PHYSIOLOGICAL ANALYSIS OF INFLUENCE OF SALINITY ON GROWTH AND DEVELOPMENT OF SAFFLOWER (*Carthamus tinctorius* L.)

By

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A Thesis submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH, RAHURI - 413 722
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1992.

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or any other person to any other University or Institute for Degree or Diploma.

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Dated : 9/9/1992.

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CERTIFICATE

This is to certify that the thesis entitled "Physiological analysis of influence of salinity on growth and development of safflower (*Carthamus tinctorius* L.) submitted to the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist : Ahmednagar for the award of the degree of MASTER OF SCIENCE (AGRICULTURE) in PLANT PHYSIOLOGY, embodies the results of a *bona fide* research carried out by SHRI VISHWANATH BHAGWANRAO DARKUNDE, under my guidance and supervision and that no part of the thesis has been submitted for any degree or diploma.

The assistante and help received during the course of this investigation have been acknowledged.

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LIST OF ABBREVIATIONS

Abbreviation		Long form
$\overline{AGR}$	:	Absolute growth rate
CD	:	Critical difference
cm	:	Centimeter
cv	:	Cultivar
g	:	Gram
i.e.	:	id est
Kg	:	Kilogram
$\overline{LAD}$	:	Leaf area duration
$\overline{LAI}$	:	Leaf area index
m	:	Meter
$\overline{NAR}$	:	Net assimilation rate
NS	:	Non-significant
$\overline{RGR}$	:	Relative growth rate
S.E.	:	Standard error
t	:	Tonne
viz.,	:	Vide licet (namely)
%	:	Per cent
/	:	Per

ABSTRACT

PHYSIOLOGICAL ANALYSIS OF INFLUENCE OF SALINITY ON GROWTH AND DEVELOPMENT OF SAFFLOWER (*Carthamus tinctorius* L.)

By

VISHWANATH BHAGWANRAO DARKUNDE

A Candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

1992.

Research Guide	:	Prof. V.A. Patil
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A pot trial experiment entitled,"Physiological analysis of influence of salinity on growth and development of safflower cultivar" was carried during the rabi season of 1988-89 at Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist: Ahmednagar, Maharashtra State.

The experiment was laid out in factorial completly Randomised Design (FCRD) with three replications. The experiment consisted three varieties viz., N 62-8, Bhima and JSF-1 and two salinity level viz., 0.1% and 0.2%

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alongwith control. The observations on different plant characters such as plant height, number of branches, leaf number, leaf area, dry matter content of stem, leaves and caputulum, growth functions were recorded. Simultenously chemical analysis of plant parts for N, P, K, Na and Ca was worked out.

The main object being to understand the influence of salinity on safflower varieties in terms of growth responses and chemical composition.

There was definite reduction in height of plants, number of branches per plant, number of leaves per plant, leaf area and leaf area duration under salt treatments were observed. The flowering period was delayed while the maturity of the crop was earlier under the salinity treatments.

Total dry weight of shoot was reduced significantly and reduction was due to combined effect of significant reduction in component plant parts at all sampling occasions. This effect of salinity in depression of leaf weight during grain development stage may further have affected grain filling and thus final 1000-grain weight and final grain yield.

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INTRODUCTION

1. INTRODUCTION

In India oilseeds form the second major group of agricultural crops, next to food grains. Safflower is the second important oilseed crop next to groundnut, not only in India but in the world. Until recent years, safflower (Carthamus tinctorius L.) was confined to the regions of Asia, Africa, Europe, Australia, North America and California. In its evolutionary history, mankind domesticated this plant for the colour of flowers but now it plays a significant role as an oilseed crop in the world's economy.

Safflower (Carthamus tinctorius L.) is a member of the compositae family Asteraceae with diploid chromosome number 2n = 24 in cultivated safflower varieties. Safflower is an important rabi oilseed crop, being xerophyte, it is grown under dry farming areas of Maharashtra, Gujarath, Madhya Pradesh, Andhra Pradesh and Karnataka. Safflower is reported to be a drought tolerant crop because of its strong tap root system, which penetrates deep into the soil upto the depth of about 7 feet. It remains succulent in early stages of growth and assumes xerophytic nature at later stages and, thus, considerably reduces the moisture loss. This has facilitated its cultivation in scarcity zones receiving annual precipitation of 300-500 mm. As it is hardy in nature and require low input on cultivation, it has become a precious crop to dry land farmers.

Safflower is potential oilseed crop for 'Vanaspati' industry, since its oil is suitable for hybrogenation. Oil has excellent storage properties as it contains negligible amount of linolenic acid. Safflower is an important source of edible oil and it is considered superior over groundnut oil (Rao and Ayyanger, 1956). Commercial safflower varieties contain about 40 per cent hull, 32 to 37 per cent oil, 3 per cent minerals and 18 to 20 per cent carbohydrates (Applewhite, 1966). It also contains vitamin 'A' and vitamin 'D' in sufficient quantities. Safflower oil contains 93% of unsaturated fatty acids of which 72 to 78 per cent is linoleic acid, which is the highest amongst all the edible oils. In addition to this, it also contains 11 per cent oleic, 6 per cent plamatic and 3 per cent stearic acid. Therefore, its daily consumption not only prevents further deposition of cholesterol but also reduces the level of cholesterol in the blood. So due to its anticholesterol property, it can be safely used by the patients of cardio-vascular diseases.

Total area under oilseed crops in the country is about 173.57 lakh hectares. India is a major safflower growing country in the world and stands first both in area and production. Area under safflower in the country is about 7.82 lakh hectares which is 75 per cent of worlds acerage and the annual production is about 4.29 lakh tonnes (Anonymous, 1989).

In Maharashtra State, safflower is one of the major oilseed crops, next to groundnut occupying 22 per cent area. Area under safflower in Maharashtra is about 5.84 lakh hectares and the annual production is about 3.28 lakh tonnes, (Anonymous, 1988-89). Maharashtra stands first in both area and production as it occupies 75 per cent area and 77 per cent production of the country. The average production of safflower in Maharashtra is 463 kg per hectare which is very low as compared to other countries. The area under safflower cultivation is increasing every year in Maharashtra State and also in other states due to the fact that it does better under adverse conditions.

According to the nutritionalists, the body requirement of edible oil per capita per day is about 30 gms, but consumption is only 12 gm of oil per capita per day in India, which is very less as against 50 to 70 gms in the developed countries. From this, it is clear that our consumption is very less than that of other countries because of acute shortage and high prices of oil. At present, there is about 14 lakh tonnes of oil shortage in the country and to meet this demand our country has to pay nearly 800 to 1000 crores of rupees per year in foreign currency. Therefore, to save the foreign exchange on the import of edible oil and to increase the consumption of oil, it is necessary to increase the production of oil which can be achieved by increasing the area under safflower crop and evolving the varieties which will have high yield as well as high percentage of oil under variable environmental conditions.

The basic biological principle is that the various physiological processes, which determine the yield of crop in respect of quality as well as quantity, are primarily governed by three complex factors viz., (i) climate (ii) plant factors and (iii) soil factors. Amongst the soil factors, the overwhelming accumulation of salts in the rhizosphere results in the reduced plant growth principally due to development of high osmotic pressure in the root medium and also due to nutritional disturbances or disturbed metabolism.

Salinity is the limiting factor for the agricultural production. Large area on the earth surface i.e. about 9×10^8 hectare's of land become problematic due to salinity and become unfit for crop production. This area is one third of all irrigated land affected by salt.

In Maharashtra State, the salinity problem is principally of two types. In coastal regions, it is because of the tidal indation of sea water which results in continuous deposition of salts in the cultivable fields or because of shallow water table and in planes it is because of faulty irrigation practices, accompanied by aridity and ill drainage conditions. Kakade (1968) estimated, that the inland salt affected soils are above 1,00,000 acres of which major area is in the districts of Ahmednagar, Poona, Satara, Sangli and Solapur.

It is well known that certain species of crops have a versatile characteristics of withstanding the saline conditions. The ecologist and plant physiologist regard this issue in terms of tolerance and response of plants, whereas soil scientists or agriculturists are more concerned with soil conditions. An effective approach in growing plants under saline conditions warrants the better understanding of the physiological basis of salt tolerance of plants. It is ob vious that when availability of water is restricted by a salinity all the factors which regulate or influence water absorption and water loss by plants contribute in some way to the resultant which is termed as 'salt tolerance'. The salt tolerance is the ability of plant to tolerate high concentration of soluble salts in the root medium. It, usually, is expressed by reference to the salinity level that causes a certain decline in yield.

The discussion about the physiological causes of salt injury to the plants from excessive accumulation of salts in the soil largely revolves around two mechanisms. At one time, it was proconceived that the excessive accumulation of soluble salts in the root zones of plants results in the development of high external water potential through which the availability of water is reduced which in turn results in the retarded plant growth, a mode of injury that is often called as osmotic effect. This osmotic inhibition hypothesis was postulated by Wadleigh and Gauch (1944), Magisted (1945) and has been further supported by Bernstein and Pearson (1954), Janes (1966) and Parsons (1968). But it has also been observed that plants do absorb the constituants of saline solution to varying degree which may bring about nutritional disturbances or toxic effects presumably being the result of some interaction between salts and organic substances (Uvhits, 1946).

The problem of salinity may be reddressed by using technological and biological approaches. The technological approaches includes try to find inexpensive and cost efficient ways of desalting sea water to be used for irrigation purposes, soil-water management and irrigation methodology. Biological approaches include identification of halophytes study their tolerance mechanism, if necessary, try to introduce more desirable horticultural or agronomic traits into them, the introduction of salt tolerance characteristic into crop plants, the majority of which are glycophytes. Recent investigations on the physiological analysis of salt tolerance have laid much emphasis on the protoplasmic characters and properties. Based on these properties, the tests for salt tolerance and methods for induction of salt hardiness are given out (Sakai and Rodrigo, 1960).

Safflower is said to be tolerant to salinity. Work on this factor is very meagre. Investigations on the salt tolerance of safflower in India at germination stage have been initiated in varieties of safflower by Bangal et al. (1984), Patil and Bangal (1985). Investigations on this aspect have been attempted in various parts of the world. However, the physiological analysis of this problem is not fully explored.

In view of the above considerations, the present investigation "physiological analysis of influence of salanity on growth and development of safflower" was undertaken with the following main objectives :

a) To study the influence of salinity on growth, yield and yield attributes of safflower.

b) To study the influence of salinity on physiological functions of safflower.

c) To study the influence of salinity on uptake of nutrients.

d) To study the influence of salinity on dry matter production and distribution.

e) To study the variety x Salinity interactions.

f) To study the salt tolerance of safflower cultivars i.e. N-62-8, Bhima and JSF-1.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Safflower (Carthamus tinctorius L.) is an important oilseed crop. However, till 1956 very little research work was reported on safflower. Safflower is a young crop from physiological angle, so lot of research work is needed on safflower crop (Rao and Ayyangar, 1956; Ramanmurthy and Kulkarni, 1967). The literature available on this crop on environmental and physiological aspects particularly on salinity is very limited. Hence, an attempt is being made here to review the available literature in brief, particularly with reference to salinity.

There is general agreement that exposure of plants to substrate solution or soils containing soluble salts in excess of those required for normal growth, usually results in decreased absorption of water, disturbed nutrient uptake and metabolism and reduced growth. But certain species of plants possess versatility to withstand such adverse conditions. An understanding of the novel features of physiology of salt tolerance has been an important object of many investigations. Various aspects of salinity and its effects on plants have been reviewed in detail by number of workers (Bernstein, 1962; Allison, 1965; Rage and Chattopadhy, 1966; Aslam, 1975; Rai, 1977; Ahmed, et al. 1977; Devi, et al. 1980; Singh et al. 1981; Kurian and Iyengar, 1972; Bangal et al. 1984; Janardhan, et al. 1986; Rao, et al. 1987; Patil et al. 1988; EL Wakhlaway and EL-Fawal, 1989). However, here the aspect of salinity is reviewed with reference to agricultural crops, in general and safflower, in particular.

2.1 Terminology

Niemannand Poulson. (1967) defined salinity as the presence of excessive concentration of soluble salts in the soil solution. The unit of measure of salinity is electrical conductivity expressed in ds m^{-1} at $25^{0}C$. As per the U.S. salinity laboratory (1954), a soil for which electrical conductivity of the saturation extract (E.Ce) is more than four millimhos per cm at $25^{0}C$ and the exchangable sodium percentage (E.S.P.) is less than 15 and pH usually less than 8.5 is considered as a saline soil. According to Heimann (1959), right chemical balance of the ionic environment is of major importance and to a lesser degree only the absolute amount of Na and thus, the above general statement may need modification.

According to Hayward and Bernstein (1958) and Lopez (1966), the salt tolerance of varieties can be scaled out in three ways : (1) the simple survival of plant against high salt concentration without any economic production. This valuation is more ecological than agronomical. (2) a more agronomic way is to evaluate salt tolerance through the productive ability of different species or varieties, at a certain salinity level, considering as salt resistant those that under par conditions give the best production. (3) to compare the relative performance of a variety or species at a given level of soil salinity to its performance on a comparable non-saline soil. This third criterion provides a more sound basis for appraising varietal differences.

2.2 Physiology of salt tolerance

Soil salinity is harmful to plants in two ways. First, physically there may be enough soluble salts in the soil to build up the osmotic pressure of the soil solution to a point which will retard or prevent intake of necessary water and secondly from chemical point of view, certain salt constituents, may be toxic to plant growth and may produce specific effects which may lead to a variety of nutritional disturbances, or a combined effect of the both. These effects are discussed in brief here again.

2.2.1 Osmotic effects and water relations

Gauch and Magistad (1943) illustrated the relation between plant growth and salt concentration. They reported that the rate of reduction in yield of Alfalfa was about 10 per cent for increase of osmotic pressure by one atmosphere within the range of 0.5 to 4.5 atm developed by addition of NaCl to the nutrient solution.

Ayers et al. (1951) carried out the studies on Lettuce and concluded that since the inhibition of growth was more closely related to salt content of the soil, the observed growth responses were predominantly due to physiological scarcity of the water.

Throughton (1967) noticed that an increase in osmotic pressure from 2.5 to 5 atm resulted in retardation of the growth of all parts of Lolium perenna. An increase of 10 atm osmotic pressure resulted in the death of some plants and the remainders were deformed.

Heikal (1977) observed that under saline conditions, created by adding NaCl and $CaCl_2$, the water content of leaves of safflower was significantly decreased at a high salinity level (6000 ppm) only.

Bernstein and Hayward (1958) observed that osmotic pressure developed in soil solution is firstly exercised on the cells of the root system and after that on the cell-sap and fluids in the whole plant. The root sap has markedly lower osmotic pressure than the above ground parts of plants and also seems to have a lower range of adjustment to increase osmotic pressure of the medium.

The cause of growth reduction, associated with increasing osmotic pressure of the rooting medium has been attributed to decreased water entry or availability (Klepper, 1967 and Parsons, 1968).

Long (1943) reported that the growth inhibition, accompanying increasing concentration of added salts was virtually linear for numerous crops, with increase in osmotic pressure and was largely independent of whether the added salts were chlorides or sulphates when supplied on iso-osmatic basis.

Rao et al. (1981) observed that leaf cell-sap osmotic pressure and leaf K: Mg ratios were often higher at certain growth stages in tolerant than in susceptible cultivars.

Neimann and Roulson (1967) proposed the hypothesis that a larger part of the reduction in plant growth on saline media is the result of combined suppressing action of salinity and transpiration of plant water potential. They compared the effects of salinity on plant growth under conditions of low and high atmospheric humidity. As predicted, high humidity consistently relieved the suppressive effects of salinity almost completely in cotton without greatly altering the ion content of the tissues on a dry matter basis.

Janes (1966) studied in detail the mechanism of development of counteracting osmotic pressure in Pepper and

Tomato plants by subjecting them to water stress by gradual addition of NaCl or Polyethylene glycol (PEG) to increase the osmotic pressure of nutrient solution and noticed that the initial increase in the osmotic pressure of the leaves was due to dehydration followed by an accumulation of soluble material.

To summarise, it is evident that one of the main effects of salinity is to limit water supply by increasing osmotic pressure of the soil solution. The effect is further mediated by an increase in soil moisture tension and their combined effects which condition the plant growth.

2.2.2 Specific ion effect

Besides the major effects, osmotic inhibition of water by excess of salts in substrate, the component parts of salts, which may be absorbed by plants, also do play various roles in governing the various physiological processes in the plant. These effects which are independent of the osmotic effects are termed as "specific ion effects". Such effects may cause nutritional imbalance or disturbed metabolism or toxicity. A toxic effect is considered to be due to the presence of an ion in solution which causes direct damage to the plant and injury usually associated with the accumulation of harmful concentrations of toxic ion in the plant tissue which may show another significant changes in the mineral nutrition.

Long (1943) considered that the salts in contact with the absorbing membrances of root cells or accumulated salts within the plant may produce deleterious effects on protoplasm directly and one result of such injury is the reduced nutrient uptake.

It was also indicated that the nature of salts also governs the type of effect. Thus, sulphate salinity is believed to bring about osmotic effects, whereas under chloride salinity the toxic effect was predominant one (Strongonov, 1964).

Bangal et al. (1984) reported that the highest toxicity was shown by HCO_3 ions followed by SO_4, Cl as $CaCl_2$ and Cl as NaCl during their experiment on relative salt tolerance of safflower cultivars at germination.

Irwing et al. (1988) reported that increasing salinity also increased Cl, Ca and Na but reduced P and Mg content in leaves of safflower.

2.2.2.1 Nutritional effects

Out of the large number of ionic species which may occur in solution or in the absorbed state in the soils, relatively few contribute to salinity in a given saline soil. The cations Ca^{++}, Na^{+} and Mg^{++} and the anions Cl^{-},

HCO_3^- and CO_3^{2-} generally predominate although in any given soil the proportions may vary considerably.

Numerous studies have been made to understand the effects of excess of these ions on growth of different species, some of these studies are reviewed here.

2.2.2.1 Sodium (Na)

The response of plants to excess sodium may be complicated by the number of factors.

Ratner (1935) observed that as level of exchangeble sodium in the soil increased, there is corresponding decrease in absorption of calcium by plants.

Lipman et al. (1926) noticed that the accumulation of Na in plants growth in substrate rich in this ion. Similar results were reported by Batchelder et al. (1963) in vegetables and Greenway et al. (1965) in case of Barley.

Shourbagy and Wallace (1965) reported that the decreased Ca content in the top as well as in root of Barley grown in culture solution containing 40 m eq Na per litre.

Bernstein (1964) observed that when leaves of fruit and root crops, woody or ornamental and shade tree accumulated more than 1/4th per cent of sodium, caused death of tissues and the bleaching out of the leaf pigments resulting in a margin or tip burn symptoms.

Aslam (1975) conducted solution culture experiments, where 7 days old safflower plants were grown for 28 days with K at 6 levels from 0.1 to 1.0 meq/1 and Na at 0 to 4 meq/1. He observed that added Na reduced the K content of all plant parts when K was deficient and of young leaves when K was sufficient and this added Na significantly increased the Mg content of stems and leaves but had no effect on Ca content.

Heikal (1977) observed that when safflower was grown in saline culture solution prepared by adding NaCl and $CaCl_2$, the Na and Ca content of all test plants increased progressively with salinity. Nitrogen content of leaves increased significantly but there was non-significant effect of P content. K and Mg content of all test plants significantly decreased by salinity. Janardhan et al. (1986) observed, a comparatively lower accumulation of Na and relatively higher content of K in the leaves was associated with, salt tolerance. Kurian and Iyengar (1972) reported that N, K and Ca content increased in the plants of safflower when Na uptake was reduced.

Shaddad et al. (1988) studied the effects of N ($NaNO_3$, NH_4Cl or Urea) application on NaCl treated safflower plants and observed that N content of variously treated plants were raised except in the case of safflower plants treated with NaCl alone.

2.2.2.1.2 Magnesium (Mg)

Excessive quantities of magnesium may prove toxic in soultion cultures, an effect which may offset the presence of sufficient amounts of calcium leading to a phenomenon of antagonism (Gauch and Wadleigh, 1951).

Gabaly (1955) reported the magnesium injury due to the inadequate supply of calcium. Aslam (1975) observed that in stem and older leaf, Mg content decreased with increasing K but this Mg content significantly increased with increasing Na, in case of safflower, Heikal (1977) reported that Mg content of safflower was significantly reduced by salinity. Irwing et al. (1988) noticed that Mg content in leaves of safflower was decreased with increase in salinity and also there was decrease in plant height and total seed yield.

2.2.2.1.3 Calcium (Ca)

Calcium in plant is of great importance because of its relationship to cell-wall formation and hence permeability. Any ion that may adversely affect calcium metabolism of cell-wall . will obviously affect cell-growth. However, the excessive accumulation of Ca in the soil may be toxic and its specific effects vary with the crop. Gauch and Wadleigh (1942) observed that $CaCl_2$ was more toxic to plants than NaCl in case of dwarf red kidney beans.

The excessive accumulation of Ca in plants resulted in disturbed equilibrium of ions which resulted in detrimental effects on the production of both foliage and roots in [illegible] beet (Lehr, 1942).

Wadleigh et al. (1951) observed that the extreme levels of calcium were lethal to the orchard grasses. Aslam (1975) observed that in safflower under saline conditions in stem and older leaf, Ca decreased with increasing K but significantly increased with increase in Na level. Bangal et al. (1984) observed that $CaCl_2$ is more toxic than NaCl in safflower cultivars at germination. Similar results were reported by Jadhav (1985).

2.2.2.1.4 Chlorides

Bernstein (1964) reported that chloride toxicity was accelarated by hot and dry climate or periods of high temperature. Abel and Mackenzie (1964) observed mortality of salt sensitive bean plants when they accumulated excess of chlorides.

Lessani and Marschner (1978) observed that growth depression was caused by an increasing supply of NaCl but there was increase in Cl content which was more than Na content in the shoots. Bangal et al. (1984) reported that Cl as $CaCl_2$ was more toxic than Cl as NaCl at germination of safflower seeds under saline conditions.

2.2.2.1.5 Sulphates

Sulphate salinity at flowering stage of Sorghum vulgare resulted in burning of leaves (Eaton, 1942).

Ramdeo et al. (1968) observed that there was higher Ca content in Bajra plants grown in sulphate salinity as compared to chloride, bicarbonate and carbonate salinity.

El. Wakhlway and El. Fawal (1989) reported that sodium cloride had more adverse effects on germination than sodium sulphate in saflower.

2.2.2.1.6 Bicarbonates

The bicarbonates in excess are generaly toxic to the plants although the sensitivity varies with the species. In saline soils, bicarbonate ion causes precipitation of calcium thereby favouring an increase in exchangable sodium (Wilcox et al. 1954). Abdel et al.(1965) studied and reported that in beans, Ca content of both tops and pods decreased with increasing levels of bicarbonates.

They further observed that bicarbonate ions upto 6.5 meq per litre had no effect on plant growth, whereas at 41 meq per litre the yield was reduced upto 80 per cent and the effect was more severe at high salinity. Further it was reported that the excessive salts may affect the absorption of macro-elements such as N,P,K and also some micronutrients. However, these effects will depend on the type of salts and the species of plant.

Dastur (1960) observed bad opening of bolls to low K content in the carpels of cotton bolls induced by high subsoil sodium salts.

Ramdeo et al. (1968) reported that in Bajra comparatively at all salinity levels, uptake of nitrogen in presence of chloride ions was higher than bicarbonate ions whereas, in presence of carbonate ions it was lower than the both. Sodium sulphate at 0.05 and 0.1 per cent salt concentrations did not affect the uptake of nitrogen but it decreased at 0.4 per cent level. Phosphorus content of plants was found to decrease as the concentration of chloride, bicarbonate and carbonate ions increased.

Heikal (1977) reported that when safflower crop grown in saline culture solution prepared by adding NaCl and $CaCl_2$, water content of leaves significantly decreased, Na and Ca content of all test plants increased progressively with salinity, total N content of leaves significantly increased but there is non-significant effect of P content, whereas K and Mg content significantly decreased with salinity.

Irwing et al. (1988) reported that increasing salinity also increased Cl, Ca and Na but reduced P and Mg content in the leaves of safflower.

2.2.2.1.7 Ionic balance

The living cell systems exposed to an ion-charged aqueous environment is conditioned by a well-balanced ratio between these ions. In this direction, some workers in the field of plant physiology developed a new approach to the problem of plant growth under saline conditions. This new concept indicates the importance of a balanced ionic environment. Actually, it was proved that plants in all stages of their development can withstand much higher osmotic pressure in physiologically balanced solutions than in those of single salts or unbalanced mixtures (Heiman,1966).

