annual report

CENTRAL SOIL SALINITY RESEARCH INSTITUTE
KARNAL (Haryana) INDIA, 132001

1972

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CONTENTS

INTRODUCTION

The Government of India constituted an Indo-American team in 1967 to assist in developing, under I.C.A.R. leadership, comprehensive water management research programme for the Fourth Plan Period. The team consisted of three Indian members viz. Dr. R.C. Hoon, Director, Central Water & Power Commission (Retired), Dr. S.D. Nijhawan, Agricultural Chemist, Punjab (Retired) and Sh. C.S. Sridharan, Deputy Agriculturel Commissioner and three Americans viz. Dr. C.E. Evans, Mr. S.J. Mech of U.S. Department of Agriculture, Agricultural Research Service and Dr. P.R. Stout of the University of California, Davis. This team recommended establishment of a national centre for research on salinity and alkalinity.

The Government of India considered these recommendations and decided to establish Central Soil Salinity Research Institute as a Fourth Plan project and the project was sanctioned vide I.C.A.R. letter No. F. 20-4/66-AI. III dated 13-3-1968. The Institute started functioning on 1-3-1969 at Hissar (Haryana) when the Director of the Institute joined. Later, on the recommendations of a committee constituted by the Director General, I.C.A.R., the Institute was shifted from Hissar to Karnal in October, 1969.

In February 1970, the Central Saline Rice Research Station Canning, West Bengal which was formerly part of the Central Rice Research Institute, Cuttack was transferred to this Institute vide I.C.A.R. letter No. 16-21/66-A.I. (II)/F.C. (1) dated 3-2-1970.

In June 1972, at the time of mid-term appraisal of the Fourth Five Year Plan the facilities at the Institute were strengthened. 19 additional posts of scientists were created and an additional amount of Rs. 28.00 lakhs for buildings was also sanctioned.

OBJECTIVES

In India large areas of land are rendered uncultivable because of salinity, alkalinity and water-logging. A conservative estimate indicates that nearly 7 million hectares of otherwise productive land is lying barren due to alkalinity and salinity.

The objectives of the institute are broadly to carry out research on the reclamation and utilization of salt affected soils and to evolve technology to arrest the further spread of such soils in the new areas coming under canal irrigation. Specifically the objectives of the institute are :

(i) to collect detailed information concerning the formation, distribution, extent and characteristics of salt-affected soils in different parts of the country ;

(ii) to conduct research on the methods of reclamation of salt-affected soils ;

(iii) to investigate the methodology and techniques of drainage of such soils ;

(iv) to investigate the feasibility of utilizing poor quality waters for irrigation of various crops under different soil and climatic conditions ;

(v) to conduct research on the effect of irrigation under varying conditions of soil, topography and geological formations on water table, salinity development and crop growth with a view to evolve optimum irrigation and water-use practices for arid and semi-arid areas ;

(vi) to evolve varieties of crop plants suitable for growing in salt-affected and water-logged areas ;

(vii) to investigate the physiological attributes responsible for salt tolerance in plants ;

(viii) to evolve suitable agro-techniques for growing crops on salt affected soils ; and

(ix) to collaborate with Agricultural Universities and other Central and State Research Institutes in the organization and development of soil salinity and water management research, training and extension programmes.

ORGANIZATION

The research in the Institute is conducted in its three Divisions (i) Division of Engineering (ii) Division of Genetics and Plant Physiology and (iii) Division of Soils and Agronomy. In addition, the institute has an extension unit, a library unit and farm unit. The Project Coordinator and the Coordination Cell of the Projects on, "Water Management and Salinity" and on "Use of Saline Water in Agriculture" are also located at Karnal. For research work on salt affected soils of coastal areas, the Institute has a sub-station at Canning, West Bengal. One of the Centres of the Water Management and Salinity Project is also functioning at Canning.

STAFF

At the time of mid-term appraisal in June 1972, 19 additional scientific and 4 other posts were sanctioned by the I.C.A.R. vide their letter No. 3-15/71-S & W dated 14.6.1972. For the extension work at the farmers' fields an Extension Unit was created but before the vacancies could be filled, recruitment was banned by the Council vide their letter No. 20-7/72-R.I. dated 7.10.1972. Dr. M.N. Sarin, who was the Head of the Division of Genetics and Plant Physiology, expired on 14.7.1972 after a short illness of 2 days. The institute suffered a great loss in his death. Dr. G.P. Bhargava, Junior Soil Scientist, was selected as Soil Scientist and joined the new post on 13.3.1972.

Shri S.K. Gupta, Senior Research Assistant was selected as Assistant Engineer (Drainage) and joined the new post on 1.4.1972.

The following members joined the institute during the year under report :

Division of Genetics and Plant Physiology

Dr. T.N. Singh (Plant Physiologist) 1.5.1972

Division of Soils and Agronomy

Dr. C.L. Acharya (Junior Soil Physicist) 3.2.1972.

Shri Milap Chand, Senior Research Assistant in the Division of Soils and Agronomy resigned his post to join the Punjab Agricultural University as a Ph.D. Scholar.

Sh. R.K. Bhattacharya, Plant Breeder continued to work at the Sub-station at Canning and Dr. A.K. Bandyopadhya, Soil Physicist was transferred to that sub-station on 1.5.72.

The staff position as on 31.12.72 is shown in appendix I.

PHYSICAL FACILITIES

Buildings

The institute continues to be located in a hired building. Additional funds for the construction of residantial and other buildings were sanctioned by the Indian Council of Agricultural Research and 33 houses (12 type I, 4 type II, 4 type III, 4 type IV, 4 type V and 5 type VI) are under construction.

Library

The library facilities were further developed during the year and as on 31.12.1972 the library had 4126 books and 1346 bound journals. The institute library contributes to 181 current journals (49 Indian and 132 foreign).

Farm

The institute has a farm of about 76 hectares, a large portion of which is affected by salinity and alkalinity and is subject to flooding during monsoon. The entire farm has now been laid out in fields, 100 m x 25 m size. Farm operations are mechanised and no bullock is used at the farm. The irrigation is provided by 4 cavity tube-wells and one deep tube-well. About 40 hectares of the farm has an underground water-conveyance system. To store excess run-off water three farm ponds with a storage capacity of 246 ha.cm. have been dug. The stored water is being used for irrigation during lean rainfall period in the monsoon season itself. Observation wells for continuous record of ground water table fluctuations have been installed at 100 m grid.

EDUCATIONAL PROGRAMMES

(a) U.N.D.P. Project on Post-graduate Education and Research

The institute had a collaborative programme with Haryana Agricultural University, Hissar on Water Management under the above project. The main objective of this projeet is to train post graduate students. One of the Ph. D. students of Haryana Agricultural University, Hissar in the above project will conduct his research work at this institute after completion of his course work.

(b) Summer Institute

A Summer Institute for College and University teachers and research workers on Saline and Alkali Soils and their Management sponsored by the Indian Council of Agricultural Research was conducted for the second year in succession. 20 teachers and research workers from different parts of the country participated.

(c) Ph. D. Programme

Under joint programme with Haryana Agricultural University and the Punjab Agricultural University three students (2 from Haryana Agricultural University and I from Punjab Agricultural University) worked in the institute on their research projects for Ph. D.

(d) Conferences

A meeting of the Senior Scientists engaged in research in the Use of Saline Water in the States of Punjab, Haryana,U.P. and Gujarat was convenedi from February 21 to February 22, 1972. After thorough discussions, criteria to be used for judging the suitability of water for irrigation were adopted.

VISITS ABROAD

(1) Dr. I.P. Abrol, Head, Division of Soil Science and Agronomy visited U.S.A. as an Andre Mayer Senior Fellow for a period of 8 months from April 1972 to December 1972.

(2) Dr. K.S. Dargan, Agronomist visited U.S.S.R. for one month (18.11.1972 to 18.12.1972) to study the work on saline soils in that country.

(3) Dr. D.R. Bhumbla, Director, visited Iraq in October 1972 as a member of the Indian delegation to help Iraq in the development of their agriculture.

(4) Dr. D.R. Bhumbla, Director and Dr. I.P. Abrol, Head, Division of Soil Science and Agronomy participated in the International Symposium on Salt Affected Soils held at Cairo, Egypt from 4.12.1972 to 9.12.1972.

(5) Dr. R.K. Rajput. Agronomist visited Laos for a period of six weeks as an expert member of a team to study the feasibility of a lift irrigation project.

Foreign Experts

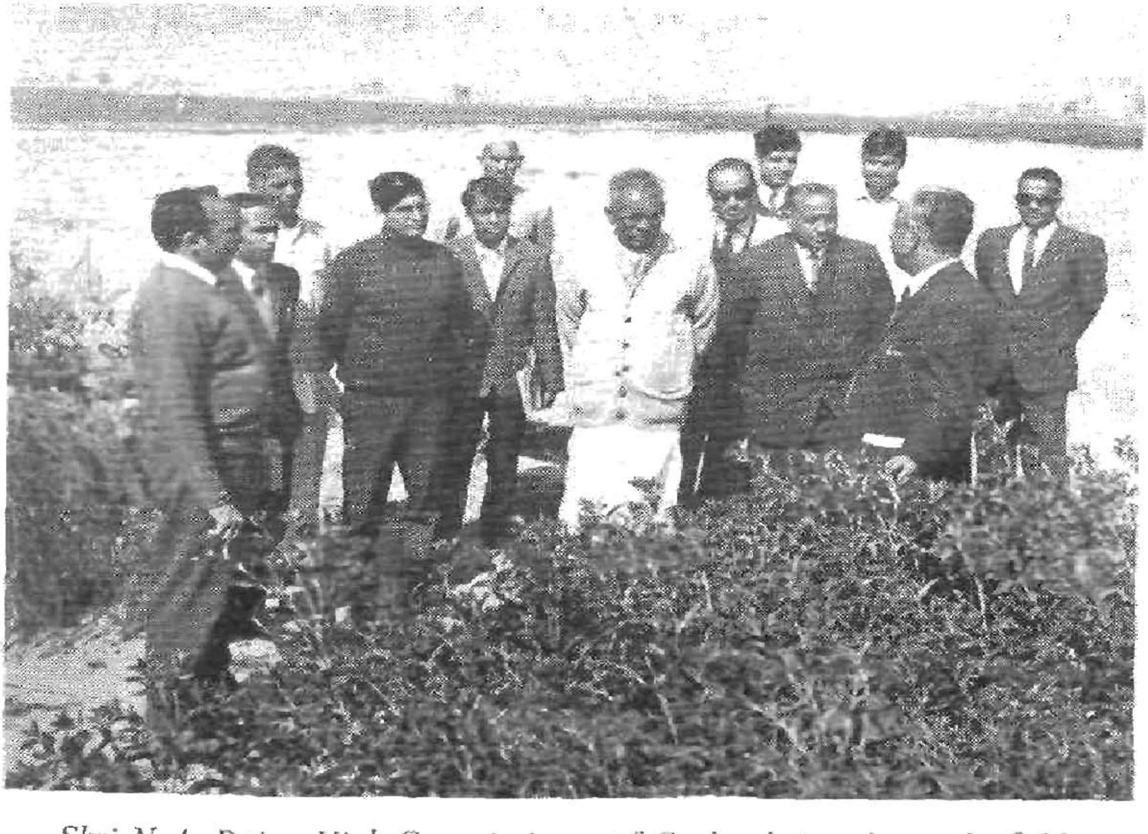
Dr. J.W. Kijne who came as an Expert on Irrigation to HAU, Hissar under UNDP project visited the Institute.

VISITORS

The list of the important persons who visited the Institute is given in appendix II.

Research work in Plant Physiology being explained to Dr. M.R. Swaminathan, Director-General, I.C.A.R., New Delhi

Visit of the Members of the Parliament to the Institute.



Shri N.A. Dais, High Commissioner of Ceylon being shown the field experiments during his visit to the Institute.

Farmer's Day

During the year 1972 the institute organised two Farmers' Days one on 17.3.1972 and the other on 29.9.1972 where more than 2000 farmers participated.

Finance

The expenditure figures for the financial year 1971-72 are given below :

Sr. No.	*Head*	*Expenditure (Rs.)*
1.	Staff	4,64,206
2.	Other charges	8,92,576
3.	Buildings	3,47,033
	Total :	17,03,815

Weather

The mean monthly values of weather elements recorded in the Institute's Weather Station during the year 1972 are summarized in Table 1. The subnormal values of maximum temperature during March and April and of minimum temperature during April were favourable for the growth of *rabi* crops, particularly cereals and forages. The maximum and minimum temperatures during other months of the year under review were normal. The relative humidity during February, March, April, November and December was more than the normal values whereas the months of May and June were comparatively drier and the evaporative demand of the atmosphere was the highest.

The data on rainfall and evaporation reveal that there was a net deficit of about 1500 mm during the year under review. The net deficit during April, May and June accounts for about 1100 mm. The rainfall during January, February and March, though slightly subnormal, was very helpful for the growth of standing *rabi* crops and resulted in saving of irrigation water. The onset of monsoon rainfall was timely and the sowing of *kharif* crops could be accomplished on stored moisture. Not only the rainfall during July and August was very much higher than the normal but the distribution was very erratic. The heavy downpour of 166 mm and 101 mm received on 8th and 12th July respectively, and of

Technology developed at the Institute for reclamation and utilization of salt affected soils being explained to farmers on Farmer's day.

TABLE 1. *Mean monthly weather conditions at Central Soil Salinity Research Institute, Farm Karnal During 1972.*

Longitude—76°58'E　　Latitude—29°43'N　　Elevation 245 m a. s. l.

Months	Temperature-(°C)			Relative Humidity (%)		Vapour Pressure (mm of Hg)		Rain fall (mm)	No of rainy days	Evaporation from open pan		Sun Shine (Hrs/day	(Wind speed (km/h
	Max.	Min	Average	I	II	I	II			(mm/month)	(mm/day)		
January	19.8	6.9	13.3	87	36	6.5	6.3	7.8	2	74	2.4	*	*
February	22.2	6.4	14.3	84	34	6.6	5.9	23.5	4	116	4.0	*	*
March	26.5	13.6	20.1	81	29	10.0	8.5	12.7	2	183	5.9	*	*
April	32.1	16.5	24.3	65	20	11.0	7.3	12.2	4	282	9.4	*	*
May	39.3	23 2	31.3	34	08	9.5	5.1	0.0	—	484	15.6	*	*
June	39.3	26.4	32.9	48	28	15 1	13.0	45.8	2	408	13,6	*	*
July	33.6	26.7	30.2	76	59	22.1	22.4	315.1	7	198	6.4	*	*
August	31.5	25.6	28.6	85	65	22.5	22.0	330.0	14	140	4.5	*	*
Sept.	32.2	21.5	26.9	79	49	18.1	17.0	4.4	2	150	5 0	*	*
Oct.	30.5	16.0	23.3	81	42	13.5	11.0	28.4	1	136	4.4	10.2	6.0
Nov.	25.8	11.4	18.6	91	59	11.1	14:9	28.7	4	84	2.8	9.5	5.4
Dec.	20.7	8.0	14.4	94	63	8.4	11.4	2.1	2	59	1.9	8 2	6.4
							Total :	810.7	44	2314			

I = First reading at 0722 hrs. IST
II = Second reading at 1422 hrs. IST

*Data not available

74 mm and 20 mm received on 24th and 25th August respectively resulted in temporary waterlogging and considerable water was lost as run-off. The intense dry spell which prevailed between 13th July and 8th August necessitated supplimental irrigation to save crops from moisture deficiency. September was practically dry. The rainfall during November resulted in delayed sowing of wheat in rice-wheat rotation, particularly on salt affected soil by about 3 weeks, though it was beneficial to early sown crops.

DIVISION OF SOILS AND AGRONOMY

S. A. 1. 1 : Studies on optimum combination of leaching practices for the removal of salts from saline sodic soil. (I. P. Abrol and D. R. Bhumbla).

(a) An experiment was started in summer 1970 in a soil which had high exchangeable sodium percentage (50-80) to a depth of 180 cm. The salt content was high only in the upper 45 cm (ECe 6.20—10.34) Sodium was the prodominant cation and carbonate and bicarbonate the predominant anions. The treatments consisted of combination of 3 methods of water application (continuous ponding, alternate ponding with 7.5 cm standing water and alternate ponding with 15.0 cm water) and two levels of gypsum application (0 and 14.5 t/ha). As reported earlier (Annual Report, 1970) continuous and alternate ponding of water did not show significant difference in salt removal which was attributed to the poor permeability of these soils resulting in unsaturated movement of soil water even under ponded conditions. But the application of gypsum greatly increased the efficiency of leaching.

The experiment was continued without any leaching treatment. Rice and wheat were grown in rotation. The yields of paddy and wheat are given in Table 2.

TABLE 2. *Yield of paddy and wheat as affected by gypsum application (q/ha)*

Treatment	Paddy		Wheat	
	1971	1972	1971	1972
No gypsum	45.1	54.8	21.4	33.4
Gypsum @ 14.5 t/ha	55.1	63.9	32.3	44.5
C. D. at 5%	4.00	5.25	4.79	7.37

It would be observed that the yield of paddy increased in the second year in both gypsum treated and untreated plots. The increase may be attributed to the increased solubility of soil calcium carbonate and resultant decrease in exchangeable sodium.

Soil samples were again taken to a depth of 180 cm in November. 1972 and analysed for pH, E.C. and exchangeable cations (NKCl extractable). The data for pH and E.C. from representative plots are given in *Fig. 1 and 2.*

It is apparent that in gypsum treated plots, as expected, the pH is lower in the surface layer by about 0.5 units but considerable improvement in this respect has been observed even in lower layers (upto a depth of 60 cm).

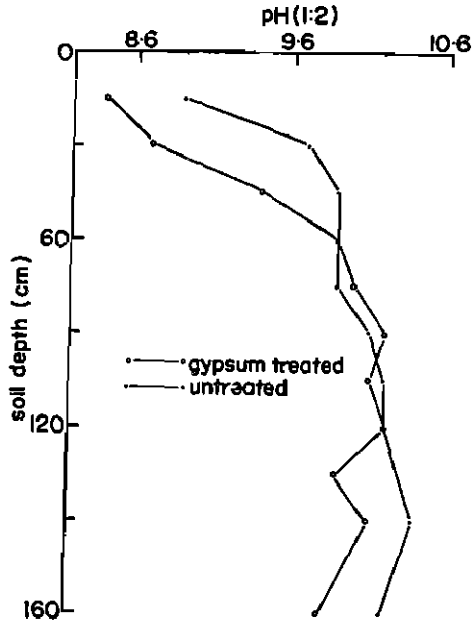
It is interesting to observe that with three years of cropping the peak salt concentration which was at the surface to begin with is now at a depth of 150-180 cm in the case of gypsum untreated plots while in the case of gypsum treated plot, salts got leached beyond 180 cm. This indicates that with continuous cropping and rice as a crop in the rotation salts once leached to lower layers are not likely to move upwards to the surface.

S. A. 1. 11 : Dynamics of calcium—sodium exchange under unsaturated flow condition (I. P. Abrol and I. S. Dahiya).

Leaching of soluble salts is one of the important aspects of the management of salt affected soils. Several studies have shown that the efficiency of salt leaching can be considerably improved by controlling the degree of water saturation and flow rate of water through the soil. In addition to the leaching of salts, replacement of exchangeable sodium by more favourable calcium is attempted for the reclamation of saline sodic soils. In this case leaching is often accomplished after the application of an amendment to the soil. The purpose of this investigation was to see how water application rate and consequently the degree of water saturation influences the exchange of sodium for calcium in saline sodic soils. For the purpose of this study a highly saline sodic soil collected from the farm of the Central Soil Salinity Research Institute, was leached with calcium containing water at different flow velocities and the resulting moisture and exchangeable calcium distribution in the columns was studied. Results in *Fig. 3* show that with decreasing degree of saturation obtained from controlled leaching, there was comparatively lesser exchange of sodium by calcium compared to conditions where flow rate was not restricted. From this similarity between experimental moisture and exchangeable calcium profiles, it would appear that effective exchange capacity decreased nearly proportionally with a decrease in degree of water saturation. Reasons for such decreased calcium exchange capacity under unsaturated flow conditions are under investigation.

S. A. 1. 12 : Studies on the precipitation of soluble sodium carbonate in sodic soils (I. P. Abrol and I. S. Dahiya).

Saline-sodic soils occurring in many parts of the world contain substaintial quantities of soluble sodium carbonate. When an amendment (soluble calcium salt) is added to the soil surface and soil leached,



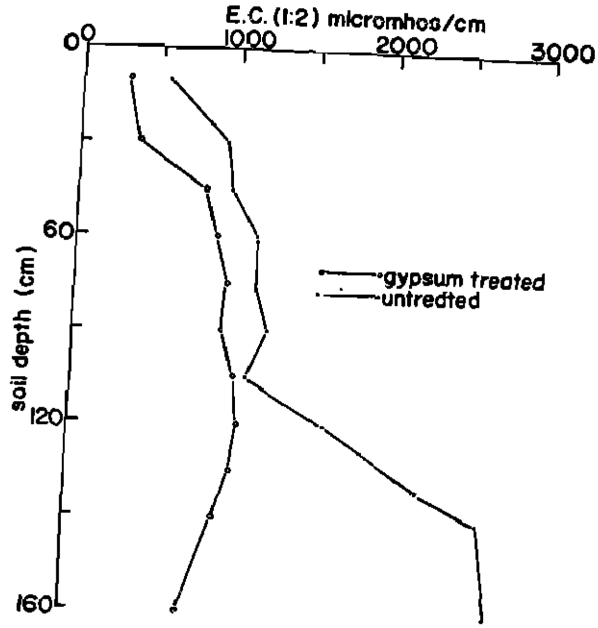


Fig. 1 & 2. pH and EC of soil profile in gypsum treated and untreated plots

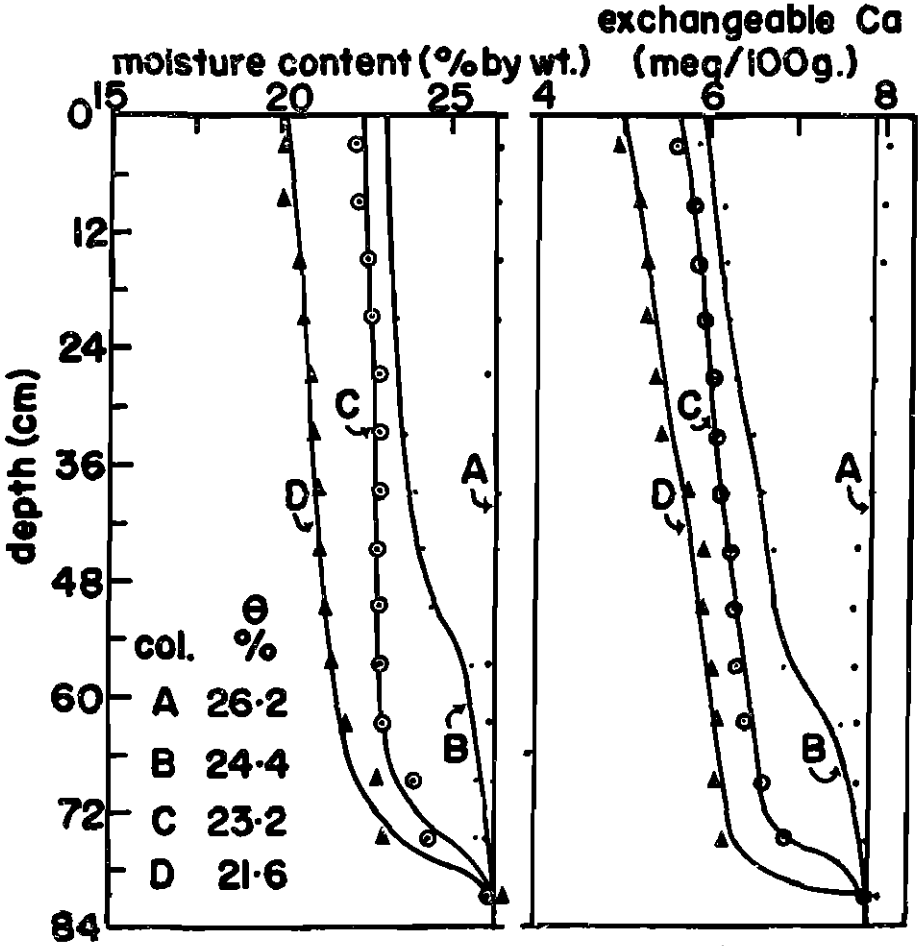


Fig. 3 : Effect of degree of saturation obtained by controlled leaching on exchange of sodium by calcium.

a fraction of the added calcium salt reacts with soluble carbonates, forming relatively insoluble calcium carbonate. A laboratory experiment was, therefore, conducted in columns by leaching a highly saline-sodic soil (pH 10.0, ESP 100, soluble carbonates 7.8 meq/100 g) with calcium containing water to study the effect of (a) flow velocities and degree of water saturation and (b) calcium concentration in the leaching water on the extent of carbonate precipitation.

The results showed that with increasing (a) flow velocity and degree of soil saturation (Fig. 4) and (b) the concentration of calcium in the leaching solution. there was an increased precipitation of soluble carbonates in the soil. It is suggested that by controlling the extent of carbonate precipitation, the quantity of calcium containing amendment necessary for the reclamation of sodic soils rich in soluble carbonates could

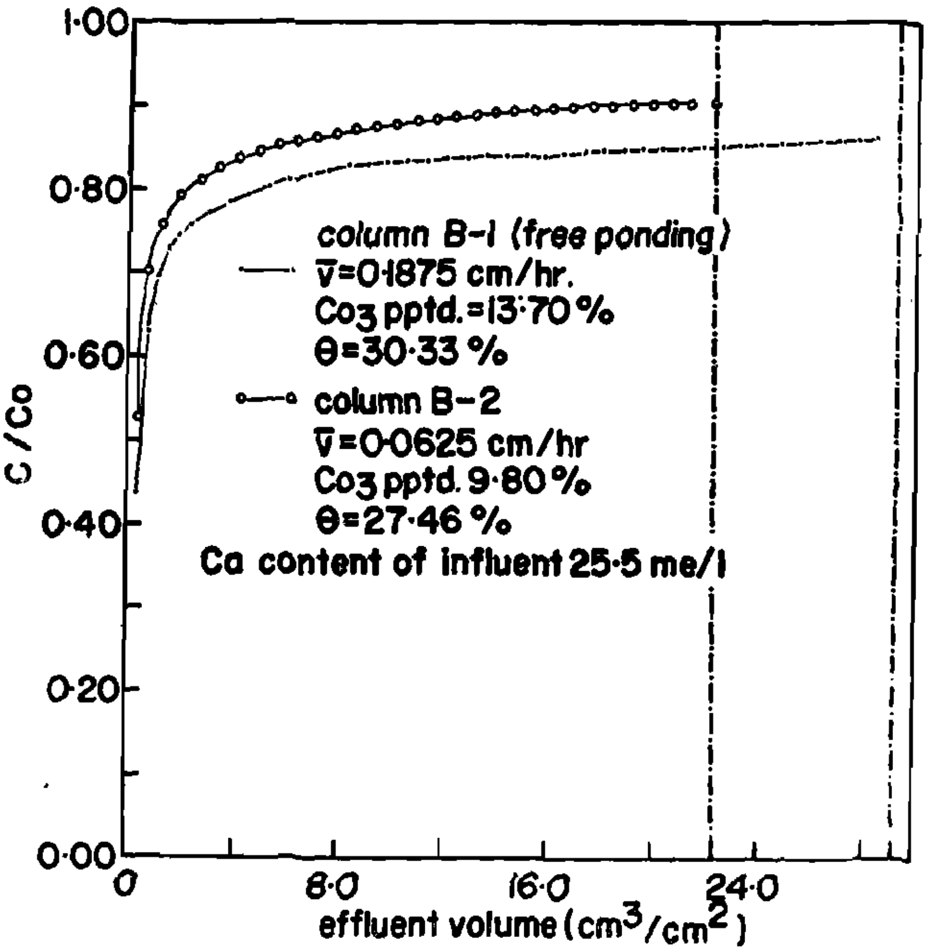


Fig. 4. Effect of flow velocity and degree of soil saturation and concentration of Calcium in soil solution on precipitation of soluble Carbonates.

be considerabley reduced. The results of this experiment have also revealed that the usual method of determining the gypsum requirement of soils (Schoonover, 1952) tends to considerably overestimate the gypsum needs of these soils since a large portion of the soluble carbonates gets leached unreacted with the added gypsum.

S. A. 1. 13 : Effect of mulches and gypsum on salts and moisture distribution and crop growth in a saline-sodic soil. (I. P. Abrol and O. P. Dhankar).

In salt affected soils experiencing monsoon type climate the salts get leached to lower soil depths in the rainy season and again move the soil surface in the post monsoon season in response to atmospheric evaporative demand. A field experiment was undertaken to investigate the effect of surface applied mulch on the salt and moisture distribution following the leaching of salts in the rainy season. The treatments consisted of three depths of rice husk i.e. 3, 5 and 8 cm mulch and a control plot. In one set of plots gypsum was applied @ 12.5 t/ha in June 1971. Periodic observations on the moisture and salt distribution in the soil profile were made. In July, 1972 rice was grown to see the effect of treatments on crop performance. The results of the experiments are summed below.

(1) Monsoon leaching resulted in reduced salt concentration in the surface 55 to 60 and 70-85 cm soil depth in gypsum untreated and treated plots. Leaching to lower soil depths in gypsum treated plots occurred due to improved permeability and conseqently greater amount of water infiltrated in gypsum treated plots.

(2) Upward rise of salts in the post monsoon season decreased with increase in mulch thickness and in 5 and 8 cm mulched treatments, there was practically no upward movement of salts. This was due to lower soil moisture gradients and moisture flux in mulched plots compared to unmulched plot. An upward flux of 7, 22 and 26 cm of water was calculated for 5, 3 and 0 cm depth of mulch respectively during the period September 22 to May 15.

(3) Leaching af soluble salts during monsoon resulted in reduction of soil pH due primarily to leaching of sodium carbonate and bicarbonate and the possible release of calcium from native calcium carbonate.

(4) Data on crop yield shown in Fig. 5 for different treatments show that paddy yield increased with increasing depth of mulch applied. Crop yield was found to be related to changes in soil pH and exchangeable calcium in the surface 30 cm of soil.

S.A. 1.2 : Effect of water table, rainfall and evaporation on the distribution of salts in saline sodic soils (O.P. Dhankhar and I.P. Abrol).

Moisture content and suction changes in a normal and a sodic soil under natural conditions were followed with a view to characterize the direction and rate of water movement in two soils during different periods of the year. Table 3 gives changes in moisture content during the the period 2.10.1971 to 12.5.1972 in a normal and a sodic soil.

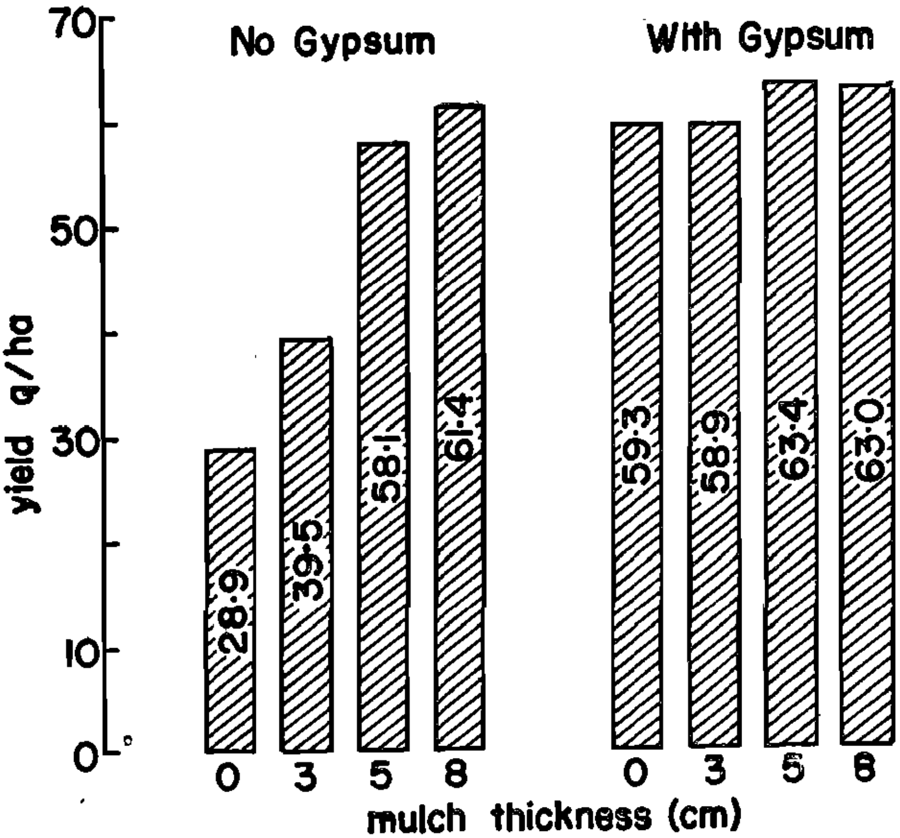


Fig 5. Effect of mulch thickness on the yield of paddy.

