Thesis Component - IV

ECOSYSTEM OPTIMIZATION

Experimental Results - Discussions

Thesis Component IV

Ecosystem Optimization

Unit - I

Ecosystem Optimization and

Agricultural output optimization

Ecosystem Optimization : a macroview :

Watt (1966) has emphasized that ecosystem optimization is one of the major facets of ecological research. According to Pattern (1966) a system can only be optimized with respect to specific objectives. The objectives for man-manipulated systems are usually clear but in natural adaptive ecosystems they are likely to be ambiguous (Patten, 1966). Possible objectives such as maximization of power output, survival potential, standing biomass, and stability or minimization of effects of chemical or other contamination are some such man made objectives. Patten (1966) concludes that optimization of ecosystem is a multiple objective process. The major aspect that needs careful consideration is the optimum net work problem as defined by Ore (1963). According to Patten (1966) this aspect can be looked from the simplified point of view. The concept of optimum net work borrowed from Cybernetics may be simplified thus : Given a set of resources, habitat and other variables and also given a set of objectives one can allocate resources under the habitat constraints to develop a production and utilization pattern, such that the best relations are established between the variables for optimum achievement of the objectives (Patten, 1966).

II. Optimization of agricultural output :

Basic to any ecosystem optimization approach is the optimization of land use and primary productivity of the biosphere (Clapham, 1965). Domros (1976) is for the agro-climatological classification of the land use patterns to achieve the optimization of the agro-ecosystems which is the world's most pressing social political and moral problem. (Van Overbeek,1976).

Ecosystem optimization programmes therefore, must necessarily include approaches for the optimization of agricultural crop systems in response to the world food situation.

Frequent references are made to the information theory (patten, 1966; Watt, 1966; Simon, 1973) as an extension of probability to comprehend the net work concept of ecosystem and to solve the optimization problem : Given a set of resource, habitat and other variables what is the best composition of optimizing machinery for the given conditions. This problem can be set in relation to any agricultural environment for optimization of the output of crop system in question.

III. A look at Optimizing machinery for Agriculture :

Optimizing machinery in case of the agro-ecosystem optimization has to consider the crop variety grown for the plant-environment interactions are the central areas of concern while probing into the aspects of optimization. The inputs of fertilizer-pesticide complex come at the second stage of optimization process. In the words of Domros (1976) the two basic questions for optimization of agro-ecosystems can be put plainly as : (i) Does the crop grow where it should grow? (ii) Is the crop-variety grown the most suitable variety for that edapho-physical environment? The proper selection of variety for a particular ecological zone or the habitat is the first step towards the optimization of the agricultural output (Odum, 1971; Stoy, 1973; Larcher, 1974).

Variety-Environment-Interaction :

The environmental parameters have profound effect on plant growth and plant function. The environmental complexes have always been responsible for changing the ecological viability of the habitats. It is therefore, essential to recognize the importance of variety-environment-interactions in agro-ecosystems. The optimizing strategies have to be dependent upon the data generated by the investigations of interactions of variety-environment complex (Cooper, 1971). Cooper (1971) and Breese (1971) have conducted analysis of genotype environment interaction for dry matter production among the varieties of *Lolium perenne*. Such an analysis was used in Britain for planning the further strategies of improving crop production in many areas. (Jones, 1971). Lewis (1970) has pointed out that selection of suitable varieties is of great importance in optimization of production since the net primary production of an ecosystem is not only dependent upon the environmental factors but also on the genetic make up of the plants.

'Input' as an aid for ecosystem optimization :

Mechanized agriculture is yet not possible in our country especially in the ecosystems where the population is below poverty line. Van Overbeek (1976) states clearly that to produce more one needs more energy that is no longer easily available without perturbing the ecosystem assets. On the Indian scene we cannot afford the industrialized agriculture and even cannot afford expensive fertilizer-pesticide inputs while the western world using 'excessive' fertilizer-pesticide input is suffering from major ecological crisis - and the attempts are made to return to 'Biological' farming or 'Natural farming' for ecosystem optimization (Barry Commoner, 1977). In words of Van Overbeek (1976), the western agriculture has reached the stage where the 'law of diminishing returns' operates and thus the eco-crisis continues undaunted in that part of the world. Cornell study (Van Overbeek, 1976) brought to light an interesting fact. It was found that to achieve 2.4 fold increase in Corn production in the United States the energy input had increased 3.2 fold and the figures were further calculated to include other energy requiring process such as canning, packing etc. They realized that by the time the food is canned and packed the energy input is six times more than the caloric food value of its content.

