I. Seasonal Fluctuations in Quality of Well Waters from Mahatma Phule Krishi Vidyapeeth, Central Campus Farm Rahuri, (M. S.) and its Vicinity.

II. Use of Saline Water for Jowar (*Sorghum vulgare*, Pers. Variety, CSH-4) Crop Production.

by

Tushar D. Patil
B. Sc. (Agri.) First Class.

A THESIS
submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH
(AGRICULTURAL UNIVERSITY)
Rahuri, Dist. Ahmednagar (Maharashtra)

in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (AGRICULTURE)
in
Agricultural Chemistry and Soil Science

DIVISION OF AGRICULTURAL CHEMISTRY AND SOIL SCIENCE,
POST-GRADUATE SCHOOL, RAHURI.
MAY, 1974

Dedicated

to

My Late Mother

AKKATAI

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Approved by the Advisory Committee

Chairman and
Research Guide ________________ Prof.M.D.Patil

Member ________________ Prof. G.K. Zende

Member ________________ Dr.B.R.Patil.

CERTIFICATE

This is to certify that the thesis entitled

I. " Seasonal Fluctuations in Quality of Well Waters from Mahatma Phule Krishi Vidyapeeth, Central Campus Farm, Rahuri (M.S.) and its Vicinity",

II. " Use of Saline Water for Jowar (*Sorghum vulgare*, Pers. variety, CSH-4) Crop Production ",

submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth (Agricultural University), Rahuri, District Ahmednagar (Maharashtra) in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL CHEMISTRY AND SOIL SCIENCE

embodies the results of a piece of bonafide research work carried out by Shri. TUSHAR DATTATRAYA PATIL under my guidance and supervision and that no part of the thesis has been submitted for any other degree or publication.

Prof. M.D. Patil,
Research Guide

Division of Agricultural
Chemistry and Soil Science,
Post-Graduate School,
Mahatma Phule Krishi Vidyapeeth,
Rahuri (Dist : Ahmednagar).

Date : 17-5-1974

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Division of Agricultural
Chemistry and Soil Science,
Post-Graduate School,
Mahatma Phule Krishi Vidyapeeth,
Rahuri, Dist : Ahmednagar.

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CHAPTER I

INTRODUCTION

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INTRODUCTION

Good and assured water supply is one of the important factor for increasing agricultural production. The concentration and composition of dissolved constituents in water determine its quality for irrigation purpose. The quality of irrigation water is the limiting factor in the irrigation of many areas in India.

In India, out of total cultivated area of 163.9 million hectares, only 35 million hectares are under irrigation (Naigamvala, 1973). Out of the total irrigated area, about 41.4 per cent is covered by canals, 26 per cent by open wells, 7.7 per cent by tubewells, 16.87 per cent by tanks and 8.10 per cent by other sources. The sources of irrigation waters are different in different parts of India, but all waters contain some quantity of soluble salts. Final results of the use of such waters containing soluble salt is the development of salinity, alkalinity or both.

In Maharashtra, out of 19.43 million hectares of gross area sown, 1.43 million hectares are under irrigation. The area irrigated by well waters in Maharashtra is about 57.38 per cent to net irrigated area (1969-70). In Ahmednagar district out of 1.3242 million hectares of gross area sown, 0.146537 million hectares are under irrigation. Area irrigated by well waters in the district is about 41155.80 hectares and in Rahuri taluka it is about 8462 hectares.

Jowar is the main cereal crop grown in Ahmednagar district. The area of about 210440.71 hectares is under *jowar* cultivation, mainly in *rabi* season. Of the total area under *jowar* cultivation, about 20684.34 hectares are under irrigation.

Success of irrigated agriculture mainly depends upon efficient use of irrigation water, without allowing soil salinity, alkalinity or water logging conditions to develop. This will need knowledge of quality of irrigation water and its suitability to major crops of the region.

There are also number of methods which have been suggested for improving saline water in this country for irrigation purpose viz., 1) by dilution with good quality water, 2) by treating with amendments like gypsum, farm yard manure, pressmud, basic slag etc. to reduce sodium hazard and (3) by passing through ion exchange materials. Except dilution none of these methods have been tried under field conditions.

The present work was, therefore, undertaken with two main objectives :-

1) to assess the quality of well waters from the University farm and the adjoining villages,

2) to assess the use of saline waters with amendments for crop production on saline and non-saline soils.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The main cause of declining the productivity of lacs of acres of land in Punjab, Rajsthan, Uttar Pradesh, Gujrath and Maharashtra State, is the influence of salts which are present in soils. Now days the irrigation facilities are increasing in the State due to construction of head canals and implementation of co-operative lift irrigation schemes. But we should use these facilities very wisely and properly. The land becomes unproductive due to faulty irrigation practices and use of poor quality irrigation water. So to avoid further danger of salts accumulation in the soil, we should have a thorough knowledge of the soil, quality of water, the behaviour of soils and plants on its application and the ameloriating agents which can improve the quality of water and/or neutralise the effect of bad quality irrigation water on soils.

2.1 Quality of water :

The criteria used for the deciding the quality of waters has been discussed by Agarwal R.R. and Gupta R.N. (1968). The quality of river waters and canal waters in India has been found to be very high order,(Mann and Tamhane 1910, Trylor *et al*. 1935, Venkataraman 1941, Asghar and Dhawan 1947, Agarwal and Mehrotra 1952, Govind Iyer 1957). Well waters represent two sources of underground waters namely - tube wells and shallow wells. These waters are usually of varing composition which usually depends upon the nature of the substrata and season.

The major criteria used for the quality of irrigation water are :

1) Salinity expressed in E.C.

2) S.A.R.

3) HCO_3^-

4) Cl^-

5) Boron

6) R.S.C.

7) S.S.P.

8) Salt Index

9) Hardness

10) Gypsum equivalent

Sometimes nature of salts present in irrigation water is more important than its concentration. Even we can use the doubtful quality water without serious damage to soils and crops, if we use it with precautions taken in irrigation and soil management (Thorne and Thorne 1951).

According to Scofield (1935), the maximum boron tolerance limit in irrigation water and its classes are given as under -

Table 2.1 : Classification of water Boron (ppm).

B_1	B_2	B_3	B_4	B_5
0.67	0.67-1.33	1.33-2.0	2.0-2.50	2.50

Magistad and Christensen (1946), have suggested the limits of sodium and boron standards for irrigation waters.

Table 2.2 : Limits for Sodium and boron concentrations in water.

Class	S S P	Boron content (ppm)
I	60	0.5
II	60-75	0.5-2.0
III	75	2.0

Magistad and Chrisenson found 0.14 ppm of boron in the water of the lower Colorado river at Yums, Arinzon and 0.71 ppm in water of wells in the Coachella Valley, California.

Smith (1949), have stated the suitability of irrigation water according to chloride content. The waters containing >5.8 meq per litre Chloride are not suitable for irrigation purposes.

Eaton (1950), has suggested the limits for classification of water according to R S C values, as under.

Table 2.3 : Limits for classification of water according to R S C values.

R S C		Class value	Interpretation
1.25	meq per litre	I	Suitable
1.25-2.5	meq per litre	II	Marginal
2.5	meq per litre	III	Unsuitable

Durand (1956), classified 40 waters of Algeria in relation to their salinity, boron toxicity and alkalinity. Waters having conductivity upto 0.250 millimhos per cm (C_1)

were most suitable. Waters of 0.250-0.750 millimhos per cm (C_2) were suitable for most of the plants. Waters with 0.750-2.250 millimhos per cm (C_3) can be used in soils with good drainage, waters with above 2.250 (C_4) were unsuitable for most of the crops. The alkalinity was measured by the means of S A R. Waters with ratio 0-10 (S_1) were most suitable, water with 10-18 (S_2) were dangerous for fine textured and high exchange capacity soils. The waters having S A R of 18-26 and above 26 are unsuitable for irrigation.

Agarwal, Mehrotra and Ganwar (1956), analysed the waters from U.P. The quality of well waters were dependent upon the nature of substrata and its ground water level.

Govind, Iyer and Subramanian (1960), analysed waters from a locality of Madras for its quality. The canal and river waters are of good quality, while those of wells are of medium quality.

Singh and Kanwar (1963), analysed the well waters from Palli (Amritsar) and found them to contain boron within safe limit i.e. 0.33 ppm. But the boron concentration of the saturation extract of the soil irrigated with those waters varied from 1.42 to 2.90 ppm. which was considered unsafe for sensitive crops.

Sharma, et al. (1963), studied the underground waters in lower Luni catchment and arrived at conclusion that nearly 50 per cent of the waters are saline and 40 per cent are both saline and alkaline on either sides of the river.

Dara, Mehta and Pareek (1964), reported the quality of irrigation waters in Rajasthan. It was classified as saline and alkaline. Canal waters are of good quality while well waters vary with soil types from moderately alkaline to highly alkaline.

Babrekar et al. (1965), reported that the changes in the season brought about fluctuations in pH, T.S.S. content and ionic concentrations. All waters were safe for irrigation in rainy season because S S P was below 60. They have analysed 15 samples from Agricultural College Dhulia Farm. They have also indicated the suitability of irrigation waters according to S A R, S S P and R S C values.

Nathani et al. (1966), found the range of boron in the ground waters of the Chambala commanded area from 0.1 to 3.0 ppm. Boron increases with increase in E.C., pH, S A R and R S C values.

Talati et al. (1966), reported that with the gypsum treatment, E.C. did not increase beyond 4 millimhos per cm in any salinity class of water. Fair correlation of increase in E.C. was observed with the increase in salinity class. The S. A. R. values, except upto medium alkaline waters, did not show any improvement in quality of waters, but 50 per cent or more decrease is found with gypsum treatment. The R S C was reduced to nil.

Handa (1966), studied the quality of ground water in Kutch and stated that the ground waters vary from medium to highly saline and can be used for irrigating plants with moderate to high salt tolerance. Most of the waters with higher sodium concentration can be made suitable for irrigation by addition of $CaSO_4$ or some other cheap calcium salt.

Landey and Murty (1967), reported that the quality of irrigation waters from Mysore State. They observed high to very high salinity in the water samples.

Satyanarayan et al. (1967), gave the seasonal fluctuation in quality of well waters. Two sets of well waters were collected - one before the monsoon in the month of June and second after the cessation of monsoon, rains in the month of October. After the rains, salt concentration in the well waters was generally reduced. Soil samples were also collected from areas irrigated by water of some of these wells and analysed to study the effect of continuous use of irrigation water on them. The continuous use of saline water did not show any apparent effect on well drained soils of the area, indicating that many waters apparently of questionable quality may actually be used with success, on light and well-drained soils.

Shree Ramulu and Thyagarajan (1967), reported that the saline well waters in the Periyane gamun area can be used successfully if proper management practices are adopted. The rest of water found in the area can be used for irrigation without any risk of sodium or salinity hazards.

Subramani and Varma (1969), stated that in evaluating the quality of irrigation water, the result of analysis in the laboratory have to be considered along with two important soil characteristics which have a bearing on irrigation, namely soil texture and permeability and the salt tolerance of crops proposed to be irrigated. They suggested that if the sum of the class values in respect of conductivity, alkalinity, R S C of a given water sample and class values in respect of soil texture and permeability of the soil to be irrigated is eleven or greater, the water is unsuitable for irrigation.

Tripathi, Singh and Dixit (1961), studied the quality of irrigation water in semi-arid tract of U.P. Six hundred samples obtained from different districts were analysed to assess their suitability for irrigation. The irrigation waters have been found to be free from appreciable amounts of sodium. Salinity problem is serious with the waters of all the districts which increases with aridity of the tract.

Bhadrapur and Seshagiri (1972), analysed Tungabhadra project canal, drainage and seepage waters periodically for one year to assess their suitability for irrigation. These waters contained more salts in summer months. Due to the high evapotranspiration in the summer months, it is advisible to use seepage water for heavy irrigation with adequate drainage facilities. Otherwise there is risk from both salinity and alkalinity hazards.

Govind Iyer, Jayachndran, Thandavaryan (1972), analysed well waters of the Regional Agricultural Research Station, Tindivanam in November 1969. During this period of the year, all the wells have ample water for irrigation to paddy and other crops. All the waters were found to be quite suitable for the semi-tolerant crops like paddy, castor, groundnut grown in the light textured soils of the farm possessing moderate to high soil permeability.

Somavanshi and Sinha (1972), tested irrigation waters from 117 places from Gwalior and Bhind, in northern districts of M.P. for suitability. The dominating cations were divalent ions Ca^{++} and Mg^{++} and the dominating anions were HCO_3^-, Cl^-, SO_4^{--}. The concentration of Boron was within permissible limits but that of nitrates varied widely. So the waters of northern M.P. are of medium to high salinity but showed low alkali hazard. Gwalior waters were better than Bhind waters for irrigation.

Sharma and Abrol (1973), have given the amount of gypsum needed which will depend upon the quality of water. The water test report will contain data on the RSC expressed in meq per litre. If the E.C. of water < 4 millimhos per cm and the water RSC is 2 or <2 then there is no necessity of adding gypsum. But for every additional one meq per litre RSC value, add 4 quintal gypsum per hectare of land irrigated by this water. The application of gypsum shall have to be repeated every year or every alternate year depending upon the improvement attained.

2.2 Use of saline water for crop production :

I) Effect on germination :

Malek T. Kaddah (1962), concluded that salinity levels in irrigation waters upto 2000 ppm resulted in delayed germination but had little effect on percentage germination.

Malek T. Kaddah and Salma Ghowail (1964), found that corn was quite salt tolerant during germination. But increasing salinity delayed germination and had no detrimental effect on percentage of immergence.

Bhattacharya (1965), observed that 1.0 per cent salt solution, some varieties of rice gave 100 per cent and others below 50 per cent germination and there was also delay in the emergence of seedlings. Two per cent salt solution showed very poor germination which was delayed to a very great extent. Some varieties did not germinate at all. None of the varieties germinated with 2.5 per cent salt solution.

Lall and Deore (1971), compared nine varieties of sorghum for their salt tolerance at germination. Na_2CO_3 and NaCl salts at 1.5, 3, 4.5 atm and 5, 8, 11 atm concentration levels respectively depressed the germination. Highest levels were more injurious. C.K. 60 A and CSH-1 showed salt tolerance while N.J. 156 and N.J. 164 showed higher susceptibility during germination.

Singh and Singh (1972), found the significant negative correlations between electrical conductivity and the germination percentage ($r = -0.644$) and SAR and germination ($r = -0.595$). Na + Mg/Ca of irrigation water was positively correlated with Na and Mg in plants.

II) Effect on plant growth and development :

Kelley (1963), revealed that Cl appears to be decidedly toxic to citrus trees. If the Cl concentration of irrigation water exceeds 5 meq per litre the leaves of trees show burning along their margines.

Bains and Milton Fireman (1968), concluded that the soil alkalinity or salinity caused drastic reduction in the growth of sorghum. The reduction was even greater in the presence of both alkalinity and salinity. The effect of alkalinity and salinity were greater on the non-calcarious soils than on the calcarious soils. It is also concluded that the adverse effects of salinity and alkalinity on plant growth was not reduced by fertilizers. Rather that a partial response to fertilizers may be expected where nutrient deficiencies limit growth more than salt or alkali does.

Paliwal and Maliwal (1971), found that Maize was satisfactorily grown on irrigation water having salinity upto 28 meq per litre and SAR of 25 corresponding to EC_e of 6.5 millimhos per cm and E.S.P. of 32. Application of normal doses of fertilizers and manures was more effective upto moderate levels of salinity and E.S.P. Fertilization is of little value on highly saline sodic soils.

Patel and Dastane (1971), observed the Leaching upto 10 per cent was favourable when saline irrigations were given at a later stage of crop growth. There was decrease in salt accumulation as the texture become lighter which may be of long term advantage.

Maliwal and Paliwal (1972). In a pot culture using artificially salinized clay loam soil, the effects of fertilizers and Farm Yard Manure on the growth of wheat were studied.

Growth was satisfactory when the soil EC_e value was about 6.5 millimhos per cm and the exchangeable Na was 33 per cent.

Paliwal (1972), found that there was an increase of 15 to 45 per cent in the growth of wheat, barley, maize and bajra while irrigating with saline waters having total salt concentration upto 28 meq per litre corresponding to an E.C. value of 6-6.5 millimhos per cm of soil solution and E.S.P. of about 30.

Sinha and Dev (1972), observed that the use of sodium water (12.8 meq per litre Na) drastically reduced the yield of berseem by affecting plant servival and growth.

III) Effect on yield, nutrient uptake and nutrient availability :

Wahhab and Zahir Hussain Shah (1952), indicated that liming as compared to no treatment has increased the absorption of CaO in the Sorghum plant, Sorghum grain and oats; and also the uptake of P_2O_5 and nitrogen. The increase of N in the plant is probably due to the fact that calcium stimulates bacterial activity which helps fixation of nitrogen in the soil.

Malek T. Kaddah and Salma I. Ghowail (1964), revealed that the sum of total cation contents of seedlings tops of corn was not greatly affected by increasing salinity in the substrata since any increase in one or more cations was compensated to some extent by decrease in one or more other cations. The reciprocal relationship between Ca + Mg were quite pronounced. Sodium salts induced moderate lowering both Ca and Mg in tops. Na in tops was generally low and was little affected by addition of other salts.

Lunin and Gallatin (1965), observed that cation composition of the bean plant has been closely related to the cation composition of the soil solution, although this is not always true in all crops. The Ca and Mg contents of the leaves were more affected by salinity than those of the stems where as Na and K contents of stems were more affected than those of the leaves. The N and P contents of plant were also affected by soil salinity. In most instances, at a given salinity level crop yields tend to be higher where soils are adequately fertilized than where some nutrient deficiency exists. Although optimum levels of fertility are desirable when using saline water for irrigation, one should not forget that high rates of fertilization contribute significantly to soil salinity.

Talati (1968), observed that there is beneficial effect of saline water irrigation on crop performance like tobacco and <u>rabi</u> vegetables, in Gujrath State.

Langdale and Thomas (1971), concluded that there was no response obtained from P fertilization. Significant interactions occured for both dry matter and protein-N yields with soil salinity and N supply treatments. Soil salinity of 5.3 and 6.6 millimhos per cm yielded the most dry matter and protein - N, respectively in the presence of N fertilizers. Dry matter and protein synthesis were seriously restricted at the 14.4 millimhos per cm salinity, however salinity levels did not restrict N absorption by coastal bermudagrass.

Paliwal and Maliwal (1971), found that the absorption of N, P, Ca, Mg, Fe, Mn and CHO content decreased and Na increased in case of maize with the increase of salinity and E.S.P. Uptake of N,P, Ca and Mg correlated negatively with the E.S.P. of soils and of Na correlated positively with the E.S.P. and soluble Na content.

