 50 | 1.00 | 1.00 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 |
| 50 | 1.00 | 1.00 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 |
| 25 | 1.00 | .50 | .60 | .60 | .60 | .60 | .60 |
| 25 | 1.00 | .50 | .60 | .60 | .60 | .60 | .60 |

| DATE | 4.26 | 5.03 | 5.12 | 5.20 | 5.31 | | |
|---|---|---|---|---|---|---|---|
| IRRIGATION NUMBER | 8 | 9 | 10 | 11 | 12 | STORED | |
| % ET | LITERS | | | | | | TOTAL ADDED |
| 110 | 2.40 | 2.40 | 2.40 | 2.34 | 2.44 | 1.62 | 28.61 |
| 110 | 2.40 | 2.40 | 2.40 | 2.34 | 2.44 | 1.62 | 28.61 |
| 100 | 2.16 | 2.16 | 2.16 | 2.13 | 2.20 | 1.46 | 26.08 |
| 100 | 2.16 | 2.16 | 2.16 | 2.13 | 2.20 | 1.46 | 26.08 |
| 75 | 1.80 | 1.80 | 1.80 | 1.76 | 1.83 | 1.35 | 21.85 |
| 75 | 1.80 | 1.80 | 1.80 | 1.76 | 1.83 | 1.35 | 21.85 |
| 50 | 1.20 | 1.20 | 1.20 | 1.17 | 1.22 | 1.19 | 15.18 |
| 50 | 1.20 | 1.20 | 1.20 | 1.17 | 1.22 | 1.19 | 15.18 |
| 25 | .60 | .60 | .60 | .59 | .61 | 1.42 | 8.92 |
| 25 | .60 | .60 | .60 | .59 | .61 | 1.42 | 8.92 |

Experiment 2: Liters of Water Used per Irrigation Period

| % ET | 6.11 | 6.20 | 6.27 | 7.03 | 7.11 | 7.18 | 7.25 |
|---|---|---|---|---|---|---|---|
| IRRIGATION NUMBER | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | LITERS | | | | | | |
| 110 | 1.71 | 1.68 | 1.87 | 2.20 | 1.11 | 1.36 | 1.63 |
| 100 | 1.40 | 1.51 | 1.68 | 1.86 | 1.09 | 1.07 | 1.43 |
| 75 | 1.46 | 1.07 | 1.26 | 1.54 | 1.05 | .82 | .96 |
| 50 | 1.12 | .75 | .83 | 1.07 | .81 | .43 | .66 |
| 25 | .62 | .38 | .42 | .55 | .51 | .10 | .34 |

| % ET | 8.01 | 8.08 | 8.15 | 8.22 | 8.29 | 9.05 | 9.12 |
|---|---|---|---|---|---|---|---|
| IRRIGATION NUMBER | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | LITERS | | | | | | |
| 110 | 1.60 | .88 | 1.21 | 1.44 | .98 | 1.00 | .98 |
| 100 | 1.42 | .86 | 1.04 | 1.21 | .89 | .84 | .86 |
| 75 | 1.22 | .73 | .94 | .97 | .78 | .73 | .65 |
| 50 | .77 | .58 | .64 | .45 | .54 | .43 | .45 |
| 25 | .45 | .31 | .33 | .21 | .16 | .14 | .21 |

| % ET | 9.19 | 9.26 | TOTAL USED |
|---|---|---|---|
| IRRIGATION NUMBER | 27 | 28 | |
| | LITERS | | |
| 110 | 1.03 | .71 | 21.37 |
| 100 | .88 | .60 | 18.64 |
| 75 | .71 | .45 | 15.32 |
| 50 | .49 | .35 | 10.34 |
| 25 | .22 | .20 | 5.12 |

Experiment 2: Liters of Water Applied per Irrigation Period

| | DATE | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 6.11 | 6.20 | 6.27 | 7.03 | 7.11 | 7.18 |
| | IRRIGATION NUMBER | | | | | | |
| | STORED | 13 | 14 | 15 | 16 | 17 | 18 |
| % ET | LITERS | | | | | | |
| 110 | 2.70 | 2.44 | 1.48 | 1.85 | 2.75 | 2.22 | 1.18 |
| 100 | 2.28 | 2.22 | 1.35 | 1.68 | 2.50 | 2.02 | 1.07 |
| 75 | 1.33 | 1.80 | 1.02 | 1.26 | 1.87 | 1.52 | .80 |
| 50 | .69 | 1.22 | .69 | .84 | 1.25 | 1.01 | .54 |
| 25 | .45 | .61 | .36 | .42 | .62 | .51 | .27 |

| | DATE | | | | | | |
|---|---|---|---|---|---|---|---|
| | 7.25 | 8.01 | 8.08 | 8.15 | 8.22 | 8.29 | 9.05 |
| | IRRIGATION NUMBER | | | | | | |
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| % ET | LITERS | | | | | | |
| 110 | 1.47 | 1.88 | 1.65 | 1.04 | 1.46 | 1.36 | .92 |
| 100 | 1.33 | 1.71 | 1.50 | .94 | 1.35 | 1.24 | .84 |
| 75 | 1.00 | 1.28 | 1.13 | .71 | 1.20 | .93 | .63 |
| 50 | .67 | .86 | .75 | .47 | .68 | .62 | .42 |
| 25 | .34 | .43 | .38 | .24 | .33 | .31 | .21 |

| | DATE | | | |
|---|---|---|---|---|
| | 9.12 | 9.19 | 9.26 | |
| | IRRIGATION NUMBER | | | |
| | 26 | 27 | 28 | |
| %ET | LITERS | | | TOTAL ADDED |
| 110 | 1.05 | 1.08 | 1.14 | 27.67 |
| 100 | .95 | .98 | 1.03 | 25.20 |
| 75 | .71 | .74 | .78 | 19.23 |
| 50 | .48 | .49 | .52 | 12.73 |
| 25 | .24 | .25 | .26 | 6.38 |

# APPENDIX C

# GROWTH DATA

Experiment 1: Cm Total Growth per Harvest Period

HARVEST 1..............................................

..................MEASUREMENT NUMBER....................

| % ET | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | | | | CM | | | |
| 110 | .0 | 1.4 | 3.1 | 5.2 | 6.8 | 7.8 | 8.5 |
| 100 | .0 | 1.3 | 2.4 | 4.7 | 6.1 | 7.8 | 8.7 |
| 75 | .0 | 1.9 | 3.5 | 6.8 | 8.5 | 10.1 | 10.6 |
| 50 | .0 | 1.2 | 2.7 | 4.7 | 5.8 | 6.5 | 6.9 |
| 25 | .0 | 1.8 | 3.4 | 6.0 | 7.7 | 8.1 | 8.1 |

| 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|
| 9.2 | 9.4 | 9.8 | 10.8 | 11.8 | 12.5 | 12.9 |
| 9.7 | 10.1 | 10.7 | 11.6 | 12.7 | 13.3 | 13.6 |
| 11.2 | 11.6 | 12.2 | 13.2 | 13.8 | 14.5 | 14.5 |
| 7.2 | 7.3 | 7.4 | 7.6 | 8.7 | 9.0 | 9.0 |
| 8.0 | 8.0 | 8.4 | 8.5 | 8.9 | 8.9 | 8.9 |