From the above account it is evident that the basic approach of ecosystem optimization consists in selection of a suitable variety for a particular ecozone and minimization of the input of energy into the farm consistent with the optimum yield.

Thesis Component IV

Ecosystem Optimization

Unit - II.

Optimization in Natural Farming Systems -

Assessment of Chokari agro-ecosystems

I. Natural Farming System and Optimization :

Circumstances of the past few years especially in the western world have generated concern over the heavy reliance of modern agriculture on inorganic fertilizers and chemical pesticides (Commoner, 1976). This concern centers on the input of energy in an ecological system for optimization. The consequences have already been discussed in the preceeding unit. Western world therefore, is in search of strategies to lower down the energy input of the farms. One of the strategies lies in the return to 'organic' farming or 'Natural farming' or 'biological farming' (Odum, 1971; Commoner, 1976).

In India the situation is quite different. Being a developing country,India lacks resources to mechanize the agriculture and also to obtain more input of energy into the farms. Rural ecosystems in India are neglected and are below the standard compared to the counterparts in the western world. The practice of 'Natural' farming or 'organic farming' is already in vogue in some parts of the country including some parts of the Gujarat State, not as result of advanced development but as a result of underdeveloped conditions.

Natural farming system poses the specific situation for the purposes of ecosystem optimization. Many of the limitations of resources and energy creep in along with the process. It would be proper to look into the optimization strategies for the natural farming systems.

It is essential to point out here that the natural farming system relies on the plant nutrients that are supplied through organic wastes; livestock manures, leguminous green manures etc. Crop rotations are done to reduce the weed and insect problems.

In India natural farming is generally associated with small-scale labour intensive, subsistence farms wherein the marginal farmer survives by the 'input' of his labour and yields are the function of the edapho-physical environment and the genetic potential of the crop variety grown.

With the above resource limitations as well as the limitations of the edaphic and the physical environment which are beyond the remedy by the marginal farmer, the only plausible optimization strategy for natural farming systems of India lies in the fact that the most suited and ecologically viable variety with a genetic constitution which would suit the habitat complex and the prevalent agro-economic operations of human component must be grown.

Considering these basic conceptual foundations, an ecosystem assessment of the Chokari rural complex was undertaken to determine the strategies for optimization.

Chokari agro-ecosystems : an assessment and Optimization strategies :

It is earlier mentioned that the ratio of cultivated land : person is quite low (0.077 hectare/person) in Chokari ecosystem area. An analysis of yield of Chokari agro-ecosystems reveals the fact that saline ecozone of the area shows the poorest yield. In the non-saline ecozone the yields are comparable if not at par with other rural complexes. As has been discussed earlier the non-saline ecozone is faced with the problem of energy subsidies for irrigation-fertilization and pesticidal input. The marginal farmer of the saline ecozone also faces these problems. In addition to the 'input' problems the production of this zone is further limited by salinity gradient existing in the edaphic environment. The yield is limited by this factor to a considerable extent (Strognov, 1964) which is reflected in the poorer socio-economic conditions of the farmers of this zone than that of non-saline ecozone.

It has been discussed earlier that the entire agro ecosystem follows the 'natural' or 'organic' farming system; the optimization of this ecosystem can be on the patterns discussed in the preceding paragraphs.

Chokari rural ecosystem complex has two farming zones. The details of the two farming zones are discussed earlier. The non-saline zone is the zone where comparatively better 'harvest' yields are obtained by various agronomic operations and this production zone is on the land area of non-saline ecozone. The optimization of this production zone can be achieved by energy subsidies as discussed earlier.

The real optimization problem is of the agroecosystems of saline zone of Chokari ecosystem area.

Optimization of the saline ecozone agro-ecosystems can be done on the basis of the optimization concepts which are discussed under the heading of variety - environment - interactions and also under the heading of natural farming optimization.

The strategies for saline zone agroecosystem optimization therefore, would include evaluation of the ecological viability of the various crops grown in the saline ecozone. Also, it is imperative to evaluate the ecological behaviour of the varieties of the different crops and only on the basis of such an evaluation the selection of a variety which would be able to tolerate the edaphic salinity gradients and growt in that zone to give comparatively better yield can be made.