Paliwal (1971), observed that the NO_3 content of irrigation waters which significantly correlated with the available nitrogen of the irrigated soils, seems to create a favourable environment in root zone under saline substrata.

Poonia, Virmani and Bhumbla (1972), revealed that increasing levels of Na saturation in the substrate have a definite depressive effect on the uptake of applied as well as native Ca by the plant. The Ca content in the plant is positively and Na negatively related with the yield of crop.

Shrivastava and Sharafat Ali and Dev (1972), found that the availability of N and P in a slightly alkaline soil (pH 7.5) and in a strongly alkaline soil (pH 10.0) was increased by the addition of 8-16 meq Ca followed by 3 wetting and drying cycles.

Yadav (1972), observed the grain yield of wheat decreased with increased conductivity of irrigation water beyond 8 millimhos per cm in sandy soil at Jobner, but leaching to the extent of 15 per cent was found beneficial for attaining lower salt status and higher yield.

IV) Effect of saline water on soil properties :

Puffeles (1939), observed that if the very saline water is used for irrigation under favourable climatic and drainage conditions, the salts will not accumulate, but after some time alkaline soil will formed by base exchange. This soil will eventually be useless for agricultural purpose.

Kelley, Brown and Liebig Jr. (1940), observed that the presence of absorbed Na in soils tends to affect their physical properties adversely. The ratio of Na to Ca in the solution has relatively great influence on the absorption of Na. If this ratio is not greater than 2 to 1, very little Na will be absorbed, but as this ratio exceeds 2 to 1 the absorption of Na tends to increase proportionately. If the soil is Ca saturated, less Na will be absorbed from a given solution. If it is Mg saturated, very little Na is absorbed from saline soils in which the ratio of Na/Ca is not greater than 2:1, it does not follow that the application of a comparatively dilute saline irrigation water containing Na and Ca + Mg in the ratio of 2:1 will have not deleterious effects on the soil.

Hausenbuiller *et al.*(1960), analysed the soils and compared with composition of irrigation water. Significant correlation were obtained between exchangeable Na in soil and RSC content, SSP and SAR of the waters. The HCO_3^- + $CO_3^=$ ions increased the effective salinity of water while increasing the SSP through precipitation of soluble Ca and Mg.

Jacobs et al. (1961), observed that the regression equation between EC_e of soil and EC_{iw} for 26 soils is : $EC_e \times 10^3 = 1.08\ (EC_{iw} \times 10^3) + 0.39$. The correlation co-efficient (0.86) is significant at 0.01 per cent level and also found that the regression of E.S.P. of soil V/S SAR of irrigation water. The equation is $E.S.P. = 0.45 + 1.35\ SAR_{iw}$. The correlation co-efficient (0.81) is significant at 0.01 per cent level.

Paliwal and Maliwal (1971), observed that the E.C., Ca, Mg, Na and K contents of poor quality, alkaline irrigation waters from 86 wells were significantly correlated with those of the saturation extracts of the soils which were irrigated with them. The SAR of both irrigation waters and saturation extracts were significantly correlated with exchangeable Na percentage in the soils but there was no relationship between SAR and exchangeable Na ratio.

Singh and Sharma (1970), concluded in investigations with $C_4\ S_4$, C_3S_3 and C_3S_1 waters, light textured soils were less affected than heavier soils. Silt + clay increased with depth, $CaCO_3$, pH, exchangeable Na and Na saturation were greater and pore space was reduced in irrigated soils.

V) Reclamation of saline and alkali soils :

Kibe and Narayan (1941),noted that fairly large areas of cultivable land in the Bombay, Karnatak was getting almost barron. They added some of the more common amendments like F.Y.M., green manure, gypsum, sulphur etc. to saline soil kept in pots and jowar grown in them. The effect of these treatments were studied.

Talati (1947), applied different amendments like gypsum, sulphur, sheep manure, F.Y.M., compost, oil cakes and molasses singly and in various combinations, in salty soils of Baramati of Bombay deccan. Gypsum at 2-3 tonnes per acre gave significant increase in yields.

1) Addition of Organic matter :

Mathur, Singh, Bhshnoi and Brajendra Singh (1973), concluded that the F.Y.M. greatly increased the yield of paddy even in the very first year over control. The significant increase in yield of paddy due to F.Y.M. continued in the 2nd and 3rd years too. Application of $CaSO_4$ decrease the yield in first year but increase was significant from second year onwards. $CaCl_2$ showed significant increase in yield after 3 years.

2) Press mud :

Dhar and Mukherjee (1936), emphasized the application of molasses and pressmud in reclaining alkali soils. Their experimental results showed that highly alkaline soils (pH 10.8) can be reclained by the application of molasses.

Talati (1947), proved much more promising from the reclaimation stand point is pressmud, a waste product of cane sugar factory. This material contains on an average 50-55 per cent organic matter, 0.8 to 1.0 per cent N, 2.5 to 3.0 per cent phosphric acid 0.8 to 1.0 per cent K and 6.8 per cent lime. Used either alone or with molasses on markedly alkaline soils at the rate of 2 to 5 tonnes per acre, it was proved successful in Mysore, U.P., Bihar and Bombay presidency.

3) Sulphur :

Lipman (1916), made the suggestion that the change of sulphur to H_2SO_4 in the soil caused by the action of micro-organisms might be employed for converting Na_2CO_3 into the Na_2SO_4 and making productive the barron alkali lands.

Thomas (1936), reclained black alkali soils with sulphur. He used five different kinds of sulphur in the laboratory experiment and four in the field experiments. These were :

i) Sulphur inoculated with the oxidising bacterium, *Thiobacillus thioxidans*.

ii) Uninoculated finely ground elemental sulphur

iii) Uninoculated coarse sulphur

iv) Uninoculated colloidal sulphur

v) Uninoculated sulphur concentrated.

The first treatment i.e. of sulphur inoculated with the oxidising bacterium showed best results as compared to the other treatments.

Basu and Tagare (1943), found that the best reclaining agent for alkaline soils is a mixture of sulphur and F.Y.M. applied at the rate of 1/2 tonnes and 2 tonnes per acre respectively. Molasses (10 tonnes per acre) was also found useful but it proves less effective when compared with sulphur-F.Y.M. mixture.

Fitts, Lyons and Rhodes (1943), stated that on the calcarious soil slick spots in Nebraska only, the 2727 kg of sulphur treatment had a marked effect on the pH and exchangeable Na content. They found that sulphur was more effective than gypsum or calcium chloride.

Somani (1972), conducted a field trial to reclain a saline-alkali soil. He used green manure by <u>dhaincha</u>, and F.Y.M. and gypsum and sulphur and their combinations. The study has very clearly indicated that the combinations of organic sources with inorganic amendments are superior over sum of individuals. Of all the treatments tested. Sulphur + <u>dhaincha</u> as green manure has given the best results. The beneficial effect of various treatments are in the order of sulphur + <u>dhaincha</u> $>$ sulphur + F.Y.M. = gypsum + <u>dhaincha</u> $>$ gypsum + F.Y.M. $>$ sulphur $>$ gypsum $>$ <u>dhaincha</u> F.Y.M. control.

4) <u>Gypsum</u> :

Leather (1914), conducted experiments with different treatments and came to the conclusion that the only treatment which could reclaimed the 'Usar land' was application of gypsum.

Tamhane and Krishna (1930), found that $CaSO_4$ has given the best results. It was also observed that in the case of $CaSO_4$ treatment, phosphate was not leached.

Islur (1941), wrote as regards reclamation of alkali lands, $CaSO_4$ is only popular chemical at present recommended all over the world. The usual maximum dose in the Deccan is 3 tonnes per acre.

Graveland and Toogood (1963), found that the gypsum was an effective ameliorating agent only when exchangeable Na was $<$ 20 - 5 per cent of the total C.E.C., assuming that the effective solubility of gypsum in the field is about half that of its saturated concentration.

Padhi *et al*. (1965), stated that there was increase in water percolation and Na removal from solonetzic soils with the application of gypsum.

Puntamkar, Mehta and Seth (1972), observed that the gypsum and manure increased the yield of wheat (Sonora 64) separately and highest yield of wheat was recorded with 20 tonnes of gypsum per hectare alone. Exchangeable sodium decreased by 1.6 to 10.9 per cent while exchangeable calcium increased upto 17.7 per cent.

CHAPTER III

MATERIALS, METHODS AND EXPERIMENTAL

CHAPTER III

MATERIALS METHODS AND EXPERIMENTAL

The investigations presented in this thesis were carried out with the following objectives and have been discussed in two parts.

1) To study the seasonal fluctuations in the quality of well water at Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri and its vicinity.

2) Use of saline water for crop production (Jowar, CSH-4).

PART I

Quality of well waters

3.1 Materials :

3.1.1 Collection of water sample :

The well water samples were collected from the Mahatma Phule Krishi Vidyapeeth, Central Campus Farm, Rahuri and its adjoining areas i.e. from Rahuri Factory, Digras, Pimpri Avghad, Sade and Khadambe villages from Rahuri taluka. The samples were collected during three seasons i.e. *kharif*, *rabi* and summer (first week of July, 1973, first week of November 1973 and in first week of March 1974). The details of location of wells, survey numbers etc. are given in table No. 3.1 and in map of Mahatma Phule Krishi Vidyapeeth, Rahuri.

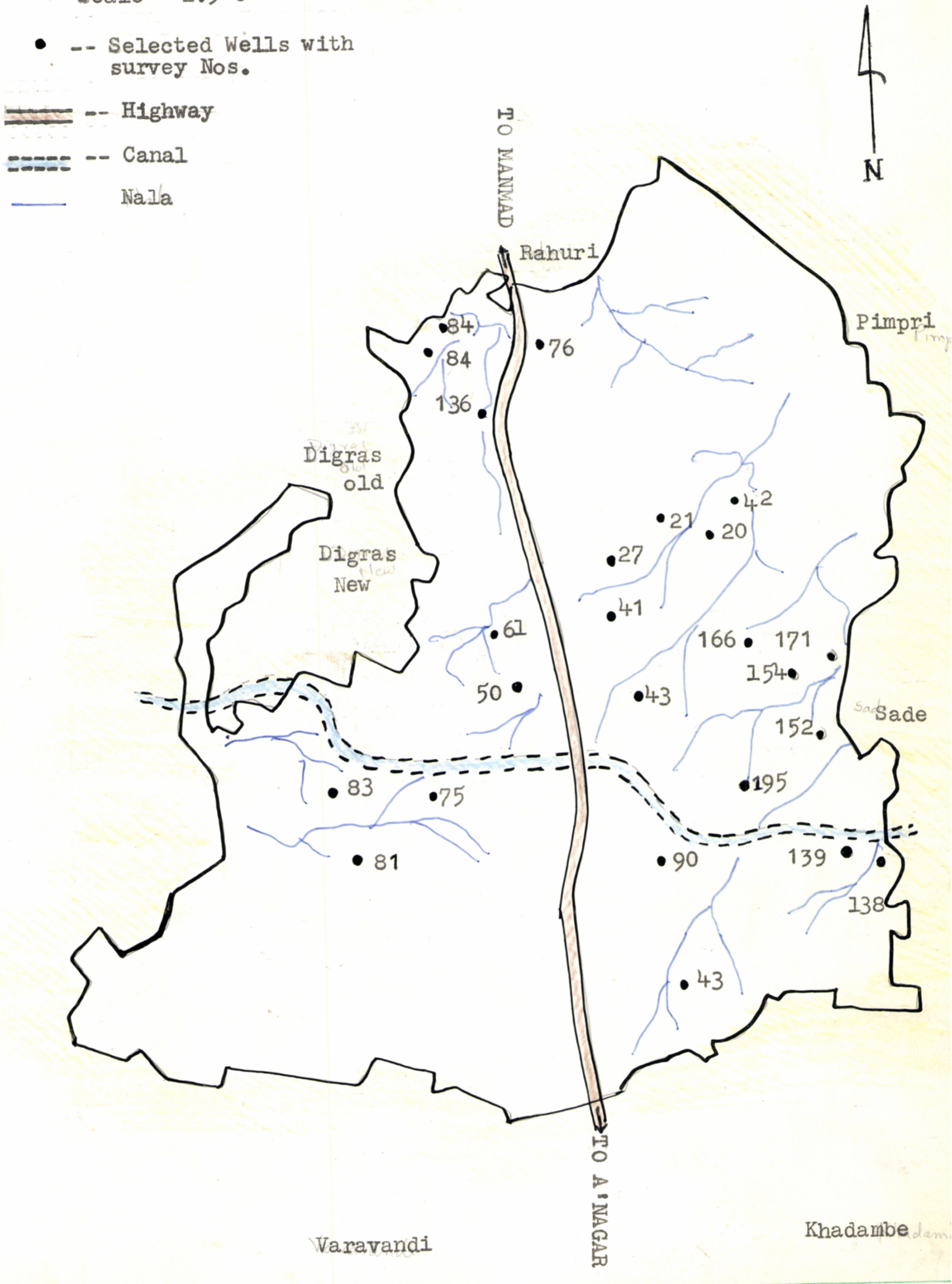
While collecting the samples, the bottles were rinsed thoroughly twice with the water samples to be collected. Nearly one litre of water samples were collected in clean plastic bottles, stoppered tightly and brought to the laboratory for analysis.

Table 3.1 : Physical Information Regarding Selected Wells.

Sr. No.	Village	Survey No.	Soil type	Depth in meters	Diameter in meters	Water bearing formation	Builded Non-Builded	Water is used or not	Remark
1	2	3	4	5	6	7	8	9	10
1	RAHURI FACTORY	76 B	M.Black	15	10	H.P.	L	Used	Pollutrated by malassis
2		76 A	M.Black	18	4	L.Stone	L	Used	-
3		70	M.Black	22	5	H.P.	L	Used	-
4		64	M.Black	16	3	Graval	L	Used	-
5	DIGRAS	93	Lateritic	15	4	Sand	L	Used	-
6		1	Calcarious	12	7	L.Stone	UL	Used	-
7		142-143	M.Black	10	3	L.Stone	L	Used	-
8		146	Calcarious	12	5	L.Stone	L	Used	-
9	PIMPRI AVAGHAD	96	M.Black	12	3	L.Stone	L	Used	-
10		149/2	M.Black	12	8	L.Stone	L	Used	-
11		115	M.Black	15	4	L.Stone	L	Used	-
12		150	M.Black	15	5	L.Stone	L	Used	-
13	SADE	153	M.Black	15	5.5	S.Stone	L	Used	-
14		147	Alluvial	15	5	H.P.	L	Used	-
15		150	M.Black	12	5	Graval	L	Used	-
16		124	M.Black	13	5	S.Stone	L	Used	-
17	KHADAMBE	119/1	D.Black	17	5	H.P.	L	Used	-
18		124	M.Black	14	5	H.P.	L	Used	-
19		151/3	M.Black	13	6	H.P.	L	Used	-
20		103/3	R.Brown	16	5	Sand	L	Used	-

A MAP SHOWING THE SELECTED WELLS OF M.P.K.V. RAHURI

Scale - 2.5 cm = 1 km



The water samples were filtered through ordinary filter paper and then used for chemical analysis.

3.2 Methods for water analysis :

3.2.1 pH :

The pH of water was determined with the help of Beckman pH meter with glass electrode assembly (Piper 1966).

3.2.2 Electrical conductivity :

It was determined with the help of conductivity meter (Elico) having cell constant 1.1 (U.S.D.A., 1954).

3.2.3 Alkalinity :

Alkalinity was determined by the potentiometric titration method at two equivalent points i.e. at pH 4.4 and 4.2 (Larson and Henley, 1955).

3.2.4 Boron :

Boron was determined using carmine indicator and red colour intensity was measured on spectronic 20 at 585 millimicron (Hatcher and Wilcox, 1950).

3.2.5 Hardness :

It was determined by titrating with E.D.T.A., using E.B.T. as an indicator (Patton and Reeder, 1956).

3.2.6 Calcium and Magnesium :

These were determined by E.D.T.A. titrimetric method using 4 N. NaOH, NH_4Cl-NH_4OH as buffers and ammonium purpurate, E.B.T. as indicators respectively (Katz and Navone, 1964).

3.2.7 Sodium and Potassium :

These were estimated by the flame photometric method, using standard solutions of NaCl and KCl respectively (Fox, 1951).

3.2.8 Chloride :

It was determined by argentometric method using potassium chromate as in indicator (Haren, 1889, A.O.A.C.1950).

3.2.9 Carbonates and Bicarbonates :

These were estimated by volumetric method titrating with standard H_2SO_4 using phenolphthalein and methyl orange indicators respectively (A.P.H.A., A.W.W.A., W.P.C.F.,1971).

3.2.10 Sulphates :

It was determined by turbidity method. Barium Chloride tubidity was measured on spectronic 20 at 420 millimicron wavelenth (Rossum and Villarruz, 1961).

3.2.11 Nitrates :

It was estimated by phenoldisulphonic acid method on spectronic 20 at 410 millimicron refering to standard $AgSO_4$ solution (Taras, 1950).

All constants like SAR, SSP, RSC were calculated in terms of meq per litre.

i) $$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

ii) $$SSP = \frac{Na}{Ca + Mg + Na + K} \times \frac{100}{1}$$

iii) $$RSC = (CO_3 + HCO_3) - (Ca + Mg)$$

All values of constituents are taken in terms of meq per litre.

PART II

Pot Culture Experiment

3.3 Materials :

3.3.1 Collection of Soil sample for pot culture :

Two different soils, one saline and the other non-saline in character were used for this investigation. Surface soil samples (0-15 cm) were collected from survey Nos. 61 and 24 at Central Campus, Rahuri in the month of June 1973. Physio-Chemical properties of the soils are given in table No. 3.2(a) & (b).

Table 3.2.(a) : Mechanical Analysis

Sr. No.	Particle type	Percent on air dry basis	
		S.No. 61	S.No. 24
1	Sand	27.82	25.13
2	Silt (By difference)	42.10	23.15
3	Clay	30.08	51.72
4	Textural class by triangular method	Clay loam	Clayey

It will be seen from table 3.2(a) & (b) that the soil from survey No. 61 is clay loam in texture and fairly rich in all nutrients than that of the soil from survey No. 24. The levelling was done in survey No. 24 in March, 1973. The ESP and SSP of soils from survey No. 24 and 61 were 7.629, 42.995 and 23.059, 66.797 respectively.

Table 3.2(b) : Initial Physico-Chemical Properties of soils.