Asana and Kale (1965) observed that with increase in salinity there was decrease in K/Na and K/Ca ratios. This decrease was more pronounced in stems and ears as compared to leaves of wheat varieties. It was further indicated that differential tolerance to salinity at different stages of development might partly be due to the tendency of growing tissues to accumulate less sodium.

Heiman (1966) has given much emphasis on the physiological balance between the ions in the soil solution and put forth the concept of "Balanced ionic environment". He emphasized that in spite of high water salinity good crop can be obtained if potassium is present in appreciable concentrations in relation to sodium. According to him, if potassium is not present in a proper ratio to sodium, it must be added in order to reach the ionic balance. He observed that plants irrigated with sea water in sand showed a higher tolerance to salt than plants irrigated with any other water of the same salt concentration because sea water has well balanced ratio of salts.

Rao et al. (1981) observed that leaf cell sap, osmotic pressure and leaf K: Mg ratios were often higher at certain growth stages in tolerant than in susceptible cultivars of safflower under salinity.

2.2.2.2 Metabolism

Almost all workers have reported reduction in size of plants under natural conditions of salinity and the difficulty of water absorption, hence this cannot be regarded as the most decisive or sole factor involved and in many cases it may not be operative. The effects of salinity on the various biochemical and physiological life processes in plants, is certainly much more complicated and diversified.

Salinity increases the amino acid content from 10 per cent to 15-18 per cent of the dry matter of the plants. Salinity also brings about contraction of protoplast and destroy the intercellular connections which further results in diminution in the uptake of water and nutrients and hence the stunted plant growth (Strogonov, 1964).

Furguson (1966) reported the decrease in total lipid content per plant of Barley when they were grown in NaCl solution culture. Lapina (1966) reported that carbohydrate metabolism was adversely affected and assimilatory and synthetic activities of maize roots were reduced at high salinity level of NaCl.

Slonov (1966) observed that the application of micronutrients like Al, Bo, Mn and Zn to sunflower and prose millet grown in artificially salinized pot culture, increased the contents of hydrophillic colloids and the viscosity of the protoplasm and reduced its permeability and the accumulation of mineral elements in the leaves.

Shervykva (1966) studied the influence of salts on the biosynthesis of certain sulphur containing amino acids in leaves of Vicia faba and observed that the chloride as well as sulphate salinity retarded the primary synthesis of S^{35} containing amino acids (Cystein-cystine) and inhibited the second stage of synthesis.

In soybeans, the sodium sulphate salinity inhibited the growth promoting activity of nucleic acids more than did potassium sulphate salinity. This salinity drastically reduced P^{32} incorporation into nucleic acids in the salt sensitive soybean but less in salt tolerant variety. From this, they put forth a tentative hypothesis which explains that K and Na displace calcium and magnesium from cell membrane and nucleic acids, consequent RNA degradation in Viva leads to a loss of functional messenger RNA and enzyme synthesis fails (Hauser and Hanson, 1966). Shah and Wedding (1968) reported the sodium ion influences on phosphorylations associated with oxidation of succinate by turnip root mitochondria and found that the activity of first site that associated with the reduction of chromosome C, was stimulated about three fold by 10^{-3} molar NaCl whereas, phosphorylation at the second site, coupled with the oxidation of ferrocytochrome C, was slightly inhibited by the same NaCl concentration.

Balasubramanian et al. (1974) reported that nitrate reductase activity and enzyme activity differed with species of crop under salinity condition.

Aslam (1975) observed that when 7 days old safflower plants were grown for 28 days with K at 6 levels from 0.1 to 1.0 meq/1 and Na at 0 to 4 meq/1, the added Na reduced the K content of all plant parts when K was deficient and of young leaves when K was sufficient, stem and older leaf Ca and Mg content decreased with increasing

K but Mg content significantly increased with added Na.

Rhodes and Matsuda (1976) reported that growth rate reduction may be directly proportional to reduction in polyribosome levels during water stress under salinity condition.

Tesu et al. (1976) reported in sunflower, that increased soil salinity reduced carbohydrate synthesis and accumulation but did not affect amino acid synthesis. In safflower increased salinity reduced the contents of histidine, lysine, glutamic acid and in particular tryptophan.

Ahmed et al. (1977) reported that in safflower, the pigment content and photosynthetic activity increased with NaCl concentration to a maximum at 0.04 - 0.06 m NaCl, then decreased slightly, Radioactive C tracing indicated that at high salinity levels C was incorporated into malic acid at the expense of aspartic acid in safflower, and with increased salinity more C was incorporated into organic acids and less into amino acids.

Lessani (1978) studied and observed that in safflower Cl content increased more than Na content in the shoots with an increasing supply of NaCl, and decreased K

Devi et al. (1980) reported that $^{14}CO_2$ incorporation was higher in the NaCl treated plants than in control plants and as there was a positive correlation between growth rate and rate of CO_2 incorporation, it was suggested that Na could have increased the metabolic activity of plants.

Felipe et al. (1983) noted that at 5 atm safflower chloroplasts showed swelling and undulation of the thaylakoids, the mitochondria changed shape and increased in number and in the spongy parenchyma, chloroplasts and cytoplasm organelles accumulated in one part of the cell under salinity condition.

Radi et al. (1988) reported that the percentage germination and water content of salt stressed seed, and the transpiration rate and stomatal frequency of salt-stressed seedling and dry matter yields of salt stressed plants were significantly lower than in the control safflower plants.

To summarize, it is evident from the above reports that besides, osmotic effects, specific ions may influence the plant dynamism. However, the magnitude and severity of these effects vary with the nature of the ion, its concentration and also crop species. It would also appear from these studies that the plant growth bears a definite relationship to the osmotic pressure of substrate and that different species and their varieties exhibited different sensitiveness to increase in osmotic pressure. Specific ion effects such as toxicities and nutritional disturbances may be super-imposed on the general osmotic effects. Crops are known to show differential responses to salinity in different phases of growth and also differential response among themselves. U.S. salinity laboratory (1954) regarded the electrical conductivity of the saturation extract of soil as the suitable measurement for appraising soil salinity and its relation to crop condition and plant growth. Based on this Bernstein (1964) reported a decreasing order of field crop as barley, cotton, safflower, wheat, sorghum, soybean, rice and corn.

Plant growth is adversely affected by salinity and its resistant property which varies with the species, varieties and even at different stages of growth. (Greenway et al. 1965; Sadayappan and Shrinivasan, 1966 and Kaliappan and Rajgopal, 1968).

Some of the effects of salinity on the different growth stages of crops are summarized below :

2.3 Germination and emergence

Increasing salinity generally causes a progressive retardation in germination at the lower range of concentration. At higher salinity levels germination percentage also begins to be affected. In general, the delayed germination and injury to seeds and seedlings is in direct proportion to the osmotic pressure. Those seeds which do not develop high imbibition pressures are incapable of absorbing a sufficient quantity of water to initiate the processes involved in germination (Hayward, 1956).

Maliwal and Paliwal (1967) reported that both osmotic as well as specific ion effects may be related with the decrease in germination.

Mulwani and Pollard (1939) observed that in barley increasing concentrations of salts delayed as well as decreased germination percentage. They noted that Na_2Co_3 was the most detorious followed by $MgCl_2$, [illegible] and Na_2SO_4.

Macky and Chapman (1954) demonstrated that salinity was in most cases only as inhibitor because if ungerminated seeds from conditions of high salinity are subsequently placed in lower salinity they germinate quite freely.

Pearson et al. (1966) found that rice seed germinated in sand saturated with solution having electrical conductivity value as high as 40 mmhos per cm. The electrical conductivity value associated with 50 per cent reduction in germination one week after planting ranged from 21.2 to 30.5 mmhos per cm for some varieties.

Kaliappan et al. (1967) observed varietal differences in barley at germination. In general, the germination was sharply decreased in the treatments receiving 6,000 ppm ($NaCl + CaCl_2$) and above. The early vigour was much affected by salinity.

Ghorashy et al. (1972) studied and reported that safflower seed germination on filter paper wetted with 0 to 2 per cent NaCl solution showed reduction in germination from 90 per cent to 60-70 per cent as NaCl concentration increased from 0 to 1 per cent.

Rai (1977) reported that when ten safflower varieties were grown for two years in the field and irrigated with water containing $CaCl_2$, $NaSO_4$ and $NaHCO_3$, the seed germination was reduced in all ten varieties but with some varietal differences.

Goswami et al. (1978) observed 100 per cent seed germination at salt concentration upto 6 mmoh/cm in safflower but germination gradually decreased to 23.3 to 53.3 per cent with further increase in salt concentration upto 20 mmho.

Devi et al. (1980) reported that seedling emergence was delayed by 2 and 5 days at 0.2 and 0.4 per cent NaCl salinity, respectively.

Guerrier (1983) reported that seed germination was reduced due to accumulation of excess Na with very low Ca or K seed reserve when planted in solution containing 0-500 mM NaCl. Bangal et al. (1984) reported that germination in four safflower varieties decreased with increasing salt concentration and the highest toxicity observed by HCO_3 ions, followed by SO_4, Cl as $CaCl_2$ and Cl as NaCl. Similar results were reported by Patil and Bangal (1985). Further Jadhav (1985) reported that N 62-8 was the most tolerant variety of safflower to salinity.

Patil et al. (1988) conducted the field experiment with safflower, irrigation with saline water (1 to 16 ds/m) and reported the decreased germination percentage and seedling vigour because of the accumulation of cations Na, K, Ca and Mg in seeds. Similar results were reported by Radi et al. (1988).

El. Wakhlaway and El. Fawal (1989) reported reduced germination percentage and normal seedling growth as the salinity concentration increased in safflower crop and they noted that sodium chloride had more adverse effect on germination than sodium sulphate.

2.4 Vegetative growth and maturation

In general, the first physiological reaction to increased salt concentration is reduced entry of water which tends to inhibit the meristematic activity and elongation of the roots (Hayward and Spurr, 1943) and reduced the vascular system and cambial activity (Hayward and Spurr, 1944). According to Ahmed (1965), important aspect of growth depression under saline conditions was retarded differentiation rate at the shoot apex or growing tip which further reduced total leaf area.

Vegetative growth was reduced as the osmotic pressure of the substrate was increased and this reduction in growth was reported to be in proportion to the amount of salts present in the substrate medium (Bernstein, 1964). However, soil salinity often restricts plant growth severely without these effects being apparent.

Kale (1964) observed depression in tillers, reduction in dry matter production, root growth, absolute growth rate, net assimilation rate, leaf size and height due to salt treatments in wheat. Reduced leaf size reduced photosynthetic rate which further influenced the grain filling.

Sarin (1963) observed depressing effects of salinity on dry weight of shoot, seed yield and 1000 grain weight of gram. The opening of first flower was also delayed by 6 days in treated sets as compared to control. Moreover, the adverse effects of salinity were gradual with increase in age and maturity of the crop.

Francois and Bernstein (1964) reported that in safflower, 10 per cent and 20-25 per cent yield reduction associated with the E.Ce values 7 and 11 per cm, respectively. These yield reductions were attributed to the decreased number of flowering heads and the yields of seeds per head the latter being affected by seed weight and not by seed number.

Younger et al. (1967) observed differential behaviour of grass varieties to salinity. They found that top growth of all the varieties decreased with increasing levels of salinity.

Kurian and Iyengar (1972) reported that in pot trials, 45 days old safflower seedlings were irrigated with sea water at 15,000 to 20,000 ppm and observed reduced plant height and number of leaves which resulted into reduced plant growth.

Abaza et al. (1974) noted that salinity limits to growth were 4140 ppm TSS (10 per cent sea water) for safflower when irrigated with sea water having range of 4140-4120 ppm total soluble salts.

Rhodes and Matsuda (1976) observed that polyribosome per cent and growth rate were reduced in proportion to loss of tissue water under salinity.

Lessani and Marschner (1978) observed the depression in dry matter production and corresponding growth depression caused by an increasing supply of NaCl in safflower plants.

Devi et al. (1980) observed that seedling emergence was delayed by 2 and 5 days at 0.2 and 0.4 per cent salinity respectively, however growth rate i.e. plant height, dry weight and Leaf Area Index (LAI) after emergence were much faster in the NaCl treated plants of safflower.

In a field experiment with safflower, irrigation with saline water (1 to 16 ds/m) decreased the number of branches per plant, number of heads per plant and seedling vigour (Patil, et al. 1988).

Irwing et al. (1988) reported that in safflower crop, increasing salinity decreased the plant height. Growth rate increased with increasing salinity and was indicated by earlier maturity dates in the salt stressed plant.

2.5 Yield and yield attributes

Sarin (1963) observed depressing effect of salinity on dry weight of shoot, seed yield and 1000-grain weight of gram. The opening of first flower was also delayed by 6 days in treated sets as compared to control.

Francois and Bernstein (1964) reported that in safflower, 10 per cent and 20-25 per cent yield reduction was associated with E.Ce values 7 and 11 per cm respectively. These yield reductions were attributed to the decreased number of flowering heads and the yields of seed per head, the latter being affected by seed weight and not by seed number.

Rage and Chattopadhyay (1966) reported that seed yield from safflower grown in a saline soil was 20 per cent lower than the average yield for the farm.

In pot culture trails, 45 days old safflower seedlings were irrigated with sea water at 15,000 to 20,000 ppm and observed that there was reduction in seed yield and 1000 seed weight (Kurian and Iyengar, 1972).

Safflower was grown in various soils with salinity ranging from 26.33 to 639.33 mg salt/100 gm soil and observed that yields were highest at 1.39 tonnes seed per hectare in the control but for other soils yield decreased with increasing salinity (Tesu et al. 1975; Rai, 1980).

Singh et al. (1981) reported that dry matter production and grain yield of safflower decreased continuously with an increase in exchangable sodium percentage (ESP) of the soil and a reduction of 50 per cent grain yield occurred at an ESP of 14 for safflower.

The reduction in yield of safflower under saline water irrigation was mainly due to a decrease in number of heads on secondary branches and to a lesser extent of 100 seed weight and seed yield per head (Janardhan, et al. 1986; Maliwal, 1986).

In field experiment with safflower, irrigation with saline water (1 to 16 ds/m) decreased the number of heads per plant, seed yield, 1000 seed weight and oil content (Patil et al. 1988).

MATERIAL AND METHODS

3. MATERIAL AND METHODS

A pot culture trial on physiological analysis of the influence of salinity on growth and development of safflower (*Carthamus tinctorius* L.) was conducted during the rabi season of 1988-89 at Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra State). The details of materials used and methods followed are presented in this chapter.

3.1 Preparation of pots

This experiment was carried out in pot culture. One hundred eighty cement pots of similar size i.e. 30 x 30 cm were used for this purpose. These pots were filled with fertile soil and compost in the proportion of 2 : 1. During pot filling the care was taken that each pot contained, ten kilogram of soil-compost mixture. Some upper space was kept open in each pot for better irrigation.

3.2 Experimental layout

The experiment was laid out in a factorial completely randomised design (FCRD) replicated three times.

3.3 Seeds and sowing

Three safflower varieties viz., N 62-8, Bhima and JSF-1 belonging to species *Carthamus tinctorius* L.

were used in this experiment. In each pot, 6-8 seeds were sown. Germination was completed after eight days. After about 12 days from sowing, gap filling was carried out with the help of seeds of respective variety. After 20 days from sowing first thinning was done, at this time 5 healthy plants were kept in each pot. Second thinning was done after 30 days from sowing and 4 healthy plants were kept in each pot. Plants were protected from aphid attack by spraying recommended insecticide.

3.4 Treatments

After 30 days from sowing the different salinity levels were created by adding the salts ($NaCl$ + $CaCl_2$) on weight basis as each pot contained 10 kg soil-compost mixture.

i)	Control	:	Salts not added	- (S_0)
ii)	0.1%	:	5 gm $NaCl$ + 5 gm $CaCl_2$ in 10 kg soil	- (S_1)
iii)	0.2%	:	10 gm $NaCl$ + 10 gm $CaCl_2$ in 10 kg soil	- (S_2)

Salts first dissolved in a little quantity of water and then added. Irrigations followed as per necessity.

3.5 Growth observations

For growth observations, three plants were selected randomly in each treatment. These plants were marked by tagging the lebeles. Following periodical observations were recorded at an interval of 15 days starting from 30 days after sowing and continued upto the harvest.

3.5.1 Height of plant

Total plant height (in cm) of the observational plants was recorded from the ground level to the base of the last fully opened leaf. Observations were recorded at an interval of 15 days starting from 30 days and were continued till harvest.

3.5.2 Number of branches

Total number of branches, viz., primary, secondary and teritary whenever observed were recorded separately after every 15 days interval. Observations were recorded at an interval of 15 days starting from 30 days were continued till harvest.

3.5.3 Number of green leaves per plant

Total number of green leaves of observational plants were recorded after every 15 days interval.

3.6 Growth phases

3.6.1 Days required for 50% flowering

Days taken to 50% flowering were recorded in each variety whenever observed.

3.6.2 Days required for maturity

In all the varieties the number of days required for maturity of plants were recorded. The parameter that is complete yellowing and browning of capsules was taken as the indication of complete maturity.

3.7 Plant sampling

Plant sampling was done from 60 days after sowing. Three pots were harvested at each sampling. In all five samples were collected. Sampled plants were separated into different plant parts i.e. leaf, stem, capsules, primary, secondary and tertiary branches etc. The leaf area was recorded immediately on automatic leaf area meter and all these plant parts were dried well in electrically operated thermostatic hot air oven regulated at 90^0 for first one hour and then at constant temperature of 70^0C for two days and then the further observations were recorded.

3.7.1 Leaf area

Three pots were selected randomly at each sampling. The plants from these pots were separated into the stem, leaves and capsules. Leaf area of these plants (dm^2) was measured with the help of automatic leaf area meter. These observations were recorded from 60 days after sowing till the harvest, at an interval of 15 days.

3.7.2 Leaf area duration ($\overline{LAD}$) (days)

Leaf area duration of different occasions was worked out by multiplying leaf area with interval between two sampling occasions.

$$\overline{LAD} = \frac{(L_1 + L_2) \times (t_2 - t_1)}{2}$$

Where, L_2 and L_1 represent the leaf area per plant at t_2 and t_1 times, respectively.

3.8 Dry matter studies

Three pots were selected randomly and harvested at each sampling starting from 60 days of sowing. In all five samples were collected. Sampled plants were separated into leaf, stem, branches, caputulum etc. Then these separated plant parts were dried in electrically operated thermostatic hot air oven, regulated at $90^{0}C$ for first one hour and then at constant temperature of $70^{0}C$ for 2 days. After complete drying, dry weights were recorded separately and total dry matter was computed.

3.9 Growth functions

From dry matter data the growth functions such as, absolute growth rate ($\overline{AGR}$), relative growth rate ($\overline{RGR}$) net assimilation rate ($\overline{NAR}$) were estimated with the help of total dry weight of plant and leaf area per plant.

3.9.1 Absolute growth rate ($\overline{AGR}$) or crop growth rate ($\overline{CGR}$) (g/day)

Absolute growth rate was calculated from total dry matter accumulation by using the formula given by Redford (1967).

$$\overline{AGR} = \frac{(W_2 - W_1)}{(t_2 - t_1)}$$

Where, W_2 and W_1 refers to weights of the total dry matter per plant at the time of t_2 and t_1, respectively.

3.9.2 Relative growth rate ($\overline{RGR}$) (g/g/day)

The rate at which plant incorporate new material into its substance was measured by $\overline{RGR}$, which is expressed mathematically from the following formula given Briggs et al. (1920) and Fisher (1921).

$$\overline{RGR} = \frac{(\log_e W_2 - \log_e W_1)}{(t_2 - t_1)}$$

Where, W_2 and W_1 represented total dry matter per plant at t_2 and t_1 times, respectively.

3.9.3 Net assimilation rate ($\overline{NAR}$) (g/cm^2/day)

The net assimilation rate represents photosynthetic efficiency of leaves. The relationship between leaf area and dry matter accumulation is measured with the help of formula suggested by Gregory (1926).

$$NAR = \frac{(W_2-W_1)}{(L_2-L_1)} \times \frac{\text{Log}_e\ L_2 - \text{Log}_e\ L_1)}{(t_2 - t_1)}$$

Where, W_2 and W_1 represent the total dry matter and L_2 and L_1 denote the leaf area per plant at t_2 and t_1 times, respectively.

3.10 Harvesting

The remaining pots containing safflower plants were harvested when all the leaves and capitula on the plant become dry and brown.

3.11 Yield contributing characters

3.11.1 Number of caputula per plant

The number of caputula per plant were recorded at an interval of 15 days starting from formation and were continued till harvest.

3.11.2 Mean seed number per caputula

Seeds obtained from bulk samples of caputula at harvest were recorded. The seed number per caputula was worked out by dividing seed number by number of caputula..

3.11.3 Thousand seed weight

Thousand seed weight of seeds from bulk sample of caputulum was recorded at the time of harvest.

3.11.4 Seed yield per pot

Out of 20 pots, 5 pots were kept mainly for yield studies under each treatments, plants from these pots were harvested at maturity and seed yield was recorded per pot separately.

3.12 Chemical analysis

Plant samples collected at the time of sampling were chemically analysed for content and uptake of nitrogen, phosphorus, potassium, sodium and calcium of leaves, stem and capsules separately.

3.12.1 Nitrogen (N)

Nitrogen content in leaves, stem and capsule was estimated by micro-kjeldhal's method (A.O.A.C., 1955).

The plant samples were powdered in the grinding mill and a known quantity (0.2 gm) was digested in a mixture of 1 : 1 concentrated H_2SO_4 : H_2O_2 and the acid extract was used for determination of nitrogen, phosphorus, potassium, sodium and calcium (Nelson and Sommers, 1973).

3.12.2 Phosphorus (P)

A known quantity of acid extract (5 ml) was taken for determination of phosphorus content of plant parts. The yellow colour was developed by adding indicator prepared from ammonium metavanadate and ammonium molybdate and colour intensity was measured on Spectronic-20 at wave-length 470 nm and phosphorus was estimated (Koeing and Johnson, 1942).

3.12.3 Potassium (K)

Potassium content in leaves, stem and capsule was estimated by flame photometer method (Chapman and Pratt, 1961).

3.12.4 Sodium (Na)

Sodium content in leaves, stem and capsule was estimated by flame-photometer method.

3.12.5 Calcium (Ca)

Calcium content in leaves, stem and capsule was determined by Versanate method. A known volume of the solution was titrated with standard versanate 0.01 N EDTA solution using murexide indicator in the presence of NaOH solution. The end point was a change of colour from orange red to purple.

3.13 Statistical analysis

The data collected on different aspects, wherever possible, were analysed statistically by standard method, "Analysis of Variance". Whenever the results were significant, a critical difference (C.D.) at 5 per cent level of probability was mentioned.

EXPERIMENTAL RESULTS

4. EXPERIMENTAL RESULTS

An experiment with a view to study influence of salinity on growth and development of safflower (<u>Carthamus tinctorius</u> L.) was conducted as per details in Chapter 3. The results are described in this chapter.

4.1 Salinity status

Data on electrical conductivity (E.Ce) of soil of the pots during experiment, i.e. after giving salt treatment at 35 days after sowing and at harvest are presented in Table 1.

Table 1. Electrical conductivity (E.Ce) at saturation percentage in millimohos per cm at 25° C

Treatments	Varieties			
	N 62-8	Bhima	JSF-1	Mean
	After treatment (35 days after sowing)			
S_0	1.78	1.82	1.83	1.81
S_1	2.96	2.95	2.94	2.95
S_2	5.03	4.98	5.02	5.01
Mean	3.26	3.25	3.26	
	At harvest			
S_0	1.72	1.73	1.73	1.73
S_1	2.71	2.53	2.45	2.56
S_2	4.52	4.23	4.14	4.30
Mean	2.98	2.83	2.77	

It will be seen from the data that mean salinity value, in general, increased in proportion to the quantity of salts added. It is interesting to note that with time, mean salinity value decreased slightly.

4.2 Growth observations

4.2.1 Height

The relevant data on height at 15 days interval are summarized in Table 2 and are graphically shown in Fig. 1. Further, data showing mean effects of treatments, varieties and their interaction for these observations are given in Table 3.

The salt treatments commenced at 30 days after sowing. The mean height of all three varieties at the beginning was more or less the same under control as well as S_1 and S_2. The salt treatments reduced the mean height slightly at 45 days after sowing and thereafter both the treatments reduced height significantly and consistently with significant differences between S_1 and S_2 treatments and the treatment effects differed as $S_0 > S_1 > S_2$.

The main effects on varieties were also significant, except 60 and 75 days after sowing. Initially rate of growth in Bhima was very slow up to 45 days after sowing. The varietal differences in respect of mean height were significant except at 60 and 75 days after sowing.