The basic approach includes the evaluation of the eco-behaviour of the crop variety at seedling phenophase (Maliwal, 1970) in saline habitat as the yield improvement is a partial function of the crop density of the area.

Keeping in view the agro-ecosystem patterns in saline ecozone and the crops grown in Chokari area - a case study was planned to evaluate the eco-behaviour of wheat varieties in saline ecozone as an approach towards the ecosystem optimization. The detailed case study is presented in Unit - III.

Thesis Component IV

Ecosystem Optimization

Unit - III.

Agro-ecosystem (Saline ecozone) Optimization : Case Study :

Evaluation of halophytic potential (the eco-behaviour) of some improved wheat varieties in saline edaphic complexes for agro-ecosystem optimization.

I. Back drop :

The problems of edaphic salinity and its adverse effect on plant growth are well known (Richard, 1954). The salinity gradient and the fluctuations thereof have been serious problems of soil management and reclamation. The investigations ofs stresses on plant growth due to excessive salt accumulation have been engaging the attention of many research scientists all over the world. The responses of plants in general to the effects of soil salinity have been discussed in a number of papers and books (Ayers, 1952; Bernstein, 1958; Francois, 1958; Bernstein, 1962; Strognov, 1964; Nieman, 1965; Chapman, 1966; Ungar, 1966; Slatyer, 1967; Jennings, 1968; Chatterton, et al.,1969; Donovan, 1969; Dumbroff, 1969; Ashour, 1971; Barnes, 1971; Jefferies, 1971; Ungar, 1972; Helling, 1975; Larcher, 1975; Oviatt, 1977).

The works of Bernstein and Hayward (1958) and Strognov (1964) are quite detailed and constitute an exhaustive reference material on the subject of salinity effects on plant growth.

The research workers in India have also done extensive studies on the crop response to the salinity gradient in edaphic complexes. The researches in India are mainly on the crop plants due to the fact that saline soils are 'problem' soils for agricultural operations (Bhardwaj, 1960; Sarin, 1961; Sarin, 1963; Chaudhri, 1964, Asana, 1965; Bhardwaj, 1966; Sarin, 1966; Maliwal, 1967; Paliwal, 1968; Sarin, 1968; Narale, 1969; Janardhan, et al., 1970; Kurian, et al., 1971; Uprety, 1971; Marwah, 1972; Uprety, 1973, 1974; Joshi, 1977).

The level of salt content of the soils above which plant growth is affected depends upon several factors among which are the texture of soil, the distribution of salt in the profile, the nature of the salt and the species of the plant (Richards, 1954).

The crop plants and halophytes differ in their response to the salinity gradient of the edaphic zones. The tolerance of salinity by a crop species depends upon many factors including its genetic makeup. (Ungar, 1966; Sarin, 1973; Uprety, 1974).

In the present ecosystem analysis, it was observed that crop growth and yield is poorer in the saline edaphic zones of the ecosystem. The assessment of salinity in that particular zone has already been discussed in the unit on edaphic environment. It will not be out of place to mention that Gujarat State as a whole has about 223541 hectares of salt affected soil. The taluka of Padra has about 166.6

hectares of saline soil due to sea water ingress. The Chokari rural ecosystem area has about 70 hectares of soil which is saline in nature.

The optimization of saline ecozone therefore, is the problem of the area. The strategies for optimization of this saline ecozone have been outlined in the preceding unit.

Selection of wheat as a crop for the case study :

The crop harvest analysis of Chokari agro-ecosystem reveals the fact that the wheat yield is poor compared to the other crops in the area. At the same time the main cultivated crop is Bajari due various reasons including economic considerations. Wheat is grown as a 'subsidiary' crop in saline ecozone.

It is needless to point out the importance of wheat as compared to the jowar or bajari. The population is already protein-starved and shows acute over-all malnutrition. Wheat cultivation, therefore, needs attention from these points of view. The investigator therefore, selected 'wheat' crop for the optimization studies.

Selection of wheat varieties for experimental work :

It has been discussed already in the optimization machinery and strategies in the preceding unit that the selection of a variety suitable for the agro-economic practices and habitat complexes constitutes the basic step towards the optimization. This selection can be done only by evaluating the ecological behaviour of the varieties in the habitat in question for final 'crop' growth.

