

EFFECTS OF SALINE WATER IRRIGATION ON  
THE EARLY GROWTH AND CHEMICAL  
COMPOSITION OF SUGARCANE  
(Saccharum officinarum)

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE  
UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN SOIL SCIENCE

JUNE 1969

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## ACKNOWLEDGEMENTS

The author would like to gratefully acknowledge the scholarship awarded to him by the East West Center, (an institute for cultural and technical interchange between East and West) for the M. S. degree at the University of Hawaii. The help provided by HSPA during the course of the experiment is also acknowledged. Thanks are also due to my colleagues in the Departments and friends outside who assisted me at various stages of this work . Special thanks to Mr. Charles L. Shroth who helped with the computer programming for various statistical analysis. My appreciation for Dee whose constant persuasion and encouragement expedited writing of this thesis.

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## INTRODUCTION

For irrigation agriculture to be permanent, it is essential that a favorable salt-balance be maintained over a period of time. The salts brought in through irrigation waters should be carried below and away from the root zone of plants if salt accumulation is to be prevented. Water in excess of the actual use by the crop has to be added to remove these salts beyond the rhizosphere. For example, studies with sprinkler irrigation by the Hawaiian sugar industry suggest that for every 2.5 cm. of irrigation water required over a specific time interval at least 3 cm. be applied to remove the salts from the root zone (43). The quantity of water to be added over and above the direct crop and evaporative uses will increase in direct proportion to the salt content of irrigation water. When the salt content of irrigation water becomes relatively high, the application of such water can cause deterioration in the physical properties of a soil. However, relatively high levels of salinity and high proportions of sodium in irrigation waters may be tolerated by a soil which:

- 1) Allows sufficient downward movement of the large water application necessary to prevent salt accumulation in the root zone.
- 2) Resists detrimental peptization.

Preliminary studies by Ahmed (1) and a recently published work by El-Swaify et al. (26) on the salt tolerance of

Tropical Red Earths, and Tropical Red Desert have shown that these soils can tolerate relatively large amounts of salts in irrigation waters without developing detrimental saline or sodic conditions. On the basis of these results, the authors have suggested the possibility of increasing the permissible limits of salinity and sodium in irrigation water for these and similar soils. This offers great prospects for areas where such soils are found but where inadequate and/or unassured water supply prevent effective agricultural development. Saline water sources can include partially converted sea waters, mixture of pure and saline waters, drainage waters, or underground waters of relatively low quality.

The proper choice of crops which can tolerate relatively high levels of salt in irrigation waters without unprofitable decline in their yields will be essential for an irrigation regime involving saline waters. Alternatively, salt resistant varieties can be developed in case of crops which are commercially important and show varietal differences in salt tolerance.

Sugarcane is an important crop of the tropical and subtropical areas of the world. It is the most important commercial crop in the Hawaiian Islands, occupying an area of 237,000 acres and producing 1/5 of the total sugar produced in the U.S., and 2% of the entire world production. About 53% of the cane area is irrigated producing 2/3 of the

cane crop (35).

The soils in the Molokai family are one of the best in the Hawaiian Islands for sugarcane cultivation. These soils are exceptionally well adapted to irrigation, being porous, and yet fine-textured, which gives them a high water holding capacity (65). However, because of low precipitation, moisture is a principal limiting factor. At the same time, sugarcane is a thirsty plant. It transpires 2000 lbs. of water to produce just one pound of sugar. In fact, the total amount of water needed to grow a single crop of cane in Hawaii is to the tune of 480 billion gallons (35). In order to obtain commercially profitable yields supplemental irrigation is, therefore, needed on most of these soils. However, with such a high water requirement of this crop, it is not surprising that on some of these areas an optimum supply of irrigation water cannot be guaranteed.

In Hawaii 1000 ppm of soluble salts is presently considered the upper limit of good quality water (43). If pumps supply water which contains more than this amount of soluble salts, it is mixed with the one containing less salts. However, on the soils above, with proper allowance for water needed to leach-out additional salts, the upper limit of salts in irrigation water could be raised to an extent determined by the tolerance of the grown crop. Studies on salt tolerance of sugarcane are yet to be conducted under Hawaiian conditions. However, some studies have

been reported from various other places. Investigations by Liu (48), Shen and Tung (64), and Bernstein et al (15) have indicated varietal differences in salt tolerance, suggesting the possibilities that varieties can be selected/or developed which will grow at a relatively high salt level in the soil and still produce commercially profitable yields. In view of the commercial importance of sugarcane in the Hawaiian Islands, the present work was, therefore, undertaken to study the potential use of saline water for sugarcane irrigation. The objectives of this study may be stated as follows:

- 1) To apply the salt-balance principle to greenhouse irrigation of sugarcane on a structurally stable soil.
- 2) To study the effect of saline waters containing different salt types and concentrations on the early growth and chemical composition of sugarcane crop.
- 3) To compare the salt tolerance of two important varieties of sugarcane, namely N. Co. 310, and H 50-7209 under Hawaiian agro-climatic conditions.

## REVIEW OF LITERATURE

The effects of salt on plant growth occur through modifications in the soil and soil solution. It is expected, therefore, that the relative tolerance of plants to salt concentration in irrigation water would be the same as to salinity in the soil solution (Novikoff 1946, Rolet 1928 cited in 34)

Different methods have been used to assess the salinity in the soil. Accordingly, units of measurement and modes of expressing the salt content in the soil vary greatly in various reports on salt tolerance of crops. Some authors have reported salt content on a dry soil basis only, and have related crop tolerance to the amount of salt expressed as percent of dry soil. This however, does not give any idea about the concentration of soil solution, and therefore, has very little value in connection with studies on salt tolerance of crops. Other authors have considered both the moisture factor, as well as the salt content of the soil (37, 29, 70). Dutch and French workers measure both the salt and moisture, and express the salt concentration of the soil solution in grams/liter. Thus, investigators in Netherlands have reported their studies by relating percent decrement in yield of a crop to a salinity value referred to as the "salt index" and expressed as g of NaCl/l in soil water at a given depth in the profile (cited in 37). Measuring the electrical conductivity (ECe) of the solution extracted from a saturated

soil paste is another way which has been used to evaluate soil salinity (70,73). Besides taking into account the moisture status of the soil this method has the advantage that E<sub>ce</sub> is closely correlated with osmotic pressure (O.P.) of soil solution. Moreover, soil salinity can be evaluated without analyzing for specific ions the proportion of which can vary from soil to soil. An additional advantage is that this method is relatively simple and convenient. The list of relative salt tolerance of crops compiled by the U. S. Salinity Laboratory Staff (70) is based on salinity values expressed as E<sub>ce</sub> of saturation extract in mmhos/cm at which 50% decrement in yield of crop took place.

By and large one or more of the following three criteria have been employed by investigators in judging salt tolerance of plants.

- 1) Ability to survive under increasingly saline conditions. This criterion does not give sufficient information about the growth relationships and therefore, has limited use in commercial agriculture.
- 2) The absolute yield of a plant at a given level of salinity. This is a useful index for comparing the strains and varieties of a given crop and is widely used by agronomists.
- 3) Relative performance on a saline soil compared to similar non-saline soil. By this criterion different species whose absolute yields cannot be directly

compared may be readily evaluated (viz. sugarcane v/s cotton) It has been used in compiling a list of relative tolerance of crops, (34,70). As discussed later, criteria 2 and 3 have been employed in the present study.

### EFFECTS OF SALINITY ON GROWTH OF PLANTS

The presence of excessive concentration of soluble salts in the root zone of a crop is known to affect its growth in one or more than one of the following ways:

- 1) Osmotic effects.
- 2) Specific ion effects which may be due to:
  - a) Nutritional imbalance, b) Toxic effects.

Osmotic Effects: The osmotic pressure (O.P.) of the soil solution increases as salt content in the rhizosphere increases (46,53). This tends to restrict the uptake of water by plant roots and diminish growth. All plants are subject to this influence, although sensitivity to this effect varies widely for different species (9, 34, 53, 72). These osmotic effects, according to Vant Hoff equation, are due to the total concentration of salts, regardless of the ions present. These effects are of a physico-chemical nature when they refer to the nutrient or soil solution. However, they are barely distinguishable from physiological effects where they influence the state of water within the plant (46). Soil moisture tension increases with decreasing moisture in the soil. The resultant pressure is additive to

the O.P. of the soil solution in limiting the availability of water to plants. The sum of soil moisture tension and the O.P. of the soil solution is called "total soil moisture stress". Studies have indicated that plant growth is a function of total soil moisture stress, regardless of the relative contribution of O.P. or moisture tension. Thus, Wadleigh and Ayers (71) have demonstrated that the growth of beans and guayule was a function of the total soil moisture stress. O.P. was predominant factor in the saline, low tension treatment, while moisture tension predominated in the non-saline, high tension treatment. In addition to the direct effects of decreased water absorption on plant growth, moisture deficits in the plant may cause changes in the rate of metabolic processes and thereby affect the growth of plants indirectly (71).

Specific Ion Effects: Specific ion effects result, because plants absorb the constituent ions in the saline media to varying degrees. This may result in causing direct toxicity i.e., inhibition in growth or function which appears to be connected solely to the excessive accumulation of a certain ion (14, 33). There may also be a decreased or increased absorption of some essential nutrients causing a variety of nutritional effects (37.54). However, it is sometimes difficult to separate the toxic and other specific effects such as nutritional effects. These effects are related largely to the relative ionic concentrations and their

influence is essentially of a physiological nature (46). Although O.P. relationships account for the major effect of salinity on plant growth, the specific ion effects may occasionally be extremely important, even limiting (11). Specific toxicity of Cl and Na has been demonstrated for a number of fruits and ornamental crops by various workers (cited in 37). Similarly, deleterious effects of Cl, Na, Mg, and other ions including Borate, Bicarbonate, Lithium and others have been reported in various investigations (Garner et al., 1930; Gauch and Wadleigh, 1945; Hayward et al., 1946; Wallace et al., 1948, cited in 37).

Salinity may also affect plant growth indirectly due to the adverse effect of some ions specially Na on the structure and other physical properties of the soil (Grillot and Bryssine 1942, Tames 1935 cited in 34).

The overall effects of salinity as well as the component effects, viz. osmotic, toxic, nutritional on a crop may vary depending on the crop and its variety including its root characteristics and stage of its development (3, 4, 15, 49, 51, 56, 61, 67). Moreover, the effect may be intensified or mitigated due to environmental factors such as humidity, etc., and management practices such as irrigation regime, type of beds, etc. (16, 55).

#### EFFECTS OF SALINITY ON SUGARCANE

Not much work has been reported in literature on the salt tolerance of sugarcane. The crop is neither mentioned

in the reviews on "salinity and plant growth relationships" (37, 39, 52), nor included in the lists of crops compiled by various workers giving their relative tolerance to salts (8, 50, 70). Recently, however, interest has been growing in the field. Investigations carried out at Riverside, California, Iran, Taiwan, Puerto Rico and other places have provided interesting information which is being discussed below.

Osmotic Effects: The osmotic effects of salinity on sugarcane have been reported by various authors. Humbert (43) discussing this subject stated that salinity affects the growth of sugarcane in three ways:

- 1) With increasing osmotic pressure the rate and quantity of water that can be absorbed by the plant roots is reduced, and the growth is diminished at a virtually linear rate.
- 2) Na and other ions may create unfavorable physical conditions in the soil, thereby indirectly affecting the plant growth.
- 3) Some ions, otherwise, harmless have toxic effects on plants because of their high concentration.

Other investigators have similarly reported an adverse affect of salinity on the growth of sugarcane as a result of increasing O.P. in the root zone of plants. However, varying critical levels of salinity were reported at which significant reduction in the growth or/and yield was noted. Thus,

Bernstein et al., (15) report that the greenhouse yields of N. Co. varieties decreased by 10% at 3 m.mhos/cm. and by 25% at about 5 m.mhos/cm. Shoji and Sund (66) working in Iran reported that an electrical conductivity of 4 m.mhos/cm. was the threshold above which the growth of cane was drastically reduced. Robinson and Worker (59) obtained 25% reduction in yield of cane growth in areas irrigated with Colorado River water when salinity was 4.2 m.mhos/cm. The depression in growth as reflected by a decrease in the rate of stalk elongation was observed when the salinity was increased from 2.5 to 3.3 m.mhos/cm. On the basis of these results they concluded that sugarcane plants should be considered salt sensitive. The results obtained by Leverington (47) in Queensland also indicated similar osmotic effects. Reduction in the growth of roots and shoots of cane grown in sand cultures was observed at an osmotic concentration of 2.5 atmospheres and above. Studies by Foligata (30) in Tucuman, and a Hawaiian Sugar Planters Association (HSPA) report 1957 (cited in 19) indicated much greater sensitivity than reported by the above authors. Thus, in Tucuman the growth and sucrose content of sugarcane decreased greatly at values > 1.95 m.mhos/cm. (30). According to the HSPA report, the growth of cane spindle and sheath ceased when NaCl at 2 atmospheres O.P. (about 2.5 m.mhos/cm.) was added to a culture solution. The same report also mentions complete inhibition in sprouting at 7 atmospheres O.P. (about 8.6

m.mhos/cm.). This again is more drastic effect than reported by Bernstein et al. (15) which gives approximately a 50% decrease in sprouting at the same level of salinity. Studies in Puerto Rico have also shown higher tolerance of cane crop to salinity. Liu (48) found no significant effects on stem growth and root development when several cane varieties were grown at conductivity levels of  $< 5.4$  m.mhos/cm. In treatments with conductivity  $> 5.4$  m.mhos/cm., plants were quite similar to those in the control for the first three weeks but later decreased in stem growth as the conductivity was increased. He also observed no significant difference between percentage germination of nine varieties of cane (out of ten tested) in a soil salinized to a conductivity level of 5 m.mhos/cm. and in another soil with a conductivity of 0.2 m.mhos/cm. (48).

Specific Ion Effects: Nutritional effects due to saline media in the root zone of cane crops have been reported in various studies. Shen and Tung (63) demonstrated that K contents in young cane decreased with increasing NaCl concentration. However, Foligata and Aso (28) found no significant correlation between percentage exchangeable Na in soil and concentration of N, P and K in leaves of 9 months old cane when grown on a site high in both soluble and exchangeable Na. Evans (27) noted that in sugarcane leaves Cl is accumulated in much larger amounts than Na of NaCl. The Cl ion inhibits in particular the uptake of N and

P in the cane leaves. The  $\text{SO}_4$  ion had no such apparent effect. Innes in Jamaica (cited in 27) obtained high values for Na in the leaf blades of cane which were associated with high Na content in the soil. Hartt (cited in 19) found that percentage of P in the cane plant decreased when the amounts of K, Ca, Mg, and S were high. Studies on the salt tolerance of N. Co. varieties in the greenhouse and in salinized field plots at Riverside, California also indicate that mineral content (Na, Ca, Mg, K, Cl) of the cane was increased by salinity. In general, however, salinity did not greatly affect the mineral content of the leaves (15).

Toxic effects of Cl, Na, and other ions in case of sugarcane have been reported by many workers. Humbert (43) has demonstrated that some salts that are harmless at low concentrations may actually be toxic to cane in high concentrations. B and Li are toxic in relatively small amounts, and Cl, Na, and  $\text{HCO}_3$  ions are toxic when present in high concentrations. Salinity studies at Western Puerto Rico indicate that sugarcane grew poorly in lands that contained 0.75-2 ppm in available B, 0.53-1.19% NaCl, 20-72.9% extractable Na, and Na/Ca ratios from 2.5 to 3.1, and a PH of 8.3-9.2 (17). Poey (58) has suggested from his experience that NaCl content of the soil should not exceed 0.15%. Damage is perceptible at 0.12%. Deleterious effects of Cl,  $\text{SO}_4$ , Na,  $\text{HCO}_3$ , and K ions on the growth of cane have also been reported from Tucumán (30,31). Thus, Foligata

noted adverse effect on cane growth when soil Cl + SO<sub>4</sub> reached 0.21% and soil CO<sub>3</sub> reached 0.26% (31).

#### VARIETAL DIFFERENCES IN SUGARCANE TOLERANCE

Varietal differences in salt tolerance of sugarcane were reported by Robinson and Worker (59) and other investigators. Row (60) working on the effect of salinity on the growth and composition of sugarcane varieties noted that soft; thick, juicy varieties do not come up at all in saline land. Thin and less juicy varieties, however, come up fairly well. Liu (48) studied the reaction of ten sugarcane varieties to various levels of NaCl under greenhouse conditions. He observed that the adverse effects of salinity on the germination, and growth varied significantly in those varieties. Shen and Tung (64) reported from Taiwan that variety N. Co. 310 was slightly more salt tolerant than F-146. Bernstein et al. (15) at Riverside, California demonstrated that N. Co. 293 was more salt tolerant than N. Co. 310 at moderate and high salinities. At a low salinity, however, both varieties had same tolerance. The study also indicated that ratoon crops were only half as salt tolerant as the seed crops, and that differences in salt tolerance between the varieties diminished during the second year. Studies on sprouting of these varieties revealed that sprouting of N. Co. 310 was retarded at a moderate salinity level of 6.4 m.mhos/cm., while that of N. Co. 293 was already affected at 3.6 m.mhos. H 50-7209

was found comparable to N. Co. 310 in this respect (15).

#### METHODS AND INDICES USED FOR EVALUATING CROP TOLERANCE

Methods used in salinity studies vary depending on the scope of study, kind of crop, and stage of growth emphasized. Thus, studies on salinity and plant growth relationships have been carried out in the greenhouse (32), in the field (17, 18) in culture solutions (33, 44), or in sand and pot culture (2, 53, 56, 72). Various studies were conducted using inorganic and organic substrates (38). Perhaps the most widely used procedure has been to add iso-osmotic concentrations of single salts to nutrient solutions. It is possible in this manner to study the osmotic and specific effects separately and uncomplicated by the complex and dynamic processes present in the soil. However, it has been found that at a given iso-osmotic concentration the same salt may be more toxic to plant growth if applied alone rather than as a mixture of salts viz. sodium chloride versus sodium chloride + calcium chloride (Osterhout 1912, cited in 67). Some investigators have used inert materials like carbowax Polyethylene glycol to distinguish between osmotic and specific effects (46). Such method has the advantage that these compounds while lowering the partial molar free energy of water, at the same time are inert with respect to the metabolism of the plant tested. Tolerance of a plant to salinity may vary at different stages of growth. Ayers and Hayward ((3) found that corn germinated at a higher level of

NaCl than sugarbeet or alfalfa, but less tolerant of salinity during the later stages of growth. Investigators have therefore, emphasized different stages of growth in salt tolerance studies to establish permissible limits of salinity at the time of growth when the crop under study is most sensitive to salinity (4, 56). Importance of the stage of growth at the time of salinization has also been demonstrated for barley and wheat,(2).

Studies on salt tolerance of sugarcane have been carried out in the greenhouse as well as in the field. Pot culture experiments using soil (48) or sand (47) are however, more popular. Shen and Tung (64) have also used culture solution. Salinity was achieved by adding various concentrations of NaCl to the nutrient solution.

Methods of soil salinization and the time of initiation of salinity also differ in various studies. Liu (48) studied the reaction of several cane varieties to various levels of soluble NaCl in the greenhouse using a clay loam soil. The salinity was allowed to build up during the entire growth period of the crop, and the salinity levels were determined by reading conductivity of the saturation extract of the soil. Bernstein et al. (15) initiated differential gradual salination when seedlings were about five weeks old by adding a mixture of NaCl and CaCl<sub>2</sub> to demineralized water. The cultures were brought to final levels of salinity (ECe) in three weeks after which demineralized water was used for

irrigation. In the field plots differential salination was initiated when the plants were well established at about seven months of age.

Growth is a rate process, a sequence of changes in an organism with time. The main effect of salinity on plants is to reduce the rate of change. Observations on physical parameters such as height and girth of cane, length and number of internodes etc. have been emphasized to study the effect of salinity on the growth of plants. Besides, visual symptoms indicating strains and stresses, or injury to plants such as burning of tips, rolling of leaves etc. have also been observed. Humbert (43) noted burning of the tips of the young leaves and of the edges of the older leaves as a result of excess salt absorbed by cane plants. He also observed that plants grown in soil with high salt content had leaves which appeared withered or rolled which gave an indication of acute water stress. He further noted that when plants are young, growth may appear normal but the growth is retarded as soon as first internode of millable cane appears. The old leaves begin to dry, followed by the younger ones under severe salt condition the spindle and the plant finally dies. Robinson and Worker (59) measured length of stalk to define the influence of soil salinity on sugarcane plants. Liu (48) found the daily average stem growth as the most effective indicator of the effect of salinity on sugarcane. The other two parameters studied

were percentage germination, and dry weight of roots. Bernstein et al. (15) compared the various growth measurements of two N. Co. varieties and noted that yield, number of stalks, cane weight, cane cross sectional area, cane length, number of internodes per stalk, and internode length were affected by salinity. The study revealed that the greater decrease in internode length in case of N. Co. 310 was primarily responsible for its greater yield decline. In ratoon crop again, the influence of salinity on cane weight and length was predominant. However, in this case the length as well as number of internodes were both strongly affected indicating lower salt tolerance than the seed crop. In a companion study (15) it was found that the effect of salinity on cane weight was four times more than the effect on pol percent.

## MATERIALS AND METHODS

The sugarcane plants were grown in pot cultures in the greenhouse. The crop was planted in the first week of November, and harvested in the first week of June. The saline water treatments were initiated in the second week of February. Observations on height, emergence of leaves, etc. were recorded during the growth period of the crop. The variables studied were as follows:

A) Soil-Molokai Silty Clay.

B) Varieties.

V<sub>1</sub>) N. Co. 310.

V<sub>2</sub>) H 50-7209.

C) Salt Type.

\*  
S<sub>1</sub>) NaCl.