Sr. No.	Property	Unit	Initial soils	
			Saline S.No. 61	Normal S.No. 24
1	Moisture	Per cent	14.900	13.600
2	pH	-	8.250	8.000
3	E.C.	mmhos/cm	2.640	0.142
4	Organic Carbon	Per cent	0.584	0.330
5	Free $CaCO_3$	Per cent	2.400	3.900
6	G.R.	mg/100 g	894.400	206.400
7	C.E.C.	meq/100 g	48.410	52.490
8	Total N	mg/100 g	34.000	30.000
9	Available P	mg/100 g	24.640	10.560
10	Exchangeable Cations	mg/100 g	340.740	484.990
	Ca	mg/100 g	113.870	341.870
	Mg	mg/100 g	73.370	100.870
	Na	mg/100 g	146.500	37.000
	K	mg/100 g	7.000	5.250
11	SAR	-	4.845	0.505
12	ESP	Per cent	42.995	7.629
13	Water soluble cations	mg/100 g	179.650	13.010
	Ca	mg/100 g	56.130	8.130
	Mg	mg/100 g	2.630	1.130
	Na	mg/100 g	120.000	3.000
	K	mg/100 g	0.890	0.750
14	SSP	Per cent	66.797	23.059

3.3.2 Fertilizers :

The fertilizers used in the present investigations were of chemically pure and their chemical composition is given in table No. 3.3.

Table 3.3 : Chemical composition of fertilizers used.

Sr. No.	Particulars	Total N per cent	Total P_2O_5 per cent	Total K_2O per cent
1	Ammonium sulphate	20.00	-	-
2	Ammonium dihydrogen orthophosphate	16.20	61.70	-
3	Potassium sulphate	-	-	46.10

3.3.3 Amendments :

The four amendments used in the pot culture experiment were mule dung, pressmud, sulphur and gypsum. The gypsum was added on the basis of gypsum requirement of soils. Sulphur was added equivalent to sulphur content in gypsum. Pressmud was added equivalent to calcium content of gypsum. And mule dung was added equivalent to organic carbon content of the pressmud. The details of chemical characteristics and quantities of amendments used are given in table No. 3.4(a) and (b).

Table 3.4(a) : Chemical composition of Amendments used.

Constituents	Mule dung	Pressmud	Gypsum	Sulphur
Calcium per cent	1.20	3.60	23.28	-
Organic carbon per cent	17.33	33.90	-	-
Nitrogen mg per 100 g	410	1290	-	-
Phosphorus mg per 100 g	66	1848	-	-
Potassium mg per 100 g	166	2482	-	-

Table 3.4(b) : Quantities of Amendments added.

Amendments	Soil from S.No.24		Soil from S.No.61	
	g/8 kg soil	tonnes/ha	g/8 kg soil	Tonnes/ha
Mule dung	208.65	57.54	904.06	249.30
Pressmud	106.67	29.42	462.20	127.46
Sulphur	3.07	0.847	13.31	3.67
Gypsum	16.51	4.55	71.55	19.73

3.3.4 Waters :

The two types of waters were used for irrigating the soils. One water of C_3S_3 Class which was saline in character, artificially prepared in laboratory by addition of different chemicals and other water was tap water having C_1S_1 Class. The quantities of chemicals added for preparing saline water are given in table No. 3.5 and the chemical composition of both the waters are given in table No. 3.6.

Table No. 3.5 : Quantity of Chemicals added in distilled water for preparation of saline water.

Sr. No.	Chemical	Quantity added in mg per litre
1	Calcium Nitrate	14.00
2	Magnesium Sulphate	130.00
3	Sodium Chloride	197.00
4	Sodium Carbonate	106.00
5	Sodium bicarbonate	394.00
6	Potassium Nitrate	6.00
7	Potassium Sulphate	200.00
8	Ammonium Chloride	120.00
9	Boric acid	6.00

Table 3.6 : Chemical composition of waters used.

Sr. No.	Character	Unit	Tap water	Saline water
1	pH	-	7.50	8.75
2	Electrical conductivity	millimhos/cm	0.171	1.750-1.800
3	Calcium	meq/litre	0.900	0.115
4	Magnesium	meq/litre	0.300	1.037
5	Sodium	meq/litre	1.957	11.762
6	Potassium	meq/litre	0.029	2.355
7	Carbonates	meq/litre	Traces	1.998
8	Bicarbonates	meq/litre	2.500	4.689
9	Chlorides	meq/litre	6.300	7.321
10	Sulphates	meq/litre	5.000	3.330
11	Nitrates	meq/litre	0.036	0.108
12	Boron	mg/litre	0.080	1.000
13	SAR	-	2.509	17.800
14	SSP	Per cent	61.420	77.030
15	RSC	meq/litre	+ 1.300	+5.535
16	Water class	-	C_1S_1	C_3S_3

3.4 Methods for Analysis :

3.4.1 Preparation of soil sample :

After harvesting the jowar crop, soil samples were collected from 0-20 cm. layer from each pot separately. Samples were air dried and pounded in the wooden mortor and pestle, passed through a 2 mm sieve and then used for chemical analysis.

3.4.2 Moisture :

It was determined by dehydrating known weighed soil at 105°C in an electrical oven (A.O.A.C. 1950).

3.4.3 Mechanical analysis :

It was done by pippette method. Silt percentage was determined by difference (U.S.D.A. 1954).

3.4.4 Organic carbon :

It was estimated by method as described by Walkley and Black using diphenylamine as an indicator, 1934.

3.4.5 pH :

This was determined by using 1:25 soil water ratio, saturation extract on Beckman pH meter with glass electrode assembly (Piper, 1966).

3.4.6 Electrical conductivity :

It was determined with the help of conductivity meter (Elico) having cell constant 1.1. Soil-water ratio was 1:25 (U.S.D.A., 1954).

3.4.7 Gypsum Requirement :

It was estimated by adding 100 ml saturated gypsum solution to 5 g soil and titrated with standard E.D.T.A. solution using E.B.T. as an indicator (Schoonover, 1952).

3.4.8 Cation Exchange capacity :

It was determined by $CaCl_2$ extractant method using centrifuge as described by Hesse, 1971.

3.4.9 Total Nitrogen :

It was estimated by macrokjeldhal method (Piper, 1966).

3.4.10 Available Phosphorus :

Available phosphorus was determined by using sodium bicarbonate as an extractant adjusted to pH 8.5. The colour was measures on spectronic 20 using red filter at 660 millimicron (Olsen, *et al*. 1954).

3.4.11 Available Potassium :

Using normal neutral ammonium acetate solution as an extractant 5 gram of soil sample was taken and 25 ml of ammonium acetate was added. Then shaken for 5 minutes and filtered. Two drops of butyl alcohol was added and K was determined on the flame photometer (Fox, 1951).

3.4.12 Exchangeable Cations :

The extract obtained for determination of exchangeable 'K' was directly used for the determinations of exchangeable cations.

1) Calcium and Magnesium :

These were determined by E.D.T.A. titrimetric method using 4 N. NaOH, NH_4Cl - NH_4OH mixture as buffers and ammonium purpurate, E.B.T. as indicators respectively (Katz and Navone, 1964).

2) Sodium :

It was estimated by the flame photometric method, using standard solution of NaCl (Fox, 1951).

3.4.13 Water soluble cations :

The soil water suspension (1:2.5) was prepared and filtered it after 30 minutes constant stirring. The extract obtained was used for analysis of Ca, Mg, Na and K.

1) Calcium and Magnessium :

These were determined by E.D.T.A. titrimetric method using 4 N. NaOH, NH_4Cl - NH_4OH mixture as buffers and ammonium purpurate, E.B.T. as indicators respectively (Katz and Navone, 1964).

2) Sodium and Potassium :

These were estimated by the flame photometric method, using standard solutions of NaCl and KCl respectively as reference (Fox, 1951).

3.4.14 Preparation of plant samples :

The whole plants from each pot were air dried and ground in Willey's mill. The ground sample was used for determination of total nitrogen. The ground material was also taken for wet digestion for determination of Phosphorus and Ca, Mg, Na, K cations.

3.4.15 Wet digestion :

One gram of well mixed plant powder was taken in conical flasks and 20 ml of nitric acid was added. Contents were then slightly heated, cooled and then 10 ml of perchloric acid was added. The material was digested until little colourless solution obtained. It was then cooled and by addition of distilled water, volume was made to 100 ml., filtered. This acid extract was used for determination of phosphorus, Ca, Mg, Na and K. (Toth and Associates, 1948).

3.4.16 Total Nitrogen :

It was estimated by micro-kjeldhal method (A.O.A.C., 1950).

3.4.17 Phosphorus :

The phosphorus was determined from the diacid extract by measuring the intensity of the vanadophosphomolybdate yellow colour on spectronic 20 at 420 millimicron (Jackson, 1967).

3.4.18 Sodium and Potassium :

These were estimated by the flame-photometric method using standard solutions of NaCl and KCl respectively (Fox, 1951).

3.4.19 Calcium and Magnessium :

These were determined by E.D.T.A. titrimetric method using 4 N. NaOH, NH_4Cl - NH_4OH mixture as buffers and ammonium purpurate, E.B.T. as indicators respectively (Katz and Navone, 1964).

3.5 Statistical Analysis :

The statistical Analysis of varience method, correlation-co-efficient and line of regression were done as per the methods described by Panase and Sukhatme, 1961.

3.6 Experimental :

The earthen pots used in the experiment had a height of 35 cm and a diameter of 30 cm and were provided with a hole at the bottom for removing excess of water. The pots were rapped from inside by plastic cloth by keeping a bottom hole open. Then pots were filled with rounded stones and pebbles to a layer of 3 cm thick and were numbered serially. Eight kilo of air dried soil was filled in each pot.

Ten pots were filled with soil saline in character and other ten pots were filled with normal soil in each replication.

The details of the treatments used in the experiment are given in Figure No. I. The amendments namely mule dung, pressmud, sulphur, gypsum were thoroughly mixed with soils filled in pots. The basal dose of fertilizers was also well mixed with soils. Then the pots number from 1 to 5 and 6 to 10 from each soil type were irrigated with artificially prepared saline water and tap water respectively. The drainage system of the pots were kept excellent. In all there were 20 treatments and each treatment was replicated 3 times. Therefore, the total number of the pots in the experiment were 60. The design was completely randomised design. Presowing irrigation was given on 26th September 1973. Ten seeds of CSH_4 variety of jowar were dibbled in each pot insuring uniform spacing. The germination took place within 7 days after sowing and five healthy plants in each pot were allowed to grow after 30 days from sowing. The pots were kept in plastic cloth house after 30 days from sowing.

3.6.1 Details of cultural practices :

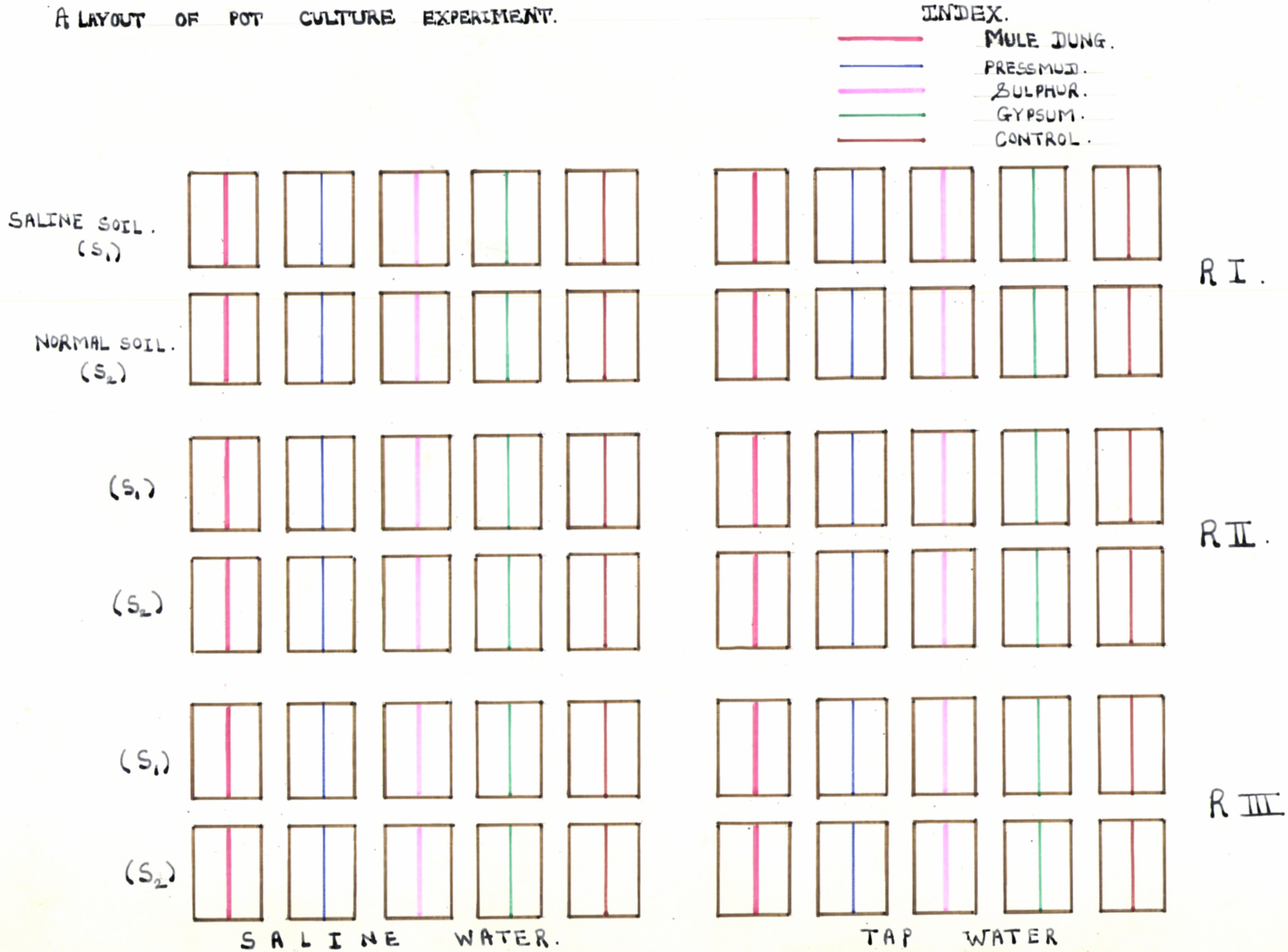
i) Date of sowing : 27th September, 1973.

ii) Basal dose : Total doses - N-125, P-75 and K-77 kg per hectare were given. Out of which N-90, P-75 and K-62 kg per hectare was given on 26th September, 1973 as basal dose.

iii) Top dressing : After 30 days i.e. on 28th October, 1973, 35 kg per hectare N was given. After 60 days, tip burning along with margines of leaves were observed in plants

FIGURE-I

A LAYOUT OF POT CULTURE EXPERIMENT.



grown on soil from S.No. 24. So, K was added at the rate of 15 kg per hectare in the form of K_2SO_4 for both the soils.

iv) Plant protection measures : Endrine was sprayed with the concentration of 0.05 per cent after 8, 20, 40, 46, 64, 77 and 85 days from sowing.

v) Interculturing : Surface soil from each pot was stirred for better airaction and leaching. Interculturing was done after 40, 65, 75 and 85 days from sowing.

vi) Irrigation : Irrigations were given as under :-

After 8, 12, 21, 28, 35, 41 days from sowing at the rate of 0.5 litre per pot and after 47, 52, 57, 62, 66, 70, 74, 78, 83, 86, 89, 92, 95, 98, 101, 104, 107, 109, 112 and 115 days from sowing at the rate of 1.0 litre per pot. Totally 26 irrigations were given and 23 litres of water was given to each pot.

vii) Harvesting : Harvesting was done 121 days after sowing i.e. 23rd January, 1974.

The morphological character namely height of the plant was taken after 35, 70 and 90 days from sowing. Germination and earhead emergence observations were also recorded. Dry matter yield was recorded. Soils collected after harvesting were analysed for pH, E.C., Organic Carbon, G.R., exchangeable cations and water soluble cations namely Ca, Mg, Na and K, and available Phosphorus. Plant samples were analysed for total nitrogen, phosphorus and Ca, Mg, Na, K contents.

3.6.2 The pot culture experiment conducted, covered following aspects :-

1) Effect of saline water alone and in combination with amendments on chemical properties of two soils.

2) Effect of saline water and amendments on germination of jowar crop in saline and non-saline soils.

3) Effect of saline water and amendments on jowar crop growth i.e. height of the plant, emergence of earheads and dry matter yield at maturity stage in saline and non-saline soils.

4) Effect of saline water and amendments on N, P, K, Ca, Mg, Na content of jowar plant at maturity stage in saline and non-saline soils.

3.6.3 Abbreviations used in the present investigations :

3.6.3.1 Part-I :

1) H.P. - Hard pan
2) L.Stone - Lime Stone
3) S.Stone - Sand Stone
4) L - Lined
5) UL - Unlined
6) S - Suitable or Soft
7) M.- Medium
8) H - Hard
9) V.H. - Very Hard
10) NS - Not suitable

3.6.3.2 Part II :

1) M.D. - Mule dung
2) P.M. - Pressmud
3) S. - Sulphur
4) G. - Gypsum
5) C. - Control
6) S.S. - Saline Soil
7) N.S. - Normal Soil
8) S.W. - Saline Water
9) T.W. - Tap water

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CHAPTER IV

RESULTS AND DISCUSSION

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PART I

Seasonal Fluctuations in Quality of Well Waters :

The ground well water samples collected from Rahuri Factory, Digras, Pimpari Avaghad, Sade and Khadambe villages and from Mahatma Phule Krishi Vidyapeeth, Central Campus Farm were analysed for pH, E.C., cations, anions, boron , alkalinity and hardness. The analytical results of well waters are presented in the Appendix I. The average analytical values of various constituents of well waters, village-wise and blockwise are given in the Appendix II. Similarly, percentage classification of well waters on the basis of different criteria have been presented in the Appendix III. The well waters are classified according to U.S. salinity laboratory classification on the basis of SAR and E.C. The results obtained are discussed below.

4.1.1 Cations :

1) Calcium :

The Calcium content of well waters from Rahuri Factory, Digras, Khadambe and five blocks of the University farm showed continues increase from *kharif* to *rabi* and *rabi* to summer seasons. But Calcium content of well waters from Sade and Pimpari Avaghad showed no definite trend in its fluctuation as per seasons.

2) Magnesium :

The Magnesium content of well waters from Rahuri Factory, Digras, Pimpari Avaghad, Sade, Blocks A, B-I, B-II increased during *rabi* season. The Magnesium conetnt of well waters from Khadambe did not increase during three seasons, while Mg content of well waters from block C and Dairy showed contineous increase from *kharif* to *rabi* and *rabi* to summer seasons.