For this purpose four varieties of wheat namely the Sonalika, Kalyansona, J-24 and J-40 were selected. Out of the four varieties selected for experiments, the varieties Sonalika and Kalyansona are already in cultivation in the ratio of 3 : 1 (i.e. out of the total wheat sown area only one fourth area is sown with Kalyansona while the rest is sown with Sonalika). The varieties J-24 and J-40 are not sown in the area. An inventory was made to obtain information from the concerned farmers to know the reasons of their selection of Sonalika and Kalyansona. The inventory responses led the author to conclude that the farmers had selected the varieties due to their improved nature and resistance to the pests and parasites. Another factor which played a significant part in the selection of these two varieties was the easy availability of the seed.

The investigator selected J-24 and J-40 varieties released by the Wheat Breeder of Wheat Research Station, Vijapur, Mehsana with a view to comparing the eco-behaviour of the four varieties in an attempt to select the most efficient variety for the saline ecozone of Chokari ecosystem area.

The National Commission on Agriculture on Wheat (1973) has given priority to the breeding of wheat varieties for saline and alkaline soils. As the specific saline resistant strains of wheat for Gujarat region are yet to be developed, this case study was undertaken. Suggestions were received to try some coastal saline resistant wheat varieties (Kharchi) but it did not seem plausible as the problems of estuarine environment are entirely different from those of coastal environments. Moreover, the salinity in Chokari saline ecozone varies in gradients. There is no uniform concentration of the salts in any field. The salinity values vary from patch to patch in a field (Richard, 1954). Due to these fluctuations in the edaphic status the estuarine ecosystems are dynamic and need 'reappraisal' of the optimization strategies time and again.

Studying the halophytic potential (eco-behaviour) as a step towards optimization in saline zones :

In the present case study following eco-behavioural aspects were studied to evaluate the halophytic potential of the four wheat varieties in saline ecozone of Chokari ecosystem area.

I. Germination behaviour
(including percentage mortality)

II. Morphological behaviour

III. Functional behaviour

IV. Growth behaviour.

The methodology is discussed in the Thesis Component I in the unit on 'Approaches used in the present work'.

<u>The importance of Germination and Seedling phenophases in saline ecozone studies</u> :

Of all the phenophases during the life cycle of a crop the two important phenophasic stages are the germination and the early growth of the cotyledon dependent radicle and plumule making the transition of germinated seed into the autophytic seedling. The process of germination is the cumulative process in which the contributing three growth phases are the phase of hydration, the phase of activated metabolism and the phase of interaction between the storage tissue and the growing neo-seedling. The process of germination on completion results into the initiation of the next phenophase that of seedling which is autophytic with primary structural attributes. During this phenophase, the seedling has to establish itself into the given environmental complex of edaphic and physical nature.

These two phenophasic stages of germination and establishment of the seedling are considerably sensitive to the soil salinity due to the various factors like the genetic potential of the species. Many research reports therefore deal with the adverse effect of edaphic salinity gradient on these two phenophases (Asana, 1950, Richard, 1954; Stragnov, 1964; Maliwal, 1967, 1968; Paliwal, 1968; Nahale, 1969; Kurian, 1971; Uprety, 1974).

These observations led the author to analyse and evaluate the halophytic potential of wheat varieties at the germination and seedling phenophases. The halophytic potential of a crop at seedling phenophase has been correlated to the yield performance (Uprety, 1973). Studies like those of Bernstein and Hayward (1958) and Richard (1954) reveal the fact that it is essential to thoroughly know the germination behaviour in the process of selection of a 'crop' for saline soils.

Experimental Results :

(a) Germination behaviour including percentage mortality :

(i) Salinity Gradient I

The field experiments in this salinity gradient showed quite a good percentage germination pattern at 5 cm depth. There was no appreciable difference between the varieties Sonalika and J-24. The variety Kalyansona performed slightly better than the former two. The variety J-40 showed maximum percentage of germination in this salinity gradient.

Nearly ten per cent decrease was observed in almost all the varieties at 10 cm depth. The varieties Sonalika, Kalyansona and J-24 did not show much variation in the germination count. The variety J-40 shows far greater reduction at 10 cm depth compared to the sowing depth of 5 cm its performance was observed to be better than rest of the three varieties.

