2. MATERIALS AND METHODS

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This chapter deals with the methodology followed and materials used in this study, the schematic representation of which is given in Figure 3. The study has been divided in two parts viz., monitoring of soil and vegetational degradation comprising of remote sensing studies and other field studies and laboratory experiments to screen different cultivars of rice using different saline medium equivalent to that found in affected soils.

2.1 MONITORING OF SOIL AND VEGETATIONAL DEGRADATION

2.1.1 Remote Sensing Studies

2.1.1.1 Data Products

The study was carried out using multidate, multispectral and multistage remote sensing data in the form of positive image transparencies or Computer Compatible Tapes (CCT) obtained from National Remote Sensing Agency (NRSA, Hyderabad) or referred from image library of Space Applications Centre (SAC), Ahmedabad. The data products used were of Landsat 3,4,5 MSS/TM, FCC of bands 5,6,7 of MSS or 2,3,4 of TM or B&W (bands 5/7 of MSS or 2/4 of TM), positive transparencies at 1:1 million scale or paper print of 1:250,000 scale of path 148 and row 44/45 and of the dates, March 1975, March 1977, October 1978, November 1982, March/May 1983, May 1984, March/May 1985, May 1986 and March 1987. In addition, TERRA data of Kate-140 of April 1984 and IRS-1A LISS II CCT of May 1988 of path 31 and row 52 were also used. The images gave the coverage of the entire study area whereas the CCT coverage excluded extreme western part of the taluka.