| 15 |
|---|
| 13.3 |
| 13.8 |
| 14.5 |
| 9.1 |
| 8.9 |

HARVEST 2

| % ET | 16 | 17 | 18 | 19 | 20 | 21 |
|---|---|---|---|---|---|---|
| | CM | | | | | |
| 110 | .0 | 1.4 | 3.4 | 6.7 | 9.6 | 11.3 |
| 100 | .0 | 1.9 | 4.5 | 7.6 | 10.5 | 12.5 |
| 75 | .0 | 2.0 | 4.7 | 7.7 | 10.3 | 12.6 |
| 50 | .0 | 2.0 | 6.0 | 8.7 | 11.3 | 12.8 |
| 25 | .0 | .5 | .8 | .9 | 1.6 | 1.7 |

| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
|---|---|---|---|---|---|---|
| 12.6 | 13.2 | 14.6 | 15.8 | 16.9 | 17.6 | 18.3 |
| 14.2 | 14.8 | 15.7 | 17.2 | 18.3 | 18.9 | 19.6 |
| 13.6 | 13.8 | 14.6 | 15.6 | 16.4 | 16.9 | 17.0 |
| 13.4 | 13.6 | 14.6 | 15.9 | 16.9 | 17.4 | 17.8 |
| 1.7 | 1.7 | 2.1 | 2.2 | 3.1 | 3.2 | 3.3 |

| 29 | 30 | 31 | 32 | 33 | 34 | 35 |
|---|---|---|---|---|---|---|
| 18.3 | 18.9 | 19.3 | 20.0 | 20.8 | 21.0 | 21.4 |
| 19.6 | 19.9 | 20.3 | 20.5 | 21.0 | 21.2 | 21.4 |
| 17.1 | 17.2 | 17.4 | 17.7 | 18.4 | 18.5 | 18.7 |
| 18.0 | 18.4 | 18.8 | 19.4 | 19.8 | 19.9 | 20.0 |
| 3.3 | 3.6 | 4.0 | 4.5 | 4.8 | 5.0 | 5.2 |

HARVEST 3..........................................

| % ET | 36 | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|---|
| 110 | .0 | 2.5 | 5.6 | 9.7 | 12.5 | 16.3 | 18.5 |
| 100 | .0 | 2.4 | 5.0 | 8.8 | 12.6 | 15.5 | 18.9 |
| 75 | .0 | 1.9 | 5.3 | 9.0 | 12.7 | 15.8 | 18.5 |
| 50 | .0 | 1.7 | 3.6 | 5.4 | 7.3 | 9.7 | 11.6 |
| 25 | .0 | .3 | .3 | .6 | 1.1 | 1.4 | 1.5 |

Measurement number (CM)

| 43 | 44 | 45 | 46 | 47 | 48 | 49 |
|---|---|---|---|---|---|---|
| 21.0 | 23.4 | 25.2 | 25.4 | 25.4 | 25.8 | 26.6 |
| 22.1 | 24.9 | 27.1 | 28.1 | 28.2 | 29.1 | 30.1 |
| 21.3 | 23.1 | 23.8 | 24.1 | 23.9 | 24.0 | 24.5 |
| 13.1 | 13.6 | 13.6 | 13.7 | 13.8 | 13.9 | 14.4 |
| 1.7 | 1.7 | 1.7 | 1.8 | 1.8 | 1.9 | 2.0 |

| 50 | 51 |
|---|---|
| 27.3 | 27.9 |
| 31.1 | 31.9 |
| 25.0 | 25.4 |
| 14.6 | 15.0 |
| 2.2 | 2.3 |

.........................................................

HARVEST 4................................................

..................MEASUREMENT NUMBER....................

| % ET | 52 | 53 | 54 | 55 | 56 |
|---|---|---|---|---|---|
| | CM | | | | |
| 110 | .0 | 2.1 | 4.5 | 6.3 | 8.0 |
| 100 | .0 | 2.2 | 4.3 | 5.9 | 6.7 |
| 75 | .0 | 2.1 | 3.5 | 4.9 | 5.0 |
| 50 | .0 | 1.4 | 2.5 | 3.3 | 3.6 |
| 25 | .0 | .3 | .3 | .5 | .6 |

| 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|
| 8.4 | 8.9 | 10.1 | 11.8 | 13.1 | 14.0 | 14.8 |
| 7.3 | 7.7 | 8.6 | 9.6 | 10.9 | 11.7 | 12.3 |
| 5.3 | 5.2 | 6.1 | 7.1 | 8.3 | 9.2 | 9.8 |
| 4.1 | 4.4 | 5.4 | 6.6 | 7.8 | 8.4 | 8.8 |
| .8 | .9 | 1.1 | 1.5 | 1.8 | 1.8 | 1.9 |

| 64 | 65 |
|---|---|
| 15.1 | 15.3 |
| 12.6 | 12.8 |
| 9.8 | 10.0 |
| 9.0 | 9.2 |
| 1.9 | 1.9 |

Experiment 2: Cm Total Growth per Harvest Period

HARVEST 5................................................

....................MEASUREMENT NUMBER....................

| % ET | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | CM | | | | | | |
| 110 | .0 | 1.4 | 4.3 | 9.4 | 10.4 | 10.6 | 10.7 |
| 100 | .0 | 1.1 | 2.7 | 7.5 | 8.5 | 8.7 | 9.1 |
| 75 | .0 | .5 | 1.3 | 3.8 | 4.3 | 4.5 | 4.6 |
| 50 | .0 | .1 | .3 | 1.6 | 1.7 | 1.8 | 2.1 |
| 25 | .0 | .0 | .2 | 1.1 | 1.3 | 1.6 | 1.6 |

| % ET | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|
| 110 | 11.3 | 13.4 | 13.5 | 13.6 | 14.5 | 18.4 |
| 100 | 9.5 | 11.0 | 11.1 | 11.3 | 11.8 | 14.3 |
| 75 | 4.7 | 5.8 | 5.9 | 6.0 | 6.7 | 11.0 |
| 50 | 2.2 | 2.6 | 2.6 | 2.6 | 3.3 | 5.2 |
| 25 | 1.7 | 1.9 | 2.0 | 2.0 | 2.6 | 4.0 |

HARVEST 6..............................................

................MEASUREMENT NUMBER..................

| % ET | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|
| | | | | CM | | | |
| 110 | .0 | 2.1 | 4.0 | 6.9 | 12.9 | 14.3 | 14.7 |
| 100 | .0 | 1.9 | 3.2 | 6.1 | 12.1 | 12.9 | 13.4 |
| 75 | .0 | .5 | 1.0 | 1.8 | 4.3 | 4.7 | 4.9 |
| 50 | .0 | .3 | .6 | 1.6 | 3.9 | 4.1 | 4.2 |
| 25 | .0 | .2 | .2 | .5 | 1.0 | 1.1 | 1.2 |

| % ET | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|
| 110 | 14.9 | 15.2 | 16.5 | 16.6 | 16.6 | 16.6 | 16.6 |
| 100 | 13.7 | 14.3 | 15.8 | 16.0 | 16.4 | 16.5 | 16.8 |
| 75 | 5.1 | 5.4 | 6.7 | 6.7 | 6.7 | 6.8 | 6.9 |
| 50 | 4.2 | 4.9 | 5.5 | 5.6 | 5.7 | 5.9 | 6.1 |
| 25 | 1.2 | 1.3 | 1.6 | 1.6 | 1.7 | 1.7 | 1.8 |

| % ET | 28 | 29 |
|---|---|---|
| 110 | 17.1 | 17.1 |
| 100 | 17.2 | 17.4 |
| 75 | 7.3 | 7.4 |
| 50 | 7.0 | 7.1 |
| 25 | 2.1 | 2.2 |

HARVEST 7.............................................