S<sub>2</sub>) Na<sub>2</sub>SO<sub>4</sub>

S<sub>3</sub>) Sea Water.

D) Salt Concentration (EC).

L<sub>1</sub>) 2 m.mhos/cm.

L<sub>2</sub>) 4 m.mhos/cm.

L<sub>3</sub>) 6 m.mhos/cm.

L<sub>4</sub>) 8 m.mhos/cm.

The Soil: The top 30 cm. of Molokai Silty Clay collected from Kunia substation, HSPA was used for this study. Molokai soil is an important soil series in Hawaiian agriculture. Besides being used for pineapple cultivation, it is extensively used for sugarcane production in Hawaii. It is

a Low Humic Latosol which under the official U. S. Classification system has been classified as a Tropeptic Haplustox. The mineralogical composition is predominantly that of kaolin and hydrated oxides of iron and aluminum. Profile studies show a weak A horizon overlying a weathered B horizon containing as much as 55-88% kaolin clays (65). The soils occur at elevation from sea level to about 500 meters, and receive only 40-65 cm. of annual precipitation. This rather low precipitation necessitates supplemental irrigation for profitable agricultural development specially for cane production.

These soils possess highly stable structures and excellent water transmission properties. Being highly aggregated, they have physical properties similar to those of coarse sand (62). The virtual absence of swelling 2:1 layer silicates and the presence of large amounts of free iron oxides indicate that soil physical properties are less likely to be altered in the presence of saline irrigation waters. Laboratory Studies by El-Swaify et al. (26) have shown that these soils maintained their excellent physical characteristics when subjected to saline water treatments.

The chemical analysis of the experimental soil was done by HSPA staff. The results are reported in table 1.

TABLE 1. SOME CHEMICAL PROPERTIES OF THE  
MOLOKAI SILTY CLAY SOIL

pH	7.6
Ca (1 N neutral ammonium acetate extract)	3700 ppm
Mg (1 N neutral ammonium acetate extract)	400 ppm
K (1 N neutral ammonium acetate extract)	355 ppm
P (Truog)	55 ppm
Si (0.5 N ammonium acetate extract pH 4.85)	185 ppm
S (1 N neutral ammonium acetate extract)	135 ppm
N (Available)	39 ppm
N (Mineralisable)	10 ppm

Sugarcane Varieties: The two varieties studied were H 50-7209 and N. Co. 310. H 50-7209 is a locally bred important commercial variety, occupying 40 percent of the cane producing area in Hawaii (40). It is a drought resistant high yielding variety, harvested as a 24 month crop (40). N. Co. 310 is not grown commercially in the Hawaiian Islands. At Ewa plantation however, it has given rather good yields, harvested as a 26 month crop. It is also an important variety in other sugar producing countries such as Iran, Iraq, and Pakistan.

Experimental Design: Three variables namely, variety, salt type, and salt concentration with 2, 3, 4, sub-classes respectively, were involved. Therefore, a 2 x 3 x 4 factorial was laid out in Randomized Block design with three

replications. Within each replicate the pots were rotated from time to time to minimize the variation in temperature and other conditions to which the pots were exposed in the greenhouse.

Preparation of Pots: Five gallon (19 liters) paint cans, 30 cm. in diameter and 45 cm. tall, were used for this study. The soil was air dried and screened through a 1.25 cm. mesh sieve. The cans were lined with two layers of polyethylene bags and filled to a constant volume by approximately 18 kg. of soil on oven dry basis. A hole 2 cm. in size, was provided in the bottom of each can to allow for drainage and leaching of salts. The five gallon cans were placed on a raised platform, and one gallon cans lined with a single layer of polyethylene bag were placed directly below and under each to collect the leachate.

Planting: The sugarcane stalks of N. CO. 310, and H 50-7209 were obtained from the Kailua experiment station, HSPA. One eye-seed pieces or 'setts' were cut from the stalks. Each seed piece consisted of one node with about 5 cm. of internode on either side of the eye.

Before planting, the setts were dipped in 10% Phenyl Mercuric Acetate (PMA) solution for five minutes to guard against the possible fungal attack and other infections. Two setts were planted in each can at about 7.5 cm. depth and 7.5 cm. apart. The planting was followed by irrigation

and application of basal dose of fertilizer mixture.

Fertilization: The pots were fertilized with a basal application of 224 kg. of N, 179 kg. of P, and 286 kg. of K/hectare. These nutrients were added as  $\text{Ca}(\text{NO}_3)_2$ , Ca orthophosphate, and  $\text{KNO}_3$  respectively. Additional 448 kg. of N and 381 kg. of K per hectare were supplied in split doses during the growth period of the crop, both in solution form. Each pot was also supplied with micronutrients distributed over the growth period of the crop at fortnightly intervals as follows:

Zn	25 ppm	applied as	$\text{ZnSO}_4$
Cu	10 ppm	applied as	$\text{CuSO}_4 \cdot 2\text{H}_2\text{O}$
B	2 ppm	applied as	Boric Acid
Mo	1 ppm	applied as	$(\text{NH}_4)_6 \text{Mo O}_{24} \cdot 4\text{H}_2\text{O}$

Fe was applied firstly as spray of Fe-chelate (0.25%) and later as Ferric Ammonium citrate 1% solution at fortnightly intervals.

Preparation of Saline Waters: The saline water treatments were initiated in the second week of February, when the plants were about 13 weeks old. Until then tap water was used for irrigating all the treatments. Stock solutions of 5N NaCl, and 2N  $\text{Na}_2\text{SO}_4$  were prepared. Sea water <sup>1</sup> was

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<sup>1</sup> Average composition of sea water as given by H. U. Sverdrup et al. (1960) is reported in Appendix table 31.

collected from a suitable spot at Sandy Beach, Honolulu to ensure uniformity in composition and concentration of water collected at different dates. These stock solutions were diluted before each irrigation in large plastic buckets to obtain the desired levels of concentration. For NaCl, and Na<sub>2</sub>SO<sub>4</sub> treatments the dilution factors were obtained from the curve giving relationship between the concentration of single salt solutions in meq/l and electrical conductivity (EC) in m.mhos/cm. (70). In case of sea water, the electrical conductivity for various dilutions of sea water were measured and used to construct a standard curve. The dilution factors calculated from this curve were used to prepare desired solutions.

Frequency of Irrigation: The best barometer for a plant regarding to its needs is the plant itself. Irrigation frequency was therefore, controlled by observing the curl in the second leaf of the plant as classified by Clements et al. (23). These observations were supplemented by tensiometer readings installed in the control cans at 1/3 bar suction. In the beginning tensiometer readings coincided with the curl in the second leaf. However, as the experiment progressed and while the tensiometers read 1/3 bar, the plants did not show any apparent symptom of water stress. Therefore, towards the later part of the experiment the frequency of irrigation was guided mainly by observing the curl in the

second leaf. Sugarcane as noted earlier is a thirsty plant and needs frequent irrigation. In this study on an average, plants were irrigated as frequently as every third day. The method of water application in the cans was essentially similar to flooding in the field.

Quantity of Irrigation: Rather than differential gradual salinization of soil to certain given levels (15), or irrigating the plants with waters containing different levels of salt concentration without maintaining one salinity level throughout the growth period of the crop (48), an attempt was made to create and maintain specified levels of salinity throughout the proposed growth period of sugarcane by direct application of saline waters. In the beginning, the amount of irrigation water was regulated by using the Leaching Requirement (LR) formula as suggested by the United States Salinity Laboratory (USSL) staff (70). This formula is based on the "Salt Balance" principle and can be derived as follows:

Conservation of mass principles require that:

$$S_{iw} = S_{dw} + S_{soil}$$

Where

$S_{iw}$  = Amount of salt in irrigation water applied.

$S_{dw}$  = Amount of salt in drainage water.

$S_{pl}$  = Amount of salt extracted by plants.

$S_{soil}$  = Amount of salt remaining in soil.

Since the amount of salt in saline irrigation water is relatively large,  $S_{pl} + S_{soil}$  can be treated as negligible.

Thus:

$$S_{iw} = S_{dw}$$

Expressing the amount of salt in terms of volume (V) and concentration (C) we get:

$$V_{iw} \cdot C_{iw} = V_{dw} \cdot C_{dw}$$

or,

$$\frac{V_{dw}}{V_{iw}} = \frac{C_{iw}}{C_{dw}}$$

Expressing volume and concentration in terms of depth (D) and electrical conductivity (EC), respectively, we obtain the following relationship:

$$* \frac{D_{dw}}{D_{iw}} = \frac{EC_{iw}}{EC_{dw}} = L.R.$$

Where L.R. is the leaching requirement, it gives the fraction of the irrigation water that must be passed through and beyond the root-zone to control soil salinity at any specified level, which is determined by the salt tolerance of the crop grown.

It may be noted here that the above equations are based on the assumptions of uniform application of water to the soil, no precipitation of soluble salt in the soil, negligible salt removal in the harvested crop, and soil permeability and drainage adequate to allow the required leaching (70). The procedure prescribed by this formula was employed after the first application of saline water

treatments to regulate the volume of subsequent irrigations. Thus, on the day when plants in the control cans showed curling of the second leaf, conductivity readings of the leachate collected from the previous saline water application were measured using a solo-bridge. The volume of irrigation for the respective saline water treatment was then determined using the L.R. formula. However, it was soon realized that the results actually obtained by the use of this formula were not satisfactory. In fact, calculations based on this formula gave results just opposite to its theory. Taking for example 8 m.mhos/cm. treatment, the L.R. formula would be  $8/EC_{dw}$ . If the conductivity readings of the leachates from three cans are 10, 16, 20 m.mhos/cm., the L.R. comes to 80, 50, and 40% respectively. The L.R. therefore, decreases with increasing concentration in the drainage water which is not what the theory of the formula implies. It seems that the L.R. formula might be applicable only if one level of concentration in drainage water is desired from irrigation waters of different salt concentrations. As an example, for field crops where a value of  $EC_{dw} = 8$  m.mhos/cm. can be tolerated, the  $L.R. = EC_{iw}/8$ . For irrigation waters with EC of 1, 2, 3, m.mhos/cm., the L.R. will be 13, 25, and 38% respectively.

The above formula was therefore, abandoned after first few irrigations in favor of calculations based on consumptive use of crop, soil moisture content, and the concentration of

salt in effluent waters. Thus, it was found that when tensiometer in the control can read 1/3 bar, and four liters of irrigation water were applied two liters were received as leachate. It was therefore, assumed that about 2 liters of water were needed to saturate the soil from field capacity. On this basis 3 liters of water were applied to control cans and 4, 5, and 6 liters to 2, 4, and 6 and 8 m.mhos treatments respectively. The conductivities of the leachates were taken from time to time, and the volume of water was increased or decreased if the conductivity readings of the leachates differed very much from the conductivity of the irrigation water applied.

#### OBSERVATIONS RECORDED DURING GROWTH

Observations were recorded on sprouting of seed-pieces, apparent health of the plants, and any attack of insect, pest, or disease. When the seedlings were about six weeks old attack of sugarcane aphids was observed. The incidence of attack was, however, not severe, and it was quickly and effectively controlled by spraying 0.025 percent malathion. DDT was occasionally sprayed as a preventive measure against further possible attack of insects, etc.

Germination: The 'setts' were planted directly into pots because the number of seed pieces available for N. Co. 310 was only enough to plant two 'setts' per treatment. By planting the 'setts' directly into pots two plants were intended to grow in every pot. However, because of the

failure of a few seed pieces to sprout some of the pots had only one plant. There was also great variation in the time needed by individual seed pieces to sprout. The difference between the earliest and the last sprouting was about three weeks. To overcome this variation in the age of sprouts among different treatments, transplanting was done from one pot to another so that each pot had at least one plant of similar age and growth to others. This plant was labeled as plant No. 1, and the other plant, if any, was labeled as plant No. 2. In case plant No. 1 had died in any pot plant No. 2 could serve as a substitute. Observations were recorded separately on plants 1 and 2, except in cases where only one plant remained in the pot. However, in the following pages observations on plant 1 alone will be considered. This is because of the great variation in age and height between plants 1 and 2 at the time when saline treatments were initiated. Since at the time of germination saline treatments had not been initiated, the data on sprouting of seed pieces is not being reported.

Height: Height of the plants was recorded at least once a month until harvest. Height recorded a day before saline water treatments were initiated was considered as the initial height. This initial height was subtracted from the subsequent measurements to obtain the increment in height of plants during any given period. For measuring the height a thin wooden piece was placed at the rim of the can, and the

height was measured from the rim to the top-most visible dewlap (Clements et al. 1952). For one month period height was also measured up to the tip of the plant as an index to the maximum length for the plant. Data on monthly increment in height of plants are included in Appendix. Analysis of variance of the total increment in height of plants from the time saline treatments were initiated until harvest of the experiment is given in Appendix table 32. Rate of stalk elongation discussed in the following chapters as the increment increase in centimeters was calculated from this data.

Rate of Leaf Emergence: Number of leaves on the plants at the time of initiation of saline treatments were considered as the initial readings. Subsequent counts gave the number of new leaves which emerged during any given period. The data on total number of leaves which appeared on the main stalk of the plant during the period between initiation of saline treatment and harvest of the experiment (Feb.15-June 2) is included in the Appendix. However, because of certain discrepancies in recording the data it is not being included in Results and Discussion.

#### HARVESTING AND PREPARATION OF PLANT SAMPLES FOR ANALYSIS

All the treatments were harvested early morning on the same day. Plants were cut by a shearer close to the soil. The green weight of plants was recorded soon after harvest.

The individual weight includes all the stalks in a stool.

Counting from the top, sheaths and blades No. 3, 4, 5 and 6 as classified by Clements et al. (24) were separated. Fresh weight of the above sheaths was recorded. The sheaths were then chopped up and kept for drying in a ventilated oven set at 70°C. for two days. The oven dry weight was recorded and the sheath moisture was calculated as percent of the green weight of sheaths. The middle six-inches portions of the leaf blades associated with 3, 4, 5, and 6 were cut. The mid-ribs were stripped and discarded and the six-inches blade portions were then kept for oven drying at 70°C. The oven dry weight of the blades was noted.

According to Clements crop log method (23) the fifth mature internode downward from the oldest living leaf is used for P determination. In this experiment, however, the cane stalks were young and the fifth mature internode was not available in all the plants. Therefore, the first internode below the last living leaf was sampled. These were sliced and oven dried at 70°C. The oven dry weight was noted.

After separating sheaths 3, 4, 5, and 6 and corresponding leaf blades, and internode as noted above the remaining plant material was chopped up, mixed and dried at 70°C. for two days. Subsequently the oven dry weight of the plant material was recorded.

The chopped, oven dried samples of sheaths, blades, and

internodes were ground in a laboratory wiley-mill using a stainless steel screen. The ground material was stored in snap-cap 15 dram plastic vials. The plant material was ground in a large grinder, and the material was then transferred in large bottles. Small sub-samples were taken after thorough mixing and stored in 15 dram plastic vials.

#### CHEMICAL ANALYSIS OF PLANT MATERIALS

Samples of sheaths and plant as noted earlier were analyzed for Na, K, Ca, Mg, Cl, and P. The plant samples were also analyzed for N. Leaf blades were analyzed for N, and the internodes for P determination only.

The vials containing tissue samples were kept in oven at 70°C. for 24 hours before weighing out samples for analysis. This procedure obviated the necessity of determining moisture content in the samples prior to analysis. It is especially useful if the tissue samples available for analysis are small in quantity, as are samples for blades and internodes in the present study.

Preparation of Extracts: One g. (oven dried) sample was weighed out into a 30 ml porcelain crucible and ashed overnight in a muffle furnace at 525°C. The ashing was not complete as there was much residue material left. To this ash, therefore, added 1 ml of 1 N HNO<sub>3</sub>, dried it on a hot plate, and kept in the muffle furnace at 525°C. for about five hours. After cooling, 10 ml of N HCl were added to

this ash, and dried completely on a hot plate. The ash was then dissolved in 10 ml of 4 N HCl, and the volume was reduced by keeping on a hot plate. It was then filtered through what-man 40 filter-paper, the residue washed 3-5 times with hot distilled water into 100 ml volumetric flask, and the volume was made up. This extract was used for determinations of Na, K, Ca, Mg, and P. Samples for sulphur determinations were ashed at 525°C. for two hours after fusion with 20% solution of  $MgNO_3 \cdot 6H_2O$  in 95% Ethanol.

Sodium: Na was read on a Perkin-Elmer Atomic Absorption unit.<sup>1</sup> The original extract was diluted so that the Na concentration in the sample extracts would fall within the working range (0.3-3 ppm) of the instrument (57).

Potassium: K was determined on a Beckman Du flame photometer with hydrogen-oxygen Burner. The extract was flamed and the emission measured at 767 mu. The amount of K was calculated by reference to a standard curve.

Calcium and Magnesium: Ca and Mg were read on a Perkin-Elmer Atomic Absorption unit.<sup>2</sup> Suitable aliquots from the original extract were diluted to bring the sample into optimum working range of the instrument, namely 1-10 ppm and

---

<sup>1,2</sup> The Atomic Absorption unit for the determinations of Na, Ca, and Mg was operated by Mr. Robert H. Suehisa, and Miss Gladys L. N. Yee, Junior Plant Physiologist, and Assistant, respectively in the Plant Physiology Department, University of Hawaii.

0.2-2 ppm in aqueous solutions for Ca and Mg respectively. Five ml of stock lanthanum solution (5% in 25% HCl) were added to each aliquot before making up diluted volumes.

Phosphorus: A five ml aliquot was pipetted into a 50 ml volumetric flask, and diluted to about 35 cc. The volume was then made up after adding 5 ml of vanadomolybdate solution-Barton's Reagent (20). The contents of the flask were shaken, allowed to develop color for 30 minutes, and read on a colorimeter at 470 mu. By reference to a standard curve the concentration of P in the sample was calculated.

Sulphur: Sulphate S was determined by turbidimetric measurements. All S compounds are converted to  $SO_4$  which is then precipitated as the barium salt in a manner suitable for turbidimetric measurement. Five ml of aliquot was transferred into a colorimeter tube. One ml of 0.5% gum Acacia, and 4 ml of distilled water were added and mixed thoroughly. An excess of  $BaCl_2$  was added and mixed with the contents of the tube. The contents were allowed to stand with occasional mixing for exactly 5 minutes. Absorbance was read in an Evelyn colorimeter using the blue filter # 420. The concentration of sulphate S was found by reference to a standard curve. Results are reported as S content in sheath/plant in parts per million.

Chloride: Determination was made by electrometric titration of Cl (20). The Cl is dissolved from the plant tissue by

dilute  $\text{HNO}_3$ . The Cl is then titrated with standard  $\text{AgNO}_3$  solution, using the potential difference between a glass electrode and Ag-electrode as an indication of the end point. One half gm oven dried tissue was digested over-night in 100 ml  $\text{HNO}_3$  solution. The digest was then titrated with standard  $\text{AgNO}_3$  using the Beckman Expandomatic electrodes. Mv scale was used for the determination.

Nitrogen: Total N in the samples was determined by the method recommended by H. Y. Young and adapted by the Agronomy and Soils Department. Organic ammoniacal N is converted to ammonia by digesting with concentrated  $\text{H}_2\text{SO}_4$  in the presence of selenium and sodium sulphates. Organic matter is simultaneously completely oxidized. Nitrate, if any is reduced to ammonia with iron and dilute acid before digesting with concentrated acid. The formed ammonia is distilled and titrated with standard acid.

#### TREATMENT OF DATA

The detailed data on dry matter yield, green weight of plant, height of plants, sheath moisture, sheath weight, number of new leaves, and concentration of Na, K, Ca, Mg, Cl, S, P, and N in plant tissue and in sheath/blade/mature internode are reported in the Appendix. The data for the above variables except number of leaves and P in mature internode was statistically analyzed using computer technique. F values and levels of significance are given in Appendix.

Duncan's multiple range (DMR) test was made for variables where-ever considered necessary. Analysis of regression for dry matter yield, green weight of plants, and total increment in height of plants was done with salt concentration as the X variable. Values for coefficient of correlation and F value of regression are also given in Appendix. Summarized tables of the above data have been given in the chapter on Results and Discussion.

## RESULTS AND DISCUSSION

Experimental data are given in tables and are averaged for all three replicates. Arbitrary levels of salinity were chosen for salt concentrations in irrigation water of 2, 4, 6 and 8 m.mhos/cm., corresponding to average readings of 3.5, 5.5, 8, and 10 m.mhos/cm. respectively as recorded in the leachates one day before harvest of the experiment. These four levels were named low salinity, medium, medium-high, and high salinity respectively. The average conductivity of leachates from control cans was 1 m.mhos/cm.

### DRY MATTER YIELD

Detailed data on dry matter yields are given in the Appendix.\* Tables (2,3) give a summary of that data. The overall effect of salt treatments was to reduce the combined yield of varieties by 20% compared to the no-salt treatments. This reduction in yield is significant at 5% level (Appendix table 32).

Salt Concentration: The combined dry matter yield of sugarcane plants declined consistently with increasing salt concentration. The yields diminished by about 10% at low salinity and by about 35% at high salinity. Analysis of variance of the data gave a highly significant effect (1% level) of salt concentration on dry matter production. Duncan's multiple range (DMR) test was made for significant differences between salinity levels. It shows that yields

TABLE 2. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE DRY MATTER YIELD OF SUGARCANE PLANTS

Controls	Varieties Combined	N. Co. 310	H 50-7209
	132.5 g	142.0 g	123.0 g
Salt Treatment	Percent of Control		
Salt Effect	80.08	71.20	90.33
<u>Salt Concentration</u>			
Low	90.48	89.43	91.69
Medium	84.86	76.83	94.13
Medium-High	79.41	63.29	98.02
High	65.57	55.29	77.50
<u>Salt Type</u>			
NaCl	79.68	75.11	84.25
Na <sub>2</sub> SO <sub>4</sub>	83.61	70.47	98.78
Sea Water	76.95	68.01	87.26

TABLE 3. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON DRY MATTER YIELD OF SUGARCANE PLANT

Salt Concentration	Control = 132.5 g		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	99.87	80.37	91.19
Medium	96.60	82.26	75.72
Medium-High	68.55	97.86	71.82
High	53.71	73.96	69.05

at low and medium salinity are significantly greater (1% level) than the yield at high salinity. Difference between medium-high and high salinity treatments is significant at 5% level only. Differences between low, medium, and medium-high salinity are however, not significant (Appendix table 35).