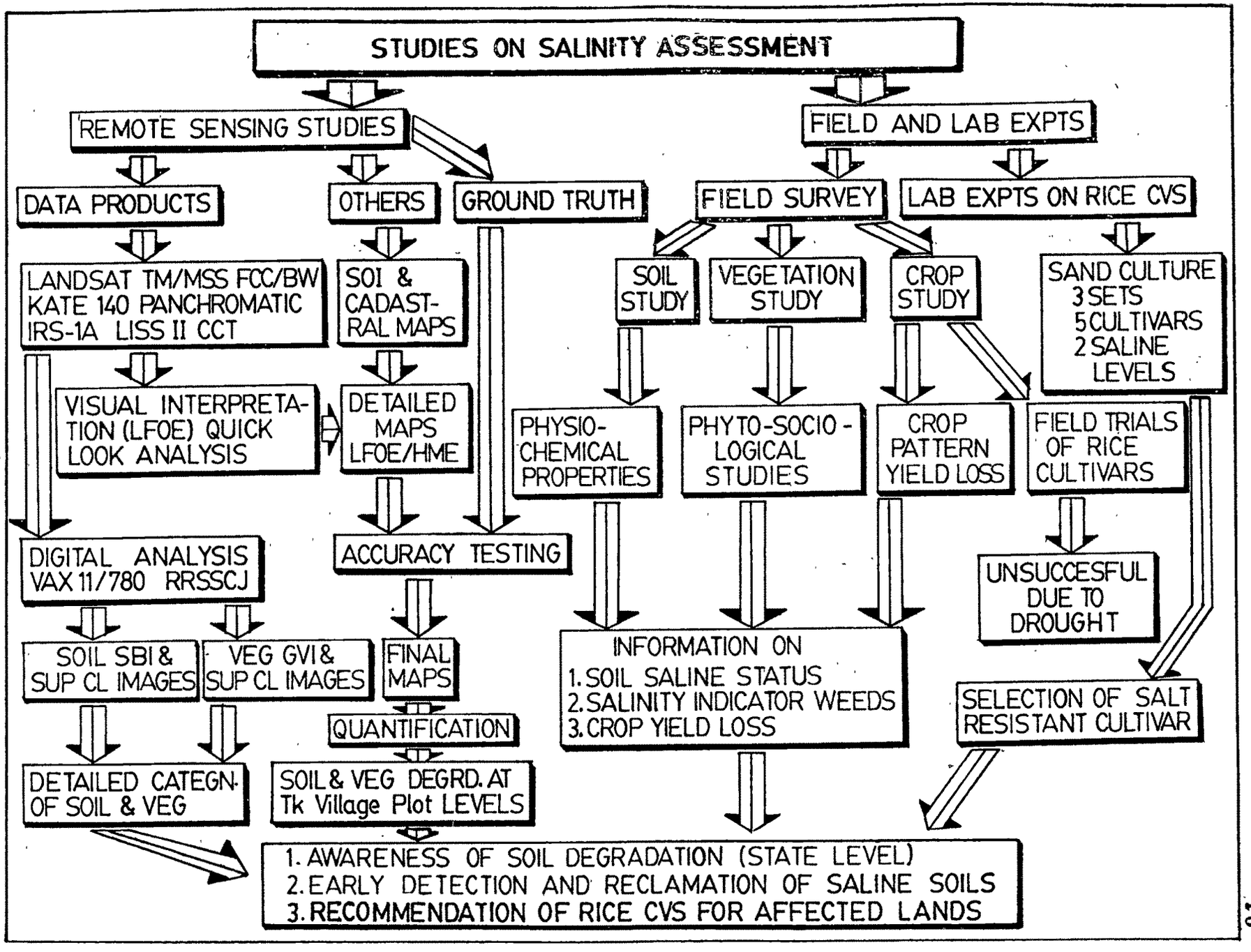


FIG. 3. SCHEME TO ILLUSTRATE THE METHODOLOGY.

2.1.1.2 Other Data Inputs

The Survey of India (SOI) toposheets numbered 46B at 1:250,000 scale and numbered 46B-6,7,10,11 at 1:50,000 scale were used as base maps during the study. In addition, the village cadastral maps were used to map saline soils on plotwise basis.

2.1.1.3 Interpretation

A systematic visual image interpretation technique was adopted for mapping saline soils using the black-and-white and false coloured images. The categorisation of saline soils and vegetation was based on the tonal variation. The aids used during the interpretation of these images were Simple Light Table, Optical Reflecting Enlarger, Large Format Optical Enlarger and High Magnification Enlarger.

Simple Light Table

It was used for quick look analysis of the transparencies and the interpretation of paper print product at 1:250,000 scale.

Optical Reflecting Enlarger (ORE)

This was used in order to bring maps of different scales to a standard scale.

Large Format Optical Enlarger (LFOE)

This apparatus could enlarge the images fourfold. The multitemporal images of all the different years were almost at 1:1 million scale. These were enlarged fourfold and matched with the SOI toposheets at 1:250,000 scale. The saline soils and vegetation were mapped from this at the scale of 1:250,000 following the methodology of Sahai et al., (1980 and 1981).

High Magnification Enlarger (HME)

The instrument used in the study was a trial set developed by SAC, Ahmedabad and used for 2Ø fold enlargement in the Visual Image interpretation Laboratory of Space Applications Centre, Ahmedabad. Selected satellite images were studied at 1:5Ø,ØØØ scale. Mapping of saline soils and degraded vegetation at an enlarged scale of 1: 5Ø,ØØØ using SOI toposheets of the same scale aided in the study at the village level. Further the transfer of this data on village cadastral map helped in the plotwise mapping of saline soils.

2.1.1.4 Digital Analysis

IRS-1A LISS II CCT was digitised on VAX/11/78Ø computer with VIPs 32 software at the Regional Remote Sensing Service Centre at Jodhpur. In order to generate different levels of salinized soil and vegetation, different indices were attempted by the application of MSS equivalent coefficient values as suggested by Kauth and Thomas (1976) to IRS data.

1. SBI IRS = (SOIL BRIGHTNESS INDEX)
   Ø.332 IRS1 + Ø.6Ø3 IRS2 + Ø,675 IRS3 + Ø.262 IRS4
2. GVI IRS = (GREENNESS VEGETATION INDEX)
   -Ø.283 IRS1 + Ø.66Ø IRS2 + Ø.577 IRS3 + Ø.388 IRS4

Making use of the ground truth data, a supervised classification scheme was adopted to classify saline soils into different levels. The variance and covariance were calculated for each spectral class to know the dependency of one band on the other and the spectral separability of the classes. The "Confusion Matrix" was worked out and the commission and omission

errors were calculated based upon this statistics of training sets. The "Maximum Likelihood Classifier" rule was performed to each pixel to allocate them to particular class of salinity. For classifying vegetation, a non-supervised scheme was followed and different classes of vegetation were obtained.