The sowing at depth of 15 cm lowered the percentage germination to a much greater extent in all the three varieties other than J-40 as compared to the latter. The trend was comparable to that of reduction during the shift of depth from 5 cm to 10 cm in the three varieties viz. the Sonalika, the Kalyansona and J-24.The variety J-40 performed better at 15 cm depth showing about fifteen to twenty per cent increase in the germination count over the other three varieties. The minimum values are recorded for variety J-24 in all the three depth sowings.

(ii) Salinity Gradient II

In this salinity gradient, the adverse effect of increasing total soluble salts in the soil was observed. The germination percentage of all the varieties showed reduction. The highest percentage of germination was shown by the variety J-40 at all the three depths of sowing. There was no great difference observed in the trend of germination between the varieties Sonalika and J-24 in all the three depths of sowings. The variety Kalyansona performed slightly better compared to the Sonalika and J-24 only at the depth of 5 cm. It was observed that variety J-24 shows the minimum values compared to the other three varieties at all the three depths of sowings.

(iii) Salinity Gradient III

Salinity stresses in this zone considerably lower the percentage of germination. However, at depth 5 cm, great differences are not noted when compared with the salinity gradient II. The adverse effect of depth is however evident at depths 10 cm and 15 cm. The evaluation of the performance of the four varieties indicates similar trends as observed in the first two cases. From Germination pattern it was evident that the varieties Sonalika and J-24 were adversely affected while Kalyansona performed better to a certain extent. The variety J-40 though it shows considerable decrease in germination, it is quite tolerant at germination phenophase to the salinity of this gradient.

It is obvious from the germination pattern of the three salinity gradients that the percentage of germination is adversely affected by the increase in salinity of the edaphic layers.

The assessment of the performance of any individual variety was also indicative of the fact that increasing salinity reduced the germination percentage. The individual performance of the four varieties followed almost a similar trend except in the variety J-40 which showed slightly better performance at this phenostage (PLATE 49) (Table 40).

Percentage Seedling Mortality

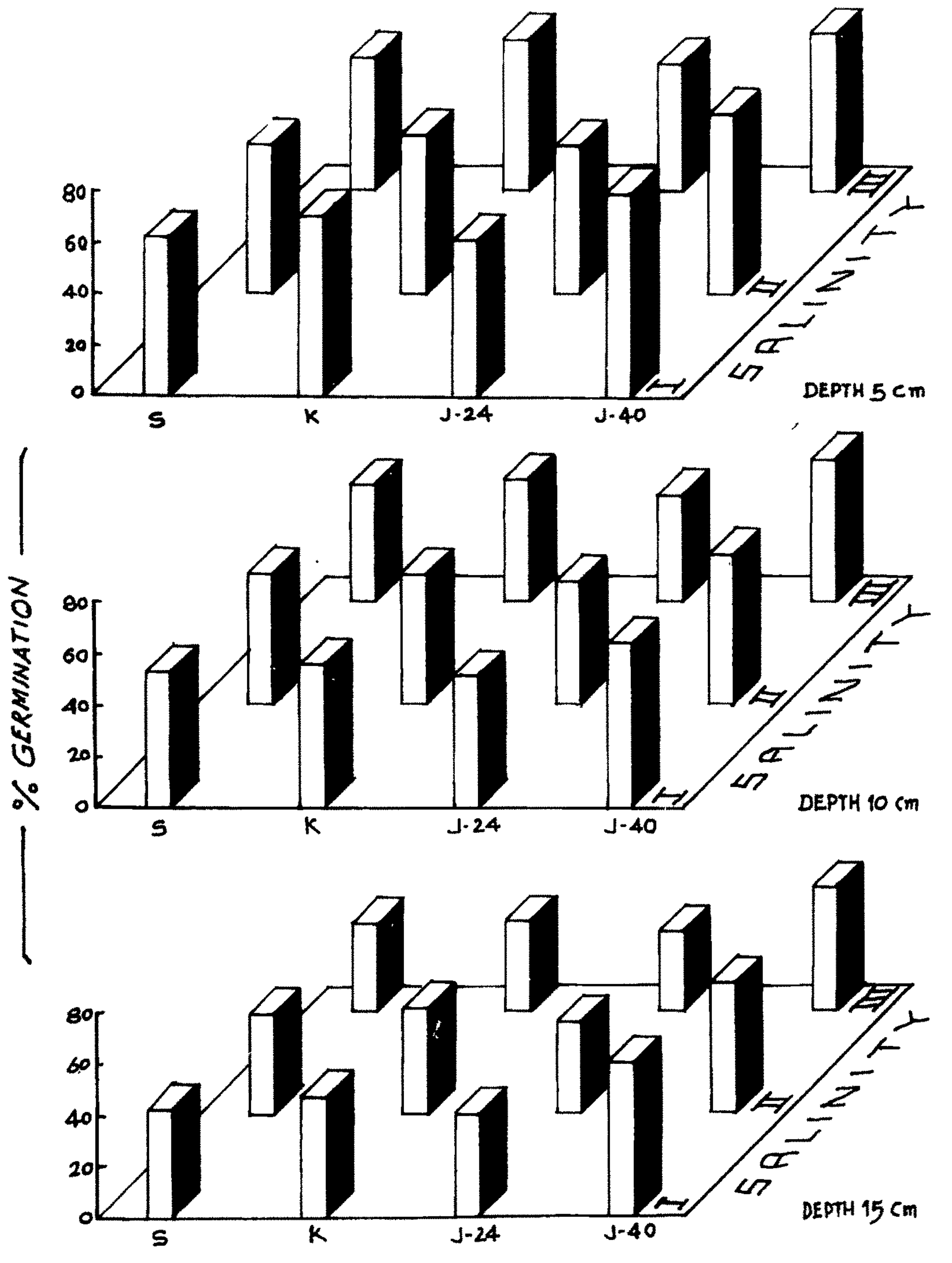
The determination of the percentage seedling mortality is a useful criterion in assessment of the response of the