Table 2. Progressive mean height in cm

Days after sowing	Varieties								
	N 62-8			Bhima			JSF-1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
30	5.67	5.33	5.33	2.33	2.33	2.67	4.00	4.00	4.33
45	25.67	22.67	19.67	14.33	12.00	11.67	19.00	18.00	17.33
60	46.67	[illegible]	38.67	43.00	38.67	37.00	45.00	39.67	37.67
75	[illegible]	44.67	43.00	53.00	43.67	42.67	53.00	43.67	42.00
90	[illegible]	46.33	44.33	55.33	45.67	43.67	55.67	45.33	43.67
105	[illegible]	47.33	45.67	57.00	46.67	44.67	57.00	46.33	44.67
120	[illegible]	47.33	45.67	57.67	46.67	44.67	57.67	46.33	44.67

Table 3. Mean effects of varieties, treatments and their interaction on mean height in cm

	Days after sowing						
	30	45	60	75	90	105	120
Varieties :							
N 62-8	5.44	22.67	41.78	47.89	49.89	51.22	51.22
Bhima	2.44	12.67	37.36	40.44	46.22	49.44	49.44
JSF-1	4.11	16.11	40.78	40.22	48.22	49.33	49.56
S.E. ±	0.28	0.53	0.74	0.54	0.49	0.51	0.52
C.D. at 5%	0.83	1.58	NS	NS	1.46	1.52	1.54
Treatments :							
S_0	4.00	19.67	44.89	54.00	56.67	58.22	58.44
S_1	3.89	17.56	39.44	44.00	45.78	46.78	46.78
S_2	4.11	16.22	37.78	42.56	43.89	45.00	45.00
S.E. ±	0.28	0.53	0.74	0.54	0.49	0.51	0.52
C.D. at 5%	NS	1.58	2.21	1.59	1.46	1.52	1.54
Interaction	NS	NS	NS	NS	NS	NS	NS

NS = Not-significant.

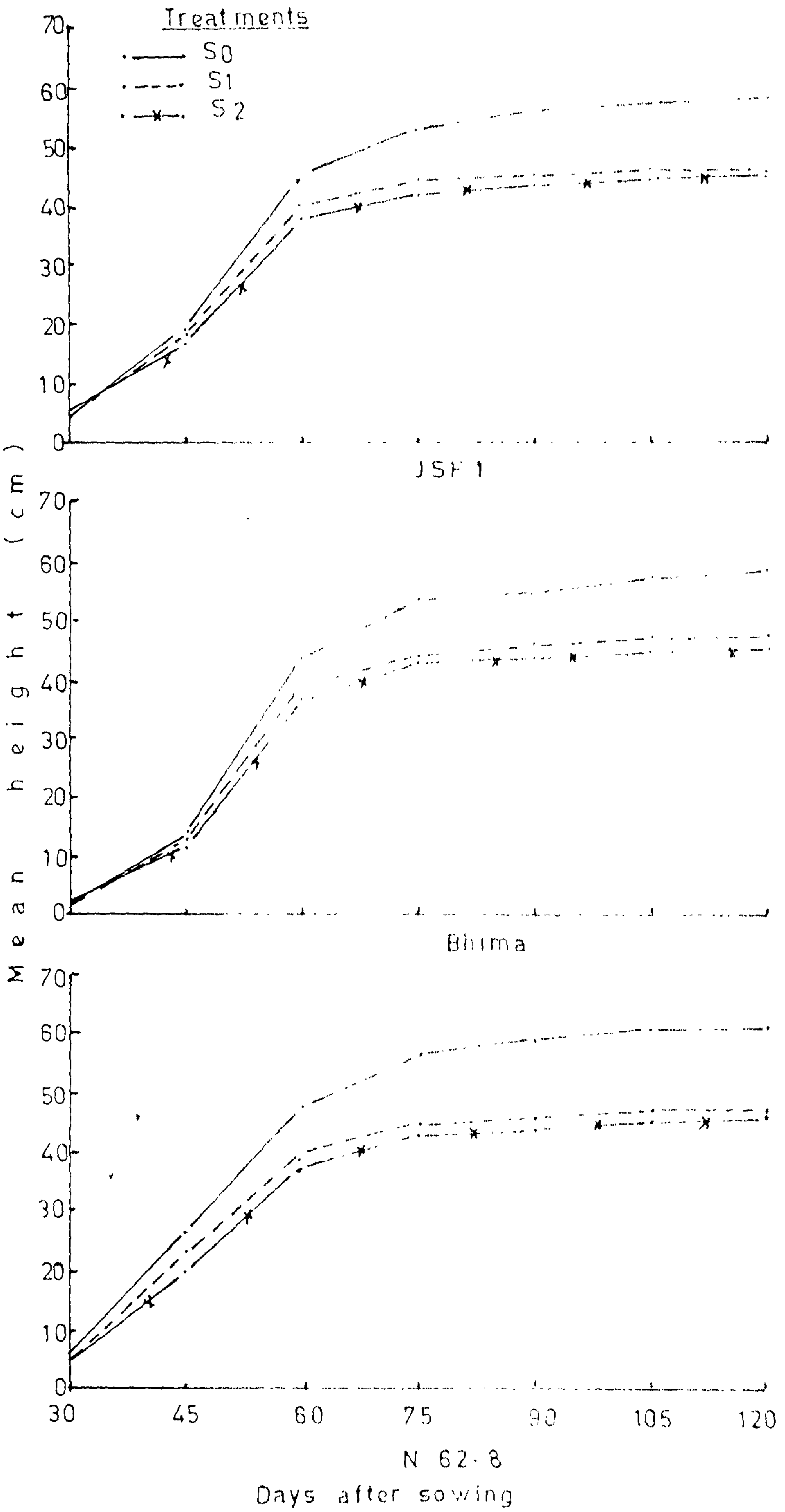

Fig.1: Mean height of plant (cms)

Similarly, the treatment differences were significant at all occasions, except at 30 days. Thus, there were consistent and significant differences among the treatments which varied in descending order as $\underline{S_0}$ $\underline{S_1}$ $\underline{S_2}$ at all occasions.

4.2.2 Number of primary branches per plant

The data on the number of primary branches are presented in Table 4 and 5 and are graphically shown in Fig. 2.

The data regarding number of primary branches revealed that the salt treatments reduced the number of primary branches. Both the salt treatments reduced the number of primary branches significantly over the control with significant differences between S_1 and S_2 treatments. The treatment differences varied as $S_0 > S_1 > S_2$.

The differences between varieties were not conspicuous to warrant any conclusion, but from mean it would be seen that number of primary branches are more in variety N 62-8 at all occassions and order was as N 62.87 > Bhima > JSF-1.

4.2.3 Number of secondary branches per plant

The relevant data showing number of secondary branches at periodic intervals are summarized in Table 6 and shown in Fig. 3. Data showing mean effects of treatments,

Table 4. Progressive mean number of primary branches per plant

Days after sowing	Varieties								
	N 62-8			Bhima			JSF-1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
60	6.00	4.33	3.00	5.33	3.67	2.67	4.67	3.67	3.00
75	7.67	5.33	4.33	6.33	5.00	4.00	6.67	5.00	4.00
90	8.33	6.00	4.33	7.67	6.33	4.67	7.67	5.67	4.67
105	8.67	6.00	4.67	7.67	6.33	5.00	7.67	5.67	4.67
120	8.67	6.00	4.67	7.67	6.33	5.00	7.67	5.67	4.67

Table 5. Mean effects of varieties, treatments and their interaction on number of primary branches

	Days after sowing				
	60	75	90	105	120
<u>Varieties</u> :					
N 62-8	4.44	5.78	6.22	6.44	6.44
Bhima	3.89	5.11	6.22	6.22	6.33
JSr-1	3.78	5.22	6.00	6.00	6.00
S.E. ±	0.29	0.26	0.29	0.30	0.30
C.D. at 5%	NS	NS	NS	NS	NS
<u>Treatments</u> :					
S_0	5.33	6.89	7.89	7.89	8.00
S_1	3.89	5.11	6.00	6.00	6.00
S_2	2.89	4.11	4.56	4.78	4.78
S.E. ±	0.29	0.26	0.29	0.30	0.30
C.D. at 5%	0.87	0.79	0.85	0.89	0.89
Interaction	NS	NS	NS	NS	NS

NS = Non-significant.

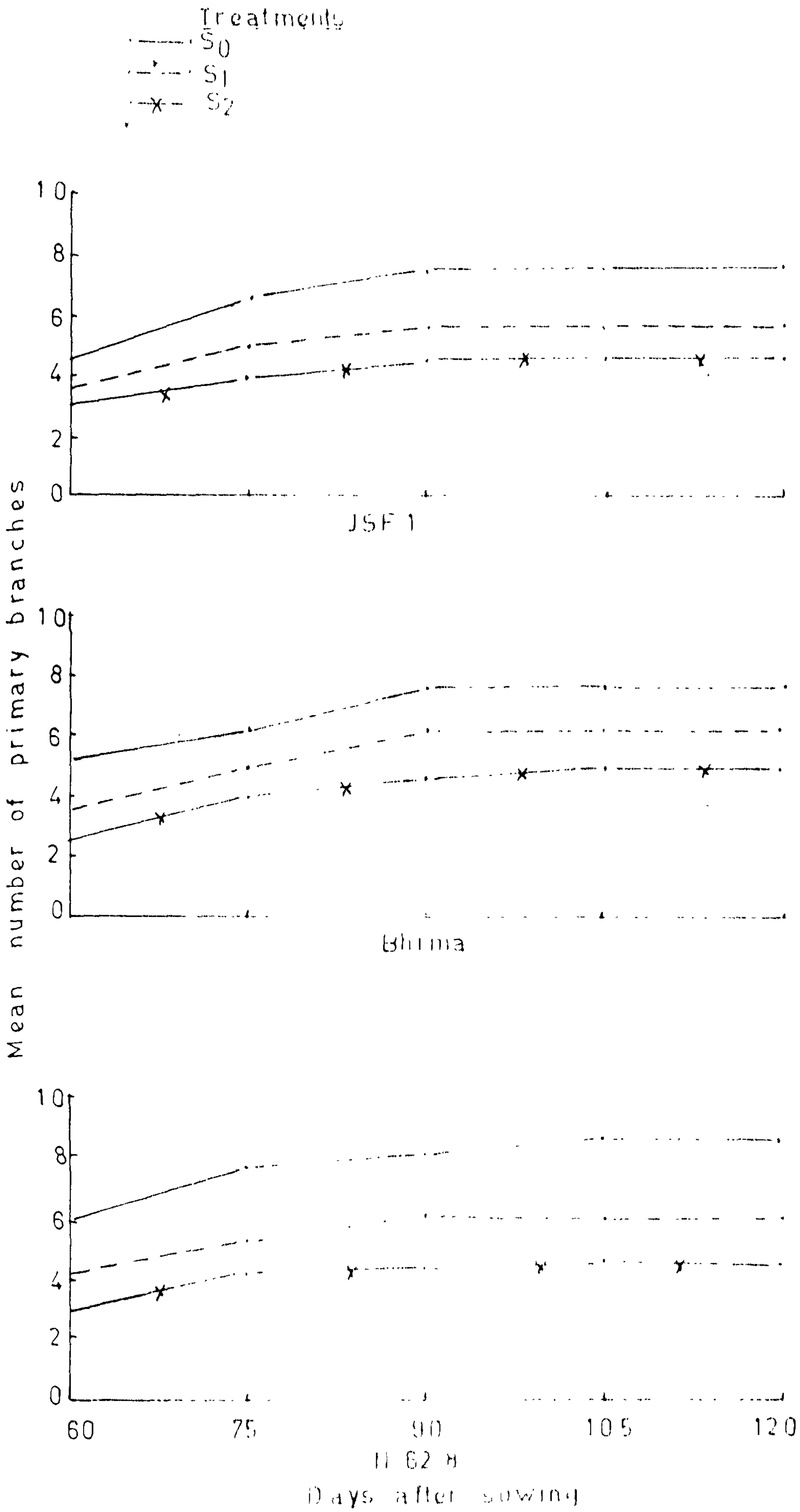

Fig.2:Mean number of primary branches per plant.

Table 6. Progressive mean number of secondary branches per plant

Days after sowing	Varieties								
	N 62-8			Bhima			JSR-1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
75	8.67	5.33	4.00	8.67	4.33	2.00	[illegible]	4.00	3.00
90	10.33	6.33	5.00	11.67	6.00	4.33	[illegible]	5.67	3.67
105	11.33	7.33	5.33	12.33	6.67	4.67	10.33	6.33	3.67
120	11.33	8.00	5.33	12.33	6.67	4.67	10.33	6.33	3.67

Table 7. Mean effects of varieties, treatments and their interaction on mean number of secondary branches

	Days after sowing			
	75	90	105	120
Varieties :				
N 62-8	6.00	7.22	8.[illegible]	[illegible]
Bhima	5.00	7.33	7.[illegible]	7.[illegible]
JSF-1	5.11	[illegible]	[illegible]	[illegible]
S.E. ±	0.36	0.37	0.42	[illegible]
C.D. at 5%	NS	NS	[illegible]	[illegible]
Treatments :				
S_0	8.56	10.56	11.33	[illegible].33
S_1	4.56	6.00	6.78	7.00
S_2	3.00	4.33	4.56	4.56
S.E. ±	0.36	0.37	0.42	0.41
C.D. at 5%	1.08	1.11	1.24	1.22
Interaction	NS	NS	NS	NS

NS = Non-significant

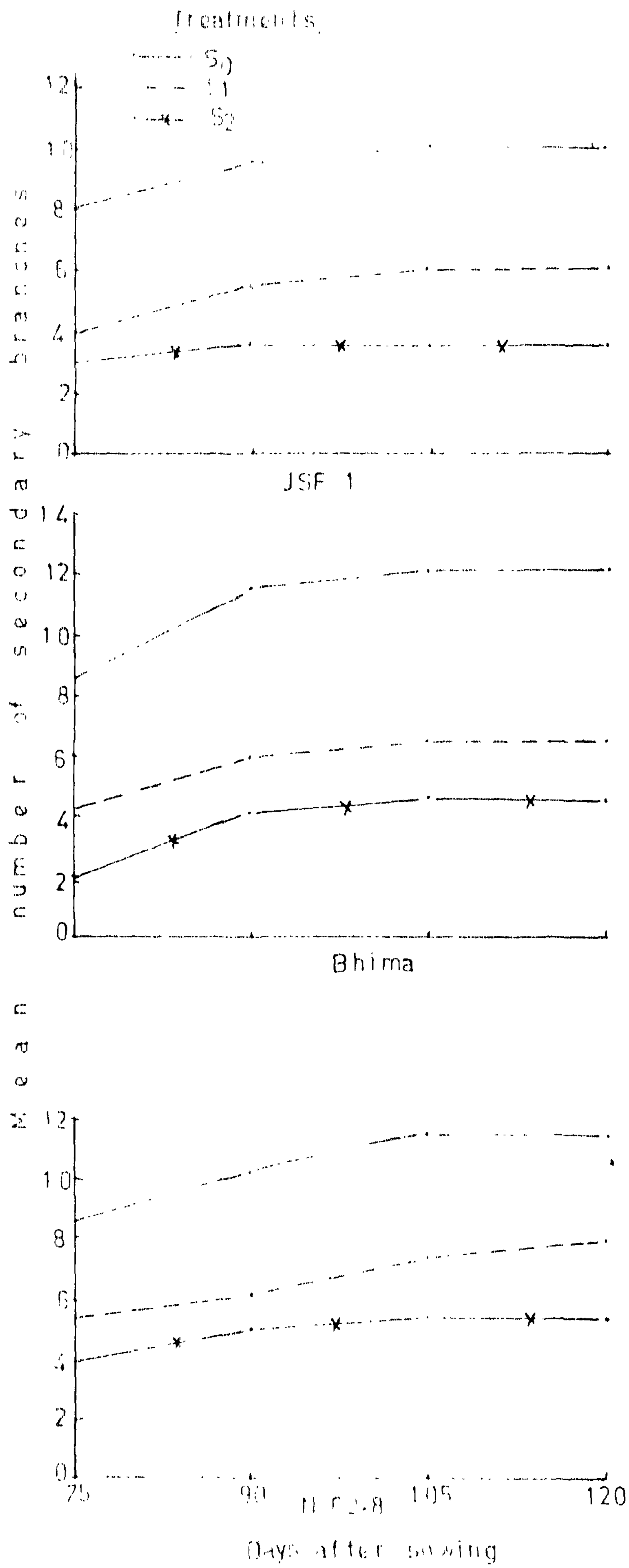

Fig.3:Mean number of secondary branches per plant.

varieties and their interaction for these observations are given in Table 7.

The data regarding number of secondary branches revealed that, the salt treatments tended to reduce the number of secondary branches per plant. Both the salt treatments reduced the number of secondary branches significantly, with significant differences between S_1 and S_2 treatments. Treatment effects differed as $S_0 > S_1 > S_2$.

The main effects of varieties were not conspicuous to draw any conclusions, except at 120 days after sowing. At this stage N 62-8 was significantly superior to JSF-1 but equal to Bhima and Bhima was equal to both.

4.2.4 Number of tertiary branches per plant

The data showing number of tertiary branches at periodic intervals are summarized in Table 8 and graphically shown Fig. 4. Further data showing mean effects of treatments, varieties and their interactions are given in Table 9.

The data regarding number of tertiary branches revealed that, the salt treatments reduced the number of tertiary branches at all occassions. It was evident that the number of tertiary branches was significantly and consistently higher under control than S_1 and S_2 treatments.

Table 8. Progressive mean number of tertiary branches per plant

Days after sowing	Varieties								
	N 62-6			Anima			JSr-1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
90	1.67	0.33	[illegible]	1.00	0.66	-	1.33	0.33	-
105	2.67	1.33	0.67	[illegible]	[illegible]	[illegible]	[illegible]	1.00	0.33
120	3.67	2.00	1.00	3.00	1.67	[illegible]	2.67	1.00	0.33

Table 9. Mean effects of varieties, treatments and their interaction on mean number of tertiary branches

	Days after sowing		
	90	105	120
<u>Varieties</u> :			
N 62-8	0.78	1.56	2.22
Bhima	0.67	1.33	1.89
JSF-1	0.56	1.11	1.33
S.E. ±	0.20	0.22	0.30
C.D. at 5%	NS	NS	NS
<u>Treatments</u> :			
S_0	1.44	2.22	3.11
S_1	0.44	1.22	1.56
S_2	0.11	0.56	0.78
S.E. ±	0.20	0.22	0.30
C.D. at 5%	0.61	0.66	0.89
Interaction	NS	NS	NS

NS = Non-significant

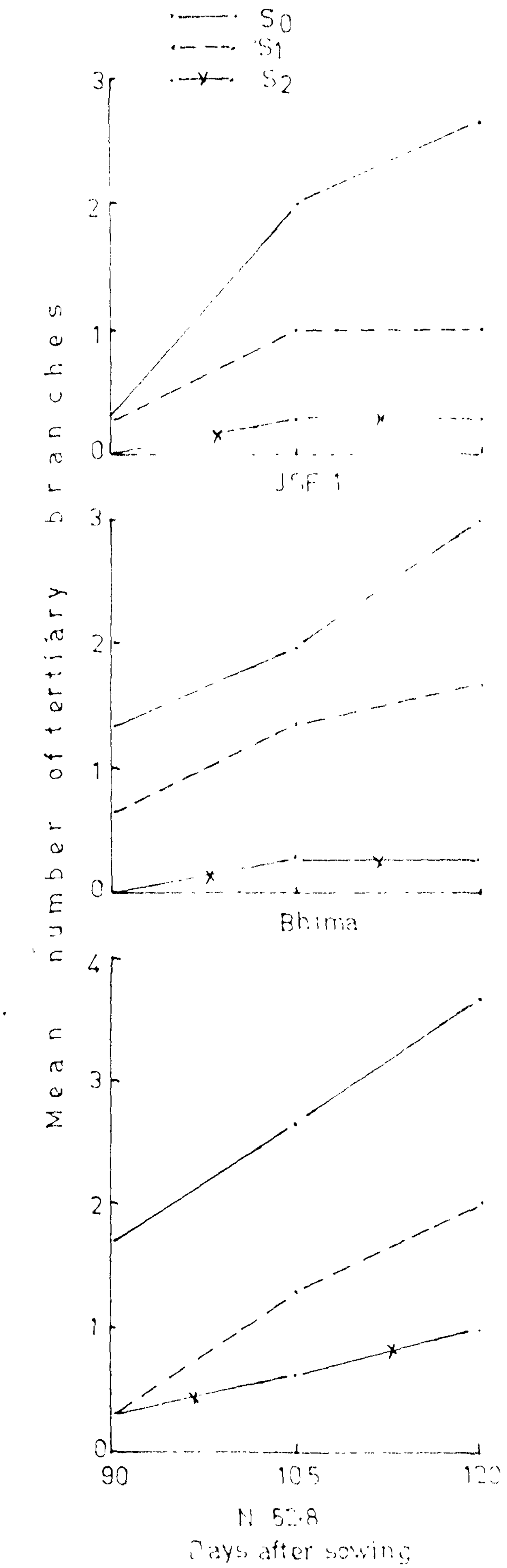

Fig.4: Mean number of tertiary branches per plant.

Both the salt treatments reduced the number of tertiary branches significantly, with significant differences between S_1 and S_2 treatments and treatment effects differed as $S_0 > S_1 > S_2$.

The varietal differences were not statistically significant, however, there were more number of tertiary branches in variety [illegible] as compared to [illegible] and JSR-1, whereas JSR-1 had least mean number of tertiary branches at all occassion. The interaction effects between varieties and salt treatments were not significant indicating similar response of varieties to the salt treatments.

4.2.5 Total number of caputulum per plant

The data showing number of total caputulam per plant at periodic interval are summarized in Table 10 and graphically shown in Fig. [illegible] and further data showing mean effects of treatments, varieties and their interactions are given in Table 11.

The rate of production of caputulum was significantly and consistantly higher under the control than S_1 and S_2 treatments. Both the treatments reduced the mean total number of caputulum at all the occassions of plant growth, with significant differences between S_1 and S_2 treatments and treatment effects differed as $S_0 > S_1 > S_2$.

Table 10. Progressive mean caputulum number per plant

Days after sowing	Varieties								
	N 62-8			Bhima			JSF -1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
75	15.67	9.33	6.33	13.67	7.67	6.00	13.67	6.33	4.67
90	19.67	12.67	7.67	16.67	10.67	8.33	16.67	10.00	7.00
105	21.33	13.67	11.00	20.33	13.33	9.67	18.67	11.67	8.33
120	22.00	16.00	12.33	22.33	14.67	11.00	20.67	13.33	9.67

Table 11. Mean effects of varieties, treatments and their interaction on mean caputulum number

	Days after sowing			
	75	90	105	120
<u>Varieties</u> :				
N 62-8	10.44	13.33	15.33	16.78
Bhima	9.11	11.89	14.44	16.00
JSF-1	8.22	11.22	12.89	14.56
S.E. ±	0.38	0.49	0.55	0.78
C.D. at 5%	1.13	1.45	1.64	NS
<u>Treatments</u> :				
S_0	14.33	17.67	20.11	21.67
S_1	7.78	11.11	12.89	14.67
S_2	[illegible]	7.67	9.67	11.00
S.E. ±	0.38	0.49	0.55	0.78
C.D. at 5%	1.13	1.45	1.64	2.31
Interaction	NS	NS	NS	NS

NS = Non-significant

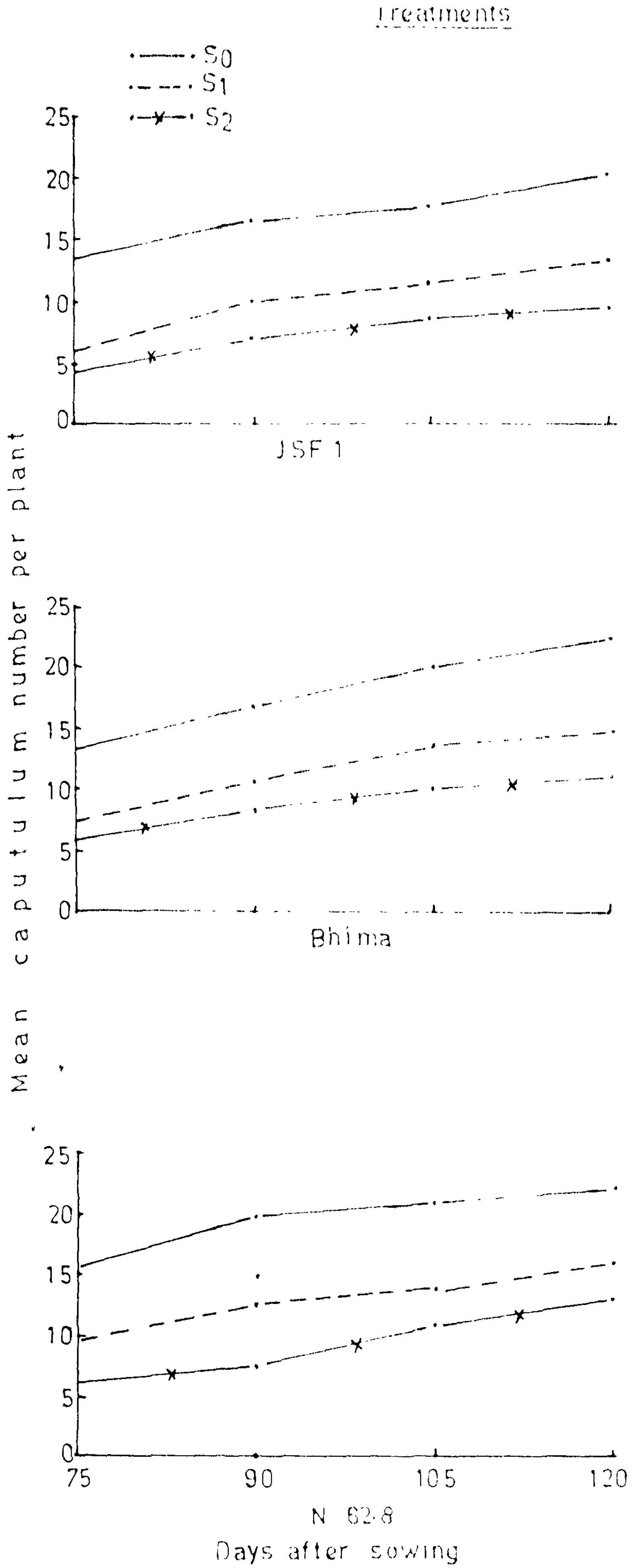

Fig.5: Mean number of caputulum per plant.