2.1.2 Field Studies

2.1.2.1 Ground Truth Survey

The quick look analysis of the images was carried out and the saline soils were roughly mapped based on the tonal variation. This was followed by a preliminary reconnaissance survey of the study area. This survey included frequent visits to the saline affected fields of different villages, discussions with the local farmers, study of different factors contributing to the occurrence of salinity in this area and so on. Based on the information collected from the above survey the saline soils were then accurately mapped. After the final mapping a detailed ground truth survey was carried out. The ground truth study included the collection of soils and plants from the detected areas.

2.1.2.2 Soil and Plant Analysis

A saturated extract (1:2) of the soil was made for the determination of pH and ECe (Jackson, 1967). Soluble ions in the soil, like Na^+ and K^+ were extracted and assayed flamephotometrically (Richards, 1968). Ca^{2+} and Mg^{2+} were analysed on Atomic Absorption Spectrophotometer (AAS) following the method of Gaines and Mitchell (1979). Anions like CO_3^{2-} and

HCO_3^{2-} and Cl^-, were determined titrimetrically (Richards, 1968) and SO_4^{2-} by colorimetric method (Hunt, 1980). Similarly weeds and rice crop were collected from the salinity affected fields. These samples were dried, crushed, powdered, and analysed for their Na^+ and K^+ using Flamephotometer (Storey and Wyn Jones, 1977), while Ca^{2+} and Mg^{2+} on AAS meter (Gaines and Mitchell, 1979). The chloride was estimated by Mercuric nitrate method (Clarke, 1950).

2.1.2.3 Vegetational Survey

A survey of weeds in the rice fields was carried out in order to understand the changes in their pattern and distribution at different salinity levels using 20 quadrats (2 X 2m). Important Value Index, an integrated measure of the relative values of frequency, density and dominance of each different species was calculated following the method of Curtis (1959). In addition few indices giving species structure in communities were calculated. They are as follows.

1. Index of Dominance (Simpson, 1949) using formula,

$$C = \sum (ni/N)^2$$

Where, C = Index of dominance,

ni= number of each species,

N = Total number of each species.

2. Index of Similarity (Sörenson, 1948) for comparing similarity of species, at different levels using the formula,

$S = 2C/A + B$ Where A = number of species in sample A, (at one level),

B = number of species in sample B, (at another level),

C = number of species common to both samples, (or observed at both the levels).

3. Shannon Index of general diversity ($\bar{H}$) (Shannon and Weaver, 1949; Margalef, 1968) using the function given below:

$$\bar{H} = -\sum_{i=1}^{n} (ni/N) \log (ni/N)$$

$\bar{H}$ = Index of general diversity

where ni = number of each species (individuals of a species)

N = Total number of species (individuals of all species)

4. Evenness index (e) (Pielou, 1966) using the function

$e = \bar{H}/\text{Log } S$ where $\bar{H}$ = Shannon index,

S = number of species

5. Species richness Index (Menhinick, 1964) using formula.

$d = S/\sqrt{N}$ where S = number of species

$\sqrt{N}$ = number of individuals

2.1.2.4 Agronomical Studies in The Field

An attempt was made to grow different salt resistant rice cultivars in the salt affected fields of Padra in the Kharif season of 1988. The different cultivars chosen for the study were AU1, CO-36, CO-43, CSC-1, CSC-2, SRB 26, TKM 4 and TKM 9 from

Tamil Nadu Agricultural University, Coimbatore, India and Bhura rata, GR_3, IR2Ø, IR28 and SLR-51425 from Navagam Rice Research Station, Gujarat, India. A plot of one acre having normal soil was chosen for raising the seedlings. The seeds were sown following the normal Indian agricultural practices with the help of local farmers and transplanted to four different saline fields ranging from normal to severe. This experiment was not successful due to the severe drought in the year 1987 and due to the nonavailability of canal water to irrigate the crops. We couldn't attempt this trial again due to shortage of funds.