Table 40 : Germination behaviour - Percentage of Germination.

	Depth (cm)	Sonalika	Kalyansona	J-24	J-40
	5	62.4	69.3	61.3	78.6
Salinity Gradient I	10	53.3	56.2	51.4	63.9
	15	42.3	47.4	40.2	60.2
	5	58.3	62.3	58.2	71.3
Salinity Gradient II	10	51.2	51.2	48.3	59.2
	15	39.3	41.2	36.3	51.2
	5	52.3	58.5	51.2	63.6
Salinity Gradient III	10	46.3	48.3	42.3	56.3
	15	34.5	35.6	31.3	48.2

(Significant at 1% level)

Plate - 49 : Germination response to the three salinity gradients at the three different depths of sowing.



GERMINATION BEHAVIOUR

PLATE-49

crop plant at seedling phenostage towards the salinity status of the edaphic environment. The germination response, though a useful criterion, has limited value for the germinated seeds may not be able to 'survive' the complex interplay of the physical and edaphic environmental factors.

The percentage seedling mortality was also determined to assess the effect of salinity on the four varieties of wheat. The varieties Kalyansona and Sonalika showed a similar trend in terms of percentage mortality of the seedlings. The variety J-24 was indicative of poor performance. The mortality in this variety was higher compared to the Sonalika and Kalyansona in all the three salinity gradients. The J-24 variety seems to be quite 'sensitive' to the salinity gradients at this phenophase. The least values for this parameter were obtained for the variety J-40. At this phenophase J-40 appears to be quite sturdy in tolerance of the salinity of the habitat.

The percentage mortality was studied only at 5 cm depth sowing as the adverse effects of other depths on the germination as noted in the earlier field experiments were too great to consider them for normal agronomic practice (PLATE 50) (Table 41).