TABLE 3. *Moisture content changes in a normal and a sodic soil (per cent).*

Depth	Normal soil		Sodic soil	
(cm)	2.10.71	12.5.72	2.10.71	12.5.72
0- 15	13.53	4.43	13.53	6.20
15- 30	15.90	7.95	17.08	13.75
30- 45	16 90	8.25	18.96	16.69
45- 60	18.08	9.00	19.17	18.65
60- 75	19.34	9.60	20.68	20.62
75- 90	19.92	11.22	21.62	21.10
90-120	22.18	13.16	22.63	21.95
120-150	23.40	14.28	22.75	22.28

These data show comparatively rapid loss due to evaporation from normal compared to the sodic soil and is due to the poor transmission characteristics of sodic soils at different moisture contents. Hydraulic conductivity of the two soils at different suctions was evaluated. The data are given in Table 4.

TABLE 4. *Hydraulic conductivity of a normal and a sodic soil.*

Normal soil		Sodic soil	
Suction (cm)	K (S) (mm/day)	Suction (cm.)	K (S) (mm/day)
0	526.00	0	21.30
90	21.48	140	4.60
110	11.55	240	1.11×10^{-1}
125	6.52	357	4.13×10^{-2}
130	5.96	400	3.50×10^{-2}
160	2.98		

Evaluation of suction gradients showed that water flux continued to be in the direction of water table till the latter was deeper than 130 cm from the soil surface. This and the low transmission rate of sodic soils prompts to the conclusion that contribution from the ground water table in these areas may not be a major factor in the formation of these soils.

S.A. 1.3 : Studies on the improvement of permeability characteristics of sodic soils. (C.L. Acharya and I.P. Abrol)

To improve the permeability of sodic soils addition of sand is a common practice with many farmers. Experimental evidence of the effect of such additions on the physical improvement of soils is lacking. A study was, therefore, conducted in the laboratory to evaluate the effect of addition of varying quantities of sand on the permeability of a highly sodic soil (pH_2=10.2). Measurements of water flux through sand-soil mixtures was evaluated in metallic cores 7.5 cm diameter and 11.2 cm high maintaining constant water head.

Data showed that in mixtures containing large fractions of sand, there was a sharp decrease in water flux with time. Further increase of soil in the mixture did not show much difference in the water flux and was nearly constant at 0.1 cc/hour which was nearly the same for the soil alone. Changes in water flux as a result of mixing sand were expecteu to result from changes in pore size distribution and their continuity (Table 5).

TABLE 5. *Percentage of pores drained at vari.us suctions*

Mixture (Sand: Soil) composition	Suction (bar)		
	1/10	1/3	1/2
7:1	35	37	38
6:2	29	34	36
4:4	26	33	34
1:7	12	19	26

A high initial water flux and its sharp decrease with time in mixture containing a large fraction of sand indicates that the improvement in the hydraulic conductivity of the mixture is lost rapidly. Since the soils have pre-dominantly non-expanding type of clays the mechanism of swelling of clay particles does not seem to contribute much towards the major decrease in water flux. Because of their dispersed nature, it is likely that clay particles get physically displaced and block the pores created by the addition of sand particles. Fig. 6 depicts the ratio of water flux obtained in the first 15 minutes to the nearly constant flux obtained over prolonged periods for different sand soil mixtures. It is clear that the decrease in water flux is most rapid where the initial water flux is also high. Since high initial water flux would favour greater displacement of clay particles the results tend to indicate that the clay displacement is the chief cause of reduced water flux in mixtures containing large amounts of sand.

It would, therefore, appear from these preliminary studies that addition of sand in quantities usually practised in saline sodic soils is not likely to result in substantial improvement in their permeability characteristics.

S.A. 1.31 : Effect of depth of mixing gypsum on soil properties and yield of crops. (B.K. Khosla and I.P. Abrol).

As reported earlier (Annual Report 1971) a field experiment was conducted in a highly sodic soil to see the effect of mixing gypsum in diffe-

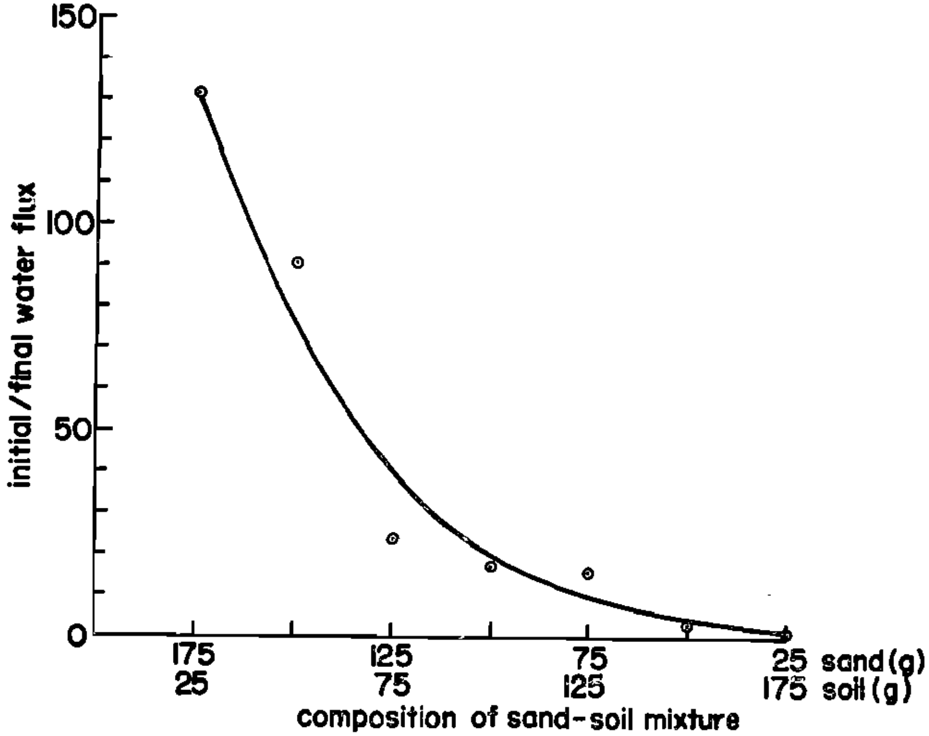


Fig.6. Effect of sand-soil mixture on the ratio of initial/final water flux.

rent soil depths on soil properties and crop growth. Treatments of all combinations of three levels of gypsum (0, 13.5 and 27.0 t/ha) and three depths of mixing (10, 20 and 30 cm). Yields of barley and paddy, reported earlier, indicated that mixing gypsum in soil depths greater than 20 cm resulted in lowering the crop yields. The experiment was continued during 1972 in the same plots with wheat and cotton. Yield data are given in Table 6 and changes in soil properties in Table 7. These data again show that deeper mixing of gypsum is not helpful because of the dilution of applied gypsum.

TABLE 6. *Effect of gypsum levels and depth of mixing on the yield of wheat and cotton.*

Gypsm level (t/ha)	Depth of mixing (cm)	Yield (q/ha)	
		Wheat	Cotton
0	10	20.4	2.58
	20	17.7	0.85
	30	9.3	1.53
13.5	10	32.8	4.62
	20	31.6	5.64
	30	20.0	3.64
27.0	10	36.8	8.74
	20	36.8	6.39
	30	35.3	7.58
C. D. at P=0.05		4.1	1.66
S. Em ±		1.35	0.81

TABLE 7. *Some soil properties after wheat 1971-72*

Treatment		pH_2			EC_2		
		Soil Depth (cm)			Soil Depth(cm)		
Gypsum (t/ha)	Depth of mixing (cm)	0-10	10-20	20-30	0-10	10-20	20-30
0	10	9.55	10.06	10.23	0.51	0.81	1.09
	20	9.67	10.20	10.30	0.64	0.94	1.16
	30	9.58	10.10	10.18	0.62	0.88	1.06
13.5	10	9.02	9.58	9.90	0.34	0.60	0.77
	20	9.22	9.75	10.00	0.61	0.73	0.76
	30	9.47	9.88	9.83	0.43	0.80	1.39
27.0	10	9.00	9.72	10.10	0.33	0.66	0.92
	20	9.07	9.38	9.55	0.40	0.51	0.55
	30	8.65	9.08	9.42	0.24	0.36	0.67

S.A. 1.4 : Effect of different amendments on physical and chemical properties of saline sodic soils and crop growth. (Milap Chand, I.P. Abrol and D.R. Bhumbla).

An experiment to study the effect of different amendments on soil properties and crop growth was initiated in *rabi* 1970 with barley as the test crop. Changes in some soil properties and the yield of subsequent paddy crop were reported earlier (Annual Report 1970). Yield of barley and subsequent crops grown in the same layout are given in Table 8. pH of O—15 cm soil samples taken after wheat 1971-72 is given in Table 9.

In the first crop of barley control plots gave practically no yield (0.21 q/ha). Sulphuric acid, gypsum and aluminium sulphate treated plots all gave high yield of barley and the yield was not significantly different from each other. Yield from pressmud (C) and F.Y.M. treated plots was the lowest. Application of pressmud (S) at high dose gave a yield of 11.7 q/ha of barley. High yield of subsequent paddy crop was obtained in all the treatment including control plots which gave a yield of 42.4 q/ha. Yield data in respect of subsequent wheat and paddy crops showed that the differences in yield between control and treated plots further narrowed down. Data on pH of surface soil samples after wheat 1971-72, however, shows that degree of soil improvement was much more in sulphuric acid, gypsum, aluminium sulphate and ferrous sulphate treated plots compared to those treated with the two pressmuds and farm yard manure. The results show that when applied in equivalent quantities the effect of sulphuric acid, gypsum and aluminium sulphate on soil properties and crop growth is likely to be comparable and that choice of particular amendment will therefore depend on the prevailing cost of these amendments.

S.A. 2.1 : Optimum quantity of gypsum for the improvement of sodic soils. (D.R. Bhumbla and I.P. Abrol)

An experiment was started in June, 1970 in a soil which had pH higher than 10.0 to a depth of about 150 cm. The soil was nearly saturated with sodium. Gypsum requirement as determined in the laboratory was 60 t/ha. Electrical conductivity of the saturation extract was 8-16 mmhos/cm in the upper 45 cm with sodium carbonate as the predominant salt. Texture varied from sandy loam at the surface to clay loam in lower layers.

Gypsum was applied at the rate of 7.5, 15.0, 22.5 and 30 t/ha. Paddy and wheat/barley were grown in rotation. Data for grain yield of rice (paddy) and wheat for the first year were reported in the last years' report.

TABLE 8. *Yield of crops (q/ha) as affected by different amendments*

Level*	Sulphuric acid	Nitric acid	Pressmud (C)	Pressmud (S)	Gypsum	F.Y.M.	Aluminium sulphate	Ferrous sulphate
Barley 1970-71 (Control Yield 0.21)								
33% GR	26.2	25.4	1.2	3.1	23.9	1.3	23.7	18.4
66% GR	34.8	25.3	0.9	3.5	32.1	1.4	33.7	24.6
100% GR	35.1	25.1	1.0	11.7	36.6	5.9	36.1	35.7
Paddy 1971 (Control Yield 42.4)								
33% GR	70.8	60.6	57.8	68.5	57.2	69.3	54.6	63.9
66% GR	69.1	68.9	57.0	67.8	59.1	69.9	60.2	65.6
100% GR	75.6	76.2	53.3	73.5	71.4	77.6	77.6	74.3
Wheat 1971-72 (Control Yield 15.5)								
33% GR	20.8	21.2	19.2	17.8	20.2	17.2	14.9	19.0
66% GR	18.7	21.7	14.2	16.8	22.1	15.9	21.9	21.7
100% GR	25.2	23.7	21.4	22.6	26.1	21.0	28.6	23.8
Paddy 1972 (Control Yield 70.4)								
33% GR	75.5	74.5	76.1	76.8	72.8	77.8	69.3	80.7
66% GR	73.2	80.6	80.0	73.5	73.0	74.6	73.8	71.8
100% GR	81.9	81.3	80.6	85.0	82.1	87.1	79.7	78.0

* See Annual Report 1971 for exact amounts of different amendments added.

TABLE 9. *pH of 0-15 cm soil after wheat crop (April, 1972)*

Level	Gypsum	Sulphuric acid	Nitric acid	Aluminium sulphate	Ferrous sulphate	Pressmud (S)	Pressmud (C)	F.Y.M.
33% GR	9.12	9.41	9.36	9.41	9.12	9.20	9.52	9.56
66% GR	9.01	9.23	9.00	9.05	9.02	9.17	9.40	9.62
100% GR	8.73	8.87	9.05	8.82	8.66	9.46	9.53	9.16

pH of untreated plots=9.58

The grain and straw yield of paddy and wheat for the second year are reported in Table 10.

TABLE 10. *Effect of gypsum application on yield of paddy and wheat.*

Gypsum levels t/ha	Wheat 1971-72	Paddy 1972
0	31.7	69.9
7.5	36.3	72.0
15.0	40.2	72.8
22.5	37.7	69.8
30.0	38.7	71.9
C.D. at 5%		N.S.

During the second year the effect of the application of gypsum on the yield of paddy was not significant though the highest yield was obtained in the treatment where gypsum at the rate of 15.0 t/ha was applied.

The increase in the yield of wheat even during the second year was more than 8 q/ha in the treatment where gypsum at the rate of 15.0 t/ha was applied. In barley the difference between levels of gypsum except the highest were non-significant.

The changes in the pH, E.C. and ESP of the soil in 0-15 cm and 15-30 cm are reported in Tables 11 and 12.

TABLE 11. *Effect of the application of gypsum on pH, E.C. and ESP of the soil 0-15 cm depth.*

Gypsum (t/ha)	pH (1:2)			E.C.(1:2)mmhos/cm			ESP		
	11/70	11/71	11/72	11/70	11/71	11/72	11/70	11/71	11/72
0	10.2	9.6	9.1	0.88	0.77	0.53	72.3	42.2	24.2
7.5	9.8	8.9	8.6	0.68	0.70	0.64	43.6	27.3	17.8
15.0	9.5	9.0	8.6	0.92	0.85	0.50	32.9	22.9	21.4
22.5	9.2	8.6	8.6	0.65	0.83	0.54	21.2	18.8	9.8
30.0	9.2	8.7	8.5	1.16	1.14	0.45	19.1	12.8	13.6

TABLE 12. *Effect of the application of gypsum on pH, E.C. and ESP of the soil 15-30 cm depth.*

Gypsum	pH (1:2)			E.C. (1:2)mmhos/cm			ESP	
(t/ha)	11/70	11/71	11/72	11/70	11/71	11/72	11/71	11/72
0	10.4	10.0	10.0	1.12	0.71	0.74	74.3	66.8
7.5	10.3	9.9	9.6	1.11	0.60	0.62	63.2	57.1
15.0	10.3	9.6	9.7	1.11	0.60	0.62	41.9	51.6
22.5	10.2	9.2	9.2	0.98	0.51	0.41	37.7	30.9
30.0	10.1	9.3	9.2	1.16	0.55	—	39.2	39.5

The application of gypsum as expected resulted in considerable reduction in the pH and ESP of surface soil. Even in the lower layers there has been gradual improvement particularly in the gypsum treated plots. The data further indicate that rice can grow satisfactorily at an ESP value of 45 but for wheat the ESP should be lower than 30 (Fig. 7).

S.A. 2.2 : Effect of quality of irrigation water on soil properties and plant growth (Daya Ram, R.C. Mondal and I.P. Abrol).

In many arid and semi-arid regions of the country saline ground waters contain appreciable quantities of nitrates in addition to the usual salts. It is believed that nitrates might have some counteracting effect of salinity of irrigation water on crops. A pot experiment with four levels of EC of irrigation water (2000, 5000, 10,000 and 15,000 micromhos/cm) and four nitrate levels (0, 1/24th, 1/12th, 1/6th part of total anions) was initiated in July, 1971 with Jowar fodder as test crop. Data for jowar fodder, was reported last year. Subsequently wheat and maize fodder, were grown in these pots. The yield data for wheat straw and grain and maize fodder presented in Tables 13 to 15.

TABLE 13. *Wheat straw yield (g/pot)*

EC	Nitrate levels (Parts of total anions)				Mean
μ mhos/cm	0	1/24th	1/12th	1/6th	
2000	60.3	66.3	69.2	74.4	67.5
5000	62.8	75.8	72.0	73.9	71.1
10000	58.7	66.2	68.7	78.8	68.1
15000	44.8	49.0	61.2	71.5	56.6
Mean	56.6	64.3	67.8	74.6	

CD at 5% for Nitrates or E. Conductivity 3.8; Interaction 7.5

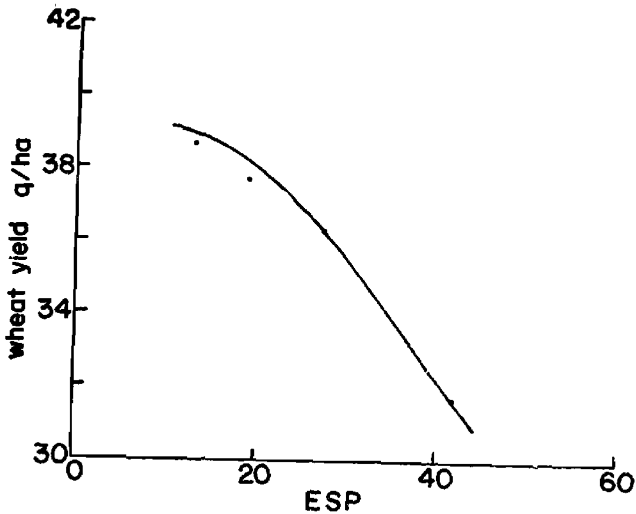
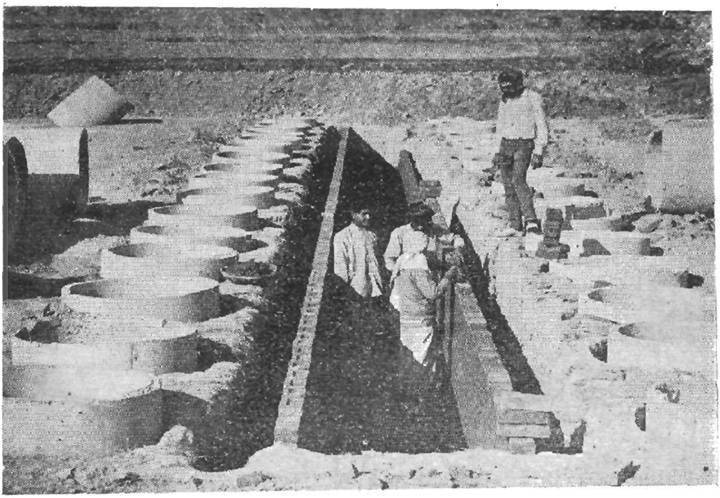


Fig. 7. Relation between ESP and grain yield of wheat

TABLE 14. *Wheat grain yield (g/pot)*

EC	Nitrate levels (Parts of total anions)				Mean
μ mhos/cm	0	1/24th	1/12th	1/6th	
2000	69.3	73.3	77.5	78.0	74.5
5000	72.2	75.4	74.0	73.2	73.8
10000	60.5	61.2	59.8	64.3	61.2
15000	47.5	43.9	50.9	51.4	48.4
Mean	62.4	63.4	65.2	66.7	

CD for Nitrates or E. C. 3.1



Lysimetric set-up for experiments on use of saline water for irrigation.

TABLE 15. *Maize fodder yields (g/pot)*

EC (micromhos/cm)	Nitrate levels (Parts of total anions)				Mean
	0	1/24th	1/12th	1/6th	
2000	231	366	393	427	354
5000	157	170	180	185	173

The results indicate that nitrates significantly increased the wheat straw yield. The yield values in the highest level of nitrate (i.e. 1/6th part) are not statistically different at various values of EC of irrigation water treatment. Thus at this level of nitrogen the otherwise depressing effect of EC is levelled off (Table 13). In case of grain such effect could not be reflected, however treatments with 1/6th part of nitrate resulted in statistically higher yield over control.

Poor reflection of the results of increased straw on grain yield could partly be due to the delayed maturity brought about by high nitrates and abrupt rise of temperature resulting in shrivelled grain formation, which was also a common feature in all the nitrate treatments. Grain yield declined almost linearly beyond EC 5000 (Fig. 8)

The maize fodder crop was allowed to establish for 15 days with good quality water. After two irrigations of 3 cm each with different quality waters the crop completely failed at EC 10,000 and 15,000 micromhos/cm and there occurred 50% reduction in fodder yield at 500 compared with yield when water of EC 2000 was applied. Nitrates appeared to have promoting effect on fodder yield at both the levels of salinity of water. This effect was much pronounced at zero and slight at 5000 (Table 15). An abrupt drop in yield at 5000 and complete failure of crop at 10,000 and 15,000 EC of irrigation water is ascribed to salts build up in the pots. After the harvest, the soil attained EC (1 : 2) of the following order.

ECi (*μmhos*)	EC_2 (*mmhos*)*cm*
2000	0.95
5000	1.80
10000	3.14
15000	4.10

S.A. 2.3 : Distribution of boron, lithium, fluorine, selenium and molybdenum in saline-sodic soils and their relationship to plant growth (I.C. Gupta).

Saline-sodic soils sometimes contain lithium in amounts that may be injurious to some crops. Vertical distribution of lithium was therefore, studied in some salt affected soil profiles, collected from Mathura district in Uttar Pradesh. The highest content of lithium observed was 2.5 ppm. and saline-sodic soils, in general, contained lithium more than 0.5 ppm (Table 16) Lithium increased with increase in electrical conductivity and organic carbon. The coefficients of correlation between lithium and other characteristics of the soil are shown in Table 17.

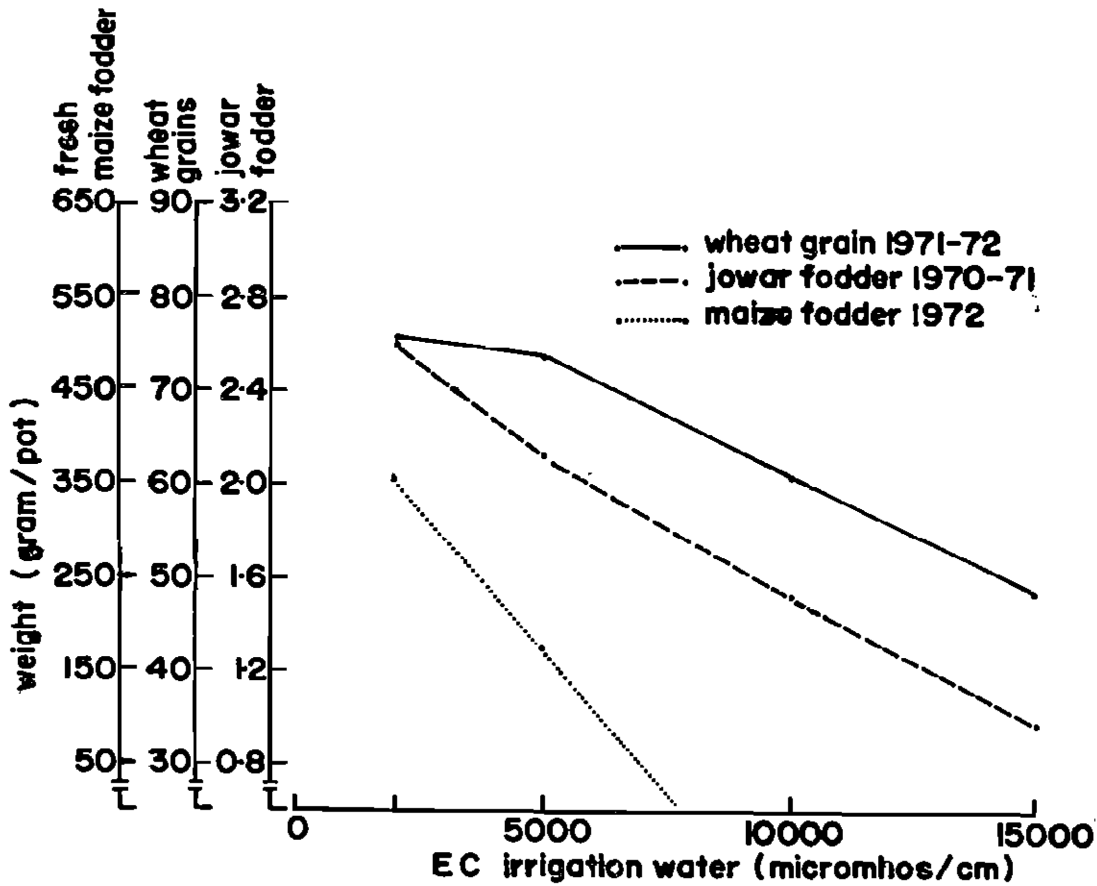


Fig 8. Effect of water quality on grain yield of wheat and fodder yields of jowar and maize

TABLE 16. *Distribution of lithium in soil prfioles*

Soil depths (cm)	pH_2	ECe (mmhos/cm)	ESP	Li (ppm)
	Profile 1	*Ustorthents*		
0-18	8.9	0.84	4.6	0.4
18-55	8.7	1.42	4.0	0.6
55-79	8.8	0.90	4.5	0.4
79-108	9.0	1.14	4.0	0.5
108-170	9.6	0.50	2.6	0.4
	Profile 2	*Ustorthents*		
0-16	8.3	38.20	91.9	2.5
16-46	8.7	16.80	50.9	0.5
46-88	8.9	14.70	45.1	0.5
88-115	9.0	13.00	54.1	0.4
115-170	9.4	6.88	46.6	0.4
	Profile 3	*Ustifluvents*		
0-12	8.3	1.16	10.9	0.5
12-26	8.0	1.56	11.7	0.5
26-40	7.6	3.12	9.4	0.5
40-59	7.7	3.72	6.3	0.4
59-114	8.1	2.23	10.0	0.5
114-180	7.7	2.83	10.9	0.5
	Profile 4	*Ustifluvents*		
0-9	8.8	19.37	11.4	2.0
9-30	9.9	7.20	40.3	1.7
30-65	9.6	9.23	28.5	0.5
65-95	9.4	3.84	15.8	0.4
7-95	9.3	3.72	7.5	1.8

TABLE 17. *Relationship of lithium with soil properties*

Relationship of lithium with	Coefficient of correlation (r)
ECe (mmhos/cm)	0.76**
pH_2	0.08 N.S.
ESP	0.25 N.S.
Clay (percent)	0.25 N.S.
Free $CaCO_3$ (percent)	0.22 N.S.
Organic carbon (percent)	0.59**

S.A. 2.4 : Use of saline water for reclamation of alkali soils (R.C. Mondal and D.R. Bhumbla).

Ground waters in many arid and semi arid regions are highly saline, and contain sodium as the dominant cation followed by magnesium and calcium. The soils in these regions invariably contain some calcium carbonate and illite is the predominant clay mineral in many of these soils. In view of this the effect of some saline ground waters on a laboratory prepared Na-illite clay in presence of native $CaCO_3$ was investigated. The composition of the saline ground waters used for this study are given in Table 18. 50 ml of water was shaken with 3 g. Na-illite mechanically for 2 hrs in the presence and absence of native salt free $CaCO_3$ (1.5 g) passed through 60 mesh screen. After centrifugal separation of the extract its pH, Ca and Mg were estimated. Exchangeable Ca and Mg of the equilibrated clay were also estimated. The chemical composition of the native $CaCO_3$ samples that was collected from the C-horizon of a soil profile at the Institute Research Farm, and used in this experiment is as follows: $CaCO_3$—35.75%, $MgCO_3$—6.03%; NaCl—0.79%; KCl—0.32 and insoluble residue (silica)—50.30%.

Na- illite at equilibrium with saline waters adsorbed Ca and Mg both in the presence and absence of $CaCO_3$. In the presence of $CaCO_3$ the amount of exchangeable Ca increased over that in the absence of $CaCO_3$ and there occurred a decrease of exchangeable Mg in most cases. These findings are in conformity with the earlier work which showed that chloride solution of high Mg/Ca ratio increases the exchangeable Ca/Mg ratio of the clay in the presence of soil $CaCO_3$ due to the release of Ca from $CaCO_3$.

TABLE 18. *Chemical composition of ground waters*

Sample No.	pH	EC (mmhos)	Cations (me/l)				Anions (me/l)				SAR	Mg/Ca
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	CO_3^{2-}	HCO_3^-		
1	8.6	5.2	32.17	0.74	1.52	16.05	40.5	2 72	1.50	5.75	10.97	10.6
2	8.4	5.2	28.69	2.82	3.70	28.50	40.0	19.71	1.00	3.00	7.15	7.7
3	8.0	6.7	61.73	0.15	17.39	17.61	19.0	73 25	0.25	4.38	14.76	1.0
4	8 1	7.4	45 21	2.43	16.30	26.53	35.5	49.84	0.25	4.38	9.78	1.6
5	7.9	5.5	17.39	3.89	14.78	28.52	23.5	38.08	Nil	3.00	3.73	1.9
6	7.9	4.9	19.13	0.15	17.39	13.48	44.5	3.15	Nil	2.50	4.88	0.8
7	7.7	6.1	20.86	0.10	25.00	21.74	57.0	8.70	Nil	2.00	4.31	0.8
8	8.2	6.5	46.08	2.12	6.41	17.61	50.0	16.22	1.00	5.00	13.31	2.7
9	8.3	6.1	33.04	1.71	2.83	20.43	42.5	11.88	0.05	3.38	9.68	7.2
10	8.7	6.9	61.69	0.48	0.48	17 83	47.5	24.93	2.00	6.00	20.42	41.5
12	8.5	6.4	56.48	0.07	1.52	15.22	26.5	42.29	1.00	3.50	19.54	10.0
13	8.8	5.1	40.02	0.05	0.87	13.26	39.0	7.95	2.50	4.75	14.10	15.2

Although exchangeable Mg generally decreased due to the presence of $CaCO_3$, there was a net gain in the exchangeable Ca+Mg with most of the waters. It was also found that $CaCO_3$ tends not to increase the exchangeable Ca+Mg at higher pH values of the waters because of the low adsorption of Mg. At pH values of about 8.7 and above the exchangeable Ca+Mg in the presence of $CaCO_3$ decreased from those observed in the absence of $CaCO_3$, possibly because the presence of $CaCO_3$ helped as a nucleus for the precipitation of Ca at higher pH values of the ground waters. It may be inferred that the increase of exchangeable divalent cations and exchangeable Ca/Mg ratio of the clay is an important contribution of high Mg-saline ground waters when in association with soil $CaCO_3$

Exchangeable sodium percentage of the clay increased with the increase of the pH of the ground waters. $CaCO_3$ however, helped to reduce the E S.P. to less than 10 only in the case of two waters although appreciable reduction of ESP ranging from 13.4 to 80.9% took place due to $CaCO_3$ in the case of 9 out of 12 ground waters. The Ca/Mg ratio of the ground waters was correlated at 1% level with exchangeable Ca/Mg ratio both in the presence of $CaCO_3$ ($r = 0.77$) and in its absence ($r = 0.87$). In the absence of $CaCO_3$, the origin of the regression line was very near to zero, whereas in the presence of $CaCO_3$ it intercepted the ordinate above the zero point (Fig 9). This shows that with only magnesium present in the ground water, Ca was still adsorbed by the illite. The source of Ca obviously in $CaCO_3$ which releases Ca in solution under the influence of the saline ground waters of high Mg/Ca ratio.