...............MEASUREMENT NUMBER..................

| % ET | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|
| | CM | | | | | | |
| 110 | .0 | 1.2 | 2.5 | 3.8 | 9.3 | 10.0 | 10.3 |
| 100 | .0 | 1.3 | 2.6 | 4.0 | 7.2 | 7.6 | 7.9 |
| 75 | .0 | .3 | .6 | 1.4 | 3.4 | 3.6 | 3.6 |
| 50 | .0 | .1 | .1 | .5 | .7 | .7 | .8 |
| 25 | .0 | .1 | .1 | .4 | .9 | 1.0 | 1.1 |

| % ET | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|
| 110 | 10.4 | 10.8 | 12.5 | 12.6 | 12.7 | 12.8 | 13.2 |
| 100 | 8.1 | 8.4 | 10.1 | 10.5 | 10.5 | 10.7 | 11.0 |
| 75 | 3.6 | 3.9 | 4.8 | 5.0 | 5.0 | 5.1 | 5.3 |
| 50 | .8 | .9 | 1.2 | 1.3 | 1.3 | 1.3 | 1.4 |
| 25 | 1.2 | 1.4 | 2.2 | 2.3 | 2.3 | 2.3 | 2.6 |

HARVEST 8.............................................

................MEASUREMENT NUMBER..................

| % ET | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
|---|---|---|---|---|---|---|---|
| | | | | CM | | | |
| 110 | .0 | 1.2 | 2.5 | 3.0 | 4.5 | 6.5 | 6.8 |
| 100 | .0 | .1 | .2 | .5 | 1.3 | 2.6 | 2.9 |
| 75 | .0 | .1 | .2 | .2 | .3 | .6 | .6 |
| 50 | .0 | .0 | .1 | .1 | .2 | .8 | .9 |
| 25 | .0 | .0 | .1 | .1 | .3 | .6 | .6 |

| % ET | 51 | 52 | 53 | 54 | 55 | 56 | 57 |
|---|---|---|---|---|---|---|---|
| 110 | 6.8 | 7.0 | 7.3 | 7.7 | 7.9 | 8.0 | 8.0 |
| 100 | 3.1 | 3.2 | 3.6 | 3.9 | 4.0 | 4.0 | 4.0 |
| 75 | .7 | .7 | .8 | 1.1 | 1.1 | 1.1 | 1.1 |
| 50 | .9 | .9 | 1.0 | 1.2 | 1.2 | 1.2 | 1.2 |
| 25 | .8 | .9 | 1.1 | 1.2 | 1.2 | 1.3 | 1.3 |

| % ET | 58 | 59 | 60 | 61 |
|---|---|---|---|---|
| 110 | 8.2 | 8.5 | 8.6 | 8.6 |
| 100 | 4.0 | 4.2 | 4.3 | 4.3 |
| 75 | 1.2 | 1.5 | 1.5 | 1.6 |
| 50 | 1.2 | 1.5 | 1.6 | 1.6 |
| 25 | 1.4 | 1.5 | 1.5 | 1.5 |

# APPENDIX D

# SOIL PROFILE WATER AND SALINITY

End of Experiment 1: Treatment 1-5

TREATMENT 1: 110% ET

| DEPTH (CM) | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .02 | 71.63 | -15.00 | -30.35 | -45.35 |
| -6.5 | .08 | 16.35 | -15.00 | -6.29 | -21.29 |
| -11.5 | .09 | 15.28 | -5.50 | -5.86 | -11.36 |
| -16.5 | .10 | 21.28 | -2.80 | -8.33 | -11.13 |
| -21.5 | .10 | 32.21 | -2.80 | -12.96 | -15.76 |
| -26.5 | .11 | 39.29 | -1.80 | -16.01 | -17.81 |
| -31.5 | .13 | 42.47 | -.90 | -17.40 | -18.30 |
| -36.5 | .13 | 43.31 | -.90 | -17.76 | -18.66 |
| -41.5 | .14 | 46.66 | -.90 | -19.23 | -20.13 |
| -46.5 | .15 | 42.17 | -.70 | -17.26 | -17.96 |
| -51.5 | .16 | 39.58 | -.60 | -16.14 | -16.74 |
| -56.5 | .16 | 37.40 | -.60 | -15.19 | -15.79 |
| -61.5 | .18 | 37.33 | -.50 | -15.16 | -15.66 |
| -66.5 | .18 | 41.59 | -.50 | -17.01 | -17.51 |
| -71.5 | .18 | 51.36 | -.50 | -21.30 | -21.80 |
| -76.5 | .18 | 50.96 | -.50 | -21.12 | -21.62 |
| -77.5 | .17 | 53.50 | -.60 | -22.24 | -22.84 |
| -78.5 | .18 | 53.61 | -.50 | -22.29 | -22.79 |
| -79.5 | .17 | 65.65 | -.60 | -27.66 | -28.26 |
| -80.5 | .16 | 70.91 | -.60 | -30.03 | -30.63 |
| -81.5 | .16 | 73.66 | -.60 | -31.27 | -31.87 |
| -82.5 | .15 | 71.45 | -.70 | -30.27 | -30.97 |
| -83.5 | .15 | 80.02 | -.70 | -34.15 | -34.85 |
| -84.5 | .14 | 82.27 | -.80 | -35.18 | -35.98 |
| -85.5 | .13 | 94.45 | -.90 | -40.75 | -41.65 |
| -86.5 | .11 | 106.10 | -1.70 | -46.12 | -47.82 |
| -87.5 | .07 | 103.89 | -15.00 | -45.10 | -60.10 |
| -91.5 | .04 | 82.27 | -15.00 | -35.18 | -50.18 |
| -96.5 | .03 | 101.13 | -15.00 | -43.82 | -58.82 |

TREATMENT 2: 100 % ET

| DEPTH (CM) | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .03 | 82.82 | -15.00 | -35.43 | -50.43 |
| -8.0 | .09 | 14.04 | -15.00 | -5.35 | -20.35 |
| -13.0 | .09 | 20.69 | -5.50 | -8.09 | -13.59 |
| -18.0 | .10 | 33.55 | -2.60 | -13.53 | -16.13 |
| -23.0 | .12 | 41.34 | -1.20 | -16.90 | -18.10 |
| -28.0 | .14 | 44.96 | -.80 | -18.48 | -19.28 |
| -33.0 | .14 | 48.52 | -.70 | -20.05 | -20.75 |
| -38.0 | .15 | 46.21 | -.70 | -19.03 | -19.73 |
| -43.0 | .17 | 43.26 | -.60 | -17.74 | -18.34 |
| -48.0 | .18 | 37.56 | -.50 | -15.26 | -15.76 |
| -53.0 | .19 | 35.94 | -.45 | -14.56 | -15.01 |
| -58.0 | .18 | 36.77 | -.45 | -14.92 | -15.37 |
| -61.0 | .18 | 37.33 | -.50 | -15.16 | -15.66 |
| -68.0 | .18 | 36.61 | -.50 | -14.85 | -15.35 |
| -69.0 | .17 | 40.14 | -.50 | -16.38 | -16.88 |
| -70.0 | .18 | 40.18 | -.50 | -16.40 | -16.90 |
| -71.0 | .16 | 42.94 | -.60 | -17.60 | -18.20 |
| -72.0 | .17 | 47.18 | -.60 | -19.46 | -20.06 |
| -73.0 | .16 | 39.97 | -.60 | -16.31 | -16.91 |
| -74.0 | .16 | 44.12 | -.60 | -18.12 | -18.72 |
| -75.0 | .15 | 42.15 | -.65 | -17.25 | -17.90 |
| -76.0 | .14 | 45.99 | -.80 | -18.93 | -19.73 |
| -77.0 | .13 | 52.03 | -.90 | -21.59 | -22.49 |
| -78.0 | .11 | 60.08 | -1.80 | -25.17 | -26.97 |
| -79.0 | .07 | 47.10 | -15.00 | -19.42 | -34.42 |
| -84.0 | .04 | 62.55 | -15.00 | -26.27 | -41.27 |