2.2 LABORATORY EXPERIMENTS

Pot culture investigations to choose resistant cultivars of rice was carried out between 1987-88 in plastic containers. The temperature and rainfall during the period of experimentation is presented in Fig. 4. The seeds of the rice cultivars, Bhura rata, GR3, IR-2Ø, IR-28, Mahsuri and SLR-51425 were procured from Navagam Rice Research Centre, Gujarat, India and cultivars, CO-43, Gettu and SRB-26 were supplied from Tamil Nadu Agricultural University, Coimbatore, India. The experimental plan consisted of mandatory features of the pot culture trials using plastic pots and randomised block design with five replicates (Dospakhov, 1984). Set I was conducted using 5 cultivars, GR3, IR-28, IR-2Ø, Mahsuri and SRB-26 at three different levels of NaCl salinity with medium of ECe 1.6, 8.Ø, and 16.Ø dSm^{-1} while Set II consisted of 5 cultivars of rice viz., CO-43, Gettu, IR-28, Mahsuri and SLR at 3 different NaCl saline medium levels of ECe 1.6, 8.Ø and 14.Ø dSm^{-1} and two

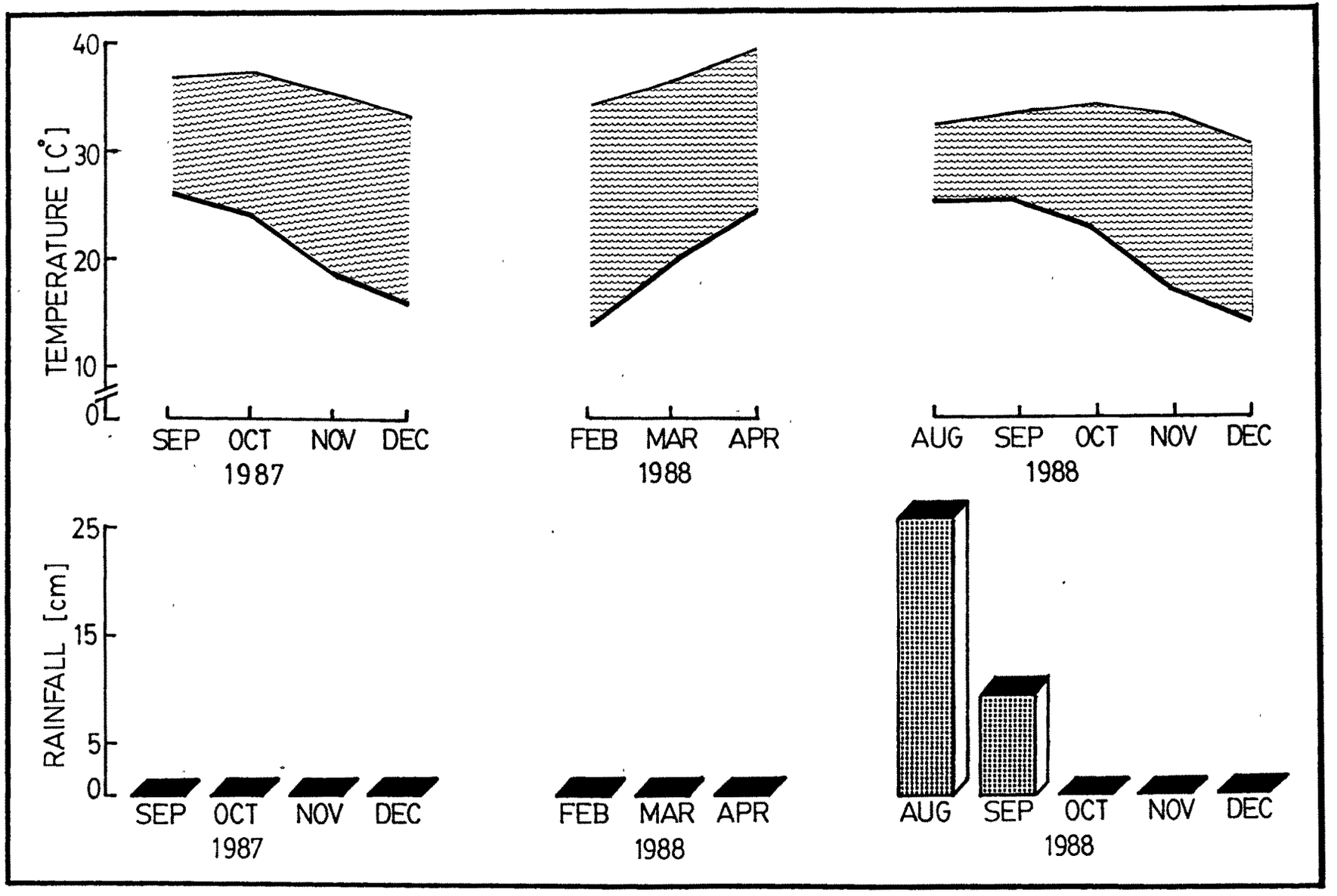


FIG. 4. THE MEAN TEMPERATURE AND RAINFALL DURING POT CULTURE EXPERIMENTS.

levels of nitrogen (normal and high 8Ø-12Ø ppm) under each saline treatment. Set III was conducted with rice cultivars Bhura rata, IR-28 Mahsuri and SLR-51425 under three levels of NaCl salinity and the medium was of ECe of 1.6, 8.Ø and 14 dSm^{-1}.