3) Sodium :

The sodium content of well waters from all five villages and blocks B-I, B-II and C increased in rabi season. But there was no definite trend in increase of sodium content of well waters from the block A and Dairy as per seasons. On an average sodium was the dominating cation in well waters.

4) Potassium :

The potassium content of well waters from all the villages (except Rahuri Factory) and the blocks were found to be increased in *rabi* and summer seasons than the K content of well waters during *kharif* season.

The cations contents of well waters from five villages and all the blocks of University farm at Rahuri showed fluctuation during three seasons. Similar trend was observed by Babrekar *et al*. (1965) and Satyanarayana *et al*.(1967).

4.1.2 Anions :

1) Carbonates :

The Carbonates contents of well waters from Rahuri Factory, Sade, Khadambe, blocks A, B-II, C and Dairy increased during summer season, while carbonates content of well waters from Digras, Pimpari Avaghad and Block B-I increased during *kharif* season.

2) <u>Bicarbonates</u> :

There was no fluctuations observed in bicarbonates contents of well waters from all the villages and the blocks of the University farm during three seasons. The values of bicarbonates content were higher than values of carbonates content present in well waters through out the year.

3) <u>Chlorides</u> :

The Chloride was dominating anion in the well waters from all the villages and the blocks, throughout the year. Slight increase in chlorides contents of well waters from all the five villages and the blocks was observed in *rabi* season.

4) <u>Sulphates</u> :

The average sulphates contents of well waters from all the five villages and the blocks of University farm incfeased with the season from *kharif* to *rabi* and *rabi* to summer.

5) <u>Nitrates</u> :

Fluctuations in the nitrates content of well waters from five adjoining villages and all the blocks of University were observed during three seasons. There was no definite trend observed in fluctuation of the nitrate content.

The analytical values regarding the anions content of well waters from all the villages and the blocksof the University farm at Rahuri showed fluctuation during three seasons. Similar trend was also observed by Babrekar *et al*. (1965) and Satyanarayana *et al*. (1967).

4.1.3 <u>pH Value</u> :

The pH values of 93 per cent of well waters from all the villages and the blocks were above 7.5 which tends to be alkaline in reaction. The pH values of well waters from all the five villages and the blocks slightly changed during three seasons.

4.1.4 Electrical Conductivity :

Electrical conductivity is an index of salinity. The E.C. values of well waters from five villages showed no change during *kharif* and *rabi* seasons. But E.C. was found to be increased during summer season. Similar increase in the electrical conductivity of well waters from block A and B-I was also observed. There was no increase in electrical conductivity of well waters from B-II and C blocks seasonwise. But the well waters from Dairy block showed increase in E.C. values from *kharif* to summer seasons. About 94 per cent of well waters from all the blocks of the University farm and about 72 per cent of well waters from the adjoining villages had E.C.below 2250 micromhos per cm.

4.1.5 Boron :

Boron is essantial to the normal growth of all plant, but exceedingly toxic at concentration slightly above optimum limit (0.33 mg per litre for sensitive crops). The boron content of all the well waters was within safe limit. It was below 1.33 mg per litre in all the water samples throughout the year. Average boron content of well waters from all the villages and the blocks, slightly decreased during *rabi* season. From the Appendix III, it is observed that 81.83 per cent of the well waters are of good quality on the basis of boron content and suitable for most of the crops as per Scofield, 1936.

4.1.6 Alkalinity :

Alkalinity is expressed in terms of mg per litre of $CaCO_3$. The average alkalinity values of well waters from five villages and University farm were 341.54 and 249.97 mg per litre respectively. Alkalinity of all the well waters increased with the season i.e. from *kharif* to *rabi* and *rabi* to summer.

4.1.7 Hardness :

It is expressed in terms of mg per litre of $CaCO_3$. The average hardness values of all the well waters are above 180 mg per litre and these waters may be called as 'very hard' water.

4.1.8 Sodium Adsorption Ratio :

It gives an idea about the relative proportions or concentrations of sodium, calcium and magnesium. The average SAR values of well waters from five villages and all the blocks were 5.161 and 4.381 respectively.

On the basis of SAR values of well waters from all the blocks of University farm, it is observed that 80 per cent well waters are under (S_1) class which is most suitable for all the soils and 9.5 per cent well waters are under (S_2) class. The SAR values of well waters from five villages, it is seen that 55 per cent well waters are under (S_1) class and 35 per cent well waters are under (S_2) class which will be dangerous to fine textured with high exchange capacity of soils as stated by Durand, 1956.

4.1.9 Relationship between SAR and E.C. values of Water :

The relationships between SAR and E.C. values of well waters from five villages and from the University farm for three seasons are given in the table 4.1.1.

From the table 4.1.1, it is observed that the SAR values and the E.C. values of well waters showed a positive correlation throughout the year. The correlation co-efficients for waters from the University farm were statistically significant for three seasons. But the correlation co-efficients for the well waters collected seasonwise from five villages were statistically non significant. The correlation co-efficient of waters from the University farm during *rabi* season was highly significant; while for other two seasons, it was significant. The regression equations for all the waters are presented in table 4.1.1 and also represented graphically in Figure II and III.

4.1.10 Soluble Sodium Percentage :

SSP values for all well waters from five villages were below 60 per cent throughout the year, except the well waters from Sade. The SSP values of well waters from Sade during *kharif*, *rabi* and summer seasons were 64.07, 66.34, and 66.51 per cent respectively. The average SSP values of well waters from the University farm were below 60 per cent which indicate that the water may be safely used for irrigation.

4.1.11 Residual Sodium Carbonates :

The average RSC values of all the well waters under study were below 1.25 meq per litre and are probably safe for irrigation as per Eaton, 1950.

Table 4.1.1 : Relationships between SAR and E.C. Values of Well waters for three seasons.

Relationship / Place	Seasons	Correlation coefficient	t value: Cal.	t value: Table 0.05 Per cent	t value: Table 0.01 Per cent	Regression equation
University farm blocks	Kharif	0.470	2.4975*			E.C.= 31.724 SAR + 546.103
	Rabi	0.530	2.8305**	2.074	2.819	E.C.= 84.2185 SAR + 639.7894
	Summer	0.500	2.707*			E.C.= 46.2 SAR + 806.278
Adjoining villages to the University	Kharif	0.352	1.104			E.C.= 91.155 SAR + 1461.733
	Rabi	0.182	0.793	2.101	2.878	E.C.= 45.813 SAR + 1638.048
	Summer	0.294	1.3064			E.C.=148.378 SAR + 1524.3989

* Significant at 0·05 per cent level.

** Significant at 0·01 per cent level.

E.C.= micromhos/cm

FIGURE-II RELATION BETWEEN SAR VALUES AND E.C. OF WELL WATERS FROM UNIVERSITY FARM FOR THREE SEASONS.

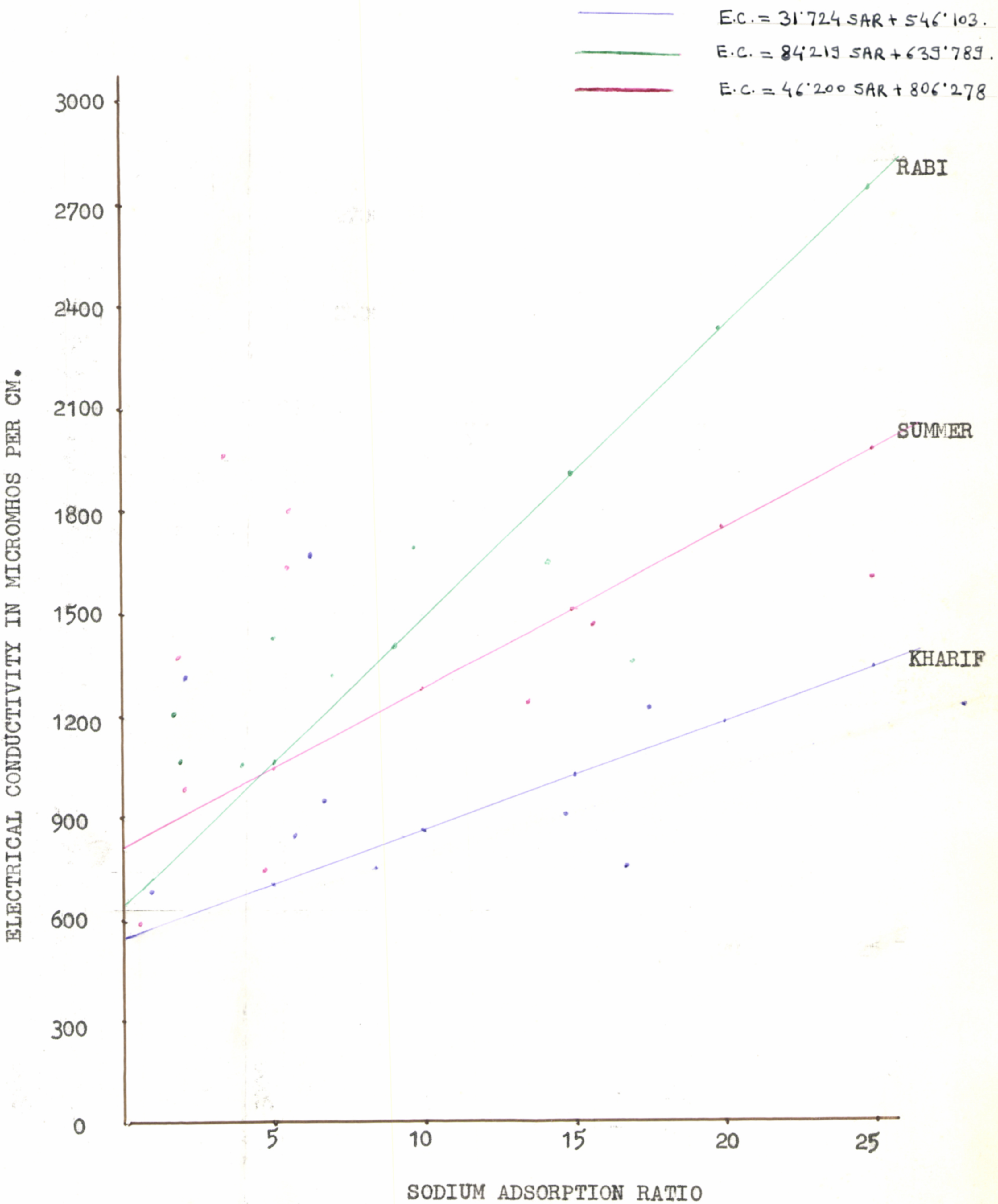
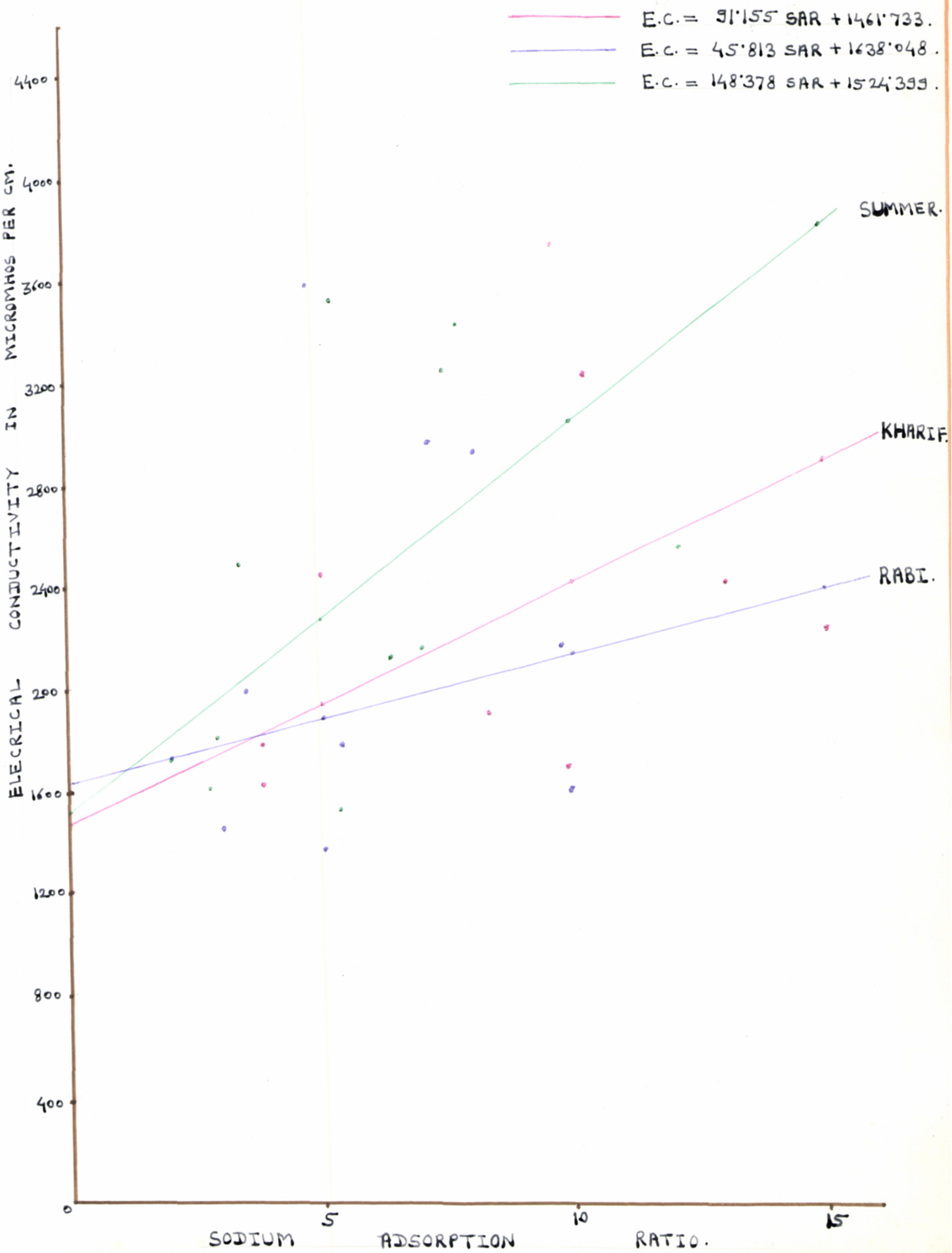


FIGURE-III RELATION BETWEEN SAR VALUES AND E.C. OF WELL WATERS FROM FIVE VILLAGES FOR THREE SEASONS.



PART II

The object of present investigations, as already indicated earlier, was to study the effect of water salinity with and without amendments on chemical characters of two soils, plant growth, uptake of N, P, K and cations by *jowar* plant, under pot culture conditions. The studies were carried out on following lines :-

4.2.1 Chemical properties of soils :

a) pH
b) Organic Carbon
c) Electrical conductivity
d) Gypsum Requirement
e) Available Phosphorus
f) Available Potassium
g) Exchangeable Sodium Percentage
h) Sodium Adsorption Ratio
i) Soluble Sodium Percentage
j) Exchangeable Cations :- i) Calcium ii) Magnesium iii) Sodium
k) Water Soluble Cations :- i) Calcium ii) Magnesium iii) Sodium iv) Potassium

4.2.2 Effect on plant growth and nutrient uptake :

a) Germination
b) Height of the plant
c) Emergence of earheads
d) Dry matter yield
e) Different elements contents in plants :- i) Nitrogen ii) Phosphorus iii) Potassium iv) Calcium v) Magnesium vi) Sodium

The results of the effects of soil salinity water salinity and amendments on soil properties and plant growth are discussed in succeeding paragraphs.

4.2.3 Effect on chemical characters of soils :

1) Soil pH :

The data pertaining to pH values are given in table 4.2.1.

Table 4.2.1 : Mean values of pH, Organic Carbon content of soils as affected by saline water and amendments.

Treatments	pH	Organic Carbon per cent
M.D.	7.854	0.552
P.M.	7.879	0.546
S.	7.700	0.460
G.	7.887	0.424
Control	8.141	0.414
S.Soil	7.99	0.604
N. Soil	7.80	0.354
S. Water	7.951	0.491
T. Water	7.833	0.488

The soil salinity and the water salinity had shown increasing effect on Soil pH by 0.19 and 0.12 units respectively. The use of sulphur, M.D. P.M. and gypsum as amendments have decreased soil pH as compared to the control. The addition of sulphur had shown better effect on reduction of soil pH i.e. by 0.44 units as compared to the control. Other amendments showed more or less same effect on decreasing pH value.

Fitts, Lyons and Rhodes (1943), have stated that the 2727 kg of sulphur treatment had marked effect on reduction of soil pH. Singh and Sharma (1972), concluded that pH was greater when soils irrigated with C_4S_4, C_3S_3, C_3S_1 class waters.

The probable reason for reduction in pH, due to addition of sulphur is that, sulphur is oxidised into SO_3 and with water, it is converted into H_2SO_4 which had acidic effect.

2) Organic carbon :

Organic carbon gives an idea about total nitrogen content of soils by C:N ratio. The mean values of organic carbon content of all treatments are given in Table 4.2.1.

All the amendments, had increased the organic carbon content of soils as compared to control (0.414). The use of Organic amendments had increased organic carbon content of soils as compared with the use of chemical amendments.

3) Electrical conductivity of soils :

E.C. is the major character of soil to measure the soil salinity.

The data regarding the E.C.of soils have been presented in Table 4.2.2.

Table 4.2.2. : Electrical conductivity of soils as affected by saline water and amendments,

Treatments	Saline Soil		Normal Soil		Mean micro-mhos/cm	SE ±	CD at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	872.67	517.00	579.33	223.67	548.1	27.243	75.290
P.M.	1061.67	541.33	377.67	206.67	546.8		
S.	744.33	553.67	530.00	252.33	520.0		
G.	1070.67	315.33	666.00	346.67	599.6		
Control	2167.00	1558.00	286.00	154.00	1041.4		

Mean micromhos/cm Soils : Saline -940.10 Normal- 362.20 Waters:Saline-835.40 Tap -466.80

S.E.± 17.230
C.D. at 5 per cent 47.617

Soils, waters, amendments and all interactions are highly significant except WXA interaction, which is only significant. Saline soil and saline water significantly increased the E.C. of soils. Use of all amendemtns significantly decreased the E.C. of soils as compared with control.

Many workers found the positive correlationship in between E.C. i.w. and E.C. of soils (Jacobs et al. 1961, Kanwar and Mehta, 1970; Singh and Bhumbla, 1968). According to Paliwal (1961), concentration of soil solution increases from 1.03 to 7 times that of irrigation water for sandy to clay loam soils.