Salt Type And Interaction With Salt Concentration: The effect of salt type on dry matter yield is statistically non-significant. However, it seems that  $\text{Na}_2\text{SO}_4$  was least damaging. The interaction between salt type and concentration is significant at 1% level. Thus, the yields declined with increasing salt concentration in the three salt types, except in case of  $\text{Na}_2\text{SO}_4$  which gave higher yield at medium-high salinity than at the two lower levels. Of the three salts NaCl at higher salinity levels (medium-high, high) was most damaging, with 47% reduction in yield at high salinity. At lower salinity levels, however, there is no appreciable reduction in yield due to NaCl. Except at low salinity, sea water reduced the yields more than  $\text{Na}_2\text{SO}_4$  at all other levels.

Variety: The differences in yield due to variety are statistically non-significant (Appendix table 32). However, apparent differences were observed between the two varieties which are worth discussing. It seems that the adverse effect of increasing salt concentration has been mainly on N. Co. 310 (Figs. 1, 2, 3). Thus from table (1) it may be

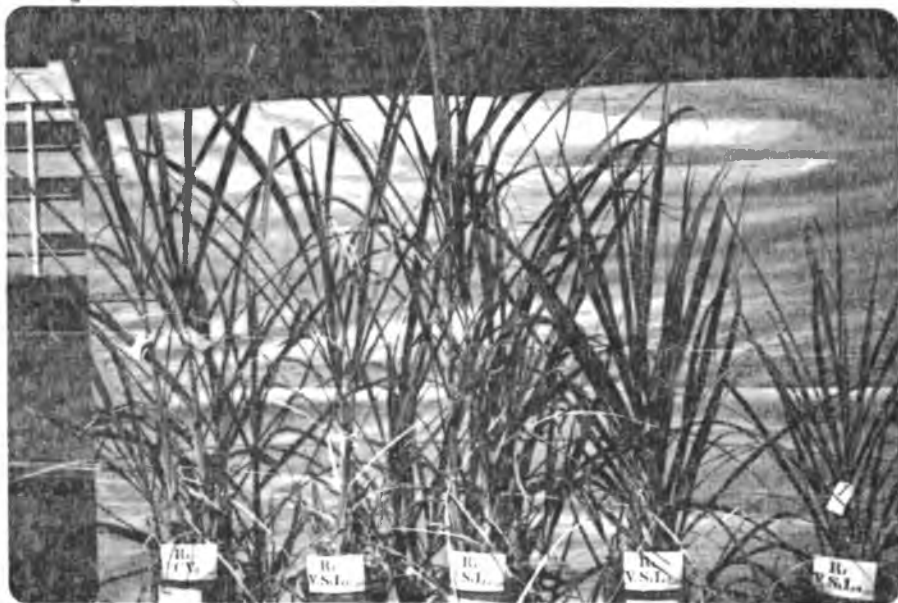
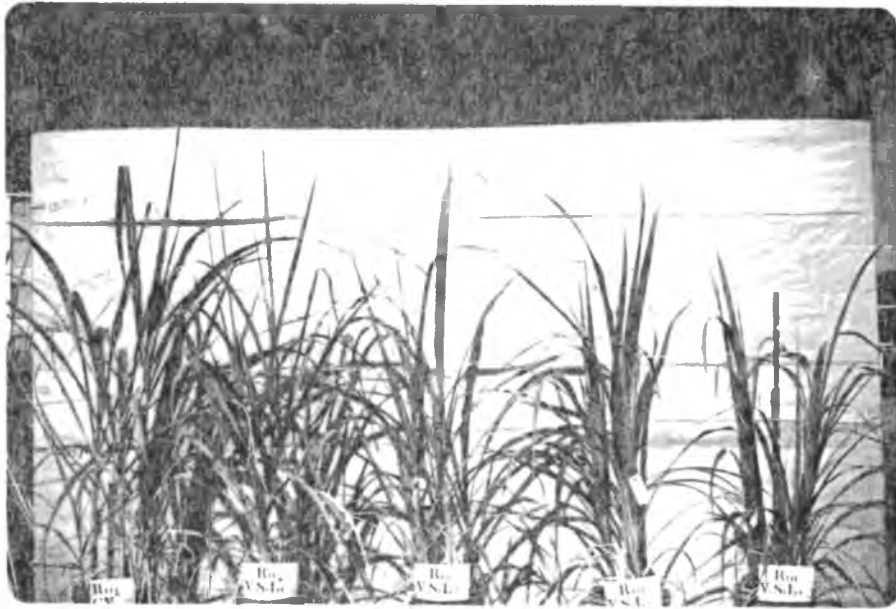


FIGURE 1. APPEARANCE OF N. Co. 310 (TOP), AND H 50-7209 (BOTTOM) PLANTS ONE WEEK BEFORE HARVEST UNDER NaCl TREATMENTS.  
LEFT TO RIGHT: CHECK, LOW SALINITY, MEDIUM SALINITY, MEDIUM-HIGH SALINITY, AND HIGH SALINITY.



FIGURE 2. APPEARANCE OF N. Co. 310 (TOP), AND H 50-7209 (BOTTOM) PLANTS ONE WEEK BEFORE HARVEST UNDER  $\text{Na}_2\text{SO}_4$  TREATMENTS. LEFT TO RIGHT: CHECK, LOW SALINITY, MEDIUM SALINITY, MEDIUM-HIGH SALINITY, AND HIGH SALINITY.

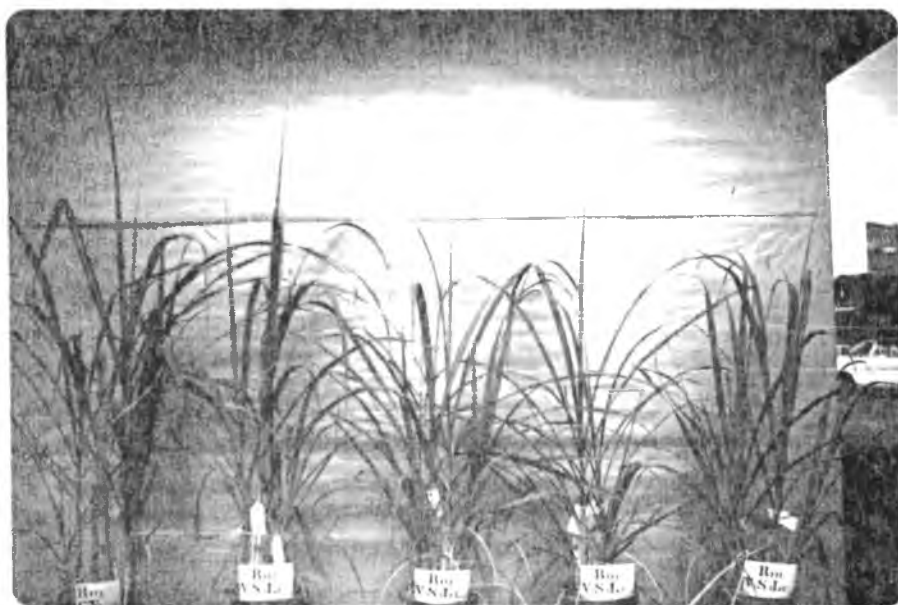


FIGURE 3. APPEARANCE OF N. Co. 310 (TOP), AND H 50-7209 (BOTTOM) PLANTS ONE WEEK BEFORE HARVEST, UNDER SEA WATER TREATMENTS. LEFT TO RIGHT: CHECK, LOW SALINITY, MEDIUM SALINITY, MEDIUM-HIGH SALINITY, AND HIGH SALINITY.

noted that the yields for this variety diminished in an almost linear fashion with increasing salt concentration. Even at low salinity yield diminished by 11%, with the loss in yield increasing to 45% at high salinity. The yield of H 50-7209 was not adversely affected due to increasing salt concentration in the same way. Thus, there is insignificant reduction in yield up to medium-high salinity. At high salinity, however, yield diminished by 23%, which is a significant reduction from commercial point of view. To look into the results further, analysis of variance of the data for two varieties was carried out separately. In case of N. Co. 310, F values are highly significant for salt concentration and salt versus no salt, but in case of H 50-7209 the F values fell much below significance (Appendix table 33). That the yield of N. Co. 310 was influenced very significantly by salt concentration, but the yield of H 50-7209 was not so affected is further verified by the regression analysis (Appendix 34). The F value for regression of yield on salt concentration is significant at 1% level for N. Co. 310 but is much below significance for H 50-7209. The correlation coefficient is high for N. Co. 310 (-0.697) but is far too low (-0.139) in case of H 50-7209. Thus, the negative effect of increasing salt concentration was almost entirely on the yield of N. Co. 310.

When the overall effect of salt treatments on the two varieties is compared, it is again apparent that N. Co. 310

is more susceptible to adverse effect of salinity than H 50-7209. Thus, the yield declined by 29% in case of N. Co. 310 compared to 10% decline in the yield of H 50-7209. The differences due to salt type are statistically non-significant for both varieties (Appendix table 33).

Green Weight: The data on green weight of plants (table 4) shows similar trend as observed for dry-matter yield. However, the magnitude of the influence of salinity is greater. Thus, due to salt treatments fresh yield of plants diminished by 34% compared to a 20% decline in dry matter yield. The combined salt effect on green weight is significant at 1% level (Appendix table 32).

\*

Salt Concentration: The yields decreased consistently with increasing salt concentration, with 18% reduction at low salinity and 49% reduction at high salinity. Statistically the effect of salt concentration on green yield is significant at 1% level. DMR test for significant differences in yield at the four salinity levels indicated that medium, medium-high, and high salinity reduced the yields very significantly over no salt treatment. The yield at high salinity is significantly less (1% level) than the yields at low, and medium salinity. The difference between medium-high salinity, and low salinity is also significant at 1% level (Appendix table 36).

TABLE 4. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE GREEN WEIGHT OF PLANTS

	Varieties Combined	N. Co.310	H 50-7209
Controls	666.0 g	734.7 g	597.3 g
Salt Treatment	Percent of control		
Salt Effect	66.29	56.52	78.31
<u>Salt Concentration</u>			
Low	82.09	78.93	85.99
Medium	70.31	59.04	84.16
Medium-High	61.08	46.43	79.11
High	51.69	41.69	63.98
<u>Salt Type*</u>			
NaCl	67.22	60.83	75.09
Na <sub>2</sub> SO <sub>4</sub>	69.54	65.39	85.71
Sea Water	62.11	52.34	74.13

Salt Type And Interaction With Salt Concentration: The differences in yield due to salt type and interaction of salt type and concentration are statistically non-significant. However, it appears from the data that sea water had the most effect and  $\text{Na}_2\text{SO}_4$  had the least effect on green weight of plants.

Variety: Variety as a variable is statistically non-significant. However, it is obvious that at the four levels of salinity there was consistently greater reduction in yield of N. Co. 310 compared to H 50-7209. Thus, the yield of N. Co. 310 decreased by 21% and 58% at the low and high salinity respectively compared to 14% and 36% reduction in yield of H 50-7209 at the same levels. The analysis of variance of the data for two varieties separately indicated highly significant effect of salt concentration (1% level) on the yield of N. Co. 310, but the effect is non-significant on H 50-7209. The overall effect of salt treatments on the two varieties also showed higher reduction in yield of N. Co. 310 compared to H 50-7209. Compared to controls the losses in green yield of two varieties are 44% and 22% respectively. The F value for salt effect is significant at 1% level for N. Co. 310, and non-significant for H 50-7209. The results are supported by regression analysis between salinity and yield of two varieties (Appendix table 34). A high negative correlation coefficient value was obtained for,

N. Co. 310 (-0.727) compared to a low value (-0.349) for H 50-7209. The effect of salt type is statistically non-significant for both the varieties.

The significant reduction in the dry matter yield and green weight of plants under saline treatments seems to be mainly due to the osmotic effect of the saline media (Fig. 4), although possibility of specific ion effects are also suggested (Fig. 5). It is noticeable that salt concentration is the single factor which is uniformly significant in its damaging effect on the yield and its components. Regardless of the composition of the salt solution, it appears that it is the osmotic effect which tends to restrict water absorption by plant roots. This adversely affects the growth and yield of plants. Even at low salinity there seems to have been enough increase in the osmotic pressure of soil solution to cause a 10% reduction in the yield of plants. The loss in yield continued with increasing salt concentration until at high salinity the yield was 35% less than the non-saline plants. Similar results have been reported by Bernstein (15). A 10% reduction in the yield of N. Co. varieties was obtained at an ECe of 3 m.mhos/cm. However, at 5 m.mhos (corresponding to medium salinity) the reduction in yield was 25%, suggesting greater sensitivity of crop than indicated by this study. Some other studies have suggested even greater sensitivity than reported above (HSPA report 1957 cited in 15, 29, 47, 59). Thus, Robinson

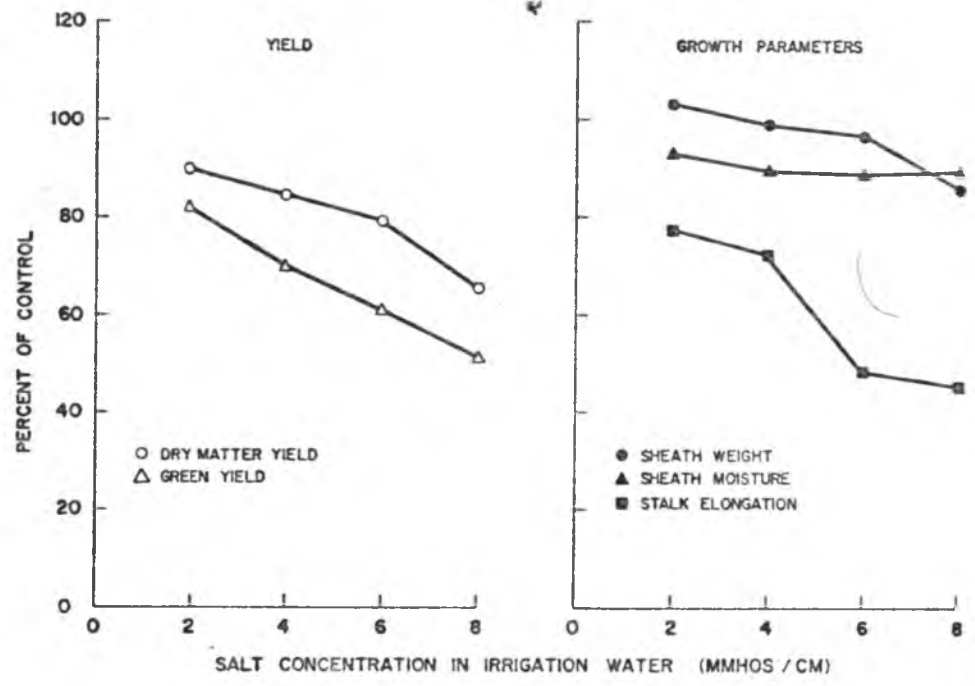


FIGURE 4. EFFECT OF SALT CONCENTRATION ON YIELD AND SOME PHYSICAL GROWTH PARAMETERS OF SUGARCANE PLANTS.

and Worker (59) found that dry matter yield of N. Co. 310 ratoon decreased by 50% when ECe was increased from 2.5 to 4.2 m.mhos/cm. He considered N. Co. 310 as sensitive to salinity. However, other studies have indicated higher tolerance of cane crop than suggested by these workers. Liu (48) could not find any significant effect on the stem growth of plants below 5.4 m.mhos/cm. Visible differences in cane growth were shown only when salt conductivity reached 20 m.mhos/cm. This is much higher tolerance than indicated in this study. Measurements on height, sheath moisture and sheath weight (tables 5, 6, 7) reveal that reduction in the height, and volume of cane (reflected by sheath weight) were responsible for the decline in plant yield. However, the effect on height seems to be greater. Other studies have given similar indications (15, 48). Although salt type is statistically non-significant, it seems that the relatively greater decline in yield due to NaCl and sea water might have been caused by the high levels of Cl (tables 19, 21) causing toxicity to plants. Toxicity due to B present in sea water is also suspected. The adverse effect of salinity on the sheath moisture was maximum due to  $\text{Na}_2\text{SO}_4$  (table 6). Since sheath moisture is highly correlated with growth units (24) it is expected that  $\text{Na}_2\text{SO}_4$  should have the most adverse effect on yield. However, the data indicates that  $\text{Na}_2\text{SO}_4$  had the least effect. This supports the conclusion that the greater reduction in

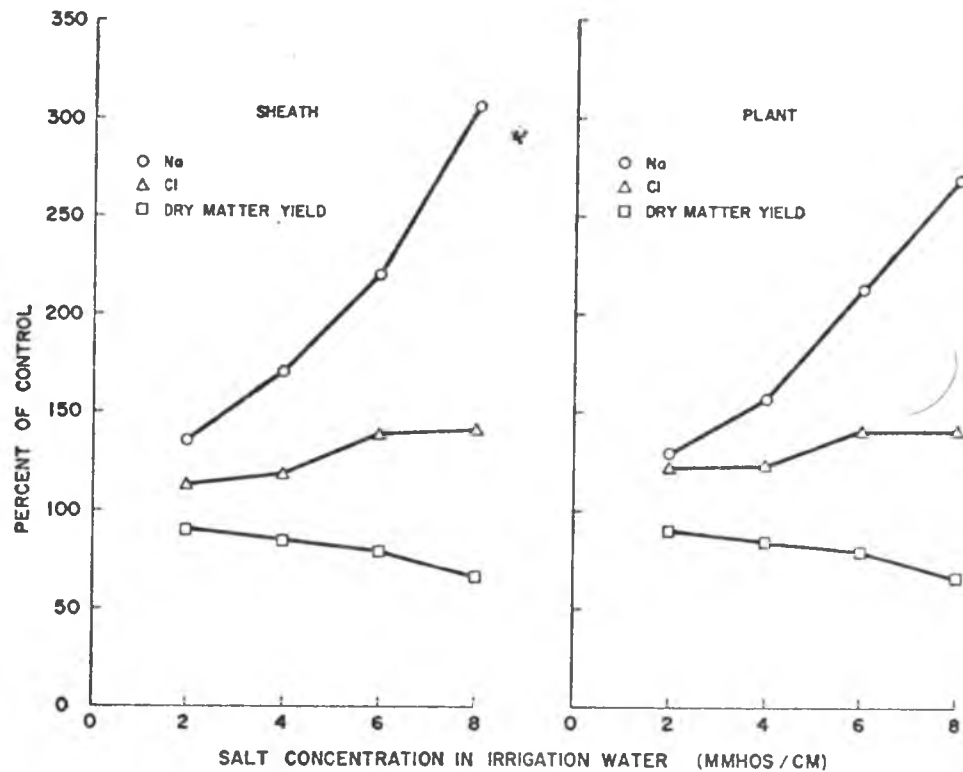


FIGURE 5. RELATIONSHIP BETWEEN Na AND Cl CONTENTS OF SUGARCANE SHEATH AND PLANT AND DRY MATTER YIELD AT VARIOUS SALT CONCENTRATIONS IN IRRIGATION WATER.

yield due to NaCl and sea water might have been caused by Cl and B toxicity (43). In case of  $\text{Na}_2\text{SO}_4$ , beneficial nutritional and ameliorative sulfate effects may have reduced salt damage. It is noteworthy that the effect of salt treatments was mainly on N. Co. 310 (Fig. 1, 2, 3). Thus, when a separate analysis of variance was run for the two varieties, it was found that salt effect was highly significant on N. Co. 310, but the F value in case of H 50-7209 was much below significance. It is possible that for H 50-7209, being drought resistant (40), the effect of limited water availability on its yield was small compared to N. Co. 310. Furthermore, the tendency of certain crops to accumulate K in higher concentrations is thought by certain workers to be a reason for higher tolerance to salt (12). Tables 12 and 13 show H 50-7209 to have this tendency. However, the control plants of this variety have themselves given a rather low yield along with abnormally low sheath moisture and sheath weight. If certain unknown factors caused low yield in control cans and did not exist in saline treated cans, then the apparent salt tolerance of H 50-7209 may not be real. On the other hand, varietal differences in salt tolerance have been observed by Shen and Tung (64) and Bernstein et al. (15). Bernstein has reported that N. Co. 310 was less tolerant than N. Co. 293 at moderate and high salinities (15).