Generally the seeds were treated with Ø.1 % $HgCl_2$ for a minute and washed thoroughly using distilled water after which they were soaked overnight in distilled water. Twenty five seeds were sown in each pot containing 7 kg of neutral acid and alkali washed sand. The pots (19x21 cm) were fitted with glass tubes 4 mm inner diameter and 9 cm length, at the side close to the lower end to facilitate the drainage of liquid. A rubber tube with a pinch clip helped in controlling the retention of the medium. For one week after the sowing the seedlings were irrigated with demineralised water, after which it was irrigated with the full strength of the special nutrient medium for the growth of rice seedlings (Yoshida et al., 1976; Table 4). Two days after the irrigation with the above medium the sand was washed four to six times to leach out the ions before irrigating it with a freshly made medium. The required ECe values were adjusted by the addition of Analar grade NaCl. The part of salt treatment and mode of harvesting for each salt treatment varied slightly (Fig. 5).

Growth analysis included the study of different growth characters like, plant height, shoot length, root length, leaf area, fresh and dry weights of plants, panicle length, spikelet number and dry weights of filled and unfilled grains, biological yield, harvest index etc. The data were statistically analysed using either analysis of variance (with 5 replicates) or standard

Table 4. Composition of the nutrient medium (pH 5.2 and ECe 1.6 dSm^{-1})

	Element	Reagent	Conc. ppm
1.	N	NH_4NO_3	4Ø
2.	P	$NaH_2PO_4.2H_2O$	4Ø
3.	K	K_2SO_4	4Ø
4.	Ca	$CaCl_2$	4Ø
5.	Mg	$MgSO_4.7H_2O$	4Ø
6.	Mn	$MnCl_2.4H_2O$	Ø.5
7.	Mo	$(NH_4)_3 MO_7 O_2.4H_2O$	Ø.Ø5
8.	B	H_3BO_3	Ø.2
9.	Zn	$ZnSO_4.7H_2O$	Ø.Ø1
1Ø.	Cu	$CuSO_4.5H_2O$	Ø.Ø1
11.	Fe	$FeCl_3.6H_2O$	2.Ø