The varietal difference were also significant, excepts 120 days after sowing. It can be seen that the mean number of total caputulum was higher in variety N 62-8 as compared to Bhima and JSF-1 at all occassions. The rate of production of caputulum was significantly higher in N 62-8 and it was significantly higher than JSF-1 but it was at par with Bhima, except at 75 days after sowing, whereas variety JSF-1 was significantly inferior than N 62-8 but at par with Bhima at all occassions.

4.2.6 Number of leaves per plant

The relevant data are summarized in Table 12 and graphically shown in Fig. 6 and Table 13.

The differences in number of leaves per plant were statistically significant at all the occassions, except at 30 days of plant growth stage where the differences were not significant.

The number of leaves per plant was significantly and consistantly higher under control at all occassions of plant growth than S_1 and S_2 treatments, indicating retarding effect of salinity on leaf number. Both the treatments reduced the number of leaves significantly, with significant differences between S_1 and S_2 treatments. Treatment differences varied as $S_0 > S_1 > S_2$. The leaf number per plant increased upto 90 days of the crop growth stage in

Table 12. Progressive mean leaf number per plant

Days after sowing	Varieties								
	N 62-8			Bhima			JSr -1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
30	9.00	8.33	7.67	7.00	7.33	7.33	7.67	8.67	9.00
45	25.00	19.00	17.33	19.67	16.00	14.67	19.33	18.00	16.33
60	73.67	45.33	33.00	61.00	32.00	31.67	54.33	48.67	32.00
75	126.67	83.67	63.33	110.33	69.67	66.67	107.33	72.67	54.00
90	163.00	121.00	95.33	147.00	101.00	92.00	143.33	87.33	67.67
105	117.00	96.00	66.67	108.00	73.33	72.00	109.67	72.00	44.33
120	82.00	66.33	49.33	86.00	56.67	51.67	72.33	46.00	35.33

Table 13. Mean effects of varieties, treatments and their interaction on mean leaf number

	Days after sowing						
	30	45	60	75	90	105	120
Varieties :							
N 52-6	8.33	20.44	51.00	91.89	125.78	93.22	65.89
Bhima	7.22	16.78	41.67	82.89	113.33	84.44	64.78
JSr -1	8.44	17.89	44.00	78.00	99.44	75.33	51.22
S.E. ±	0.38	0.64	1.87	2.98	4.01	3.97	3.26
C.D. at 5%	NS	1.91	5.58	8.86	11.92	11.79	9.69
Treatments :							
S_C	7.89	21.33	53.00	115.44	157.11	111.56	80.11
S_1	8.11	17.67	42.44	75.33	103.11	80.11	56.33
S_2	8.00	16.11	32.22	62.00	85.33	61.33	45.44
S.E. ±	0.38	0.64	1.87	2.98	4.01	3.97	3.26
C.D. at 5%	NS	1.91	5.58	8.86	11.92	11.79	9.69
Interaction	NS	NS	NS	NS	NS	NS	NS

NS = Non-significant.

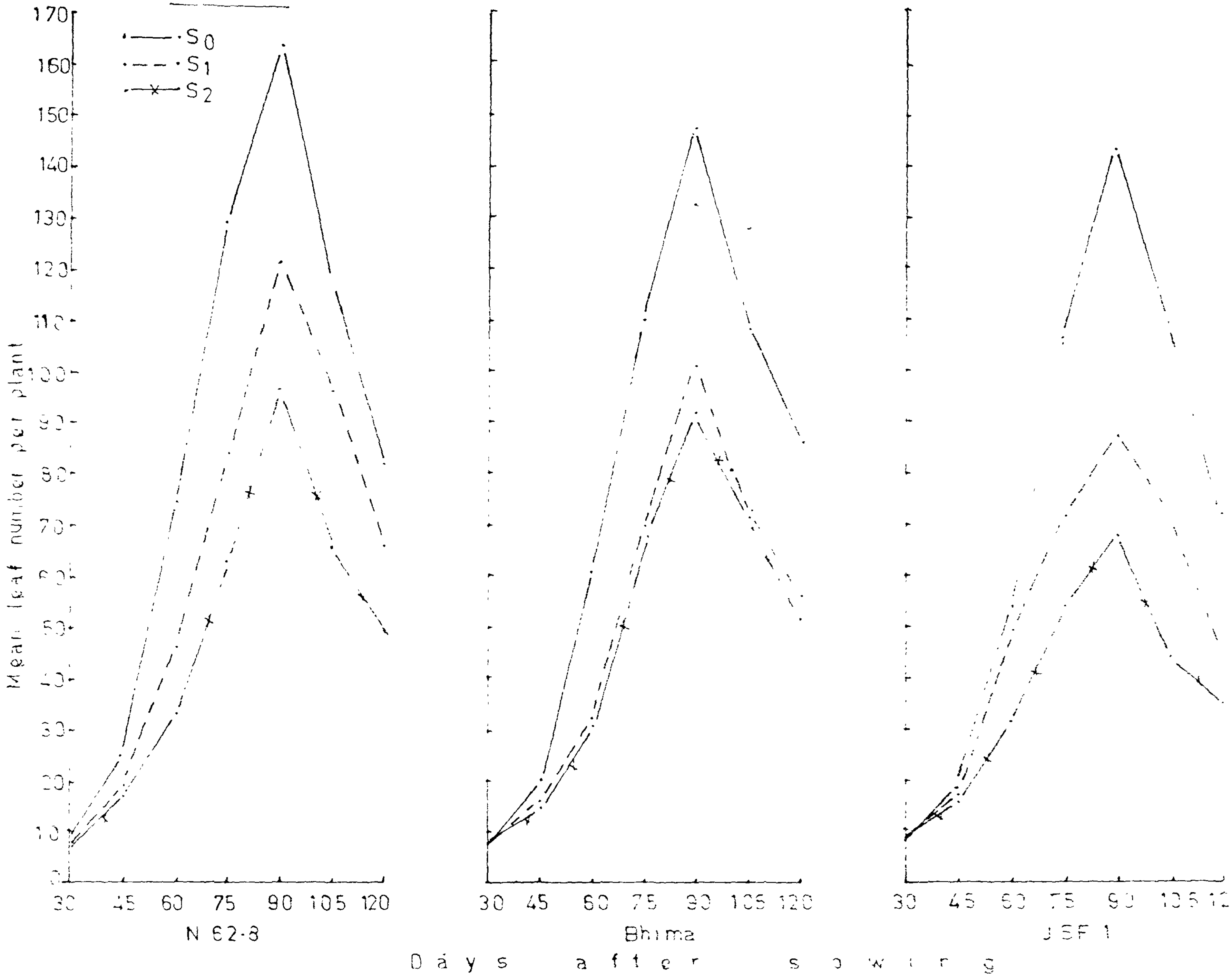

Fig.6: Mean number of leaves per plant.

all three treatments and also in all three varieties and thereafter it was decreased continuously till harvest. This may be due to the senescence of old leaves at maturity.

The varietal differences were also significant, except 30 days after sowing. The number of leaves per plant was significantly higher in variety N 62-8 than Bhima and JSF-1 at all stages of plant growth. The number of leaves per plant in variety Bhima and JSF-1 was more or less same upto the 75 days of crop growth stage and thereafter Bhima was significantly superior than JSF-1 where JSF-1 was significantly inferior than both the varieties.

4.3 Leaf area per plant (dm^2)

The mean leaf area per plant at different stages under treatments are given in Table 14, 15 and graphically shown in Fig. 7, 16

The data regarding mean leaf area revealed that the salt treatments reduced the mean leaf area from 60 days crop growth stage till harvest. The mean leaf area was significantly and consistantly higher under control than S_1 and S_2 treatments. Both the treatments reduced the mean leaf area significantly. Treatment effect differed as $S_0 > S_1 > S_2$.

Table 15. Mean effect of varieties, treatments and their interaction on mean leaf area (dm^2).

	Days after sowing				
	60	75	90	105	120
Varieties :					
N 62-8	[illegible]	[illegible]	[illegible]	[illegible]	1.53
Brima	3.57	[illegible]	[illegible]	[illegible]	1.02
JSF-1	[illegible]	[illegible]	[illegible]	[illegible]	1.25
S.E. ±	0.24	0.53	0.43	0.20	0.10
C.D. at 5%	NS	NS	NS	NS	0.29
Treatments :					
S_0	[illegible]	[illegible]	[illegible]	[illegible]	2.79
S_1	2.08	4.07	2.99	[illegible]	1.25
S_2	2.18	3.38	2.33	1.47	0.36
S.E. ±	0.24	0.53	0.43	0.20	0.10
C.D. at 5%	0.73	1.57	1.28	0.61	0.29
Interaction	NS	NS	NS	NS	NS

NS = Non-significant.

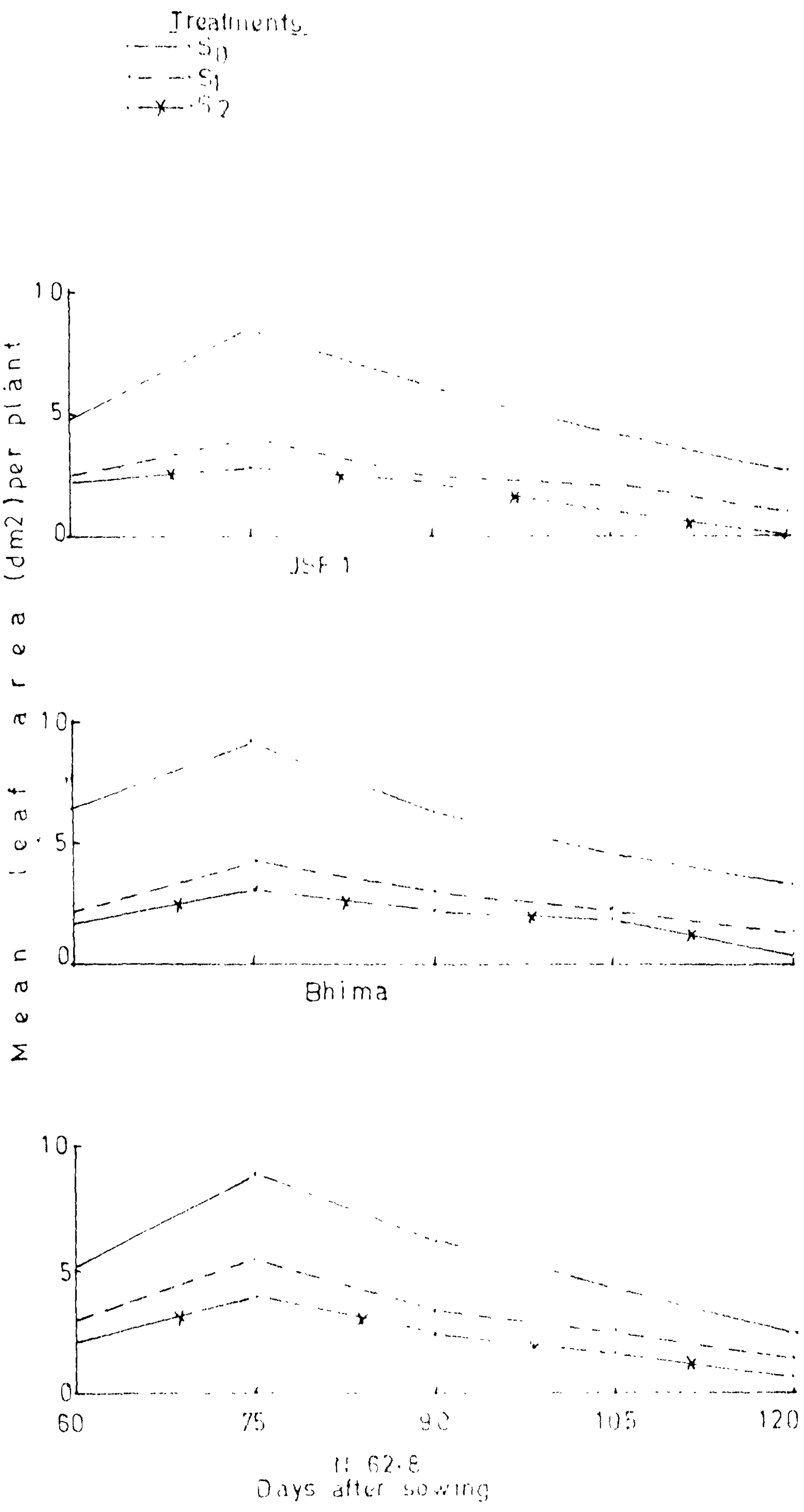

Fig.7:Mean leaf area per plant (dm2).

The significant differences between S_1 and S_2 were not evident upto 90 days of crop growth stage. Thereafter S_1 treatment was significantly superior to S_2 treatment.

The varietal differences were statistically not significant, except at 120 days of crop growth stage. In general, it will be seen from the data that there was slightly more leaf area in variety N 62-8 than Bhima and JSF-1. Interestingly at 120 days of crop growth stage the mean leaf area under variety Bhima was more, than N 62-8 and significantly higher than JSF-1.

The maximum leaf area under all three varieties and treatments was observed at 75 days crop growth stage, then the reduction in leaf area after attaining maximum value was evident under all the three varieties and treatments.

4.3.1 Leaf area duration ($\overline{LAD}$)

The data regarding leaf area duration are presented in Table 16 and Table 17.

It will be seen from the data that the leaf area duration ($\overline{LAD}$) was maximum at initial growth phase (60-75 days after sowing) and it declined rapidly with the advancement of crop age under all the three treatments and varieties.

Table 16. Progressive mean leaf area duration (LAD) per plant (days)

Days between	Varieties								
	[illegible]			Bhima			JSr-1		
	Treatments								
	S_0	S_1	S_2	S_0	S_1	S_2	S_0	S_1	S_2
60 - 75	[illegible]	[illegible]	30.[illegible]	54.56	43.92	[illegible]	[illegible]	34.75	24.15
75 - 90	[illegible].32	3[illegible].5[illegible]	25.35	49.52	35.50	[illegible].40	43.4[illegible]	25.21	15.50
90 - 105	[illegible]	24.5[illegible]	15.70	35.4[illegible]	24.65	[illegible].05	34.55	[illegible]	16.0[illegible]
105 - 120	33.55	2[illegible].85	14.09	29.48	14.95	14.05	23.45	14.50	13.2[illegible]

Table 17. Mean effect of varieties, treatments and their interaction on mean LAD (days)

	Days between			
	60-75	75-90	90-105	105-120
<u>Varieties</u> :				
N 62-8	48.13	37.92	26.90	21.50
Bhima	43.33	34.14	27.03	19.49
JSF-1	41.32	29.07	24.40	17.05
S.E. ±	2.27	1.42	1.38	1.18
C.D. at 5%	NS	4.21	NS	3.51
<u>Treatments</u> :				
S_0	64.01	47.61	36.15	28.83
S_1	41.79	33.07	22.73	15.43
S_2	26.96	20.45	19.45	13.78
S.E. ±	2.27	1.42	1.38	1.18
C.D. at 5%	6.75	4 21	4 09	3.51
Interaction	NS	NS	NS	NS

NS = Non-significant

The leaf area duration ($\overline{LAD}$) was significantly and consistantly higher under control than S_1 and S_2 treatments. Both the salt treatments i.e. S_1 and S_2 reduced the leaf area duration significantly and consistantly. Treatment effects differed as $S_0 > S_1 > S_2$. Thus, control had significantly higher $\overline{LAD}$ than both S_1 and S_2 treatments at all growth phases. Further S_1 treatment was also significantly superior over S_2 treatment at 60-70 and 75-90 days after sowing and thereafter significant differences were not evident but was having higher mean value than S_2 treatment.

The varietal differences were statistically significant at 75-90 and 105-120 days after sowing where variety N 62-8 was significantly superior over JSF-1 and at par with Bhima. In general, the mean leaf area duration was slightly higher under variety N 62-8 at all crop growth stages and varietal effects differed as N 62-8 > Bhima > JSF-1.

4.4. Growth phases

4.4.1 Days required for 50 per cent flowering and for maturity

In order to study the effect of salts on reproductive growth phases the observations on days required for 50 per cent flowering and for maturity were recorded. These data are given in Table 18. The data are not

Table 18. Mean days required for fifty per cent flowering and full maturity

Treatments	Varieties		
	N [illegible]-8	Br[illegible]n[illegible]	[illegible]Sr-1
	Fifty per cent flowering		
S_0	7[illegible].3	7[illegible].[illegible]	70.0
S_1	74.0	77.[illegible]	79.3
S_2	7[illegible].3	7[illegible].0	[illegible]
	Full maturity		
S_0	130.6	13[illegible].[illegible]	13[illegible].[illegible]
S_1	12[illegible].3	1[illegible].[illegible]	1[illegible].[illegible]
S_2	1[illegible].[illegible]	[illegible]27.3	1[illegible]

statistically analysed and inferences are drawn from mean values.

It is evident from the results that salinity tended to increase the time required for 50 per cent flowering. Thus days required for 50 per cent flowering was more under both treatments i.e. S_1 and S_2 than control, and treatment effects were in order as $S_2 > S_1 > S_0$. Flowering was delayed relatively more in JSF-1 and was early in N 62-8.

It will be seen from the data that salinity reduced the time required for maturity. Thus, salt treatment enhances the maturity. Time required for maturity was relatively more under control as compared to S_1 and S_2 treatments and relatively less under S_2 treatment.

4.5 Dry matter production

The data showing the effect of salt treatments on mean dry weight of sampled plants at five different stages and mean dry weight of component plant parts are given in Tables 19, 20, 21, 22 and 23.

During the first sampling (60 days after sowing) the salt treatments reduced the total dry weight as well as dry weight of component plant parts significantly. Salt treatments at both the levels reduced dry matter production.

Table 19. Mean dry weight of shoot and plant parts in gm per pot (oven dry basis)

First sampling (60 days after sowing)

Treatments	N 62-8	Bhima	JSF-1	Mean
		Leaves		
S_0	26.31	27.40	25.99	26.56
S_1	21.48	20.75	18.63	20.29
S_2	18.52	18.21	17.08	17.93
Mean	22.10	22.12	20.56	
		Stem		
S_0	21.80	25.01	22.79	23.20
S_1	19.29	20.09	17.73	19.03
S_2	17.40	18.12	14.74	16.75
Mean	19.50	21.07	18.42	
		Capitulum		
S_1	-	-	-	-
S_2	-	-	-	-
S_3	-	-	-	-
		Total		
S_1	48.10	52.41	48.76	49.75
S_2	40.77	40.84	30.36	39.32
S_3	35.92	36.33	31.82	34.69
Mean	41.60	43.19	38.98	

C.D at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	1.15	-	2.14
Treatments	1.54	1.15	-	2.14
Interaction	NS	NS	-	NS

NS = Not significant.

Table 20. Mean dry weight of shoot and plant parts in gm per pot (oven dry basis)

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	36.59	39.08	34.28	36.85
S_1	30.40	27.05	24.82	27.42
S_2	28.12	25.79	24.29	26.07
Mean	31.71	30.84	27.80	
		Stem		
S_0	33.61	36.96	31.94	34.17
S_1	27.60	25.13	23.39	25.37
S_2	25.66	24.19	21.71	23.85
Mean	28.96	28.76	25.76	
		Caputulum		
S_0	27.30	29.29	26.01	27.54
S_1	24.27	24.21	19.97	22.82
S_2	22.78	21.19	18.42	20.79
Mean	24.78	24.90	21.47	
		Total		
S_0	97.50	105.94	92.24	98.56
S_1	82.27	74.30	68.17	74.93
S_2	76.56	71.15	64.42	70.71
	85.44	83.82	74.94	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	2.17	8.07
Treatments	3.59	3.02	2.17	8.06
Interactions	NS	NS	NS	NS

NS = Not significant.

Table 21. Mean dry weight of shoot and plant parts in gm per pot (oven dry basis)

(Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	29.65	30.76	29.11	29.84
S_1	24.95	22.65	21.3[illegible]	22.97
S_2	22.72	21.28	20.28	21.43
Mean	25.77	24.89	23.57	
		Stem		
S_0	38.12	39.55	37.42	38.36
S_1	31.52	28.84	28.63	29.66
S_2	28.75	27.56	26.94	27.75
Mean	32.80	31.98	30.99	
		Caputulum		
S_0	73.42	76.18	72.10	73.89
S_1	59.04	56.08	55.68	56.93
S_2	55.16	52.91	52.56	53.55
Mean	62.54	61.72	60.11	
		Total		
S_0	141.18	146.48	138.63	142.10
S_1	115.51	107.56	105.63	109.57
S_2	106.63	101.76	99.78	102.72
	121·11	118·60	114·68	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	2.65	3.[illegible]6	5.33	10.86
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 22. Mean dry weight of shoot and plant parts in gm per pot (oven dry basis)

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	28.01	28.73	27.29	28.03
S_1	22.65	21.66	19.80	21.37
S_2	20.40	19.07	18.37	19.28
Mean	23.69	23.18	21.82	
		Stem		
S_0	42.34	43.50	41.28	42.38
S_1	34.79	31.95	29.86	32.20
S_2	31.41	29.45	27.82	29.56
Mean	36.18	34.96	32.99	
		Caputulum		
S_0	88.20	88.83	84.55	87.19
S_1	70.20	65.51	59.80	65.17
S_2	63.31	60.41	57.93	60.55
Mean	73.91	71.58	67.42	
		Total		
S_0	158.56	161.12	153.12	157.60
S_1	127.64	119.12	109.53	118.76
S_2	115.12	109.08	104.12	109.44
Mean	133.77	129.77	122.27	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	2.27	3.86	7.31
Treatments	1.80	2.27	3.86	7.31
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 23. Mean dry weight of shoot and plant parts in gm per pot (oven dry basis)

Fifth sampling (120 days after sowing

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	19.36	16.73	19.01	19.03
S_1	14.72	15.63	11.65	14.00
S_2	12.34	12.83	10.13	11.77
Mean	15.48	15.73	13.60	
		Stem		
S_0	38.39	40.48	37.08	38.65
S_1	31.92	26.70	26.92	28.51
S_2	28.15	25.29	25.[illegible]	26.25
Mean	32.82	30.82	29.77	
		Capitulum		
S_0	112.07	114.92	108.88	111.96
S_1	90.54	81.17	74.80	82.19
S_2	78.59	73.99	71.70	74.76
Mean	93.74	90.03	85.15	
		Total		
S_0	169.84	174.12	164.97	169.64
S_1	137.18	123.50	113.43	124.70
S_2	119.08	112.26	107.13	112.82
Mean	142.03	136.63	128.[illegible]	

C.D. at 5% P for	Leaves	Stem	Capitulum	Total
Varieties	NS	NS	4.[illegible]1	7.07
Treatments	1.87	3.56	4.[illegible]1	7.07
Intèraction	NS	NS	NS	NS

NS = Not significant.