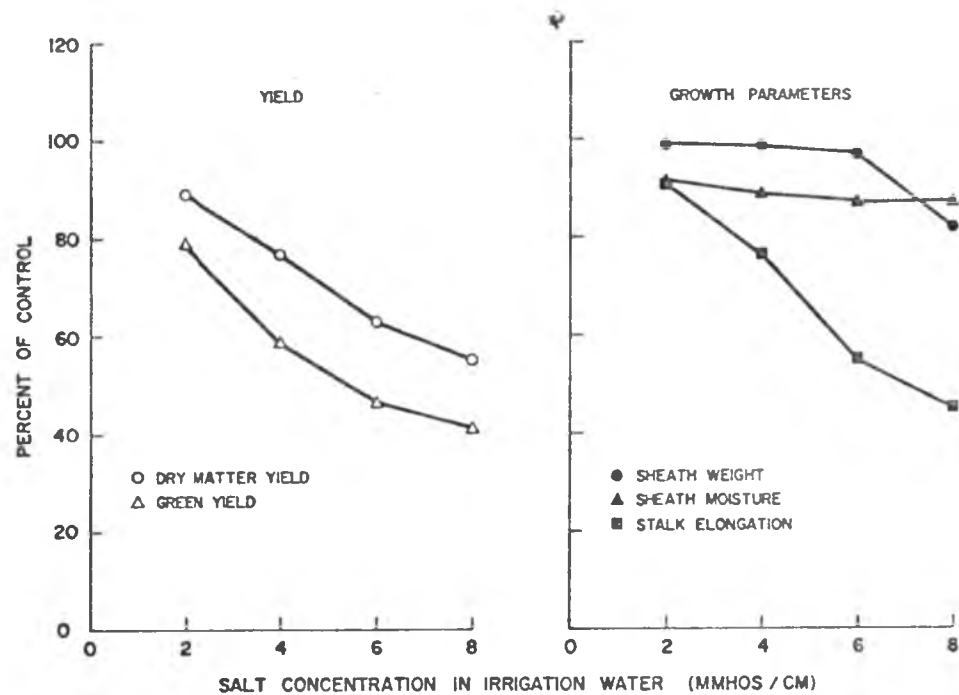


FIGURE 6. EFFECT OF SALT CONCENTRATION ON YIELD AND SOME PHYSICAL GROWTH PARAMETERS OF N. Co. 310 PLANTS.

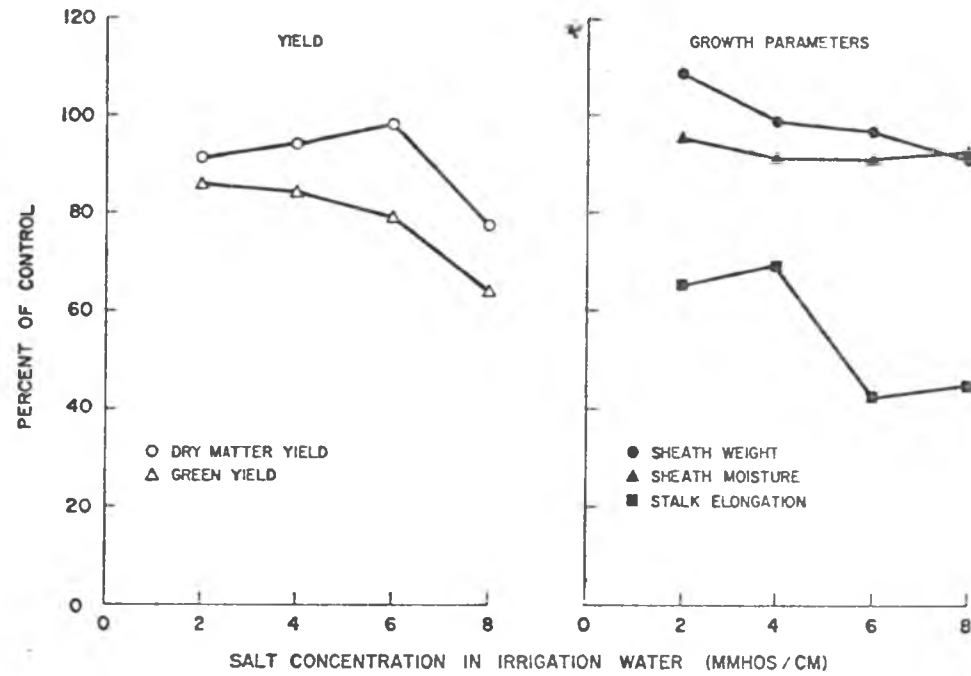


FIGURE 7. EFFECT OF SALT CONCENTRATION ON YIELD AND SOME PHYSICAL GROWTH PARAMETERS OF H 50-7209 PLANTS.

INCREMENT IN HEIGHT OF PLANTS

Salt treatments significantly (1% level) slowed down the rate of increase in the height of plants (Appendix table 32). Thus, for the same period the increment in the length of plants subject to salt treatments was 39% less compared to control plants (table 5).

Salt Concentration: Increment in the length of stalks of the two varieties combined is consistently less with increasing salt concentration. Compared to controls there was 22% less elongation of stalk at low salinity with the loss in elongation increasing to 55% at the high salinity. The F value for salt concentration is significant at 1% level. DMR test of the data on height increment (Appendix table 37) indicated that differences between control plants and low salinity plants are significant at 5% level, and between control plants and medium, medium-high, and high salinity plants are significant at 1% level. The differences between medium high and high salinity on the one hand and low and medium salinity on the other are also significant at 1% level. It appears that the effect of increasing salt concentration on the rate of stalk elongation becomes pronounced at medium high salinity and up. Up to medium salinity the loss in increment of height is 28% over control whereas the loss at medium-high salinity is almost doubled (52%). F value for regression of height on salinity (Appendix table 34) is significant at 1% level, and the

TABLE 5. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE INCREMENT IN HEIGHT OF PLANTS  
(Feb.15-June 2)

	Varieties Combined	N. Co.310	H 50-7209
Control _____	118.66 cm	114.83 cm	122.50 cm
<hr/>			
Salt Treatment	Percent of Control		
<hr/>			
Salt effect	60.86	66.76	55.33
<u>Salt Concentration</u>			
Low	77.76	90.85	65.48
Medium	72.38	76.19	68.80
Medium-High	48.39	54.81	42.35
High	44.92	45.18	44.66
<u>Salt Type</u>			
NaCl	56.22	56.45	56.01
Na <sub>2</sub> SO <sub>4</sub>	66.98	73.40	60.95
Sea Water	59.37	70.31	49.01

correlation coefficient value is negative and high (-0.662).

Salt Type And Interaction With Salt Concentration:

Differences due to salt type and interaction of salt type and concentration are statistically non-significant.

However, it seems that NaCl had the most effect and Na<sub>2</sub>SO<sub>4</sub> least.

Variety: Difference between varieties is statistically non-significant. However, it appears that the adverse effect of salt treatments was greater on H 50-7209 (55% of control) than on N. Co. 310 (66% of control). Again, it is obvious that compared to low and medium salinity, medium-high salinity and up drastically cut down the elongation rate of plants. In case of N. Co. 310 the four salinity levels seem to be significantly different from each other, but in case of H 50-7209 the differences between low, and medium salinity on the one hand, and medium-high and high salinity on the other are negligible. Analysis of regression of height increment on salinity gave a highly significant F value (1% level) for both varieties, and nearly an equal value for the correlation coefficient. The interactions between variety and salt type, and concentration are statistically non-significant.

Height provides a linear measure of growth rate, and is highly correlated with soil moisture availability to plant roots (24). Since, saline conditions tend to restrict the

moisture availability to plant, stalk elongation has been widely used as an index for assessing the effect of salinity on the growth of sugarcane and some other field crops (15, 48, 59). The data in this study suggests that the effect of increasing salt concentration on the combined heights of plants is negative and highly significant. The reduction in stalk elongation was considerable even at low and medium salinity (about 25% of control). This shows greater sensitivity to salt than reported by Liu (48). He found no significant effect on stem growth of sugarcane varieties below 5.4 m.mhos. However, Robinson and Worker (59) obtained 50% reduction in stalk elongation when ECe increased from 2.5 to 3.4 m.mhos. In this study 50% and greater reduction in stalk length was obtained at medium-high and high salinity, corresponding to 8 and 10 m.mhos. in leachates (table 5). Although salt type is not significant it may be noted that  $\text{Na}_2\text{SO}_4$ , as in the cases of dry matter yield and green weight of plants, has also caused the least reduction in the height of plants. A high negative correlation coefficient value (-0.662) gives further credence to this discussion. Liu (48) also obtained high coefficient values for several cane varieties. It might be interesting to note that the salt treatments decreased the stalk length of H 50-7209 relatively more than that of N. Co. 310 (Figs. 6 and 7). But the reverse is true for dry matter and green yield. The likely reason is that plants with shorter main stalk, but more tillers would still give higher total

green weight and dry yield.

### SHEATH MOISTURE

Salt treatments reduced the sheath moisture by about 10% over control (table 6). F value for salt effect is significant at 1% level (Appendix table 32).

Salt Concentration: Sheath moisture of plants decreased with salt concentration. The effect of salt concentration is significant at 1% level. The DMR test indicated that the four salinity levels are significantly different from control (1% level). A comparison between the salinity levels shows that the sheath moisture at low salinity is significantly higher (93% of control) compared to sheath moisture at the other three levels (89% of control).

Salt Type And Interaction With Salt Concentration: The effect of salt type is significant at 5% level. The sheath moisture was lowest under  $\text{Na}_2\text{SO}_4$  treatment. The interaction between salt type and concentration is statistically non-significant.

Variety: Salt treatments reduced the sheath moisture of N. Co. 310 by 12% and of H 50-7209 by 8% (table 6). The difference between the two varieties is significant at 1% level. However, it may be noted that differences between controls for two varieties are also significant at 1% level. The differences due to interaction between variety and salt

TABLE 6. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE SHEATH MOISTURE OF SUGARCANE PLANTS

	<u>Varieties Combined</u>	<u>N. Co. 310</u>	<u>H 50-7209</u>
Control _____	81.44%	85.26%	77.74%
Salt effect	90.33	88.41	92.41
<u>Salt Concentration</u>			
Low	93.02	90.94	95.27
Medium	89.82	88.55	91.21
Medium-High	89.06	87.21	91.07
High	89.40	86.94	92.08
<u>Salt Type</u>			
NaCl *	91.05	88.91	93.36
Na <sub>2</sub> SO <sub>4</sub>	89.11	87.40	90.95
Sea Water	90.83	88.92	92.91

type, and concentration are also statistically non-significant (Appendix table 32). Analysis of regression of sheath moisture on salt concentration gave a correlation coefficient of  $-0.727$  for N. Co. 310 compared to  $-0.349$  for H 50-7209.

In sugarcane moisture content of sheaths 3, 4, 5, 6 is an important index, representing an integration of internal and external factors related with the energy receipt and its dispersal (23). The highly significant effect of salts and their increasing concentration in reducing sheath moisture indicates an increasingly restricted moisture availability to plants. The low availability of soil moisture in this case is mainly due to the increasing osmotic pressure of the soil solution, which adds to soil moisture stress. A marked depression in sheath moisture shows that the osmotic effect due to salts can severely reduce the water uptake by roots even when salts are present only in small quantities. This low water status in the plant may affect the overall growth in more ways than one. Ultimate results are reduced vegetative growth, slow rates of stalk elongation and finally poor yields. Clements et al. (23) have obtained high positive correlation between sheath moisture and soil moisture. Varietal differences are noticeable. The greater reduction in the sheath moisture of N. Co. 310 along with an equally greater reduction in dry matter yield compared to H 50-7209 (Figs. 6, 7) suggest a

close relationship between the sheath moisture and yield of the crop. The control plant of H 50-7209 are unusually low in moisture level. According to the crop-log system developed by Clements et al. (23), such a low moisture level corresponds to the ripening stage of the crop. The likely reason is that the control plants of H 50-7209 must have been over due for irrigation on the day of harvest. Therefore, the moisture status in the plant at this time was much lower than at other times. This might also be the reason for apparently small reduction in sheath moisture of salt treated plants compared to controls.

#### SHEATH WEIGHT

Due to salt treatments the combined sheath weight of two varieties declined by 4% over the control (table 7). Nevertheless, the difference is statistically non-significant (Appendix table 32).

Salt Concentration: The effect of salt concentration on sheath weight of plants is significant at 5% level. Except at low salinity where there is a slight increase, the sheath weight declines with increasing salt concentration. A comparison between salinity levels by DMR test (Appendix table 39) indicates that sheath weight at high salinity is significantly less (5% level) than that at medium, and medium-high. Thus, at medium, and medium-high salinity sheath weight decreased only slightly, but at high

salinity the sheath weight diminished by 14%.

Salt Type and Interaction with Salt Concentration: The difference due to salt type is statistically non-significant. However, the interaction between salt type and concentration is significant at 5% level. At low and medium salinity levels there is not much difference between the various salt types (table 8). However, at the medium-high and high salinity levels, especially the latter, NaCl had the most effect. At this level, NaCl reduced the sheath weight by 24% over control compared to 7 and 12% due to  $\text{Na}_2\text{SO}_4$  and sea water, respectively.

Variety: The F value for variety is significant at 1% level. However, it may be noted that difference between the controls of the two varieties is also significant at 5% level (Appendix table 32). In fact, only at low salinity, and high salinity the differences between the two varieties become pronounced. Thus, at low salinity the sheath weight of N. Co. 310 decreased by 1% while that of H 50-7209 increased by 8% over control. At high salinity, sheath weight of both varieties diminished but the reduction in sheath weight of N. Co. 310 is greater, being 18% over control compared to 9% for H 50-7209. Regression of sheath weight on salt concentration gave low correlation coefficient values for both varieties. Interactions between variety and salt type, and concentration are statistically non-significant. However, NaCl had the most effect on sheath

TABLE 7. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE SHEATH WEIGHT OF SUGARCANE PLANTS

	Varieties Combined	N. Co. 310	H 50-7209
Controls _____	32.08 g	36.67 g	27.50 g
Salt Treatment	Percent of Control		
Salt effect	96.25	94.30	98.80
<u>Salt Concentration</u>			
Low	103.30	99.23	108.69
Medium	98.97	99.07	98.80
Medium-High	96.78	96.97	96.58
High	85.91	81.97	91.09
<u>Salt Type</u> *			
NaCl	95.07	91.00	100.43
Na <sub>2</sub> SO <sub>4</sub>	97.35	98.85	95.30
Sea Water	96.32	93.04	100.61

TABLE 8. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON SHEATH WEIGHT OF SUGARCANE PLANT

Salt Concentration	Control = 32.08 g		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	113.78	91.71	104.43
Medium	100.53	95.85	100.53
Medium-High	89.87	108.32	92.21
High	76.12	93.52	88.06

weight of N. Co. 310, and  $\text{Na}_2\text{SO}_4$  had the most influence on H 50-7209.

Sheath weight reflects girth of the plant. Along with rate of leaf emergence it is an important morphological factor having influence on growth units in sugarcane crop (24). The highly significant effect of increasing salt concentration on the green weight of sheath indicates that increasing osmotic pressure and decreasing moisture availability affects not only linear growth (stalk elongation) but volume of cane as well (girth). However, it may be observed that while the effect of salinity on sheath moisture and height is apparent at low salt concentration, its effect on sheath weight and therefore, on the girth of the cane showed up significantly only at high salt concentration. Thus, up to medium-high salinity the differences due to salt concentration when compared to control are not appreciable. The reduction in sheath weight of H 50-7209 is very small. The two possible reasons are that H 50-7209 being drought resistant is not affected by low moisture availability to the same extent as N. Co. 310. Another reason of this apparently small reduction could be that sheath weight of control plants is rather low. This again might be due to the fact that sheath moisture is a major component of the green weight of sheath, which for reasons noted earlier is unusually low.

## SODIUM IN SHEATHS

The sodium content of cane sheath increased as a result of the combined salt treatments to more than double the concentration found in the sheath of control plants (table 9). The salt effect is significant at 1% level (Appendix table 40).

Salt Concentration: The Na in the sheaths increased with increasing salt concentration in an almost linear fashion. Compared to control, at low salinity sheath Na went up by 35%, with the concentration rising by two fold at medium salinity and by three fold of control at high salinity. DMR test (Appendix table 45) indicated that medium and higher levels of salinity are significant at 5% level. Sheath Na at high salinity is significantly greater than at lower salt concentrations (1% level). Medium-high salinity is significant at 1% level from no salt, and low salinity, and at 5% level from medium salinity.

Salt Type and Interaction with Salt Concentration: Na content of sheath increased under all the three salt types, compared to control (table 10). However, the maximum increase in concentration was due to NaCl (235% of control), followed by sea water and Na<sub>2</sub>SO<sub>4</sub> treatments. Among the three salts, the sheath Na was lowest under Na<sub>2</sub>SO<sub>4</sub>. The differences between NaCl and Na<sub>2</sub>SO<sub>4</sub> are significant at 1% level. On the other hand differences between sea water and

TABLE 9. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Na CONTENT OF SUGARCANE SHEATHS

	<u>Varieties Combined</u>	<u>N. Co.310</u>	<u>H 50-7209</u>
Control _____	0.076%	0.080%	0.072%
<u>Salt Treatment</u>	<u>Percent of Control</u>		
Salt effect	208.51	215.20	201.11
<u>Salt Concentration</u>			
Low	135.58	134.42	136.87
Medium	171.03	164.94	177.65
Medium-High	220.63	226.63	214.10
High	306.87	334.79	275.69
<u>Salt Type</u>			
NaCl	235.97	229.27	243.43
Na <sub>2</sub> SO <sub>4</sub>	178.96	188.81	168.15
Sea Water	210.58	227.38	191.75

TABLE 10. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON Na CONTENT OF SUGARCANE SHEATH

Salt Concentration	Control = 0.076%		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	132.05	130.92	143.73
Medium	170.61	160.36	181.98
Medium-High	246.49	190.10	225.37
High	394.81	234.65	291.00

NaCl or  $\text{Na}_2\text{SO}_4$  are non-significant. The interaction between salt type and concentration is significant at 5% level. It is apparent that at all salinity levels sheath Na is consistently higher due to NaCl and sea water as compared to  $\text{Na}_2\text{SO}_4$ . However, Na content increased most under sea water, reaching 143 and 182% compared to 132 and 171% of control for NaCl at low and medium levels, respectively. This is also indicated by DMR test. Thus, at medium salinity of sea water, sheath Na is sufficiently higher than at control to be significant at 5% level. The difference in case of NaCl and  $\text{Na}_2\text{SO}_4$  became significant at medium-high salinity. However, NaCl was most effective at high salinity in raising the Na content of sheath, increasing it to almost four times of control compared to 135% and 191% increase under  $\text{Na}_2\text{SO}_4$ , and sea water respectively. The differences between the three salts at this salinity level are significant at 1% level.

Variety: Due to salt treatment there was greater increase in sheath Na of N. Co. 310 compared to H 50-7209. Thus, Na content in sheath of N. Co. 310 rose to 215% of control compared to 201% in H 50-7209. The difference between the two varieties is significant at 5% level. The interactions of variety with salt type and concentration were statistically non-significant. However, it seems that at high salinity Na concentration in sheaths of N. Co. 310 tends to be appreciably higher than in H 50-7209.

TABLE 11. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Na CONTENT IN SUGARCANE PLANTS

	<u>Varieties Combined</u>	<u>N. Co. 310</u>	<u>H 50-7209</u>
Control _____	0.122%	0.122%	0.122%
Salt Treatment	Percent of Control		
Salt effect	192.34	198.68	185.92
<u>Salt Concentration</u>			
Low	129.05	140.00	118.10
Medium	157.44	160.98	153.82
Medium-High	213.16	209.30	217.03
High	269.54	284.44	254.65
<u>Salt Type</u> *			
NaCl	223.20	227.73	218.60
Na <sub>2</sub> SO <sub>4</sub>	165.26	178.60	152.09
Sea Water	188.39	189.71	187.07

## SODIUM IN PLANT

Na content of plant tissue is higher than sheath Na by  $1\frac{1}{2}$  times. As in sheath, salt treatments considerably increased the Na concentration in plant tissue. The net increase was 92% over control (table 11). The salt effect is significant at 1% level (Appendix table 40).

Salt Concentration: Again, Na content in plant tissue increased with increasing salinity. Thus at low salinity the plant Na is 129% of control rising to 269% of control at high salinity. DMR test (Appendix table 44) indicates that plant Na of medium salinity and up is very significantly (1% level) higher than at control. Similarly, differences between high salinity and lower concentrations, and between medium-high, and low and medium salinity are significant at 1% level. However, the difference between low salinity and control is not significant.

Salt Type and Interaction With Salt Concentration: The influence of salt type on plant Na is significant at 1% level. As in sheath Na, NaCl was most effective in raising Na concentration in plant tissue followed by sea water and  $\text{Na}_2\text{SO}_4$ . However, interaction between salt type and concentration is statistically non-significant.

Variety: Differences in plant Na due to variety and due to variety by salt interaction are non-significant. However, interaction of variety with concentration is significant at

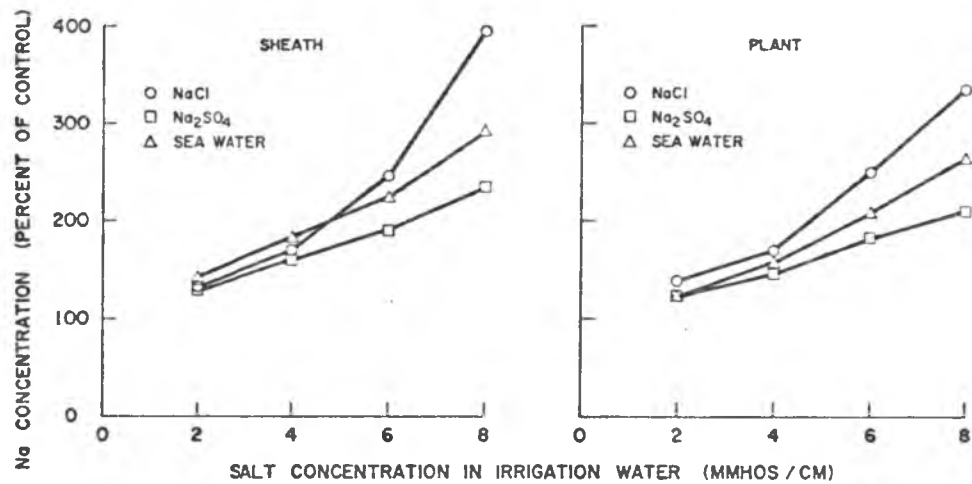


FIGURE 8. EFFECT OF SALT TYPE ON THE Na CONTENT OF SUGARCANE SHEATH AND PLANT AT VARIOUS SALT CONCENTRATIONS IN IRRIGATION WATER.