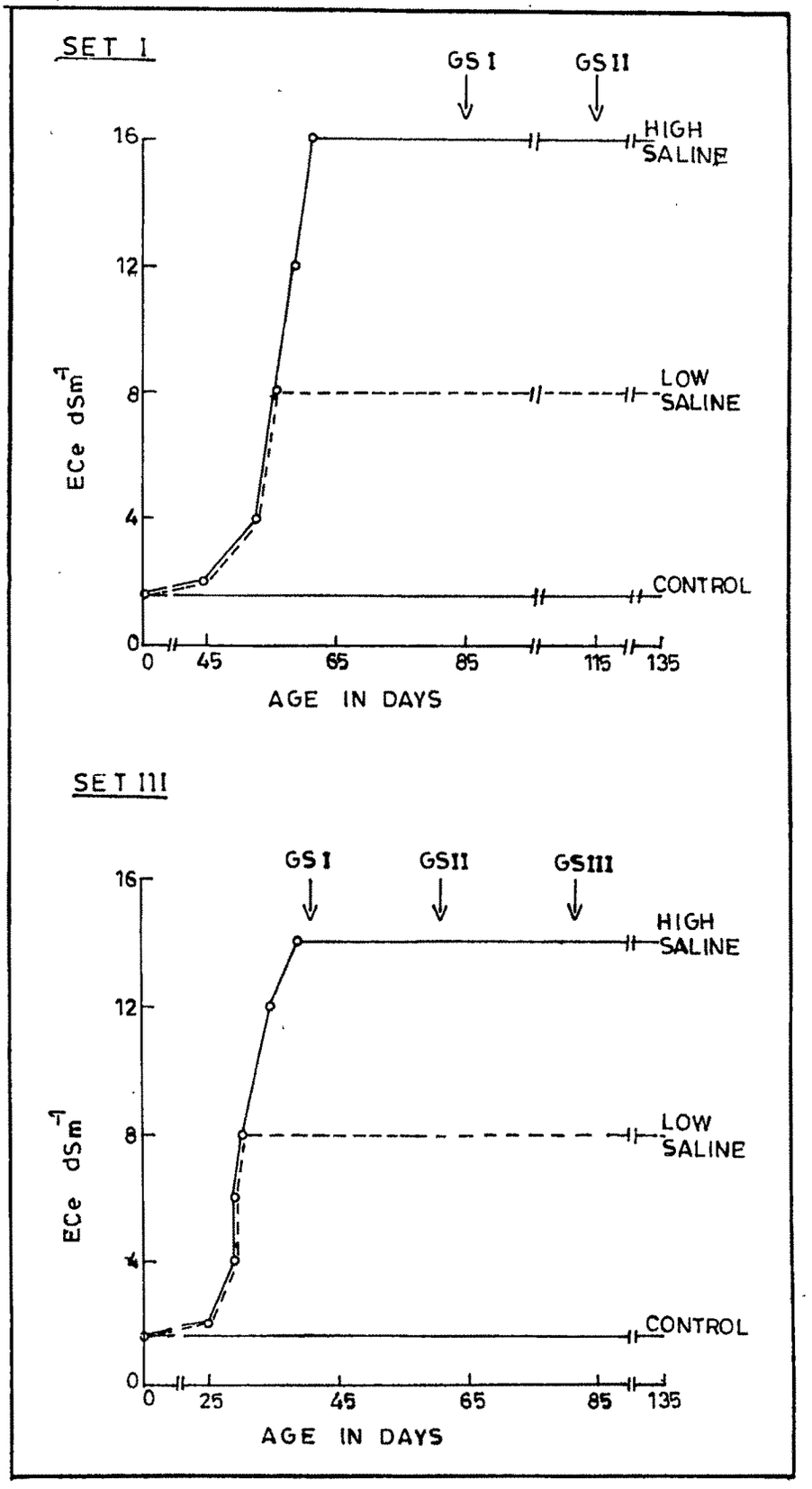
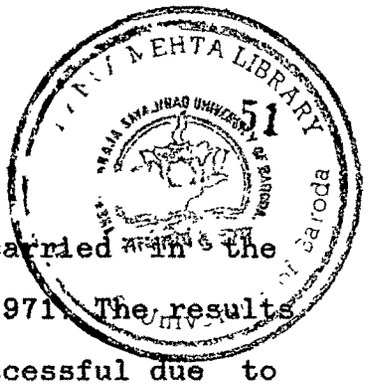


FIG.5. GRAPH ILLUSTRATING THE TREATMENT IMPOSITION DURING POT CULTURE EXPERIMENTS.



error (3 or 5 replicates). Pigments study was carried in the plants of set III using method of Sestak et al., 1971. The results of set II are not presented here as it was not successful due to severe adverse climatic factors.