4) Gypsum requirement of the soil :

Gypsum Requirement is one of the measures, which can judge the soil salinity. The data regarding the G.R. values are reported in Table 4.2.3.

Table 4.2.3: Gypsum requirement of soils as affected by saline water and amendments.

Treatments	Saline Soil		Normal Soil		Mean mg per 100 g	S.E. ±	C.D. at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	321.066	206.400	366.933	298.133	298.13	25.262	69.814
P.M.	206.400	114.666	412.800	344.000	269.53		
S.	309.600	172.00	344.000	114.666	235.06		
G.	-	-	275.200	80.266	88.86		
Control	378.400	229.433	366.933	378.400	338.29		

Mean mg/100 g Soils : Saline - 193.790 Waters: Saline-298.300
Normal - 298.120 Tap -193.800

S.E.± 35.726

C.D.at 5 per cent 98.732

From the table 4.2.3, it has been observed that soils and waters had highly significant effect on G.R. and S x A interaction was also significant. Reduction in G.R. value was more in case saline soil as compared with normal soil. Saline water significantly increased the G.R. value of the soil.

The use of gypsum gave promising decrease in the G.R. value of soils as compared with other three amendments and control. While M.D., P.M. did not differ statistically. The M.D., P.M. and control, also were sulphur on par. By using tap water with gypsum as an amendment, there is reduction in the G.R. value of the saline soil.

5) Available phosphorus content of soils :

Phosphorus is one of the major nutrient required by the plant. The data pertaining to available P content in soils have been given in Table 4.2.4 and graphically presented in Figure IV.

Table 4.2.4 : Available Phosphorus content of soils as affected by saline water and amendments.

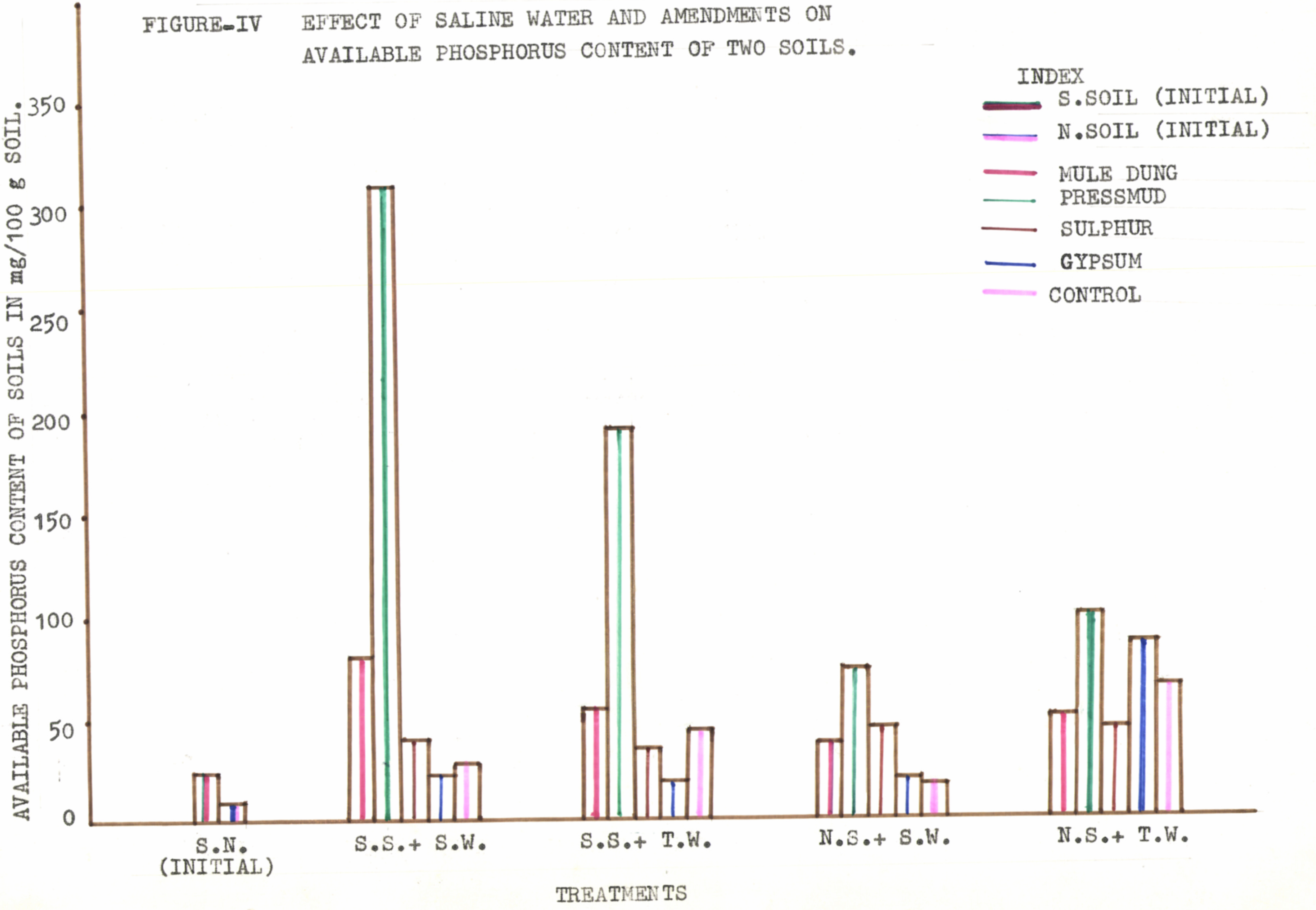
Treatments	Saline Soil		Normal Soil		Mean mg/100 g	S.E. ±	C.D. at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	81.546	56.906	37.546	51.040	56.76	7.740	21.390
P.M.	319.733	182.453	74.506	99.146	168.96		
S.	42.240	34.026	44.586	44.586	41.46		
G.	22.293	19.946	19.946	86.826	37.25		
Control	26.986	44.586	17.600	64.533	40.25		

Mean mg/100 g Soils : Saline - 83.070 Normal - 54.030

S.E.± 4.895

C.D. at 5 per cent 13.528

FIGURE-IV EFFECT OF SALINE WATER AND AMENDMENTS ON AVAILABLE PHOSPHORUS CONTENT OF TWO SOILS.



Soils and amendments were highly significant. All first order interactions were highly significant. The second order interaction i.e. S X A X W was significant.

In case of soils, saline soil had significantly more available phosphorus. While in case of amendments, pressmud has significantly increased available P content of soils. Other amendments did not differ significantly. Saline soil with the use of pressmud as an amendment has the best effect in increasing available P content of soils. The reasons may be that the high P content of pressmud. Shrivastava, Sharafat Ali and Dev (1972), found that by addition of Ca in soil, the availability of P can be increased.

The high values of available P content in soils after harvesting, may be due to high dose of applied phosphate (i.e. 75 kg P per hectare).

6) Exchangeable potassium :

Potassium is one of the most important element required for plant growth. The data regarding exchangeable K content of soils have been given in Table 4.2.5 and graphically represented in Figure V.

Table 4.2.5 : Exchangeable Potassium content of soils as affected by saline water and amendments.

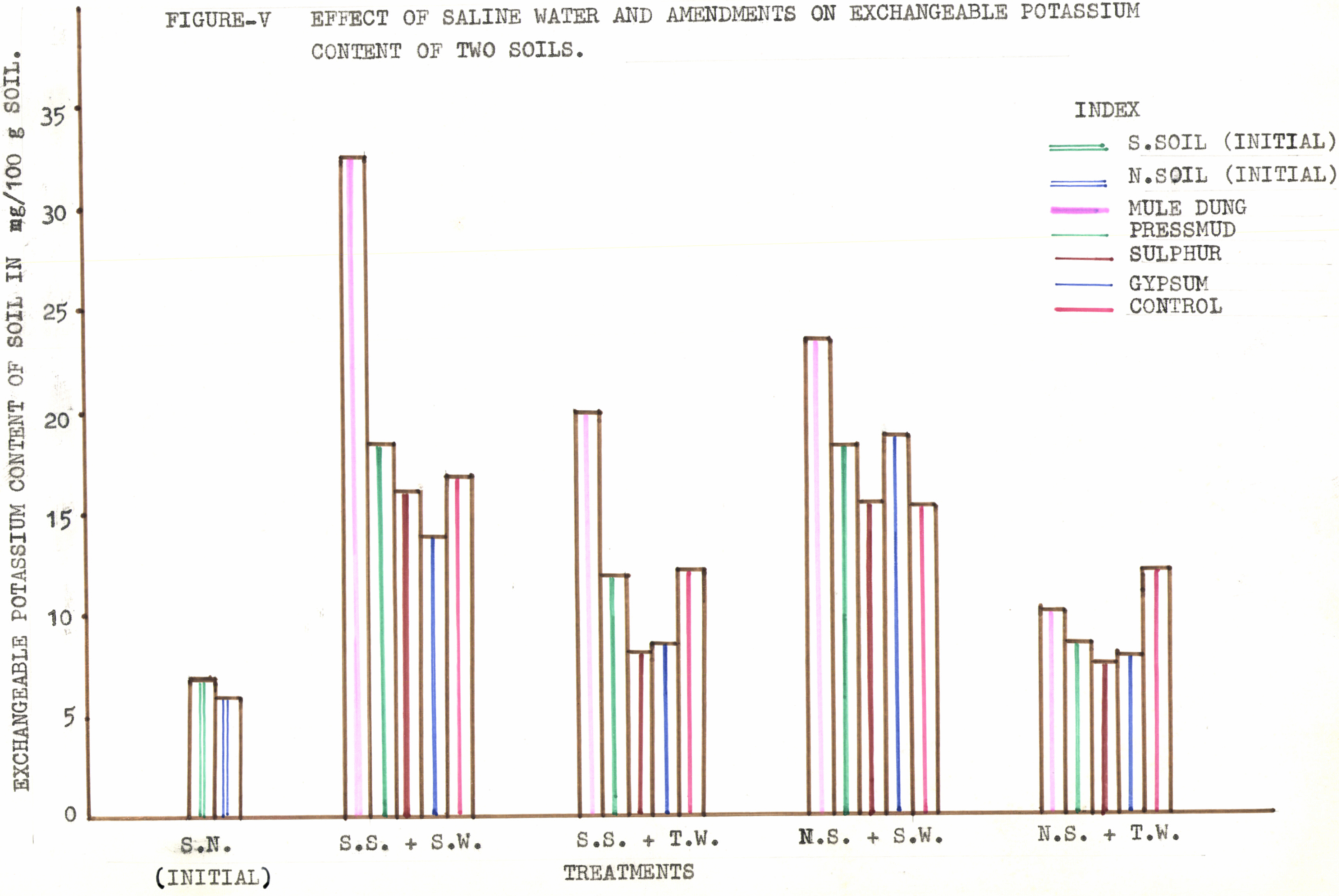
Treatments	Saline Soil		Normal Soil		Mean mg/100 g	S.E. ±	C.D. at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	32.508	19.920	23.516	9.960	21.476	1.2277	3.3928
P.M.	18.536	11.896	18.398	9.545	14.594		
S.	16.046	7.608	15.493	7.331	11.620		
G.	13.833	8.023	18.675	7.608	12.035		
Control	18121	12.173	15.355	12.035	14.421		

Mean mg/100 g Waters : Saline - 19.048 Tap - 9.610

S.E.± 0.7764

C.D.at 5 % 2.1456

FIGURE-V EFFECT OF SALINE WATER AND AMENDMENTS ON EXCHANGEABLE POTASSIUM CONTENT OF TWO SOILS.



Waters and amendments had significantly increased exchangeable K content in soils at one per cent level. The SXA interaction was also significant.

Irrigation with saline water have increased exchangeable K than the irrigations with tap water. The probable reason may be the higher K content of saline water. In case of amendments, mule dung has shown the best increase in exchangeable K, while others did not differ significantly.

Saline water containing KNO_3 was used by Talati (1968), for tobacco and *rabi* vegetables, showed beneficial effect. The presence of NO_3 and K ions in irrigation waters have an ameliorating effect on soils.

7) Exchangeable cations :

The mean values of exchangeable Ca, Mg and Na are given in Table 4.2.6.

Table 4.2.6 : Exchangeable Cations (Ca, Mg, Na) content of soils as affected by saline water and amendments.

Sr. No.	Treatments	Exchangeable cations mg per 100 g		
		Ca	Mg	Na
1	M.D.	273.54	58.375	47.750
2	P.M.	265.420	71.500	39.130
3	S.	265.170	58.750	31.041
4	G.	285.210	78.333	25.291
5	Control	270.630	59.500	62.583
6	S.Soil	202.316	40.683	55.366
7	N. Soil	341.666	89.900	26.950
8	S.Water	265.250	70.966	59.900
9	T.Water	278.730	59.616	20.416

i) Calcium :

It is one of the elements which reduce the soil alkalinity.

The normal soil has more exchangeable Ca than that of saline soil. The effect of waters was not so marked. The exchangeable Ca in the saline soil decreased than the exchangeable Ca content of the normal soil.

In case of amendments, gypsum and mule dung have increased exchangeable Ca, while other amendments have decreased exchangeable Ca content of soils as compared to control. But magnitude of decrease due to pressmud and sulphur was equal. Gypsum promisingly increased the exchangeable Ca as compared to mule dung.

Puntamkar, Mehta and Seth (1972), observed that the exchangeable Calcium was increased upto 17.7 per cent by application of 20 tonnes gypsum per hectare in saline soil.

ii) Magnesium :

Magnesium is also soil alkalinity reducing agent. The mean values of exchangeable Mg are given in Table 4.2.6.

The exchangeable Mg content in normal soils was increased than that of the exchangeable Mg content in saline soils.

But saline water irrigations increased exchangeable Mg content of soils as compared with tap water irrigations. The reason may be the higher Mg content of saline water as compared to the tap water.

In case of amendments, gypsum and pressmud have increased the exchangeable Mg content of soils as compared to control.

The addition of sulphur and mule dung as amendments have no effect on exchangeable Mg content of soils.

iii) Sodium :

It is a very dangerous element if it is present in excess amount. It leads to the development of alkalinity in the soil. The mean values of exchangeable Na contents under various treatments are given in Table 4.2.6.

The saline water has increased the exchangeable Na content of soils, as compared with the tap water.

The application of C_4S_4, C_3S_3, C_3S_1 class waters increased exchangeable sodium and sodium saturation, (Singh and Sharma, 1970).

In case of amendments, the addition of gypsum promisingly decreased the exchangeable Na as compared to the addition of other amendments.

The sequence of the amendments in decreasing exchangeable Na content of soils is as follow :

Gypsum > Sulphur > P.M. > M.D.

Increasing amount of sodium removal from solonetzic soils with the application of gypsum was observed by Padhi et al. (1965). Similarly Puntamkar, Mehta and Seth (1972), reported that by application of 20 tonnes gypsum per hectare exchangeable sodium was decreased by 1.6 to 10.9 per cent.

8) Sodium Adsorption Ratio and Exchangeable Sodium Percentage of soils :

The SAR and ESP values of soils are the parameters of measuring soil salinity and/or alkalinity. The data pertaining to SAR values and ESP values of soils are given in Table 4.2.7(A) and 4.2.7(B) respectively.

Table 4.2.7(A) : SAR values of soils as affected by saline water and amendments.

Treatments	Saline soil S.W.	Saline soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean	S.E. ±	C.D. at 5 per cent
M.D.	1.354	0.737	0.671	0.111	0.719	0.03068	0.0848
P.M.	1.257	0.568	0.431	0.085	0.584		
S.	0.967	0.450	0.449	0.080	0.489		
G.	0.735	0.299	0.388	0.059	0.371		
Control	1.880	1.017	0.771	0.191	0.953		

Mean Soils : Saline - 0.927 Waters : Saline - 0.891

Normal - 0.319 Tap - 0.355

S.E. ± 0.01939

C.D. at 5 per cent 0.0536

Table 4.2.7(B) : ESP values of soils as affected by saline water and amendments.

Treatments	Saline Soil S.W.	Saline Soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean %	S.E. ±	C.D. at 5 per cent
M.D.	25.166	14.686	10.273	2.003	13.032	0.361	0.996
P.M.	22.663	11.690	7.826	1.573	10.938		
S.	19.160	9.456	7.586	1.520	9.430		
G.	14.323	6.153	6.330	1.083	6.972		
Control	31.326	18.823	12.493	2.476	16.280		

Mean % Soils : Saline - 17.345 Waters : Saline - 15.715

Normal - 5.316 Tap - 6.947

S.E. ± 0.228

C.D. at 5 per cent 0.630

All factors and first order interactions were highly significant. Saline soil and saline water have increased the SAR and ESP values of soils, significantly as compared to the normal soil and tap water respectively. All the amendments have significantly decreased SAR and ESP values of soils. Gypsum has given best effect in decreasing SAR and ESP values of soils.

Paliwal and Maliwal (1971), observed that the SAR of irrigation water was significantly correlated with ESP value of soil. Similar observations were made by Yadav (1970-71), Singh (1966), and Jacobs *et al*. (1961). SAR and ESP values of soils were directly proportional to the sodium content of irrigation water and soil, while inversaly proportional to the Ca and Mg contents of irrigation water and soil.

9) Water soluble cations :

The mean values of water soluble cations are given in Table 4.2.8.

Table 4.2.8 : Water soluble cations (Ca,Mg,Na,K) content in soils as affected by saline water and amendments.

Sr. No.	Treatments	Water soluble cations (mg/100 g)			
		Ca	Mg	Na	K
1	M.D.	7.450	1.503	9.500	1.905
2	P.M.	13.730	2.283	7.510	1.420
3	S.	15.150	1.565	7.710	1.164
4	G.	20.470	2.158	5.990	1.392
5	Control	9.320	0.948	5.810	1.357
6	S.Soil	14.480	1.943	9.740	1.575
7	N. Soil	11.600	1.440	5.770	1.099
8	S.Water	16.110	1.693	11.320	1.825
9	T.Water	10.230	1.689	4.180	0.849

i) <u>Calcium</u> :

Water salinity has increased the water soluble Ca content of soils. The probable reason may be that the Na present in saline water might exchange the adsorbed Ca by soil and get it free in soluble form. All the amendments have increased water soluble Ca as compared to control, except M.D. The effect of other three amendments in increasing water soluble Ca is in the following order; Gypsum > Sulphur > P.M. Water soluble Ca content in saline soil has been increased than the water soluble ca content in non saline soil.

ii) <u>Magnesium</u> :

Water salinity had more or less no effect on water soluble Mg content of soils. The addition of amendments have increased water soluble Mg content of soils as compared to the control. Gypsum and P.M. had better effect in increasing Mg content of soils than that of sulphur and M.D.

iii) <u>Sodium</u> :

Water salinity and soil salinity have increased the water soluble Na content of soils in high amounts. The water soluble Na was increased by addition of all the amendments except the addition of gypsum, which has more or less no effect on water soluble Na content of soil.

iv) <u>Potassium</u> :

Water salinity has increased the water soluble K content of soils. The probable reason may be the higher K content of saline water than that of tap water. The addition of M.D. and

P.M. have increased water soluble K as compared with control. Gypsum has more or less no effect on water soluble K content of soils.