S.A. 2.42 : Effect of FYM on the solubility of $CaSO_4$ under alkaline condition (R C. Mondal).

Application of gypsum ($CaSO_4$) alongwith FYM has been found to increase crop yield over that of the application of gypsum alone. One possible reason for this is the increased solubility of $CaSO_4$ in the presence of FYM. The solubility of $CaSO_4$ in water and in Na_2CO_3 and $NaHCO_3$ solutions of varying concentration was, therefore, determined in the presence and absence of FYM. Results are given in Table 19.

TABLE 19. *Effect of FYM on the solubility of $CaSO_4$*

Treatment	Date of observation							
	1.4.72		12.4.72		25.4.72		1.5.72	
	pH	Ca	pH	Ca	pH	Ca	pH	Ca
$CaSO_4+H_2O$	6.85	31.07	6.85	30.75	7.4	30.75	7.4	30.53
$CaSO_4+H_2O+FYM$	7.05	30.96	7.00	34.40	7.15	36 55	7.3	39.13

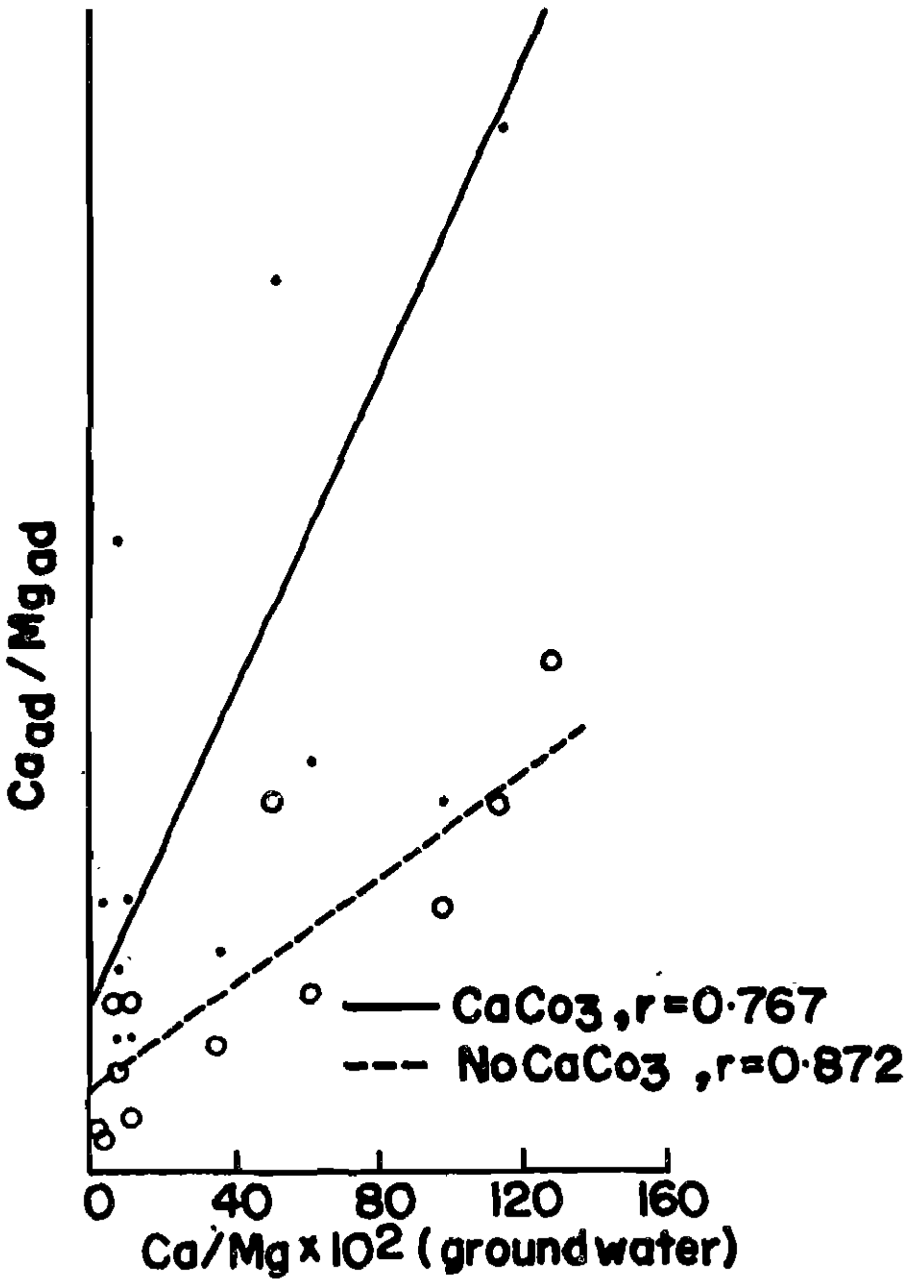


Fig. 9 Effect of Ca/Mg ratio of ground water on adsorbed Ca/Mg ratio in the presence of $CaCo_3$.

It was observed that solubility of $CaSO_4$ in water increased from 30.96 to 39.13 me/l after one month due to the presence of FYM which itself released about 3 me/l of Ca in water indicating thereby that increased solubility of $CaSO_4$ might be a factor for increased crop yield.

S.A. 3.1 : Characterization and classification of salt affected soil (G.P. Bhargava and S.K. Singhla).

Uttar Pradesh : It is estimated that there are nearly 1.25 million hectares of salt affected soils in the state of Uttar Pradesh. In order to study their nature and characteristics, profiles were exposed at eight places in the state. The location of the profile sites is shown in Fig. 10. Profile sites were chosen such that each site represented large areas of the salt affected soils in the district. The morphological features of the profiles were described in the field and soil samples collected for detailed analysis in the laboratory. Morphological characters in respect of one profile from Etah district are given below and analysical data are presented in table 20.

Profile I.

Location :		About 4 km. N-E of Etah—Mainpuri road, 0.5 km. W. of village Kurawali and 6.5 km. from Etah.
Relief		Normal *Parent Meterial* Alluvium
Drainage:		Well drained externally an moderately drained internally.
Erosion		Slight *Stoniness*: Nil
Slope		1 per cent north-east to south.
Ground water table depth:		Present at 3 metre depth.
Present land use:		Barren
Natural vegetation:		Few *Acacia* plants and patchy grass growth.
Date of Collection:		18. 11. 1971.
Horizon	*Depth (cm)*	*Macromorphology*
A_1	0-18	Olive (5 Y 5/4 M); sandy loam; moderate, medium, angular blocky; hard, firm, slightly sticky and slightly plastic; concretion and mottles absent; strong effervescence; few roots; moderate permeability; diffuse and smooth boundary; few sand pockets with micaceous particles present.
A_2	18-29	Olive (5 Y 4/3 M); sandy loam; weak, medium, angular blocky; hard, firm, very

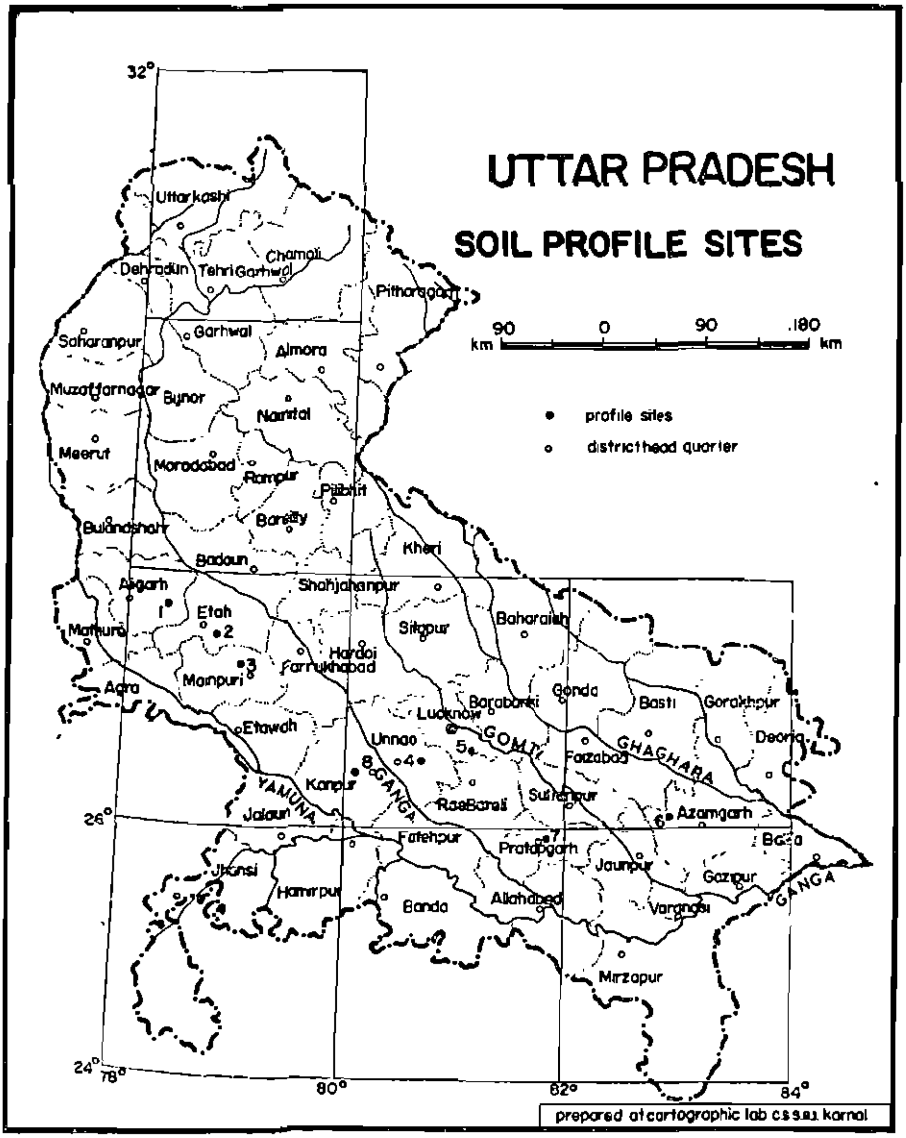


Fig. 10 Location of profile sites.

TABLE 20. *Physico-chemical characteristics of soil profile (Etah district U.P.)*

Depth (cm)	$CaCO_3$ >2mm %	pH_2	ECe mmhos/cm	Saturation extract ions (me/l) Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
0-18	1.7	10.7	14.43	0.5	1.7	214.0	0.2	149.0	27.5	13.7	22.4
18-29	3.8	10.5	11.97	1.0	1.5	193.0	0.2	130.0	21.5	15.0	14 1
29-62	3.5	10.0	4.32	0.4	0.9	47.1	0.1	31.0	9.5	10.5	2.6
62-80	2.5	10.2	1.76	1.1	1.4	18.1	0.1	3.0	13.5	5.5	Tr
80-104	11.5	9.8	1.61	0.4	1.6	17.0	Tr	3.0	8.7	6.5	Tr
104-122	24.5	9.5	2.24	0.4	0.6	22.8	0.1	7.5	10.5	6.5	Tr
122-140	26.5	9.0	1.20	1.2	1.5	12.3	Tr	1.0	6.5	6.5	Tr

Depth (cm)	C.E.C. (me/100g)	Exchangeable cations (me/100g) Na	K	Ca	Mg	ESP	Clay %	Silt %
0-18	6.6	5.9	0.6	Tr	Tr	89.4	13.1	23.0
18-29	7.2	6.4	0.6	Tr	Tr	88.9	15.3	25.6
29-62	16.8	11.2	0.4	1.8	3.4	67.7	34.9	22.1.
62-80	14.1	10.9	0.4	1.3	2.2	77.0	27.1	35 0
80-104	13.4	3.0	0.5	4.2	5.4	22.4	27.8	30.5
104-122	11.2	3.4	0.3	3.3	3.7	30.3	21.0	25.0
122-140	7-6	1.4	0.2	2.4	2.9	22.4	12.5	13.0

		slightly sticky and very slightly plastic; concretions and mottles absent; strong effervescence; roots absent; moderate permeability; diffuse and smooth boundary few sand pockets with micaceous particles present;
B_1	29-62	Olive gray (5 Y 5/3 M); sandy loam; moderate, medium, subangular blocky hard, firm, sticky and plastic; no concretions and mottles; strong effervescence roots absent; moderate permeability; diffuse and smooth boundary;
$B2_1$	62-80	Olive gray (5 Y 4/2 M); clay loam; strong, medium, subangular blocky; hard, firm, very sticky and very plastic; Fe-Mn concretions upto 4 mm in dia. present about 6 per cent by volume; mottles absent; violent effervescence; no roots; slow permeability; diffuse and smooth boundary; few krotoninas present;
$B2_2$	80-104	Grayish brown (2.5 Y 5/2 M); clay loam; moderate, coarse, subangular blocky; hard, firm, very sticky and very plastic; Fe-Mn concretions upto 2 mm in dia. present about 5 percent by volume; no mottles; violent effervescence; no roots; slow permeability; abrupt and smooth boundary;
C_1-ca	104-122	Pale olive 5 Y 6/3 m); sandy loam; massive very hard, sticky and slightly plastic; $CaCo_3$ concretions upto 8 cm in length and 2 cm in dia. present about 50 per cent by volume; violent effervescence; no roots; slow permeability; clear and smooth boundary.
C_2-ca	122-140	Pale olive (5 Y 6.5/3M); sandy clay loam; moderate, medium, subangular blocky; hard, firm, very sticky and very plastic; $CaC0_3$ concretions upto 5 mm in dia. present about 5 per cent by volume, few; coarse, distinct olive yellow (2.5 6/6 m) mottles present; violent effervescence; no roots; slow permeability.

These and data from other profile of the State permit to draw the following general conclusions regarding the characteristics of these soils.

1. The soils have a high concentration of soluble salts, chiefly in the surface 0-60 cm. (ECe upto 30 millimhos/cm). Below this depth the concentration of salts decreases and is often less than 4 millimhos/cm.
2. Carbonates and bicarbonates of sodium constitute the major fraction of soluble solts in the soils except for profiles from Rae Bareli and Azamgarh where carbonates were absent in the saturation extract, chlorides and sulphates were present in varying amounts in all the profiles.
3. Soluble calcium and magnesium were practically absent in all the profiles studied.
4. ESP of the soils is high, often exceeding 80 in the surface layer which decreases slightly with depth and this high ESP persists throughout the profile. pH of 1:2 soil water suspension exceeded 9.8 and was often in the range of 10.4 to 10.7 in the surface soil layers in most of the profiles. The pH of the soil decreased somewhat in lower soil depths.
5. The clay content generally increases with depth upto about 1 m. and the texture which is often sandy loam in the surface horizon changes to clay loam in the sub-surface layer (s).
6. Soil material >2 mm contained calcium carbonate in all the profiles and in all the depths. The amount generally increased with depth. The content of calcium carbonate varied from 1 to 6 per cent in the surface soil layers and from 6 to 26 percent in the lower soil layers.
7. In all the profiles the presence of a calcic horizon was conspicuous. The depth of this layer varied from 75 cm to about 1.5 meter from the soil surface.

West Bengal : Detailed soil survey of the experimental farm at the Canning Town sub-station (West Bengal) was carried out and a soil map in the scale of 1:772 was prepared. The topographic variation coupled with macromorphological characteristics facilitated their demarcation and mapping into three categories viz; (i) *Aquic Pellic Fluventic Halaquepts*. (ii) *Aeric Pellic Fluventic Halaquepts*, and (iii) *Pello-Aeric Fluventic Halaquepts*. Morphological and physico-chemical characteristics of a typical deltaic alluvium experiencing serious salinity problem reveal that being of recent origin they seldom show any sign of genetic development. Being of alluvial origin their textural monotony is conspicuous throughout the profile. These soils have formed under humid and tropical climate which facilitates leaching, but as a result of shallow water table, soils experiencing an aquic moisture regime and frequent inundations from the high salt back waters in the river give rise to excess accumulation of soluble salts throughout the profile. Chlorides and sulphates of sodium and magnesium are the dominant salts followed by calcium among the cations. Soluble carbonates are absent and so is calcium carbonate. The ESP in these soils is usually more than 15 but seldom higher than 35 (Table 21). Being in the deltaic region the soils are heavy in texture (clay) and are usually stratified.

Profile II

Location:	39 metres in west along the NW corner of the meteorological observatory and 8 m in south in field No. 18 of experimental farm of C. S. S. R. I. Sub-station, Canning Town (W. B.)
Relief:	Normal
Parent material	Alluvium Deltaic alluvium)
Drainage	Restricted. *Erosion:* Nil
Stoniness:	Nil *Slope:* Gentle to moderate NE to SW.
Ground water table	Fluctuates between 0.2 to 2 meter depth.
Present land use:	Fallow after paddy.
Date of collection	22. 3. 72
Horizon Depth (cm)	*Macromorphology*
Ap 0-12	Light brownish gray (2.5 Y 6/2 d) to dark grayish (2.5 Y 4/2 m); silty clay loam; moderate, fine, angular blocky breaking to granular; dry hard, moist firm, west very sticky and very plastic; few fine, distinct yellowish brown (10 YR 5/6 m) mottles, concretions absent, very mild localised effervescence; many fine roots; very slow permeability; clear and smooth boundary; few fine sand pockets present with abundant micaceous particles.
12-28	Light brownish gray (2.5 Y 6/2 d) to dark grayish brown (2.5 Y 4/2m) clay; moderate medium, angular blocky; dry hard, moist firm, wet very sticky and very plastic, many, medium, faint to distinct light olive brown (2.5 Y 5/6 m) mottles, concretions absent, no effervescence, few, fine roots, very slow permeability, wavy and smooth

TABLE 21. *Physico-chemical characteristics of soil profile (Canning Town, WB)*

Depth (cm)	$CaCO_3$ >72mm %	pH_2	ECe mmhos/cm	Saturation extractions (me/l)							
				Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
0-12	1.0	7.2	20.9	29.0	120.5	156.1	Tr.	Absent	Absent	313.0	16.2
12-28	-do-	7.5	6.5	11.0	16.5	37.5	Tr.	-do-	-do.	57.0	8.0
28-80	-do-	7.5	7.0	16.5	18.0	43.3	Tr.	-do-	-do-	73.0	9.1
80-105	-do-	6.7	7.5	15.5	16.0	47.0	Tr.	-do-	-do-	74.5	9.1
105-162	-do-	6.4	9.3	17.5	76.5	71.2	Tr.	-do-	-do-	96.0	8.5
162-184	-do-	6.9	9.9	19.0	27.0	73.8	Tr.	-do-	-do-	96.0	11.2

Depth (cm)	C.E.C me/100	exchangeable cations (me/100 g.)				ESP	Clay	Silt
		Na	K	Ca	Mg		%	
0-12	15.1	4.6	0.7	4.5	4.9	30.4	42.5	25.0
12-28	17.8	2.5	0.6	6.1	6.7	14.0	43.6	37.7
28-80	19.5	2.6	9.6	8.6	6.7	15.3	45.0	36.5
80-105	16.3	2,6	0.6	6.8	6.0	18.0	37.3	41.2
105-162	18.2	3.9	0.5	5.4	8.0	21.2	43.8	39.7
162-184	18.4	3.9	0.7	5.6	8.1	21.3	44.0	40.6

	boundary, few sand pockets with micaceous particles.
28-80	Light olive brown (2.5 Y 5/2 d) to gray (2.5 Y 5/10 m) clay, strong, medium angular blocky; firm, very sticky and very plastic, many, fine to medium, distinct very dark grayish brown to (10 YR 3/2 m) and yellowish brown (10 YR 5/6 m) mottles, concretions absent, no effervescence; few fine roots; very slow permeability, wavy and smooth boundary; many, fine sand pockets with micaceous particles.
80-105	Light olive brown (2.5 Y 5-5/2 d) to gray (2.5Y 5/0 m) mottles; concretions absent; no effervescence; few fine roots; very slow permeability, diffuse and smooth boundary; many fine sand pocket with micaceous particles.
105-162	Light olive brown (2.5 Y 5.5/2 d) to gray (2.5 Y 5/0 m); clay; massive; firm; very sticky and very plastic; many distinct, fine to coarse dark brown, (7.5 YR 3/2 and 4/4 M) mottles; concretious absent; no effervescence; few worm holes present; very few, fine roots; very slow permeability; many fine sand pockets present with micaceous particles; clear and wavy boundary;
162-184	Light olive brown (2.5 Y 5/2 d) to dark gray (10 YR 4/1 m); clay; massive; firm; very sticky and very plastic; many distinct coarse dark brown (7.5 YR 3/2 m) mottles concretions absent; no effervescence; roots absent: very slow permeability; no sand pockets and wrom holes.

Haryana : A map of Karnal district (including Kurukshetra and part of Jind) in the scale of 1:63360 and 1:126720 showing the distribution of saline-sodic soils has been prepared after undertaking a general reconnaissance survey and using aerial photographs. The total area affected with salinity and alkalinity was found to be about 126624 hectares (3, 12, 885 acres) with tehsilwise breakup as follows :

Tehsil	*Area affected with salinity/alkalinity (hectares)*
Thanesar	13634
Gulha	18252
Kaithal	22987
Panipat	25494
Karnal	46257
Total	126624

S.A. 3.2: Survey and characterization of ground water in problem area (R. C. Sharma).

Two districts of Haryana viz. Jind and Karnal were surveyed for the quality of ground water for irrigation purposes.

Jind District

The number of water samples collected and number of villages from each block are given below :—

Block	*No. of villages*	*No. of water samples*
Saffidon	19	31
Jind	30	72
Uchana	13	18
Narwana	17	28
Kalayat	9	20

The waters were alkaline in nature, pH varying between 7.80 to 8.95. The average E.C. was 2497, 2634, 3012, 3267 and 4474 mmhos/cm for Saffidon, Narwana, Jind, Kalayat and Uchana blocks respectively.

The distribution of waters in different E.C. classes alongwith the relative concentration (percent) of different ions is given in Table 22.

About 73, 14 and 13 percent of waters have E.C. less than 4, 4-6 and more than 6 mmhos/cm respectively. In all the waters magnesium content is more than calcium and magnesium to calcium ratio was 1.9:1 and 2.3:1 for waters having E.C. less than 4 and more than 4 mmhos respectively. The water with E.C. less than 1 mmhos have magnesium even more than sodium and constitute 42% of the total cations, whereas the water having E.C. more than 1 mmhos have the cations in the order sodium>magnesium>calciump>otassium. Sodium is the major cation and constitutes more than 50 percent of the total cations.

Waters with E.C less than 2 mmhos generally contain soluble carbonates. High amount of residual sodium carbonate is responsible for the poor quality of some waters. The waters with E.C. between 2 and

TABLE 22: *Composition of waters from Jind district, Haryana*

Conductivity classes (μ mhos/cm)	No. of samples	Relative concentration (%) of differentions							
		Cations				Anions			
		Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
<1000	41	24.5	41.8	31.5	3.0	15.5	65.5	10.0	6.6
1000-2000	39	16.0	30.8	50.8	2.2	12.6	48.7	22.2	12.6
2000-4000	44	11.5	24.0	61.3	3 0	7.4	30.5	35.3	24.0
4000-6000	24	10.9	26.2	61.1	1.6	4.0	18.4	46.5	29.8
6000-8000	11	11.9	32.3	53.8	1.8	3.0	10.5	44.4	35.3
8000-10000	2	14.5	32.2	52.7	0.4	2.1	7.0	58.7	31.8
>10000	8	12.4	28.3	57.1	2.1	1.3	4.2	61.3	32.5

4 mmhos have the anions in the order chloride>carbonate>sulphate>bicarbonate, whereas the chloride is followed by sulphate, bicarbonate and carbonate in the waters with E C. more than 4 mmhos.

Due to considerable amount of magnesium present in these waters the sodium adsorption ratio is not so high so as to make these waters unfit for irrigation from sodium hazard point of view. But about 37 percent waters have soluble sodium percentage more than 60 which is considered to be the upper limit for the good quality water. Therefore, it appears that these waters have a mild to medium effect of sodium hazard.

About 63 percent of the waters contain boron, the boron content varying between 0.10 to 3.38 ppm.

The average nitrate content for these waters was 0.58 me/l and in some waters its content was as high as 10.7 me/l.

To conclude, the waters having E.C. below 4 millimhos/cm have high RSC. Therefore, these waters can be made use of after treating with gypsum or by diluting the waters with good quality. About 27 percent waters have the problem of high salt content. These waters can also be used by paying a little attention towards soil drainage and selection of crops. Alternate irrigation or mixing of canal water will also be helpful for utilizing the waters with high salt content.

Karnal District

A total of 222 water samples from 105 villages were collected. The waters were alkaline in nature, pH varies from 8.1 to 9.4. The average electrical conductivity for the ground waters in the district was 1196 μ mhos. The water throughout the district have low salt content except in Ranjod block.

Table 23 shows the distribution of number of samples in different E C. classes and the relative concentration (percentage) of different ions. About 90 percent waters have E.C. less than 2 mmhos and 7 percent and 3 percent between 2-4 and more than 4 mmhos/cm respectively. Therefore, salinity of ground water is not the problem in the district. The trend for cations is sodium>magnesium>calcium>potassium.

The magnesium in all the waters was more than calcium and the magnesium to calcium ratio was 3.6:1 and 2.6:1 for waters having E.C. less than 4 and more than 4 mmhos respectively.

Carbonates are the dominant anions in the waters with low salt content whereas chloride is the dominant anion in high salt content waters.

The main problem in the western parts of the district is the high residual sodium carbonate. Almost all ground waters in Kaithal, Pundri and Gulha have high RSC, but all these waters have low salt content.

Table 23. *Composition of waters from Karnal district, Haryana*

Conductivity classess (μ mhos/cm)	No. of samples	Relative concentration (%) of differentions							
		Cation				Anions			
		Ca	Mg	Na	K	CO_3	HCO_3	Cl_4	SO_4
<1000	154	14.1	34.7	50.2	1.0	26.5	45.7	14.5	13.2
1000-2000	47	6.6	21.6	70.3	1.5	20.6	34.5	20.6	26.3
2000-4000	16	6.9	23.3	68.8	1.0	12.1	18.8	32.6	36.5
4000-6000	2	2.2	9.2	88.3	0.3	20.5	18.8	32.0	29.2
>6000	3	10.6	14.1	65.1	0.2	2.7	3.6	50.9	42.8

S.A. 3.3 : Studies on the genesis of saline sodic soils of Indo-gangetic alluvium. (S.K. Singhla and G.P. Bhargava).

The saline-sodic soils in the Indo-gangetic alluvial plain have developed under semi-arid climatic conditions having an aquic to para-aquic moisture regime. They are highly sodic and pose some problems in their logical classification following the principles laid down in "Soil Taxonomy" 1970. The difficulties experienced are mainly with respect to the colour of the matrix and the structural development in these soils.

To be classified as Typic of Aquic calciorthids, Camborthids and Halpustalfs, as they generally are, a soil should have either aquic moisture regime or should be artificially drained, and characteristics associated with wetness, with one of the following :

(a) An argillic horizon that has chromas of 2 or less accompanied by mottles within the peds.

(b) If no mottles in the argillic horizon, chromas are 1 or less.

Accounting for the dominant characteristics of these soils the following criteria has been found to hold good with reference to their colour requirements.

"Have dominant chromas of 4 or less in hues of 2.5 Y or yellower in the matrix of the argillic horizon accompanied by mottles of higher chromas of Fe-Mn concretions or both".

In order to classify them as *Natric* in addition to the properties of the argillic horizon they should have either.

1. (a) Prismatic or, more commonly columnar structure, or
   (b) Rarely a blocky structure with tongues of an eluvial horizon with uncoated silt or sand grains extending more than 2.5 cm into the horizon, and more than 15 per cent saturation with exchangeable sodium in some sub horizon within 40 cm of the upper boundary.

Since these soils lack a prismatic or columnar structure and also the tongue of an albic horizon the structural requirements need to be modified as : either Prismatic or, more commonly, columnar structure, or rarely, a blocky structure with or without to gues of eluvial horizon.

Further to take into account the high amounts of salts present in these soils that interfere with normal crop growth but are insufficient to qualify for a salic horizon a salic sub-ground is proposed with the following definition.

—do not have an average minimum of 1 per cent salts (when associated with sodium) with minimum thickness of 15 cm and the product of the per cent salts and thickness is not 30 or more within 75 cm of the surface.

In case of typic camborthids or typic calciorthids, and

—do not have an average minimum 1 per cent salts (when associated with 15 per cent or more saturation with sodium with a minimum thickness of 15 cm and the product of the per cent salts and thickness is not 30 or more within 75 cm of the surface. In case of Halaquepts, Natrustalfs, Natraqualfs, Natrargids, Natraquolls, Natrustolls etc.

The introduction of salic sub-groups in soils having high ESP carries much significance for the practical land use. However the limits proposed above are purely tentative and need to be tested over a large numberof field observations and corresponding laboratory data.

S.A. 4.1 : Selection of effective strains of rhizobia for saline and sodic soils (K.K.R. Bhardwaj).

Since rhizobia play an important role in the establishment and nitrogen nutrition of legumes, the growth and development of the latter in saline and sodic soils will be greatly influenced by the abundance and effectiveness of the indigenous rhizobia of these soils. Studies were made to assess the quantity and symbiotic qualities of the native rhizobial flora or some legumes in saline-sodic soils so that suitable legume inocul-

TABLE 24. *Number of rhizobia of seven legumes in the salt-affected soil.*

Leguminous plant	Nodulation		No. of rhizobia/g soil	
	Before the crop	After the crop	Before the crop	After the crop
Indian clover (*Melilotus parviflora*)	++	++	3.2×10^3	3.1×10^5
Dhaincha (*Sesbania aculeata*)	+++	+++	2.8×10^3	3.6×10^5
Berseem (*Trifolium alexandrinum*)	++	+++	2.8×10^3	2.7×10^5
Guar (*Cyamopsis tetragonoloba*)	+	+	2.8×10^1	2.2×10^3
Cowpea (*Vigna sinensis*)	—	—	0	0
Lentil (*Lens esculenta*)	—	—	0	0
Pea (*Pisum sativum*)	—	—	0	0

+++ good ; ++ fair ; + poor ; —nil

ants for these soils could be selected. The effect of some soil amendments on the growth of *Rhizobium* species in a saline-sodic was also studied. The pH and ECe of the experimental soil were 10.3 and 22.5 respectively.

Though the soil has not been under cultivation of any leguminous crop for a very long period, it was found to have indigenous Rhizobium species of many legumes (Table 24). Fair nodulation was observed in *dhaincha* and Indian clover, intermediate in berseem and poor in guar. The nodulation as well as the number of rhizobia of these crops increased after the original soil was cultivated for one crop. No nodulation was observed in cowpea lentil and pea and their specific rhizobia were also found to be absent.

Observations on the nodulation of various legumes made in the field revealed that the indigneous *Rhizobium* sp. of some legumes were in abundance in the saline-sodic soil. The growth and nodulation of Indian clover and dhaincha were found to be fairly satis factory. Quantitatively berseem was also well nodulated but the pattern of nodulation did not seem to be much effective. The growth of lentil was moderately good but the quantity of nodulation was very poor. The growth and nodulation of guar and cowpea were also poor. No nodulation was observed in pea which in conformity with plant infection test

TABLE 25. *Nodulation of the seven legumes under field conditions*

Legminous plant	No. of plants examined	No nodulated	Nodulation	Nitrogen %
Indian clover (*Melilotus parviflora*)	200	179	Fairly good	2.9
Dhaincha (*Sasbania aculeata*)	200	192	-do-	3.0
Berseem (*Trifolium alexandrinum*)	250	202	Moderately good	2.6
Guar (*Cyamopsis tetragonolobia*)	100	32	Poor	1.7
Cowpea (*Vigna sinensis*)	80	18	V. poor	1.8
Lantil (*Lens esculenta*)	250	9	V. poor	2.3
Pea (*Pisum sativum*)	40	0	No Nodulation	1.6

indicated that the specific rhizobia of pea were absent in the soil. *Rhizobium* species of cowpea and lentil were found to be absent in the soil by the plant infection test (Table 25). However, these legumes were found to be nodulated sparcely when grown under field conditions in the same soil. It seems that the presence of rhizobia of these legumes could not be detected by plant-infection test due to their very low numbers in the original soil. Under field conditions where the spectrum of infection was much wider the plant could be nodulated.