TREATMENT 3: 75 % ET

| DEPTH (CM) | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .06 | 87.43 | -15.00 | -37.53 | -52.53 |
| -5.0 | .07 | 32.04 | -15.00 | -12.88 | -27.88 |
| -10.0 | .09 | 16.52 | -5.50 | -6.36 | -11.86 |
| -15.0 | .10 | 25.14 | -3.10 | -9.95 | -13.05 |
| -20.0 | .11 | 28.01 | -2.00 | -11.17 | -13.17 |
| -25.0 | .12 | 43.43 | -1.30 | -17.81 | -19.11 |
| -30.0 | .15 | 44.26 | -.80 | -18.18 | -18.98 |
| -35.0 | .14 | 43.25 | -.80 | -17.73 | -18.53 |
| -40.0 | .16 | 39.65 | -.60 | -16.17 | -16.77 |
| -45.0 | .15 | 43.47 | -.70 | -17.83 | -18.53 |
| -50.0 | .17 | 40.68 | -.50 | -16.61 | -17.11 |
| -55.0 | .16 | 40.35 | -.50 | -16.47 | -16.97 |
| -59.0 | .16 | 42.48 | -.50 | -17.40 | -17.90 |
| -60.0 | .16 | 43.44 | -.60 | -17.82 | -18.42 |
| -62.0 | .15 | 39.78 | -.60 | -16.22 | -16.82 |
| -63.0 | .15 | 43.30 | -.70 | -17.76 | -18.46 |
| -64.0 | .15 | 29.42 | -.70 | -11.77 | -12.47 |
| -65.0 | .14 | 34.01 | -.70 | -13.73 | -14.43 |
| -66.0 | .14 | 21.58 | -.80 | -8.46 | -9.26 |
| -67.0 | .13 | 11.45 | -.90 | -4.31 | -5.21 |
| -68.0 | .13 | 19.35 | -1.00 | -7.53 | -8.53 |
| -69.0 | .12 | 16.27 | -1.00 | -6.26 | -7.26 |
| -70.0 | .11 | 26.25 | -2.00 | -10.42 | -12.42 |
| -71.0 | .09 | 37.35 | -5.50 | -15.17 | -20.67 |
| -76.0 | .06 | 43.76 | -15.00 | -17.96 | -32.96 |

TREATMENT 4: 50 % ET

| DEPTH (CM) | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .03 | 56.69 | -15.00 | -23.66 | -38.66 |
| -9.0 | .09 | 25.05 | -15.00 | -9.91 | -24.91 |
| -14.0 | .10 | 41.05 | -2.80 | -16.78 | -19.58 |
| -19.0 | .11 | 53.12 | -2.00 | -22.08 | -24.08 |
| -24.0 | .12 | 52.14 | -1.30 | -21.64 | -22.94 |
| -29.0 | .13 | 62.44 | -.90 | -26.22 | -27.12 |
| -34.0 | .13 | 62.31 | -.90 | -26.16 | -27.06 |
| -39.0 | .13 | 53.90 | -.90 | -22.42 | -23.32 |
| -44.0 | .12 | 54.10 | -1.30 | -22.51 | -23.81 |
| -49.0 | .12 | 52.46 | -1.30 | -21.78 | -23.08 |
| -54.0 | .12 | 45.57 | -1.30 | -18.75 | -20.05 |
| -56.0 | .11 | 24.07 | -2.00 | -9.50 | -11.50 |
| -58.0 | .11 | 17.38 | -2.00 | -6.72 | -8.72 |
| -60.0 | .13 | 18.19 | -1.00 | -7.05 | -8.05 |
| -61.0 | .13 | 23.95 | -1.00 | -9.45 | -10.45 |
| -63.0 | .13 | 11.07 | -.90 | -4.15 | -5.05 |
| -65.0 | .13 | 11.87 | -.90 | -4.48 | -5.38 |
| -66.0 | .12 | 9.78 | -1.70 | -3.64 | -5.34 |
| -67.0 | .11 | 22.93 | -2.00 | -9.02 | -11.02 |
| -69.0 | .10 | 13.78 | -2.80 | -5.25 | -8.05 |
| -70.0 | .08 | 22.05 | -15.00 | -8.65 | -23.65 |
| -71.5 | .08 | 45.30 | -15.00 | -18.63 | -33.63 |
| -76.5 | .05 | 49.04 | -15.00 | -20.27 | -35.27 |

TREATMENT 5: 25 % ET

| DEPTH (CM) | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .02 | 116.93 | -15.00 | -51.15 | -57.09 |
| -6.0 | .08 | 33.81 | -15.00 | -13.64 | -27.17 |
| -11.0 | .09 | 39.21 | -5.50 | -15.98 | -19.62 |
| -16.0 | .08 | 55.31 | -15.00 | -23.05 | -34.91 |
| -21.0 | .09 | 46.96 | -15.00 | -19.36 | -31.91 |
| -26.0 | .09 | 48.42 | -15.00 | -20.00 | -32.43 |
| -31.0 | .10 | 48.36 | -2.80 | -19.97 | -20.21 |
| -36.0 | .10 | 45.23 | -2.70 | -18.60 | -18.98 |
| -41.0 | .10 | 45.72 | -2.50 | -18.82 | -18.96 |
| -46.0 | .10 | 59.44 | -2.80 | -24.88 | -24.20 |
| -51.0 | .09 | 51.40 | -15.00 | -21.31 | -33.50 |
| -56.0 | .07 | 44.18 | -15.00 | -18.14 | -30.91 |
| -58.0 | .08 | 30.54 | -15.00 | -12.24 | -26.00 |
| -59.0 | .09 | 30.53 | -15.00 | -12.24 | -25.99 |
| -60.0 | .09 | 29.59 | -15.00 | -11.84 | -25.65 |
| -61.0 | .10 | 25.01 | -15.00 | -9.90 | -24.00 |
| -64.0 | .10 | 18.96 | -2.70 | -7.37 | -9.52 |
| -66.0 | .10 | 16.85 | -15.00 | -6.50 | -21.06 |
| -68.0 | .10 | 23.34 | -15.00 | -9.19 | -23.40 |
| -70.0 | .08 | 29.19 | -15.00 | -11.67 | -25.51 |
| -72.0 | .08 | 34.43 | -15.00 | -13.91 | -27.40 |
| -73.0 | .07 | 43.87 | -15.00 | -18.01 | -30.79 |
| -75.0 | .05 | 48.68 | -15.00 | -20.12 | -32.53 |
| -80.0 | .04 | 51.93 | -15.00 | -21.55 | -33.70 |