5% level. Thus at low and high salinity, Na of N. Co. 310 plants increased to 140% and 284%, but that of H 50-7209 increased to 118% and 254% of control respectively. The overall effect of salt treatments is also greater on plant Na of N. Co. 310 compared to H 50-7209.

The previous results indicate that Na content of sheath and plant increased markedly with increasing Na concentration in the substrate. Similar results have been reported by Bernstein et al.(15), Shen and Tung (64), and Innes (cited in 27) who associated high Na in the cane blades with high Na in the soil. Batchelder and Gallatin (6) salinized the plots with dilutions of sea water and found that increasing Na content in plant tops of vegetables increased with increasing salinity. Although the increase in Na content due to salinity is relatively greater in sheath, the absolute amounts of Na are high in the plant. This is because sugarcane plant does not readily translocate Na from older sections to younger sections (15). The maximum increase in Na content of sheath and plant was due to NaCl, followed by sea water and Na<sub>2</sub>SO<sub>4</sub> (Fig. 8). This might be because of the tendency of cations to be absorbed more rapidly in the presence of a readily absorbable anion than of one which is taken up slowly. However, Gauch and Wadleigh (32) found that bean plants contained higher Na in case of Na<sub>2</sub>SO<sub>4</sub> compared to NaCl at iso-osmotic solution. It may be noted that sea water containing a mixture of ions also favoured Na absorption by plants more than Na<sub>2</sub>SO<sub>4</sub>.

Varietal differences are significant with respect to sheath Na and appreciable with respect to plant Na. N. Co. 310 tends to accumulate higher concentrations of Na compared to H 50-7209. This is important because a high concentration of Na in plant is associated with lower yield perhaps because of harmful effects of Na. Shen and Tung (64) had reported that with increasing NaCl in culture solution the Na content of plant increased, cane growth and K content decreased. A high Na level of control plants is perhaps due to the high Na content of tap water.

#### POTASSIUM IN SHEATH

K content of sheath was not affected significantly due to salt treatments. Thus, plants under salt treatments had sheath K only 3% less than the control (table 12).

Salt Concentration: At low and medium salinity sheath K is lower than control by 7 and 9% respectively. There is negligible increase at high salinity. However, these differences were too small to be statistically significant (Appendix table 40).

Salt Type and Interaction With Salt Concentration: Sheath K was depressed due to  $\text{Na}_2\text{SO}_4$ , being 88% of control. It also decreased slightly under NaCl, but increased slightly under sea water. The difference between  $\text{Na}_2\text{SO}_4$ , and NaCl and sea water are significant at 5% and 1% level, respectively. However, the interaction of salt type and concentration is

TABLE 12. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE K CONTENT IN SUGARCANE SHEATH

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	3.45%	3.20%	3.70%
Salt Treatment	Percent of Control		
Salt effect	96.81	91.25	101.62
<u>Salt Concentration</u>			
Low	93.33	89.68	96.75
Medium	91.30	85.31	96.48
Medium-High	100.00	89.06	109.45
High	102.60	100.93	104.05
<u>Salt Type</u>			
NaCl	98.55	95.31	101.35
Na <sub>2</sub> SO <sub>4</sub>	88.40	82.18	93.51
Sea Water	103.76	96.25	110.00

statistically non-significant.

Variety: Sheath K of N. Co. 310 was depressed by 9% under K content of control. However, sheath K of H 50-7209 was slightly increased due to salt treatments. Statistically the variety variable is highly significant. The differences due to interaction of variety with concentration are not consistent. The interaction of variety with salt merely reflects the predominant effect of salt type.

#### POTASSIUM IN PLANT

As in sheath, the net effect of salt treatments is not appreciable, and statistically falls below significance level (Appendix table 40).

Salt Concentration: Compared to control, increasing salinity depressed plant K except at low salinity which increased it slightly (table 13). This behavior is reversal of the trend observed in sheath K. None of the salinity levels are significantly different from control (Appendix table 46). However, the differences between low salinity on one hand, and medium-high and high salinity on the other are highly significant. Medium and medium-high salinity levels are also significantly different from each other.

Salt Type And Interaction With Salt Concentration: The three salts depressed plant K but the effect was maximum under  $\text{Na}_2\text{SO}_4$ , decreasing plant K by 7% below control. The

TABLE 13. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE K CONTENT IN SUGARCANE PLANT

	Varieties Combined	N. Co. 310	H 50-7209
Control	2.34%	2.36%	2.32%
Salt Treatment	Percent of Control		
Salt effect	96.58	89.83	103.44
<u>Salt Concentration</u>			
Low	102.56	96.62	108.18
Medium	98.29	91.52	104.74
Medium-High	91.88	82.20	101.29
High	93.58	88.13	99.13
<u>Salt Type</u>			
NaCl	97.43	89.83	104.74
Na <sub>2</sub> SO <sub>4</sub>	92.73	86.44	98.70
Sea Water	99.57	92.79	106.46

effect of NaCl and sea water is negligible. The difference between  $\text{Na}_2\text{SO}_4$  and sea water is significant at 5% level. The interaction of salt type and concentration is statistically non-significant.

Variety: Plant K of N. Co. 310 decreased by 10% but that of H 50-7209 increased by 3% over control under salt treatments. The difference is significant at 1% level. None of the interactions with variety are statistically significant.

Sugarcane is a heavy feeder of potash, especially during the early growth. Hence, adequate levels of K are important for the normal growth of the crop. In the control plants level of sheath K seems to be adequate (23). K content of sheath is higher than in plant. This is expected as K content is generally higher in young tissue compared to mature parts of the plant. It seems that saline treatments tend to depress K content of sheath and plant. However, the differences are not pronounced. Increasing salinity had no significant effect on K level in sheath. In case of plant K although differences among salinity treatments are significant none of the salinity levels is significant compared to control. This rather small reduction in the K contents of sheath and plant may be explained in terms of competitive absorption of Na and K (42). In fact the two ions behave antagonistically (1962). However, these alkali cations do not compete with one another on equal terms, and K absorption is not usually as strongly inhibited by the

presence of Na, as Na is reduced by K (67). Thus, the small reduction in K level of plant was perhaps due to very high concentration of Na in substrate. Differences in K level of sheath and plant are significant.  $\text{Na}_2\text{SO}_4$  was most depressive and sea water least as it in fact increased sheath K. In general high  $\text{SO}_4$  concentration limits the uptake of Ca and associated with this decrease are increases in absorption of Na and K (70). In this study the results partially differ from this generally accepted trend. Thus,  $\text{Na}_2\text{SO}_4$  significantly reduced uptake of Ca (tables 14, 16). However, it has also depressed sheath and plant K. It cannot be presumed that absorption of K was depressed by Na of  $\text{Na}_2\text{SO}_4$  because Na increased less under  $\text{Na}_2\text{SO}_4$  compared to other salts (tables 9, 11). Therefore, this unusual behavior needs explanation especially because the trend is consistent for both varieties.

Varietal differences in K accumulation are noticeable. In case of H 50-7209, K content of sheath and plant has slightly increased, but that of N. Co. 310 was appreciably reduced. High K content of H 50-7209 seems to be a varietal characteristic (Heinz and Urata 1968). This tendency of H 50-7209 to accumulate higher concentration of K is important in relation to salt tolerance.

#### CALCIUM IN SHEATH

Under salt treatments sheath Ca is very significantly lower than the control (table 14).

TABLE 14. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Ca CONTENT IN SUGARCANE SHEATH

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	0.156%	0.158%	0.154%
Salt Treatment	Percent of Control		
Salt effect	73.87	75.52	72.18
<u>Salt Concentration</u>			
Low	85.36	85.28	85.44
Medium	72.33	68.29	76.54
Medium-High	71.11	79.39	62.63
High	66.68	69.05	64.19
<u>Salt Type</u> >			
NaCl	82.60	82.11	83.17
Na <sub>2</sub> SO <sub>4</sub>	56.41	59.48	53.34
Sea Water	82.54	84.90	80.11

TABLE 15. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON Ca CONTENT IN SUGARCANE SHEATH

Salt Concentration	Control = 0.156%		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
Percent of Control			
Low	85.88	77.28	92.81
Medium	81.06	59.44	76.51
Medium-High	83.44	50.96	78.88
High	80.04	37.93	81.96

Salt Concentration: Sheath Ca decreased with increasing salinity. Thus, at low salinity sheath Ca is 15% lower than the control, declining to 34% of control at high salinity. All the four salinity levels are significantly different from control at 5% level. Compared to low salinity medium-high, and high salinity are significant at 1% level (Appendix table 47).

Salt Type and Interaction With Salt Concentration: Sheath Ca is significantly lower than the control under the three salt types. However,  $\text{Na}_2\text{SO}_4$  had the maximum effect decreasing Ca content by 44% over control. Considering the interaction between salt type and concentration, it is apparent that at all levels, increasing concentration of  $\text{Na}_2\text{SO}_4$  was more depressive compared to NaCl and sea water. In fact, differences due to increasing concentration of NaCl and sea water do not suggest any trend. At high salinity the effect of  $\text{Na}_2\text{SO}_4$  on sheath Ca is very severe reducing it to 38% of control.

Variety: Differences due to variety either alone or in combination with salt type or concentration are negligible and statistically non-significant (Appendix table 41).

#### CALCIUM IN PLANT

The depressive effect of salt treatments on plant Ca is slight compared to its effect on sheath Ca (table 16). Statistically it is also non-significant (Appendix table 41).

TABLE 16. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Ca CONTENT IN SUGARCANE PLANT

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	0.198%	0.237%	0.160%
Salt Treatment	Percent of Control		
Salt effect	93.09	81.71	109.95
<u>Salt Concentration</u>			
Low	98.38	81.71	123.04
Medium	82.01	68.53	102.06
Medium-High	99.79	88.16	117.03
High	92.14	88.41	97.62
<u>Salt Type</u>			
NaCl	102.11	89.89	120.28
Na <sub>2</sub> SO <sub>4</sub>	64.58	57.16	75.64
Sea Water	112.49	98.06	133.87

Salt Concentration Type and Their Interaction: The effect of increasing salt concentration on plant Ca is variable and does not suggest any trend. However, depressive effect of  $\text{Na}_2\text{SO}_4$  is apparent. Plant Ca under this salt is 36% lower than the control. NaCl and sea water had a slightly favorable effect but the differences are too small. The interaction of salt type and concentration is statistically non-significant. The data only suggests the predominant influence of salt type.

Variety: Salt treatments reduced plant Ca of N. Co. 310 by 18% but increased that of H 50-7209 by 10% over respective controls. However, statistically the difference is non-significant. It may be noted that controls of the two varieties are significantly different, and plant Ca of H 50-7209 is rather low. None of the interactions with variety are significant. However, it is apparent that NaCl and sea water increased plant Ca of H 50-7209 but decreased it in case of N. Co. 310.  $\text{Na}_2\text{SO}_4$  also depressed Ca content in N. Co. 310, more than in H 50-7209.

Ca content of sheath was significantly reduced due to increasing salinity. The likely reason is excessive Na in saline substrate. Generally, in a mixture of alkali cations and earth cations in the substrate, earth cations tend to be depressed (67).  $\text{Na}_2\text{SO}_4$  tended to depress Ca accumulation in leaves and plant more than NaCl and sea water. This is related to the tendency of high  $\text{SO}_4$  concentration to limit

the uptake of Ca by plants (70). Relatively high Ca content of plant under sea water treatments seems to be due to presence of Ca in sea water. This can also be inferred from variety x salt concentration x salt type interaction. The higher plant Ca in N. Co. 310 compared to H 50-7209 might be due to varietal characteristic and/or greater ratio of old to young cane tissue.

#### MAGNESIUM IN SHEATH

Under salt treatments sheath Mg is 17% higher than the control (table 17). The increment is significant at 1% level (Appendix table 41).

Salt Concentration, Type and Their Interaction: Sheath Mg at medium-high, and high salinity is appreciably higher than control and medium salinity. Compared to low salinity sheath Mg is lower at medium salinity. However, the difference is not significant, (Appendix table 48). All the three salts increased Mg content of sheath. However, sea water had the maximum effect and  $\text{Na}_2\text{SO}_4$  least. The differences among the three salts are significant at 1% level.

Variety: Mg content of sheath increased due to salt treatments in both varieties. However, the varietal differences are statistically non-significant. Differences due to variety by salt type interaction are not appreciable. The two varieties behaved differently with increasing salt

TABLE 17. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Mg CONTENT IN SUGARCANE SHEATH

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	0.185%	0.180%	0.190%
Salt Treatment	Percent of control		
Salt effect	117.38	121.62	113.44
<u>Salt Concentration</u>			
Low	116.09	116.17	116.01
Medium	109.23	113.45	105.30
Medium-High	124.08	125.62	122.68
High	120.19	131.35	109.76
<u>Salt Type</u>			
NaCl	117.60	122.79	112.71
Na <sub>2</sub> SO <sub>4</sub>	104.42	105.78	103.20
Sea Water	130.18	136.35	124.42

concentration. The maximum increase in the sheath Mg of N. Co. 310 was at high salinity, but in case of H 50-7209 the Mg content is highest at medium-high salinity, declining appreciably at high salinity. The interaction of variety with concentration is significant at 5% level.

#### Mg IN PLANT

The net effect of salt treatments on Mg content in plant was negligible (table 18).

Salt Concentration, Type and their Interaction: No appreciable differences in plant Mg are discernable at the four salinity levels. However, salt type had highly significant effect. NaCl and Na<sub>2</sub>SO<sub>4</sub> slightly depressed Mg content of plant, but sea water increased it by 20% over control, which is significant at 1% level. Interactions with salt type and concentration are statistically non-significant (Appendix table 41).

Saline treatments increased Mg content of sheath and plant, although the increase is significant in sheath Mg only. This increase in Mg content seems to be mainly due to sea water, although NaCl has also increased sheath Mg appreciably. Higher Mg under sea water treatments may have been due to Mg content of sea water (Appendix table 31). However, translocation of Mg from old to young tissue seems to be another reason. Similar results have been reported by other workers. Bernstein et al. (15) working on N. Co.

TABLE 18. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Mg CONTENT IN SUGARCANE PLANT

	Varieties Combined	N. Co. 310	H 50-7209
Control	0.148%	0.138%	0.158%
Salt Treatment	Percent of Control		
Salt effect	104.53	109.22	100.38
<u>Salt Concentration</u>			
Low	107.51	107.77	107.35
Medium	100.20	99.85	100.50
Medium-High	105.01	114.46	96.76
High	105.28	114.75	97.02
<u>Salt Type</u>			
NaCl	99.32	103.05	96.07
Na <sub>2</sub> SO <sub>4</sub>	93.50	93.45	93.59
Sea Water	120.64	131.10	111.53

varieties found that Mg increased with increasing salinity, but the increase in Mg accumulation of leaves was noteworthy from Mg plots. Batchelder et al. (6) studied the cation composition of vegetable crops irrigated with dilutions of sea water. They found higher Mg especially in top parts of tomato, onion, peppers, with increasing salinity. Relatively higher Mg content in plant of N. Co. 310 compared to H 50-7209 could be because of greater ratio of young tissue to old tissue in the latter variety.

#### CHLORIDE IN SHEATHS

Salt treatments favored sheath Cl, increasing its concentration by 27% over control (table 19). The salt effect is <sup>\*</sup>significant at 5% level (Appendix table 42).

Salt Concentration: There is a consistent rise in sheath Cl with increasing salt concentration. Cl concentration at low salinity increased by 13%, rising to 141% of control at high salinity. DMR test indicated that comparing with control differences become significant only at medium-high, and high salinity. These salinity levels are also significantly different from low and medium salinity (Appendix table 49). Thus, sheath Cl increased by 18% at medium salinity but by 38% over control at medium-high salinity.

Salt Type and Interaction with Salt Concentration: Although there was a net increase in sheath Cl due to salt treatments not all the three salts were responsible for this increment

TABLE 19. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Cl CONTENT IN SUGARCANE SHEATH

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	1.70%	1.53%	1.87%
Salt Treatment	Percent of Control		
Salt effect	127.64	134.64	121.92
<u>Salt Concentration</u>			
Low	112.94	114.37	111.22
Medium	118.23	116.99	119.25
Medium-High	138.23	150.98	128.34
High	141.17	154.90	129.41
<u>Salt Type</u>			
NaCl	151.76	166.66	140.10
Na <sub>2</sub> SO <sub>4</sub>	75.88	73.85	77.00
Sea Water	155.29	162.74	149.19

TABLE 20. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON Cl CONTENT IN SUGARCANE SHEATH

Salt Concentration	Control = 1.70%		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	127.05	91.76	120.00
Medium	131.17	85.29	138.82
Medium-High	171.76	78.23	165.29
High	177.64	48.23	197.05

(table 20). Thus, NaCl and sea water favored sheath Cl increasing its concentration by over 50% compared to control. However, Na<sub>2</sub>SO<sub>4</sub> had a negative effect as it depressed Cl content in sheath by 25% over control. Interaction of salt type with concentration is significant at 1% level. However, it is apparent that differences due to salt type by concentration are due to the entirely opposite effect of NaCl and sea water on one hand and Na<sub>2</sub>SO<sub>4</sub> on the other (table 20). Whereas NaCl and sea water increased the Cl at the four salinity levels, Na<sub>2</sub>SO<sub>4</sub> depressed it at the same levels. Differences between NaCl and sea water are not significant at any level.

Variety:\* Salt treatments increased sheath Cl of N. Co. 310 by 34%, and of H 50-7209 by 22% over control. However, the F value for variety is not significant. Differences due to interaction of variety with salt type, or concentration are not appreciable, and fall statistically below significance level. However, it seems that the increase in sheath Cl of N. Co. 310 was due most to NaCl, but in case of H 50-7209 sea water had the maximum effect.

#### CHLORIDE IN PLANT

Cl content of plant tissue increased by 31% over control due to salt treatments (table 21). F value is highly significant for salt effect (Appendix table 42).

Salt Concentration: Cl concentration in plant as in sheath,

TABLE 21. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE Cl CONTENT IN SUGARCANE PLANT

	<u>Varieties Combined</u>	<u>N. Co. 310</u>	<u>H 50-7209</u>
Control _____	1.26%	1.22%	1.30%
<u>Salt Treatment</u>	<u>Percent of Control</u>		
Salt	131.74	141.52	130.32
<u>Salt Concentration</u>			
Low	122.22	128.46	115.57
Medium	123.01	126.15	120.49
Medium-High	141.26	141.53	140.16
High	141.26	137.69	145.08
<u>Salt Type</u> *			
NaCl	161.11	161.53	160.65
Na <sub>2</sub> SO <sub>4</sub>	75.39	78.46	72.95
Sea Water	158.73	160.76	157.37

TABLE 22. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON Cl CONTENT IN SUGARCANE PLANT

Salt Concentration	Control = 1.26%		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	137.30	96.82	133.33
Medium	143.65	80.15	145.23
Medium-High	173.01	76.19	173.01
High	191.26	50.00	183.33

has consistently risen with increasing salinity. At all four concentrations plant Cl is considerably higher than control. The level of significance is 1%. At low salinity plant Cl increased by 22% rising to 141% of control at high salinity. The differences between low and medium salinity, or between medium-high and high salinity are negligible. However, at medium -high, and high salinity plant Cl increased more considerably than at low or medium salinity. The differences are highly significant (Appendix table 50).

Salt Type and Interaction with Salt Concentration: The effect of salt type is again noticeable, with  $\text{Na}_2\text{SO}_4$  depressing Cl concentration in plant, and NaCl and sea water encouraging it. Thus, plant Cl went down to 75% of control due to  $\text{Na}_2\text{SO}_4$ , but increased by about 60% due to the other two salts. The difference between NaCl and sea water are negligible. The data on interaction of salt type and concentration again reveal the predominant effect of salt type. Thus, plant Cl consistently decreased under  $\text{Na}_2\text{SO}_4$  with increasing salinity, but increased under NaCl and sea water (table 22).

Variety: Salt treatments increased plant Cl in both varieties but the effect was greater in N. Co. 310. Thus, Cl content of N. Co. 310 increased by 41% and that of H 50-7209 increased by 30% over control. The difference between the two varieties is significant at 1% level. The interactions

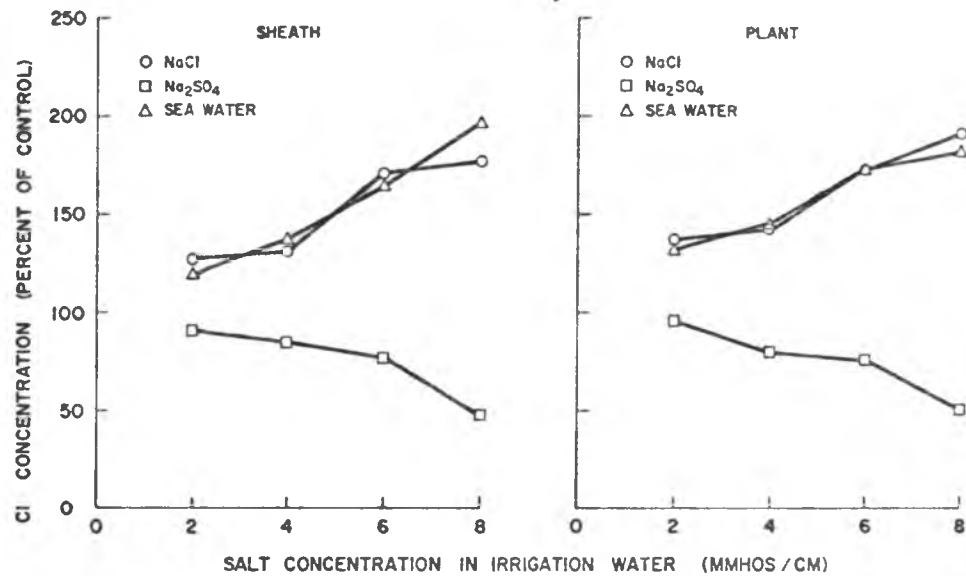


FIGURE 9. EFFECT OF SALT TYPE ON THE Cl CONTENT OF SUGARCANE SHEATH AND PLANT AT VARIOUS SALT CONCENTRATIONS IN IRRIGATION WATER.

of variety with salt type, or concentration are statistically non-significant.