Observations on the quantity and quality of nodulation of various legumes made in the field gave some evidence of the symbiotic ineffective-

TABLE 26. *Symbiotic effectiveness of some indigenous Rhizobial strains*

Host legume	No. of strains tested	No. of strains found effective	Range of effectiveness (% increase in nitrogen fixation over uninoculated control)
Indian clover (*Melilotus parviflora*)	15	7	0·41
Dhaincha (*Sesbania aculeata*)	15	9	10-51
Berseem (*Trifolium alexandrinum*)	15	4	5-30
Guar (*Cyamposis tetragonolobia*)	10	3	0-24
Cowpea (*Vigna sinensis*)	10	0	0-18
Lentil (*Lens esculenta*)	8	0	0-15

ness of some of the indigenous rhizobial flora. However, it was imperative to test adequately the efficiency of the strains. The isolations of specific *Rhizobium* strains for this purpose were made when the plants were examined for their growth and nodulation. A certain number of the strains of each *Rhizobium* species were tested. It can be seen from Table 26 that maximum number of effective strains and the highest effectively were noted among the rhizobial strains of dhaincha and clover. *Only a small number of the strains of the* berseem and guar appeared effective and the efficacy was also relatively low. Surprisingly, none of the rhizobial strains of cowpea and lentil were found to be practically effective. Evidently, berseem, cowpea, lentil and pea would need effective inoculant strains of their specific rhizobia for their establishment and nitrogen nutrition when grown in these soils.

Since in the cultivation of saline-alkali soils application of some soil amendments such as gypsum, farmyard manure etc. is essential to ensure optimum growth of crops, a study of the effect of such soil ameliorants on the growth and multiplication of rhizobial strains was made. The amendments considerably stimulated the growth and multiplication of the *Rhizobium* species (Table 27). Gypsum and farmyard manure proved to be more effective than dhaincha hay and gypsum. This indicates that where solid amendments help the crops directly, they also stimulate the growth of their rhizobial partner which in turn helps in giving better start to the crop.

TABLE 27. *Effect of some soil amendments on the growth of rhizobia in saline-alkali soil*

Host legume	No. of strains inoculated	No. of rhizobia g/soil		No. of rhizobia/g. unamended soil
		Gypsum +Dhaincha hay*	Gypsum +FYM	
Indian clover (*Melilotus parviflora*)	5	2.7×10^5	3.5×10^5	1.5×10^4
Dhaincha (*Sesbania aculeata*)	5	2.6×10^5	2.8×10^6	1.9×10^3
Berseem (*Trifolium alexandrinum*)	5	1.4×10^4	3.6×10^5	1.8×10^3
Guar (*Cyomopsis tetragonolobia*)	3	1.3×10^3	2.4×10^3	2.1×10^2
Cowpea (*Vigna sinensis*)	3	1.3×10^3	2.1×10^4	2.3×10^2
Lentil (*Lens esculenta*)	2	1.8×10^4	2.9×10^4	1.6×10^3

*powdered dhaincha straw

indicated that the specific rhizobia of pea were absent in the soil. *Rhizobium* species of cowpea and lentil were found to be absent in the soil by the plant infection test (Table 25). However, these legumes were found to be nodulated sparcely when grown under field conditions in the same soil. It seems that the presence of rhizobia of these legumes could not be detected by plant-infection test due to their very low numbers in the original soil. Under field conditions where the spectrum of infection was much wider the plant could be nodulated.

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Dhaincha (*Sesbania aculeata*)	15	9	10-51
Berseem (*Trifolium alexandrinum*)	15	4	5-30
Guar (*Cyamposis tetragonolobia*)	10	3	0-24
Cowpea (*Vigna sinensis*)	10	0	0-18
Lentil (*Lens esculenta*)	8	0	0-15

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Dhaincha (*Sesbania aculeata*)	5	2.6×10^5	2.8×10^6	1.9×10^3
Berseem (*Trifolium alexandrinum*)	5	1.4×10^4	3.6×10^5	1.8×10^2
Guar (*Cyamopsis tetragonoloba*)	3	1.3×10^3	2.4×10^3	2.1×10^2
Cowpea (*Vigna sinensis*)	3	1.3×10^3	2.1×10^4	2.3×10^2
Lentil (*Lens esculenta*)	2	1.8×10^4	2.9×10^4	1.6×10^3

*powdered dhaincha straw

S.A. 4.2: Effect of algae on the reclamation of salt affected soils. (K.K.R. Bhardwaj and I.C. Gupta).

Experiments during the past two years showed that natural algal growth in saline sodic soils is not likely to be very effective in soil reclamation. Improvements in soil obtained as a result of algal growth and standing water could be ascribed to the leaching effect of standing water rather than to algal growth. Based on these observations further experiments have been discontinued.

S.A. 5.1: Gypsum requirement of fodder species grown on saline-sodic soils (R.K. Chhillar and D.R. Bhumbla).

In this experiment after the harvest of *Kharif* crops in 1971, the yield data for which were reported in the last annual report, *Senji* (*Melilotus parviflora*) and *berseem* were grown in September, 1971. All the plots received a uniform dose of 50 kg N and 80 kg P_2O_5 in the form of ammonium sulphate and superphosphate. The yield data along with the soil pH (0-15 cm) are given in Table 28.

TABLE 28. *Effect of the application of gypsum on the yield of Senji and Berseem green fodder q/ha.*

Gypsum* (t/ha)	pH	Senji	Berseem
0	9.8	8.26	13.04
7.5	9.7	37.38	18.90
15.0	9.5	150.65	144.32
22.5	9.3	246.37	191.88
30.0	9.2	278.82	450.68
CD. at 5%		168.22	228.19

*Gypsum was applied only at the start of the experiment in kharif 1970.

S.A. 5.3. Agronomic and cultural practices for different crops on saline sodic soil (K.S. Dargan, B.L. Gaul and I.P. Abrol)

(a) Effect of farmyard manure and gypsum on the yield of berseem and paddy.

The experiment was started in *rabi* 1970-71 with berseem. Initial pH (1 : 2) of the surface soil (0-15 cm) was 10.5 and E.C. (1 : 2) was 2.4 mmhos/cm. The treatments consisted of three levels of farmyard manure (0, 25 and 50 t/ha and two levels of gypsum (0 and 11 t/ha). In *kharif* 1971 each plot was sub-divided to study the effect of application

TABLE 29. *Effect of farmyard manure, gypsum and zinc on the yield of berseem and paddy (q/ha)*

G+F t/ha	Berseem 1970-71	Paddy 1971		Berseem 1971-72				Paddy 1972		After paddy 1972	
				Residual Zn		Direct					
		0	Zn	0	Zn	0	Zn	0	Zn	pH (1:2)	ECe (1:2) (mmhos/cm)
G_0F_0	1.5	54.2	72.1	608	771	683	850	73.9	77.2	8.8	0.465
G_0F_{25}	8.3	66.1	78.4	834	855	796	930	76.5	74.5	8.7	0.471
G_0F_{50}	17.4	76.8	84.5	898	974	861	1017	75.8	81.7	8.6	0.506
$G_{11}F_0$	94.9	66.9	88.6	1002	1076	943	1036	76.5	76.8	8.5	0.469
$G_{11}F_{25}$	295.1	77.4	92.2	1100	1118	935	1006	78.3	74.0	8.5	0.498
$G_{11}F_{50}$	319.0	83.7	88.9	1129	1148	1055	1125	77.0	73.6	8.5	0.445
C.D. at 5%	G 27.5; G×F 47.7	F 33.7	G 4.68; Zn 1.87	F 5.72; F×Zn 4.59	G 128; Zn 50	F 156.7	G 676	F 82.9	N.S.		

Initial pH 10.5, EC (1:2)-2.1 mmhos/cm.

of zinc ($ZnSO_4$ @ 45 5kg/ha). The yield data for berseem (1970-71) and paddy grain (*Kharif* 1972) were reported earlier. (Annual Report 1971) and have been given alongwith the yield data of other crops.

Berseem : The crop was sown on 26.10.71. 50 kg N as ammonium sulphate and 100 kg P_2O_5 as superphosphate per hectare were applied. The yield data given in Tables 29 and 30 show that even in the third crop application of gypsum resulted in increasing the yield by about 160 q/ha.

TABLE 30. *Effect of FYM, gypsum ond zinc on the yield of berseem and paddy (q/ha), pH and E.C.*

Main factors	Berseem 1971-72		Paddy	After Paddy 1972	
	Residual Zn	Direct Zn	1972	pH	E.C.(1:2) m.mhos/cm
FYM t/ha					
F_0	864	878	76.1	8.7	0.467
F_{25}	977	917	75.8	8.6	0.484
F_{50}	1037	1014	77.0	8.5	0.476
C.D. at 5%	156.7	82.9	N.S.		
Gypsum t/ha					
G_0	823	856	76.0	8.7	0.481
G_{11}	1096	1016	76.0	8.5	0.470
$ZnSO_4$					
0	928	879	76.3	8.6	0.480
Zn	991	944	76.3	8.6	0.472
C.D. at 5%	N.S.	49.6	N.S.		

$ZnSO_4$ at 25 kg/ha for berseem and 45 kg/ha for paddy (Initial soil pH-10.5, E.C. (1:2)-2.140 mmhos/cm)

Residual effect of Zn applied to previous crop was not significant but additional application of Zn SO_4 at the rate of 25 kg $ZnSO_4$ per hectare resulted in increasing the yield of berseem fodder by about 65 q/ha.

Paddy : After the harvest of berseem, paddy (variety IT8-68) was transplanted and uniform dose 120 kg N/ha and 50 kg P_2O_5/ha and 50 kg K_2O/ha as ammonium sulphate, superphosphate and muriate of potash respectively were applied.

TABLE 31 *Effect of FYM and gypsum on the grain yield of wheat and paddy (q/ha) and pH and E.C. of surface soil (0-15 cm.)*

G+F t/ha	Paddy 1971	Wheat 1971-72	Paddy 1972	After wheat 1971-72		After paddy 1972	
				pH	E.C.(1:2) mmhos/cm	pH	E.C.(1:2) mmhos/cm
G_0F_0	24.5	10.1	58.6	10.1	1.3	9.4	0.7
G_0F_{20}	35.9	9.3	59.5	10.0	1.1	9.2	0.9
G_0F_{40}	37.4	8.7	50.7	10.1	1.2	9.5	1.0
G_9F_0	42.3	18.6	63.9	9.9	1.1	9.0	0.8
G_9F_{20}	52.9	20.3	64.1	9.8	0.8	9.1	0.8
G_9F_{40}	54.6	18.6	60.5	9.9	1.0	9.1	1.1
$G_{18}F_0$	57.0	28.6	65.6	9.7	0.8	9.0	0.9
$G_{18}F_{20}$	57.6	25.7	64.1	9.8	0.9	9.0	0.8
$G_{18}F_{40}$	68.9	26.9	58·4	9.8	0.9	9.0	0.9
C D. at 5%	F×G	G	N.S.				
	8.79	3.80					

Initial soil pH 10.6, E.C. (1:2)—2.9 mmhos/cm.

TABLE 32. *Effect of FYM and gypsum on pH, E.C. and yield of paddy and wheat (q/ha).*

Main factors	Wheat 19-72			Paddy 1972		
	Yield q/ha	pH	E.C. (1:2)	Yield q/ha	pH	E.C. 1:2
G t/ha						
G_0	9.4	10.1	1.243	56.3	9.4	0.888
G_9	19.2	9.9	0.972	62.8	9.1	0.896
G_{18}	27.1	9 8	0.872	62.8	9.0	0.857
C.D. at 5%	3.8			N.S.		
F t/ha						
F_0	19.1	9.9	1.088	62.7	9.1	0.818
F_{20}	18.4	9.9	0.975	62.6	9.1	0.821
F_{40}	18.1	9.9	1.024	56.5	9.2	1.002
C.D. at 5%	N.S.			N.S.		

The yield data given in Table 29 show that the yield difference due to different treatments was not significant.

(b) Effect of the application of gypsum and farmyard manure alone and in combination with each other on the yield of paddy and wheat.

The experiment was started in *kharif* 1971 with rice as the first crop. The initial pH (1:2) of the soil (0-15 cm) was 10.6 and E.C. (1:2) 2.9 mmhos/cm. Gypsum was applied at the rate of 0, 9 and 18 t/ha and farmyard manure at the rate of 0, 20 and 40 tonnes. Rice and wheat were grown in succession. The varieties were IR8-68 and Kalyan Sona. The wheat received 120 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha in the form of ammonium sulphate, superphosphate and muriate of potash respectively and for rice 180 kg N, 50 kg P_2O_5 and 50 kg K_2O/ha were applied. The yield data are reported in Tables 31 and 32.

The grain yield of wheat increased significantly with the application of gypsum to the previous crop of rice. But in the subsequent rice crop the differences in the paddy grain yield were non-significant.

(c) Effect of the application of graded doses of gypsum over years.

The experiment was started in *kharif* 1971. Yield data of paddy grain were reported in the last year'r report. Following rice, wheat (variety Kalyan Sona) was sown. After the harvest of wheat rice (variety IR8-68) was transplanted. The yield data for these crops are given in Table 33.

TABLE 33. *Effect of graded doses of gypsum on the yield*

Gypsum t/ha	Grain yield (q/ha)		
	Wheat 1971-72	Paddy 1972 *a*	Paddy 1972 *b*
6.5	35.8	70.9	70.0
13.0	40.5	68.0	71.6
19.5	42.2	67.9	65.8
26.0	45.2	65.8	69.1
C.D. at 5%	4.3	N.S.	

In kharif 1972 in some of the plots (b) additional application of gypsum 6.5 t/ha was made to see if such addition would be beneficial to the crop. The data given in the above table clearly indicate that whereas in case of wheat the yield increased with increasing quantity of gypsum in rice grown in the second year, the grain yield was not affected either due to initial or subsequent application of gypsum.

(d) Effect of date of transplanting on the paddy grain yield of IR8-68 variety of rice.

Rice is the most important *kharif* crop in alkali soils. To obtain information about the optimum date of transplanting 35 days old seedlings were transplanted on June 24, June 30, July 7, July 12 and July 18. The yield data are given in Table 34.

TABLE 34 *Effect of date of transplanting on the yield of rice (IR8-68)*

Date of transplanting	Paddy grain yield (q/ha)	Data of harvesting
24th June	63.6	19.10.1972
30th June	71.9	25.10.1972
6th July	57.7	2.11.1972
12th July	66.9	6.11.1972
18th July	45.6	10.11.1972
C.D. at 5%	7.1	

Apart from low yield late transplanting has the disadvantage as the sowing of subsequent wheat crop is considerably delayed.

(e) Effect of the age of seedling on the yield of rice.

This was the first year of the experiment. Seedling of paddy variety IR8-68 of different ages viz. 24, 28, 32, 36 and 40 days were transplanted on 12.7.1972. The highest yield of 56.5q/ha of paddy was obtained with 36 days old seedling and this was significantly higher than the yield obtained with 24 days old seedlings.

S.A. 5.4 : Salt dynamics in soils as influenced by irrigation frequencies (B.L. Gaul, I.P. Abrol and K.S. Dargan).

In order to confirm the findings of the previous year the experiment was continued during the rabi 1971-1972 also by using the wheat variety Kalyan Sona, with a slight modification in the irrigation treatments. Since there was a linear increase in the yield of wheat grain during the previous year even upto 11 irrigations, hence the range of irrigation treatments was further narrowed and the depth of water per irrigation was also reduced from 80 per cent to 60 per cent of cumulative pan evaporation reading fixed for the irrigation treatment concerned; because the effective root zone found during 1970-71 was only 15 cm.

The experiment was laid out in a (5×5) latinsquare design having the 7.6×3.8 m plot size. The irrigation treatments included application of water when cumulative evaporation from U.S. open pan evaporimeter amounted to 30, 50, 70, 90 and 110 mm which were designated as E 30, E 50, E 70, E 90, E 110. The rainfall received during the crop period was 5.6 cm and the total water applied during the season was 34 cm which was nearly the same for all treatments. The crop was sown on November 23, 1971 and harvested on April, 26, 1972. The irrigation treatments E 30, E 50, E 70, E 90, and E 110 received 14, 9, 7, 6 and 5 irrigations respectively which are inclusive of one (first) common irrigation given at crown root initiation stage. Some important physico-chemical properties of the experimental site are given in Table 35.

TABLE 35. *Some physico-chemical properties of soil*

Depth (cm)	pH_2	EC_2 (mmhos/cm)	Field capacity %	Bulk density gm/cc
0-7.5	9.0	0.78	21.0	1.55
7.5-15	9.7	0.65	21.2	1.55
15-30	10.1	0.76	21.1	1.71
30-45	10.1	0.90	20.0	1.70
45-60	10.1	1.00	20.7	1.70
60-75	10.2	1.05	21.5	1.60
75-90	10.2	1.17	21.3	1.50

TABLE 36. *Effect of irrigation treatments on EC_2 (mmhos/cm.) and pH_2 (1 : 2) of the soil.*

Depth (cm)	Initial soil analysis		Final soil analysis									
	pH	EC	E 30 (14)*		E 50 (9)		E 70 (7)		E 90 (6)		E 110 (5)	
			EC	pH	EC	pH	EC	pH	EC	pH	EC	pH
0-7.5	9.0	0.78	0.56	9.2	0.67	9.2	0.68	9.4	0.57	8.8	0.64	8.8
7.5-15	9.7	0.65	0.80	9.6	0.90	9.6	0.83	9.7	0.89	9.4	1.01	9.6
15-30	10.1	0.78	0.85	9.9	0.98	9.9	0.80	9.8	0.95	9.9	0.98	10.0
30-45	10.1	0.90	0.81	10.0	1.01	10.0	0.98	9.9	0.95	9.9	1.07	10.0
45-60	10.1	1.01	1.03	10.0	1.10	10.0	0.94	9.9	1.07	9.9	1.10	10.0
60-75	10.2	1.05	1.10	10.0	1.09	10.0	0.98	10.0	1.12	9.9	1.18	10.0
75-90	10.2	1.11	1.21	10.1	1.17	10.0	1.05	9.9	1.14	9.9	1.22	10.1

* Figures in parenthesis refer to number of irrigations applied.

For salt distribution studies the EC and pH measurements were taken in 1 : 2 soil water suspension, the data are presented in Table 36. The data reveal that the EC and pH of the soil increased with depth but there was not much difference between the initial and final salinity status of the soil and so was amongst various irrigation treatments also.

Unlike the previous year (1970-71) of experiment there was not much effect of intensity of irrigation on the salt distribution in the root zone, but the intensity of irrigation did show very marked effect on the grain yield of wheat.

The data on different biometric observations are presented in Table 37.

TABLE 37. *Effect of irrigation on various growth and yield characters of wheat*

Treatments	Irrigation No.	Plant height (cm)	Ear length (cm)	1000 grain weight (gm.)	Grain yield (q/ha)	Water use efficiency (kg/cm/ha)
E 30	14	85.2	10.2	38.40	26.27	50.1
E 50	9	88.3	10.2	38.57	25.70	52.0
E 70	7	85.2	9.9	34.71	23.24	50.0
E90	6	78.3	10.0	35.12	20.44	44.9
E 110	5	73.1	9.9	34.14	14.64	36.9
F Test	—	Sig.	—	—	Sig.	—
C.D. at 5%	—	4.2	—	—	4.58	With missing
		3.8	—	—	4.17	Without missing

In this experiment the crop in the E 30 treatment in 3rd row was exceptionally poor, hence the missing plot technique was applied to estimate the value of this plot. As it is evident from Table 36 that the yield increased with increase in irrigation frequency ; but statistically the treatments E 30, E 50 and E 70 were at par with each other. The higher frequency treatments (E 30 and E 50) having frequencies 14 and 9 respectively were found to be significantly superior to the higher intensity treatments (E 90 and E 110). The E 70 and E 90 were at par with each other but gave significantly higher yield than the E 110 treatment, which was having the highest intensity and lowest frequency in the range selected for investigation. Similar is the picture with other biometric characters. During the year 1970-71 the response to irrigation was linear and significant even upto 11 irrigations but in the second year the crop showed the response upto 7 irrigations only though the numerical increase in the yield was noted upto 14 irrigations but statistically it was not significant. The main reason for this trend seems to be related to the transmission characteristics of the soil which was less sodic in the second year.

The soil moisture determinations were made from the soil samples taken from surface down to the depth of 90 cm at various intervals before and after each irrigation.

(i) Consumptive use of water : The total consumptive use values for the season were 525, 494, 465, 455 and 397 mm for E 30, E 50, E 70, E 90 and E 110 treatments respectively. The rate of consumptive use per day was higher in the wetter moisture regimes.

(ii) Soil moisture extraction pattern : The data pertaining to the moisture extraction pattern are depicted in Fig. 11. The data reveal that the soil moisture depletion decreased with depth in general. It may be seen that the maximum depletion of the order of 80 to 86 percent was from the top 30 cm layer beyond which it decreased considerably. The moisture from the lower layer was utilized more efficiently in comparatively drier moisture regimes. Keeping in view the previous years results as discussed earlier it seems that there has been some improvement in the physical condition of soil by continuous cropping as it is revealed in the soil moisture extraction studies that the active roots in the second year went deeper in comparison to the previous year. Thus the effective root zone for this year may be considered as 30 cm instead of 15 cm; hence it may be concluded that with the improvement in soil brought about by continuous cropping the irrigation practice may be modified accordingly.

(iii) Response to water use by the crop : The data presented in Table 36 indicate that response to per unit of water used by the crop was nearly equal for the E 30, E 50 and E 70 treatments as beyond 7 irrigations more frequent irrigations did not produce significantly higher grain yield but for other treatments the water use efficiency decreased with decrease in irrigation frequency while in the first year there was marked increase in water use efficiency with increase in irrigation frequency.

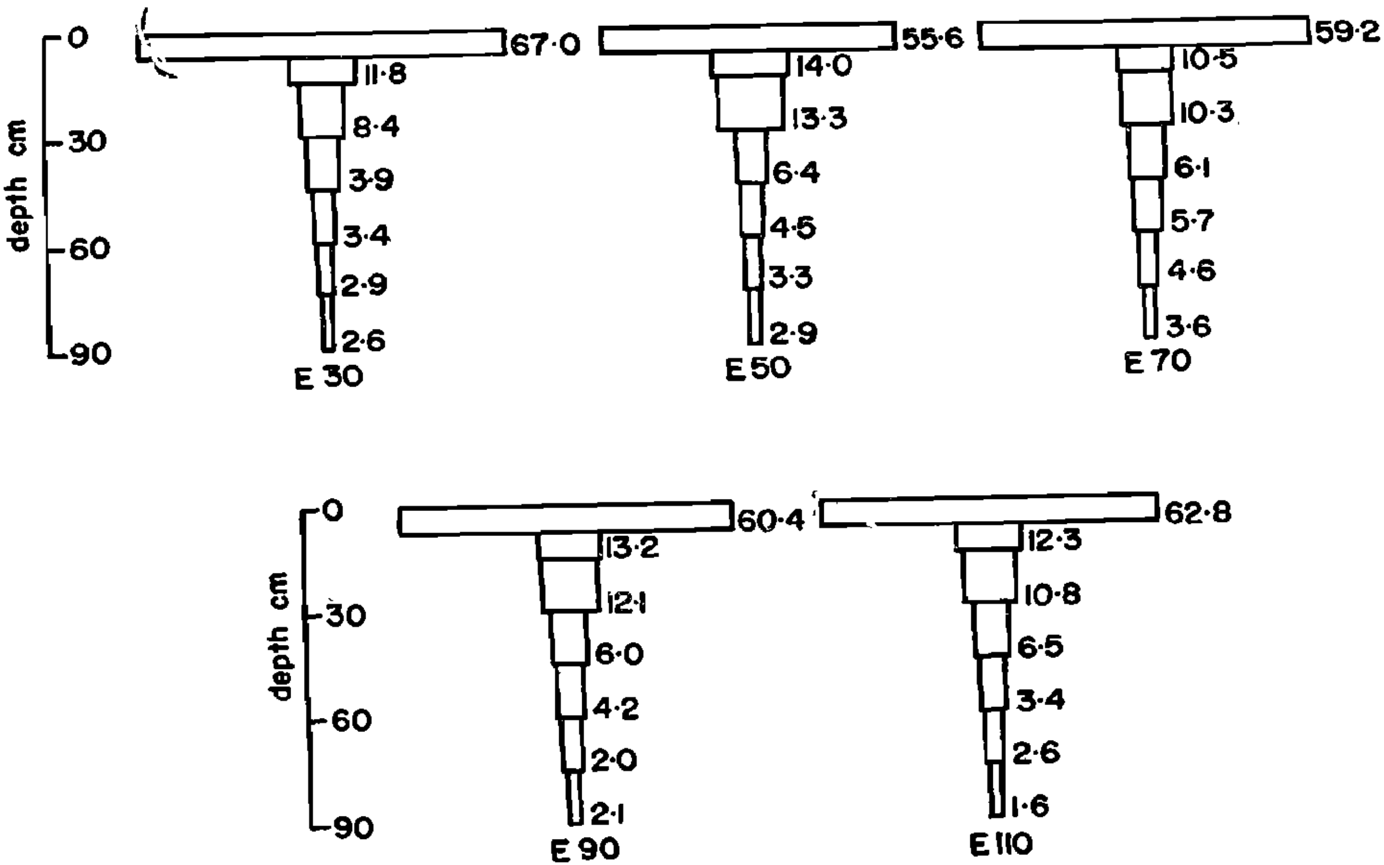

Fig. 11. Moisture use pattern by wheat on saline sodic soil under different treatments.

S.A. 5.5 : Efficiency of different fertilizers on salt affected soils (H.C. Nitant, K.S. Dargan and I.P. Abrol).

Transformation of urea in salt affected soils :

A laboratory study was conducted to study the changes in NH_4, NO_2 and NO_3 forms of nitrogen at 0, 125, 250 and 500 ppm concentration of urea fertilizer for periods of 1, 2, 3, 8, 16, 24, 32 and 40 days. The samples were incubated at 28°C±1 and at 60 percent moisture of saturation percentage in normal, saline and saline-sodic soils.

The data showed that the urea-nitrogen at all the concentration, was completely hydrolysed after one day in normal, three days in saline and four days in saline-sodic soil. The rate of hydrolysis increased with increasing concentration of urea. The amount of nitrate increased with increasing time. Nitrite accumulation was maximum in saline sodic followed by saline and normal soil. It increased with increasing concentration of urea nitrogen. It is evident from Fig. 12 that in normal soil the nitrite did not persist for more than five days. In saline soil NO_2 may persist upto about 2 weeks and in saline-sodic for more than 4 weeks particularly where high amounts of urea were applied.

Effect of different doses and sources of ntirogen on the grain yield of paddy and wheat :

One pot and two field experiments were conducted taking wheat and paddy as test crops to study the effect of different doses and sources of nitrogen.

A pot experiment was conducted to study the effect of three nitrogenous fertilizers viz. ammonium sulphate, calcium ammonium nitrate and urea, on germination, yield and nitrogen uptake of wheat in a saline sodic soil (ECe 11.77 mmhos/cm and pH of saturation paste 9.9).

Germination was quicker in presence of ammonium sulphate followed by calcium ammonium nitrate and urea. Similar trend was observed in case of yields (grain and straw) and percentage nitrogen utilized.

This is the second year of the field trial with five levels of nitrogen at 60, 90, 120, 150 and 180 kg N/ha and three sources of nitrogen viz. ammonium sulphate, calcium ammonium nitrate and urea as the treatments. The crops sown were paddy (IR8-68) and wheat (Kalyan Sona). Soil samples taken before the start of the experiment had pHs of 10.0 and electrical conductivity (mmhos/cm) of saturation extract as 11.23. Data presented in Table 38 show that the grain yield of wheat is maximum with ammonium sulphate followed by calcium ammonium nitrate and urea, whereas the decreasing order for paddy yield was ammonium

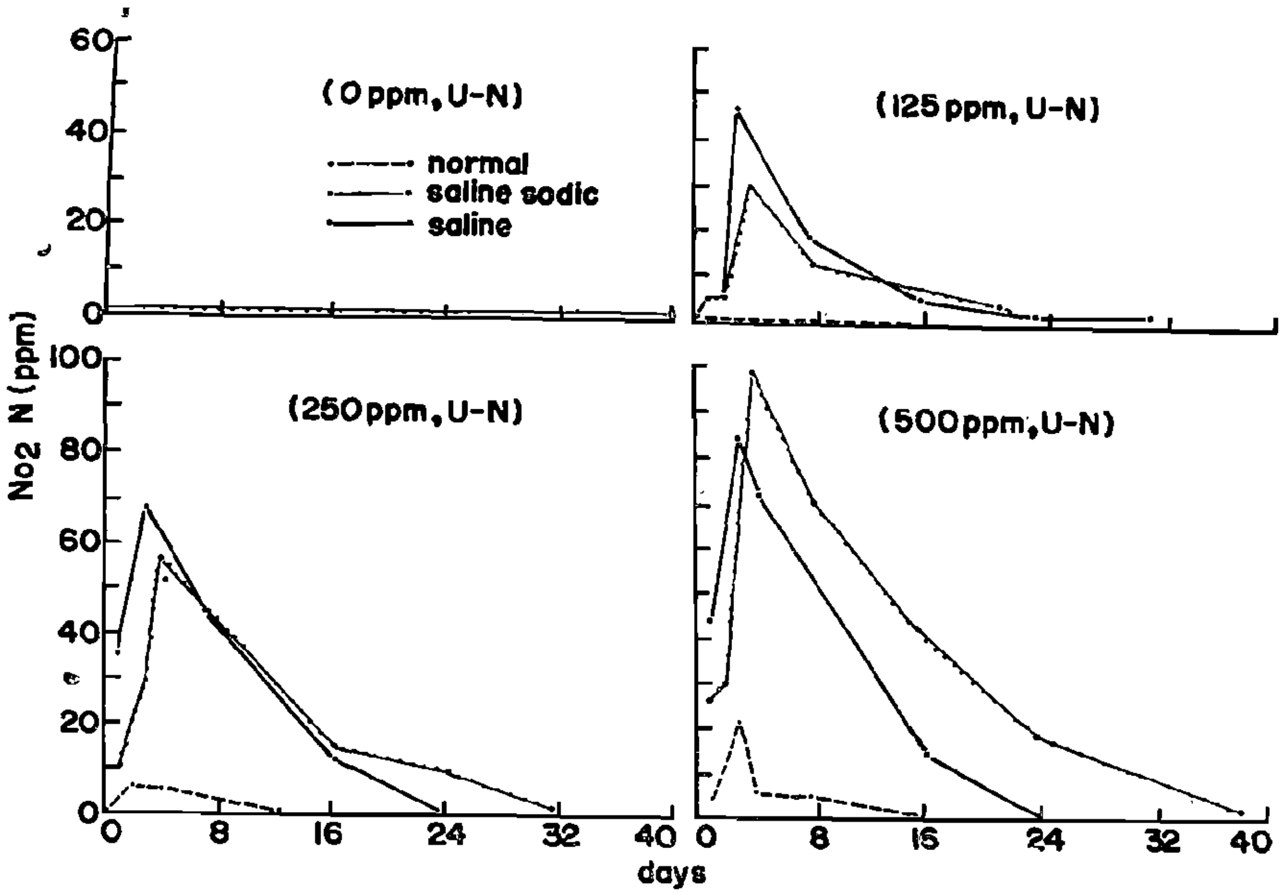

Fig. 12. Hydrolysis of urea nitrogen on saline sodic soil of different concentrations of nitrogen.

sulphate urea calcium ammonium nitrate, which is in conformity of last year trial in the same field.