However, mean treatment effects varied as $S_0 > S_1 > S_2$ for mean total dry weight as well as mean stem weight and mean dry weight of leaves.

During the first sampling the mean total dry weight of Bhima was slightly higher than N 62-8 but did not differ significantly whereas both these varieties had significantly higher dry weight than JSF-1. Bhima had higher mean total dry weight, due to its marked and significantly higher dry weight of stem, however, the varieties did not differ as regards their mean dry weight of leaves.

During the second sampling (75 days after sowing) salt treatments, at both the levels, reduced dry matter production. However, mean treatment effects varied as $S_0 > S_1 = S_2$ for mean total dry weight as well as mean dry weights of stem, leaves and caputulum. Thus, dry weight under control was significantly superior over both S_1 and S_2 treatments.

During this second sampling the mean total dry weight of N 62-8 was slightly higher than Bhima but there were no significant differences, whereas both these varieties were significantly higher than JSF-1 and this was due to their marked and significantly higher dry weight of caputulum. Though the varieties did not differ as regards their mean dry weights of leaves and stem but having higher mean values and varied in order as N 62-8 > Bhima > JSF-1.

Similarly, during third sampling (90 days after sowing) the salt treatments reduced the total dry weight as well as dry weights of component plant parts significantly. Thus, salt treatments reduced the dry matter production at both the levels, however, mean treatment effects varied as $S_0 > S_1 = S_2$, for mean total dry weight as well as mean dry weights of leaves, stem and caputulum.

During the same sampling period variety N 62-8 had slightly higher values of mean total dry weight, mean dry weight of leaves, stem and caputulum than Bhima and JSF-1 which varied in order as N 62-8 > Bhima > JSF-1. However, the effects did not reach the level of significance.

At fourth sampling (105 days after sowing) salt treatments at both the levels reduced dry matter production and mean treatment effects varied as $S_0 > S_1 > S_2$ for mean total dry weight as well as mean dry weight of stem, leaves and caputulum.

During the same sampling (105 days after sowing) the mean total dry weight as well as component plant parts i.e. leaves, stem and caputulum in N 62-8 was slightly higher than Bhima but the effects did not reach the level of significance, whereas both these N 62-8 and Bhima were significantly higher than JSF-1 as regards mean total dry weight as well as mean dry weights of stem and caputulum. The varieties did not differ as regards their mean dry weight of leaves.

At fifth sampling (120 days after sowing) salt treatments reduced dry matter production significantly, and mean treatment effects varied as $S_0 > S_1 > S_2$ for mean total dry weight as well as dry weights of leaves and caputulum but in the case of stem dry weight treatment effects varied as $S_0 > S_1 = S_2$.

During the fifth sampling variety N 62-8 had slightly higher value as regards mean total dry weight, mean dry weights of leaves, stem and caputulum but the effects did not reach the level of significance, whereas variety N 62-8 and Bhima have significantly higher values than JSF-1 for mean total dry weight and mean dry weight of caputulum. The varieties did not differ as regards their mean dry weight of leaves and stem.

4.6 Growth functions

4.6.1 Absolute growth rate ($\overline{AGR}$) or crop growth rate ($\overline{CGR}$)

Absolute growth rate was worked out as detailed in chapter 3 and the data showing the effect of salt treatments on mean $\overline{AGR}$ are given in Table 24.

Table 24. Mean effect of varieties treatments and their interaction on mean AGR (g/day)

	Days after sowing			
	60-75	75-90	90-105	105-120
Varieties				
N 62-8	0.76	0.63	0.25	0.16
Bhima	0.75	0.61	0.24	0.14
JSF-1	0.70	0.63	0.18	0.13
C.D. at 5%	NS	NS	0.047	0.035
Treatments				
S_0	0.91	0.76	0.34	0.23
S_1	0.68	0.58	0.18	0.12
S_2	0.63	0.52	0.14	0.06
C.D. at 5% P	0.063	0.066	0.047	0.035
Interaction	NS	NS	NS	NS

NS = Not significant.

It will be seen from the table that salt treatments reduced mean $\overline{AGR}$ significantly and consistantly with significant differences between control, S_1, S_2 treatments and treatment effects differed as $S_0 > S_1 = S_2$ except at 105-120 days after sowing, where treatment effects differed as $S_0 > S_1 > S_2$. Initially, at 60-75 days after sowing $\overline{AGR}$ values were higher under and subsequently declined till harvest. At all stages of crop growth, though there were not significant differences between S_1 and S_2 treatments, under S_1 treatments $\overline{AGR}$ values were slightly higher than S_2 treatments.

The main effects of varieties were not statistically different at 60-75 and 75-90 days after sowing but having higher values of AGR in variety N 62-8 as compared to Bhima and JSF-1. At 90-105 and 105-120 days after sowing mean effects of varieties were significantly different. At 90-105 days after sowing $\overline{AGR}$ value in N 62-8 and Bhima were more or less the same and significantly higher than JSF-1, whereas at 105-120 days after sowing N 62-8 was significantly higher than JSF-1 but at par with Bhima and JSF-1 was significantly inferior to N 62-8 but at par with Bhima.

4.6.2 Mean relative growth rate ($\overline{RGR}$)

The data showing the effect of salt treatments on mean $\overline{RGR}$ are given in Table 25.

Salt treatments reduced mean $\overline{RGR}$ significantly and consistantly at all growth phases, except at 75-90 days

Table 25. Mean effect of varieties, treatments and their interaction on mean $\overline{RGR}$ (g/g/day)

	Days after sowing			
	60-75	75-90	90-105	105-120
Varieties				
N 62-8	0.021	0.011	0.003	0.002
Bhima	0.020	0.011	0.002	0.002
JSF 1	0.020	0.011	0.002	0.001
C.D. at 5% P	NS	NS	NS	NS
Treatments				
S_0	0.023	0.012	0.0033	0.003
S_1	0.019	0.011	0.0020	0.001
S_2	0.019	0.010	0.0017	0.001
C.D. at 5% P	0.003	NS	0.0012	0.0008
Interaction	NS	NS	NS	NS

NS = Not significant.

after sowing. At initial states i.e 60-75 days after sowing, $\overline{RGR}$ values were higher and thereafter $\overline{RGR}$ declined continuously upto the harvest. Salt treatments reduced mean $\overline{RGR}$ and treatment effects differed as $S_0 > S_1 = S_2$ at all growth phases, except 75-90 days after sowing.

The main effects of varieties were not conspicuous to warrant any conclusions.

4.6.3 Mean net assimilation rate ($\overline{NAR}$)

The data showing the effect of salt treatment on mean $\overline{NAR}$ are given in Table 26.

From the table it will be seen that at 60-75 and 75-90 days after sowing $\overline{NAR}$ significantly increased with salt treatments and treatment effects differed as $S_2 > S_1 > S_0$. Whereas at 90-105 days after sowing difference were not significant, but at 105-120 days after sowing treatment effects differed as $S_0 > S_1 > S_2$. From this it will be seen that decline in $\overline{NAR}$ was very fast under salt treatments than the control.

The main effects of varieties were not significantly different except at 90-105 days after sowing where N 62-8 and Bhima was significantly higher in $\overline{NAR}$ than JSF-1.

Table 26. Mean effect of varieties, treatments and their interaction on mean $\overline{NAR}$ (g/cm²/day)

	Days after sowing			
	60-75	75-90	90-105	105-120
Varieties				
N 62-8	0.069	0.054	0.027	0.021
Bhima	0.068	0.058	0.026	0.020
JSF-1	0.065	0.059	0.020	0.015
C.D. at 5% P	NS	NS	0.0055	NS
Treatments				
S_0	0.052	0.046	0.024	0.025
S_1	0.067	0.059	0.025	0.019
S_2	0.083	0.066	0.023	0.013
C.D. at 5% P	0.009	0.0069	NS	0.0059

NS = Not significant.

4.7 Yield studies

4.7.1 Grain yield

Data showing the effect of salt treatments on the final grain yield are given in Table 27 and graphically shown in Fig. 8.

The mean effect of salt treatments was highly significant. Both the levels of salt treatments reduced the mean grain yield. Statistically the effects of treatments was significant at both S_1 and S_2 level and the treatments varied in the order of $S > S_1 > S_2$.

Variety N 62-8 was with slightly higher grain yield than Bhima but the difference did not reach the level of significance, whereas both these varieties, N 62-8 and Bhima, out yielded JSF-1.

The effect of interaction between varieties and treatments was not significant indicating more or less similar response of varieties to the salt treatments.

4.8 Yield components

Data on total grain yield were further analysed for yield characters such as grain number per caputulum and 1000-grain weight. These data are presented in Tables 28 and 29 and also graphically shown in Fig. 9 and 10.

Table 27. Mean grain yield in gm per pot at harvest

Treatments	Varieties			
	N 62-8	Bhima	JSF-1	Mean
S_0	65.58	66.96	63.21	66.25
S_1	57.35	56.39	51.27	55.00
S_2	49.55	46.94	41.37	45.95
Mean	57.49	56.76	51.95	

C.D. at 5% for Varieties - 3.55

Treatments - 3.55

Interaction - NS

NS = Not significant.

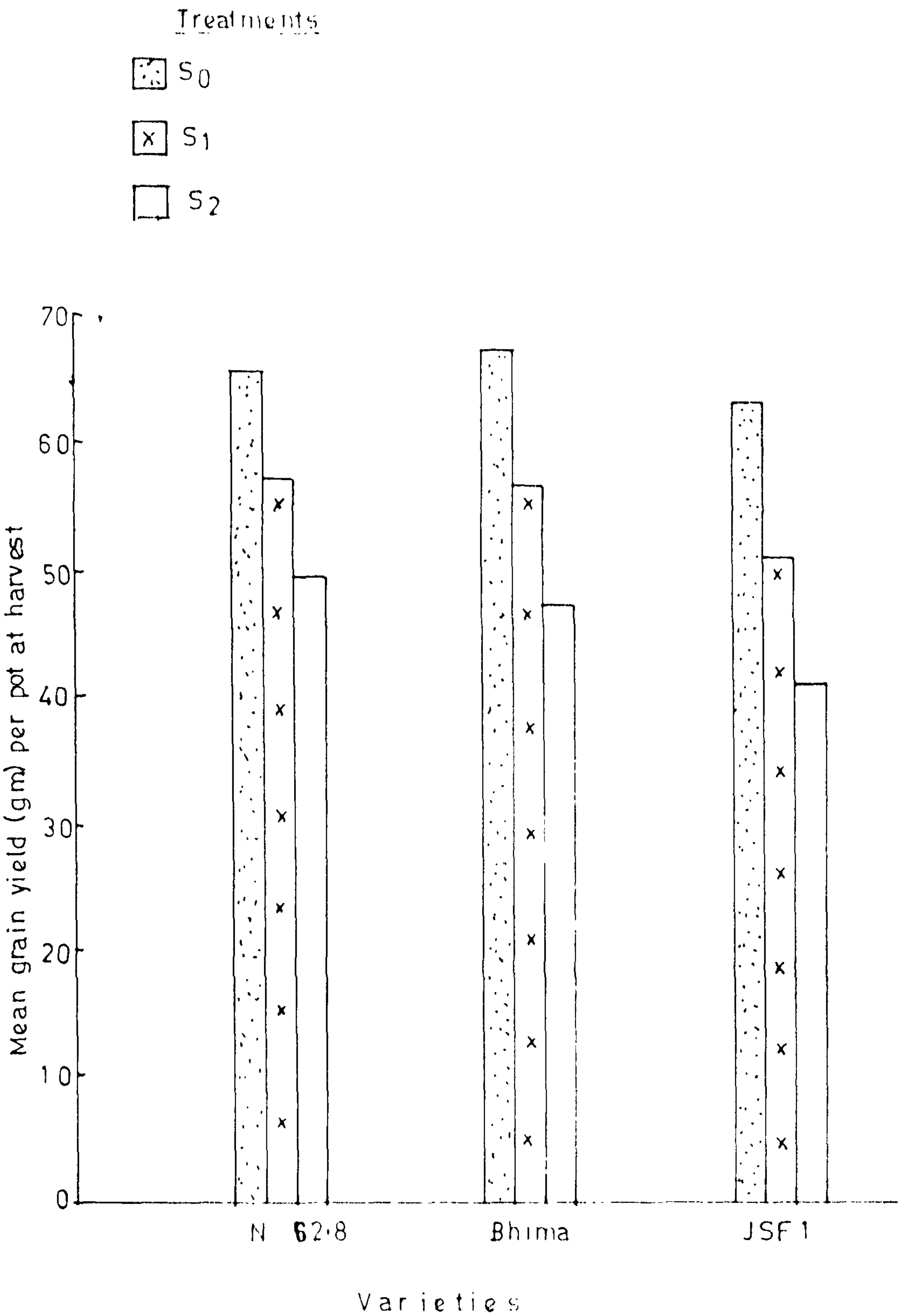

Fig. 8: Mean grain yield (gm) per pot at harvest.

Table 28. Mean number of grains per capitulum at harvest

Treatments	Varieties			Mean
	N 62-8	Bhama	JSF-1	
S_0	22.33	23.67	22.00	22.67
S_1	20.67	21.33	18.66	20.22
S_2	20.33	20.00	18.00	19.44
Mean	21.11	21.67	19.55	

C.D. at 5% P for Varieties - 0.99

Treatments - 0.99

Interaction - NS

NS = Not significant.

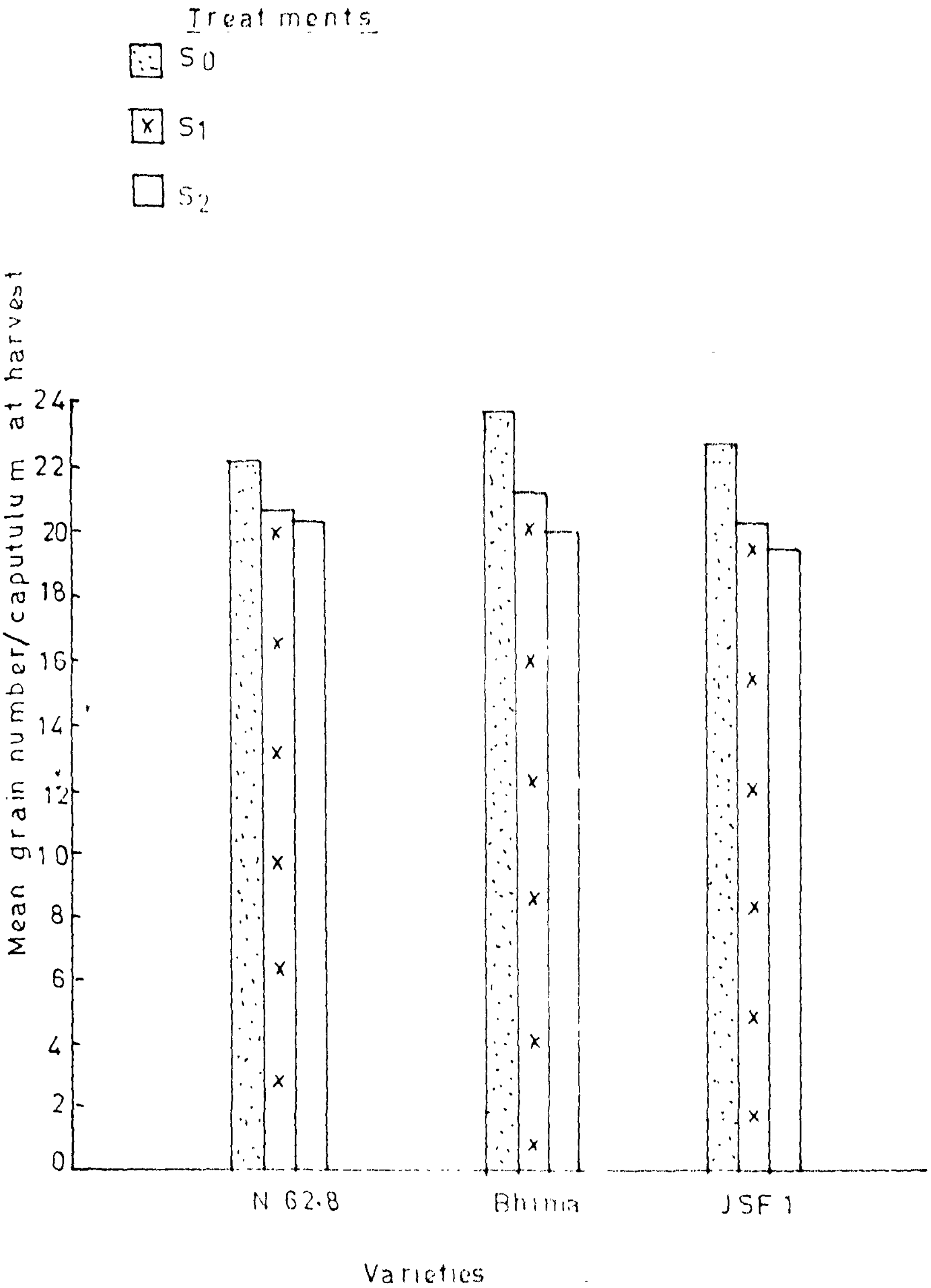

Fig. 9: Mean grain number per caputulum at harvest.

Table 29. Mean 1000-grain weight in gm at harvest

Treatments	Varieties			Mean
	N 62-8	Bhima	JSR-1	
S_0	60.27	61.66	60.15	60.69
S_1	58.73	58.47	56.49	57.90
S_2	57.29	57.28	55.17	56.58
Mean	58.76	59.14	57.27	

C.D. at 5% P for Varieties - 1.12

Treatments - 1.12

Interaction - NS

NS = Not significant.

4.8.1 Grain number per capitulum.

The mean effect of salt treatments was significant on mean grain number. Thus both S_1 and S_2 treatments reduced the mean grain number per capitulum. However, the effect differed as $S_0 > S_1 = S_2$.

Mean grain number per capitulum of the varieties differed significantly as Bhima = N 62-8 > JSF-1.

4.8.2 Thousand grain weight

The salt treatments reduced 1000-grain weight significantly. Thus both S_1 and S_2 treatments had significantly less 1000-grain weight than control. The treatment effects differed as $S_0 > S_1 > S_2$.

Mean 1000-grain weight of varieties differed significantly as Bhima = N 62-8 > JSF-1. In general, these observations reveal that salinity influenced both the yield components and thus, final grain yield and these effects were consistently evident at high salt level.

4.9 Chemical composition

The plant samples collected on five occasions for dry matter production studies were further analysed for N, P, K, Na and Ca contents.

4.9.1 Nitrogen content

The relevant data are summarised in Table 30, 31, 32, 33 and 34.

It would be seen from these results that the main effects of treatments were significant at both S_1 and S_2 level at all occasions and with all plant parts. Salt treatments increased 'N' content significantly at both S_1 and S_2 levels.

At first sampling treatment effect differed as $S_2 = S_1 > S_0$ and $S_2 > S_1 = S_0$ in the case of 'N' content of leaves and stem, respectively.

At second sampling treatment effects differed for 'N' content of leaves, stem and caputulum as $S_2 = S_1 > S_0$, $S_2 = S_1 > S_0$ and $S_2 > S_1 > S_0$ respectively. At third sampling treatment effects differed for 'N' content of leaves, stem and caputulum as $S_2 > S_1 > S_0$, $S_2 = S_1 > S_0$ and $S_2 > S_1 > S_0$, respectively.

At the fourth sampling treatment effects differed as $S_2 = S_1 > S_0$, $S_2 = S_1 > S_0$ and $S_2 = S_1 > S_0$ for mean 'N' content of leaves, stem and caputulum, respectively.

At fifth sampling treatment effects differed as $S_2 > S_1 > S_0$, $S_2 = S_1 > S_0$ and $S_2 > S_1 > S_0$ for mean 'N' content of leaves, stem and caputulum, respectively.

It may be noted that during the vegetative and pre-flowering stage, i.e. the first and second samplings salt treatments induced significantly more accumulation of

Table 30. Mean nitrogen content of plant parts as influenced by treatments (per cent oven dry basis)

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	2.11	2.38	2.14	2.21
S_1	2.71	3.03	3.33	3.02
S_2	3.41	3.59	3.64	3.55
Mean	2.74	3.00	3.04	
		Stem		
S_0	0.75	0.79	0.79	0.78
S_1	0.79	0.98	1.12	0.96
S_2	1.07	1.26	1.35	1.23
	0.87	1.01	1.09	
		Capulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	
Treatments	0.59	0.19	
Interaction	NS	NS	

NS = Not significant.

Table 31. Mean nitrogen content of plant parts as influenced by treatments (per cent oven dry basis)

Second sampling (75 days after sowing)

Treatments	Varieties: N 62-8	Bhima	JSF-1	Mean
		Leaves		
S_0	3.03	2.98	3.13	3.04
S_1	3.31	3.45	3.73	3.50
S_2	3.59	3.93	4.02	3.85
Mean	3.31	3.45	3.63	
		Stem		
S_0	0.93	0.98	0.98	0.96
S_1	1.12	1.31	1.31	1.25
S_2	1.21	1.35	1.45	1.34
Mean	1.09	1.21	1.25	
		Caputulum		
S_0	2.43	2.52	2.47	2.47
S_1	2.57	3.08	3.17	2.94
S_2	3.41	3.50	3.64	3.52
Mean	2.80	3.03	3.09	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.45	0.17	0.27
Interaction	NS	NS	NS

NS = Not significant.

Table 32. Mean nitrogen content of plant parts as influenced by treatments (per cent oven dry basis)

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JJF-1	
		Leaves		
S_0	2.29	2.29	2.26	2.28
S_1	2.47	2.75	3.27	2.83
S_2	3.03	3.36	3.50	3.30
Mean	2.30	2.80	3.02	
		Stem		
S_0	0.84	0.87	0.84	0.86
S_1	1.21	1.21	1.[illegible]	1.17
S_2	1.26	1.26	1.31	1.24
Mean	1.01	1.12	1.14	
		Capitulum		
S_0	3.27	3.19	3.19	3.22
S_1	3.51	3.51	3.60	3.54
S_2	3.69	3.79	3.84	3.78
Mean	3.49	3.50	3.54	

C.D. at 5% P for	Leaves	Stem	Capitulum
Varieties	NS	NS	NS
Treatments	0.43	0.17	0.[illegible]
Interaction	NS	NS	NS

NS = Not significant.

Table 33. Mean nitrogen content of plant parts as influenced by treatments (per cent oven dry basis)

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	2.15	2.01	2.20	2.12
S_1	2.52	2.36	2.43	2.44
S_2	2.86	2.57	2.43	2.61
Mean	2.51	2.32	2.35	
		Stem		
S_0	0.55	0.60	0.56	0.57
S_1	0.70	0.87	0.93	0.84
S_2	0.87	0.98	1.03	0.96
Mean	0.71	0.82	0.84	
		Caputulum		
S_0	2.15	1.99	2.28	2.14
S_1	2.57	2.38	2.57	2.50
S_2	2.80	2.47	2.52	2.60
Mean	2.50	2.28	2.46	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.21	0.16	0.24
Interaction	NS	NS	NS

NS = Not significant.

Table 34. Mean nitrogen content of plant parts as influenced by treatments (per cent oven dry basis)

Fifty sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.73	1.68	1.82	1.74
S_1	2.11	2.35	2.38	2.28
S_2	2.57	2.61	2.66	2.62
Mean	2.14	2.21	2.29	
		Stem		
S_0	0.45	0.51	0.45	0.47
S_1	0.61	0.70	0.70	0.67
S_2	0.70	0.75	0.84	0.76
Mean	0.59	0.65	0.66	
		Caputulum		
S_0	1.91	1.96	1.91	1.93
S_1	2.10	2.27	2.38	2.26
S_2	3.38	2.47	2.52	2.46
Mean	2.13	2.24	2.27	

C.D. at 5% P for	Leaves	Stem	Capitulum
Varieties	NS	NS	NS
Treatments	0.32	0.12	0.18
Interaction	NS	NS	NS

NS = Not significant.

'N' in plant parts and the highest at second sampling. However, during the flowering, post flowering and grain development stage i.e. the third, forth and fifth sampling salt treatments brought about distinct reduction in the percent 'N' content in plant parts.

It would be seen from the results that statistically the main effects of varieties were not consistently significant with any growth stage as well as with different plant parts. Although these effects did not reach the level of significance, it may be noted that variety JSF-1 had slightly more per cent N in plant parts than Bhima and least in N 62-8.

In order to study the effect of salt treatments, on uptake of nutrients, the absolute quantities of nitrogen per pot were worked out and are presented in Table 35, 36, 37, 38 and 39 for the five samplings.