In general the increase in Cl concentration of sheath and plant due to saline treatments is significant. However, the effect of salt type is predominant (Fig. 9). Thus, there has been about  $1\frac{1}{2}$  times increase in Cl content of sheath and plant due to NaCl and sea water. This might be attributed to the fact that Cl concentration in leaves usually bears close relationship to the Cl concentration of substrate (70). Other workers have also reported increase in Cl accumulation due to saline conditions in the root zone of cane plant. Bernstein et al. (cited in 14) found that under saline conditions the Cl accumulation in leaves of plants may increase up to 150 meq/100 g or more. The lower Cl content of sheath and plant under  $\text{Na}_2\text{SO}_4$  is noticeable. This trend is also apparent in the interaction of salt type and concentration (table 22). Such effect has not been reported by other workers. Varietal differences are noticeable. Plant Cl in H 50-7209 and N. Co. 310 increased significantly under salt treatments, but that of N. Co. 310 increased more, indicating greater tendency of this variety to accumulate Cl under saline conditions. Varietal differences in Cl accumulation have been reported for sugarcane (15) and for other crops (Ravikovitch and Bildner 1937, cited in 70). The higher Cl content in sheath compared to old tissue has also been reported by Bernstein et al. (15). Higher Cl in non saline plants seems to be due to Cl content

of tap water which was used for irrigating control plants.

### SULPHUR IN SHEATH

As in plant, sheath S increased due to salt treatments by 8% over control (table 23). But the increment is statistically non-significant (Appendix table 42).

Salt Concentration: Compared to control, at low and medium salinity S in sheath decreased slightly, but at medium-high, and high salinity it increased by 17% and 23% respectively. The salt concentration as a variable is significant at 1% level.

### Salt Type and Interaction With Salt Concentration:

Differences due to the three salts are again noticeable (table 24).  $\text{Na}_2\text{SO}_4$  enhanced S concentration in plant increasing it to 177% of control, but NaCl and sea water depressed it by 28% and 15% over control respectively. Salt type is significant at 1% level. The interaction of salt type with concentration is also highly significant. However, the differences appear magnified because the three salts affected sheath S in opposite direction (table 24). Between NaCl and sea water, the effect of NaCl was more depressive at the four salinity levels. At medium-high and high salinity the differences between these two salts are quite significant.

Variety: Due to salt treatments sheath S of N. Co. 310 was

TABLE 23. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE S CONTENT IN SUGARCANE SHEATH

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	0.12%	0.16%	0.08%
Salt Treatment	Percent of Control		
Salt effect	108.78	97.78	131.29
<u>Salt Concentration</u>			
Low	95.19	87.96	109.92
Medium	99.50	90.17	118.06
Medium-High	117.08	69.41	143.76
High	123.21	73.83	152.92
<u>Salt Type</u>			
NaCl	62.68	55.15	77.86
Na <sub>2</sub> SO <sub>4</sub>	177.77	158.72	217.04
Sea Water	85.73	79.48	98.47

TABLE 24. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON S CONTENT IN SUGARCANE SHEATH

Salt Concentration	Control = 0.12%		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	70.97	135.15	79.27
Medium	72.47	150.41	75.78
Medium-High	58.20	193.86	99.17
High	48.92	231.84	88.88

slightly depressed, but that of H 50-7209 increased by 31% over control. The difference is significant at 1% level. The interaction of variety and salt type is also highly significant. Under  $\text{Na}_2\text{SO}_4$  sheath S of H 50-7209 increased by 117% over control compared to 58% increase in sheath S of N. Co. 310. Also, the depressive effect of NaCl and sea water is significantly less on sheath S of H 50-7209. However, it may be noted that S concentration in sheath from control plants of H 50-7209 is very low compared to N. Co. 310.

Interaction of variety with salt concentration is statistically non-significant.

#### SULPHUR IN PLANT

The net effect of salt treatments was to increase the plant S by a negligible amount of 3% over control (table 25).

Salt Concentration: The S content of plant did not change significantly with increasing salt concentration. The differences are statistically non-significant (Appendix table 42).

Salt Type and Interaction With Salt Concentration: The salt type had a considerable effect on S content of plants. Thus,  $\text{Na}_2\text{SO}_4$  favored S concentration in plant increasing it by 57% over control. But NaCl and sea water depressed it decreasing it by 33% and 15% below control respectively.  $\text{Na}_2\text{SO}_4$  is significant at 1% level compared to no-salt, NaCl, and sea

TABLE 25. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE S CONTENT IN SUGARCANE PLANT

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	0.22%	0.20%	0.23%
Salt Treatment	Percent of Control		
Salt effect	103.43	119.61	89.45
<u>Salt Concentration</u>			
Low	104.26	123.42	87.72
Medium	99.72	114.21	87.20
Medium-High	104.17	121.92	88.93
High	105.56	118.81	94.03
<u>Salt Type *</u>			
NaCl	67.62	78.87	57.90
Na <sub>2</sub> SO <sub>4</sub>	157.32	173.87	143.04
Sea Water	85.25	106.00	67.41

TABLE 26. EFFECT OF INTERACTIONS BETWEEN SALT TYPE AND CONCENTRATION ON S CONTENT IN SUGARCANE PLANT

Salt Concentration	Control = 0.22%		
	NaCl	Na <sub>2</sub> SO <sub>4</sub>	Sea Water
	Percent of Control		
Low	93.87	122.82	96.10
Medium	72.72	142.85	83.48
Medium-High	55.84	172.82	83.85
High	48.14	190.81	77.64

water. The differences between NaCl and sea water are significant at 5% level. The interaction of salt type and concentration is also significant at 1% level. However, the predominant effect of salt type is apparent (table 26). Thus, plant S consistently increased with increasing concentration of  $\text{Na}_2\text{SO}_4$  but declined with increasing concentration of NaCl and sea water. At all the four salinity levels the decline in plant S is greater under NaCl compared to sea water. The differences between the two salts become very significant at medium-high, and high salinity.

Variety: The salt treatments increased plant S of N. Co. 310 by 19% but decreased that of H 50-7209 by 11% below control. The difference is significant at 5% level. Although interaction of variety with salt or concentration is statistically non-significant, but it is apparent that the favorable effect of  $\text{Na}_2\text{SO}_4$  is greater on plant S of N. Co. 310 and the depressive effect of NaCl and  $\text{Na}_2\text{SO}_4$  is appreciably greater on H 50-7209.

The differences in S content of sheath and plant are mainly due to the predominant effect of salt type (Fig.10) and variety. Thus, sheath and plant S increased markedly under  $\text{Na}_2\text{SO}_4$  but declined under NaCl and sea water. Although, S content increased relatively more in sheath than plant, the absolute amounts are greater in plant. The sheath S of control plants seems to be rather low (23). This could have been due to the tendency of  $\text{SO}_4$  to leach out

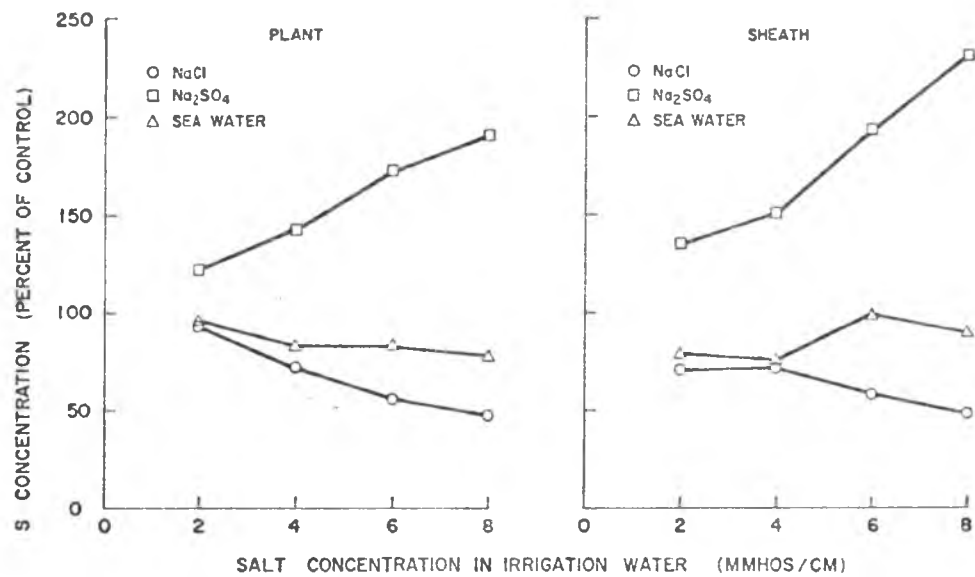


FIGURE 10. EFFECT OF SALT TYPE ON S CONTENT OF SUGARCANE SHEATH AND PLANT AT VARIOUS SALT CONCENTRATIONS IN IRRIGATION WATER.

easily (69). Since the leachates were not poured back in the cans, loss of  $\text{SO}_4$  in leachates might have caused low sheath S of controls. The higher amount in plant tissue indicates that S is not easily translocated from old to young parts (69). In view of rather low sheath S, the effect of  $\text{Na}_2\text{SO}_4$  from nutrient point of view might have been beneficial. Varietal differences are apparent. The favorable effect of  $\text{Na}_2\text{SO}_4$  and depressive effect of NaCl and sea water are relatively greater in case of N. Co. 310. The predominant effects of salt type and variety are reflected in interactions of salt type with concentration and of salt type with variety. Varietal differences in accumulation of  $\text{SO}_4$  have been reported for field crops like cotton (Harres et al. 1925 cited in 34).

#### N IN BLADE

N content of blades is 19% lower under salt treatments compared to control (table 27). The salt effect is significant at 1% level. However, neither salt concentration, nor type, nor their interactions are statistically significant (Appendix table 43).

The adverse effect of salt treatments was greater on blade N of H 50-7209 compared to N. Co. 310. Thus, salt treatment lowered the blade N of N. Co. 310 by 12% but that of H 50-7209 by 23% over control. The difference between two varieties is also significant at 5% level. The interactions are statistically non-significant.

TABLE 27. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE N CONTENT IN SUGARCANE BLADE

	Varieties Combined	N. Co 310	H 50-7209
Control _____	1.82%	1.74%	1.91%
Salt Treatment	Percent of Control		
Salt effect	81.31	87.93	77.48
<u>Salt Concentration</u>			
Low	80.21	85.63	74.86
Medium	81.86	89.08	74.34
Medium-High	80.76	89.08	72.77
High	81.86	88.50	75.39
<u>Salt Type</u>			
NaCl	81.86	87.93	75.91
Na <sub>2</sub> SO <sub>4</sub>	81.31	88.50	74.34
Sea Water	80.21	87.93	73.29

N IN PLANT

The data indicate negligible effect of salt treatments on N content in plant (table 28). At medium-high and high salinity plant N increased by 7 and 8% over control respectively. At low and medium salinity it is slightly depressed. The differences between high salinity and other three levels are significant at 1% level. Neither the salt type, the variety, nor their interactions are statistically significant (Appendix table 43).

Salinity treatments significantly lowered the N content of blades. This seems to be the result of relatively poor growth under salt treatments. However, there is another possibility that Cl and SO<sub>4</sub> inhibited the uptake of N. Evans (cited in 19) has reported tendency of Cl ion to inhibit the uptake of N and P in sugarcane. Similarly, deficiency of ions such as K in cane plant has been considered to lower (Clements cited in 19) or increase total N (Suzuki and Kenjo cited in 19) in the plant. However, other evidence indicates that interference in absorption of essential anions from saline substrates is of relatively minor importance (70). Thus, the findings are contradictory and even in the present study it is difficult to attribute the significant decline in blade N to Cl and SO<sub>4</sub> anions in irrigation water. Another possible reason is that uptake of N and P is reduced when the water available is restricted. Thus, due to saline conditions in root zone uptake of N and P was restricted.

TABLE 28. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE N CONTENT IN SUGARCANE PLANT

	<u>Varieties Combined</u>	<u>N. Co. 310</u>	<u>H 50-7209</u>
Control	1.04%	1.03%	1.04%
<u>Salt Treatment</u>	<u>Percent of Control</u>		
Salt effect	102.41	102.91	102.88
<u>Salt Concentration</u>			
Low	98.55	96.11	100.00
Medium	98.55	100.97	96.15
Medium-High	107.24	105.82	107.69
High	108.21	106.79	108.65
<u>Salt Type</u> *			
NaCl	101.44	98.05	104.80
Na <sub>2</sub> SO <sub>4</sub>	102.41	105.82	99.03
Sea Water	104.34	103.88	104.80

Considering the varietal differences, it is observed that N content was more reduced in blades of H 50-7209 compared to N. Co. 310. The blade N of N. Co. 310 is slightly less than the calculated normal nitrogen (23), but that of H 50-7209 seems to be high. However, the apparent adequacy may be deceptive because the sheath moisture of H 50-7209 control plant was unusually low. The higher N in blades of N. Co. 310 under saline treatment is noticeable, in view of the fact that N. Co. 310 plants gave high absolute yield.

#### PHOSPHORUS IN SHEATH AND PLANT

Salt treatments increased P content in sheath and plant possibly because present anions discourage P fixation. However, the increment increases in P are not significant (Appendix table 43). Increasing salinity had variable effect on sheath P. Thus, at low salinity sheath P is 10% higher than control, but then declines with increasing concentration. However, at high salinity it again rose to 16% of control. The effect of salt concentration is significant at 5% level on sheath P, but is non-significant on plant P. Considering the varieties it is observed that sheath P in case of N. Co. 310 is slightly lower but plant P is 31% higher than the control. The reverse is true for H 50-7209. Plant P decreased by 11% and sheath P increased by 24% over control. Statistically varietal differences are significant for plant P only (1% level). The differences between the

TABLE 29. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE P CONTENT IN SUGARCANE SHEATH

	Varieties Combined	N. Co. 310	H 50-7209
Control _____	0.113%	0.125%	0.101%
Salt Treatment	Percent of Control		
Salt effect	108.96	96.54	124.08
<u>Salt Concentration</u>			
Low	110.73	100.56	123.09
Medium	105.59	95.74	117.74
Medium-High	103.46	90.44	119.42
High	115.97	99.51	136.17
<u>Salt Type</u>			
NaCl	106.47	93.57	122.39
Na <sub>2</sub> SO <sub>4</sub>	110.47	97.11	126.95
Sea Water	109.76	99.03	122.99

TABLE 30. EFFECT OF SALT TYPE AND CONCENTRATION  
ON THE P CONTENT IN SUGARCANE PLANT

	<u>Varieties Combined</u>	<u>N. Co. 310</u>	<u>H 50-7209</u>
Control _____	0.076%	0.055%	0.097%
<u>Salt Treatment</u>	<u>Percent of Control</u>		
Salt effect	104.62	131.13	89.55
<u>Salt Concentration</u>			
Low	103.96	130.76	88.72
Medium	94.17	119.78	79.62
Medium-High	109.25	130.21	97.41
High	110.84	143.58	92.24
<u>Salt Type</u>			
NaCl	109.39	135.71	94.41
Na <sub>2</sub> SO <sub>4</sub>	98.01	122.52	83.97
Sea Water	106.34	134.79	90.07

controls of the two varieties are also highly significant.

The overall effect of salt treatment on P content of sheath and plant was insignificant. Rather low P content of N. Co. 310 plant might have been the result of translocation from old tissue. However, the data on P content of sheath and blades does not lead to any definite conclusions (tables 29, 30).

## SUMMARY AND CONCLUSIONS

Effects of saline water irrigation on the early growth of N. Co. 310 and H 50-7209 sugarcane varieties were studied under the greenhouse conditions. Pot cultures of Molokai silty clay soil were used because this soil had shown high resistance to salinity and sodium hazards (26). Irrigation waters containing NaCl, Na<sub>2</sub>SO<sub>4</sub>, and sea water at concentrations of 2, 4, 6, and 8 m.mhos/cm. were used for irrigation. Based on the results obtained, the following conclusions can be made:

- 1) The Leaching Requirement (LR) formula suggested by the United States Salinity Laboratory staff (70) was found inapplicable when applied to control salinity levels in the irrigated cultures. This is because the formula was designed to calculate the required irrigation water excess when a certain level of salinity is desired in drainage water.
- 2) Salinity reduced the combined dry matter and fresh yields of sugarcane crop by 20% and 34%, respectively. The effect of salt concentration was predominant. This indicates that the osmotic component of salinity was more influential than other components in reducing yields. The loss in yield increased with increasing salt concentration. The loss in dry matter yield at low salinity (3.5 m.mhos/cm. in leachate) was 10%. The loss in yield increased to 35% at high salinity

(10 m.mhos/cm. in leachate). The effect of salt type was not significant. However, sea water reduced the yields most and  $\text{Na}_2\text{SO}_4$  least. This suggests the possibility of Cl and B toxicity. Varietal differences are statistically non-significant. However, it seems that the effect of salinity was greater on N. Co. 310 than on H 50-7209, especially at the lower salinity levels.

3) The increment increase in the height of plants during treatments was 39% less under saline water irrigation. Only the effect of salt concentration was significant. The increment in height decreased with increasing salt concentration.

4) Salinity reduced moisture content of sheaths number 3, 4, 5, and 6 by 10%. The effects of salt type and concentration were significant at 5% and 1% level respectively.  $\text{Na}_2\text{SO}_4$  had the most effect and sea water least. The combined losses in sheath moisture at low and medium salinity were 7 and 10% respectively. Varietal differences are significant at 1% level. Sheath moisture of N. Co. 310 was reduced by 12% and H 50-7209 by 8%. This indicates that H 50-7209 can absorb more water at a given salt concentration, than N. Co. 310.

5) The green weight of sheaths decreased with increasing salt concentration. The effect of salt concentration is predominant and is significant at 5% level.

Varietal differences are highly significant. Sheath weight of N. Co. 310 reduced by 6% but that of H 50-7209 by merely 1%. This suggests that the reduction in the volume growth (girth) of cane is greater in N. Co. 310 than H 50-7209.

6) The Na content of sheath and plant increased with increasing salt concentration in an almost linear fashion. The effect of salt type was highly significant. The maximum increase in sheath and plant Na was under NaCl and least under  $\text{Na}_2\text{SO}_4$ . Varietal differences are significant. Compared to H 50-7209, N. Co. 310 accumulated more Na. This might have been one reason for the greater decline in yield of N. Co. 310.

7) Difference due to salt type and variety are significant in affecting K content in sheaths. Salt concentration effect was also significant in affecting K content of plant. The effect of  $\text{Na}_2\text{SO}_4$  in reducing K concentration of sheath and plant is significant. NaCl and sea water had negligible effects. Sheath K and plant K of N. Co. 310 decreased but that of H 50-7209 slightly increased. Tendency of H 50-7209 to accumulate higher amounts of K might be the reason for its tolerance to salinity.

8) The depressive effect of salinity was significant in respect of sheath Ca but was non-significant in respect of plant Ca. The effect of salt type is highly significant.  $\text{Na}_2\text{SO}_4$  depressed Ca content of sheath and

plant more than NaCl and sea water. The effect of salt concentration was highly significant on sheath Ca but was non-significant on plant Ca. Sheath Ca decreased with increasing concentration.

9) Salinity increased the Mg content of sheath and plant. The effect of salt type was highly significant. Sea water increased Mg concentration in sheath and plant more than NaCl and  $\text{Na}_2\text{SO}_4$ . The effect of salt concentration is significant only on sheath Mg. It increased with increasing concentration. Varietal differences are significant only in respect of plant Mg. N. Co. 310 accumulating more Mg than H 50-7209.

10) Salinity increased sheath and plant Cl significantly. The effects of salt type and concentration were highly significant. Thus the Cl concentration in sheath and plant increased with increasing concentration of sea water and NaCl but decreased with increasing concentration of  $\text{Na}_2\text{SO}_4$ . Salinity increased plant Cl of N. Co. 310 more than that of H 50-7209. The difference is highly significant. The higher Cl accumulation by N. Co. 310 coupled with lower yield under saline treatments indicates possibility of Cl toxicity.

11) The effect of salt type was most important in affecting S content of plants.  $\text{Na}_2\text{SO}_4$  favored S accumulation in sheath and plant but NaCl and sea water depressed it. This suggests that higher concentrations of chloride in substrate tend to depress  $\text{SO}_4$  uptake by plants. The

effect of salt concentration is highly significant but the effect of salt type is predominant.

12) Salinity depressed N content of blades. However, the main effect was that of salt concentration. Blades N decreased with increasing salinity. This seems to be due to an overall reduction in the growth of plants, rather than any direct effect of salinity. The effect on P content of sheath and plant was not significant.

13) This study was limited in its scope because sugarcane was grown in pot cultures in the greenhouse for seven months only. It is now suggested that a similar study should be carried out in the field for full growing period of the crop. Such a study will allow full assessment of the effects of saline treatments on various aspects of this crop including sugar content and quality at maturity.

APPENDIX  
TABLES (31-81)

LIST OF ABBREVIATIONS USED IN  
APPENDIX TABLES

V <sub>1</sub>	N. Co. 310
V <sub>2</sub>	H 50-7209
CV <sub>1</sub>	Control for N. Co. 310
CV <sub>2</sub>	Control for H 50-7209
L <sub>1</sub>	2 m.mhos/cm. Salt concentration in irrigation water (EC).
L <sub>2</sub>	4 m.mhos/cm. Salt concentration in irrigation water (EC).
L <sub>3</sub>	6 m.mhos/cm. Salt concentration in irrigation water (EC).
L <sub>4</sub>	8 m.mhos/cm. Salt concentration in irrigation water (EC).
S <sub>1</sub>	NaCl
S <sub>2</sub>	Na <sub>2</sub> SO <sub>4</sub>
S <sub>3</sub>	Sea water.
R <sub>1</sub> , R <sub>2</sub> , R <sub>3</sub> ,	are Replications No. 1, 2, 3, respectively.
DMR Test	Duncan's Multiple Range Test.
--	Non significant.