TABLE 38. *Effect of the application of nitrogenous fertilizers on the paddy and wheat grain yields (q/ha.)*

N	A/S		CAN		Urea		Mean	
Kg/ha	Paddy	Wheat	Paddy	Wheat	Paddy	Wheat	Paddy	Wheat
60	37.83	17.31	29.38	15.20	32.65	11.54	33.27	14.68
90	43.56	21.07	36.59	16.75	37.72	15 90	35.46	17.87
120	51.34	22.24	42.87	21.81	43.35	20.13	45.82	21.39
150	60.24	30.54	55.14	26.88	49:54	21.96	55.17	26.46
180	63.05	29.28	57.98	27.02	59.11	21.96	60.01	26.09

C.D. at 5 % Sources 1.71 Levels 6.94

Another field experiment was conducted on paddy of same variety but on a less deteriorated soil. The soil pH (Sat. paste) and ECe mmhos/cm were 9.2 and 7.2 respectively. There were 15 combinations of 3 sources of nitrogen namely ammonium sulphate, calcium ammonium nitrate and urea, each at 5 levels viz. 0, 50, 100, 150 and 200 kg N/ha. It is observed from Table 32 that application of ammonium sulphate resulted in higher yield of paddy grain than other fertilizers.

TABLE 39. *Effect of the application of IR8-68 nitrogeneous fertilisers on paddy (q/ha)*

N Kg/ha	A/S	CAN	Urea
0	45.44	41.04	43.98
50	59.37	57.17	57.90
100	68.16	63.03	65.90
150	79.89	69.63	73.30
200	80.63	72.56	74.76

Among levels of nitrogen dose of 150 kg N/ha was better than 0, 50 and 100 kg N/ha but at par with 200 kg N/ha.

S.A. 5.6 : Requirement of nutrients of different crops in saline sodic soils. (K.S. Dargan, R.K. Chhillar and D.R. Bhumbla).

(a) Effect of the application of the phosphorus and zinc on the yield of wheat and rice.

The experiment which was started in *kharif* 1971 was continued in 1972.

In wheat only the residual effect of P and Zn applied to the previous crop was studied but in rice, grown in *kharif*, 1972, phosphorus and zinc were again applied to the respective plots. The yield data of wheat 1971-72 and rice *kharif* 1972 are given in Table 40. Neither the residual nor direct application of these nutrients had any significant effect on the grain yield of paddy and wheat.

TABLE 40. *Effect of phosphorus and zinc on the yield of paddy and wheat.*

Treatment		Grain yield (q/ha)	
P_2O_5 (kg/ha)	Zn SO_4 (kg/ha)	Wheat 1971-72	Paddy 1972
0	0	15.1	61.6
	40	15.8	63.9
0	80	15.8	65.0
40	0	17.1	67.4
40	40	20.3	65.3
40	80	20.5	71.7
80	0	15.9	64.1
80	40	22.2	65.6
80	80	18.6	67.2
120	0	19.9	65.7
120	40	17.6	64.9
120	80	22.5	66.0

C.D. N.S.

(b) *Effect of foliar and soil application of urea on the yield of wheat and rice.* (*K.S. Dargan, Harish Chandra and D.R. Bhumbla*).

Experiments conducted on saline sodic soils indicated that in highly sodic soil, application of N in the form of urea is not as effective as ammonium sulphate. One of the reasons could be the high pH of the soil. An experiment was, therefore, conducted to see the relative effect of soil and foliar application of a part of nitrogen. All plots received 80 kg N, 80 kg P_2O_5 and 80 kg K_2O per hectare in the form of urea, superphosphate and muriate of potash respectively and 40 kg/ha of zinc sulphate. The soil pH (1 : 2) was 9.9 and E.C. (1 : 2) was 1.5 mmhos/cm. The yield data of wheat are given in Table 41.

TABLE 41. *Effect of foliar v/s soil application of urea on wheat yield (q/ha)*

Treatment	Wheat yield
Control	19.5
20 kg N/ha—soil	25.1
40 kg N/ha—soil	36.5
60 kg N/ha—soil	45.3
20 kg N/ha—foliar	42.4
40 kg N/ha—foliar	45.2
C.D. at 5%	7.16

S.A. 5.7 : Cropping patterns for saline sodic soils (*K.S. Dargan, R.K. Chillar and D.R. Bhumbla.*)

Realizing the need for an proper cropping pattern for saline sodic soils an experiment has been laid out with the following treatments :—

1. Paddy—Wheat—fallow (without irrigation)
2. Paddy—Wheat—fallow (with irrigation)
3. Paddy—Wheat—Dhaincha (G.M)
4. Paddy—Wheat—Cowpea fodder

5. Paddy—Wheat—Jowar fodder
6. Paddy—Wheat—Bajra
7. Paddy—Berseem
8. Paddy—Sugarbeet

Since paddy was the first crop, no treatment differences could be expected.

S.A. 5.8 : Studies on water use efficiency with pitcher technique for irrigation (R.C. Mondal).

Slow release of water from earthen pitcher burried in the soil was made use for economising the water requirement of crop grown under conditions of high evapotranspiration. For the purpose of experiments earthen pitcher 30 cm dia were buried at distance of about 3 m from each other. Pumpkin and Cucumber were sown in the immediate vicinity of pots. Pots were daily filled with water. Preliminary observations showed that this might be a good method for reducing water requirement of crops for growing selected crops under saline condition. The distribution of soil moisture around the pitcher under experimental condition is given in Table 42. Further detailed studies are in progress.

TABLE 42. *Moisture distribution in soil (percent) around the earthen pitcher*

Soil depth (cm)	Horizontal distance (cm) from the vertical axis of the pitcher			
	15-15	25-35	35-45	45-55
10	17.6	15.4	12.2	—
15	18.7	17.6	14.4	9.4
30	17.1	15.3	13.9	9.9
45	16.3	15.1	13.9	8.5
60	9.7	10.5	10.1	9.7
70	9.6	—	—	—

DIVISION OF GENETICS AND PLANT PHYSIOLOGY

G. P. 1 Evolving crop varieties for saline-sodic soil.

G. P. 1.1 Wheat Triticum aestivum (B. Mishra and M. N. Sarin)

A varietal trial with 17 popular high yielding and fertilizer responsive varieties was conducted in a soil with pH 9.1 and EC(1:2) 2.9 mmhos/cm. Fertilizers were added @150 kg N as ammonium sulphate, 60 kg P_2O_5 as superphosphate, 150 kg K_2O as muriate of potash and 30 kg zinc sulphate per hectare. Varieties WG 357, Sonalika and Hira have shown good promise (Table 43). These varieties will again be tested next year.

TABLE 43. *Performance of wheat varieties in partially reclaimed soil*

Variety	Grain yield q/ha	Variety	Grain yield q/ha
WG 357	58	Safed Larma	50
Sonalika	56	Chhoti Larma	49
Hira	55	UP 301	49
WG 377	53	J-22	45
Sharbati Sonora	53	K-818	44
Kalyan Sona	51	NV (1) 5643	42
PV-18	51	C-306	38
WL-812	51	C-273	35
HD-1944	50		

C. D. at 5% 3.9

G.P. 1.2 *Brassica* (K.N. Singh and Y.C. Joshi)

Performance of 25 varieties of *taramira* was seen in a saline sodic soil. The yields in respect of ten promising varieties are given in table 44. These varieties did not differ among themselves.

TABLE 44. *Performance of taramira varieties in saline; sodic soil.*

Variety	Yield (q/ha)	Variety	Yield (q/ha)
T-62	7.2	T-129	6.0
T-53	7.1	T-70	6.0
T-43	6.4	T-13	6.0
T-45	6.1	T-128	6.0
T-123	6.1	T-17	5.9

G. P. 1.3 Rice Oryza sativa B. Mishra, M. N. Sarin and T. N. Singh

A varietal trial was conducted to see the performance of 34 varieties of rice. Transplanting was done on 8th July, 1972. Fertilisers were used at the rate 160 kg N, 50 kg, P_2O_5 60 kg K_2O per hectare in the form of ammonium sulphate, superphosphate and muriate of potash, respectively Zinc sulphate at the rate of 25 kg/ha was added. *Jaya* gave the highest yield. This variety also yielded the highest in trial conducted in 1971 (Table 45).

TABLE 45. *Performance of rice varieties in saline sodic soil.*

Variety	Yield q/ha	Variety	Yield q/ha
Jaya	95.0	Pusa 2-21	71.0
IET-1136	94.7	Vijaya	68.7
IR-8-68	82.1	CR-44-35	67.0
IR-8	80.6	Jhona-351	67.9
Palman-579	78.8	Hamsa	61.2
C-579	78.1	HM-484	61.2
HM-474	77.3	Jagannath	60.6
Sabarmati	77.3	DR-36-148	60.0
IET-1991	75.7	Cauvery	55.8
CR-441	74.9	Kusma	54.7
IR-22	74.2	IET-849	52.7
HM-452	73.2	IET-1039	52.6
Ratna	73.0	Suma	51.4
Padma	73.0	Karuna	51.0
HM-473	72.7	Pal-246	49.0
Krishna	71.3	Basmnti-370	49.0
TN-1	17.5	Jhona-20	49.0

C.D. at 5% 7.1

Three more trials namely, uniform varietal trial-2A (U.V.T.-2A) with 12 varieties, Basmati derivatives trial (B.D.T.) with 15 varieties and slender grain varietal trial S.G.V.T. with 49 varieties were also conducted in cooperation with All India Coordinated Rice Improvement Project, Hyderabad. Variety Jaya yielded highest and was followed by IET-1991, IET-1451, IET-2295, in U.V.T.-2A Trial. In B.D.T. trial, varieties Jaya, Improved Sabarmati, IET-2850, IET-1991, performed better. The performance of varieties IET-2868, IET-2880, Ratna and Jaya check in S.G.V.T. was better.

G.P. 1.4 Millets (K.N. Singh)

(i) Bajra (Pennisetum typhoides)

An experiment with 64 selected strains of *bajra* from the last year's initial evaluation trial was conducted. Sowing was done on 19th July, 1972. Fertilizers were applied at the rate of 100 kg N, 40 kg P_2O_5 and 40 kg K_2O in the form of ammonium sulphate, superphosphate and muriate of potash, respectively. The crop was harvested on 25th October, 1972 and the yield data of promising varieties are given in table 46. Genetic diversity in relation to saline condition in *bajra* is being analysed.

TABLE 46. *Performance of Bajra varieties in saline sodic soil*

Variety	Yield (q/ha)	Variety	Yield (q/ha)
I.P. 11	14.9	I.P. 342	11.0
I.P. 2	14.9	$23D_2$Ax440	10.9
I.P. 50	12.1	I.P. 370	10.8
I.P. 14	12.0	I.P. 87	10.6
I.P. 327	11.9	I.P. 68	10.2

C.D. at 5% =4.6

ii) Jowar (Sorghum vulgare)

The trial was conducted on *jowar* varieties which had been tested in the previous year for grain production. The growth was very much affected by saline sodic conditions and only few varieties could flower but they did not give any yield because of poor seed setting.

G.P.2. 1 Sugarcane (Saccharum officinale) (B. Mishra and K.S. Gill)

A varietal trial on fifteen promising varieties which had been selected from previous year' initial evaluation trial was carried out on saline sodic soil. Fertilisers were added at the rate of 150 kg N, 60 kg P_2O_5, 60 kg K_2O and 25 kg $ZnSO_4$/ha, respectively. Variety CO 453 ranked first followed by CO 1341, CO 6801 and CO 62329 giving average cane yield of 721, 709 690 and 689 q/ha, respectively (Table 47), Variety CO 453 also yielded the highest in 1971 and thus appears to be promising for cultivation under sodic condition.

TABLE 47. *Performance of sugarcane varieties in saline sodic soil*

Variety	Cane yield (q/ha)	Variety	Cane yield (q/ha)
CO 453	721	CO 975	576
CO 1341	709	CO 6806	565
CO 6909	690	CO 1158	559
CO 62329	689	NCO 310	529
CO 1111	652	CO 1335	482
CO 62422	634	Mutant 997	385
CO 1148	606	MG-32	347
B-37172	578		

C.D. at 5%=102

G.P. 2.4 Safflower (Carthamus tinctorius) (K.N. Singh and T.N. Singh)

During *rabi* season,13 varieties of safflower were grown on saline sodic soil receiving a fertilizer dressing of 80 kg N, 30 kg P_2O_5 and 30 kg K_2O per hectare. The crop was given four irrigations during the growing season. The grain yield data revealed poor performance of all the varieties tried. Severe reduction in branching, size and number of capitula was the main reason of poor yield. Safflower is reported to be tolerant to salinity but in the present study, the high pH and the exchangeable sodium in the soil appear to have caused more adverse effect on grain yield.

G.P. 2.5 Sunflower (Helianthus annus) (K.N. Singh and T.N. Singh)

A preliminary trial with variety Sunrise (sown on 19th November, 1971 and harvested on 28th April, 1972) showed that very much reduced growth in the early stages with poor seed setting resulted in poor yield of sunflower on salt-affected soil.

G.P. 2.7 Sugarbeet (Beta vulgaris) (M.N. Sarin, B. Mishra and K.S. Gill)

A varietal trial on five varieties was carried out in soil having pH 9.3. Ammonium sulphate, superphosphate and muriate of potash were given in amounts so as to add 150 kg N, 100 kg P_2O_5. 120 kg K_2O/ha, respectively. Zinc sulphate was also added @ 25 kg/ha. Though the variety Erotype-E ranked first in root yield but the variety Maribo-Resistapoly produced the highest amount of sugar per hectare (Table 48). This was due, in part, to higher content of sucrose in roots of this variety. This trial will will be repeated next year.

TABLE 48. *Performance of sugarbeet in saline sodic soil*

Variety	Root yield (q/ha)	Sucrose (%)	Sugar yield (q/ha)
Maribo-Magnapoly	970	13.7	133
Kawe-Gigapoly	952	16.4	156
Erotype-E	1011	14.0	142
Maribo-Resistapoly	888	17.6	156
Ramonskaya	806	15.7	127

Distribution of Na and K in shoot and root of sugarbeet is given in table 49. It was interesting to note that under saline sodic conditions a large amount of Na was accumulated in shoot. It is probable that the capacity to transport much of absorbed Na from root to shoot and retain there is in some manner related to high degree of salt tolerance in this crop.

TABLE 49. *Distribution of Na and K in sugarbeet varieties*

Variety	Ratio of cation in shoot to cation in root			
	Normal Soil		*Saline sodic soil*	
	Na	K	Na	K
Maribo-Magnapoly	2.7	2.8	15.0	2.3
Kawe-Gigapoly	1.8	3.6	11.4	1.3
Erotype-E	1.8	3.6	6.4	1.4
Maribo-Resistapoly	2.5	3.7	16.6	3.0
Ramonskaya	0.9	1.6	12.9	2.4

G.P. 5 Physiological basis of salt resistance in dhaincha (sesbania aculeata) (K.S. Gill and M.N. Sarin)

It is well known that *dhaincha* is resistant to saline-sodic soil environment whereas cowpea is very sensitive to such type of edaphic environ-

TABLE 50. *Effect of ESP levels on growth of cowpea and dhaincha*

ESP Level	*Cowpea*			*Dhaincha*		
	(Days after sowing)					
	15	30	45	15	30	45
			Plant height (cm)			
11.0	10	19	25	11	35	90
16.6	9	17	20	9	35	86
22.2	9	14	17	9	30	82
26.0	9	14	19	10	30	82
33.3	7	-	-	9	29	74
			Leaf number/plant			
11.0	2	15	28	6	16	31
16.6	2	13	13	6	17	27
22.2	2	11	13	7	17	26
26.0	2	10	9	6	16	26
33.3	2	-	-	7	16	24
			Fresh weight/plant (g)			
11.0	3.3	24.0	39.4	2.1	22.4	89.3
16.6	3.4	23.7	30.8	2.5	19.2	71.8
22.2	3.8	13.7	37.7	2.2	17.6	55.7
26.0	3.0	12.6	23.3	2.0	17.4	56.5
33.3	2.5	-	-	2.1	17.1	49.0
			Dry weight/plant (g)			
11.0	0.3	3.8	13.4	0.2	2.9	19.1
16.6	0.3	3.3	4.8	0.3	4.1	15.6
22.2	0.4	2.1	5.9	0.3	3.9	12.9
26.0	0.3	1.6	3.7	0.3	3.0	12.7
33.3	0.2	-	-	0.2	3.1	10.5
			Branch number/plant			
11.0	-	8	10			
16.6	-	6	7			
22.2	-	6	6			
26.0		3	6			
33.3	-	-	-			

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Erotype-E	1.8	3.6	6.4	1.4
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Ramonskaya	0.9	1.6	12.9	2.4

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	(Days after sowing)					
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			Plant height (cm)			
11.0	10	19	25	11	35	90
16 6	9	17	20	9	35	86
22.2	9	14	17	9	30	82
26.0	9	14	19	10	30	82
33.3	7	-	-	9	29	74
			Leaf number/plant			
11.0	2	15	28	6	16	31
16.6	2	13	13	6	17	27
22.2	2	11	13	7	17	26
26.0	2	10	9	6	16	26
33.3	2	-	-	7	16	24
			Fresh weight/plant (g)			
11.0	3.3	24.0	39.4	2.1	22.4	89.3
16.6	3.4	23.7	30.8	2.5	19.2	71.8
22.2	3.8	13.7	37.7	2.2	17.6	55.7
26.0	3.0	12.6	23.3	2.0	17.4	56.5
33.3	2.5	-	-	2.1	17.1	49.0
			Dry weight/plant (g)			
11.0	0.3	3.8	13.4	0.2	2.9	19.1
16.6	0.3	3.3	4.8	0.3	4.1	15.6
22.2	0.4	2.1	5.9	0.3	3:9	12.9
26.0	0.3	1.6	3.7	0.3	3.0	12.7
33.3	0.2	-	-	0.2	3.1	10.5
			Branch number/plant			
11.0	-	8	10			
16.6	-	6	7			
22.2	-	6	6			
26.0		3	6			
33.3	-	-	-			

ment. To understand the physiological basis of salt resistance in *dhaincha* and injury in cowpea,an experiment was conducted in pots maintained at known levels of exchangeable sodium percentage (ESP). Different levels of ESP (ranging from 11 to 33) were prepared artificially by alkalinization of normal soil using sodium bicarbonate. Twelve water soaked seeds were sown per pot which were later thinned to four plants in each pot maintaining ten such pots for each treatment. It was observed that the emergence of cowpea was delayed and reduced even at the lowest level of ESP whereas in case of *dhaincha* no such effect was noticed. Under the ESP level of 33.3, the cowpea seedling died after 15 days of sowing, The data on height, leaf number, fresh weight, dry weight and branch number reveal that in case of cowpea, the adverse effect of ESP was noticed at the 15th day of sowing; the effect being marked only at the higher levels of ESP (Table 50). On 30th day of sowing the reduction in these characters was pronounced even at the ESP level of 16.6 and was further magnified on 45th day of sowing. In case of *dhaincha* the adverse effect of ESP was noticed only at higher levels on 30th day after sowing but was discernible from the ESP level of 16.6 onward at 45th day of sowing. The relative reduction in *dhaincha* was less than cowpea in all the growth characters. In grain and pod yields of cowpea, a reduction of about 50% was noticed at ESP 16.6 whereas *dhaincha* yield was not significantly reduced even at the highest level of ESP (table 51).

Biochemical tests at successive growth stages of two crops revealed that the chlorophyll and protein contents were higher in *dhaincha* than cowpea at all levels of ESP. The RNA and DNA components were less disturbed in *dhaincha* than in cowpea. These may be responsible for vigorous growth and tolerance of *dhaincha* to sodic condition.

TABLE 51 *Effect of various ESP levels on yield components in cowpea and dhaincha.*

ESP	*Cowpea* Pod No/ pot	Pod weight/ pot (g)	Grain weight/ pot (g)	*Dhaincha* Pod No/ pot	Pod weight/ pot (g)	Grain weight pot (g)
11.0	22	7.5	5.6	104	64	41.2
16.6	14	3.2	2.8	140	89	52.8
22.2	15	4.4	3.0	134	86	55.4
26.0	9	2.0	1.3	118	84	43.9
33.3	—	—	—	122	81	42.2
C.D. at 5%	2.6	1.6	1.4	NS	NS	NS

G.P. 6 Studies on nitrogen metabolism in plants grown under saline sodic conditions (T.N. Singh).

There is evidence that under conditions of water stress there is accumulation of free proline in some plants. Preliminary studies, therefore, were undertaken to study the effect of soil salinity on the concentration and changes in the proline content in leaves of wheat and sugarbeet. Results showed a marked increase in the content of this metabolite with increasing salinity. The accumulation of this metabolite was traceable within five hours of salt stress. On the other hand, plants cultured on nutrient solution alone did not accumulate proline. It was further observed that two crops varied widely in capacity to accumulate proline with the advancing period of treatment (Table 52). Interestingly, the concentration of proline decreased when the stress was relieved by transferring plants from salt solution to nutrient solution. Attempts to measure other amino acids are also being made. The capacity of different organs of plant to accumulate proline in response to salt and water stress and its role in plant metabolism are being investigated.

TABLE 52. *Effect of salt stress on proline accumulation in wheat and sugarbeet.*

Crop	mg/g dry weight	
	Control	NaCl-stress
Wheat	245	2,305
Sugarbeet	319	3,850

G.P. 8 Physiology of grain development in plants grown under saline sodic conditions : Wheat (M.N. Sarin and Y.C. Joshi)

Anthesis and grain filling are the two developmental stages which are very sensitive to salt and water stress. Such stresses invariably decrease both the number and size of grains. Since photosynthesis and leaf area duration after anthesis are important for proper grain filling, it was of interest to investigate such aspects for further understanding of underlying causes of shrivelled grain formation, a process of common occurrence under saline-sodic condition.

Experimental material consisted of the samples of developing grains of 16 wheat varieties as reported in Annual Report of 1971, harvested at different intervals after anthesis. Efficiency of grain filling per day was calculated from the linear part of the curve drawn from the periodical increase in dry weight of grains after anthesis. Effective Filling Period Duration (EFPD) could be obtained by dividing the final matured grain weight by efficiency/day. Finally, two factors, i.e. efficiency per day and effective filling period duration were obtained for all the treatments. No correlation of yield to either of the two factors could be obtained. Further analysis revealed that yield was significantly correlated with a factor of grain development which had both the components of EFPD as well as efficiency per day. This factor has been tentatively called as grain filling potential (GFP) which is mathematically equal to grain weight. The correlations of GFP and yield were not altered in plants raised at varying levels of salinization; however, there was increase in the slope of regression line (Table 53 and Fig 13).

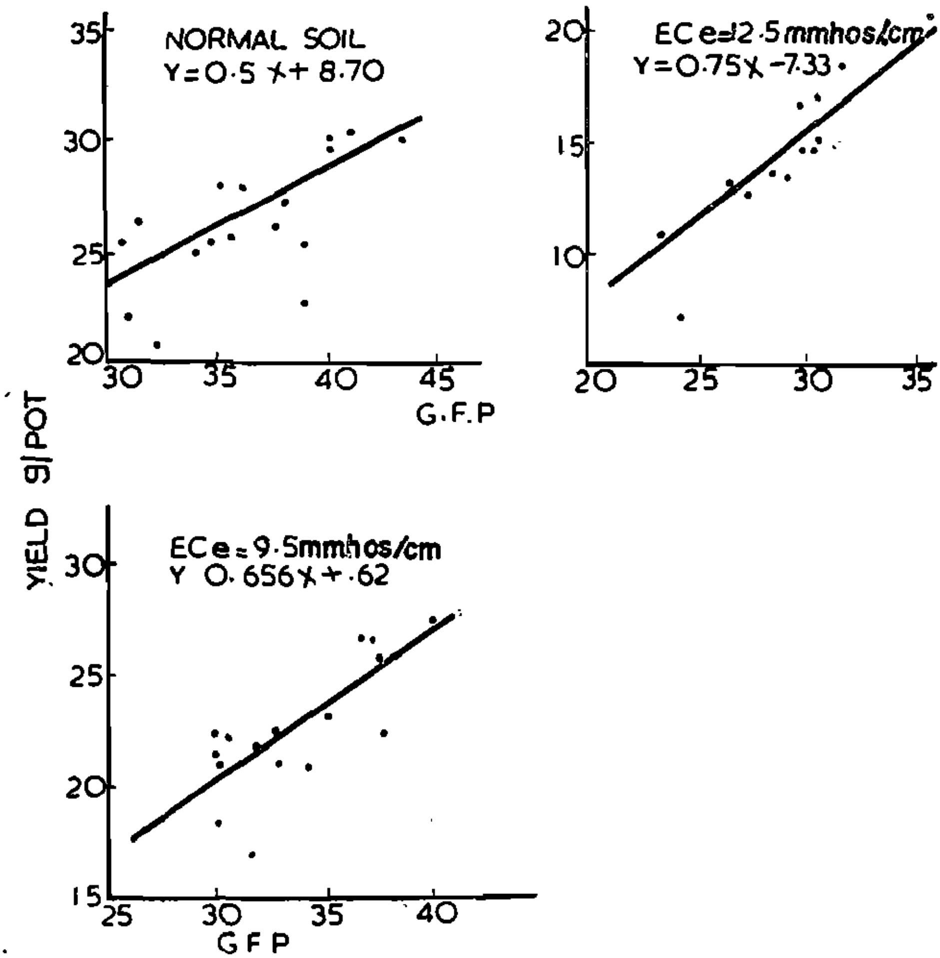


Fig. 13. Relation between grain filling potential (GFP) and yield of wheat at varying salinity levels

TABLE 54. *Effect of salinity on the starch content and its yield in the developing grain of different varieties of wheat.*

Treatment	Days after anthesis			
	7	12	17	Mature
	Starch Content (Percent)			
HD 1949				
Control	23.7	38.0	52.3	68.7
ECe x 10^3 12.5	18.7	29.0	47.0	65.0
UP 307				
Control	24.0	47.0	47.5	67.7
ECe x 10^3 12.5	20.0	42.5	42.5	67.5
WG 357				
Control	24.0	40.0	47.5	65.0
ECe x 10^3 12.5	23.0	40.0	47.5	65.0
Safed Larma				
Control	22.0	40.6	55.0	67.5
ECe x 10^3 12.5	20.0	35.0	47.5	67.5
C 306				
Control	24.0	45.0	50.0	67.5
ECe x 10^3 12.5	20.0	42.5	47.5	68.7
	Starch Yield (mg/grain)			
HD 1949				
Control	2.3	6.0	13.4	26.9
ECe x 10^3 10.5	1.4	2.8	9.4	16.0
UP 307				
Control	3.2	7.1	13.2	24.4
ECe x 10^3 12.5	1.3	5.1	10.3	21.7
WG 357				
Control	2.0	7.0	13.4	26.1
ECe x 10_3 12.5	1.3	6.1	12.1	24.7
Safed Larma				
Control	1.7	7.3	16.1	26.1
ECe x 10^3 12.5	1.2	4.7	10.7	23.3
C 306				
Control	1.4	7.5	12.4	27.5
ECe x 10^3 12.5	1.0	6.1	9.6	21.2

Table 53. *Effect of salinity on the slope of the regression line between grain yield and grain filling potential.*

Treatment	Regression equation
Control	$y=0.500x+8.70$
ECe 9.5	$y=0.656x+0.62$
ECe 12.5	$y=0.750x-7.35$

y=Yield g/pot; x=G.F.P.

The starch content in the wheat grain was lowered by salinity during early period of grain development in all varieties, but mature grains did not show any difference (Table 54). The starch yield was reduced by salinity at all stages of development and in all varieties but the reduction at maturity was relatively less in WG 357, UP 307 and Safed Lerma, suggesting their better adaptability in saline sodic media.

DIVISION OF ENGINEERING

E.1. *Effect of open ditches and tile drains on the salt and water balance in the soil profile.* (*S.R. Jaiswal and R.N. Pandey*)

In order to provide suitable criteria and specifications for the design of sub-surface drainage in the saline and water-logged areas of the region, this experiment has been installed at the research farm. By field investigations, the hydraulic conductivity, drainage coefficient and the depth of impermeable layer were determined. The drain spacing given below was computed by the various formulas developed from the theories of ground water movement after substituting the numerical values of the above parameters :

Formula	*Spacing (S)* (*m*)
Hooghout	18.4
Kirkham	17.4
Bureau of Reclamation	28.6
Bureau of Reclamation *With equaivalent depth*	18.9
Bureau of Reclamation (*Moody's correction*)	19.5

For drain size, a minimum diameter of 12.5 to 15 cm is recommended to be used in flat lands and so the size of the drain was kept as 15 cm. Similarly for the open drain a bottom width of 0.6 m, top width of 2.6 m and side slopes of 1.5 vertical to 1 horizontal have been adopted to provide stable side slopes, minimum working space for digging and minimizing the loss of land under the drains.

The design drain spacing is about 20 m. In order to see the adequacy of the spacing two more widely differing spacings (10 m and 30m) were chosen for comparison in the experiment. The experimental layout is shown in *Fig. 14*.

The observations recorded during the monsoon (July-October), 1972 revealed that the performance of open drains was not satisfactory because of slumping of the earth from sides due to poor stability. Sub-surface flow was noticed only through the 10 m spaced open ditches. The water table remained within 150 cm below ground level during the

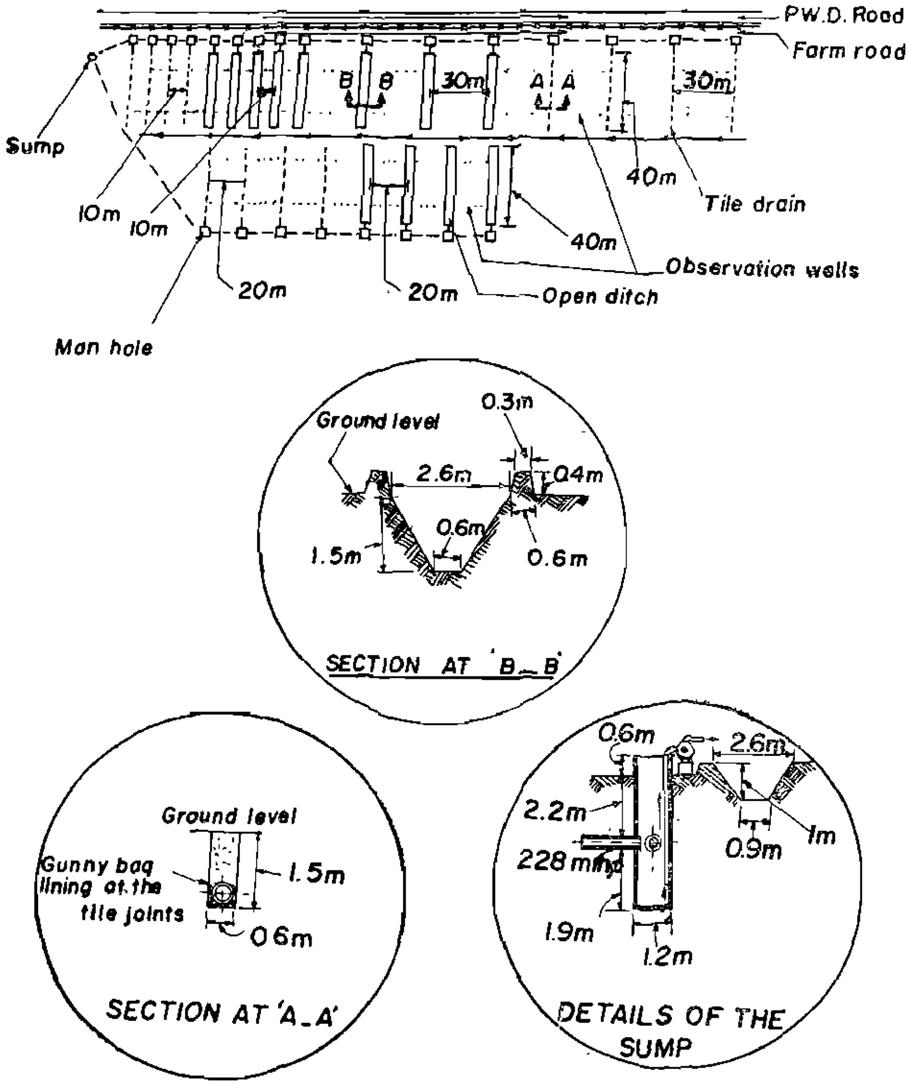


Fig 14. Layout Details of the Subsurface Drainage Experiment on C.S.S.R.I. Research Farm.

last week of August and the whole of September (*Fig. 15*) and during this period the drains were discharging some runoff. The maximum discharge for each spacing corresponded to the maximum water table rise which occurred during the 1st week of September. The maximum water table recession rates corresponding to drain spacings of 10,20 and 30 m were 0.6, 0.4 and 0.1 cm/ day, respectively. The recession rates were greater in the plots drained by the tiles at 10 m spacing. The flow per unit area drained was greater in the case of drains spaced at 10 m spacing (*Table 55*). The maximum discharge rate for each spacing occurred on 7.9.72 and corresponding to the highest water table level of 105 cm. While the 30 m spaced drains functioned only for 18 days, the drains in the other two treatments functioned for 33 days.