10) Soluble Sodium Percentage of soils :

The SSP is also one parameter to measure the soil salinity or alkalinity. The data regarding SSP values of soils are presented in Table 4.2.9.

Table 4.2.9 : SSP values of soils as affected by saline water and amendments.

Treat-ments	Saline Soil		Normal Soil		Mean %	S.E. ±	C.D.at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	47.63	46.91	53.61	19.44	41.89	0.7968	2.202
P.M.	26.66	33.78	44.06	14.59	29.77		
S.	45.14	29.04	31.83	8.96	28.74		
G.	27.08	19.84	39.15	10.47	24.13		
Control	49.22	50.07	54.60	21.51	43.85		

Mean % Soils : Saline - 37.530, Normal - 29.820; Waters : Saline - 41.900, Tap - 25.530

S.E. ± 0.5039

C.D.at 5 per cent 1.3925

Soils, waters, amendments and all interactions have highly significant effect on SSP values of soils except WXA interaction which was significant at 5 per cent.

Soil salinity and water salinity have significantly increased the SSP values of soils, while amendments have significantly decreased the SSP values of soils, except mule dung. The addition of mule dung did not affect SSP values of soils. But pressmud and sulphur have decreased SSP values of soils as compared to mule dung and control. Gypsum has the best effect in decreasing SSP values of soils.

4.2.4 Effect of saline water on chemical properties of soils (Control) :

The chemical properties of two soils (Control treatments) collected after the completion of the pot culture experiment are presented in Table 4.2.10.

The following observations have been made after comparing the chemical properties with initial soil properties.

i) pH :

pH values of normal soil irrigated with saline water have been increased while pH values of saline soil irrigated with saline water have been slightly decreased.

ii) Electrical conductivity :

In case of normal soil, E.C. was increased, but in case of saline soil E.C. was decreased by irrigations with saline waters. The probable reason may be the leaching of salts, due to use of ample quantity of irrigation water.

Satyanarayana *et al.*(1967), observed that continuous use of saline water did not show any apparent effect on well drained soils, indicating that many waters apparently of questionable quality may actually be used with success on well drained soils.

Table 4.2.10 : Effect of saline water on chemical properties of soils.

Sr. No.	Property	Unit	Initial soils		Soils after harvesting	
			Saline	Normal	Saline	Normal
1	pH	-	8.250	8.000	8.200	8.150
2	E.C.	mmhos/cm	2.640	0.142	2.167	0.286
3	Organic Carbon	Per cent	0.584	0.330	0.563	0.343
4	G.R.	mg/100g	894.400	206.400	378.400	366.733
5	Available P.	mg/100 g	24.640	10.560	26.987	17.600
6	Exchangeable Cations	mg/100 g	340.740	484.990	331.203	465.526
	Ca	mg/100 g	113.870	341.870	166.664	319.997
	Mg	mg/100 g	73.370	100.870	47.447	77.497
	Na	mg/100 g	146.500	37.000	100.247	53.290
	K	mg/100 g	7.000	5.250	16.955	14.742
7	SAR	-	4.845	0.505	1.759	0.691
8	ESP	Per cent	42.995	7.629	30.268	11.447
9	Water soluble cations	mg/100 g	179.650	13.010	19.918	12.695
	Ca	mg/100 g	56.130	8.130	8.336	5.003
	Mg	mg/100 g	2.630	1.130	0.663	0.503
	Na	mg/100 g	120.000	3.000	9.753	6.376
	K	mg/100 g	0.890	0.750	1.166	0.813
10	SSP	Per cent	66.797	23.059	49.223	49.824

iii) Organic Carbon :

The organic carbon contents of both the soils collected after the harvesting of crop, grown by irrigating with saline water were found to be more or less equal.

iv) Gypsum requirement :

The G.R. of saline soil was reduced while that of normal soil was increased.

v) Available phosphorus :

Available P content of both soils collected after harvest of the crop have been increased. But magnitude of increase in normal soil was higher as compared to saline soil. The probable reason for increase in available P in both the soils may be due to addition of higher dose of P fertilizer initially (75 kg P per hectare).

vi) Exchangeable cations :

There was decrease in total exchangeable cations in both the soils. But magnitude was greater in case of saline soil. Exchangeable calcium content of both the soils were decreased by 25 mg/100 g of soil. Exchangeable magnesium was also decreased in both the soils. In case of sodium, it was increased in normal soil and decreased in saline soil. The reason may be that the SSP values of Saline soil was 66.797 per cent. So there was more possibility of leaching of sodium. The potassium content of both the soils was highly increased. It may be due to the higher K content of saline water i.e. 2.355 meq per litre.

vii) Sodium Adsorption Ratio and Exchangeable sodium Percentage :

Both these values were increased in case of normal soil, while these were decreased in saline soil.

viii) Water soluble cations :

These were increased in case of normal soil while they were decreased in case of saline soil. The Ca and Na were increased in normal soil, while they were decreased in saline soil. Magnesium was decreased in both the soils. As regards K, it was increased in both the soils because of the higher K content of saline water than that of tap water.

ix) Soluble sodium percentage :

The SSP of saline soil was reduced while of normal soil, it was highly increased.

4.2.5 Effect on jowar plant :

1) Germination :

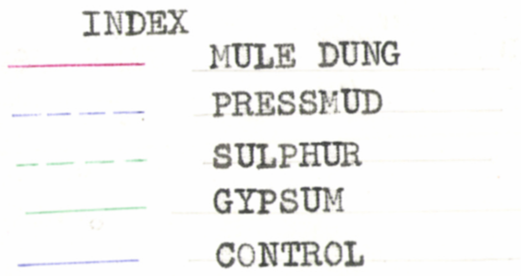
At 6 days after sowing 84.33 per cent germination took place. This indicates that there was not so much influence of saline water on the germination of jowar.

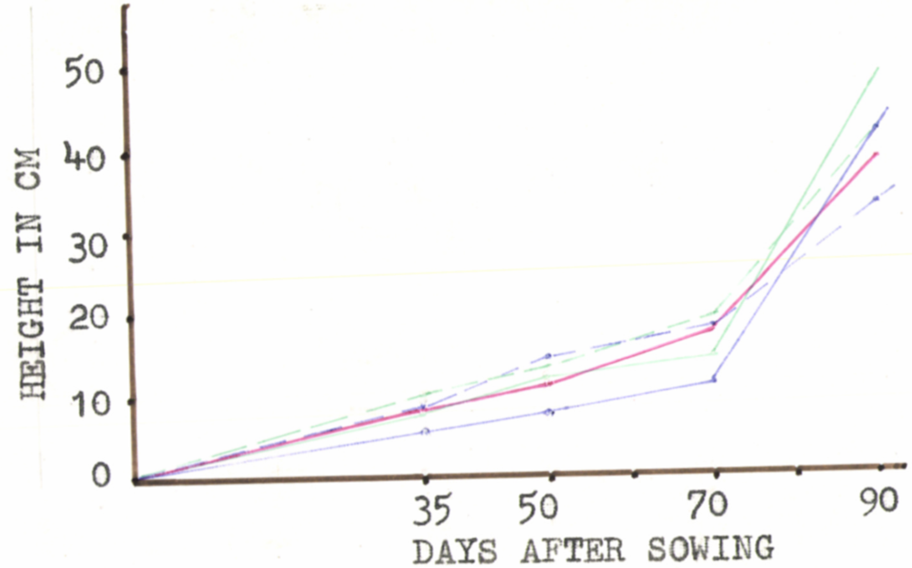
The data regarding germination of jowar at 6 days after sowing are given in Table 4.2.11.

Table 4.2.11 : Effect of water salinity and amendments on germination of jowar crop at 6 days after sowing in saline and non saline soils.

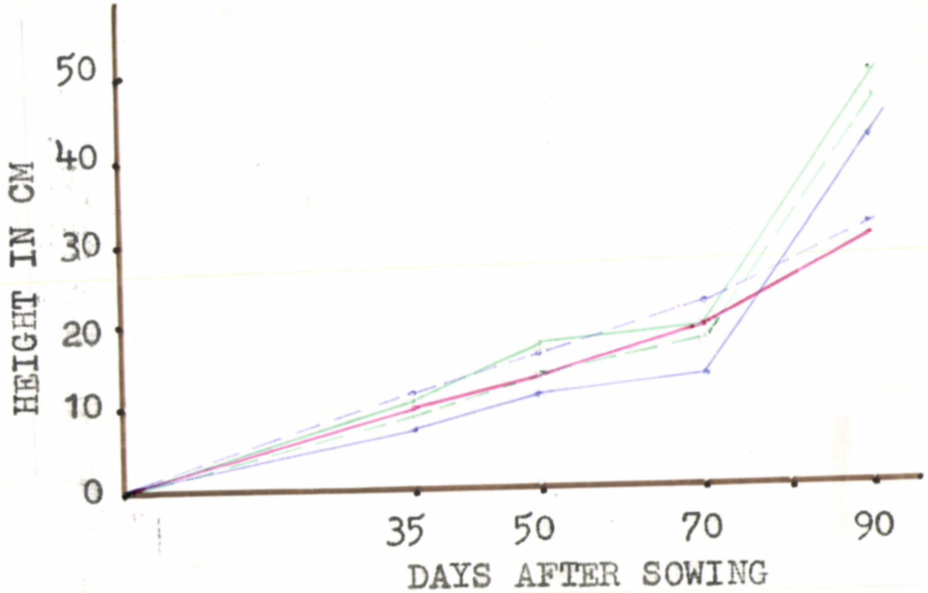
Treatments	Saline Soil		Normal Soil		Mean Ars. Tran.	S.E. ±	C.D.at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	61.223	72.783	68.853	75.000	69.465	9.1365	25.2496
P.M.	59.006	68.853	68.853	83.853	70.142		
S.	61.223	57.000	70.776	61.223	62.556		
G.	61.713	59.706	66.636	83.853	71.311		
Control	59.216	63.930	72.783	70.076	66.502		
Mean Ars.Tran.	Soils :	Saline - 62.466		Waters :	Saline - 65.029		
		Normal - 72.191			Tap - 69.628		
S.E.±	1.9117						
C.D.at 5 per cent	5.2831						

FIGURE-VI EFFECT OF SALINE WATER AND AMENDMENTS ON HEIGHT OF JOWAR PLANTS GROWN IN TWO SOILS.

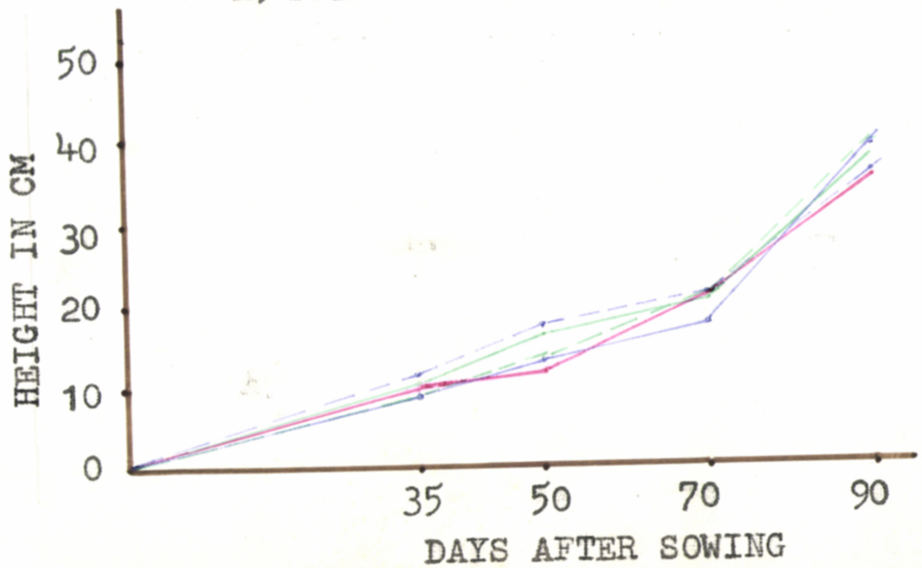




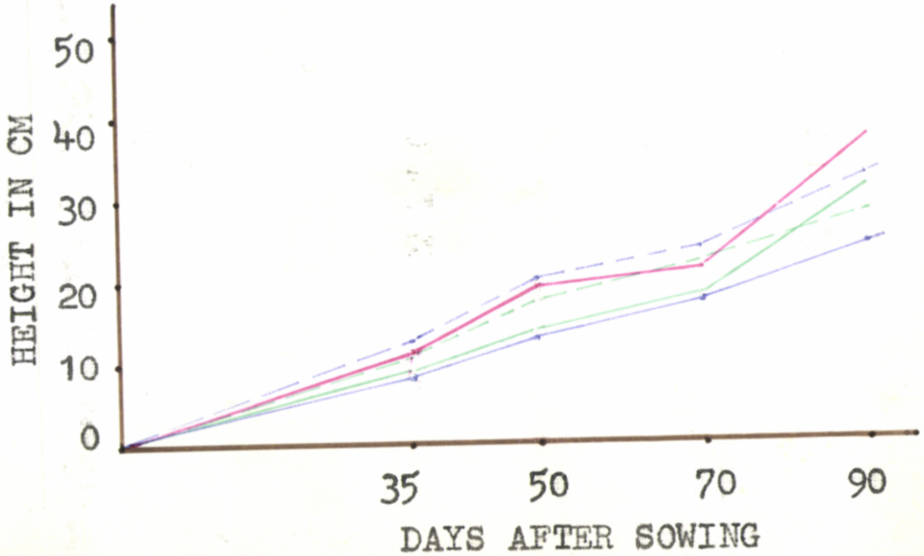
A) SALINE SOIL + SALINE WATER



B) SALINE SOIL + TAP WATER



C) NORMAL SOIL + SALINE WATER



D) NORMAL SOIL + TAP WATER

At six days after sowing, the germination of jowar was significantly reduced in saline soil. The reason may be that the osmotic pressure of soil solution is increased which will affect the absorption of water and nutrients required for germination.

Malek T. Kaddah (1962), Malek T. Kaddah, and Salma I. Ghowail (1964), Lall and Deore had stated that the increasing levels of salinity delayed germination and had no detrimental effect on [redacted] germination percentage. Singh and Singh (1972), found the negative correlation in between E.C. and germination percentage.

2) Morphological characters of plants :

The effect of water salinity, soil salinity and different amendments under study on the morphological characters of jowar are discussed below.

I) Height :

The observations on height recorded at 35, 70 and 90 days after sowing are presented below.

i) Thirty five days :

The data pertaining to the height of jowar plant at 35 days after sowing are given in Table 4.2.12(A).

Soils, water andamendments have highly significant effect on height of the plant. Saline soil and saline water have reduced the height of plants as compared to the normal soil and tap water respectively. In case of the amendments, pressmud has the best effect in increasing height of plants. There was no statistical difference among M.D., Sulphur and gypsum which were used as amendments.

Table 4.2.12(A) : Effect of water salinity and amendments on height of *jowar* plants at 35 days after sowing in saline and non saline soils.

Treat-ments	Saline Soil S.W.	Saline Soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean cm	S.E. ±	C.D.at 5 per cent
M.D.	7.95	9.47	9.52	11.07	9.500	0.3583	0.9901
P.M.	8.80	10.97	10.87	12.47	10.775		
S.	9.33	8.68	8.89	11.00	9.476		
G.	7.55	9.87	10.27	9.20	9.221		
Control	5.20	6.80	8.68	8.47	7.288		
Mean cm	Soils :	Saline - 8.462		Waters :	Saline - 8.705		
		Normal - 10.042			Tap - 9.798		
S.E. ±	0.2264						
C.D.at 5 per cent	0.6256						

ii) Seventy days :

The data regarding to height of plants, at 70 days after sowing are presented in Table 4.2.12(B).

Table 4.2.12(B) : Effect of water salinity and amendments on height of *jowar* plants at 70 days after sowing in saline and non saline soils.

Treat-ments	Saline Soil S.W.	Saline Soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean cm	S.E. ±	C.D.at 5 per cent
M.D.	17.00	19.00	21.10	21.27	19.592	0.7974	2.2036
P.M.	17.53	21.97	20.83	23.53	20.967		
S.	18.40	17.70	20.37	21.47	19.483		
G.	14.10	18.73	20.27	18.07	17.792		
Control	10.53	12.73	17.30	17.40	14.492		
Mean cm	Soils :	Saline - 16.75					
		Normal - 20.16					
S.E. ±	0.5043						
C.D.at 5 per cent	1.3936						

Soils and amendments have highly significant effect while S x W interaction has significant effect on height of the plant at 70 days after sowing. Soil salinity has reduced height of the plant. The amendments namely P.M., M.D. and sulphur have increased height of plants significantly over gypsum and control; while M.D. sulphur, gypsum have significantly increased height of plant over control.

iii) Ninety days :

The data regarding height of plants at 90 days after sowing are presented in Table 4.2.12(C).

Table 4.2.12(C) : Effect of water salinity and amendments on height of jowar plants at 90 days after sowing in saline and non saline soils.

Treat-ments	Saline Soil		Normal Soil		Mean cm	S. E. ±
	S.W.	T.W.	S.W.	T.W.		
M.D.	38.00	30.00	34.50	37.33	34.125	
P.M.	33.00	31.50	35.00	32.50	33.000	
S.	41.00	47.50	38.66	27.83	38.750	
G.	47.50	50.00	36.50	30.83	41.208	
Control	41.33	42.00	38.66	24.00	36.500	
Mean cm	Saline Soil - 40.18		Normal Soil - 33.25			
S.E.±	1.503					
C.D.at 5 per cent	4.154					

Soils have highly significant effect on height of jowar plant. Saline soil has significantly increased height of the jowar plant at 90 days after sowing.Other treatments were statistically nonsignificant.

Effect of saline water and amendments on the height of jowar plants grown in saline and nonsaline soils is graphically represented in Figure VI.