TABLE 31. CONCENTRATIONS OF MAJOR IONS IN SEA WATER<sup>1</sup>

Ion	Concentration equivalent/L
Cl	0.5483
SO <sub>4</sub>	0.05644
HCO <sub>3</sub>	0.002356
Br	0.000819
F	0.000102
B	4.262 ppm
Na	0.4702
Mg	0.1071
Ca	0.02049
K	0.009936
Si	0.000307

<sup>1</sup> H. U. Sverdrup, et al., 1960. The Oceans, their Physics, Chemistry and General Biology, Prentice-Hall, Inc. 9th printing.

TABLE 32. ANALYSIS OF VARIANCE F VALUES AND LEVEL OF SIGNIFICANCE

Source	Degree	F Values				
	of Freedom	Dry Matter yield	Green Wt. of Plants	Increment in Height Feb.15-June 2	Sheath Moisture	Sheath Weight
Variety (V)	1	3.27	2.97	2.94	48.51 **	39.23 **
Salt (S)	2	0.86	0.92	2.14	3.86	0.13
Concentration (L)	3	6.54 **	8.05 **	14.50 **	8.53 **	4.03
V x S	2	1.52	0.84	1.89	0.11	1.26
V x L	3	2.92 *	1.90	1.26	0.68	0.73
S x L	6	3.40 **	1.68	0.78	1.88	2.49 *
V x S x L	6	1.82	1.33	0.87	0.76	1.15
Salt versus no salt	1	7.00 *	16.68 **	24.75 **	73.95 **	0.32
CV <sub>1</sub> versus CV <sub>2</sub>	1	0.98	1.69	0.18	18.22 **	4.99 *
Error	50	--	--	--	--	--
Error Mean Square		550.86	16731.32	482.63	4.66	25.24
Coeff. of Variation		21.70	28.20	29.00	2.90	16.20

\* Significant at 5% level.

\*\* significant at 1% level.

TABLE 33. ANALYSIS OF VARIANCE F VALUES AND LEVEL OF SIGNIFICANCE

Source	Degree of Freedom	F. Values			
		Dry Matter Yield		Green Weight of Plants	
		N. Co 310	H 50-7209	N. Co 310	H 50-7209
S	2	0.65	1.50	0.68	1.04
L	3	8.58 **	1.64	7.79 **	1.88
S x L	6	2.23	2.73	1.10	1.86
Salt versus no salt	1	9.63 **	0.59	16.36 **	2.73
Error	24	--	--	--	--
Total	38	--	--	--	--
Error Mean Square	--	480.68	661.82	17264.99	16996.99

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 34. REGRESSION OF YIELD AND HEIGHT  
ON SALT CONCENTRATION IN LEACHATES

Variable	F Values for Regression	Coefficient of Correlation
<u>Dry Matter Yield</u>		
N. Co 310	34.91 **	-0.697 **
H 50-7209	0.73	-0.139
<u>Green Weight of Plants</u>		
N. Co 310	41.45 **	-0.727 **
H 50-7209	5.14 *	-0.349
<u>Increment in Height</u>		
N. Co 310	28.99 **	-0.663 **
H 50-7209	31.24 **	-0.677 **

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 35. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
DRY MATTER YIELD OF SUGARCANE PLANTS

Salt Concentration	No salt	Low	Medium	Medium- High
Low	*	--	--	--
Medium	*	--	--	--
Medium-High	*	--	--	--
High	**	**	**	*

TABLE 36. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
GREEN WEIGHT OF SUGARCANE PLANTS

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	**	--	--	--
Medium-High	**	**	--	--
High	**	**	**	--

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 37. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
INCREMENT IN HEIGHT OF SUGARCANE PLANTS

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	*	--	--	--
Medium	*	--	--	--
Medium-High	**	**	**	--
High	**	**	**	--

TABLE 38 DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
SHEATH MOISTURE OF SUGARCANE PLANTS

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	**	--	**	*
Medium	**	--	--	--
Medium-High	**	**	--	--
High	**	**	--	--

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 39. DMR TEST FOR SIGNIFICANT DIFFERENCES  
 BETWEEN SALINITY LEVELS IN RELATION TO THE  
 SHEATH WEIGHT OF SUGARCANE PLANTS

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	--	--	--	--
Medium-High	--	--	--	--
High	--	*	*	*

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 40. ANALYSIS OF VARIANCE F VALUES AND LEVEL OF SIGNIFICANCE

Source	Degrees of Freedom	F. Values			
		Sodium		Potassium	
		Sheath	Plant	Sheath	Plant
V	1	7.07 **	1.75	54.34 **	36.25 **
S	2	5.90 **	12.14 **	7.40 **	4.25 *
L	3	24.94 **	41.57 **	2.60	5.75 **
V x S	2	1.01	0.54	0.55	0.15
V x L	3	2.07	0.74	1.28	0.90
S x L	6	2.61 *	2.30 *	2.26	2.18
V x S x L	6	0.32	0.22	0.55	0.60
Salt Versus no Salt	1	19.66 **	1.23	0.28	0.92
CV <sub>1</sub> versus CV <sub>2</sub>	1	0.05	28.16 **	1.62	0.08
Error	50	--	--	--	--
Total	77	--	--	--	--
Error Mean Square	--	189460.96	247595.41	0.24	0.04

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 41. ANALYSIS OF VARIANCE F VALUES AND LEVEL OF SIGNIFICANCE

Source	Degrees of Freedom	F. Values			
		Calcium		Magnesium	
		Sheath	Plant	Sheath	Plant
V	1	2.70	2.85	0.32	4.45 **
S	2	31.41 **	28.19 **	30.81 **	39.74 **
L	3	6.66 **	2.16	5.62 **	1.37
V x S	2	0.44	0.02	0.83	3.11
V x L	3	2.81	1.45	3.12	3.75 *
S x L	6	2.36 *	0.94	0.86	1.66
S x V x L	6	1.22	0.48	0.55	1.41
Salt versus no salt	1	21.73 **	0.49	12.98 **	0.91
CV <sub>1</sub> versus CV <sub>2</sub>	1	0.05	4.25 *	0.37	2.28
Error	50	--	--	--	--
Total	77	--	--	--	--
Error Mean Square	--	42300.90	213062.84	44332.05	26918.54

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 42. ANALYSIS OF VARIANCE F VALUES AND LEVEL OF SIGNIFICANCE

Source	Degrees of Freedom	F Values			
		Chloride		Sulfur	
		Sheath	Plant	Sheath	Plant
V	1	3.87	11.78 **	84.20 **	4.65 **
S	2	57.33 **	282.52 **	192.50 **	63.84 **
L	3	4.29	10.15 **	7.09 **	0.14
V x S	2	0.46	0.09	7.85 **	0.67
V x L	3	0.66	1.42	0.01	0.13
S x L	6	5.64 **	18.26 **	10.40 **	4.85 **
V x S x L	6	0.51	0.78	1.06	0.69
Salt versus no salt	1	4.95 *	27.78 **	0.89	0.08
CV <sub>1</sub> versus CV <sub>2</sub>	1	0.69	0.28	15.81 **	0.38
Error	50	--	--	--	--
Total	77	--	--	--	--
Error Mean Square		0.24	0.03	1.68	9.86

\* Significant at 5% level

\*\* Significant at 1% level

TABLE 43. ANALYSIS OF VARIANCE F VALUES AND LEVEL OF SIGNIFICANCE

Source	Degrees of Freedom	F Values			
		Nitrogen		Phosphorus	
		Blade*	Plant	Sheath	Plant
V	1	31.05 **	0.37	1.85	12.11 **
S	2	0.53	0.57	0.59	1.42
L	3	0.47	5.25 **	3.10 *	1.74
V x S	2	0.63	2.50	0.34	0.06
V x L	3	1.07	0.90	0.94	0.42
S x L	6	1.05	0.69	0.40	0.91
V x S x L	6	0.97	0.20	1.11	0.52
Salt versus no salt	1	93.68 **	0.39	2.43	0.19
CV <sub>1</sub> versus CV <sub>2</sub>	1	6.040	0.00	3.65	7.95 **
Error	50	--	--	--	--
Total	77	--	--	--	--
Error Mean Square		0.007	0.01	23042.98	33407.99

TABLE 44. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
Na CONTENT IN SUGARCANE PLANT

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	**	*	--	--
Medium-High	**	**	**	--
High	**	**	**	**

TABLE 45. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
Na CONTENT IN SUGARCANE SHEATH

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	*	--	--	--
Medium-High	**	**	*	--
High	**	**	**	**

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 46. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
K CONTENT IN SUGARCANE PLANT

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	--	--	--	--
Medium-High	--	**	*	--
High	--	**	--	--

TABLE 47. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
Ca CONTENT IN SUGARCANE SHEATH

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	*	--	--	--
Medium	**	**	--	--
Medium-High	**	**	--	--
High	**	**	--	--

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 48. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
Mg CONTENT IN SUGARCANE SHEATH

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	**	--	--	--
Medium	--	--	--	--
Medium-High	**	--	**	--
High	**	--	**	--

TABLE 49. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
Cl CONTENT IN SUGARCANE SHEATH

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	--	--	--	--
Medium-High	*	*	*	--
High	**	**	*	--

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 50. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
Cl CONTENT IN SUGARCANE PLANT

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	**	--	--	--
Medium	**	--	--	--
Medium-High	**	**	**	--
High	**	**	**	--

TABLE 51. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
S CONTENT IN SUGARCANE SHEATH

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	--	--	--	--
Medium-high	--	**	*	--
High	*	**	**	--

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 52. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
N CONTENT IN SUGARCANE PLANT

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	--	--	--	--
Medium-High	--	--	*	--
High	--	**	**	--

TABLE 53. DMR TEST FOR SIGNIFICANT DIFFERENCES  
BETWEEN SALINITY LEVELS IN RELATION TO THE  
P CONTENT IN SUGARCANE SHEATH

Salt Concentration	No Salt	Low	Medium	Medium- High
Low	--	--	--	--
Medium	--	--	--	--
Medium-High	--	--	--	--
High	*	--	*	*

\* Significant at 5% level.

\*\* Significant at 1% level.

TABLE 54. EFFECT OF SALT TREATMENTS ON  
 DRY MATTER YIELD OF PLANTS, GRAMS

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	125	135	166	135	123	111
S <sub>1</sub> L <sub>1</sub>	195	104	148	116	104	127
L <sub>2</sub>	138	132	103	121	82	192
L <sub>3</sub>	96	97	98	77	85	92
L <sub>4</sub>	43	51	75	38	135	85
S <sub>2</sub> L <sub>1</sub>	123	114	105	90	91	116
L <sub>2</sub>	72	133	117	97	123	112
L <sub>3</sub>	79	105	109	126	171	188
L <sub>4</sub>	42	91	111	112	106	126
S <sub>3</sub> L <sub>1</sub>	123	105	126	134	101	136
L <sub>2</sub>	76	103	108	110	111	94
L <sub>3</sub>	70	83	72	109	92	145
L <sub>4</sub>	84	102	107	102	92	62

TABLE 55. EFFECT OF SALT TREATMENTS ON  
GREEN WEIGHT OF PLANTS, GRAMS

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	659	695	850	545	818	429
S <sub>1</sub> L <sub>1</sub>	1100	392	598	490	585	545
L <sub>2</sub>	526	511	417	527	358	820
L <sub>3</sub>	355	426	375	309	296	370
L <sub>4</sub>	170	205	288	165	586	332
S <sub>2</sub> L <sub>1</sub>	596	543	503	462	417	476
L <sub>2</sub>	282	576	458	398	601	511
L <sub>3</sub>	298	392	370	471	765	721
L <sub>4</sub>	147	385	422	407	430	485
S <sub>3</sub> L <sub>1</sub>	529	444	514	581	522	545
L <sub>2</sub>	293	420	421	470	478	362
L <sub>3</sub>	258	316	280	320	363	638
L <sub>4</sub>	347	396	397	441	357	237

TABLE 56. EFFECT OF SALT TREATMENTS ON INCREMENT  
IN HEIGHT OF PLANTS, CMS (Feb. 15-June 2)

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	127.0	101.5	116.0	125.0	110.5	132.0
S <sub>1</sub> L <sub>1</sub>	116.0	81.0	57.5	87.0	103.0	74.5
L <sub>2</sub>	76.0	62.0	92.5	105.0	68.5	98.0
L <sub>3</sub>	72.5	31.0	46.5	36.0	46.5	22.0
L <sub>4</sub>	35.0	66.0	42.0	66.0	89.0	28.0
S <sub>2</sub> L <sub>1</sub>	96.5	124.0	132.5	88.0	85.0	84.0
L <sub>2</sub>	88.5	116.0	35.0	84.0	99.5	79.5
L <sub>3</sub>	107.5	64.0	46.0	90.0	62.5	60.0
L <sub>4</sub>	43.0	81.0	77.5	78.0	53.0	32.5
S <sub>3</sub> L <sub>1</sub>	95.5	104.0	132.0	46.5	71.0	83.0
L <sub>2</sub>	121.5	101.5	94.5	85.0	95.5	43.5
L <sub>3</sub>	64.0	53.0	82.0	40.0	33.0	77.0
L <sub>4</sub>	15.5	84.0	23.0	76.0	27.5	42.5

TABLE 57. EFFECT OF SALT TREATMENTS ON SHEATH MOISTURE,  
PERCENT FRESH WEIGHT BASIS

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	84.88	87.17	83.72	76.86	77.81	78.54
S <sub>1</sub> L <sub>1</sub>	77.60	78.91	77.83	80.22	67.50	74.33
L <sub>2</sub>	75.89	75.46	75.55	70.66	69.62	72.07
L <sub>3</sub>	76.20	74.48	73.52	72.00	69.76	73.72
L <sub>4</sub>	76.25	73.22	74.82	76.21	73.06	71.81
S <sub>2</sub> L <sub>1</sub>	80.00	77.87	74.13	77.19	73.96	76.18
L <sub>2</sub>	75.52	74.50	76.17	69.41	71.36	67.34
L <sub>3</sub>	73.25	73.37	71.93	68.84	69.60	67.92
L <sub>4</sub>	73.05	72.06	72.43	64.66	74.70	67.40
S <sub>3</sub> L <sub>1</sub>	78.92	75.55	77.07	72.30	73.68	71.29
L <sub>2</sub>	76.44	75.67	74.32	74.15	72.13	71.42
L <sub>3</sub>	74.54	74.62	77.33	71.55	71.42	72.41
L <sub>4</sub>	74.93	73.33	77.09	74.88	71.56	70.00

TABLE 58. EFFECT OF SALT TREATMENTS ON FRESH WEIGHT  
OF SHEATH NOS. 3, 4, 5, AND 6, GRAMS

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	44.5	40.0	25.5	26.0	28.0	28.5
S <sub>1</sub> L <sub>1</sub>	37.0	42.5	38.0	45.5	26.0	30.0
L <sub>2</sub>	40.0	33.5	36.5	30.0	27.0	26.5
L <sub>3</sub>	30.5	30.0	35.0	29.0	23.0	25.5
L <sub>4</sub>	16.5	31.0	30.0	21.0	25.5	22.5
S <sub>2</sub> L <sub>1</sub>	27.0	33.5	32.5	29.0	27.0	27.5
L <sub>2</sub>	34.0	36.0	41.0	26.0	22.5	25.0
L <sub>3</sub>	41.5	43.5	44.5	26.5	25.0	27.5
L <sub>4</sub>	30.5	33.0	38.0	16.0	35.5	27.0
S <sub>3</sub> L <sub>1</sub>	29.0	42.5	45.5	26.5	29.0	28.5
L <sub>2</sub>	32.0	39.5	34.5	27.5	31.5	28.5
L <sub>3</sub>	28.5	28.5	38.0	24.0	29.0	29.5
L <sub>4</sub>	38.0	25.5	28.0	22.5	26.5	29.0

TABLE 59. EFFECT OF SALT TREATMENTS ON INCREMENT  
IN HEIGHT OF PLANTS, CMS (February 15-March 10)

Treatment	V <sub>1</sub>			s	V <sub>2</sub>		
	R I	R II	R III		R I	R II	R III
Check	20.0	7.5	16.0		28.0	13.0	19.5
S <sub>1</sub> L <sub>1</sub>	17.0	28.0	4.0		12.0	12.0	5.0
L <sub>2</sub>	7.0	1.0	12.0		17.0	20.0	23.0
L <sub>3</sub>	0.5	2.0	5.0		8.0	13.0	9.0
L <sub>4</sub>	14.0	15.0	17.0		31.5	13.0	19.0
S <sub>2</sub> L <sub>1</sub>	7.0	14.0	37.5		14.0	27.0	6.0
L <sub>2</sub>	7.0	21.0	13.0		11.0	18.0	13.0
L <sub>3</sub>	26.5	6.5	5.0		29.0	6.0	8.0
L <sub>4</sub>	16.0	28.0	24.0		8.0	24.0	9.0
S <sub>3</sub> L <sub>1</sub>	21.0	1.0	30.0		4.0	3.0	10.0
L <sub>2</sub>	11.5	13.0	18.0		16.0	17.0	10.5
L <sub>3</sub>	17.0	5.0	23.0		6.0	8.0	22.0
L <sub>4</sub>	7.0	31.0	10.0		4.0	10.0	20.0

TABLE 60. EFFECT OF SALT TREATMENTS ON INCREMENT  
IN HEIGHT OF PLANTS, CMS (March 11-April 13)

Treatments	V <sub>1</sub>			V <sub>2</sub>			
	R I	R II	R III	R I	R II	R III	
Check	46.0	38.0	42.0	44.0	39.0	66.5	
S <sub>1</sub>	L <sub>1</sub>	28.0	25.0	19.0	35.0	29.0	43.0
	L <sub>2</sub>	35.0	26.0	34.0	26.0	16.0	14.0
	L <sub>3</sub>	18.0	9.0	21.0	7.0	13.0	6.0
	L <sub>4</sub>	10.0	18.0	11.0	7.0	18.0	5.0
S <sub>2</sub>	L <sub>1</sub>	50.0	39.0	40.0	14.0	28.0	23.0
	L <sub>2</sub>	29.0	27.0	9.0	25.0	27.0	25.0
	L <sub>3</sub>	24.0	12.0	6.0	34.0	31.0	27.0
	L <sub>4</sub>	20.0	14.0	29.0	14.0	19.0	12.0
S <sub>3</sub>	L <sub>1</sub>	31.5	31.0	36.0	5.0	20.0	21.0
	L <sub>2</sub>	25.0	15.0	30.6	19.0	29.0	18.0
	L <sub>3</sub>	10.0	18.0	21.0	16.0	9.0	17.0
	L <sub>4</sub>	2.0	24.0	6.0	22.0	1.0	15.0

TABLE 61. EFFECT OF SALT TREATMENT ON INCREMENT  
IN HEIGHT OF PLANTS, CMS (April 14-May 9)

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	41.0	36.0	39.5	32.0	17.0	36.5
S <sub>1</sub> L <sub>1</sub>	47.0	15.0	15.0	27.0	33.0	9.0
L <sub>2</sub>	23.5	8.0	25.0	46.0	15.0	44.5
L <sub>3</sub>	22.0	3.0	7.0	0.0	12.0	1.0
L <sub>4</sub>	8.0	14.0	4.0	7.0	35.0	2.0
S <sub>2</sub> L <sub>1</sub>	22.0	40.5	30.0	49.0	8.5	17.0
L <sub>2</sub>	37.0	32.0	7.0	34.0	36.0	16.5
L <sub>3</sub>	38.0	20.0	19.0	18.0	14.0	11.0
L <sub>4</sub>	0.0	7.0	12.5	32.0	6.0	5.0
S <sub>3</sub> L <sub>1</sub>	30.5	39.0	27.0	21.0	25.0	20.5
L <sub>2</sub>	57.0	36.0	25.0	27.0	33.0	12.0
L <sub>3</sub>	18.0	12.0	19.5	10.0	6.0	9.0
L <sub>4</sub>	2.5	18.0	6.0	26.0	5.0	5.0

TABLE 62. EFFECT OF SALT TREATMENTS ON INCREMENT  
IN HEIGHT OF PLANTS, CMS (May 10-June 2)

Treatments	R I	V <sub>1</sub>		R I	V <sub>2</sub>	
		R II	R III		R II	R III
Check	20.0	20.0	18.5	21.0	41.5	9.5
S <sub>1</sub> L <sub>1</sub>	24.0	13.0	19.5	13.0	29.0	17.5
L <sub>2</sub>	10.5	27.0	21.5	16.0	17.5	16.5
L <sub>3</sub>	32.0	17.0	13.5	21.0	8.5	6.0
L <sub>4</sub>	3.0	19.0	10.0	20.5	23.0	2.0
S <sub>2</sub> L <sub>1</sub>	17.5	30.5	25.0	11.0	21.5	38.0
L <sub>2</sub>	15.5	36.0	6.0	14.0	18.5	25.0
L <sub>3</sub>	19.0	25.5	16.0	9.0	11.5	14.0
L <sub>4</sub>	7.0	32.0	12.0	24.0	4.0	6.5
S <sub>3</sub> L <sub>1</sub>	12.5	33.0	39.0	16.5	23.0	31.5
L <sub>2</sub>	28.0	37.5	21.5	23.0	16.5	3.0
L <sub>3</sub>	19.0	18.0	18.5	8.0	10.0	29.0
L <sub>4</sub>	4.0	11.0	1.0	24.0	11.5	2.5