Salt treatments reduced total uptake of 'N' consistently and significantly, except at first sampling. During first sampling this effect was not significant with the plant parts viz., leaves, stem and capatulum whereas, at the subsequent four stages significant reduction in total quantity of 'N' uptake was due to a combined effect of significant reduction in absolute quantity of 'N' in caputulum and leaves and non-significant slight reduction in stem.

Table 35. Mean absolute quantity of nitrogen in gm per pot

First sampling ([illegible] days after sowing)

Treatments	Varieties			Mean
	H 62-8	Bhima	JSF-1	
		Leaves		
S_0	[illegible]	[illegible]	0.56	0.59
S_1	0.57	[illegible]	[illegible]	0.60
S_2	0.62	0.62	[illegible]	0.62
Mean	0.58	0.63	0.60	
		Stem		
S_0	0.18	[illegible]	0.19	0.19
S_1	0.14	0.18	[illegible]	0.17
S_2	0.17	[illegible]	0.17	0.17
Mean	0.16	[illegible]	0.18	
		Capitulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				
		Total		
S_0	0.75	0.85	[illegible]	0.78
S_1	0.72	0.81	0.79	0.77
S_2	0.76	0.78	0.78	0.77
Mean	0.74	0.81	[illegible]	

C.D. at 5% P for	Leaves	Stem	Capitulum	Total
Varieties	NS	NS	-	NS
Treatments	NS	NS	-	NS
Interaction	NS	NS	-	NS

NS = Not significant.

Table 36. Mean absolute quantity of nitrogen in gm per pot

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.12	1.18	1.10	1.13
S_1	1.02	0.98	0.96	0.99
S_2	0.96	0.97	0.94	0.97
Mean	1.04	1.04	1.00	
		Stem		
S_0	0.32	0.30	[illegible]	0.34
S_1	0.31	0.33	0.31	0.32
S_2	0.30	0.32	0.26	0.31
Mean	0.31	0.34	0.31	
		Capitulum		
S_0	0.69	0.74	0.73	0.70
S_1	0.62	0.72	0.64	0.66
S_2	0.64	0.66	0.63	0.65
Mean	0.65	0.71	0.65	
		Total		
S_0	2.13	2.28	2.10	2.17
S_1	1.96	2.01	1.91	1.96
S_2	1.93	1.95	1.88	1.92
Mean	2.01	2.08	1.96	

C.D. at 5% P for	Leaves	Stem	Capitulum	Total
Varieties	NS	NS	NS	0.078
Treatments	0.119	NS	NS	0.078
Interactions	NS	NS	NS	NS

NS = Not significant.

Table 37. Mean absolute quantity of nitrogen in gm per pot

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.69	0.71	0.67	0.69
S_1	0.64	0.65	0.67	0.65
S_2	0.62	0.63	0.67	0.64
Mean	0.65	0.66	0.67	
		Stem		
S_0	0.35	0.34	0.33	0.34
S_1	0.35	0.32	[illegible]	0.33
S_2	0.33	0.31	0.31	0.32
Mean	0.34	0.32	0.33	
		Caputulum		
S_0	2.40	2.43	2.31	2.38
S_1	2.09	1.97	2.01	2.02
S_2	1.96	1.92	1.93	1.94
Mean	2.15	2.10	2.08	
		Total		
S_0	3.45	3.48	3.34	3.42
S_1	3.08	2.94	3.01	3.01
S_2	2.90	2.87	2.91	2.89
Mean	3.14	3.10	3.09	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	NS	NS	0.211	0.093
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 38. Mean absolute quantity of nitrogen in gm per pot

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSr-1	
		Leaves		
S_0	0.91	0.88	0.91	0.90
S_1	0.88	0.79	0.73	0.80
S_2	0.84	0.73	0.66	0.75
Mean	0.88	0.80	0.77	
		Stem		
S_0	0.16	0.17	0.16	0.16
S_1	0.16	0.18	0.18	0.17
S_2	0.17	[illegible]	0.18	0.17
Mean	0.16	0.17	0.17	
		Capitulum		
S_0	1.92	1.81	1.94	1.89
S_1	1.80	1.62	1.56	1.66
S_2	1.74	1.49	1.47	1.57
Mean	1.82	1.64	[illegible]	
		Total		
S_0	2.98	[illegible]	3.01	2.95
S_1	2.84	2.[illegible]	2.48	2.64
S_2	2.74	2.38	2.32	2.48
Mean	2.85	2.63	2.66	

C.D. at 5% P for	Leaves	Ster	Capitulum	Total
Varieties	0.078	NS	0.083	0.13
Treatments	0.078	NS	0.083	0.13
Interactions	N.J	NS	N.S	N.S

NS = Not significant.

Table 39. Mean absolute quantity of nitrogen in gm per pot

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.34	0.33	0.35	0.34
S_1	0.31	0.32	0.28	0.30
S_2	0.30	0.32	0.26	0.29
Mean	0.32	0.32	0.30	
		Stem		
S_0	0.18	0.21	0.17	0.19
S_1	0.18	0.18	0.18	0.18
S_2	0.17	0.18	0.19	0.18
Mean	0.18	0.19	0.18	
		Caputulum		
S_0	2.24	2.26	2.17	2.22
S_1	1.95	1.85	1.82	1.87
S_2	1.83	1.82	1.78	1.81
Mean	2.01	1.98	1.92	
		Total		
S_0	2.76	2.80	2.70	2.75
S_1	2.45	2.35	2.29	2.36
S_2	2.30	2.31	2.24	2.28
Mean	2.50	2.49	2.41	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	NS	NS	0.134	0.133
Interaction	NS	NS	NS	NS

NS = Not significant.

The differences due to the varieties were non-significant during first, third and fifth samplings on total uptake of 'N' and with plant parts viz., stem, leaves and caputulum. The differences due to verieties were significant at second and fifth sampling. At second sampling, N 62-8 and Bhima were significantly superior to JSF-1. At fifth sampling N 62-8 was significantly superior to Bhima and JSF-1, due to its significant higher uptake of 'N' in caputulum.

4.9.2 Phosphorous content

The data showing the phosphorous content in component plant parts are given in Tables 40,41,42,43 and 44.

From the data, it would be seen that mean effects due to varieties, treatments and interaction were non-significant at all five occasions and with all three plant components viz., leaves, stem and caputulum. Thus salt treatments did not affect P content significantly.

In order to study the effect of salt treatments on uptake of 'P' the absolute quantities of phosphorous per pot were worked out and presented in Tables 45, 46, 47, 48 and 49.

Table 40. Mean phosphorus content o plant parts as influenced by treatments per cent oven dry basis)

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JLT-1	
		Leaves		
S_0	0.64	0.58	0.64	0.65
S_1	0.56	0.56	0.56	0.57
S_2	0.52	0.60	0.56	0.65
Mean	0.64	0.56	0.65	
		Stem		
S_0	0.46	0.44	0.45	0.46
S_1	0.45	0.53	0.46	0.47
S_2'	0.46	0.46	0.47	0.46
Mean	0.45	0.46	0.46	
		Capitulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				

C.D. at 5% P for	Leaves	Stem	Capitulum
Varieties	NS	NS	-
Treatments	NS	NS	-
Interaction	NS	NS	-

NS = Not significant.

Table 41. Mean phosphorus content of plant parts as influenced by treatments (per cent oven dry basis)

Second sampling ([illegible] days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.68	0.74	0.72	0.71
S_1	0.67	0.70	0.70	0.69
S_2	0.70	0.70	0.72	0.70
Mean	0.68	0.71	0.71	
		Stem		
S_0	0.51	0.51	0.55	0.52
S_1	0.51	0.53	[illegible]	0.52
S_2	0.48	0.48	0.51	0.49
Mean	0.50	0.51	0.53	
		Capitulum		
S_0	0.72	0.68	0.73	0.71
S_1	0.69	0.72	0.68	0.70
S_2	0.73	0.71	0.72	0.72
Mean	0.71	0.70	0.71	

C.D. at 5% P for	Leaves	Stem	Capitulum
Varieties	NS	NS	NS
Treatments	NS	NS	NS
Interactions	NS	NS	NS

NS = Not significant.

Table 42. Mean phosphorous content of plant parts as influenced by treatments (per cent oven dry basis)

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.56	0.58	0.60	0.58
S_1	0.58	0.60	0.57	0.58
S_2	0.55	0.57	0.58	0.58
Mean	0.56	0.58	0.58	
		Stem		
S_0	0.39	0.39	0.42	0.40
S_1	0.37	0.40	0.40	0.39
S_2	0.38	0.41	0.40	0.40
Mean	0.38	0.39	0.41	
		Caputulum		
S_0	0.57	0.58	0.60	0.58
S_1	0.55	0.60	0.57	0.57
S_2	0.57	0.57	0.58	0.57
Mean	0.56	0.58	0.58	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	NS	NS	NS
Interaction	NS	NS	NS

NS = Not significant.

Table 43. Mean phosphorus content of plant parts as influenced by treatments (per cent oven dry basis)

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.51	0.57	0.57	0.55
S_1	0.57	0.55	0.58	0.57
S_2	0.51	0.52	0.57	0.53
Mean	0.53	0.54	0.57	
		Stem		
S_0	0.28	0.26	[illegible]	0.29
S_1	0.32	[illegible]	[illegible]	0.29
S_2	0.28	0.28	[illegible]	0.28
Mean	0.29	0.27	[illegible]	
		Caputulum		
S_0	0.51	0.53	0.50	0.51
S_1	0.53	0.51	[illegible]	0.52
S_2	0.46	0.48	0.48	0.48
Mean	0.50	0.51	0.50	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	NS	NS	NS
Interaction	NS	NS	NS

NS = Not significant.

Table 44. Mean phosphorus content of plant parts as influenced by treatments (per cent oven dry basis)

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSr -1	
		Leaves		
S_0	0.38	0.40	[illegible]	0.40
S_1	0.40	0.41	0.39	0.40
S_2	0.38	0.38	0.39	0.38
Mean	0.39	0.40	[illegible]	
		Stem		
S_0	0.26	0.24	[illegible]	0.27
S_1	0.28	0.24	[illegible]	0.26
S_2	0.23	0.30	0.28	0.27
Mean	0.25	0.26	0.29	
		Caputulum		
S_0	0.51	0.48	0.52	0.50
S_1	0.46	0.46	[illegible]	0.47
S_2	0.46	0.46	0.49	0.48
Mean	0.49	0.47	[illegible]	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	NS	NS	NS
Interaction	NS	NS	NS

NS = Not significant.

Table 45. Mean absolute quantity of phosphorus gm per pot

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.17	0.19	0.17	0.18
S_1	0.14	0.13	0.12	0.13
S_2	0.12	0.12	0.11	0.12
Mean	0.14	0.15	0.13	
		Stem		
S_0	0.11	0.12	0.11	0.11
S_1	0.09	0.10	0.09	0.10
S_2	0.08	0.08	0.07	0.08
Mean	0.09	0.10	0.09	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				
		Total		
S_0	0.28	0.31	0.28	0.29
S_1	0.23	0.23	0.21	0.22
S_2	0.20	0.19	0.18	0.19
Mean	0.24	0.24	0.23	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	-	NS
Treatments	0.029	0.0125	-	0.036
Interaction	NS	NS	-	NS

NS = Not significant.

Table 46. Mean absolute quantity of phosphorus in gm per pot

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.25	0.29	0.25	0.26
S_1	0.21	0.19	0.18	0.19
S_2	0.20	0.18	0.17	0.18
Mean	0.22	0.22	0.20	
		Stem		
S_0	0.17	0.19	0.18	0.18
S_1	0.14	0.13	0.12	0.13
S_2	0.12	0.12	0.11	0.12
Mean	0.14	0.15	0.14	
		Caputulum		
S_0	0.20	0.20	0.19	0.20
S_1	0.17	0.17	0.14	0.16
S_2	0.16	0.15	0.13	0.15
Mean	0.18	0.17	0.15	
		Total		
S_0	0.62	0.68	0.62	0.64
S_1	0.52	0.49	0.46	0.49
S_2	0.48	0.44	0.43	0.45
Mean	0.54	0.54	0.50	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.036	0.033	0.028	0.073
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 47. Mean absolute quantity of phosphorus in gm per pot

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.17	0.18	0.19	0.18
S_1	0.15	0.14	0.13	0.14
S_2	0.13	0.12	0.12	0.12
Mean	0.15	0.15	0.14	
		Stem		
S_0	0.15	0.16	0.16	0.16
S_1	0.12	0.12	0.11	0.12
S_2	0.11	0.11	0.11	0.11
Mean	0.13	0.13	0.13	
		Capitulum		
S_0	0.42	0.44	0.42	0.43
S_1	0.33	0.34	0.32	0.33
S_2	0.31	0.30	0.31	0.31
Mean	0.35	0.36	0.35	
		Total		
S_0	0.76	0.79	0.78	0.78
S_1	0.62	0.60	0.56	0.59
S_2	0.55	0.53	0.54	0.54
Mean	0.64	0.64	0.63	

C.D. at 5% P for	Leaves	Stem	Capitulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.028	0.025	0.049	0.074
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 48. Mean absolute quantity of phosphorus in gm per pot

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.22	0.25	0.24	0.24
S_1	0.20	0.18	0.17	0.18
S_2	0.16	0.15	0.16	0.16
Mean	0.19	0.19	0.19	
		Stem		
S_0	0.08	0.08	0.09	0.08
S_1	0.07	0.06	0.06	0.06
S_2	0.06	0.05	0.05	0.05
Mean	0.07	0.06	0.07	
		Caputulum		
S_0	0.45	0.47	0.42	0.45
S_1	0.37	0.33	0.31	0.34
S_2	0.29	0.29	0.27	0.29
Mean	0.37	0.36	0.34	
		Total		
S_0	0.74	0.78	0.74	0.75
S_1	0.62	0.56	0.54	0.57
S_2	0.50	0.49	0.49	0.49
Mean	0.62	0.61	0.59	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.036	0.0165	0.06	0.07
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 49. Mean absolute quantity of phosphorus in gm per pot

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	J F-1	
		Leaves		
S_0	0.08	0.08	0.08	0.08
S_1	0.06	0.06	0.05	0.06
S_2	0.05	0.05	0.04	0.05
Mean	0.06	0.06	0.06	
		Stem		
S_0	0.10	0.10	0.11	0.10
S_1	0.09	0.07	0.08	0.08
S_2	0.07	0.07	0.07	0.07
Mean	0.09	0.08	0.09	
		Capitulum		
S_0	0.57	0.55	0.57	0.56
S_1	0.4[illegible]	0.38	0.35	0.3[illegible]
S_2	0.36	0.3[illegible]	0.34	0.35
Mean	0.45	0.43	0.42	
		Total		
S_0	0.72	0.72	0.71	0.72
S_1	0.58	0.50	0.48	0.52
S_2	0.48	0.47	0.4[illegible]	0.46
Mean	0.59	0.56	0.54	

C.D. at 5% P for	Leave	Stem	Capitulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.0148	0.0[illegible]48	0.051	0.067
Interaction	NS	NS	NS	NS

NS = Not significant.

Salt treatments consistently and significantly reduced total uptake of 'P'. At all five stages reduction in total uptake of 'P' was due to a combined effect of significant reduction in absolute quantity of 'P' in all the three components plant parts viz., leaves, stem and caputulum. The treatment effects differed significantly as $S_0 > S_1 = S_2$ for all three component plant parts and total uptake of 'P' at all five occasions.

The differences due to the varieties were not significant with component plant parts viz., leaves, stem and caputulum as well as total uptake of 'P' at all five stages.

4.9.3 Potassium content

The data showing the potassium content in component plant parts are given in Tables 50, 51, 52, 53 and 54.

On percent basis, salt treatments reduced 'K' content significantly in all the plant parts except at fifth sample where differences in case of leaves were not significant. Salt treatments reduced 'K' content significantly and consistently at both S_1 and S_2 levels. High level of salinity, in general, reduced 'K' content. The order varied as $S_0 > S_1 > S_2$ and effect being marked in caputulum, stem and leaves, respectively.

Table 50. Mean potassium content of plant parts as influenced by treatments (per cent over dry basis)

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	6.33	5.85	5.56	5.92
S_1	5.58	5.25	5.13	5.32
S_2	5.25	5.07	4.53	4.95
Mean	5.72	5.39	5.08	
		Stem		
S_0	3.99	3.06	[illegible]	3.78
S_1	3.12	3.45	3.45	3.34
S_2	3.00	3.21	3.21	3.14
Mean	3.37	3.44	3.45	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	0.46	NS	-
Treatments	0.46	0.23	-
Interaction	NS	NS	-

NS = Not significant.

Table 51. Mean potassium content of plant parts as influenced by treatments (per cent oven dry basis)

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	5.94	5.58	5.34	5.62
S_1	5.25	4.98	4.89	5.04
S_2	4.89	4.46	4.20	4.52
Mean	5.36	5.01	4.81	
		Stem		
S_0	3.99	3.66	3.54	3.73
S_1	3.21	3.21	3.2[illegible]	3.22
S_2	2.88	2.82	2.76	2.82
Mean	3.36	3.23	3.18	
		Caputulum		
S_0	5.28	4.71	4.53	4.84
S_1	4.26	3.75	4.17	4.06
S_2	3.51	3.72	3.54	3.59
Mean	4.35	4.06	[illegible]	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.55	0.32	0.55
Interaction	NS	NS	NS

NS = Not significant.

Table 52. Mean potassium content of plant parts as influenced by treatments (per cent oven dry basis)

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	5.52	5.58	5.19	5.43
S_1	5.22	4.98	4.44	4.88
S_2	4.53	4.44	3.99	4.32
Mean	5.09	5.00	4.54	
		Stem		
S_0	3.60	3.33	3.48	3.47
S_1	3.12	3.15	2.79	3.02
S_2	2.97	2.73	2.94	2.88
Mean	3.23	3.07	3.07	
		Caputulum		
S_0	4.53	4.33	4.47	4.44
S_1	3.93	3.99	3.72	3.88
S_2	3.15	3.57	3.30	3.34
Mean	3.87	3.96	3.83	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.48	0.38	0.48
Interaction	NS	NS	NS

NS = Not significant.

Table 53. Mean potassium content of plant parts as influenced by treatments (per cent oven dry basis)

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	5.16	5.28	4.74	5.06
S_1	4.77	4.74	4.17	4.56
S_2	4.32	4.26	3.93	4.07
Mean	4.75	4.76	[illegible]	
		Stem		
S_0	3.12	3.15	3.30	3.19
S_1	3.24	2.88	[illegible]	[illegible]
S_2	2.73	2.52	2.58	2.61
Mean	3.03	2.85	2.92	
		Caputulum		
S_0	4.23	4.17	4.08	4.16
S_1	3.93	3.75	3.54	3.74
S_2	3.51	3.48	3.15	3.38
Mean	3.89	3.80	3.59	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.50	0.39	0.48
Interaction	NS	NS	NS

NS = Not significant.

Table 54. Mean potassium content of plant parts as influenced by treatments (per cent oven dry basis)

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	4.59	4.26	4.05	4.30
S_1	4.02	3.84	3.51	3.79
S_2	3.69	3.57	3.18	3.48
Mean	4.10	3.89	3.58	
		Stem		
S_0	2.97	2.85	2.76	2.86
S_1	2.46	2.55	2.28	2.43
S_2	2.16	2.40	1.77	2.11
Mean	2.53	2.60	2.27	
		Caputulum		
S_0	4.05	3.57	3.57	3.73
S_1	3.48	3.24	3.09	3.27
S_2	2.97	3.03	2.94	2.96
Mean	3.50	3.28	3.20	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	NS	0.57	0.52
Interaction	NS	NS	NS

NS = Not significant.

Table 55. Mean absolute quantity of potassium in gm per pot

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.67	1.62	1.45	1.58
S_1	1.20	1.10	1.97	1.09
S_2	0.97	0.93	0.79	0.90
Mean	1.28	1.22	1.07	
		Stem		
S_0	0.67	0.92	0.85	0.88
S_1	0.61	0.69	0.61	0.64
S_2	0.53	0.58	0.45	0.53
Mean	0.67	0.73	0.65	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				
		Total		
S_0	2.54	2.53	2.32	2.46
S_1	1.81	1.79	1.58	1.73
S_2	1.50	1.48	1.28	1.42
Mean	1.95	1.93	1.73	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	0.09	NS	-	0.123
Treatments	0.09	0.069	-	0.123
Interaction	NS	NS	-	NS

NS = Not significant.

Table 56. Mean absolute quantity of potassium in gm per pot

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	2.17	2.21	1.98	2.12
S_1	1.59	1.35	1.22	1.39
S_2	1.38	1.15	1.12	1.22
Mean	1.71	1.57	1.44	
		Stem		
S_0	1.34	1.35	1.23	1.31
S_1	0.89	0.81	0.76	0.82
S_2	0.74	0.69	0.61	0.68
Mean	0.99	0.95	0.87	
		Caputulum		
S_0	1.44	1.38	1.27	1.36
S_1	1.13	1.07	0.91	1.04
S_2	0.81	0.79	0.67	0.76
Mean	1.13	1.08	0.95	
		Total		
S_0	4.94	4.92	4.49	4.78
S_1	3.63	3.24	2.89	3.25
S_2	2.92	2.64	2.42	2.66
Mean	3.83	3.60	3.27	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	0.175	0.096	0.0997	0.204
Treatments	0.175	0.096	0.0997	0.204
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 57. Mean absolute quantity of potassium in gm per pot

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.64	1.73	1.57	1.65
S_1	1.31	1.14	1.03	1.16
S_2	1.05	0.95	0.82	0.94
Mean	1.33	1.27	1.14	
		Stem		
S_0	1.37	1.32	1.32	1.34
S_1	0.98	0.92	0.81	0.90
S_2	0.85	0.78	0.80	0.81
Mean	1.07	1.01	0.98	
		Caputulum		
S_0	3.33	3.32	3.24	3.30
S_1	2.32	2.25	2.08	2.22
S_2	1.74	1.89	1.74	1.79
Mean	2.46	2.49	2.35	
		Total		
S_0	6.33	6.36	6.16	6.28
S_1	4.60	4.31	3.94	4.28
S_2	3.62	3.62	3.38	3.54
Mean	4.85	4.76	4.49	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	0.094	NS	0.097	NS
Treatments	0.094	0.092	0.097	0.32
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 58. Mean absolute quantity of potassium in gm per pot

Forth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	2.19	2.30	2.17	2.22
S_1	1.66	1.52	1.28	1.49
S_2	1.36	1.26	1.09	1.24
Mean	1.74	1.69	1.51	
		Stem		
S_0	0.88	0.91	0.90	0.90
S_1	0.73	0.62	[illegible]	0.64
S_2	0.56	0.48	0.4[illegible]	0.51
Mean	0.72	0.67	[illegible]	
		Caputulum		
S_0	3.73	3.71	3.52	3.65
S_1	2.76	2.47	2.19	[illegible]
S_2	2.22	2.12	1.85	2.06
Mean	2.90	2.77	2.52	
		Total		
S_0	6.78	6.91	6.59	6.76
S_1	5.16	4.52	4.05	[illegible]
S_2	4.12	3.87	3.43	[illegible]
Mean	5.35	5.13	4.59	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	0.114	NS	0.165	0.307
Treatments	0.114	0.077	0.165	0.307
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 59. Mean absolute quantity of potassium in gr per pot fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.89	0.81	0.79	0.83
S_1	0.59	0.61	0.43	0.54
S_2	0.46	0.46	0.34	0.42
Mean	0.65	0.63	0.52	
		Stem		
S_0	1.14	1.19	1.09	1.14
S_1	0.79	0.69	0.63	0.70
S_2	0.62	0.61	0.49	0.57
Mean	0.85	0.83	0.74	
		Caputulum		
S_0	4.54	4.72	3.89	4.18
S_1	3.15	2.64	2.33	2.71
S_2	2.33	2.25	2.13	2.24
Mean	3.34	3.00	2.78	
S_0	6.56	6.14	5.81	6.17
S_1	4.52	3.94	3.40	3.95
S_2	3.40	3.32	2.98	3.23
Mean	4.83	4.47	4.06	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	0.073	0.082	0.26	0.34
Treatments	0.073	0.082	0.26	0.34
Interaction	NS	NS	NS	NS

NS = Not significant.

Mean effects due to varieties were non-significant at all five occasions and with all three plant components, except at first sampling where varieties significantly differed for 'K' content of leaves. In general, though the differences did not reach the level of significance the variety N 62-8 had higher 'K' content and JSF-1 had least out of three.

The absolute quantities of potassium per pot were worked out and presented in Tables 55, 56, 57, 58 and 59.