End of Experiment 2: Treatments 1-5

TREATMENT 1: 110 % ET

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .18 | 110.61 | -.50 | -48.21 | -48.71 |
| -1.0 | .18 | 62.08 | -.50 | -26.06 | -26.56 |
| -2.0 | .18 | 42.83 | -.50 | -17.55 | -18.05 |
| -3.0 | .18 | 41.19 | -.50 | -16.84 | -17.34 |
| -4.0 | .19 | 33.63 | -.40 | -13.57 | -13.97 |
| -5.0 | .19 | 34.31 | -.40 | -13.86 | -14.26 |
| -6.0 | .20 | 30.96 | -.40 | -12.42 | -12.82 |
| -7.0 | .20 | 28.20 | -.40 | -11.25 | -11.65 |
| -8.0 | .20 | 30.49 | -.40 | -12.22 | -12.62 |
| -8.5 | .21 | 27.29 | -.40 | -10.86 | -11.26 |
| -9.0 | .21 | 27.15 | -.40 | -10.80 | -11.20 |
| -9.5 | .22 | 25.62 | -.40 | -10.15 | -10.55 |
| -10.0 | .21 | 27.18 | -.40 | -10.81 | -11.21 |
| -10.5 | .22 | 25.53 | -.30 | -10.11 | -10.41 |
| -11.0 | .23 | 27.30 | -.30 | -10.87 | -11.17 |
| -11.5 | .22 | 23.60 | -.30 | -9.30 | -9.60 |
| -12.0 | .23 | 26.26 | -.30 | -10.42 | -10.72 |
| -12.5 | .23 | 26.11 | -.30 | -10.36 | -10.66 |
| -13.0 | .23 | 27.73 | -.30 | -11.05 | -11.35 |
| -13.5 | .23 | 27.49 | -.30 | -10.95 | -11.25 |
| -14.0 | .23 | 25.74 | -.30 | -10.20 | -10.50 |
| -15.0 | .23 | 28.60 | -.30 | -11.41 | -11.71 |
| -15.5 | .24 | 28.22 | -.30 | -11.26 | -11.56 |
| -16.0 | .23 | 28.77 | -.30 | -11.49 | -11.79 |
| -16.5 | .24 | 28.35 | -.30 | -11.31 | -11.61 |
| -17.0 | .24 | 28.49 | -.30 | -11.37 | -11.67 |
| -18.0 | .25 | 28.17 | -.30 | -11.23 | -11.53 |
| -18.5 | .25 | 28.16 | -.25 | -11.23 | -11.48 |
| -19.0 | .25 | 28.62 | -.30 | -11.42 | -11.72 |
| -19.5 | .25 | 29.60 | -.25 | -11.84 | -12.09 |
| -20.0 | .25 | 29.56 | -.25 | -11.83 | -12.08 |
| -20.5 | .25 | 30.24 | -.30 | -12.11 | -12.41 |
| -21.0 | .25 | 30.12 | -.30 | -12.06 | -12.36 |
| -21.5 | .25 | 26.99 | -.25 | -10.73 | -10.98 |
| -22.0 | .25 | 30.38 | -.30 | -12.18 | -12.48 |
| -23.0 | .25 | 29.80 | -.25 | -11.93 | -12.18 |

TREATMENT 1: 110 % ET CONTINUED

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| -24.0 | .25 | 32.13 | -.30 | -12.92 | -13.22 |
| -25.0 | .25 | 32.57 | -.30 | -13.11 | -13.41 |
| -26.0 | .26 | 31.14 | -.25 | -12.50 | -12.75 |
| -27.0 | .25 | 31.48 | -.25 | -12.65 | -12.90 |
| -28.0 | .25 | 34.05 | -.30 | -13.75 | -14.05 |
| -29.0 | .25 | 32.78 | -.30 | -13.20 | -13.50 |
| -30.0 | .25 | 33.66 | -.30 | -13.58 | -13.88 |
| -31.0 | .25 | 33.47 | -.30 | -13.50 | -13.80 |
| -32.0 | .25 | 35.27 | -.30 | -14.27 | -14.57 |
| -33.0 | .25 | 36.53 | -.30 | -14.81 | -15.11 |
| -34.0 | .25 | 35.33 | -.25 | -14.30 | -14.55 |
| -35.0 | .25 | 34.39 | -.30 | -13.89 | -14.19 |
| -36.0 | .24 | 36.15 | -.30 | -14.65 | -14.95 |
| -37.0 | .24 | 37.76 | -.30 | -15.35 | -15.65 |
| -38.0 | .24 | 37.29 | -.30 | -15.15 | -15.45 |
| -39.0 | .25 | 36.24 | -.30 | -14.69 | -14.99 |
| -40.0 | .24 | 37.82 | -.30 | -15.37 | -15.67 |
| -45.0 | .24 | 40.29 | -.30 | -16.44 | -16.74 |
| -50.0 | .24 | 40.83 | -.30 | -16.68 | -16.98 |
| -55.0 | .24 | 40.52 | -.30 | -16.55 | -16.85 |
| -60.0 | .23 | 44.62 | -.30 | -18.34 | -18.64 |
| -65.0 | .23 | 44.86 | -.30 | -18.44 | -18.74 |
| -70.0 | .23 | 41.98 | -.30 | -17.18 | -17.48 |
| -75.0 | .22 | 42.40 | -.30 | -17.36 | -17.66 |
| -80.0 | .22 | 38.32 | -.40 | -15.59 | -15.99 |
| -85.0 | .21 | 38.97 | -.40 | -15.87 | -16.27 |
| -90.0 | .21 | 40.88 | -.40 | -16.70 | -17.10 |
| -95.0 | .21 | 52.13 | -.40 | -21.64 | -22.04 |
| -100.0 | .20 | 63.73 | -.40 | -26.80 | -27.20 |