The average electrical conductivity of the drainage water was 1.53 mmhos/cm.

E. 2. *Desalinisation of soil provided with tile drains or ditches under ponding and fluctuaing water table conditions.* (*S.R. Jaiswal, V.V. Dhruva Narayana, and A.K. Pasricha*)

In order to assess the desalinization of soils (a) provided with tile drainand ditches (b) under different methods of ponding and during differents seasons when the water table is above and below the drain level, a study was conducted in the sub-surface drainage experimental area.

During the period under report, the flow did not take place through the tile drains even after ponding for 60 days. The study is continuing.

E. 3. *Efficiency of rainwater storage in surface pond as a measure of surface drainage.* (*S.K. Gupta. and V.V. Dhruva Narayana*).

For providing surface drainage during the excess rainfall period and to conserve good quality rainwater for subsequent use for irrigation, three dug out ponds were constructed on the research farm with storage capacities of 22.2, 79.6 and 144.4 ha.cm. Surface drainage channels were provided in all the three catchments to promptly convey the precipitation excess into the dug out ponds or into the field drains. More than half the storage capacity of the pond below the ground level is filled by the gravity flow of surface drainage water or excess runoff. The storage capacity of the pond above the ground level is filled by pumping the surface drainage water into the pond. The functions of the dug out ponds as a drainage water collector as well as an irrigation water source is accomplished by the inlet-cum-outlet structure (*Fig. 16.*)

During the intense rains that occurred in July, 1972 the hydrologic data collected for the three ponds (*Table 56*) indicate that 40 to 60% of the

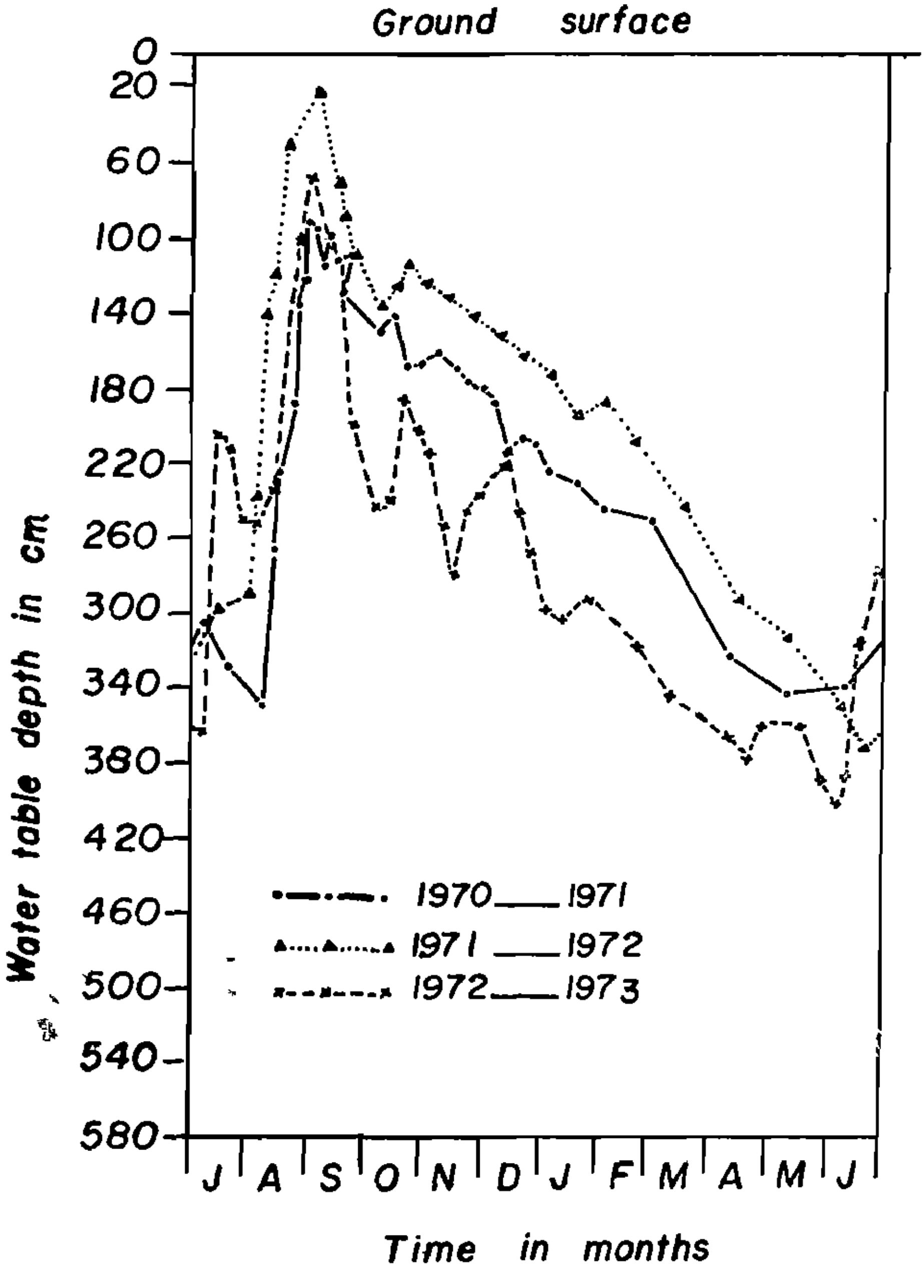
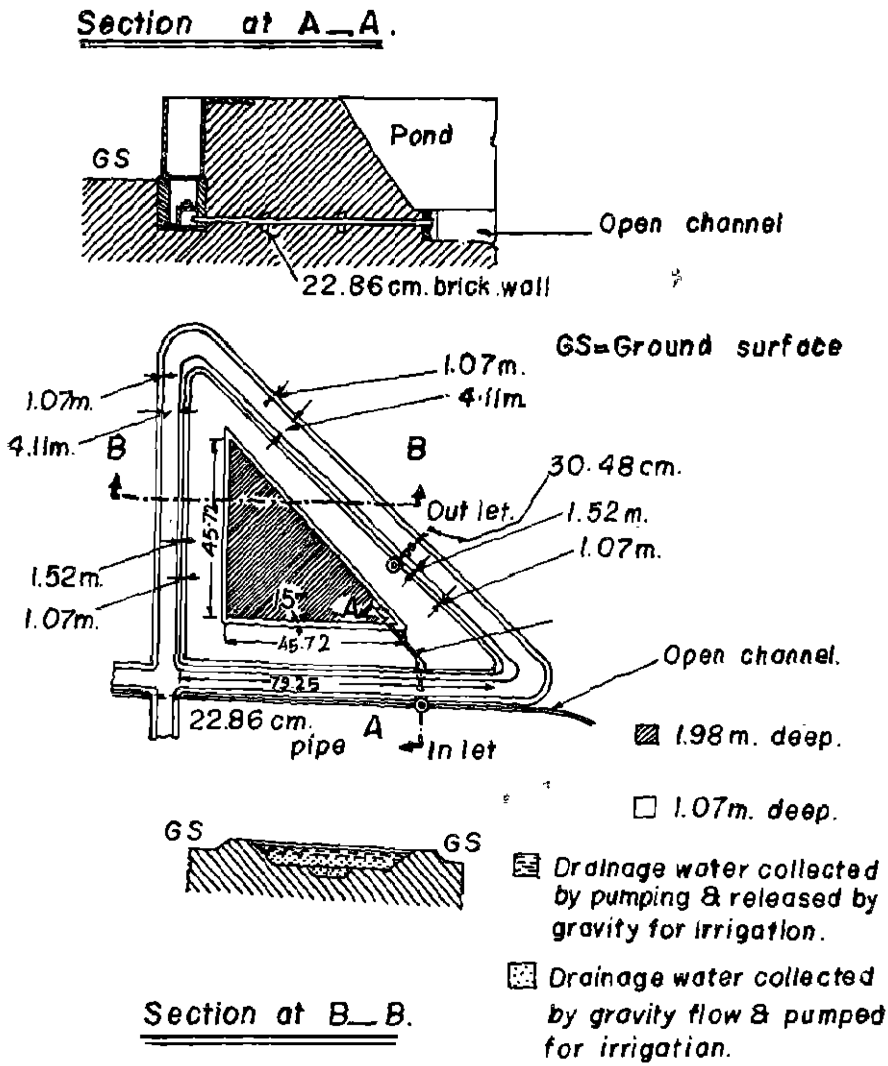


Fig 15. Water table fluctuations on the Research Farm.

TABLE 55. *Discharge of water and its quality from tile drains installed at various spacings during 1972.*

Time (Days)	Date	Discharge (l/day/ha)			pH			E.C. x 10^3		
		10 m	20 m	30 m	10 m	20 m	30 m	10 m	20 m	30 m
0	Aug. 31	—	—	—	—	—	—	—	—	—
4	Sept. 4	2600	1800	350	8.5	8.9	8.9	1.10	1.60	1.46
7	7	3400	2000	400	8.8	8.9	9.1	1.50	1.72	1.65
10	10	3300	1700	300	9.0	9.2	9.3	1.22	1.80	1.81
13	13	2900	1800	260	9.0	9.5	9.2	1.17	1.14	1.42
16	16	2900	1800	260	8.8	9.3	9.0	1.45	1.16	1.62
19	19	1700	1200	80	9.3	9.3	9.6	1.31	1.60	2.02
22	22	1400	900	40	9.3	9.1	9.2	1.28	1.20	2.20
25	25	1200	860	—	9.3	9.6	—	1.25	1.68	—
28	28	1000	560	—	9.1	9.5	—	1.32	1.72	—
31	Oct. 1	630	350	—	9.2	9.6	—	1.35	1.71	—
34	4	140	100	—	9.0	9.3	—	1.37	1.75	—



Note:- All dimensions are in metres unless otherwise specified

Fig. 16 : Details of the inlet-cum-outlet structure for the dugout pond.

TABLE 56. *Hydrologic data of dug out ponds on the CSSRI Farm, Karnal, for the period from July 7 to July 11, 1972.*

Dug out Pond No.	Catch-ment area (ha)	Rain-fall (mm)	Water yield (ha cm)	Volume ratio of water yield to rainfall	Storage capacty (ha. cm)	Storage efficien-cy ratio of stor-age cap. and water yield	Cost per ha. cm of water stored in the filling. (Rs.)
1	30	283.8	229	0.264	144	0.62	104
2	6	283.8	49	0.296	22	0.45	169
3	26	283.8	105	0.222	80	0.49	118

total water yield was stored in each of the three dug out ponds. During the lean period which prevailed in later part of July, the stored water was effectively utilized for irrigation of paddy crop. This is the chief advantage of this set up.

The cost of the dug out ponds including the inlet-cum-outlet structure worked out to about Rs 104 to 169 per ha. cm. of storage capacity of the pond. During this year's rainy season, the ponds were filled on two occassions. This conserved water provided irrigation to *kharif* and the early part of *rabi* crops on about 4 hectares.

The quality of runoff stored in the dug out ponds during the monsoon has been good (*Table 57*). The electrical conductivity was in the range of 139 to 727 micromhos/cm and the pH was in the range of 7.4 to 9.5. As most of the catchments have soils containing high concentrations of sodium carbonate, the runoff from these catchments, even with lower amounts of total dissolved solids, may contain higher amounts of sodium carbonate. In such cases the runoff water from the first rains of the season could be allowed to drain out during the storm itself or later by pumping, whichever, is practicable. Alternatively, such water with high sodium carbonate content could be used for irrigations alongwith gypsum. However, with progressive reclamation of soils within the catchment, the waters will also improve.

E.4. *Performance of Shallow and deep tubewells for vertical drainage.* (*R.N. Pandey and A.K. Pasricha*)

There are four shallow cavity wells, a shallow strainer well and deep tubewell. Observation wells are located at 100 m interval on a nearly square grid. Pump tests were conducted in three of them. The transmissibility of the shallow aquifers in the vicinity of these wells is found

TABLE 57. *Quality of runoff from the Catchment*

Date	Catchment-I EC x 10^6	pH	Catchment-II EC x 10^6	pH	Catchment-III EC x 10^6	pH
30.6.72	473	8.2	546	8.5	508	9.0
5.7.72	717	8.5	579	8.7	655	8.9
7.7.72	204	8.5	587	8.9	653	7.8
10.7.72	143	7.6	391	9.2	204	8.7
24.7.72	211	8.4	493	9.5	252	8.8
16.8.72	320	9.2	563	9.2	430	8.8
30.8.72	139	7.4	405	8.8	267	7.8
15.9.72	215	8.2	404	9.2	285	8.6

to be 191-417 m^3/day/m and the storage coefficient as 3%. In the case of tubewell No. 2, water table levels continued to decline even after 8 hours of pumping. The draw down values after 8 hours of pumping at distances of 32 m, 99 m, 134 m and 168 m were 41, 21, 14 and 5 cm, respectively.

The distance-draw down curve indicated that the radius of cone of influence is nearly 210 m from the pumped well.

E.5. *Performance of shallow tile and gravel filled drains for leaching of root zone in absence of water table.* (*R.N. Pandey, A.K. Pasricha. and S.R. Jaiswal.*)

Five lines of tile and gravel filled drains each of 5 m length and spaced at 2 m were installed at a depth of 65 cm below ground level. The initial moisture content and salt status at various depths were recorded. Leaching was done in the plots by ponding with water upto a depth of 10-15 cm.

It has been observed that flow through the sub-surface drains commenced within two hours of ponding. The flow through drains, however, stopped after 5 hours in some plots although ponding was continued. This may be due to the flow of ponded water through cracks directly into the drains and not due to flow through the soil. Where ponding is continued, these macropores or cracks got filled up, thus blocking further movement towards drain. The soil moisture observations indicated that top 1.5 m of soil was saturated.

In order to investigate the influence of the quality of ponded water on the intake rates during leaching, infiltration studies were made with the ring infiltrometers in the study area. Infiltration data with five types of waters indicate that infiltration rates decreased mainly because of the increase in sediment concentrations in the range of 1000 to 3000 ppm. (*Table 58*). Between 3000 to 4000 ppm, the decrease in infiltration rate was relatively small.

TABLE 58. *Quality parameters of water used for infiltration study.*

Water source	EC × 10^6	pH	Sediment concentration (ppm)	Infiltration rate after 100 min. (cm/hr.)
Shallow tubewell water	421	7.9	840	1.75
W.J.C. Water	190	8.1	900	1.79
Flood Water I	251	8.8	2220	1.23
Flood Water II	222	8.4	2940	0.87
Flood Water III	518	9.5	4000	0.82

E. 6. *Hydrological studies of the problem areas.* (*V.V. Dhruva Narayana, S.K. Gupta and Joginder Paul*)

In Haryana State, out of a total area of 44028 Sq km, approximately 23309 Sq km are subject to flooding annually while about 7770 Sq km remain under waterlogged condition.

TABLE 59. *Intensity of rain during monsoon at various gauging stations in Haryana.*

Name of the Place	Date of Observation	24 hr. value of rain water (cm)
Yamuna Nagar	12.7.64	5.7
	29.7.64	10.2
Tajewala	12.7.64	7.4
Chandigarh	14.7.64	4.2
Kaithal	30.7.64	8.0
Sonepat	26.8.64	5.1
	28.8.64	5.1
	2.9.64	15.2

Source : Drainage Deptt. Government of Haryana.

The runoff from intense storms (*Table 59*) is quite high even in flat plains. The measured peak values in the small streams and natural drain of Haryana state are as high as 846 cumec. These intense floods cause surface water stagnation in the flat lands for 7-10 days after the storms and damage the crops and or lands because of inadequate surface drainage measure at the farm level. Even the field drains provided by the state agencies at some places are inadequate to provide timely surface drainage of the agricultural lands.

These storms are frequently separated by long dry spells, during which the crops suffer for lack of water. The variation of monsoon rainfall (June-September) in the different regions of the state are presented in *Table 60*.

TABLE 60 *Variation of monsoon rainfall in different tracts of Haryana (mm).*

Tract	High	Average	Low	Coefficient of variability (per cent)
Ghaggar	749	474	267	30
Yamuna	1550	1127	480	26
Munak	1160	705	296	38
Rohtak	609	510	269	27

Source : Drainage Deptt., Govt. of Haryana.

The average number of non-rainy days for Karnal in the months of June, July, August and September are 26, 21· 18, and 25 respectively. Even in the wet months of July and August the dry spells are longer than 30 days. Thus, even when the total monsoon rainfall is above average, its distribution during the season is often unfavourable for agricultural production.

Data on water table levels were collected from various agencies in the state and were analyzed for study of the water balance picture of the state. The water table contour maps and some conclusions were presented in the annual report for 1971. The data on average rise in water table during the monsoon in different parts of the state (*Table 61*) reveal that it was relatively higher in Gurgaon canal and W.J.C. east circles.

The hydrology of the CSSRI research farm is being investigated in

TABLE 62 *Water table rise during monsoon in different tracts of Haryana*

Name of the tract	Year				
	1966	1967	1968	1969	1970
WJC East Circle					
No. of wells obsvd.	231	227	221	219	212
Average rise (cm)	152	254	134	142	147
WJC West Circle					
No. of wells obsvd.	113	108	102	113	98
Average rise (cm)	111	117	95	117	111
Bhakra Canal Circle					
No. of wells obsvd.	*	88	89	83	87
Average rise (cm)	*	150	122	122	140
Hissar Bhakra Canal Circle					
No. of wells obsvd.	87	85	71	57	*
Average rise (cm)	115	61	77	93	*
Gurgaon Canal Circle					
No. of wells obsvd.	*	7	7	19	7
Average rise (cm)	*	180	130	176	185

Source : Director of Land Reclamation. Govt. of Haryana.
* Data not available

some detail. Water table levels are being recorded at regular intervals from the 87 observation wells on the farm. The average monthly values of the water table levels are the deepest in the month of June and rises near to the ground surface in the month of September (*Table 62*). From the observed water table fluctuations on the research farm, the aquifer properties have been determined.

In unconfined aquifers, generally satisfying Dupuit's assumptions of predominantly lateral flow, the ground water level like river flows, can be assumed to be governed by the following expression similar to equation.

$$(h_t - h_m) = (h_o - h_m)\ e^{-kt} \qquad (1)$$

TABLE 62. *Average value of the depth of water table (cm) below ground level on the C.S.S.R I. research farm.*

Months	Depth of water table (cm)		
	1970	1971	1972
January	—	224.0	183.4
February	—	248.0	200.9
March	—	251.0	259.0
April	—	327.0	300.8
May	—	346.0	337.4
June	345.0	343.0	366.9
July	317.5	295.0	253.1
August	234.6	114.2	172.1
September	109.4	71.5	116.8
October	147.0	110.5	215.6
November	168.7	136.5	261.2
December	197.2	157.6	258.7

Where,

h_t=water level in the observation well at any time 't'

h_m=Water level for $\frac{dh}{dt}=0$, or where the rate of recession is nil.

h_o=initial water level in the observation well at the beginning of the recession.

k=recession constant.

By studying the hydrographs of water table levels, the recession rates (mean daily fall of water table calulated over continuous periods) were computed and plotted on a linear graph (*Fig. 17*) against the corresponding reduced level of water table. The recession curves in most cases are linear and the slope (K) of the recession curves varies from a low value of 0.012 to a high of 0.877 with an average of 0.029. The observed and computed hydrographs (*Fig. 18*) of the various observation wells are in close agreement.

The coefficient of storage or the specific yield in the case of an unconfined aquifer represents amount of percolation required to cause a

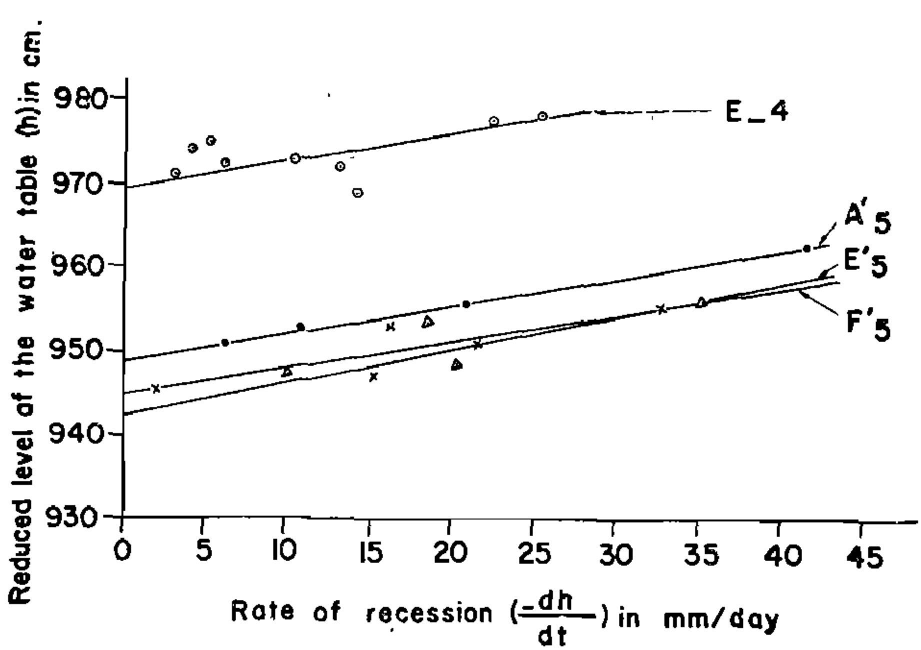


Fig. 17 : Recession Curve for the Observation Wells.

unit rise in ground water level assuming no ground water flow has occurred. The main difficulty in determining this coefficient is that the ground water conditions are not static and that the lateral flow of ground water takes place even while the water table levels are rising. The allowance for lateral ground water flow is made by correcting the change in the observed ground water levels for the recession as given by *equation (1)*. The specific yield 's' is given by the expression :

$$S = \frac{\text{Effective rainfall} - \text{Evaporation}}{\text{Change in Ground water level} + \text{Ground water recession.}} \qquad (2)$$

Typical values of the storage coefficients of the underlying aquifer in the vicinity of eight observation wells are presented in *Table 62*. The *avarage value of the specific yield for the farm area was 9.08 per cent* The coefficient of transmissibility may be defined as the quantity of water flowing through an aquifer of 1 m width and the full thickness of the saturated aquifer under a unit hydraulic gradient. The continuity equation for such a situation can be expressed as :

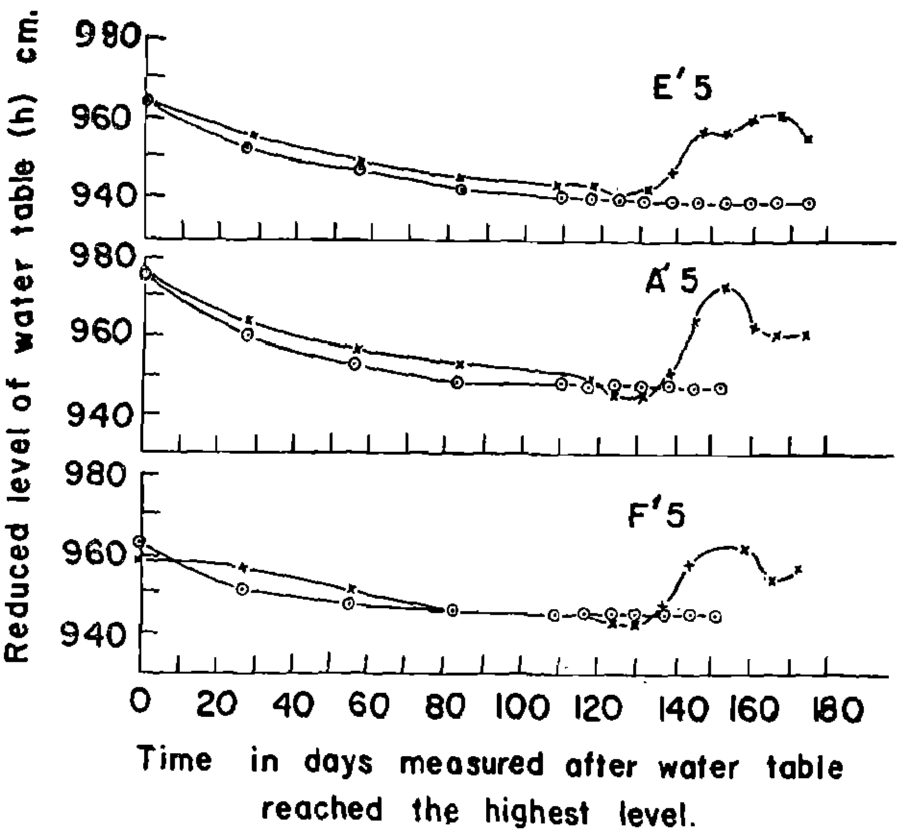


Fig. 18 : Observed and Computed Hydrograph for the Observation Wells.

TABLE 63. *Values of* $\frac{\partial h}{\partial t}$ *and* $\frac{dh}{dl}$ *for computing transmissibility.*

$\frac{\partial h}{\partial t}$	$\frac{dh}{dl}$	Storage coefficient	Coefficient of trans-missibility 'T' *
(cm/day	(x10^{-4})	S (%)	(m^3/day/m)
0.54	57	13.38	201
1.10	41	5.79	335
1.00	34	2.81	250
1.00	62	13.38	315
1.10	35	2.81	273
2.20	14	2.81	304
0.80	61	13.38	261
0.23	40	10.62	144

* $T=Sb\frac{\partial h}{\partial t}\left(\frac{dh}{dl}\right)^2$ and b=9 m.

$$\frac{1}{2} K \nabla^2(h^2) = S\frac{\partial h}{\partial t} - W \tag{3}$$

where K=hydraulic conductivity,

$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$ (x, y are horizontal distance coordinates).

S= storage coefficient

W=net rate of recharge to water table per unit horizontal area.

If, during the period of observations, there is an interval with no recharge,

$$W=O \text{ and } K = \frac{2S\frac{\partial h}{\partial t}}{\nabla^2(h^2)}$$

The transmissibility 'T' of the aquifer of saturated thickness 'b' is given by

$$T = \frac{2Sb\ \partial h/\partial t}{\nabla^2(h^2)} \tag{4}$$

These expressions were used to derive the values of 'T' for the aquifers of the research farm. *Two numerical procedures were adopted to evaluate* $\nabla^2(h^2)$ from the water table fluctuation data.

In the first method, the values of $\nabla^2(h^2)$ were computed from the water table contour maps of the farm area (*Fig. 19*) with the following approximation.

$$\nabla^2(h^2) = \frac{1}{2}\left(\frac{dh}{dl}\right)^2 \tag{5}$$

Where, $\frac{dh}{dl}$ is the water table gradient in the direction of ground water movement. Typical values of $\frac{\partial h}{\partial t}$, $\frac{dh}{dl}$ and 'T' computed in this study, are given in *table 63.*

In the second method, when there is a symmetrical arrangment of four observation wells at radius 'a' and another four at radius 'b' from the central reference point.

$$\nabla^2(h^2) = \frac{\Sigma ha^2 - \Sigma hb^2}{(a^2 - b^2)} \tag{6}$$

The graph $\frac{\partial h}{\partial t}$ Vs $\nabla^2(h^2)$ (*Table 64*) according to equation (6) is a straight line (*Fig. 20*) and the slope of this line is equal to the value of $\frac{K}{2S}$. The transmissibility value, thus, computed was 238 m^3/day/m.

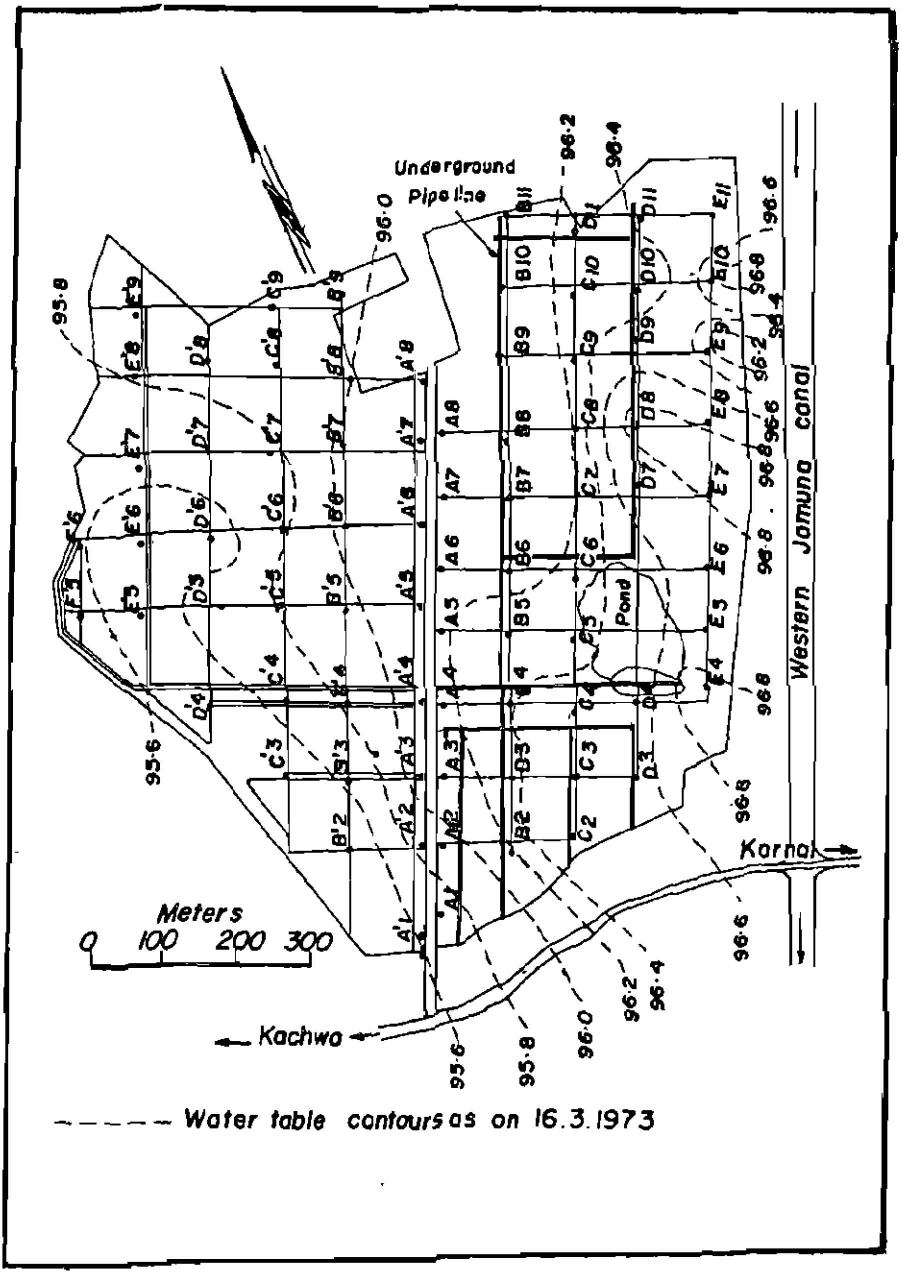


Fig. 19. Water Table Contour Map of the Farm Area.