On absolute basis, salt treatments at both the levels significantly and consistently reduced total 'K' content and this effect was significant with all plant parts at all five stages. Salt treatment reduced 'K' content under both S_1 and S_2 levels consistantly and significantly and in general order was as $S_0 > S_1 > S_2$ at all occasions and with all plant parts.

The mean effect due to varieties was also differed significantly, except at third sampling for total 'K' uptake where difference was not statistically significant. The differences due to varieties were significant with component plant parts viz., leaves, stem and caputulum at all five occasions except at third sampling where difference were not statistically significant for stem.

Variety N 62-8 accumulated more 'K' as compaired to Bhima and JSF-1 whereas J SF-1 accumulated list of 'K' as compared to both at all the five occasions.

4.9.4 Sodium content

The relevant data are summarised in Tables 60, 61, 62, 63 and 64.

It would be seen from these results that the main effects of treatments were significant at both S_1 and S_2, levels, at all occasions and with all plant parts. Salt treatment increased 'Na' content significantly at both S_1 and S_2 levels at all five occasions. 'Na' content under treatment S_2 was higher and least under control and in general order was as $S_2 > S_1 > S_0$.

The main effects due to varieties were significant at initial i.e. first sampling for leaves and stem and at second sampling for stem. At third forth and fifth sampling, differences were statistically not significant. From data it would be seen that 'Na' content for all three plant parts in JSF-1 was higher at all occasions and least in variety N 62-8.

The absolute quantities of sodium per pot were worked out and presented in Tables 65, 66, 67, 68 and 69.

Table 60. Mean sodium content of plant parts as influenced by treatments (per cent oven dry basis)

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.48	0.64	0.72	0.6[illegible]
S_1	0.56	0.74	[illegible]	0.75
S_2	0.69	0.83	[illegible]	[illegible]
Mean	0.58	0.74	0.8[illegible]	
		Stem		
S_0	0.40	0.59	[illegible]	0.54
S_1	0.57	0.61	[illegible]	0.57
S_2	0.64	0.69	[illegible]	0.72
Mean	0.52	0.63	0.7[illegible]	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	0.14	0.10	-
Treatments	0.14	0.10	-
Interaction	NS	NS	-

NS = Not significant.

Table 61. Mean sodium content of plant parts as influenced by treatments (per cent oven dry basis)

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_C	0.67	0.69	0.85	0.74
S_1	0.77	0.83	1.01	0.87
S_2	1.04	1.01	1.23	1.09
Mean	0.83	0.84	1.03	
		Stem		
S_C	0.53	0.51	0.69	0.60
S_1	0.67	0.67	[illegible]	0.75
S_2	0.88	0.91	1.04	0.92
Mean	0.69	0.72	0.88	
		Caputulum		
S_C	0.48	0.57	0.64	0.54
S_1	0.53	0.64	0.83	0.67
S_2	0.72	0.72	0.96	0.80
Mean	0.59	0.62	0.81	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	0.15	0.16
Treatments	0.21	0.15	0.16
Interactions	NS	NS	NS

NS = Not significant.

Table 62. Mean sodium content of plant parts as influenced by treatments (per cent oven dry basis)

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.69	0.72	0.72	0.71
S_1	0.85	0.85	0.93	0.88
S_2	0.96	1.04	1.09	1.03
Mean	0.84	0.87	0.92	
		Stem		
S_0	0.60	0.62	0.65	0.63
S_1	0.71	0.74	0.77	0.74
S_2	0.85	0.95	0.96	0.92
Mean	0.72	0.77	0.79	
		Caputulum		
S_0	0.51	0.51	0.67	0.56
S_1	0.59	0.69	0.72	0.67
S_2	0.69	0.83	0.88	0.80
Mean	0.59	0.67	0.76	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.198	0.14	0.17
Interaction	NS	NS	NS

NS = Not significant.

Table 63. Mean sodium content of plant parts as influenced by treatments (per cent oven dry basis)

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.59	0.64	0.61	0.61
S_1	0.77	0.77	0.85	0.80
S_2	0.93	0.83	1.06	0.94
Mean	0.76	0.75	0.84	
		Stem		
S_0	0.56	0.56	0.56	0.56
S_1	[illegible]	0.75	0.75	0.73
S_2	[illegible]	[illegible]	0.93	[illegible]
Mean	0.68	0.70	0.75	
		Caputulum		
S_0	0.48	0.51	0.51	0.50
S_1	0.59	0.64	0.72	0.65
S_2	0.67	0.77	[illegible]	0.76
Mean	0.58	0.63	[illegible]	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.19	0.13	0.16
Interactions	NS	NS	NS

NS = Not significant.

Table 64. Mean sodium content of plant parts as influenced by treatment (per cent oven dry basis)

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.53	0.53	0.58	0.55
S_1	0.58	0.56	0.72	0.62
S_2	0.66	0.74	0.72	0.71
Mean	0.59	0.61	0.67	
		Stem		
S_0	0.45	0.43	0.53	0.47
S_1	0.51	0.56	0.64	0.57
S_2	0.61	0.67	0.72	0.67
Mean	0.52	0.55	0.63	
		Caputulum		
S_0	0.40	0.35	0.45	0.40
S_1	0.43	0.48	0.58	0.49
S_2	0.51	0.56	0.69	0.59
Mean	0.44	0.46	0.58	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.14	0.14	0.16
Interactions	NS	NS	NS

NS = Not significant.

Table 65. Mean absolute quantity of sodium in gm per pot

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.14	0.18	0.18	0.17
S_1	0.12	0.15	0.15	0.14
S_2	0.12	0.14	0.14	0.13
Mean	0.13	0.16	0.16	
		Stem		
S_0	0.12	0.14	0.14	0.13
S_1	0.09	0.12	0.13	0.11
S_2	0.10	0.11	0.12	0.11
Mean	0.10	0.12	0.13	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				
		Total		
S_0	0.26	0.32	0.32	0.30
S_1	0.22	0.26	0.28	0.25
S_2	0.22	0.25	0.26	0.24
Mean	0.233	0.28	0.286	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	0.023	0.0099	-	NS
Treatments	0.023	0.0099	-	0.046
Interaction	NS	NS	-	NS

NS = Not significant.

Table 66. Mean absolute quantity of sodium in gm per pot

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.27	0.28	0.29	0.28
S_1	0.24	0.22	0.25	0.24
S_2	0.23	0.22	0.24	0.23
Mean	0.25	0.24	0.26	
		Stem		
S_0	0.19	0.21	0.22	0.21
S_1	0.18	0.17	0.20	0.18
S_2	0.18	0.17	0.20	0.18
Mean	0.18	0.18	0.21	
		Capitulum		
S_0	0.15	0.15	0.17	0.16
S_1	0.13	0.14	0.15	0.14
S_2	0.13	0.14	0.15	0.14
Mean	0.14	0.14	0.16	
		Total		
S_0	0.61	0.64	0.68	0.643
S_1	0.54	0.54	0.59	0.556
S_2	0.52	0.51	0.58	0.536
Mean	0.556	0.563	0.616	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.043	NS	NS	0.078
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 67. Mean absolute quantity of sodium in gm per pot

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.22	0.23	0.21	0.22
S_1	0.21	0.20	0.20	0.20
S_2	0.20	0.20	0.20	0.20
Mean	0.21	0.21	0.20	
		Stem		
S_0	0.24	0.25	0.24	0.24
S_1	0.22	0.22	0.22	0.22
S_2	0.22	0.22	0.23	0.22
Mean	0.2[illegible]	0.23	[illegible]	
		Capitulum		
S_0	0.38	0.39	0.44	0.40
S_1	0.35	0.37	0.34	0.35
S_2	0.36	0.38	0.41	0.38
Mean	0.36	0.38	0.41	
		Total		
S_0	0.85	0.87	0.89	0.87
S_1	0.78	0.79	0.81	0.79
S_2	0.77	0.78	0.80	0.78
Mean	0.80	0.81	0.8[illegible]	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	NS	NS	NS	NS
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 68. Mean absolute quantity of sodium in gm per pot

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.26	0.27	0.26	0.26
S_1	0.25	0.24	0.25	0.25
S_2	0.26	0.24	0.25	0.25
Mean	0.26	0.25	0.26	
		Stem		
S_0	0.16	0.16	0.16	0.16
S_1	0.15	0.16	0.14	0.15
S_2	0.15	0.15	0.15	0.15
Mean	0.15	0.16	0.15	
		Caputulum		
S_0	0.43	0.45	0.43	0.44
S_1	0.41	0.41	0.42	0.41
S_2	0.41	0.42	0.43	0.42
Mean	0.42	0.43	0.43	
		Total		
S_0	0.85	0.88	0.85	0.86
S_1	0.81	0.82	0.82	0.82
S_2	0.80	0.81	0.82	0.81
Mean	0.82	0.84	0.83	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	NS	NS	NS	NS
Interaction	NS	NS	NS	NS

NA = Not significant.

Table 69. Mean absolute quantity for sodium in gm per pot

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.10	0.10	0.11	0.10
S_1	0.09	0.09	0.08	0.09
S_2	0.08	0.09	0.07	0.08
Mean	0.09	0.09	0.09	
		Stem		
S_0	0.17	0.18	0.19	0.18
S_1	0.16	0.16	0.16	0.16
S_2	0.16	0.15	0.17	0.16
Mean	0.16	0.16	0.17	
		Caputulum		
S_0	0.45	0.41	0.48	0.45
S_1	0.39	0.38	0.43	0.40
S_2	0.39	0.38	0.42	0.40
Mean	0.41	0.39	0.44	
		Total		
S_0	0.72	0.69	0.78	0.73
S_1	0.64	0.63	0.66	0.64
S_2	0.62	0.62	0.65	0.63
Mean	0.66	0.65	0.70	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.0015	NS	NS	0.074
Interactions	NS	NS	NS	NS

NS = Not significant.

Salt treatments reduced total uptake of 'Na'. The mean effect due to treatments was significant during first, second and fifth sampling for total uptake of 'Na' whereas at third and forth sampling results were statistically non-significant. Reduction in total uptake during first, second and fifth sampling was due to a significant reduction in absolute quantity of 'Na' in leaves. From the data it would be seen that salinity reduced total 'Na' uptake at all occasions.

The mean effect due to varieties was only significant at first sampling for leaves and stem but at all five stages difference were non-significant of total uptake of Na, but in general total Na uptake in variety JSr-? was slightly higher than other two at all occasions and least in N 62-8.

4.9.5 Calcium content

The relevant data are summarised in Table 70, 71, 72, 73 and 74.

It would be seen from the data that the mean effect of treatments was significant at all five stages and with all three plant parts. Salt treatments increased 'Ca' content significantly and consistantly with significant differences between S_1 and S_2 levels at all five stages and in general order varied as $S_2 > S_1 > S_0$.

The mean effect due to varieties was non-significant at all five occasions and with plant parts except at second sampling, where 'Ca' uptake of leaves of variety JSF-1 was significantly higher than N 62-8 and at par with Bhima.

The absolute quantities of calcium per pot were worked out and presented in Tables 75, 76, 77, 78 and 79.

Salt treatments reduced total uptake of 'Ca'. The mean effect due to treatments was significant during all stages and with all three plant component parts as well as total 'Ca' uptake. Mean effects differed consistantly and significantly between S_1 and S_2 levels, and in general these are differed as $S_0 > S_1 > S_2$ at all the five stages.

Mean effects due to varieties were not significant on total Ca uptake and with component plant parts at all the five occasions except at the fourth sampling where Ca uptake of caputulam and total Ca quantity of variety N 62-8 significantly higher than Bhima and JSF-1.

Table 70. Mean calcium content of plant parts as influenced by treatments (per cent oven dry basis)

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.95	1.89	1.87	1.91
S_1	2.09	2.11	2.13	2.11
S_2	2.23	2.21	2.31	2.25
Mean	2.10	2.07	2.14	
		Stem		
S_0	0.60	0.58	0.57	0.58
S_1	0.68	0.69	0.73	0.70
S_2	0.72	0.73	0.76	0.74
Mean	0.67	0.67	0.69	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	-
Treatments	0.052	0.08	-
Interaction	NS	NS	-

NS = Not significant.

Table 71. Mean calcium content of plant parts as influenced by treatments (per cent oven dry basis)

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	2.[illegible]	2.10	2.[illegible]4	2.11
S_1	2.17	2.23	2.31	2.24
S_2	2.29	2.47	2.57	2.44
Mean	2.18	[illegible]	2.34	
		Stem		
S_0	[illegible]	0.64	0.68	0.[illegible]
S_1	0.73	0.76	0.73	0.74
S_2	0.8[illegible]	0.83	0.8[illegible]	0.83
Mean	0.75	0.76	0.75	
		Capitulum		
S_0	2.17	2.12	[illegible]	2.12
S_1	2.23	2.27	2.[illegible]1	2.27
S_2	2.37	2.3[illegible]	2.47	2.41
Mean	2.25	2.26	2.29	

C.D. at 5% P for	Leaves	Stem	Capitulum
Varieties	0.108	NS	NS
Treatments	0.108	0.041	0.108
Interaction	NS	NS	NS

NS = Not significant.

Table 72. Mean calcium content of plant parts as influenced by treatments (per cent oven dry basis)

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.93	1.87	1.86	1.89
S_1	2.01	2.08	2.11	2.07
S_2	2.13	2.12	2.17	2.14
Mean	2.02	2.02	2.05	
		Stem		
S_0	0.51	0.55	[illegible]	0.59
S_1	0.57	0.55	0.56	0.57
S_2	0.69	0.71	0.73	0.71
Mean	0.66	0.65	0.66	
		Caputulum		
S_0	2.19	2.21	2.17	2.19
S_1	2.28	2.31	2.35	2.31
S_2	2.46	2.53	2.57	2.53
Mean	2.31	2.35	2.37	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.09	0.094	0.109
Interaction	NS	NS	NS

NS = Not significant.

Table 73. Mean calcium content of plant parts as influenced by treatments (per cent oven dry basis)

Fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.57	1.70	1.63	1.67
S_1	1.81	1.84	1.83	1.83
S_2	1.91	1.89	1.92	1.91
Mean	1.80	1.81	1.79	
		Stem		
S_0	0.54	0.54	0.52	0.53
S_1	[illegible]	[illegible]	[illegible]	[illegible]
S_2	0.64	0.67	0.68	0.66
Mean	0.59	0.61	0.61	
		Caputulum		
S_0	2.05	1.98	1.96	1.99
S_1	2.19	2.18	2.21	2.19
S_2	2.26	2.34	2.39	2.33
Mean	2.17	2.17	2.19	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.086	0.075	0.10
Interaction	NS	NS	NS

NS = Not significant.

Table 74. Mean calcium content of plant parts as influenced by treatments (per cent oven dry basis)

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	1.58	1.52	1.54	1.58
S_1	1.64	1.59	1.73	1.69
S_2	1.78	1.75	1.84	1.79
Mean	1.65	1.59	1.70	
		Stem		
S_0	0.4[illegible]	0.51	0.47	0.4[illegible]
S_1	0.57	0.5[illegible]	[illegible]	0.5[illegible]
S_2	0.61	0.64	0.64	0.63
Mean	0.56	0.55	0.58	
		Caputulum		
S_0	1.87	1.91	1.86	1.88
S_1	2.03	2.06	2.05	2.05
S_2	2.12	2.13	2.14	2.13
Mean	2.01	2.03	2.02	

C.D. at 5% P for	Leaves	Stem	Caputulum
Varieties	NS	NS	NS
Treatments	0.083	0.068	0.079
Interaction	NS	NS	NS

NS = not significant.

Table 75. Mean absolute quantity of calcium in gm per pot

First sampling (60 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.52	0.52	0.49	0.51
S_1	0.45	0.4[illegible]	0.41	0.43
S_2	0.41	0.4[illegible]	0.40	0.40
Mean	0.46	[illegible]	0.4[illegible]	
		Stem		
S_0	0.14	0.15	0.14	0.14
S_1	0.13	0.13	0.13	0.13
S_2	0.12	0.13	0.11	0.12
Mean	0.13	0.14	0.13	
		Caputulum		
S_0	-	-	-	-
S_1	-	-	-	-
S_2	-	-	-	-
Mean				
		Total		
S_0	0.66	0.67	0.64	0.66
S_1	.56	0.58	0.54	0.57
S_2	0.53	0.53	0.5[illegible]	0.52
Mean	[illegible]	0.59	0.56	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	-	NS
Treatments	0.061	NS	-	0.072
Interaction	NS	NS	-	NS

NS = Not significant.

Table 76. Mean absolute quantity of calcium in gm per pot

Second sampling (75 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.77	0.83	0.74	0.78
S_1	0.66	0.62	0.59	0.62
S_2	0.64	0.60	0.59	0.61
Mean	0.69	0.68	0.64	
		Stem		
S_0	0.24	0.26	0.23	0.24
S_1	0.20	0.19	0.18	0.19
S_2	0.19	0.19	0.18	0.19
Mean	0.21	0.21	[illegible]	
		Capitulum		
S_0	0.61	0.63	0.58	0.61
S_1	0.54	0.55	0.47	0.52
S_2	0.54	0.50	0.46	0.50
Mean	0.56	0.56	0.50	
		Total		
S_0	1.62	1.64	1.55	1.60
S_1	1.40	1.30	1.24	1.31
S_2	1.36	1.28	1.23	1.29
Mean	1.46	1.41	1.34	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.073	0.037	0.074	0.106
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 77. Mean absolute quantity of calcium in gm per pot

Third sampling (90 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JSF-1	
		Leaves		
S_0	0.58	0.58	0.56	0.57
S_1	0.50	0.47	0.45	0.47
S_2	0.47	0.45	[illegible]	0.45
Mean	0.52	0.50	0.46	
		Stem		
S_0	0.24	0.23	0.22	0.23
S_1	0.21	0.20	[illegible]	[illegible]
S_2	0.2[illegible]	0.19	[illegible]	[illegible]
Mean	[illegible]	0.21	0.2[illegible]	
		Capitulum		
S_0	[illegible]	1.68	[illegible]	[illegible]
S_1	[illegible]	[illegible]	[illegible]	[illegible]
S_2	1.35	1.30	1.30	1.32
Mean	1.44	1.43	1.39	
		Total		
S_0	2.41	2.49	2.36	2.43
S_1	2.06	1.98	1.96	2.00
S_2	2.01	1.94	[illegible]	1.96
Mean	2.17	[illegible]	2.0[illegible]	

C.D. at 5% P for	Leaves	Stem	Capitulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.061	NS	0.062	0.144
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 78. Mean absolute quantity of calcium in gm per pot fourth sampling (105 days after sowing)

Treatments	Varieties			Mean
	N 62-8	Bhima	JCr-1	
		Leaves		
S_0	0.72	0.74	0.69	0.72
S_1	0.63	0.59	0.56	0.59
S_2	0.60	0.56	0.54	0.57
Mean	0.65	0.63	0.60	
		Stem		
S_0	0.15	0.16	0.14	0.15
S_1	0.13	0.13	0.12	0.13
S_2	0.12	0.12	0.12	0.12
Mean	0.13	0.14	0.13	
		Caputulur		
S_0	1.86	1.78	[illegible]	1.77
S_1	1.54	1.45	1.34	[illegible]
S_2	1.43	1.41	1.35	[illegible]
Mean	1.60	1.55	1.47	
		Total		
S_0	2.98	2.66	2.55	[illegible]
S_1	2.30	2.17	2.04	2.17
S_2	2.15	2.09	2.01	2.08
Mean	2.48	2.31	2.20	

C.D. at 5% P for	Leaves	Stem	Caputulur	Total
Varieties	NS	NS	0.094	0.124
Treatments	0.066	NS	0.094	0.124
Interaction	NS	NS	NS	NS

NS = Not significant.

Table 79. Mean absolute quantity of calcium in gm per pot

Fifth sampling (120 days after sowing)

Treatments	Varieties			Mean
	N 62-6	Bhima	JSF-1	
		Leaves		
S_0	0.32	0.31	0.30	0.31
S_1	0.24	0.26	0.21	0.24
S_2	0.22	0.23	0.1[illegible]	0.21
Mean	0.26	0.27	0.23	
		Stem		
S_0	0.20	0.21	0.1[illegible]	0.20
S_1	[illegible].18	0.16	[illegible].17	0.17
S_2	0.17	0.16	0.1[illegible]	0.16
Mean	[illegible].18	0.15	[illegible]	
		Caputulum		
S_0	[illegible]	[illegible]	[illegible]	[illegible]
S_1	1.84	1.66	1.54	1.69
S_2	1.67	1.58	1.5[illegible]	[illegible]
Mean	1.87	1.82	1.7[illegible]	
		Total		
S_0	2.[illegible]	2.70	2.[illegible]	2.68
S_1	2.24	2.10	1.92	2.09
S_2	2.06	1.96	1.88	1.97
Mean	2.30	2.25	2.1[illegible]	

C.D. at 5% P for	Leaves	Stem	Caputulum	Total
Varieties	NS	NS	NS	NS
Treatments	0.056	0.027	0.099	0.124
Interaction	NS	NS	NS	NS

NS = Not significant.

DISCUSSION

5.. DISCUSSION

In the investigations to study the effect of salinity on various aspects of growth, yield and yield attributes, physiological functions and chemical composition of three varieties of safflower was assessed, the main object being to understand the influence of salinity on safflower varieties in terms of growth responses and chemical composition.

The electrical conductivity at saturation percentage of the soil in the pots associated with the two levels of salinity namely S_1 and S_2 was [illegible] and 4.30 mmhos per cm, respectively at harvest indicating a rather moderate salinity stress.

Application of salts to safflower crop depressed the growth of crop. There was a definite reduction in height of plants, number of branches per plant, number of leaves per plant under salt treatments. Similar results were reported by Abaza et al. (1974), Devi et al. (1980) and Kurian and Iyengar (1972). As the number of leaves decreased with salinity treatments, it resulted into decreased leaf area (dm^2) per plant and leaf area duration. The flowering period was delayed by 2 to 6 days, while the maturity of the crop was earlier by 2 to 9 days under salinity treatments. Similar results were reported by Kurian and Iyengar (1972) and Irwing et al. (1988) in safflower crop.

Plant samples collected at five occasions, strating from 60 days after sowing at 15 days intervals, showed that total dry weight of shoot was reduced significantly. Reduction in dry matter by salts was due to combined effect of significant reduction in component plant parts at all the five occasions. It is noteworthy that salinity effects were much pronounced on caputulum weight followed by that in leaves at early stage and in stem at later stage. The effects were much pronounced in variety JSF-1 followed by that in Bhima as compared to N 62-8. Leaf weight reduced significantly at early stage due to significant reduction of leaf number, but at grain development stages reduction in leaf weight may be due to combined effect of reduction in leaf number as well as reduction in leaf size and early senescence of leaves under the influence of salts. Reduction in dry weight of stem was also related to reduction in number of primary, secondary and tertiary branches under salt treatments. This effect of salinity in depression of leaf weight during grain development stage may further have affected grain filling and thus final 1000-grain weight and final grain yield. Similar results were reported by Janardhan et al. (1986), Patil et al.(1988) and Kurian and Iyengar (1972).

It has been reported by Astri et al. (1974) that in safflower, the number of caputulum, seed number per caputulum are the most important yield contributing characters. In these studies, decrease in mean grain yield was by 16 and 30 per cent at S_1 and S_2 levels respectively, indicating relatively more adverse effect of S_2 on grain yield. Out of the three varieties, N 62-8 maintained higher yields under the control as well as at both levels of salinity. The per cent reduction in yield of three varieties was 12, 24 in N 62-8, 16, 30 in Bhima and 19, 35 in JSF-1 at S_1 and S_2 levels, respectively. Thus, considering productive ability of the varieties as well as relative decrement in yield, as the criteria for salt tolerance, variety N 62-8 can be regarded as more tolerant as compared to Bhima and JSF-1 whereas JSF-1 is fairly tolerant to salinity.

Analysis of the effects of salinity on yield attributes will further show that these characters i.e. number of caputulum, seed number per caputulum and 1000 seed weight were affected adversely by the salinity and again these effect were significant at high level of salinity. All these characters contributed towards the grain yield. Thus, on relative basis as well as absolute basis grain number and 1000-grain weight of variety N 62-8 was maintained more stable under the influence of salinity whereas JSF-1 suffered more in these characters as compare to N 62-8 and Bhima. Therefore, the decrease in yield under saline treatments may be attributed to the reduction in number of caputulum per plant, reduction in the yield of seed per head and the 1000-grain weight.

[illegible] Francois and Bernstein (1964), Janardhan et al. (1986) and Patil et al. (1988) reported similar observations for different varieties of safflower under saline treatments.