TREATMENT 2: 100 % ET

| DEPTH CM | Wv % | ECsw dS/m | MATRIC (POTENTIAL BARS) | OSMOTIC (POTENTIAL BARS) | TOTAL (POTENTIAL BARS) |
|---|---|---|---|---|---|
| .0 | .22 | 115.13 | -.30 | -50.31 | -50.61 |
| -1.0 | .21 | 82.69 | -.40 | -35.36 | -35.76 |
| -2.0 | .21 | 56.35 | -.40 | -23.51 | -23.91 |
| -3.0 | .22 | 38.34 | -.30 | -15.60 | -15.90 |
| -4.0 | .23 | 35.07 | -.30 | -14.19 | -14.49 |
| -5.0 | .23 | 32.55 | -.30 | -13.10 | -13.40 |
| -5.5 | .23 | 31.21 | -.30 | -12.53 | -12.83 |
| -6.0 | .24 | 33.36 | -.30 | -13.45 | -13.75 |
| -6.5 | .23 | 30.69 | -.30 | -12.31 | -12.61 |
| -7.0 | .24 | 28.81 | -.30 | -11.50 | -11.80 |
| -7.5 | .24 | 29.41 | -.30 | -11.76 | -12.06 |
| -8.0 | .24 | 31.24 | -.30 | -12.54 | -12.84 |
| -8.5 | .24 | 29.79 | -.30 | -11.92 | -12.22 |
| -9.0 | .25 | 32.95 | -.30 | -13.27 | -13.57 |
| -10.0 | .24 | 32.27 | -.30 | -12.98 | -13.28 |
| -11.0 | .24 | 29.94 | -.30 | -11.99 | -12.29 |
| -12.0 | .24 | 32.75 | -.30 | -13.19 | -13.49 |
| -13.0 | .25 | 31.75 | -.30 | -12.76 | -13.06 |
| -14.0 | .24 | 33.81 | -.30 | -13.64 | -13.94 |
| -15.0 | .26 | 30.00 | -.30 | -12.01 | -12.31 |
| -16.0 | .26 | 33.55 | -.25 | -13.53 | -13.78 |
| -16.5 | .27 | 32.05 | -.25 | -12.89 | -13.14 |
| -17.0 | .26 | 32.44 | -.25 | -13.05 | -13.30 |
| -17.5 | .26 | 36.82 | -.25 | -14.94 | -15.19 |
| -18.0 | .27 | 30.45 | -.25 | -12.21 | -12.46 |
| -18.5 | .26 | 26.99 | -.25 | -10.73 | -10.98 |
| -19.0 | .26 | 39.14 | -.25 | -15.94 | -16.19 |
| -20.0 | .26 | 36.58 | -.25 | -14.84 | -15.09 |
| -21.0 | .25 | 35.54 | -.25 | -14.39 | -14.64 |
| -22.0 | .25 | 38.01 | -.25 | -15.46 | -15.71 |
| -23.0 | .25 | 34.89 | -.30 | -14.11 | -14.41 |
| -24.0 | .25 | 37.58 | -.25 | -15.27 | -15.52 |
| -25.0 | .25 | 38.21 | -.25 | -15.54 | -15.79 |
| -26.0 | .25 | 39.93 | -.25 | -16.29 | -16.54 |
| -27.0 | .26 | 38.86 | -.25 | -15.82 | -16.07 |
| -28.0 | .26 | 37.27 | -.25 | -15.13 | -15.38 |
| -29.0 | .26 | 42.26 | -.25 | -17.30 | -17.55 |
| -30.0 | .26 | 41.44 | -.25 | -16.94 | -17.19 |
| -31.0 | .25 | 39.86 | -.25 | -16.26 | -16.51 |
| -32.0 | .25 | 39.97 | -.25 | -16.31 | -16.56 |
| -33.0 | .25 | 42.66 | -.25 | -17.48 | -17.73 |

TREATMENT 2: 100 % ET CONTINUED

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| -34.0 | .24 | 42.20 | -.30 | -17.28 | -17.58 |
| -35.0 | .24 | 41.17 | -.30 | -16.83 | -17.13 |
| -36.0 | .25 | 39.97 | -.30 | -16.31 | -16.61 |
| -37.0 | .26 | 42.07 | -.25 | -17.22 | -17.47 |
| -38.0 | .27 | 38.35 | -.25 | -15.60 | -15.85 |
| -39.0 | .24 | 46.03 | -.25 | -18.95 | -19.20 |
| -40.0 | .27 | 43.44 | -.30 | -17.82 | -18.12 |
| -45.0 | .26 | 45.93 | -.25 | -18.91 | -19.16 |
| -50.0 | .25 | 50.14 | -.25 | -20.76 | -21.01 |
| -55.0 | .25 | 48.83 | -.25 | -20.18 | -20.43 |
| -60.0 | .23 | 51.90 | -.25 | -21.54 | -21.79 |
| -65.0 | .22 | 51.14 | -.30 | -21.20 | -21.50 |
| -70.0 | .22 | 47.55 | -.30 | -19.62 | -19.92 |
| -75.0 | .23 | 47.66 | -.30 | -19.67 | -19.97 |
| -80.0 | .24 | 48.26 | -.30 | -19.93 | -20.23 |
| -85.0 | .24 | 52.29 | -.30 | -21.71 | -22.01 |
| -90.0 | .23 | 46.18 | -.30 | -19.02 | -19.32 |
| -95.0 | .23 | 53.37 | -.30 | -22.19 | -22.49 |
| -100.0 | .23 | 62.51 | -.30 | -26.25 | -26.55 |
| -105.0 | .22 | 74.98 | -.30 | -31.87 | -32.17 |

TREATMENT 3: 75 % ET

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .12 | 347.15 | -1.10 | -162.99 | -164.09 |
| -1.0 | .13 | 188.38 | -.90 | -85.00 | -85.90 |
| -2.0 | .14 | 141.73 | -.70 | -62.78 | -63.48 |
| -3.0 | .15 | 77.50 | -.65 | -33.01 | -33.66 |
| -4.0 | .15 | 61.77 | -.65 | -25.92 | -26.57 |
| -5.0 | .17 | 37.21 | -.50 | -15.11 | -15.61 |
| -6.0 | .18 | 38.93 | -.50 | -15.85 | -16.35 |
| -7.0 | .18 | 40.97 | -.50 | -16.74 | -17.24 |
| -8.0 | .22 | 36.69 | -.40 | -14.88 | -15.28 |
| -9.0 | .20 | 39.57 | -.40 | -16.13 | -16.53 |
| -10.0 | .20 | 39.90 | -.40 | -16.27 | -16.67 |
| -11.0 | .21 | 42.63 | -.40 | -17.46 | -17.86 |
| -12.0 | .21 | 39.70 | -.40 | -16.19 | -16.59 |
| -13.0 | .21 | 40.60 | -.40 | -16.58 | -16.98 |
| -14.0 | .21 | 42.46 | -.40 | -17.39 | -17.79 |
| -15.0 | .22 | 43.04 | -.30 | -17.64 | -17.94 |
| -16.0 | .21 | 44.59 | -.40 | -18.32 | -18.72 |
| -17.0 | .22 | 45.37 | -.40 | -18.66 | -19.06 |
| -18.0 | .22 | 43.57 | -.40 | -17.87 | -18.27 |
| -19.0 | .22 | 47.39 | -.40 | -19.55 | -19.95 |
| -20.0 | .22 | 51.55 | -.40 | -21.38 | -21.78 |
| -21.0 | .22 | 51.79 | -.40 | -21.49 | -21.89 |
| -22.0 | .22 | 50.96 | -.30 | -21.12 | -21.42 |
| -23.0 | .22 | 52.65 | -.40 | -21.87 | -22.27 |
| -24.0 | .22 | 51.21 | -.40 | -21.23 | -21.63 |
| -25.0 | .22 | 54.92 | -.40 | -22.87 | -23.27 |
| -26.0 | .22 | 55.30 | -.40 | -23.04 | -23.44 |
| -27.0 | .22 | 59.21 | -.40 | -24.78 | -25.18 |
| -28.0 | .21 | 59.61 | -.40 | -24.96 | -25.36 |
| -29.0 | .21 | 61.22 | -.40 | -25.68 | -26.08 |
| -30.0 | .21 | 60.68 | -.40 | -25.44 | -25.84 |
| -31.0 | .22 | 58.64 | -.40 | -24.53 | -24.93 |
| -32.0 | .22 | 63.54 | -.40 | -26.72 | -27.12 |
| -33.0 | .21 | 65.22 | -.40 | -27.47 | -27.87 |
| -34.0 | .22 | 62.11 | -.40 | -26.07 | -26.47 |
| -35.0 | .22 | 66.59 | -.40 | -28.08 | -28.48 |
| -37.0 | .21 | 65.39 | -.40 | -27.54 | -27.94 |
| -38.0 | .21 | 65.59 | -.40 | -27.63 | -28.03 |
| -39.0 | .22 | 62.21 | -.40 | -26.12 | -26.52 |
| -40.0 | .21 | 63.11 | -.40 | -26.52 | -26.92 |