TABLE 63. EFFECT OF SALT TREATMENTS ON  
EMERGENCE OF NEW LEAVES

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	20	19	19	19	21	15
S <sub>1</sub> L <sub>1</sub>	20	16	15	17	18	13
L <sub>2</sub>	18	16	15	17	15	13
L <sub>3</sub>	17	18	16	15	17	15
L <sub>4</sub>	14	14	13	14	17	13
S <sub>2</sub> L <sub>1</sub>	19	18	15	17	16	17
L <sub>2</sub>	15	18	15	15	16	14
L <sub>3</sub>	15	19	14	16	19	15
L <sub>4</sub>	14	17	15	15	14	16
S <sub>3</sub> L <sub>1</sub>	18	18	18	17	15	15
L <sub>2</sub>	16	18	14	16	16	14
L <sub>3</sub>	16	18	13	15	15	13
L <sub>4</sub>	13	19	17	17	12	13

TABLE 64. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF SODIUM IN CANE SHEATH, PPM

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1090	671	628	842	541	765
S <sub>1</sub> L <sub>1</sub>	1175	823	752	1289	779	1172
L <sub>2</sub>	1376	1108	1125	1762	822	1546
L <sub>3</sub>	1438	1823	2539	2458	1005	1918
L <sub>4</sub>	4076	2862	2806	4424	1586	2155
S <sub>2</sub> L <sub>1</sub>	1104	919	1063	863	966	1024
L <sub>2</sub>	1303	1070	1568	1181	1011	1141
L <sub>3</sub>	2144	1123	1730	1282	1126	1218
L <sub>4</sub>	2534	1570	1909	1830	1297	1504
S <sub>3</sub> L <sub>1</sub>	1574	1112	1107	883	629	1215
L <sub>2</sub>	1713	1434	1119	2057	669	1263
L <sub>3</sub>	2495	1595	1345	2110	1046	1632
L <sub>4</sub>	4223	1638	2365	2388	1131	1455

TABLE 65. EFFECT OF SALT TREATMENT ON CONCENTRATION OF SODIUM IN PLANT, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1201	1164	1279	1386	1287	971
S <sub>1</sub> L <sub>1</sub>	1577	1837	2083	1524	2116	1022
L <sub>2</sub>	1764	1921	2576	2144	2442	1493
L <sub>3</sub>	2387	2193	3920	3979	2662	3029
L <sub>4</sub>	4583	3584	4783	4644	3670	3152
S <sub>2</sub> L <sub>1</sub>	1728	1497	1703	1665	1413	1025
L <sub>2</sub>	2198	1581	1837	1965	1452	1628
L <sub>3</sub>	2685	1885	2441	2033	2438	1760
L <sub>4</sub>	3152	2682	2648	2256	2769	1770
S <sub>3</sub> L <sub>1</sub>	2143	1270	1472	1648	1343	1162
L <sub>2</sub>	2344	1672	1715	2663	1848	1186
L <sub>3</sub>	2986	2605	1782	3148	3259	1429
L <sub>4</sub>	4169	2848	2658	2718	3236	3633

TABLE 66. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF POTASSIUM IN CANE SHEATH, PERCENT

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	3.10	3.20	3.30	3.42	3.85	3.84
S <sub>1</sub> L <sub>1</sub>	3.62	2.60	3.25	3.85	3.03	3.84
L <sub>2</sub>	2.75	2.41	3.00	3.33	3.63	3.54
L <sub>3</sub>	2.30	2.42	3.80	4.00	3.86	4.60
L <sub>4</sub>	4.21	3.02	3.24	3.75	3.08	4.53
S <sub>2</sub> L <sub>1</sub>	3.06	2.61	3.05	3.71	3.58	3.32
L <sub>2</sub>	2.09	3.10	2.25	3.66	3.17	4.11
L <sub>3</sub>	2.58	2.53	2.32	3.77	3.79	3.31
L <sub>4</sub>	2.16	3.24	2.60	2.32	3.70	3.34
S <sub>3</sub> L <sub>1</sub>	2.75	2.43	2.45	3.94	3.20	3.74
L <sub>2</sub>	3.44	2.62	2.91	3.11	3.75	4.09
L <sub>3</sub>	3.17	2.97	3.57	4.10	4.58	4.48
L <sub>4</sub>	4.32	2.76	3.56	3.57	4.52	5.80

TABLE 67. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF POTASSIUM IN CANE PLANT, PERCENT

Treatment	V <sub>1</sub>			V <sub>1</sub>		
	R I	R II	R III	R I	R II	R III
Check	2.34	2.20	2.55	2.04	2.59	2.32
S <sub>1</sub> L <sub>1</sub>	2.78	2.10	2.17	2.51	2.66	2.36
L <sub>2</sub>	2.16	2.10	2.18	2.55	2.45	2.55
L <sub>3</sub>	2.16	1.74	1.77	2.58	2.13	2.32
L <sub>4</sub>	2.25	1.79	2.24	2.34	2.38	2.38
S <sub>2</sub> L <sub>1</sub>	2.15	2.16	2.84	2.69	2.43	2.25
L <sub>2</sub>	2.12	2.39	1.98	2.43	2.36	2.37
L <sub>3</sub>	1.94	1.85	1.54	2.26	2.39	2.02
L <sub>4</sub>	1.58	2.17	1.76	2.04	2.17	2.08
S <sub>3</sub> L <sub>1</sub>	2.33	2.10	1.96	2.89	2.50	2.31
L <sub>2</sub>	2.10	2.27	2.11	2.40	2.33	2.47
L <sub>3</sub>	2.08	2.11	2.28	2.49	2.42	2.57
L <sub>4</sub>	2.33	2.27	2.30	2.70	2.30	2.31

TABLE 68. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF CALCIUM IN CANE SHEATH, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1676	1512	1544	1618	1192	1808
S <sub>1</sub> L <sub>1</sub>	1532	1176	821	1325	1462	1715
L <sub>2</sub>	1254	1151	1128	1263	1289	1496
L <sub>3</sub>	1415	1124	1921	1156	950	1237
L <sub>4</sub>	1463	1434	1124	1570	907	987
S <sub>2</sub> L <sub>1</sub>	1253	1395	1189	1187	895	1311
L <sub>2</sub>	806	1132	737	841	1162	881
L <sub>3</sub>	1336	798	756	706	601	659
L <sub>4</sub>	732	651	561	616	515	476
S <sub>3</sub> L <sub>1</sub>	1481	1425	1832	1595	1204	1141
L <sub>2</sub>	1286	1127	1069	1194	1222	1254
L <sub>3</sub>	1427	1481	1102	1147	1335	882
L <sub>4</sub>	1295	1210	1335	1382	1085	1358

TABLE 69. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF CALCIUM IN PLANT, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	2088	1671	3363	2073	1416	1257
S <sub>1</sub> L <sub>1</sub>	2041	2572	1409	2593	1661	2505
L <sub>2</sub>	1876	2047	1105	1797	2082	1200
L <sub>3</sub>	2398	1827	3033	2752	2497	1502
L <sub>4</sub>	2857	2733	1706	1982	1423	1061
S <sub>2</sub> L <sub>1</sub>	2205	1618	766	1395	1821	1235
L <sub>2</sub>	1328	1457	855	1501	1195	1034
L <sub>3</sub>	2177	1256	1090	1403	1323	588
L <sub>4</sub>	1740	1390	401	1164	1250	586
S <sub>3</sub> L <sub>1</sub>	2060	1847	2942	2620	1876	1980
L <sub>2</sub>	2124	2348	1500	1859	1899	2106
L <sub>3</sub>	2787	2787	2630	2618	2431	1704
L <sub>4</sub>	3073	3073	2274	1904	2338	2325

TABLE 70. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF MAGNESIUM IN CANE SHEATH, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1805	1617	1976	2130	1869	1713
S <sub>1</sub> L <sub>1</sub>	2141	2259	1895	2396	1898	2294
L <sub>2</sub>	1921	2133	2147	1961	2169	1817
L <sub>3</sub>	2159	2328	2234	2699	2373	2165
L <sub>4</sub>	2569	2511	2179	2305	1740	1936
S <sub>2</sub> L <sub>1</sub>	2050	1664	1928	1828	2206	2090
L <sub>2</sub>	1745	1552	2003	2177	1629	2072
L <sub>3</sub>	1861	1952	1938	2178	2021	1830
L <sub>4</sub>	2170	2166	1806	1663	2132	1749
S <sub>3</sub> L <sub>1</sub>	2311	2199	2327	2870	2178	2122
L <sub>2</sub>	2361	2478	2027	2085	1967	2164
L <sub>3</sub>	2869	2639	2359	2763	2830	2164
L <sub>4</sub>	2617	2728	2518	2600	2567	2118

TABLE 71. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF MAGNESIUM IN PLANT, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1350	1237	1540	1399	1666	1670
S <sub>1</sub> L <sub>1</sub>	1507	1307	1107	1472	1726	2041
L <sub>2</sub>	1342	1300	1319	1275	1657	1608
L <sub>3</sub>	1393	1349	1817	1394	1345	1450
L <sub>4</sub>	1525	1499	1560	1648	1268	1308
S <sub>2</sub> L <sub>1</sub>	1406	1161	1547	1505	1567	1734
L <sub>2</sub>	1185	1088	1361	1344	1572	1632
L <sub>3</sub>	1189	1182	1468	1367	1600	1575
L <sub>4</sub>	1445	1079	1318	1046	1486	1293
S <sub>3</sub> L <sub>1</sub>	1872	1545	1895	1970	1523	1704
L <sub>2</sub>	1604	1541	1628	1533	1852	1805
L <sub>3</sub>	1925	2098	1751	1659	1808	1545
L <sub>4</sub>	1908	2067	1815	1844	1914	1968

TABLE 72. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF CHLORIDE IN CANE SHEATH, PERCENT

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1.46	1.54	1.61	1.66	2.02	1.93
S <sub>1</sub> L <sub>1</sub>	2.09	1.93	1.78	2.35	2.93	1.87
L <sub>2</sub>	2.02	1.97	1.85	2.55	2.12	2.89
L <sub>3</sub>	2.46	1.95	4.77	2.88	3.13	2.30
L <sub>4</sub>	4.13	2.66	2.96	3.85	2.40	2.15
S <sub>2</sub> L <sub>1</sub>	1.46	1.34	1.53	1.71	1.62	1.67
L <sub>2</sub>	1.22	1.40	1.11	1.53	1.68	1.74
L <sub>3</sub>	1.23	1.21	1.06	1.48	1.56	1.46
L <sub>4</sub>	0.43	0.83	0.78	0.88	1.10	0.91
S <sub>3</sub> L <sub>1</sub>	1.99	1.66	1.97	2.09	2.25	2.26
L <sub>2</sub>	2.16	2.17	2.22	2.10	2.63	2.87
L <sub>3</sub>	2.71	2.79	2.60	2.89	3.74	2.13
L <sub>4</sub>	3.80	2.72	3.04	2.89	3.38	4.26

TABLE 73. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF CHLORIDE IN PLANT, PERCENT

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1.08	1.44	1.38	1.20	1.11	1.36
S <sub>1</sub> L <sub>1</sub>	2.03	1.56	2.07	1.54	1.64	1.53
L <sub>2</sub>	1.80	2.15	1.85	1.89	1.64	1.53
L <sub>3</sub>	2.26	2.20	2.22	2.09	1.76	2.57
L <sub>4</sub>	2.26	2.68	2.17	2.61	2.33	2.39
S <sub>2</sub> L <sub>1</sub>	1.46	1.20	1.18	1.12	1.09	1.25
L <sub>2</sub>	0.94	0.83	1.28	0.91	1.10	1.01
L <sub>3</sub>	0.86	1.21	1.16	0.87	0.83	0.84
L <sub>4</sub>	0.50	0.83	0.74	0.49	0.57	0.63
S <sub>3</sub> L <sub>1</sub>	1.84	1.80	1.92	1.48	1.34	1.69
L <sub>2</sub>	1.93	1.81	2.13	1.58	1.76	1.79
L <sub>3</sub>	2.09	2.37	2.17	2.06	2.29	2.11
L <sub>4</sub>	2.11	2.50	2.35	2.10	2.14	2.68

TABLE 74. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF SULPHUR IN CANE SHEATH, PPM\*

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	6.90	8.54	8.99	3.72	3.90	4.18
S <sub>1</sub> L <sub>1</sub>	4.36	6.90	4.18	4.18	2.27	3.54
L <sub>2</sub>	6.45	4.81	5.72	2.90	2.45	3.90
L <sub>3</sub>	5.27	3.27	3.90	4.18	1.99	2.45
L <sub>4</sub>	2.45	3.72	2.63	3.72	2.45	2.72
S <sub>2</sub> L <sub>1</sub>	10.09	10.45	10.36	4.81	6.18	17.89
L <sub>2</sub>	10.36	10.81	11.36	5.27	7.36	21.90
L <sub>3</sub>	15.81	13.27	11.90	9.54	9.27	29.17
L <sub>4</sub>	19.81	17.63	12.99	10.36	12.99	33.44
S <sub>3</sub> L <sub>1</sub>	7.36	4.18	6.18	4.18	3.54	3.27
L <sub>2</sub>	6.45	5.27	5.09	5.09	3.54	1.99
L <sub>3</sub>	7.36	6.18	9.27	6.45	3.72	2.90
L <sub>4</sub>	5.09	8.36	6.90	4.18	3.90	3.72

\* ALL Figures are to be multiplied by constant dilution factor of 200.

TABLE 75. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF SULPHUR IN PLANT, PPM\*

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	8.81	13.54	7.63	8.81	10.36	15.54
S <sub>1</sub> L <sub>1</sub>	10.81	11.09	7.36	8.36	8.99	14.90
L <sub>2</sub>	8.81	10.54	6.45	6.45	5.54	9.27
L <sub>3</sub>	7.81	8.81	6.36	4.18	4.18	4.81
L <sub>4</sub>	4.18	5.54	6.90	4.18	3.27	7.09
S <sub>2</sub> L <sub>1</sub>	13.54	18.90	9.27	11.09	10.81	15.81
L <sub>2</sub>	14.09	20.81	10.36	15.27	12.99	18.90
L <sub>3</sub>	21.54	21.81	13.27	16.45	18.54	20.18
L <sub>4</sub>	25.45	24.72	14.63	15.54	20.18	22.90
S <sub>3</sub> L <sub>1</sub>	17.63	13.54	8.81	8.36	6.45	7.36
L <sub>2</sub>	15.27	9.27	7.09	7.09	6.45	8.81
L <sub>3</sub>	13.54	8.09	8.36	7.09	8.81	8.36
L <sub>4</sub>	7.81	9.81	7.81	6.18	8.81	9.81

\* All figures are to be multiplied by constant dilution factor 200.

TABLE 76. EFFECT OF SALT TREATMENTS ON NITROGEN  
CONCENTRATION IN LEAFBLADES, PERCENT

Treatment	V <sub>1</sub>			V <sub>2</sub>			
	R I	R II	R III	R I	R II	R III	
Check	1.65	1.73	1.84	1.81	2.10	1.82	
S <sub>1</sub>	L <sub>1</sub>	1.58	1.45	1.50	1.55	1.41	1.48
	L <sub>2</sub>	1.54	1.52	1.50	1.53	1.36	1.37
	L <sub>3</sub>	1.55	1.57	1.45	1.54	1.47	1.28
	L <sub>4</sub>	1.53	1.59	1.57	1.57	1.48	1.36
S <sub>2</sub>	L <sub>1</sub>	1.60	1.39	1.42	1.47	1.43	1.35
	L <sub>2</sub>	1.52	1.68	1.42	1.52	1.37	1.52
	L <sub>3</sub>	1.58	1.55	1.54	1.47	1.30	1.24
	L <sub>4</sub>	1.66	1.60	1.56	1.64	1.37	1.31
S <sub>3</sub>	L <sub>1</sub>	1.52	1.56	1.41	1.40	1.37	1.41
	L <sub>2</sub>	1.62	1.73	1.44	1.41	1.37	1.35
	L <sub>3</sub>	1.67	1.61	1.44	1.40	1.34	1.51
	L <sub>4</sub>	1.35	1.58	1.40	1.46	1.42	1.38

TABLE 77. EFFECT OF SALT TREATMENTS ON NITROGEN CONCENTRATION IN PLANT, PERCENT

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1.04	0.90	1.15	0.91	1.10	1.11
S <sub>1</sub> L <sub>1</sub>	0.86	0.96	0.92	1.05	0.98	1.12
L <sub>2</sub>	1.00	1.04	1.01	0.90	1.16	1.07
L <sub>3</sub>	0.94	1.01	1.16	1.22	1.04	1.12
L <sub>4</sub>	1.13	1.06	1.06	1.33	0.98	1.11
S <sub>2</sub> L <sub>1</sub>	0.98	0.86	1.17	1.02	0.99	1.08
L <sub>2</sub>	1.13	1.03	1.13	0.88	0.92	1.13
L <sub>3</sub>	1.06	1.15	1.11	0.80	1.16	1.14
L <sub>4</sub>	0.98	1.19	1.26	1.02	1.16	1.12
S <sub>3</sub> L <sub>1</sub>	1.16	0.98	0.99	1.05	1.06	1.05
L <sub>2</sub>	1.03	1.02	1.01	0.88	0.78	1.24
L <sub>3</sub>	1.21	1.11	1.10	1.09	1.13	1.36
L <sub>4</sub>	0.98	1.12	1.16	1.08	1.12	1.25

TABLE 78. EFFECT OF SALT TREATMENTS ON PHOSPHORUS  
CONCENTRATION IN CANE SHEATH, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	1305	1211	1221	916	1001	1109
S <sub>1</sub> L <sub>1</sub>	1447	1157	978	1141	1175	1214
L <sub>2</sub>	1085	1266	1145	1013	1159	1225
L <sub>3</sub>	1134	956	1040	1335	1208	1180
L <sub>4</sub>	1162	1306	1320	1736	1136	1296
S <sub>2</sub> L <sub>1</sub>	1183	1213	1407	1717	1317	951
L <sub>2</sub>	1319	1205	1188	1153	1330	1268
L <sub>3</sub>	1181	998	1014	1177	1361	1210
L <sub>4</sub>	1117	1442	1253	1302	1463	1124
S <sub>3</sub> L <sub>1</sub>	1428	1284	1183	1361	1330	975
L <sub>2</sub>	1263	1117	1152	1389	1009	1144
L <sub>3</sub>	1290	1277	1254	1125	928	1318
L <sub>4</sub>	1124	1289	1150	1539	1498	1273

TABLE 79. EFFECT OF SALT TREATMENTS ON CONCENTRATION OF PHOSPHORUS  
IN MATURE INTERNODE IN SUGARCANE PLANT, PPM

Treatments	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	744	868	497	372	852	1243
S <sub>1</sub> L <sub>1</sub>	755	1107	1101	744	1054	746
L <sub>2</sub>	744	1172	1136	713	651	1562
L <sub>3</sub>	775	930	959	888	1085	888
L <sub>4</sub>	1054	1102	888	1050	845	1136
S <sub>2</sub> L <sub>1</sub>	899	852	1101	2356	1034	852
L <sub>2</sub>	959	817	923	628	682	868
L <sub>3</sub>	941	930	1917	846	888	923
L <sub>4</sub>	1669	558	921	1212	923	639
S <sub>3</sub> L <sub>1</sub>	1119	1023	852	1364	1101	1030
L <sub>2</sub>	682	1152	888	678	746	959
L <sub>3</sub>	2130	922	1212	1153	710	852
L <sub>4</sub>	868	702	768	1136	746	888

TABLE 80. EFFECT OF SALT TREATMENTS ON PHOSPHORUS CONCENTRATION IN PLANT, PPM

Treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	637	545	455	885	1250	765
S <sub>1</sub> L <sub>1</sub>	878	801	744	906	881	721
L <sub>2</sub>	612	756	575	625	633	1079
L <sub>3</sub>	749	746	743	1135	926	1403
L <sub>4</sub>	711	958	622	709	726	1208
S <sub>2</sub> L <sub>1</sub>	776	724	594	1247	795	563
L <sub>2</sub>	575	580	711	826	646	719
L <sub>3</sub>	534	565	679	953	612	674
L <sub>4</sub>	647	1033	613	899	951	865
S <sub>3</sub> L <sub>1</sub>	598	734	573	1163	521	924
L <sub>2</sub>	798	723	554	874	712	819
L <sub>3</sub>	714	823	842	888	615	1268
L <sub>4</sub>	873	691	912	871	1025	777

TABLE 81. EFFECT OF SALT TREATMENTS ON SALT CONCENTRATION IN LEACHATES  
 READ ONE DAY BEFORE HARVEST. ELECTRICAL CONDUCTIVITY (m.mhos/cm)

treatment	V <sub>1</sub>			V <sub>2</sub>		
	R I	R II	R III	R I	R II	R III
Check	0.7	0.6	1.0	0.9	1.5	1.5
S <sub>1</sub> L <sub>1</sub>	3.0	3.5	3.4	3.2	2.5	3.5
L <sub>2</sub>	6.2	5.0	5.0	5.4	6.1	6.0
L <sub>3</sub>	7.0	7.3	8.5	7.5	8.1	8.2
L <sub>4</sub>	12.0	11.1	9.8	9.0	10.1	10.4
S <sub>2</sub> L <sub>1</sub>	3.0	3.2	3.5	3.5	3.1	3.5
L <sub>2</sub>	6.0	5.4	5.2	5.8	6.2	5.2
L <sub>3</sub>	8.8	7.0	8.9	6.9	8.4	8.6
L <sub>4</sub>	10.0	11.0	11.0	9.5	10.2	12.0
S <sub>3</sub> L <sub>1</sub>	3.3	3.5	3.4	3.3	2.5	3.6
L <sub>2</sub>	6.1	5.3	5.8	5.4	5.2	5.6
L <sub>3</sub>	8.1	7.1	7.6	8.7	8.2	7.1
L <sub>4</sub>	12.2	9.2	9.0	9.6	10.0	10.2

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