Bain and Milton Fireman (1968), Sinha and Dev (1972), observed that soil salinity or alkalinity drastically reduced the growth of sorghum and berseem respectively. But Paliwal and Maliwal (1971), found that maize was satisfactorily grown on irrigation water having salinity upto 28 meq per litre and SAR of 25. Paliwal (1972), also stated that there was increase of 15 to 45 per cent in the growth of wheat, barley, maize and bajra while irrigating with saline waters upto 28 meq per litre salinity.

3) Emergence of earheads :

At 88 and 112 days after sowing the [redacted] emergence of earheads were 30 per cent and 63.33 per cent respectively.

i) Eighty eight days :

The data pertaining to emergence of earheads at 88 days after sowing are presented in Table 4.2.13(A).

Soils and amendments are highly significant while S x A interaction is significant. Saline soil has significantly increased the emegence of earheads. The use of P.M., M.D. and sulphur as amendments have increased the emergence of earheads as compared to gypsum and control. There was no statistical difference in between P.M. and M.D. and sulphur in increasing the emergence of earheads.

Table 4.2.13(A) : Effect of water salinity and amendments on emergence of earheads of *jowar* crop at 88 days after sowing in saline and nonsaline soils.

Treatments	Saline Soil S.W.	Saline Soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean Ars. Tran.	S.E. ±	C.D.at 5 per cent
M.D.	54.22	55.37	18.85	25.00	38.362	4.4644	12.3378
P.M.	71.15	72.29	26.15	26.56	49.038		
S.	46.92	41.74	33.49	26.15	37.053		
G.	36.93	21.93	17.71	8.85	21.355		
Control	8.85	8.85	8.85	-	6.640		

Mean Ars. Tran. Saline Soil - 41.827 Normal Soil - 19.163

S.E.± 2.8235

C.D.at 5 per cent 7.803

ii) <u>One hundred and twelve days</u> :

The data regarding emergence of earheads at 112 days after sowing are given in table 4.2.13(B).

Table 4.2.13(B) : Effect of saline water and amendments on emergence of earheads of *jowar* crop at 112 days after sowing in saline and non-saline soil.

Treatments	Saline Soil S.W.	Saline Soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean Ars. Tran.	S.E. ±	C.D.at 5 per cent
M.D.	81.15	90.00	28.85	30.00	57.500	4.3843	12.116
P.M.	90.00	90.00	81.15	38.85	75.000		
S.	90.00	81.96	56.51	34.22	65.673		
G.	90.00	90.00	34.63	17.71	58.084		
Control	55.37	59.22	41.93	26.56	45.769		

Mean Ars.Tran. Soils - Saline - 81.769 Waters:Saline - 64.958
Normal - 39.374 Tap - 55.852

S.E.± 2.7729

C.D.at 5 per cent 7.663

Soils and amendments, S x A interaction were highly significant while waters and S x W interaction were significant. Saline soil and saline water have statistically increased the emergence of earheads as compared to normal soil and tap water respectively. The addition of P.M. and sulphur have statistically increased emergence of earheads as compared to the addition of other amendments. These two amendments were also on par with each other. Sulphur and gypsum were also on par with each other, but were significantly superior over control.

4) Dry matter yield :

The dry matter yield gives an idea about the effect on yield. The data pertaining to dry matter yield are given in table 4.2.14 and graphically presented in Figure VII.

Table 4.2.14 : Dry matter yield of *jowar* crop as affected by saline water and amendments in saline and non-saline soils.

Treatments	Saline Soil		Normal Soil		Mean g/plant	S.E. ±	C.D.at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	4.846	3.700	5.120	3.126	4.198	0.3563	0.9847
P.M.	5.966	5.260	5.320	4.473	5.255		
S.	6.126	6.073	6.880	4.000	5.770		
G.	6.33	6.667	6.220	3.733	5.843		
Control	5.253	4.773	6.600	2.773	4.850		

Mean g/plant	Soils - Saline - 5.530 Normal - 4.824	Waters - Saline - 5.897 Tap - 4.458
S.E.±	0.2253	
C.D.at 5 per cent	0.6226	

Waters and S x W interaction were highly significant, while soils and amendments were significant. Soil salinity and water salinity have significantly increased the dry matter yield of *jowar*. The reason may be the high fertility status of saline soil and higher K and NO_3 content of saline water. The addition of gypsum, sulphur and pressmud have significantly increased the dry matter yield than the addition mule dung and control. Gypsum, sulphur, and P.M., control did not differ significantly.

Lunin and Gallatin (1965), observed that at a given salinity level crop yields tend to be higher where soils are adequately fertilized than where some nutrient difficiency exists. Talati (1968), revealed that there was beneficial effect of saline irrigation water on crop performance like tobacco and *rabi* vegetables, in Gujrath State. In Farukhabad district of Uttar Pradesh, very high yields of cash crop like potato and tobacco have been obtained without any fertilizer by using saline waters having high nitrate content (Mehrotra, 1969). Bhumbla *et al*. (1964), reported that in sandy soils appreciable reduction in yield of wheat and maize fodder occured only when the E.C. of water was more than 11,000 micromhos and in this soil, SAR upto 16 did not have much effect.

5) Different elemets content in the plant :

The effect of water salinity with and without amendments on the content on N, P, K, Ca, Mg and Na in the *jowar* plant grown on saline and non-saline soils have been discussed as under.

i) Nitrogen :

Nitrogen is one of the important constituent of protein. The data pertaining to nitrogen content of jowar plants are presented in table 4.2.15 and graphically represented in Figure VIII.

Table 4.2.15 : Nitrogen content of jowar plants as affected by saline water and amendments in saline and non-saline soils.

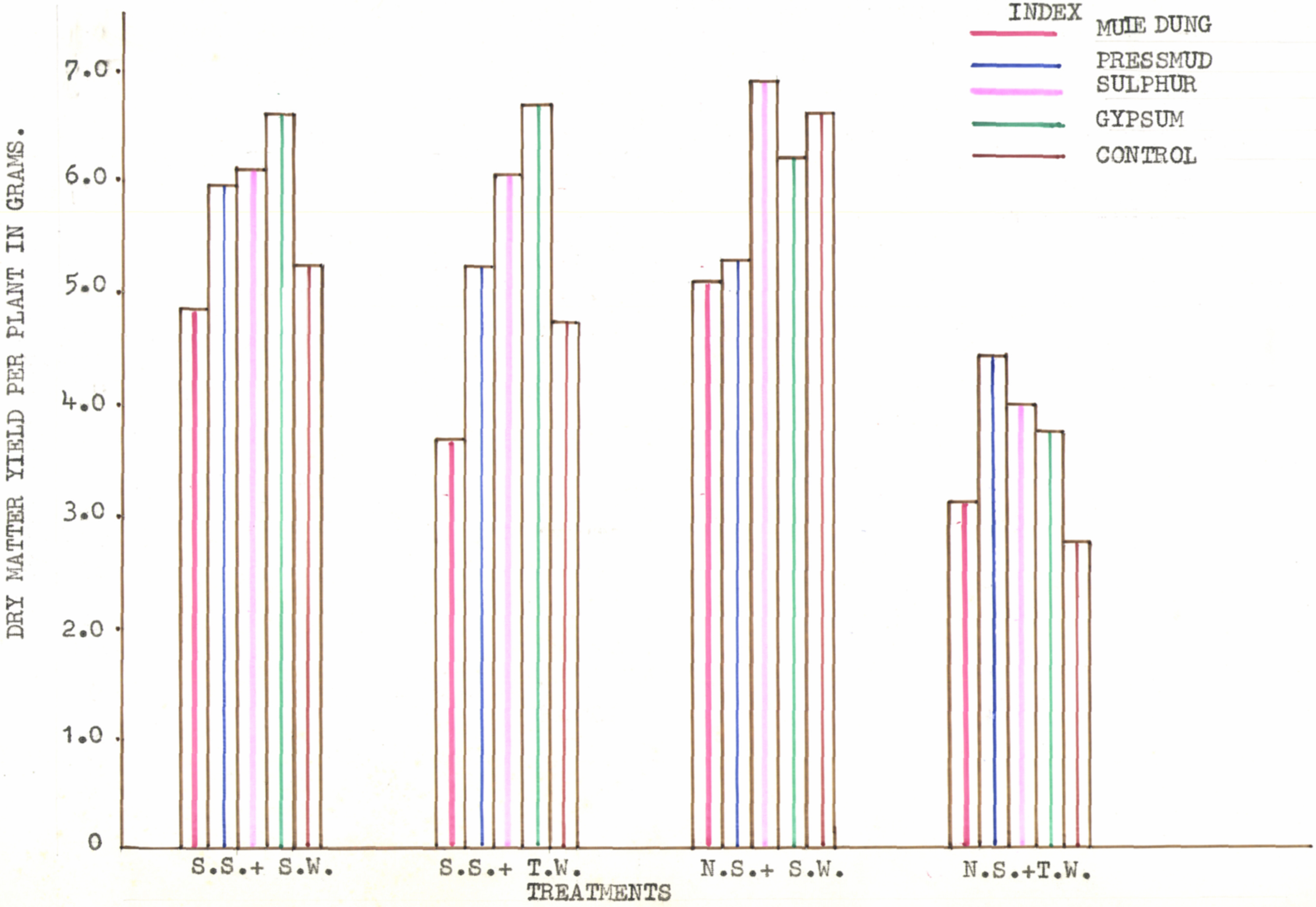
Treatments	Saline Soil		Normal Soil		Mean mg/100 g	S.E. ±	C.D.at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	879.60	822.66	815.66	434.33	738.08	6.7684	18.705
P.M.	990.00	685.33	945.66	331.00	738.00		
S.	1010.00	493.33	1074.00	1287.00	966.00		
G.	813.00	414.66	887.33	120.33	558.83		
Control	975.33	385.00	746.66	410.00	629.25		

Mean mg/100 g	Soils : Saline - 746.900	Waters : Saline - 907.067
	Normal - 705.200	Tap - 538.367
S.E.±	4.2807	
C.D.at 5 per cent	11.830	

From the data given in table 4.2.15, it is observed that all treatments and interactions were highly significant except S x W interaction.

Saline soil and saline water have significantly increased the N content of jowar plant. The addition of sulphur showed best results in increasing N content of jowar plant. Gypsum was found to be inferior in increasing

FIGURE - VII EFFECT OF SALINE WATER AND AMENDMENTS ON DRY MATTER YIELD OF JOWAR PLANTS GROWN IN TWO SOILS.



N content of plant even in comparison with control. Mule dung and pressmud were on par in increasing N content of jowar plant. Paliwal (1971), observed that the NO_3 content of irrigation water was significantly correlated with available N of the irrigated soils and create favourable environment in root zone for absorption under saline substrata.

ii) Phosphorus :

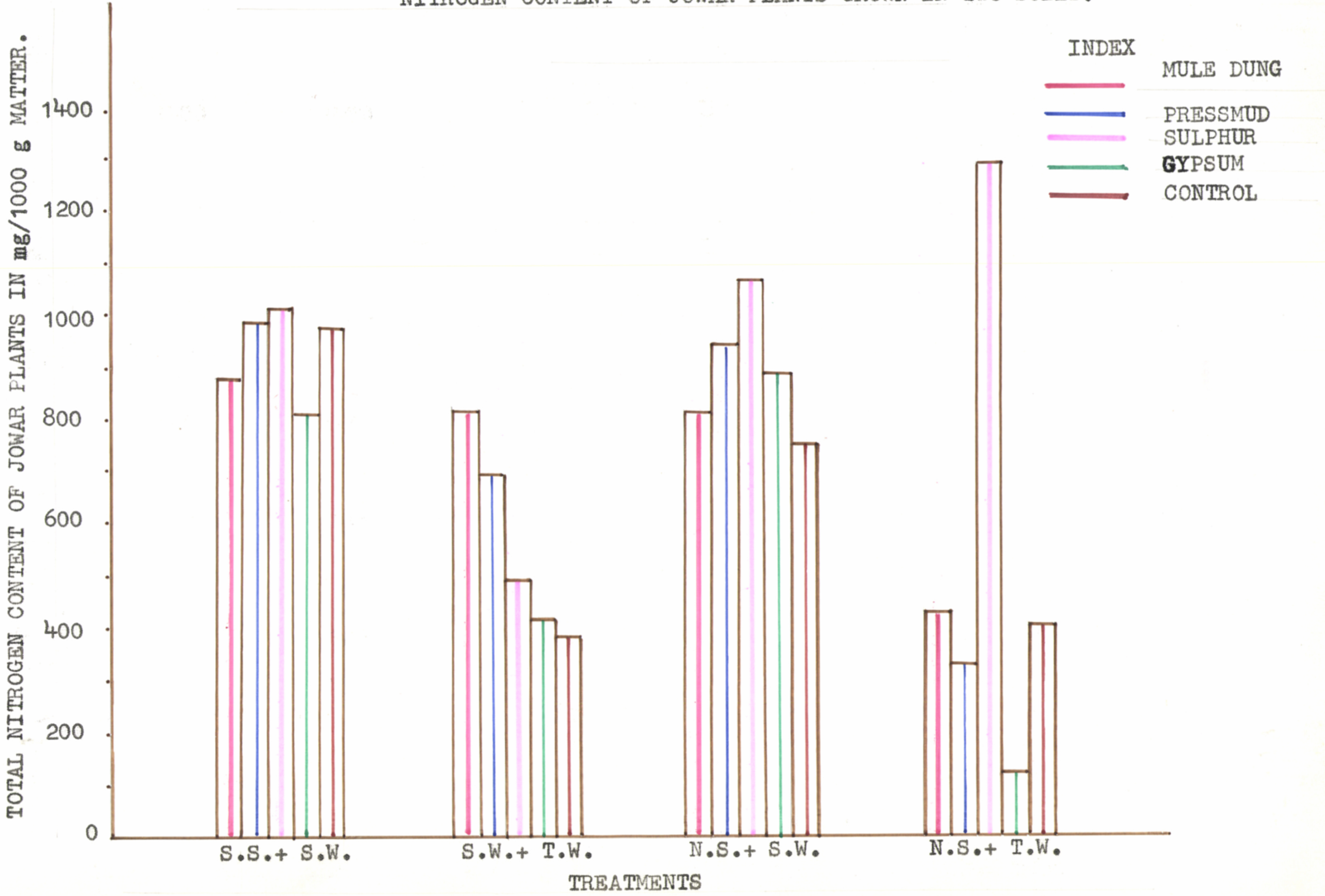
Phosphorus is another important compound present in plant. The data regarding P content of plants are given in table 4.2.16 and graphically represented in Figure IX.

Table 4.2.16 : Phosphorus content of jowar plants as affected by saline water and amendments in saline and non-saline soils.

Treatments	Saline Soil		Normal Soil		Mean mg/100 g	S.E. ±	C.D.at 5 per cent
	S.W.	T.W.	S.W.	T.W.			
M.D.	1150	683	659	467	739.6	37.116	102.573
P.M.	690	657	690	682	679.6		
S.	467	473	626	602	542.0		
G.	753	650	467	714	645.9		
Control	508	370	618	450	486.6		
Mean mg/100 g	Waters : Saline - 662.90		Tap - 574.70				
S.E.±	23.474						
C.D.at 5 per cent	64.858						

Amendments and first order interactions like S x A and W x A were highly significant. While waters have significant

FIGURE - VIII EFFECT OF SALINE WATER AND AMENDMENTS ON THE TOTAL NITROGEN CONTENT OF JOWAR PLANTS GROWN IN TWO SOILS.



effect on P content of the plant. Irrigations with saline water have increased P content of jowar plant as compared to the irrigations with tap water. The addition of M.D., P.M. and gypsum have significantly increased P content of jowar over addition of sulphur and control. The amendments, i.e. M.D., P.M. and gypsum were on par with respect to their effect on P content of jowar plant.

Wahhab and Zahir Hussain Shah (1952), observed that the liming as compared to no treatment had increased the uptake of P_2O_5 in sorghum plant. Lunin and Gallatin (1965), also reported that the P content of plants were affected by soil salinity.

iii) Cation contents of plants :

The cations in plants are most essential for the physiological functions of plants. The average values of calcium, magnesium and sodium content of jowar plant are given in table 4.2.17(A).

Table 4.2.17(A) : Mean values of calcium, magnesium and sodium content of jowar plants as affected by saline water and amendments in saline and non-saline soils.

Treatments	Ca mg/100 g	Mg mg/100 g	Na mg/100 g
M.D.	1005.00	212.00	11.670
P.M.	840.00	276.00	12.750
S.	588.33	192.00	10.730
G.	625.00	263.00	10.940
C.	890.00	270.00	11.040
S. Soil	622.00	221.60	11.625
N. Soil	1041.33	263.60	11.625
S. Water	836.67	278.00	14.375
T. Water	826.67	207.20	8.875

a) Calcium :

The calcium content of *jowar* plants grown in normal soil was increased than the calcium content of *jowar* plant grown in saline soil. There was no such effect on Ca content of plant by application of saline water and tap water. Mule dung has showed good effect in increasing Ca content of plant as compared to the control, while other amendments have decreased the calcium content of *jowar* plant.

b) Magnesium :

The Mg content of *jowar* plants grown in normal soil was increased than the Mg content of *jowar* plants grown in saline soil. But irrigations with saline water have increased the Mg content of plants over irrigations with tap water. In case of amendments, only pressmud has increased Mg content of plant over control. Other amendments have decreased Mg content of *jowar* plants.

c) Sodium :

Sodium content of *jowar* plants grown in saline and non-saline soils did not differ at all. But irrigations with saline water have increased Na content of plants than that of tap water irrigations. The addition of M.D., and P.M. have increased the sodium content of plants while the addition of sulphur and gypsum have decreased it over control.

d) Potassium :

The data pertaining to K content of *jowar* plants are given in table 4.2.17(B) and graphically represented in Figure X.

FIGURE-IX EFFECT OF SALINE WATER AND AMENDMENTS ON THE TOTAL PHOSPHORUS CONTENT OF JOWAR PLANTS GROWN IN TWO SOILS.