TREATMENT 3: 75 % ET CONTINUED

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| -45.0 | .21 | 66.61 | -.40 | -28.09 | -28.49 |
| -50.0 | .19 | 66.87 | -.45 | -28.21 | -28.66 |
| -55.0 | .19 | 61.04 | -.45 | -25.60 | -26.05 |
| -60.0 | .19 | 57.46 | -.45 | -24.00 | -24.45 |
| -65.0 | .18 | 52.33 | -.50 | -21.72 | -22.22 |
| -70.0 | .18 | 43.70 | -.50 | -17.93 | -18.43 |
| -75.0 | .17 | 44.91 | -.55 | -18.46 | -19.01 |
| -80.0 | .16 | 32.83 | -.60 | -13.22 | -13.82 |
| -85.0 | .13 | 32.13 | -.90 | -12.92 | -13.82 |
| -90.0 | .13 | 47.29 | -.90 | -19.50 | -20.40 |
| -95.0 | .10 | 50.18 | -2.90 | -20.78 | -23.68 |
| -100.0 | .08 | 51.39 | -15.00 | -21.31 | -36.31 |

TREATMENT 4: 50 % ET

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | | (POTENTIAL BARS) | |
| .0 | .05 | 769.75 | -15.00 | -380.60 | -395.60 |
| -1.0 | .05 | 480.57 | -15.00 | -230.45 | -245.45 |
| -2.0 | .07 | 232.26 | -15.00 | -106.23 | -121.23 |
| -3.0 | .09 | 153.64 | -15.00 | -68.41 | -83.41 |
| -4.0 | .11 | 79.28 | -2.40 | -33.81 | -36.21 |
| -5.0 | .13 | 68.06 | -1.00 | -28.74 | -29.74 |
| -6.0 | .14 | 43.37 | -.75 | -17.79 | -18.54 |
| -7.0 | .15 | 41.03 | -.70 | -16.77 | -17.47 |
| -8.0 | .16 | 43.42 | -.60 | -17.81 | -18.41 |
| -9.0 | .16 | 44.47 | -.60 | -18.27 | -18.87 |
| -10.0 | .16 | 46.13 | -.60 | -19.00 | -19.60 |
| -11.0 | .17 | 46.38 | -.60 | -19.11 | -19.71 |
| -12.0 | .18 | 46.56 | -.50 | -19.19 | -19.69 |
| -13.0 | .18 | 45.20 | -.50 | -18.59 | -19.09 |
| -14.0 | .19 | 45.64 | -.40 | -18.78 | -19.18 |
| -15.0 | .19 | 45.19 | -.40 | -18.58 | -18.98 |
| -16.0 | .19 | 48.60 | -.40 | -20.08 | -20.48 |
| -17.0 | .18 | 51.83 | -.50 | -21.50 | -22.00 |
| -18.0 | .19 | 57.11 | -.40 | -23.84 | -24.24 |
| -19.0 | .19 | 55.16 | -.40 | -22.98 | -23.38 |
| -20.0 | .18 | 56.56 | -.40 | -23.60 | -24.00 |
| -21.0 | .18 | 55.92 | -.40 | -23.32 | -23.72 |
| -22.0 | .18 | 65.24 | -.40 | -27.48 | -27.88 |
| -23.0 | .18 | 63.13 | -.40 | -26.53 | -26.93 |
| -24.0 | .18 | 62.63 | -.40 | -26.31 | -26.71 |
| -25.0 | .18 | 66.35 | -.50 | -27.97 | -28.47 |
| -26.0 | .22 | 57.39 | -.35 | -23.97 | -24.32 |
| -27.0 | .18 | 67.40 | -.50 | -28.45 | -28.95 |
| -28.0 | .18 | 64.81 | -.50 | -27.29 | -27.79 |
| -29.0 | .18 | 61.38 | -.50 | -25.75 | -26.25 |
| -30.0 | .18 | 68.77 | -.50 | -29.06 | -29.56 |
| -31.0 | .18 | 69.23 | -.50 | -29.27 | -29.77 |
| -32.0 | .17 | 70.97 | -.50 | -30.05 | -30.55 |
| -33.0 | .16 | 71.70 | -.60 | -30.39 | -30.99 |
| -34.0 | .16 | 68.14 | -.60 | -28.78 | -29.38 |
| -35.0 | .17 | 72.44 | -.60 | -30.72 | -31.32 |
| -36.0 | .17 | 72.95 | -.50 | -30.95 | -31.45 |
| -37.0 | .17 | 68.03 | -.55 | -28.73 | -29.28 |
| -38.0 | .17 | 70.96 | -.55 | -30.05 | -30.60 |
| -39.0 | .17 | 65.48 | -.55 | -27.58 | -28.13 |
| -40.0 | .17 | 72.23 | -.55 | -30.62 | -31.17 |

TREATMENT 4: 50 % ET CONTINUED

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| -45.0 | .16 | 65.96 | -.60 | -27.80 | -28.40 |
| -50.0 | .15 | 66.83 | -.70 | -28.19 | -28.89 |
| -55.0 | .14 | 56.99 | -.80 | -23.79 | -24.59 |
| -60.0 | .13 | 51.67 | -.85 | -21.43 | -22.28 |
| -65.0 | .13 | 27.23 | -.90 | -10.84 | -11.74 |
| -70.0 | .12 | 25.44 | -1.00 | -10.08 | -11.08 |
| -75.0 | .09 | 46.61 | -4.50 | -19.21 | -23.71 |
| -80.0 | .07 | 62.27 | -15.00 | -26.15 | -41.15 |
| -85.0 | .06 | 56.37 | -15.00 | -23.52 | -38.52 |
| -90.0 | .05 | 61.87 | -15.00 | -25.97 | -40.97 |