TABLE 64. *Value of* $\frac{\partial h}{\partial t}$ *and* $\nabla^2 (h^2)$ *for calculating Transmissibility.*

Date	$\partial h/\partial t$ (cm/day)	$\nabla^2(h^2)$ x (10^{-4})
14.10.71	—	5.27
21.10.71	5.70	1.30
28.10.71	2.70	1.80
11.11.71	0.78	6.75
25.11.71	0.86	1.85
9.12.71	0.57	1.67

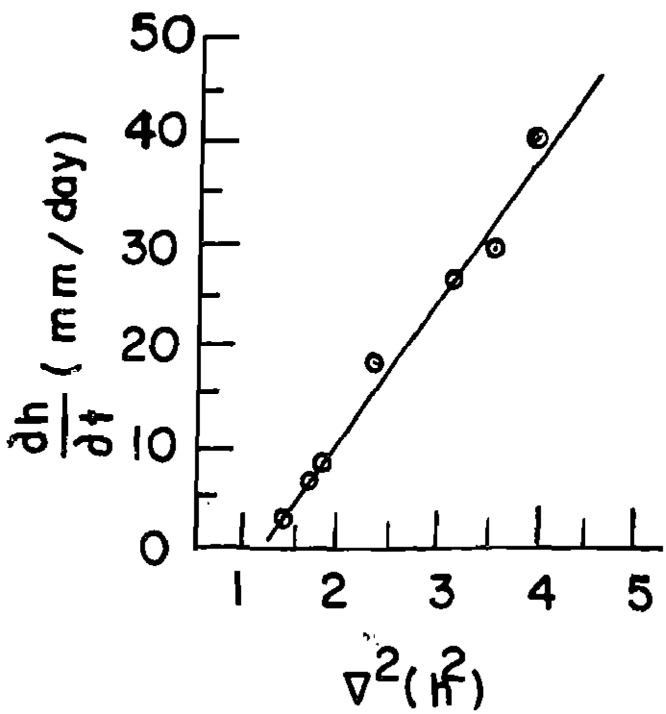


Fig 20 Relation Between $\frac{\partial h}{\partial t}$ *Vs* $\nabla^2(h^2)$

In order to verify the aquifer constants, determined in the analysis, pump tests were conducted for four cavity wells located on the research farm. Draw down observations were made in the near by observation wells. From the established procedure of Theis, the transmissibility and the storage coefficients were determined and the results of these procedures are summarised in *Table 65.*

TABLE 65. *Comparative values of aquifer properties determined by various procedures.*

Aquifer property	Method I*	Method II**	Pump Test
Storage coefficient	0.99	—	0.03
Transmissibility (m^3/day/m)	144—335	238	191—417

* $T = \frac{Sb\ \partial h/\partial t}{-(dh)/dl)^2}$, ** T is determined by plotting

$\frac{\partial h}{\partial t}$ Vs $\frac{\Sigma h_a^2 - \Sigma h_b^2}{(a^2 - b^2)}$ and slope of the regression $= \frac{K}{2S}$

This study indicated that the analysis of water table level yields the transmissibility and storage coefficient values in the same range as those obtained from pump test procedures.

E.7. Border Irrigation studies in saline sodic soils

(Joginder Paul and S.K. Gupta)

In order to determine the size of the unit stream for the borders and provide specifications for their design, an experiment with the following details was initiated:-

Length of the border	95 m
Width of the border	10 m
Slope of the border	0.05%, 0.10%, 0.15%
Size of unit stream	1.0, 1.5, 2.0, l/sec/m width of the border.
Replications	Three

The basic intake rate of the experimental area was found to be 0.24 cm/hr. Seven irrigations were given to the wheat crop and the data collected during irrigation are persented in Table 66.

TABLE 66. *Irrigation data from borders under different slopes.*

Discharge (lps)	Cut off distance (m)	Cut off time (min.)			Depth of irrigation (cm)			Velocity of flow in borders (m/min.)		
		0.05	0.10	0.15	0.05	0.10	0.15	0.05	0.10	0.15
10	75	104.0	99.5	95.0	6.7	6.4	6.1	0.72	0.76	0.79
15	70	62.5	57.5	52.5	6.0	5.6	5.1	1.12	1.22	1.33
20	63	36.0	36.0	35.7	4.7	4.7	4.6	1.75	1.75	1.77

The data in Table 65 indicate that at high discharge rates (66 to 20 lps) the depth of application of water is relatively low due to higher velocities and less opportunity time. This results in under irrigation at head and stagnation at the tail end of the border. The data further indicate that with 10 lps, it is possible to apply the normally required depth of water for wheat in each slope group. This is being verified with the soil moisture data collected before and after irrigation.

E.8. Design and performance of underground and surface methods of water conveyance on the farm

(V. V. Dhruva Narayana, Joginder Paul and R.N. Pandey)

Studies in the Punjab and else-where indicated that as much as 30 per cent of the water pumped from the tubewell is lost in the conventional surface field channels. To avoid this loss an underground pipe conveyance system 2050 m long has been designed and laid out on the research farm covering an area of 40 ha. It is a representative operational size of the farm for tubewell irrigated areas. The two specific aspects of this conveyance system are ; i) Leak proof jointing of pipes which was accomplished by stuffing the annular space between pipes with bitumen impregnated jute fibre and then sealing the annular space between pipes and concrete coller with cement mortar, ii) construction of three types of junction boxes (open, semi-closed and closed types) each one of them with definite objectives in water regulation and maintenance of the system. The cost of installation of the underground system was Rs. 18/- per meter running length and Rs. 675/- per hectare.

WATER MANAGEMENT AND SALINITY—COORDINATED PROJECT

C.1 : Effect of different soil treatments on the performance of forest species on a saline· sodic soil (J.S.P. Yadav, D.R. Bhumbla and O.P. Sharma)

The experiment on the performance of five forest species, namely *Acacia arabica, Albizzia lebbek, Eucalyptus hybrid, Prosopis juliflora* and *Terminalia arjuna*, on a saline sodic soil with five soil treatments initiated during 1970, was continued during 1972. The details of the initial soil properties and the operations regarding planting, fertilization etc. have been given in the Annual Report of 1971. During the period under review fertilizer application was given, as per treatment, twice-once in March and the other in September. (Ammonium Sulphate @200g/pit and Superphosphate @ 700g/pit) Irrigation was also given after the fertilizer applications.

The data on height increment of different forest species under different soil treatments during the period Sept. 1971 to Sept. 1972 revealed that the species varied considerably in their growth performance (Table 67.) In almost all cases the performance in the height increment was maximum in the treatment wherein the original soil was replaced by good soil in the planting pit. In case of E. *hybrid* and *P. juliflora* the height increment in the treatment of gypsum + F. Y. M., application was more or less the same as in the treatment of soil replacement. In case of *A. arabica*, gypsum application in the soil with and without F. Y. M., height increment was more or less equal but was less than the treatment of soil replacement. The performance of *A. arabica* in original soil as well as in F. Y. M. treated soil was also much better as compared to the other species. This behaviaur of *A. arabica* is due partly to its relative tolerance to soil alkalinity and partly to variation in soil alkalinity conditions in the area of one replication. The trend in height increment due to different soil treatments was most pronounced in case of *E. hybrid* in which the height increment was in the order of, original<F.Y.M. <Gypsum <Gypsum+F.Y.M.<Normal soil. The trend in height increment under different soil treatments in case of *A. lebbek* was somewhat erratic mainly due to heterogenous nature of soil. *T. arjuna*, on the whole, showed almost similar trend under different soil treatments in height increment as *E. hybrid* but its growth was slow. The two types of seedlings did not show a definite trend and therefore, choice of the type of seedling depends mainly on the economics.

The application of fertilizers boosted the growth of all the species,

TABLE 67. *Height increment (cm) of different forest species on a saline sodic soil from September 1971 to September 1972.*

Species	Type of seedling	Fertilizer treatment	Soil treatments O	F	G	GF	N
A. arabica							
	Tall	Fr	130	157	160	148	179
		U	107	127	123	146	171
	Small	Fr	157	135	90	114	193
		U	105	172	141	120	146
A. lebbek							
	Tall	Fr	57	89	82	99	136
		U	27	116	34	98	100
	Small	Fr	182	104	135	Nil	93
		U	94	103	155	116	151
E. hybrid							
	Tall	Fr	92	127	179	172	226
		U	22	92	111	169	118
	Small	Fr	29	Nil	181	218	212
		U	12	110	157	158	167
P. juliflora							
	Tall	Fr	75	146	82	176	174
		U	55	104	86	132	121
	Small	Fr	94	120	106	140	261
		U	27	110	119	123	124
T. arjuna							
	Tall	Fr	16	78	109	51	96
		U	Nil	51	65	50	78
	Small	Fr	60	73	106	109	124
		U	29	55	61	92	114

O=Original soil; F=Addition of F.Y.M @ 25 Kg/pit; G=Addition of Gypsum @ 50% of GR (3.5kg/pit) GF=Addition of Gypsum @ 50% of GR+F.Y.M.; N=Replacemt of original soil by normal soil; Fr=Fertilized U=Unfertilized the difference being more marked in the treatment where soil was imported as compared to those where no treatment was given to the original soil. The difference in height increment between fertilized and un-fertilized treatments were very much pronounced in case of *E. hybrid* and *P. juliflora* and of a smaller magnitude in case of *A. arabica, A. lebbek* and *T. arjuna.*

The response in diameter increment of different species under different soil treatments showed more or less the same trend as in case of height increment (Table 68).

C.2 : Effect of irrigation methods on salt and water distribution
(I. K. Girdhar & J. S. P. Yadav)

An experiment was conducted on a highly saline sodic soil to evaluate the comparative effect of sprinkler and surface methods of irrigation on salt distribution pattern in soil and water use efficiency of turnip and lady's finger. The data on salt distribution indicate that, in general, there was appreciable reduction in the salt content in the top soil in case of sprinkler irrigation while there had been an increase in the salt content at equivalent depth in the surface method of irrigation. Almost a reverse trend was observed in the lower layers. The decrease in salt content in the top soil under sprinkler is more in the flat method of planting than in the ridge method whereas accumulation of salts under these two surface methods of irrigation is more in the ridge planting than the flat planting. Although total quantity of irrigation water used in sprinkler and surface methods was the same but the water use efficiency was found to be greater in case of sprinkler method.

C. 3: Effect of moisture regimes on the availability of phosphorus to important pulse crops. (B. M. Sharma and J. S. P. Yadav)

Study of the root environment of pulse crops with respect to the effect of moisture and available phosphorus is of immense significance for proper understanding of response of crop in a given situation. A field experiment was initiated in *rabi* 1972 with gram (*Cicer arietinum*) var. C-235 using three levels of irrigation, (No irrigation, 5 cm irrigation after 300 mm cumulative pan evaporation value and 5 cm irrigation after 150 mm comulative pan evaporation value) and four levels of phosphorus (0, 40, 80 and 120 Kg P_2O_5/ha). The treatments are being compared in a randomized block design. The experiment is in progress.

C 4. 1.1 : Effect of moisture stress and depth of irrigation on consumptive use and yield of wheat
(R.K. Rajput, O.P. Sharma and J.S.P. Yadav)

In order to evaluate the effect of four moisture stress levels and three

TABLE 68 *Diameter increment (cm) of different forest species on a saline sodic soil from September, 1971 to September, 1972*

Species	Type of seedling	Fertilizer treatment	Soil treatments O	F	G	GF	N
A. arabica							
	Tall	Fr	1.44	2.74	2.35	2.21	2.17
		U	0.51	1.79	2.10	1.93	2.45
	Small	Fr	2.26	2.54	1.64	1.38	3.87
		U	1.00	2.42	1.51	1.29	2.06
A. lebbek							
	Tall	Fr	1.18	2.03	2.03	1.86	3.27
		U	1.48	1.65	1.90	1.97	2.85
	Small	Fr	2.68	2.63	Nil	Nil	4.13
		U	1.71	1.90	2.63	2.75	3.40
E. hybrid							
	Tall	Fr	0.04	3.71	4.19	2.93	6.78
		U	0.01	2.22	3.10	3.60	3.87
	Small	Fr	1.38	Nil	6.17	4.92	5.82
		U	1.14	3.42	2.94	2.77	3.96
P. juliflora							
	Tall	Fr	2.32	2.80	4.15	5.21	4.83
		U	1.84	1.57	2.96	4.30	5.06
	Small	Fr	2.98	2.97	4.29	4.73	4.20
		U	0.31	2.56	3.50	3.96	3.91
T. arjuna							
	Tall	Fr	0.87	3.06	3.39	3.85	3.90
		U	Nil	1.00	1.50	1.44	3.26
	Small	Fr	0.60	1.79	3.62	2.72	4.36
		U	Nil	1.23	0.90	2.29	3.83

O=Original soil; F=Addition of F.Y.M. @ 25 kg/pit; G=Addition of Gypsum @ 50% of GR (3.5kg/pit); GF=Addition of Gypsum @50% of GR+F.Y.M.; N=Replacement of original soil by normal soil; Fr=Fertilized, U=Unfertilized depths of irrigation application (6, 8 and 10 cm on water productive efficiency of wheat, a field expriment was conducted on sility loam soil. The moisture stress levels based on the ratio between the quantity of irrigation water (IW) and the cumulative open pan evaporation value (CPE) were differentiated after a common irrigation of 6 cm given at crown root initiation stage. The total winter rainfall during the growing season of wheat was 58.7 mm. The treatments were compared in a randomized block design with four replications. The crop was sown on 6 November 1971 and was harvested on 10th April, 1972. It was fertilized with 150 Kg N, 80 Kg P_2O_5, 60 kg K_2O and 25 Kg. Zinc sulphate per hectare.

The results summarised in *Table-69* reveal that under 10 cm depth of irrigation, the grain yield increased with increase in IW/CPE ratio from 0.60 to 1.05 but under 6 cm and 8 cm depths, the increase in yield was uptil IW/CPE ratio of 0.90 and thereafter the grain yield decreased substantially at IW/CPE ratio of (1.05) The overall effect of depth of irrigation was statistically non-significant. The water productive efficiency i. e. grain yield per unit area per unit of applied irrigation water increased with decrease in the IW/CPE ratio.

TABLE 69. *Effect of moisture stress and depth of irrigation on the yield of wheat (q/ha.)*

IW/CPE ratio	Depth of irrigation (cm)			Mean
	6	8	10	
0.60	52.3	50.9	44.7	49.3
0.75	53.4	52.5	48.9	51.6
0.90	55.3	56.7	50.6	54.2
1.05	47.1	50.0	55.5	50.9
Mean	52.0	52.5	49.9	

C. 4. 1.2 : Response of wheat to irrigation at different growth stages under receding water table conditions. (R.K. Rajput, J.S.P. Yadav and O.P. Sharma.)

A study was undertaken to evaluate the effect of missing irrigation at one or more growth stages on yield and water productive efficiency of wheat (Var. Kalyan Sona) on silty loam soil with receding water table condition (water table depth 120 cm in early November and 300 cm in mid April). In all, 16 treatments of missing irrigation at one or more growth stages (Late tillering, boot, flowering and early dough) were compared in a randomized block design. After a presowing irrigation the crop was sown in lines 23 cm apart on 13th Nov. 1971. It received a fertliser dressing of 100 Kg N, 80 Kg P_2O_5 and 50 Kg K_2O per hectare at the time of sowing, the second dose of 50 Kg N/ha was top dressed prior to the first common irrigation which was applied at crown root initiation stage.

The statistical analysis of the grain yield data revealed that the over all effect of the treatments was non-significant but on partitioning the variance it was observed that missing irrigation at flowering resulted in significant reduction in grain yield of wheat (*Table 70*) Missing one irrigation at any stage (treatments 2 to 5) resulted in yield reduction ranging from 4 to 12 percent, maximum reduction being in case of irrigation missed at flowering. The reduction in grain yield by missing irrigation at two or three stages (treatments 6 to 15) range from 6 to 14 per cent but the magnitude of reduction was,in general, higher in the treaments wherein one of the growth stages of missing irrigation was flowering. The reduction in yield, when four irrigations were missed at late tillering boot, flowering and early dough stages, was of the order of 17 percent. The total winter rainfall during the growing season of wheat was 58.7 mm, of which 23.5 mm was received 12 days before the boot stage irrigation. The water productive efficiency increased with decrease in the frequency of irrigation. From these results it may be inferred tentatively that under Karnal conditions it is possible to obtain an average grain yield of about 53 q/ha with only two post sowing irrigations, one at crown root initiation stage and one at flowering stage and of about 47 q/ha with only one post sowing irrigation at crown root initiation stage.

C 4.2: Effect of moisture stress and phosphate levels on water use efficiency and yield of berseem (R. K. Rajput, J.S. P. Yadav and S.N. Singh)

Berseem is an important winter season fodder of high nutritive value for the health and milk production of cattle. Being a legume of succulent nature it responds to application of irrigation water and phosphate. A field experiment comprising three moisture stresses (based on the ratio-IW/CPE of quantity of irrigation water to the cumulative pan evaporation values from a standard open pan viz. 1.0, 0.8 and 0.6) and four levels of phosphate (0, 50, 100 and 150 kg P_2O_5/ha) was conducted during *rabi* season 1971-72 on silt loam soil. The crop was sown on 16th October 1971 and was finally harvested on 4.5.1972. The crop received a common fertilizer application of 40 Kg N, 60 kg K_2O and 25 kg Zinc sulphate per hectare prior to sowing. The depth of irrigation was 5 cm uptil February and 6 cm thereafter. The rainfall of 62.2 mm was received during the crop season on 10 rainy days.

TABLE 70. *Effect of missing irrigation at one or more growth stages on grain yield of wheat*

Treatment	Depth of irrigation applied (cm)					Total irrigation		Grain yield		Relative yield
	Crowh root initiation	Late tillering	Boot	Flowering	Early dough	No.	Depth (cm)	q/ha	kg/ha/cm of water applied	
1	6	6	6	8	8	5	34	57.5	169	100
2	6	-	6	8	8	4	28	55.5	198	96
3	6	6	-	8	8	4	28	55.5	198	96
4	6	6	6	-	8	4	26	50.9	196	88
5	6	6	6	8	-	4	26	54.2	208	94
6	6	6	-	8	-	3	20	54.0	270	94
7	6	6	-	-	8	3	20	51.0	255	87
8	6	6	6	-	-	3	18	53.5	297	93
9	6	-	6	8	-	3	20	52.2	261	91
10	6	-	6	-	8	3	20	51.3	256	89
11	6	-	-	8	8	3	22	52.2	273	91
12	6	6	-	-	-	2	12	50.0	417	87
13	6	-	6	-	-	2	12	49.6	413	86
14	6	-	-	8	-	2	14	53.0	378	92
15	6	-	-	-	8	2	14	50.6	361	88
16	6	-	-	-	-	1	6	47.6	793	83
						SE(m)		±3.2		

In all, five cuts of green fodder were taken. The green fodder yield in successive cuttings as well as in aggregáte increased significantly as the IW/CPEratio was increased from 0.6 to 1.0 except in the second cutting when the difference remained slightly below the level of significance (*Table 71*). The response of berseem in aggregate green fodder yield to moisture stress levels was quadratic, the increase in yield being proportionally higher when the IW/CPE ratio was increased from 0.6 to 0.8 than when it was raised from 0.8 to 1.0 (*Fig. 21*). The favourable effect of increasing IW/CPE ratios on dry matter production was significant

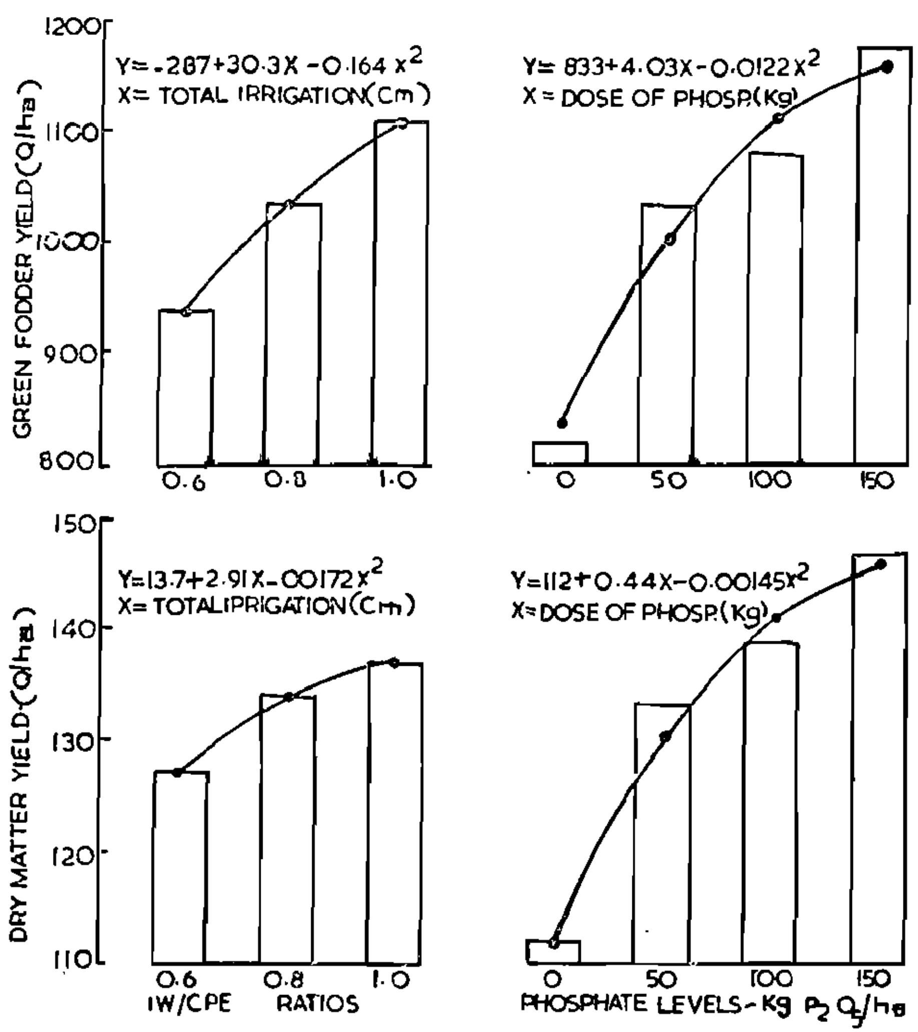


Fig : 21 Response of berseem to moisture stress and phosphate levels in green and dry matter yields.

TABLE 71. *Effect of moisture stress on the yield of berseem and productive efficiency of applied water*

IW/CPE ratio	Yield at successive cuttings (q/ha) First (55)	Second (54)	Third (40)	Fourth (22)	Fifth (29)	Aggregate yield (q/ha)	Water applied (cm)	Water productive efficiency (q/ha/cm)
				Green matter				
0.6	99	222	246	217	157	941	60	15.7
0.8	116	225	261	258	176	1036	71	14.6
1.0	121	237	282	266	203	1109	88	12.6
C.D. at 5%	7.9	N.S.	20.3	19.3	16.7	54.6		
				Dry matter				
0.6	11.2	23.5	32.1	30.5	29.5	126.7	60	2.10
0.8	12.1	23.8	33.4	33.2	31.7	134.0	71	1.89
1.0	12.9	23.9	34.3	32.9	33.1	137.1	88	1.56
C.D. at 5%	0.85	N.S.	N.S.	N.S.	N.S.	7.47		

*Figures in ( ) indicate the age of crop prior to cutting.

only in the first cutting. In other cuttings and in aggregate an increasing trend was noted with increase in the IW/CPE ratio from 0.6 to 1.0. The green and dry matter yields per unit of water applied increased with decrease in the IW/CPE ratio ; the increase being more between the IW/CPE ratio of 0.8 and 0.6 than between 0.8 and 1.0 (*Table-71*).

The effect of phosphate was significant in both, green and dry matter yields in all cuttings as well as in the aggregate. The response to phosphate application was quadratic in nature, (*Table 72 and Fig, 21.*) The interaction between moisture stress and phosphate was non-significant.

TABLE 72 : *Effect of phosphate on the yield of berseem-q/ha*

Phosphate levels (kg P_2O_5/ha)	Yield at successive cuttings					Aggregate yield
	First (55)	Second (54)	Third (40)	Fourth (22)	Fifth (29)	(200)
			Green matter			
0	102	161	202	204	153	822
50	111	227	264	257	179	1038
100	115	246	279	259	181	1080
150	122	280	305	265	202	1174
C.D. at 5%	9.2	20.7	23.4	22.7	19.3	62.4
			Dry matter			
0	11.0	18.3	26.5	27.9	27.7	111.7
50	11.8	23.3	33.0	33.8	31.6	133.6
100	12.6	25.3	35.8	33.1	32.1	138.9
150	13.0	27.8	37.7	33.9	34.3	146.7
C.D. at 5%	0.98	2.25	3.67	2.87	3.47	8.55

Figures in ( ) indicate the age of crop prior to cutting.

C 4.3 : Effect of mulches on irrigation requirement of sarson (B.K. Khosla aud B.M. Sharma).

The water table records at the experimental farm show that the water table rises during the rainy season to a depth within the rooting zone of crops and then recedes gradually. The resulting moisture profile may supply appreciable amounts of water for crop use and may reduce requirement for supplemental irrigation. A field experiment to study the effect of mulches and supplemental irrigation on the yield of *Sarson* (*Brassica compestris*) was conducted on a loam soil.

The treatments consisted of all combinations of three mulches viz. rice straw @ 5 tonnes/ha, polyethylene sheet, 66% cove-age and no mulch and two irrigation treatments i.e irrigation at 75% depletion of available soil moisture from 0-30 cm depth and no irrigation. Randomized block design was followed with four replications. Brown *sarson* variety Haryana-1 was sown on 9.10.71 in lines 45 cm apart. The plot size was 6x3.6m and plant to plant distance was kept at 15 cm. The crop received the fertilizer application of 60, 40 and 30 kg of N, P_2O_5 and K_2O per hectare, respectively.

The results revealed that the application of rice straw and polyethylene resulted in an increase in the yield under both irrigated and unirrigated conditions, (*Table*-73). Rice straw and polyethylene treatments were equally effective when no irrigation (except 4.17 cm rainfall during February) was applied, but when three irrigations were applied at 75 per cent depletion of available soil moisture, the yield was slightly higher in the case of polyethylene. Application of mulches resulted in considerable saving of water as is evident from the loss of water from the profile. The losses were, in general, higher in the treatment which received irrigation.

TABLE 73. *Grain yield of sarson and loss of water from the profile*

Mulch treatment	Grain yield (q/ha)		Loss of water from 0-120 cm depth (cm)	
	No. irrigation	Irrigation at 75% depl.	No. irrigation	Irrigation at 75% depl.
No mulch	11.64	12.98	26.2	41.7
Rice straw	14.51	14.50	23.7	36.0
Polyetheylene	14.51	16.53	23.2	34.9

C 4.5.1 : Effect of moisture stress, mulches and nitrogen levels on irrigation requirement and yield of sugarcane. (B.M. Sharma and J.S.P. Yadav)

Apart from the use of water for crop production, improving its utilization to maximise the production per unit quantity applied, is essential. This can be achieved by developing some suitable techniqnes as as to minimise the soil moisture losses. With this object in view a field experiment was conducted comprising all combinations of three mulches (No mulches, sugarcane trash mulch @ 6 tonne/ha and polythene mulch @ 66 percent coverage), three moisture stress levels (irrigation application at 25, 50 and 75 percent depletion of available soil moisture) and three nitrogen levels (100, 200 and 300 kg N/ha). The treatments were compared in a 3^3—partial confounding design with two replications. Sugarcane variety Co-1148 was planted in rows in the last week of Mareh 1972. Before the differentiation of moisture stress and mulching treatments, two common irrigations of 6 cm each weie applied for germination and establishment of the crop. Nitrogen was applied in four equal splits. Phosphate @ 80 Kg P_2O_5/ha, potassium @ 60 K_2O/ha and Zinc sulphate @ 20 Kg/ha and one fourth dose of nitrogen were aplied prior to sowing. Although the crop was harvested in the second week of January 1973, and the data were available prior to the prepration of this report, they are present here. Since none of the interactions were significant statistically, only the main effects of the three factors have been described.

The data in *Table-74* reveal that irrigation application at 50 percent depletion of available soil moisture from 0-30 cm soil depth produced significantly higher eane yield than the treatment of 75 percent depletion of available soil moisture. The treatment of irrigation at 25 percent depletion was statistically at par with that of 50 percent depletion. This trend in cane yield is partly explainable from the data on tiller number. The water use efficiency increased with increasing moisture stress prior to irrigation. The Juice quality was not affected by moisture regime treatments. Mulches resulted in economising the irrigation water but in the case of polythene mulch it was at the cost of cane yield. Application of nitrogen @ 300 Kg N/ha increased the cane yield significantly over 100 Kg N/ha level; the levels of 100 Kg and 200 Kg N/ha being statistically at par. The difference in yield between 200 Kg and 300 N/ha levels slightly fell short of the level of statistical significance. The juice quality was not altered by nitrogen levels.

C.4. 5.2 : Phasic Water needs of sugarcane (B.M. Sharma and R.K. Rajput).

Sugarcane is a long duration crop and requires large volume of water for its growth. During its growing period, the crop experiences the extremes of climate; the hottest and practically dry weather in the formative phase; warm and humid monsoonal climate in the grand growth phase and severe winter during ripening phase. In order to

TABLE 74. *Effect of moisture stress, nitrogen and mulching on yield and quality of sugarcane.*

Treatments	Height (cm)	Tillers No/hill	Cane yield (q/ha)	Water applied (cm)	Consumptive use (cm)	Yield q/ha/(cm) water applied	Water use eff. q/ha/(cm)	Juice quality	
								Brix value	Surrose (percent)
Moisture levels									
25% depl.	227	3.3	1000	70	142	14.3	7.0	18.6	13.8
50% depl.	232	3.8	1083	60	118	18.0	9.2	19.3	14.4
75% depl.	221	2.1	981	46	99	21.3	10.0	18.3	13.1
C.D. at 5%			102						
Mulches									
No mulch	223	3.5	1055	68	124	15.5	8.5	18.4	13.2
Sugarcane Trash	235	3.1	1069	54	114	19.8	9.4	18.6	13.8
Polythene	221	2.6	945	54	120	17.5	7.8	18.9	14.4
C.D. at 5%			102						
Nitrogen level									
N 100	225	2.8	953					18.5	13.7
N 200	219	2.8	1014					18.7	13.7
N 300	236	3.3	1103					19.0	14.0
C.D. at 5%			102						

quantify the soil moisture stress levels during the above growth phases of sugarcane with the object to produce higher cane yield of better juice quality with minimum irrigation water, a field experiment was conducted on a silt loam soil with variable moisture stress levels during the three growth phases. During the formative and ripening phases, irrigation was scheduled on the basis of the ratio between the quantity of irrigation water (IW) to the cumulative pan evaporation (CPE) value and during the grand growth phase on the basis of the depletion of available soil moisture from 0-30 cm soil layer prior to irrigation. The treatments comprised all possible combinations of :

Formative phase (IW/CPE Ratios)		*Grand growth phase* (Moisture depletion)		*Ripening phase* (IW/CPE ratio)
0.4		25 per cent		0.6
0.6	×	50 per cent	×	0.8
0.8		75 per cent		1.0
IW=6 cm				IW=6 cm

The treatments were compared in 3^3-partial confounnding design with two replications.

Three budded sets of sugarcane Var. Co-1148 was planted in trenches 75 cm apart in the month of March. Phosphate @ 80 Kg P_2O_5/ha and potash @ 60 Kg K_2 O/ha, Zinc sulphate @ 25 Kg/ha and B.H.C. @ 15 Kg/ha were applied at the time of planting. Nitrogen @ 240 Kg N/ha was applied in four equal doses.

The results show that during the formative phase in the premonsoon period when evaporative demand is the highest, differential irrigation at IW/CPE ratio of 0.8 and 0.6 produced slightly more yield and longer tillers than the treatment of IW/CPE ratio of 0.4, there being no difference in the former two treatments (*Table* 75). The differences were clearly discernible in the early stages but later, rainfall and common irrigations narrowed down the difference. Accordingly, the cane yield was not significantly affected by differential irrigations during the formative phase. The effect of moisture stress during this phase on juice qualities was also absent. Irrigation at IW/CPE ration of 0.4, however, saved 12 cm and 24 cm water over the IW/CPE ratios of 0.6 and 0.8, respectively.