It is generally agreed that salinization with NaCl induces accumulation of Nitrogen in plants Pearson, (1959) Gauch and Wadleigh (1942) whereas $CaCl_2$ reduces N in plants (Gauch and Wadleigh, 1942). In the present studies, salt treatments cause considerable differences in the content of mineral elements in component plant parts of the treated plants. With increase in, NaCl and $CaCl_2$ levels in the experimental pots the concentration of Na and Ca in the component parts of test plants was gradually increased. Heikal (1977) with safflower plant reported the similar results. Lunin et al. (1964) with vegetable crops reported that sodium increased progressively with saline irrigation. Francois and Bernstein (1964) with sunflower leaves. Asana and Kale (1965) with four varieties of wheat indicated that Ca' content appreciably increased with increasing salinity. Kurian and Iyengar (1972) also reported that 'Ca' content of safflower plant increased with saline water treatments.

The 'N' content of component parts of safflower plants increased progressively with increase in salinity levels. Kurian and Iyengar (1972) and Heikal (1977) reported similar results in safflower plants. Berstein (1962) reported an increased nitrogen content of plants at high levels of NaCl.

The effects of salinity on 'P' content of the test plants were non-significant. This is similar to what was reported by Heikal (1977) with safflower plants and Kaddah and Ghowail (1964) with maize.

The effect of salinity on 'K' content of component plant parts were significant but here the interesting thing was that with salinity levels 'K' content progressively decreased. Similar results were reported by Heikal (1977) in safflower plants. The drastic effect of salinity was also reported by Kaddah and Ghowail (1964) with maize tops and Mehrotra (1971) with some agricultural crops. The reduction in 'K' content may be due to the high concentration of calcium in culture medias as reported by Allison (1964), who reviewed that high concentration of 'Ca' may restrict the uptake of 'K' by beans and some carrot varieties. Janardhan et al. (1986) reported that a comparatively lower accumulation of Na and relatively higher content of 'K' in the leaves was associated with salt tolerance.

Uptake of N, P, K, Na and Ca was significantly decreased with salinity levels. As uptake of these elements was more closely related to the dry weights of varieties under salt treatments, there was decrease in the total uptake as dry weights decreased significantly with salt treatments. Though the mineral content except 'K' increased progressively with salinity the effect of dry weight on total uptake was more and therefore, there was decrease in total uptake of nutrient with salinity treatments. The above discussion permit to state that the response of plants to influence salts depends on the degree of salinization of the substrate and the degree of salt tolerance of the plants.

SUMMARY AND CONCLUSIONS

6. SUMMARY AND CONCLUSIONS

A pot culture trial, with a view to carry on physiological studies on the effect of salinity on the growth, yield, yield attributing characters and chemical composition of safflower, was conducted during the year 1988-89 at Central Campus, Mahatma Phule Krishi Vidyapeeth, Rahuri.

A pot culture experiment was conducted on three safflower varieties viz., N 62-8, Bhima and JSF-1 under artificially salinized conditions. Sowing was done on 8th Nov. 1988. Salinity was created by adding NaCl and $CaCl_2$ in equal proportion by weight, that is S_1 (0.1%) and S_2 (0.2%) levels along with control S_0. These treatments commenced at 30 days after sowing.

The periodical growth observations such as height, number of branches, number of leaves, leaf area etc. were recorded at an interval of 15 days starting from 30 days after sowing. Similarly, studies on dry matter and growth functions were carried out by collecting the plant samples at an interval of 15 days, starting from 60 days after the sowing. Chemical analysis was also done simulteneously for these collected samples.

The following conclusions were drawn from the above experiment :

1. The salt treatments, in general, depressed all growth aspects namely height, number of branches, leaf number, leaf area and dry matter production.

2. The salt treatments delayed flowering but enchanced the maturity.

3. The salinity levels S_1 and S_2 reduced the mean grain yield by 16 and 30 per cent respectively. The degree of reduction in yield was more in JSF-1, followed by Bhima and least in N 62-8.

4. The growth functions $\overline{AGR}$ and $\overline{RGR}$ were reduced with salt treatment and also with time but $\overline{NAR}$ was more under salt treatment at initial and decrease in rate was very rapid, under salt treatments with increase in time.

5. Salinization tended to increase per cent N content of all the plant parts at all five occasions, but total uptake of N was reduced by salt treatment at all occasions except at first sampling.

6. The effect of salt treatment on P content of plant parts was non-significant at all five stages but total uptake of P was significantly reduced with salt treatments.

7. The salt treatments, reduced the K content of all the plant parts at all five stages and also reduced the total uptake of K.

8. Salinization tended to increase per cent Na of all the plant parts at all five occasions.

9. The salt treatments tended to increase per cent Ca of all the plant parts but reduced the total uptake of Ca.

10. Considering productive ability of the varieties as well as relative decrement in yield as the criterion for salt tolerance, variety N 62-8 can be regarded as more tolerant as compared to Bhima and JSF-1.

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LITERATURE CITED

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Abaza, M., Ghaneim, M.F. and Zwaik, A. 1974. Use of sea water dilution for irrigation in sand dunes in the northen coasts in Libya. Libyan J. Agric. 3 : 7-18.

Abdel Salam, M.A., Sabet, S.A., Elkadi, M.A. and Harq, A.A. 1965. Plant growth and mineral content as related to varying bicarbonate ion levels in irrigation water. Plant and Soil. 23 : 192-202.

Abel, G.H. and Maekenize, A.J. 1964. Salt tolerance of soyabean varieties (Glycine max Merrill) during germination and latter growth. Crop Sci. 4 : 157-161.

Ahmed, A.M., Heikal, M.M., Radi, A.F. and Shaddad, M.A. 1977. Photosynthesis of some economic plants as affected by salinization treatments 2. Safflower and Maize. Egyptian J. Bot. 20(1) : 17-27.

Ahmed, I. 1965. Criteria of the evaluation of the quality of irrigation water and their relationship with physiology of salt tolerance. Pot. Rev. 41 st. suite Feb. 1965, 1-9.

Allison, L.E. 1965. Salinity in relation to irrigation. Adv. Agro, 16 : 139-180.

Allison, L.E. 1964. Advances in Agronomy. Academic Press Inc. (London) Ltd. 16, 139.

Anonymous, 1988-89. Empitome of Agriculture in Maharashtra. PP. 139.

Anonymous, 1989. FAO Year Book production 43 published FAO, United Nations, Rome.

A.O.A.C. 1955. Official methods of analysis of the Association of Official Agricultural Research Institute, 1943/47, Adi-laide : 109.

*Applewhite, T.H. 1966. The composition of safflower seed. J.Am. Oil Chem. Soc. 43(6) : 406-408 (Field Crop Abst. 1967). 20(3): 243.

Asana, R.D. and Kale, V.R. 1965. A study of salt tolerance of four wheat varieties. Indi. J. Plant Physiol. VIII : 5-11.

Aslam, M. 1975. Potassium and sodium inter-relation in growth and alkali cation content of safflower. Agron. J. 67(2) : 262-264.

Astri, A., Zimmer, D.E., Urie, A.L., Cahaner, A. and Marani. 1974. Evaluation of the world collection of safflower. IV yield and yield components and their relationship. Crop Sci. 14(6) : 799-803.

Ayers, A.D., Wadleigh, C.H. and Bernstein, L. 1951. Salt tolerance of six varieties of lettuce. Proc. Amer. Soc. Hort. Sci. 57 : 237-242.

Balsubramanian, V., Rajagopal, V. and Sinha, S.K. 1974. Stability of nitrate reductase under moisture and salt stress in some crops. Indian J. Genet. Plant Breed. 34 A : 1055-1061.

Bangal, D.B., Patil, V.A. and Jadhav, B.B. 1984. Relative salt tolerance of safflower cultivars (_Carthamus tinctorius_ L.) at germination. Agricultural Science Digest India 4 (4) : 211-214.

Batchelder, A.R., Lunin, J. and Galletin, M.H. 1963. Saline irrigation of several vegetable crops at various growth stages. II. Effect on cotton composition of crops and soils. Agro. J. 55 : 111-114.

Bernstein, L. and Pearson, G.A. 1954. Influence of integrated moisture stress achived by varying the osmatic pressure of culture solutions on growth of tomato and pepper plants. Soil Sci. 77 : 355-368.

Bernstein, L. and Hayward, H.E. 1958. Physiology of salt tolerance. Ann. Rev. Plant Physiol. 9 : 25-47.

*Bernstein, L. 1962. Salt affected soils and plants in the problems of arid zones. Arid Zone Res. XVIII 139-174. Unesco (Quoted from Kale, 1964).

Bernstein, L. 1964. Salt tolerance of plants. U.S. Dept. Agr. Infor. Bull. No. 263.

Briggs, G.E., Kidd, F. and West, C. 1920. Quantitative analysis of growth. Ann. Appl. Biol. 7 : 103-104.

Chapman, H.D. and Pratt, P.F. 1961. Methods of analysis of soil, plants and water. Univ. of California, Div. of Agric. Sciences, California.

Dastur, R.H. 1960. Physiology of 'bud opening' of bolls in Punjab. American Cottons. Cotton in India, Sci. Monograph. No.2, I.C.C.C. 172 PP.

Devi, C.S., Rao, G.G. and Rao, G.R. 1980. 14CO_2 incorporation studies under salt stress in safflower (Carthamus tinctorius L.) J. of Nuclear Agriculture and Biology. 9(4) : 129-132.

Eaton, F.M. 1942. Toxicity and accumulation of chloride and sulphate salts in plants. Jour. Agril. Res. 64 : 357-399.

EL-Wakhalaway, F.S. and El. Fawal, M.A. 1989. Tolerance of five oil crops to salinity and temperature stresses during germination. Acto Agronomica Hungarica. 38(1-2) : 59-65.

Felipe, M.R., Rodriguez, Paschal, M.L. 1983. Ultrastructural changes in leaves of maize (Zea mays L.) and safflower (Carthamus tinctorius L.) in response to NaCl stress. Stuttgart, German Federal Republic. 239-243.

Fisher, R.A. 1921. Some remarks on the method formulated in a recent artical on the quantitative analysis of plant growth. Ann. Appl. Biol. 7 : 367-372.

Francois, D.E. and Bernstein, L. 1964. Salt tolerance of safflower. Agro. J. 56 : 38-40.

Furguson, W.S. 1966. Salt induced changes in the composition of lipid classes in barley roots. Can J. Sci. 46 : 639-646.

Gabaly, M.M. El. 1955. Specific effects of absorbed ion on plant growth I. Effect of different combinations of calcium, magnesium and sodium on barley seedlings. Soil Sci. 80 : 235-248.

Ghorasby, S.R., Sionit, N. and Kheradnam, M. 1972. Salt tolerance of safflower varieties (Carthamus tinctorius L.) during germination. Agronomy J. 64(2) : 256-257.

Goswami, S.K., Gehlot, C.L. and Lal, K. 1978. A note on salt tolerance of different varieties of safflower (Carthamus tinctorius L.) at germination. Madras Agril. J. 65(2) : 137-138.

Greenway, H., Gunn, A., Pitman, M.G. and Thomas, D.A. 1965. Plant response to saline substrates, cholaride, sodium and potassium uptake and distribution within the plant during auto genesis of Hordeum vulgare. Aust. Jour. Biol. Sci. 18 : 525-540.

Gregory, F.G. 1926. The effect of climatic conditions on the growth of Barley. Ann. Bot. 40 : 1-26.

Gauch, H.G. and Wadleigh, C.H. 1942. The influence of saline substrate upon the absorption of nutrients by bean plants. Proc. Amer. Soc. Horti. Sci. 41 : 365-369.

Gauch, H.G. and Wadleigh, C.H. 1944. Effect of high salt concentration on growth of bean plants. Bot. Gaz. 105 : 379-387.

Gauch, H.G. and Magistad, O.C. 1943. Growth of strawberry clover varieties and alfalfa and ladino clover as affected by salt. Amer. Sco. Agro. Jour. 35 : 871-880.

Gauch, H.G. and Wadleigh, C.H. 1951. Salt tolerance and chemical composition of Rhodes and Dallis grasses in sand culture. Bot. Gaz. 112 : 259-271.

Guerrier, G. 1983. Germination in vegetables and oil plants in the presence of NaCl. Seed Sci. and Tech. 11(2): 281-292.

Hayward, H.E. and Bernstein, I. 1958. Plant growth relationships on salt affected soils. Bot. Rev. 24 : 534-636.

Hayward, H.E. and Spurr, W.B. 1943. Effect of osmotic concentration of substrates on the entry of water into corn roots. Bot. Gaz. 105-: 105-164.

Hayward, H.E. and Spurr, W.B. 1944. Salt tolerance of flax to saline conditions. Effect of NaCl, $CaCl_2$ and Na_2SO_4. Amer. Soc. Agro. J. 36 : 287-300.

*Hayward, H.E. 1956. Quoted from Raheja, 1966.

Heikal, M.M.D. 1977. Physiological studies on salinity 6, changes in water content and mineral composition of some plants over a range of salinity stresses. Plant and Soil. 48(1) : 223-232.

*Heimann, H. 1959. The irrigation with saline water and the balance of the ionic environment. Potash Rev., Berne, July, 1-17. Aug., P. 1-11, Sept, 1-10 (Quoted from Raheja, 1966).

Heimann, H. 1966. Plant growth under saline conditions and the balance of the ionic environment salinity and aridity new approaches to old problems (Edited by Boyko, 408 PP.).

Irving, D.W., Shannon, M.C., Breda, V.A. and Mackey, B.E. 1988. Salinity effects on yield and oil quality of high linoleate and high oleate cultivars of safflower (Carthamus tinctorius L.). J. of Agril. and Food Chemistry. 36(1) : 37-42.

Jadhav, B.B. 1985. Salt tolerance of safflower (Carthamus tictorius L.) varieties during germination. Agril. Science Digest, India. 5(2) : 92-94.

Janardhan, K.V., Patil, B.N. and Raiker, D.S. 1986. Relative tolerance of safflower (Carthamus tinctorius L.) varieties to saline water irrigation. Indian J. Plant Physiol. 29(2) : 118-124.

Janes, B.E. 1966. Adjustment mechanisms of plants subjected to varied osmotic pressures of nutrient solution. Soil Sci. 101 : 180-188.

Kaddah, M.T. and Ghowail, S.L. 1964. Salinity effect on the growth of corn at different stages of development. Agron. J. 56 : 214.

Kakade, J.R. 1968. Observation of soils exposed to potential hazards of salt problems in the low rainfall area of Central Maharashtra. Akola Agril. Coll. Maz. 8 : 7-16.

Kale, V.R. 1964. Tests for salt tolerance and methods for induction of salt hardiness. Poona Agril. Coll. Maz. 54 : 17-20.

Kaliappan, R., Ramchandran, M. and Rajgopal, A. 1967. Effect of salinity on the South Indian Crops. Germination and early vigour of Ragi (Eleusine Coracana Earth). Madras Agri. J. 54 : 613-623.

Kaliappan, R. and Rajagopal, A. 1968. Effect of salinity on the South Indian Field Crops. Duration and grain setting in Ragi (Elusine coracana Earth). Madras Agril. J. 55 : 125-128.

Klepper, B. 1967. Effects of osmotic pressure on exudation from corn roots. Aust. Jour. Biol. Sci. 20 : 723-735.

Koeing, R.A. and Johnson, G.R. 1942. Colorimetric determination of phosphorus in biological products. Indust. Engg. Chem. Ann. 14 : 155-164.

Kurian, T. and Iyengar, E.R.R. 1972. Response of safflower (Carthamus tinctorius L.) to salinity and sea water. Indian J. of Agril. Sci. 42(8) : 712-721.

Lehr, J.J. 1942. The importance of sodium for plant nutrition III. The equilibrium of cations in the beet root. Soil Sci. 53 : 399-411.

Lessani, H. and Marschner, H. 1978. Relation between salt tolerance and long distance transport of sodium and chloride in various crops species. Aust. J. Plant Physiol . 5(1) : 27-37.

Lipman, C.B., Davis, A.R. and West, E.S. 1926. The tolerance of plants for sodium chloride. Soil Sci. 22 : 303-322.

Long, E.M. 1943. The effect of salt addition to the substrates on water requirement and intake of nutrients by roots of approached grafted tomato plants. Amer. Bot. 30 : 544.601.

Lapina, L P 1966 The effect of high iso osmatic concentration of dextran and Nacl on nitrogen and carbohydrate metabolism of Maize Fiziol. Rast. 13 : 1029 - 1040.

Lopez, G. 1966. Irrigation with saline water in Punglia. Salinity and aridity - new approaches to old problems. (Edited by Boyko, 408 PP).

Lumin, J., Gollatin, M.H. and Batchelder, A.K. 1964. Effect of supplemental irrigation with saline water on soil composition and on yield condition content of forage crops. Soil Sci. Soc. Am. Proc. 28 : 551.

*Mackey, J.B. and Chapman, V.J. 1954. Quoted from Bayko 1966.

Magisted, O.C. 1945. Plant growth relations on saline and alkali soils. Bot. Rev. 11 : 181-230.

Maliwal, G.L. 1986 Salinity and crop productivity. Seeds and Farms. 12(9): 30-32.

Maliwal, G.L. and Paliwal, K.V. 1967. Salt tolerance studies on some varieties of wheat (<u>Triticum sativum</u>) and barley (<u>Hordeum Vulgare</u>) at germination stage. Ind. J. Plant Physiol. X. 26-36.

Mehrotra 1971. Salt tolerance of some agricultural crops during early growth stages. Indian J. Agric. Sci. 41 : 882.

Mulwani, B.T. and Pollard, A.G. 1939. Effect of alkali salts on germination of seeds. Agril. and Livestock in India, IS : 548-555.

Neimann, R.H. and Roulson, L.L. 1967. Interactive effects of salinity and atmospheric humidity on the growth of beans and cotton plants. Bot. Gaz. 128 : 69-73.

Nelson, D.B. and Sommers, D.E. 1973. Determination of total nitrogen in plant material. Agron. J. 10 : 109-112.

Pearson, G.A. 1959. Factors influencing salinity of submerged Soil and growth of colaro rice. Soil Sci. 86 : 198-206.

Patil, B.C., Vishwanath, D.P., Hynshal, C.S. and Balikai, R.A. 1988. Studies on persistence of salinity effects in the progeny seeds of safflower. J. of Maharashtra Agricultural Univ. 13(2) : 162-164.

Patil, V.A. and Bangal, D.B. 1985. Screening for salt tolerance in safflower (Carthamus tiuctorius L.) Seed Research. 13(1) : 57-61.

Parsons, R.F. 1968. Effect of Water logging and salinity on growth and distribution of three mallee varieties. Eucalyptus. Aust. Jour. Bot. 16 : 101-108.

Pearson, G.A., Ayers, A.D. and Eberhart, D.L. 1966. Relative salt tolerance of rice during germination and early seedling development. Soil Sci. 102 : 151-156.

Radi, A.F., Heikal, M.M., Abdel-Rahman, A.M. and El Deep. B.A.A. 1988. Interactive effects of salinity and phytohormones on growth and plant water relationship parameters in maize and safflower plant. Revue Roumaine de Biologie. 33(1) : 27-33.

Rage, N.D. and Chattopadhyay, S. 1966. Safflower for shallow and salty lands. Indian Fmg. 16(2) : 39-56.

Raheja, P.C. 1966. Aridity and salinity (A survey of soils and land use). Salinity and aridity new approaches to old problems. (Edited by Boy-ko, 408 PP).

Rai, M. 1977. Salinity tolerance in Indian mustard and safflower. Indian J. of Agril. Sci. 47(2) : 70-73.

Rai, M. 1980. Impact of saline water irrigation on some crops and their varieties. Annals of Arid Zones. 19(B) : 231-237.

Ramdeo, Baser, B.L. and Rahul, D.V.S. 1968. Effects of salts on the growth and mineral composition of bajra. (Pennisetum typhoides). Ann. Arid Zone. 7 : 100-104.

Ramanmurthy, C.V. and Kulkarni, C.C. 1967. Safflowers. Need a multipurpose oilseed crop at Rayal Seema Andhra State. Ind. Oilseed J. 1 : 622-31.

Rao, P.N. and Ayyangar, 1956. Need for research on safflower a multipurpose oilseed crop of Rayala Seema Andhra State. Ind. Oilseed J. 1 : 622-31.

Rao, K.B., Panchakshraiah, S., Janardhan, K.V. and Yadav, SJ.S.P. 1981. Saline water irrigation and plant growth in vertisol. Agrokemiaes Talajtan. 30 : 129-138.

Rao, M.R.G., Gururaja Rao, M.R., Manjunath, M., Vishwanath, D.P., Raikar, D.S. and Shrinivasa, N. 1987. Screening of safflower genotypes for tolerance to saline water irrigation. J. of Oilseed Research. 4(2) : 279-282.

Rather, E.I. 1935. The influence of exchangable sodium in the soil on its properties as a medium for plant growth. Soil Sci. 40 : 459-471.

Rauser, W.E. and Hanson, J.B. 1966. The metabolic status of ribonucleic acid in soyabeans roots exposed to saline media. Can. J. Bot. 44 : 759-776.

Rage, N.D. and Chattopadhyay, S. 1966. Safflower for shallow and salty lands. Indi. Farming. 16 : 39-56.

Redford, P.J. 1967. Growth analysis formulae, use and their abuse. Crop Sci. 7 : 171-175.

Rhodes, P.R. and Matsuda, K. 1976. Water stress, rapid polyribosome reduction and growth. Plant Physiol 58(5) : 631-635.

Sadayappan, S. and Shrinivasan, S.T. 1968. Salt tolerance of rice. Madras Agri. J. 55 : 337-344.

Sakai, K.L. and Rodrigo, M. 1960. Studies on a laboratory method of testing salinity resistance in rice varieties. Trop. Agril. Jour. Ceylon. 116 : 179-184.

Sarin, M.N. 1963. Physiological studies on salt tolerance of crop plants XXI Influence of sodium sulphate on growth and maturing of Cicar arietinum. Indian J. Pl. Physiol. 6 : 161-165.

Singh, S.B., Chhabra, R. and Abrol, I.P. 1981. Effect of exchangeble sodium on the yield, chemical composition and oil content of safflower and linseed. Indian J. of Agricultural Science, India. 51(2) : 885-891.

Shaddad, M.A., Ahmed, A.M. and Fayez, K.A. 1988. Alleviation of the adverse effects of salinity by nitrogen fertilization. Biologia Plantarum. 30(5) : 343-350.

Shah, B.H. and Wedding, R.T. 1968. Sodium ion influence on phosphorylations associated with oxidation of succinate by turnip root mitochondria. Science. 160 : 304-306.

*Shervykva, N.I. 1966. The influence of salts on the biosynthesis of certain sulphur containing amino acids in leaves of Vicia Faba. Dkl. Akad, Nank. U.S.S.R. 167 : 471-473 (F.C.A.No. 2268, 1966).

Shourbagy, N.E. and Wallace, A. 1965. Sodium accumulation and sodium responses of five varieties of barley. Agro. J. 57 : 448-450.

Slonov, L.H. 1966. The effects of trace elements on the physioco-chemical properties of the pro·oplasm in plants grown on saline soils. Fiziol Rast. 13 : 1024-1028.

Strogonov, B.P. 1964. Physiological basis of salt tolerance of plants (as affected by various types of salinity). Akad, Nank. SSSR, 1964, 255 PP.

Tesu, C., Merlescu, E. and Avarvarei, I. 1975. Salinity tolerance in safflower (Carthamus tinctorius L.) Agronomie-Horticultura (1975) : 49-50.

Tesu, V., Tesu, C., Toma, L.D. and Marlescu, E. 1976. Effect of saline soil on the contents of carbo--hydrates and free aminoacids in sunflower and safflower. Agronomie-Horticultura. 33-34.

Throughton, A. 1967. Effect of sodium chloride on the growth of Lolium perenna. Plant and Soil. 27 : 148-150.

Uvhits, Rabhel 1946. Effect of osmotic pressure on water absorption and germination of alfalfa seeds. Amer. Jour. Bot. 33 : 278-283.

Wadleigh, C.H. and Gauch, H.C. 1944. The influence of high concentration of sodium chloride, $CaCl_2$ and $MgCl_2$ on the growth of guayule in sand culture. Soil Sci. 54 : 399-403.

Wadleigh, C.H., Gauch, H.C. and Kolish Muria 1951. Mineral composition of orchard grass grown on Pachappa loam salinized with various salts. Soil Sci. 72 : 275-282.

Wilcox, L.V. Blair, G.Y. and Bower, C.A. 1954. Effect of bicarbonate ion suitability of water for irrigation. Soil Sci. 77 : 259-266.

Youngner, V.B., Lunt, O.R. and Nudge, K. 1967. Salinity tolerance of seven varieties of creeping bent grass Agrostics Palustris Huds. Agro. Jour. 59 : 335-336.

* <u>Originals not seen</u>