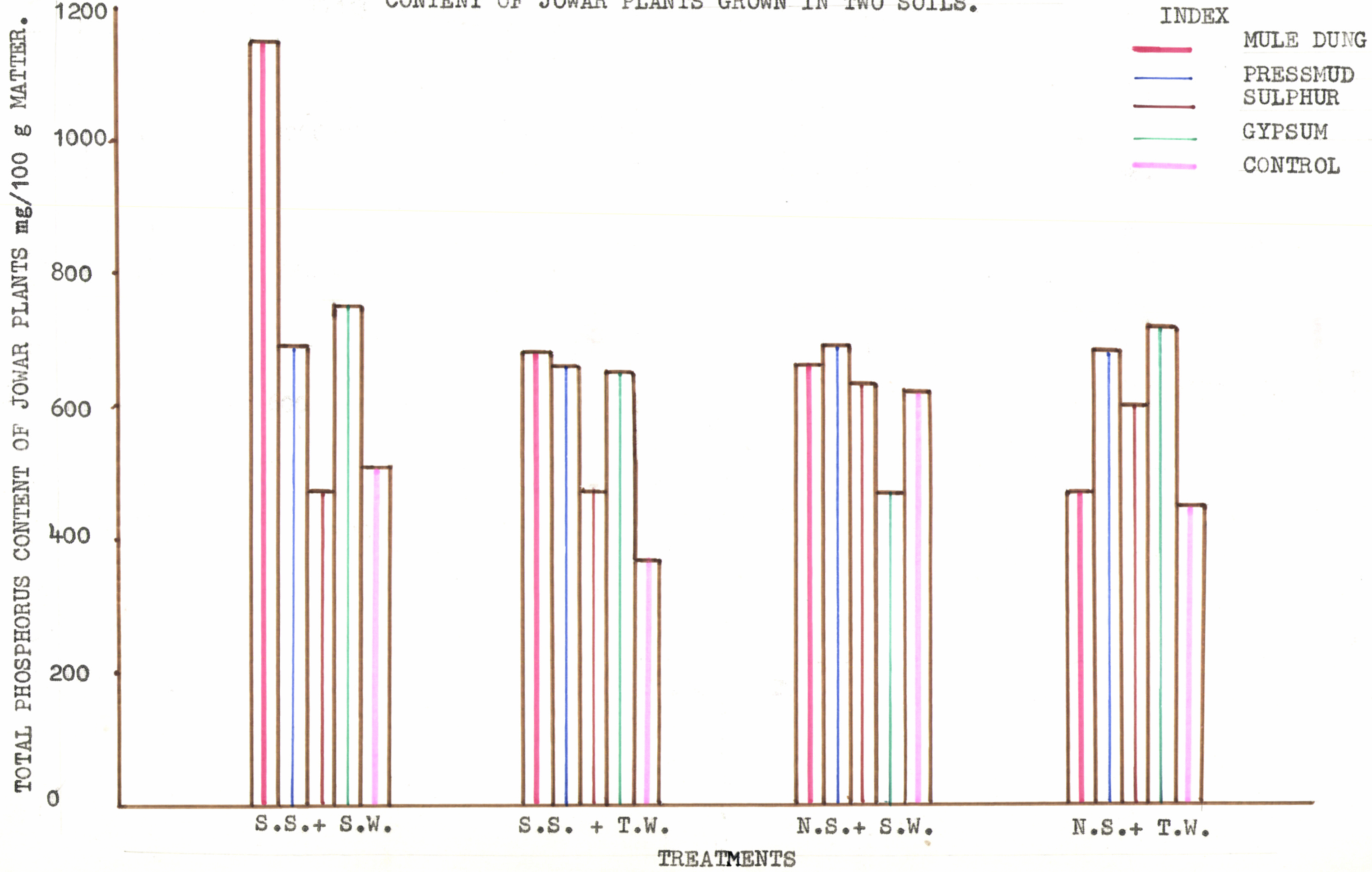


Table 4.2.17(B) : Potassium content of *jowar* plants as affected by saline water and the amendments in saline and non-saline soils.

Treatments	Saline Soil S.W.	Saline Soil T.W.	Normal Soil S.W.	Normal Soil T.W.	Mean mg/ 100 g	S.E. ±	C.D. at 5 per cent
M.D.	1549.33	1148.16	1992.00	95450	1411.00	128.3857	354.81
P.M.	2185.67	2365.50	1922.83	1701.50	2043.87		
S.	2268.67	1051.33	1092.83	1577.00	1479.45		
G.	1577.00	926.83	1383.33	1687.67	1393.70		
Control	1314.16	1604.67	1189.67	1335.50	1411.00		
S.E.±							

The amendments were highly significant in increasing K content of plant, while SxWxA interaction was significant. The addition of pressmud has significantly increased the K content of plants over the addition of all other treatments. The reason may be that the K content of added pressmud was higher.

Lunin and Gallatin (1965), observed that the Ca and Mg contents of the leaves were more affected by salinity than those of the stems, where Na and K contents of stems were more affected than those of leaves. Paliwal and Maliwal (1971), found that the uptake of Ca and Mg is negatively correlated with the ESP of soils and of Na positively correlated with the ESP and soluble Na content. Poonia, Virmani and Bhumbla (1972), revealed that increasing levels of Na saturation in the soil had a definite depressive effect on the uptake of applied as well as native calcium by the plant.

CHAPTER V

GENERAL DISCUSSION

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GENERAL DISCUSSION

The quality of irrigation waters has close relationship with the crop production. In Maharashtra State, the major source of irrigation is well waters. Lands have become unproductive due to use of poor quality of waters and faulty irrigation practices. The present investigation was therefore undertaken with the object of assessing seasonal fluctuations in quality of well waters from University farm and adjoining villages and to study the use of poor quality of well waters for crop production.

The results of the present investigations are discussed in brief as below :-

I) Seasonal fluctuations in quality of well waters and its suitability on the basis of different criteria :

Suitability of well waters can be judged by different characteristics which have been already discussed in the previous chapter. But mearly from analytical report of well waters, it is not possible to definitely comment about its suitability. For deciding the suitability of well waters, other factors like soil permeability, soil texture, salts present in the soil and salt tolerance of crops to be grown, should be considered. The suitability of well waters analysed under the present investigation have been broadly discussed here on the basis of some important criteria.

About 94 per cent of well waters from all the blocks of the University farm and 72 per cent of well waters from the adjoining villages have electrical conductivity below 2250 micromhos/cm and can be successfully used for crop production for considerable time with proper management. (Annonymous, 1954).

The SAR values of 80 per cent of well waters were under S_1 class which can be safely used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium as described by Durand, (1956). While 20 per cent well waters have SAR values above ten which indicates high concentration of sodium ions and use of these waters for irrigation needs due precautions in management practices. These waters may be used on coarse textured or organic soils with good permeability as suggested by Agarwal and Gupta, (1968).

The average RSC values of the well waters from all the villages and all the blocks from the University farm are found to be within the safe limit i.e. below 1.25 meq/litre as described by Eaton, (1950).

Boron is an essential element to plant growth, but is exceedingly toxic at concentrations slightly above optimum limit i.e. 0.33 mg/litre for sensitive crops (Scofield, 1936). The average boron content of all the well waters from five villages and all the blocks of the University farm are within the safe limit. From the Appendix III, it is observed that 81.83 per cent of the well waters are of good quality i.e. under class B-I i.e. (0.67 mg boron/litre) and remaining are under B-II Class i.e. 0.67 to 1.33 mg boron/litre) for semi-tolerant crops.

From the Appendix I, some samples (Sr.Nos. 1, 8, 9, 10, 11, 12, 14, 15, 17, 20, 25, 26, 28, 29, 36, 43, 44) are of doubtful quality, considering their SAR and the E.C. values. These waters can be successfully used by taking possible precautions as follows :-

1) These waters may be used on low textured soils like sandy soils and also in medium textured soils providing well drainage conditions. The continuous use of saline water did not show any apparent effect on well drained soils (Satyanarayana, et al. 1967). When soils are irrigated with saline waters, the E.C. of soils was found to be increased with increase in clay content of soils (Singh and Bhumbla, 1968).

2) Gypsum can be added in soils to be irrigated with these saline waters to reduce sodium hazard. The RSC values above 2 meq/litre require the addition of 4 Q/ha gypsum in the soil for every addition of one meq/litre of RSC value of irrigation water (Sharma and Abrol, 1973).

3) These saline waters, can be successfully used on saline soils for crop production by addition of gypsum in saline water for initial irrigations and later irrigations with good quality waters, which will increase the hydraulic conductivity of soils (Annonymous, 1972).

II) Use of saline water for jowar crop production :

Saline water irrigation affects the soil properties and hence the crop growth which ultimately affect the yield. The effect of saline water irrigations on soil properties and plant growth and the use of amendments to increase crop production in saline and non-saline soils have been discussed below :-

Irrigations with saline water increased the organic carbon, G.R., water soluble cation and SSP values of soils. Electrical conductivity of soil water extract was also increased due to irrigations with saline water than the irrigations with tap water. Similar observations were made by Jacobs, et al. (1961), Singh and Bhumbla (1968), Kanwar and Mehta (1970). The exchangeable Mg, Na and K were also increased due to saline water irrigations to the soils. The reason may be the higher contents of Mg, Na and K in saline water than in tap water. Talati (1968), observed that the high K content of irrigation water has an ameloriating effect on soils. Singh and Sharma (1970), have stated that by using salin water for irrigation purposes, the exchangeable sodium and sodium saturation in soils were increased. The SAR and the ESP values of soils were increased by irrigation with saline waters. Similar trend was observed by Paliwal and Maliwal (1971), Yadav (1972).

The dry matter yield of crop was increased by saline irrigation. The reason may be that the higher K and NO_3 content of saline water and high fertilizer doses. Lunin and Gallatin (1965), observed that salinity has increased the yield where soils are adequately fertilized. The nitrogen and phosphorus contents of plants were also increased by saline water irrigations. Lunin and Gallatin (1965), stated that the N and P content of plants were also affected by soil and water salinity. The cations content in the plant were also increased.

The morphological character namely the height of the plant, was reduced by the saline water irrigations. Bain, Milton Fireman (1968), and Sinha,Dev (1972) also observed that the growth of sorghum plants was reduced by salinity.

By the addition of mule dung in soil as an amendment, organic carbon content of soils, exchangeable Ca, K; water soluble Na, K contents of soils and Ca, Na, P contents of jowar plants were increased. The height of plants and emergence of earheads were also increased by the use of mule dung. The dry matter yield of jowar crop and water soluble Ca content of soils were found to be decreased by the addition of mule dung.

There was increase in the phosphorus, exchangeable Mg, water soluble Mg, Na, K contents of soils and P, Na, K contents of plants due to the addition of pressmud. The emergence of earheads and dry matter yield were also increased by addition of pressmud.

The use of sulphur has increased the emergence of earheads dry matter yield and nitrogen content of sorghum. While pH, electrical conductivity of soils and cation content of plants were decreased by the addition of sulphur in the soils. Fitts, Lyons and Rhodes (1943), stated that sulphur treatment had marked effect on the reduction of soil pH.

The addition of gypsum showed very good performance in the reclamation of saline soils. There was increase in exchangeable and water soluble Ca and Mg which helps to reduce the sodium hazard. The exchangeable Na, G.R., SAR, ESP, SSP values of soils were decreased markedly. Nitrogen and phosphorus content of plants were also decreased. Fitts, *et al*.(1943), Padhi, *et al*. (1965), and Puntamkar, *et al*.(1972) , have observed that the exchangeable sodium content of soils were decreased by the addition of gypsum which ultimately decreased the G.R., SAR, ESP values of soils.

From the results obtained in the present investigation, it may be stated that the moderately saline waters having C_3S_3 class with higher K and NO_3 content may be used with the addition of gypsum, sulphur and pressmud as amendments on saline and non-saline soils with higher fertilization and excellent drainage conditions. This may help to increase the exchangeable Ca and Mg; water soluble Ca, Mg and K contents of soils and may help to reduce the pH, electrical conductivity, exchangeable sodium and ultimately SAR, ESP, G.R. and SSP values of soils. It also may help to better crop production on saline soils and non-saline soils.

CHAPTER VI

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

PART I

Seasonal fluctuations in quality of well waters

The water samples were collected from Rahuri Factory, Digras, Pimpari Avaghad, Sade and Khadambe villages and from the University farm during *kharif*, *rabi* and summer seasons. The results of the chemical analysis of the samples are summerised as under :

1) The cation and anion contents of well waters from five villages and all blocks of the University farm showed fluctuation during *kharif*, *rabi* and summer seasons.

2) The pH values of well waters were not much affected during seasons. The average pH value of well waters from five villages was 7.95. The pH value of the well waters from the University farm was 8.05. This shows that all well waters are alkaline in nature.

3) The average E.C. value of well waters from five villages was 1974 micromhos/cm and E.C. value of well waters of University farm was 904 micromhos/cm.

4) The boron content of all the well waters was less than 1.33 mg/litre i.e. B-II boron class of water which is supposed to be safe for all crops as per Scofield, (1935). The average values of boron contents in well waters from five villages and the University farm were 0.414 and 0.390 mg/litre respectively.

5) Alkalinity of all well waters increased with the seasons i.e. from *kharif* to *rabi* and *rabi* to summer.

The average values of well waters from five villages and the University farm for alkalinity were 341.54 and 249.974 mg/litre respectively.

6) The well waters from five villages and University farm were very hard, i.e. above 180 mg/litre $CaCO_3$. Very few water samples were under soft and medium hardness class.

7) The SAR values were high in <u>kharif</u> followed by <u>rabi</u> and summer seasons. The average value of SAR for well waters from five villages and University farm were 5.161 and 4.381, respectively. On the basis of SAR values, about 80 per cent well waters from University farm and 55 per cent well waters from five villages may be placed in S_1 class (low sodium class).

8) There was positive correlation between SAR and EC values of waters throughout the year, but in case of well waters from University farm, it was found to be statistically significant while in case of adjoining area, it was found to be non-significant for all seasons.

9) The average RSC values for well waters from five villages and all blocks of University farm were below 1.25 meq/litre.

10) The average SSP values of well waters from all the five villages (except Sade) and the well waters from University farm were found to be below 60 per cent.

Some water samples (Sample Nos. 1, 8, 9, 10, 11, 12, 14, 15, 17, 20, 25, 26, 28, 29, 36, 43, 44) were found of doubtful quality for irrigation, considering their SAR and E.C.values.

PART II

The use of saline water for crop production

The pot culture experiment was undertaken to assess the effect of saline water and amendments on chemical properties of soils, plant growth and nutrient content of jowar plants. The observations recorded in these studies are summerised below.

A) Effect on chemical properties of soils :

1) pH :

With increase in salt concentration in the irrigation water, there was an increase in soil pH. Sulphur showed maximum decrease in pH, i.e. by 0.44 units.

2) Electrical conductivity :

Irrigation with saline water have increase electrical conductivity of soils, while addition of sulphur as an amendment has decreased electrical conductivity as compared with the addition of other amendments.

3) Organic carbon :

The use of both the organic amendments have also helped to increase organic carbon content of soils as compared to the use of chemical amendments.

4) Gypsum requirement :

Irrigations with saline water have increased the G.R. values of soils. The gypsum was found to be one of the best amendments which reduced the G.R. values of soils.

5) Available phosphorus :

Irrigations with saline and tap water have no effect on the available phosphorus content of soils. The use of pressmud as an amendment has increased the available phosphorus content of soils than the use of other amendments.

6) Exchangeable potassium :

The use of saline water for irrigation and mule dung as an amendment have increased the exchangeable potassium content of soils as compared with the use of other treatments.

7) Exchangeable cations (Ca, Mg, Na) :

Irrigations with saline water have decreased exchangeable calcium content of soils, while it has increased exchangeable magnesium and sodium content of soils. The use of gypsum and mule dung as amendments have increased the exchangeable calcium. The addition of gypsum and pressmud have increased exchangeable mangesium content of soils. The addition of gypsum alone has significantly decreased exchangeable sodium.

8) Sodium Adsorption Ratio and Exchangeable Sodium Percentage values :

The use of saline water for irrigation has increased the SAR and ESP values of soils. The addition of different amendments have decreased the SAR and ESP values of soils. The addition of gypsum was found significantly superior to all other amendments in reducing the SAR and ESP values of soils.

9) Water soluble cations :

Irrigations with saline water have increased the water soluble Ca, Na and K contents of soils, while water soluble Mg content remained unchanged. The addition of gypsum has increased the water soluble Ca and Mg contents of soils while Na and K content were unchanged. The addition of different amendments have increased the water soluble Ca and Mg except mule dung, which has decreased the water soluble calcium content of soils. Except gypsum, the use of other amendments have increased the water soluble sodium content of soils. The addition of mule dung and pressmud have increased the water soluble K content of soils.

10) <u>Soluble sodium percentage values of soils</u> :

Saline water irrigations have increased the SSP values of soils. The addition of amendments have decreased the SSP values of soils, except the addition of mule dung. The use of gypsum as on amendment has showed better performance in decreasing SSP values of soils.

B) <u>Effect on jowar plant</u> :

1) <u>Germination</u> :

The percentage germination of <u>jowar</u> was not affected by the use of saline water for irrigation. Soil salinity has reduced the germination percentage at 6 days after sowing. The use of amendments have not shown any effect on germination percentage.

2) <u>Height of the plant</u> :

At 35 days after sowing, soil salinity and water salinity have reduced the height of the plant. While the addition of pressmud has increased the height of plants. At seventy days after sowing, soil salinity has reduced the height of plants, while the use of organic amendments and sulphur have increased it. At 90 days after sowing, only soil salinity has reduced the height of plants.

3) Emergence of earheads :

The soil salinity, the use of pressmud, mule dung and sulphur have increased the emergence of earheads of *jowar* crop at 88 days after sowing. At 112 days after sowing, the irrigations with saline water, soil salinity, pressmud and sulphur have enhanced the emergence of earheads in *jowar* crop.

4) The dry matter yield :

The use of saline water has increased the dry matter yield of *jowar* as compared with the yield of *jowar* obtained by use of tap water. Similarly soil salinity has increased dry matter yield of *jowar* as compared with the yield of *jowar* in normal soil. The use of gypsum, sulphur, pressmud have increased the dry matter yield of *jowar* as compared with the use of mule dung.

5) Nutrients content in jowar plants :

i) Nitrogen :

Irrigations with saline water and soil salinity have increased the nitrogen content of jowar, plants, while the use of gypsum as an amendment has decreased it as compared with N content of jowar plants under other treatments.

ii) Phosphorus :

Saline water irrigations and the use of mule dung, pressmud, gypsum have increased the phosphorus content of plants as compared with the phosphorus content of plants grown by using tap water and sulphur. The soil salinity has no effect on phosphorus content of plants.

iii) Total cations :

Soil salinity has decreased the Ca and Mg content in the plant, while Na and K content were not affected. Saline water irrigations have increased the content of Mg and Na while the content of Ca and K in plants remained unchanged. The use of pressmud has increased the Mg and K content of plants, while mule dung has increased Ca content of plants. Both the organic amendments have increased the sodium content of plants.

After considering the above observations, it can be stated that the good yield of *jowar* crop can be obtained by using moderately saline water (C_3S_3 class) having more K^+ and NO_3^- content and with addition of gypsum, sulphur, pressmud and high doses of N, P, K fertilizers.

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APPENDIX