TABLE 75. *Effect of moisture stress during different growth phases on growth, yield and quality of sugarcane.*

Main effects	Hight (cm)	Tillers No/hill	Cane yield (q/ha)	Depth of water applied (cm)	Cane yield (q/ha/ cm of water)	Juice quality	
						Suc-rose per-cent)	Brix value
A. *Formative phase*							
IW/CPE-0.4	221	2.6	900	74	12.2	13.2	18.1
IW/CPE-0.6	229	3.1	925	86	10.8	13.0	18.3
IW/CPE-0.8	232	3.1	893	98	9.1	13.2	18.3
F-test	N.S.	N.S.	N.S.				
B. *Grand Growth Phase*							
75% depl.	218	2.9	833	80	10.4	12.9	17.8
50% depl.	219	3.0	936	86	10.9	13.5	18.3
25% depl.	244	2.9	950	92	10.3	13.0	18.2
C.D. at 5%	18	N.S.	83				
C. *Ripening phase*							
IW/CPE-0.6	224	3.0	909	84	10.8	12.8	18.4
IW/CPE-0.8	233	3.1	901	84	10.7	12.9	17.7
IW/CPE-1.0	224	2.9	909	90	10.1	13.6	18.3
F-test	N.S.	N.S.	N.S.				

During the stalk elongation phase, the cane growth is severely affected by soil moisture stress. Although under north Indian conditions, this phase coincides with the rainy season but it becomes necessary to irrigate the crop during the lean periods to maintain the soil moisture stress at low levels. At Karnal, during 1972 a lean period of 27 days between 13th July to 8th August and then practically dry conditions during the month of September resulted in more than 75 percent depletion of available soil moisture from 0-30 cm depth and, therefore, necessitated irrigation to maintain the soil moisture at 25, 50 and 75 percent depletions. Maintenance of a moisture regime between 100-25 percent depletion of available soil moisture during grand growth phase resulted in taller canes and higher cane yield than the drier regimes of 50 and 75 percent depletions. The difference in cane yields between the treatments of 25 per cent and 50 per cent depletions was not statistically significant. The juice quality was not affected by the moisture stress levels during this phase also (*Table 75*).

During the ripening phase, the growth of cane in terms of height, tiller number and total tonnage was not affected by differential irrigations at IW/CPE ratios of 1.0 to 0.6, but the sucrose content increased with frequent irrigations at higher IW/CPE ratio of 1.0 over IW/CPE ratios of 0.6 and 0.8.

C.4. 7 : Moisture use efficiency of cotton as influenced by moisture stress and depth of wetting. (*B.K. Khosla and S. N. Singh*)

A field experiment was conducted on a loam soil to study the moisture use efficiency of cotton as influenced by moisture stress and depth of wetting of root zone. The field moisture capacity of the soil varied from 21.7 to 18.5 per cent on oven dry basis in different layers. The bulk density ranged between 1.43 g/cm^3 in surface layer to 1.62 g/cm^3 in the sub surface layers. Cotton variety J-34 was sown on 30th April in rows 60 cm apart and plant to plant distance was kept at 45 cm. The irrigation schedule was based on the cumulative pan evaporation values. When the desired cumulative pan evaporation was reached, the soil was recharged to a certain depth. There were nine treatments which were combinations of cumulative pan evaporation values and the soil depth in which depletion was made up. Cumulative pan evaporation values were 100, 150 and 200 mm. The soil depths to which depletion was made up were kept as 60, 90 and 120 cm. Treatments were replicated four times in a randomized block design.

The yield of seed cotton and the amount of water applied under various treatments are given in *Table 76*.

TABLE 76. *Yield of seed cotton and the amount of supplemental irrigation (cm) under various treatments.*

Treatments	Depth of soil to which depletion was made up					
	60 cm		90 cm		120 cm	
Cumulative pan evaporation (mm)	yield (q/ha)	water applied (cm)	yield (q/ha)	water applied (cm)	yield (q/ha)	water applied (cm)
100	17.4	28.2	18.1	39.6	19.7	45.2
150	19.8	25.7	19.0	36.2	17.8	39.9
200	18.0	13.8	18.2	20.3	19.3	24.3

The difference in yield due to various treatments was statistically non-significant, although the amount of water applied varied from 14 to 45 cm. It appeared that the effect of treatments was masked due to the receipt of significant amount of rainfall during the crop growth period. A total of 74 cm rain was received during this period. The monthly rainfall distribution during the crop period was as follows :

Month	*Rainfall (mm)*
June	45.8
July	315.1
August	320.0
September	4.4
October	28.4
November	28.7

C.5 : Irrigation requirement of maize udner fluctuating high water table conditions. (I.K. Girdhar. J.S.P. Yadav and R.K. Rajput) .

The general trend of ground water table in the Indo-Gangetic plain is that it is the deepest prior to the onset of monsoon, rises often within one meter depth during rainy season and then recedes gradually after the cessation of rainfall. During rainy season also, there is considerable fluctuation of ground water table within shallow depth depending upon the distribution pattern of rainfall, subsoil water flow and such other related factors. This determines the frequency, time and quantity of supplemental irrigation to a crop depending on its rooting habit. Maize is an important *kharif* crop in the Indo-Gangetic plain and is sensitive to both deficiency and excess of soil moisture conditions. In order to collect quantitative data on the requirement of supplemental irrigation for maize under such fluctuating water table conditions in rainy season, a field investigation was conducted on a silty loam soil.

For scheduling irrigation, the treatments were based on water table condition as per details below and also on the depletion of avilable soil moisture to 50 per cent level from 0-30 cm depth prior to irrigation.

T_1--No irrigation through out the crop growth

T_2—Irrigation application	when water table	was	deeper than	3m
T_3--	"	"	"	2.55m
T_4—	"	"	"	2.10m
T_5—	"	"	"	1.65m
T_6—	"	"	"	1.20m
T_7—	"	"	"	0.75m
T_8—	"	"	"	0.30m

The treatments were compared in a randomized block design. Depending on the rainfall pattern and the fluctuation of water table, only four treatments viz. T_1, T_2 T_5 and T_6 were differentiated. Accordingly suitable adjustment was made in the statistical analysis of the data.

Hybrid maize Ganga-5 was planted in the first week of July in lines 50 cm apart and maintaining a plant to plant spacing of 20 cm. The crop was fertilised with 100 Kg N/ha-applied in two splits, 60 Kg P_2O_5/ha and 60 Kg K_2O/ha.

The results revealed that supplemental irrigations to maize crop improved the grain yield over the control (rainfed). The treatment T_5 which received two supplemental irrigations—one in vegetative phase and the other during grain filling stage when water table was deeper than 1.65 m produced 8.6 q/ha more grain yield than control (*Table 77*).

TABLE 77. *Effect of treatments on yield and attributes of maize.*

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	No. of cobs/ plant	Grain wt. per cob (g)	1000 grain wt.(g)
T_1—No irrigation throughout the crop groth	38.0	87.0	1.00	70.2	201
T_2—Irrigation when water table was deeper than 3.00 m	37.4	95.0	1.00	93.0	216
T_5—Irrigation when water table was deeper than 1.65 m	46.6	121.0	1.04	118.8	250
T_6—Iraigation when water table was deeper than 1.20 m	46.7	127.0	1.07	113.0	245
C.D. at 5%					
T_1 and T_5	5.2	18.1	N.S.	19.4	31
T_2 and T_6	3.0	10.4	N.S.	11.3	18
T_1 and T_2, T_5 and T_6 T_2 and T_5, T_1 and T_6	4.3	15.3	N.S.	15.9	25

Treatment T_6 in which irrigation was applied when water table was deeper than 1.2 m, received four supplemental irrigations but the additional irrigations over treatment T_5 did not improve the grain yield. The treatment T_2 which received only one irrigation during vegetative phase when water table was deeper than 3.0m was at par with the control in respect of grain yield. Almost similar trend of treatment effect was recorded in stover yield, grain weight per cob and 1000 grain weight. The number of cobs per plant was not significantly affected by the irrigation treatments.

SUB STATION, CANNING TOWN (WEST BENGAL)

Canning is situated in West Bengal and is connected by rail and road with Calcutta. The river *Matla* run on the eastern side and a canal connecting with the river is situated on the western side of the Research Station. The river is protected by earthen dike. The average annual precipitation is approx. 1740 mm. The soils are generally, heavy clay. The ECe vary from very low to as high as 40 mm hos/cm particularly in *rabi* season. The pH is round about 7.0 The depth of ground water varies from 0.30 to 1.5 m at different periods of the year. The ground water is enriched primarily with the chlorides of sodium, calcium and magnesium. Rice is the main crop and is grown as a rainfed crop in *kharif*. Irrigation facilities are meagre. In a small area rice and other crops are taken for experimental purposes in *rabi* and the fields are irrigated from pond and tubewell water.

Breeding of high yielding salt resistant rice—Hybridisation (R.K. Bhattacharya).

SR 26B, a tall indica rice variety of 150 days duration, was considered as a salt tolerant variety. Field experiments under saline soil (Average ECe 12 mm hos/cm) at the station showed that *Getu*, *Damodar*, and *Dasal* were superior to SR 26B not only in tolerance but aslo in grain yield, duration and height. They were also found superior to high yielding varieties like IR-8 and Jaya in grain yield. High yielding varieties although gave lesser grain yield than *Getu*, *Damodar* and *Dasal*, yet because of their high yielding potentiality, wide adaptibility and high nitrogen assimilation capacity, they were selected as parent for crossing with *Getu*, *Damodar* and *Dasal*.

Damodar x *IR—8 cross :*

The cross was made in 1971 (Dec. '70 to April' 71). The F_1 plant (grown in normal soil of *kharif* 1971) was like *Damodar* parent. 14, 763 F_2 plants were grown in saline soil during *rabi* 1972. The plant population segregated for tall and dwarf. Based on field observations (e.g. height, tiller and vigour) only 252 plants were selected and harvested.

The 252 selected F_3 seeds were sown on a saline soil (ECe – 18.04 mmhos/cm) in *kharif*, 1972. The germination of the seeds was good but after three weeks of sowing, the seedlings showed sign of mortality. On the basis of seedling mortality, the cultures were classified into three groups-Resistant (Less than 30% affected), susceptible (50% or more affected) and moderately resistant between the above two classes.

244 cultures involving all the three classes of seedlings with a total plant population of 67,890 were transplanted in the first week of August 1972 in a soil having ECe of 7.91 mmhos/cm. Fertilizer was applied @ 150 Kg N, 80 kg P_2O_5, 60 kg K_2O and 20 kg $ZnSO_4$/ha. Each culture was transplanted with one seedling per hill at a distance of 15 cm apart on both sides. Each culture was inspected in the field at ripening and on the basis of field observations 99 cultures were selected. 5 plants were selected from each of these 99 cultures for single plant grain yield which were compared with that of the .parents and thus finally 34 cultures were selected for study in F_4.

The data indicated that only two cultures (65 and 81) gave higher yield than any of the parents. However, it is interesting to note that some of the cultures (42, 154, 157 and 221) although classified as susceptible at seedling stage were found to give nearly the same grain yield as either of the parents.

Dasal x Jaya, Jaya x Getu and IR-8 x Dasal :

The crosses were made in *kharif*, 1971. F_1 plants of the crosses were grown in *rabi*, 1972 There were high mortality of the hybrid seedlings at F_1 stage, F_2 progenies of these crosses were grown in *kharif*, 1972. Field selections were made (26 singal plants of Dasal x Jaya, 10 single plants of Jaya x Dasal, 1 plant of Jaya x Getu and 31 plants of IR-8 x Dasal) and on the selected plants the data of height, E.B.T. and panicle length were recorded. Plants segregated into tall and dwarf types.

Dasal × T.N. 1., Getu × T.N. 1, Getu × IR-8, Damodar × Hamsa and Dasal × Hamsa.

Rice variety *Hamsa* was taken for its finer grain quality. The crosses were made in *rabi* 1972. The F_1 plants were grown in *kharif* 1972. F_1 plants were all tall. F_2 seeds obtained from F_1 plants will be grown in *rabi*, 1973.

Breeding of high yielding salt resistant rice—Mutation (T.S. Sinha)

Chemical mutagens and X-ray were tried to see whether dwarfness, high yield and earliness could be introduced in the existing salt tolerant variety *Damodar* and salt tolerant capacity in IR-8. To achieve this aim, studies on induced mutation on rice was taken up. Two chemicals (Dimethyl sulphoxide 0.5% and Triethanol amine 0.5%). and X-ray (12 kr and 20 kr.) were used for the purpose. Distilled water was used as control. The seeds of IR-8 and *Damodar* were treated singly and in combination with others. Further, there were Pre-and Post treatments of seeds.

Hundred seeds of the selected plants of M-1 generation were sown in *Kharif*. The germination percentage and the type of chlorophyll were recorded in the M-2 generation. The plant in M-2 generation were selected on the basis of 1000 gain weight, single plant yield and heading duration. Apart from that, the morphological varient were also scored.

Performance of high yielding rice varieties in saline soil : (T.S. Sinha and R.K. Bhattacharya).

The experiment was taken to see the performance of the high yielding rice varieties in coastal saline soil, The varieties (i) IR 22, (ii) Jaya, (iii) IET 1991, (iv) Vijoya, (v) I.R.20 (vi) IET 1039 and (vii) CR-10-5071 were tried against *Getu*, *Dasal* and *Damodar* as control. Thirty days old seedlings were transplanted in a saline soil (E.Ce. 5.5 mmhos/cm at transplanting and 11.80 mmhos/cm at flowering) at a spacing of 15 cm x 15 cm. 180 kg of nitrogen, 80 kg phosphate and 60 kg of potash per hectare were applied. The full doses of phosphate and potash were applied at the time of puddling, whereas nitrogen was applied in three doses—1/4th at sowing, 1/2 at tillering and remaining 1/4th at flowering. In addition, $ZnSO_4$ was also given @ 20 kg/ha.

The varietal differences in yield were statistically significant at 5% level. However, none of the high yielding varieties could out yield the salt tolerant varieties *Getu* (36.6 q/ha.), *Damodar* (38.2 q/ha) and *Dasal* (38.2 q/ha). CR. 10-5071 was the lowest yielder amongst all the varieties.

Effect of Zn on the yield of paddy (S.K. Datta)

Response of rice variety *Dasal* to application of zinc was studied in unreplicated micro plot experiment. The soil had an electrical conductivity of 8.28 mmhos/cm in saturation extract. Three doses of Zn-2.5, 5.0 and 10.0 ppm were tried as zinc sulphate.

The results indicated that addition of zinc increased the grain yield over control. Application of zinc @ 10 ppm reduced the grain yield as compared to 5 ppm level.

The experiment was repeated during *kharif* season with variety IR-8-68. The results indicated that there was no response in grain yield to application of zinc.

PUBLICATIONS

A. Research Publications

1. Bandyopadhya, A.K.	1972	Note on the formation of sodium bicarbonate in soils. *J. Indian Soc. Soil Sci.* **20** (2) : 187-188.
2. Bandyophadhya, A.K.	1972	Role of depth and quality of water table on soil salinization. *Indian Geohydrology* **B** (**1**) : 56-58.
3. Bandyopadhya A.K.	1972	Effect of rainfall on calcareous saline sodic soils. *Agrokem Talajt* **20** (**4**) : 511-514.
4. Bhardwaj, K.K.R.	1972	Note on the occurence of pigmented strains of Rhizobium in saline alkali soils. *Indian J. agric. Sci.* **42** (**9**) : 961-962.
5. Gupta, I.C. and Chandra, Harish	1972	Effect of gypsum in reducing boron hazard of saline waters and soils. *Ann. Arid Zone* **11** : 228-230.
6. Mondal, R.C.	1972	Effect of high Mg waters on a bentonite clay complex as influenced by $CaCO_3$. *Indian J. agric. Sci.* **42** (**12**) : 1095-1098.
7. Mondal, R.C. and Bhumbla, D.R.	1972	Release of divalent cations from $CaCO_3$ into chloride solutions. *Indian J. agric. Sci.* **42** (**12**) : 1091-1094.
8. Poonia. S.R. Virmani, S.M. and Bhumbla, D.R.	1972	Effect of ESP of the soil on the yield, chemical composition and uptake of applied calcium by wheat. *J. Indian Soc. Soil Sci.* **20** (**2**): 183-185.

B. Popular Articles

1. Abrol, I.P. and Bhumbla, D.R.	1972	*Mitti Ke Sudhar Ke Liye gypsum Ka Prayog.* *Kheti* **25 (4)** : 8-9
2. Bhardwaj K.K.R.	1972	*Rehi aur Khari mitti Sudhar main phalidar phaslaun ka mahatava.* *Kheti* **25** (**4**) : 25.
3. Bhumbla, D.R.	1972	Reclamation of saline and alkali soils. *Indian Fmg.* **22** (**2**) : 19-21.
4. Bhumbla, D.R.	1972	Reclamation and utilization of salt affected soils. *Indian Fmg.* **22** (**5**) ; 151-154.
5. Bhumbla, D.R.	1972	Saline and alkali soils and their management. *Haryana Fmg* **1** (**4**) : 3-6.
6. Bhumbla, D. R. and Abrol, I. P.	1972	Get eight tonnes of paddy from saline alkali soils. *Indian Fmg.* **21**(**12**) : 18-19.
7. Bhumbla, D.R. and Abrol, I.P.	1972	Is your water suitable for irrigation. *Indian Fmg.* **22** (**4**) : 15-16.
8. Dargan, K.S., Abrol I.P. and Milap Chand	1972	Gypsm—F.Y.M. good combination in saline alkali soils. *Indian Fmg.* **22** (**9**) : 27-28.
9. Dargan, K.S., Gaul, B.L. and Chhillar, R.K.	1972	*Lavniya Bhumi Ke Liye Unnat Krishi Vidhian.* *Kheti* **25** (**4**) : 23-24.
10. DhruvaNarayana, V.V.	1972	Problem and methodology in watershed research. *International Hydro Decade News Letter of India, Oct. issue.*
11. DhruvaNarayana, V.V. Gupta S.K. and Bhumbla, D.R.	1972	A dual purpose pond. *Indian Fmg.* **22** (**9**) : 9-12.

12. Gupta, I.C. and Chandra, H. — 1972 — *Sinchai ke pani ki parakh. Kheti* **25** (**4**) : 15-16.

13. Gupta I.C. and Mondal, R.C. — 1972 — *Sinchai ka pani kaisa ho. Kheti* **25** (**9**) : 18-19.

14. Yadav, J.S.P — 1972 — Coordinated research on water management and salinity. *Indian Fmg.* **22** (**2**) : 43-45.

15. Yadav, J.S.P. — 1972 — Impact of water management and salinity research on agriculture. *Indian Fmg.* **22** (**6**) : 52-58,

16. Yadav, J.S.P. — 1972 — *Lavniya bhoomi par braksha bhi ugg sakte Hain. Kheti* **25** (**4**) : 8.

C. Seminar and symposium papers

1. Abrol, I.P. and Dahiya, I.S. — 1972 — Flow associated precipitation reaction in sodic soils and their significance. *Paper presented at American Society of Agronomy meeting at Miami from* 28-31st Oct.

2. Gupta, I.C. — 1972 — Evaluation of quality of ground waters for irrigation, *Proc. Seminar Geomorphology, Geohydrology and Geotechnics of Lower Ganga Basin* (Kharagpur) B 90-98.

3. Gupta, S.K. and Dhruva Narayana, V.V. — 1972 — Surface drainage methods for saline alkali soils. *Symp. Water-logging, causes and measures for its prevention CBIP. New* Delhi *Pub. No. 118* **2** : 129-134.

4. Jaiswal, S.R. and Dhruva Narayana, V.V. — 1972 — Design of sub-surface drainage system. *Symp. Water-logging. causes and measures for its prevention, CBIP New Delhi. Pub. No. 118* **1** : 91-100.

5. Paul, J. and Pandey, R.N. 1972 Underground system—A measure to check water-logging of irrigated areas. *Symp. Water-logging, causes and measures for its preveation, C.B.I P. New Delhi. Pub No. 118* **2** : 109-114.

D. Miscelianceous Publications

1. Abrol, I.P., Bhargava, G.P. Sharma, R.C. and Singhla, S.K. 1972 Studies on ground water quality and soils of Mathura District (U.P.) *Division of Soils and Agronomy, C.S.S.R.I. Karnal.*

2. Bhargava, G P., Singhla, S.K. and Abrol, I.P. 1972 Characteristics of some typical saline sodic soils of Karnal District (Haryana), *Division of Soils and Agronomy, C.S.S.R.I., Karnal.*

3. Gupta. I.C. 1972 Bibliography of characteristics and management of salt affected soils in India. (1893-1972). *Agricultural Research Communication Centre, Karnal*, pp. 96+iv.

4. Rajput, R.K. 1972 Cropping patterns and irrigation water requirements of crops for proposed Maknao lift irrigation project, Laos. (Report) *Water and Power Development Consultancy services (India) Limited, N.D.S.E. Part II, New Delhi.*

5. Yadav, J.S.P. 1972 Annual Report of Coordinated Scheme on Water Management and salinity.

APPENDIX I

List of staff in position as on 31.12.1972.

Sr. No.	Name	Designation	Date of joining
1.	Dr. D.R. Bhumbla, M.Sc. (Ag.), Ph.D.	Director	1.4.1969
	DIVISION OF SOILS AND AGRONOMY		
2.	Dr. I.P. Abrol, Assoc. I.A.R.I., Ph.D.	Head of Division	16.10.1969
3.	Dr. K.S. Dargan, M.Sc. (Ag.), D. Phil.	Agronomist	6.4.1970
4.	Sh. R.C. Mondal, M.Sc.	Soil Chemist	23.9.1969
5.	Dr. A.K. Bandyopadhya, M.Sc., D. Phil.	Soil Physicist (working at Canning)	16.10.1969
6.	Dr. G.P. Bhargava, M.Sc., Ph.D.	Soil Scientist	13.3.1972
7.	Dr. I.C. Gupta, M.Sc., Ph.D.	Jr. Soil Chemist	4.3.1970
8.	Dr. K.K.R. Bhardwaj M.Sc., Ph.D.	Jr. Soil Microbiologist	12.12.1969
9.	Dr. C.L. Acharya, M.Sc. (Ag.), Ph.D.	Jr. Soil Physicist	3.2.1972
10.	Sh. R.K. Chillar, M.Sc. (Ag.)	Sr. Res. Asstt.	1.4.1970
11.	Sh. Daya Ram, M.Sc. (Ag.)	Sr. Res. Asstt.	22.7.1970
12.	Sh. H.C. Nitant, M.Sc.	Sr. Res. Asstt.	28.11.1970
13.	Sh. S.K. Singhla, M.Sc. (Ag.)	Sr. Res. Asstt.	9.12.1970
14.	Sh. B.L. Gaul, M.Sc.	Sr. Res. Asstt.	11.12.1970
15.	Sh. R.C. Sharma, M.Sc. (Ag.)	Sr. Res. Asstt.	11.12.1970

DIVISION OF GENETICS AND PLANT PHYSIOLOGY

16.	Sh. R.K. Bhattacharya, Assoc. I.A.R.I.	Plant Breeder (working at Canning)	19 8.1971
17.	Dr. T.N. Singh, M.Sc. (Ag.), Ph.D.	Plant Physiologist	1.5.1972
18.	Shri. Y.C. Joshi, M.Sc. (Ag.)	Sr. Res. Asstt.	5.12.1970
19.	Sh. B. Mishra, M.Sc. (Ag.)	Sr. Res. Asstt.	11.12.1970
20.	Sh. K.S. Gill, M.Sc. (Ag.)	Sr. Res. Asstt.	14.12.1970
21.	Sh. K.N. Singh, M.Sc. (Ag.)	Sr. Res. Asstt.	1.5.1971
22.	Sh. O.P. Singh, M.Sc. (Ag.)	Sr. Res. Asstt.	6.10.1972

DIVISION OF ENGINEERING

23.	Dr. V.V. Dhruva Narayana M.Sc. Ph.D.	Head of Division	22.1.1971
24.	Sh. R.N. Pandey, M. Tech.	Drainage Engineer	28.12.1971
25.	Sh. S.R. Jaiwal, M. Tech.	Asstt. Engineer	25.3.1971
26.	Sh. S.K. Gupta, B.Sc. (Ag. Engg.)	Asstt. Engineer	1.4.1972
27.	Sh. Joginder Paul, B.Sc. (Ag. Engg.)	Sr. Res. Asstt.	23.8.1971
28.	Sh. A.K. Pasricha, B.Sc. (Ag. Engg.)	Sr. Res. Asstt.	24.8.1972

COORDINATED PROJECT ON WATER MANAGEMENT AND SALINITY

29.	Dr. J.S.P. Yadav, M.Sc. (Ag.), Ph.D.	Project Coordinator	31.3.1969
30.	Dr. R.K. Rajput, M.Sc. (Ag.), Ph.D.	Agronomist	3.9.1971
31.	Dr. B.K. Khosla, M.Sc. (Ag.), Ph.D.	Soil Physicist	19.8.1971

32.	Sh. I.K. Girdhar, M.Sc. (Ag.)	Sr. Res. Asstt.	3.12.1970
33.	Sh. B.M. Sharma, M.Sc. (Ag.)	Sr. Res. Asstt.	14.12.1970
34.	Sh. S.N. Singh M.Sc. (Ag.)	Sr. Res. Asstt.	26.12.1970
35.	Sh. V.K. Katyal, M.Sc.	Statistical Asstt.	21.10.1970
36.	Sh. R.P. Mangla, Dip.Com.Art.	Artist	17.9.1972

OTHER STAFF

37.	Sh. O.S. Tomar, M.Sc. (Ag.)	Farm Superintendant	8.1.1972
38.	Sh. K.N. Pahwa, M.A., Dip. Lib. Sc.	Sr. Library Asstt.	22.1.1971
39.	Sh. K.B. Singh, B.A., LLB.	Reprographist	6.10.1972
40.	Sh. O.P. Sharma, M.Sc. (Ag.)	Sr. Tech. Asstt.	6.10.1972

C S..S.R.I. SUB-STATION, CANNING TOWN (WEST BENGAL)

41.	Dr. H. Sen M.Sc. Ph.D.	Jr. Soil Physicist	1.12.1971
42.	Dr. K.K. Mehta, M.Sc., Ph.D.	Jr. Soil Chemist	6.12.1971
43.	Sh. S.K. Dutta, M.Sc. (Ag.)	Sr. Res. Asstt.	15.3.1972
44.	Sh. T.S. Sinha, M.Sc. (Ag.)	Sr. Res. Asstt.	15.3.1972

APPENDIX II

LIST OF VISITORS

1. Sh. N.A. Dias, High Commissioner of Ceylon in India. (11.2.1972)
2. Prof. D.M. Byg, Agriculture Engineering Department, O.S.U. Columbus, Ohio (19.2.1972)
3. Dr. H.G. Pandya, Joint Director of Agriculture, Krishi Bhavan, Gujarat State, Ahmedabad-6 (22.2.1972)
4. Prof. G.S. Taylor, Agronomy Department, Ohio State University, Columbus. Ohio, U.S.A. (28.2.1972)
5. Sh. B.S. Nag, Member, National Commission on Agriculture, New Delhi (4.3.1972)
6. Sh. J.S. Sharma, Member Secretary, National Commissin on Agriculture, New Delhi (4.3.1972)
7. Dr. S.K. Mukherjee, Member, National Commission on Agriculture. New Delhi (4.3.1972)
8. D. Nr. G. Perur, Director of Instruction (Agriculture), U.A.S. Hebbal, Bangalor-24 (4.3.1972)
9. Dr. L. Musgrave, Associate Director Extension, Ohio State University, Columbus, Ohio (13.3.1972)
10. Dr. M.J. Smith, Assistant Dean, College of Agriculture and Home Economics State University Columbus, Ohio (13.3.1972)
11. Dr. G.J. Hall, Associate Professor, O.S.U,, Columbus, A.I.D., Ludhiana (14.3.1972)
12. Dr. K.V. Raman, Professor, Depatment of Soil Science, U.P. Agricultural University, Pantnagar (17.3.1972)
13. Dr. Joe Gingrich, Advisor, Department of Soil Science, U.P. Agricultural University, Pantnnagar (17.3,1972)
14. Dr. J.S. Kanwar, Deputy Director General, I.C.A.R., New Delhi (17.3.1972, 29.9.1972 and 18.11.1972)
15. Dr. J.W. Kijne, Agricultnre University, Wageningen, Netherlands (20.3.1972)
16. Dr. L.S. Cobley, Agriculture Education Division, UNESCO, Paris (29.3.1972)
17. Sh. Krishna, M.P. Chairman, Farms Corporation of India, New Delhi (17.3.1972)
18. Dr. Anup Singh, State Farms Corporation of India, New Delh.
19. Dr. K.F. Hoffmann, Special Education Service, FAO. Rome (29.3. 1972)

20. Sh. George H.W. Hutton, F.A.O. Representative India, 21-Kasturba Gandhi Marg, New Delhi (29.3.1972)
21. Sh. Nguyen Chuong. Vice Minister of Agriculture, Democratic Republic of North Vietnam (4.4.1972)
22. Sh. N.D. Nien, Deputy Chief of the Department of Agriculture, Democratic Republic of North Vietnam (4.4.1972)
23. Dr. D.E. Roston, W.T.C., I.A.R.I.. New Delhi, (5.4.1972)
24. Dr. B.A. Krantz, W.T.C., I.A.R.I., New Delhi (5.4.1972)
25. Dr. Ady, Raul da Silua, Senior Plant Scientist, Brazilian Ministry of Agriculture, Preaia De Flamengo 88-202 Rio, Brazil (25.4.1972).
26. Sh. E.D. Dartey, F.A.O. Fellow from Ghana, Irrigation Division P.O. Box M-154-Accara (6.6.1972)
27. Sh. S.A. Donkor, Irrigation Division Beposo, via Sekoudi, Ghana (6.6.1972)
28. Dr. W.H. Freeman Joint Coordinator, All India Coordinate Rice Improvement Project, Hyderabad (15.6.1972)
29. Dr. S.C. Agarwal, Professor of Botany, Lucknow University. (22.6. 1972)
30. Dr. M. Nakapa, Lecturer, Faculty of Agriculture and Veterinary Science, Nihon University, Tokyo (10.8.1972)
31. Dr. T.H. Quackenbush, Consultant in water use and management, Ford Foundation, New Delhi (21.8.1972)
32. Dr. Jakob Kampen, Ford Foundation, New Delhi (21.8.1972)
33. Sh. P.S. Gill, Director, Ganna, Vikas, Nideshalya, 19-20 Rohtak Road, New Dehli (3.10.1972)
34. Dr. S.V.S. Shastry, All India Coordinated Rice Improvement Project, Hyderabad-30 (4.10.1972)
35. Sh. S.L. Bailpur, Secretary, Agriculture, Haryana (9.10.1972)
36. Dr. R.R. Singh, Head of Agronomy, R.B.S. College. Bichpuri, Agra (9.10.1972)
37. Dr. B. Rama Moorthy, Head, Soil Science and Agricultural Chemistry Div., I.A.R.I., New Delhi (9.10.1972)
38. Sh. K. Balakrishnan Nair Editor. I.C.A.R, New Delhi (13.10.1972)
39. Sh. Kazutaka Morino c/o U.N.D.P. 21-Kasturba Gandhi Marg, New Delhi (13.10.1972)
40. Sh. Amir Singh Chaudhari, Head, Division of Seed Technology, IARI, New Delhi (19.10.1972)
41. Dr. M.S. Swaminathan, Director Generel, ICAR, New Delhi (16.10 1972)
42. Sh. R.S. Maroug, Director General of Field Crops, Baghdad, Iraq (24.10.1972)

43. Dr. T.S. Buleria, Joint Director (INP) Ministry of Agriculture (24.10. 1972)
44. Dr. Pvot Kamal Eldin Fouad, Dean, Faculty of Veterinary Medicine Cairo, Egypt (24.10.1972)
45. Sh. K.P. Singh, *Secretary, ICAR, New Delhi. (23.10.1972)*
46. Sh. R. Prasad, District Agricultural Engineering Officer, Gaya (Bihar) (7.11.1972)
47. Sh. V.S. Srinivasan, Assistant Agricultural Engineer, Government Tractor Workshop, Vellore, North Arcot, Tamil Nadu State (7.11.1972)
48. Visit of Directors of I.C.A.R. Institutes (20.11.1972)
49. Sh. N.R. Kaura. Joint Director of Agriculture, Punjab (1.12.1972)
50. Capt. Rattan Singh, Minister of Agriculture, Punjab (31.12.1972)