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TREATMENT 5: 25 % ET

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| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| .0 | .03 | 724.79 | -15.00 | -356.97 | -371.97 |
| -1.0 | .03 | 510.22 | -15.00 | -245.62 | -260.62 |
| -2.0 | .04 | 392.68 | -15.00 | -185.85 | -200.85 |
| -3.0 | .04 | 292.73 | -15.00 | -135.92 | -150.92 |
| -4.0 | .06 | 166.65 | -15.00 | -74.60 | -89.60 |
| -5.0 | .07 | 147.88 | -15.00 | -65.68 | -80.68 |
| -6.0 | .08 | 110.43 | -15.00 | -48.13 | -63.13 |
| -7.0 | .08 | 102.87 | -15.00 | -44.63 | -59.63 |
| -8.0 | .08 | 88.54 | -15.00 | -38.04 | -53.04 |
| -9.0 | .10 | 77.37 | -2.80 | -32.95 | -35.75 |
| -10.0 | .11 | 66.66 | -2.10 | -28.11 | -30.21 |
| -11.0 | .12 | 62.97 | -1.10 | -26.46 | -27.56 |
| -12.0 | .12 | 71.37 | -1.40 | -30.24 | -31.64 |
| -13.0 | .11 | 78.03 | -2.00 | -33.25 | -35.25 |
| -14.0 | .12 | 69.17 | -1.00 | -29.24 | -30.24 |
| -15.0 | .12 | 77.72 | -1.60 | -33.11 | -34.71 |
| -16.0 | .11 | 74.47 | -1.70 | -31.63 | -33.33 |
| -17.0 | .11 | 86.07 | -2.00 | -36.91 | -38.91 |
| -18.0 | .11 | 75.47 | -1.90 | -32.09 | -33.99 |
| -19.0 | .11 | 76.24 | -2.00 | -32.44 | -34.44 |
| -20.0 | .11 | 83.31 | -2.30 | -35.65 | -37.95 |
| -21.0 | .11 | 90.83 | -2.30 | -39.08 | -41.38 |
| -22.0 | .11 | 79.21 | -2.40 | -33.78 | -36.18 |
| -23.0 | .10 | 92.22 | -2.80 | -39.72 | -42.52 |
| -24.0 | .10 | 79.71 | -2.70 | -34.01 | -36.71 |
| -25.0 | .10 | 75.25 | -2.50 | -31.99 | -34.49 |
| -26.0 | .10 | 88.59 | -2.70 | -38.06 | -40.76 |
| -27.0 | .10 | 83.95 | -2.60 | -35.94 | -38.54 |
| -28.0 | .10 | 83.88 | -2.60 | -35.91 | -38.51 |
| -29.0 | .10 | 86.22 | -2.60 | -36.98 | -39.58 |
| -30.0 | .10 | 88.34 | -2.80 | -37.95 | -40.75 |
| -31.0 | .10 | 81.44 | -2.60 | -34.80 | -37.40 |
| -32.0 | .10 | 83.93 | -2.90 | -35.93 | -38.83 |
| -33.0 | .10 | 70.29 | -2.60 | -29.75 | -32.35 |
| -34.0 | .10 | 78.89 | -2.80 | -33.64 | -36.44 |
| -35.0 | .10 | 77.21 | -2.40 | -32.88 | -35.28 |
| -36.0 | .11 | 66.51 | -2.40 | -28.05 | -30.45 |
| -37.0 | .10 | 64.44 | -2.40 | -27.12 | -29.52 |
| -38.0 | .10 | 67.19 | -2.40 | -28.35 | -30.75 |
| -39.0 | .10 | 64.75 | -2.60 | -27.26 | -29.86 |
| -40.0 | .10 | 59.97 | -2.60 | -25.12 | -27.72 |

TREATMENT 5: 25 % ET CONTINUED

| DEPTH CM | Wv % | ECsw dS/m | MATRIC | OSMOTIC | TOTAL |
|---|---|---|---|---|---|
| | | | (POTENTIAL BARS) | | |
| -45.0 | .14 | 42.16 | -.80 | -17.26 | -18.06 |
| -50.0 | .11 | 56.13 | -1.70 | -23.41 | -25.11 |
| -55.0 | .12 | 53.48 | -1.40 | -22.24 | -23.64 |
| -60.0 | .14 | 21.11 | -.80 | -8.26 | -9.06 |
| -65.0 | .15 | 21.25 | -.70 | -8.32 | -9.02 |
| -70.0 | .15 | 16.20 | -.70 | -6.23 | -6.93 |
| -75.0 | .14 | 20.37 | -.80 | -7.96 | -8.76 |
| -80.0 | .09 | 41.94 | -15.00 | -17.16 | -32.16 |
| -85.0 | .09 | 64.01 | -15.00 | -26.93 | -41.93 |
| -90.0 | .06 | 49.79 | -15.00 | -20.60 | -35.60 |

Experiment 1: Soil Salinity Measurement at Harvests 1, 2 and 3.

The depths sampled were wet when the harvests were done. Values for Harvest 4 appear only for columns that were destructively sampled.

............SOIL SALINITY ECsw(dS/m).............

| % ET | DEPTH CM | 1 (3.28.85) | 2 (4.24.85) | 3 (5.16.85) | 4 (6.09.85) | AVG. |
|---|---|---|---|---|---|---|
| 110 | 15.00 | 20.00 | 18.91 | 23.29 | | |
| | 30.00 | 20.47 | 28.79 | 31.23 | | |
| | 45.00 | 42.97 | 33.88 | 32.70 | | |
| | 60.00 | | 60.67 | 36.27 | | |
| | 75.00 | | | 71.51 | | |
| 110 | 15.00 | 18.53 | 22.73 | 17.22 | 21.28 | 19.94 |
| | 30.00 | 18.35 | 32.66 | 19.93 | 42.47 | 28.35 |
| | 45.00 | 41.87 | 37.21 | 33.17 | 42.17 | 38.61 |
| | 60.00 | | 44.17 | 38.52 | 37.30 | |
| | 75.00 | | | 79.50 | 50.96 | |
| 100 | 15.00 | 24.84 | 23.53 | 18.75 | | |
| | 30.00 | 37.08 | 32.37 | 27.83 | | |
| | 45.00 | 73.89 | 42.13 | 37.34 | | |
| | 60.00 | | 89.06 | 60.65 | | |
| | 75.00 | | | | | |
| 100 | 15.00 | 18.61 | 29.98 | 18.58 | 27.00 | 23.54 |
| | 30.00 | 31.50 | 36.66 | 27.59 | 46.50 | 35.56 |
| | 45.00 | 60.76 | 40.18 | 41.02 | 40.60 | 45.64 |
| | 60.00 | | 63.08 | 64.19 | 37.00 | |
| | 75.00 | | | | 42.15 | |
| 75 | 15.00 | 24.84 | 29.85 | 23.54 | 25.14 | 25.84 |
| | 30.00 | 31.41 | 42.17 | 35.83 | 44.26 | 38.42 |
| | 45.00 | 76.36 | 59.87 | 48.08 | 43.50 | 56.95 |
| | 60.00 | | 66.52 | 68.16 | 43.40 | |
| | 75.00 | | | | 43.00 | |

.....SOIL SALINITY ECsw (dS/m) CONTINUED............

| % ET | DEPTH CM | HARVEST NUMBER 1 | 2 | 3 | 4 | AVG. |
|---|---|---|---|---|---|---|
| | DATE | 3.28.85 | 4.24.85 | 5.16.85 | 6.09.85 | |
| 75 | 15.00 | 19.16 | 34.21 | 21.28 | | |
| | 30.00 | 34.01 | 41.38 | 41.60 | | |
| | 45.00 | 53.75 | 57.82 | 50.29 | | |
| | 60.00 | | 47.30 | 53.51 | | |
| | 75.00 | | | 57.46 | | |
| 50 | 15.00 | 29.91 | 36.65 | 28.80 | | |
| | 30.00 | 46.56 | 56.15 | 54.39 | | |
| | 45.00 | 66.41 | 65.45 | 62.91 | | |
| | 60.00 | | | 58.66 | | |
| | 75.00 | | | 50.88 | | |
| 50 | 15.00 | 35.23 | 22.61 | 30.96 | 41.05 | 32.46 |
| | 30.00 | 53.25 | 60.84 | 53.32 | 62.44 | 57.46 |
| | 45.00 | 94.16 | 95.01 | 84.31 | 54.10 | 81.90 |
| | 60.00 | | | 58.99 | 18.19 | |
| | 75.00 | | | | 45.00 | |
| 25 | 15.00 | 21.09 | 35.55 | 37.26 | 55.31 | 37.30 |
| | 30.00 | 42.00 | 60.74 | 52.39 | 48.40 | 50.88 |
| | 45.00 | 63.65 | 79.73 | 70.14 | 59.40 | 68.23 |
| | 60.00 | | | | 29.59 | |
| | 75.00 | | | | 48.68 | |
| 25 | 15.00 | 24.75 | 30.46 | 49.13 | | |
| | 30.00 | 38.98 | 49.78 | 55.00 | | |
| | 45.00 | 72.33 | 76.02 | 70.57 | | |
| | 60.00 | | | | | |
| | 75.00 | | | | | |

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