(b) Morphological behaviour

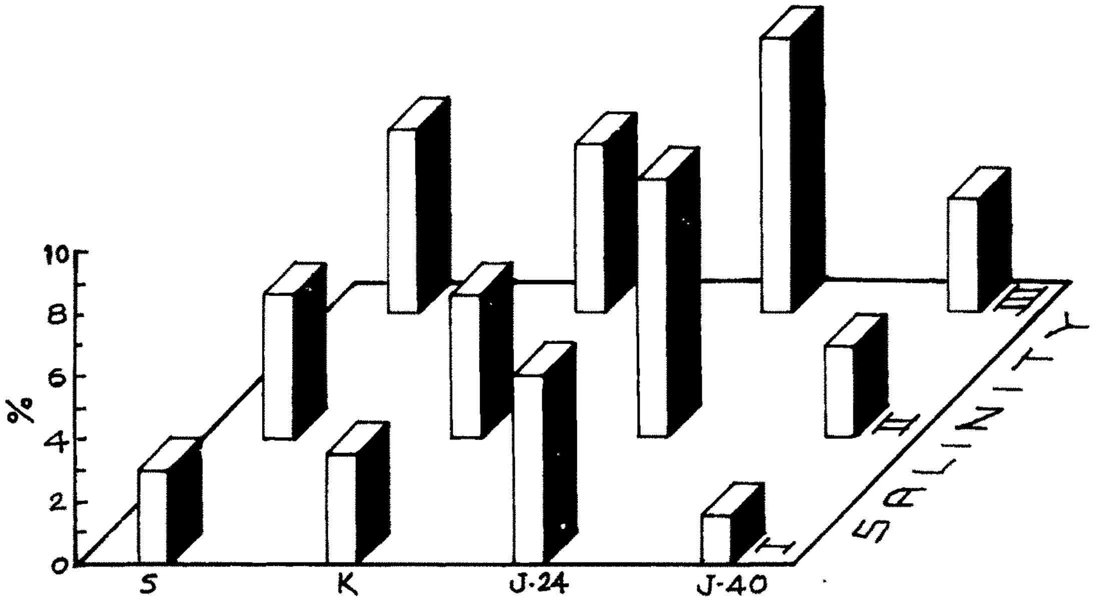
Morphological characteristics such as the length of root

Table 41 : Percentage of Seedling Mortality.

	Depth (cm)	Sonalika	Kalyansona	J-24	J-40
Salinity Gradient I	5	3.0	3.5	6.0	1.5
Salinity Gradient II	5	4.6	4.6	8.3	2.9
Salinity Gradient III	5	5.9	5.4	8.8	3.6

(Significant at 1% level)

Plate - 50 : Salinity influences on the seedling survival were determined on the four varieties by studying the percentage mortality.



% SEEDLING MORTALITY
(AT 5 cm DEPTH GERMINATION)

PLATE–50

and shoot, leaf area and the Ratio of Root to Shoot length are indirect manifestations of the growth activity being performed soon after the germination process is completed.

I. Root Length - Shoot Length :

(i) Salinity Gradient I.

Comparatively poor root growth was observed in all the four varieties. The root length at the ten day period of observation was slightly more compared to the second and third observation time. The difference in the root length of all the four varieties at ten, twenty and thirty day observation periods were not at all impressive. The overall root growth seems to be quite poor in all the varieties.

The shoot length however showed different pattern. The varieties Sonalika, Kalyansona, and J-40 showed similar trend at the ten day observation. At the twenty day observation period the varieties Kalyansona and J-40 increased in shoot length faster compared to Sonalika. During the third observation (thirty days) it was found that J-40 showed highest value for shoot length and Kalyansona came closer. Sonalika came third in root length and the variety J-24 had the least value of root as well as shoot length all throughout the observation period.

(ii) Salinity Gradient II.

The effects of salinity are visible on the root and shoot length in this gradient. There is not much difference in the length of the root. There is a slight amount of decrease in the value of observations made at thirty day period. The shoot suffered visible reduction in length in this salinity gradient. Comparisons of shoot lengths with those of shoot lengths of the salinity gradient I were evidently indicative of the relative decrease in the shoot length value at the higher level of salinity. The varieties Sonalika and J-24 showed considerable decrease in the length value compared to the Kalyansona and J-40. The performance of J-40 and Kalyansona was almost identical at this phenophase.

(iii) Salinity Gradient III.

Salinization effects of higher order of salinity level were seen on the root and shoot length of wheat varieties in this gradient. Compared to the lower salinity gradients there is a marked reduction in the length of the root as well as the shoot in all the varieties. The assessment indicated that Kalyansona which almost equalled J-40 in the root and shoot length at lower salinity could not keep up its performance at the salinity gradient III and Sonalika's performance at this higher salinity was a little better than

than Kalyansona and its values were parallel to those of Sonalika. J-24 was affected considerably by this salinity level. The variety J-40 gave consistently higher values compared to Kalyansona and Sonalika. The effect of higher salinity in reducing the length of the shoot and dwarfing the varieties was clear at this salinity gradient (PLATE 51) (Table 42).

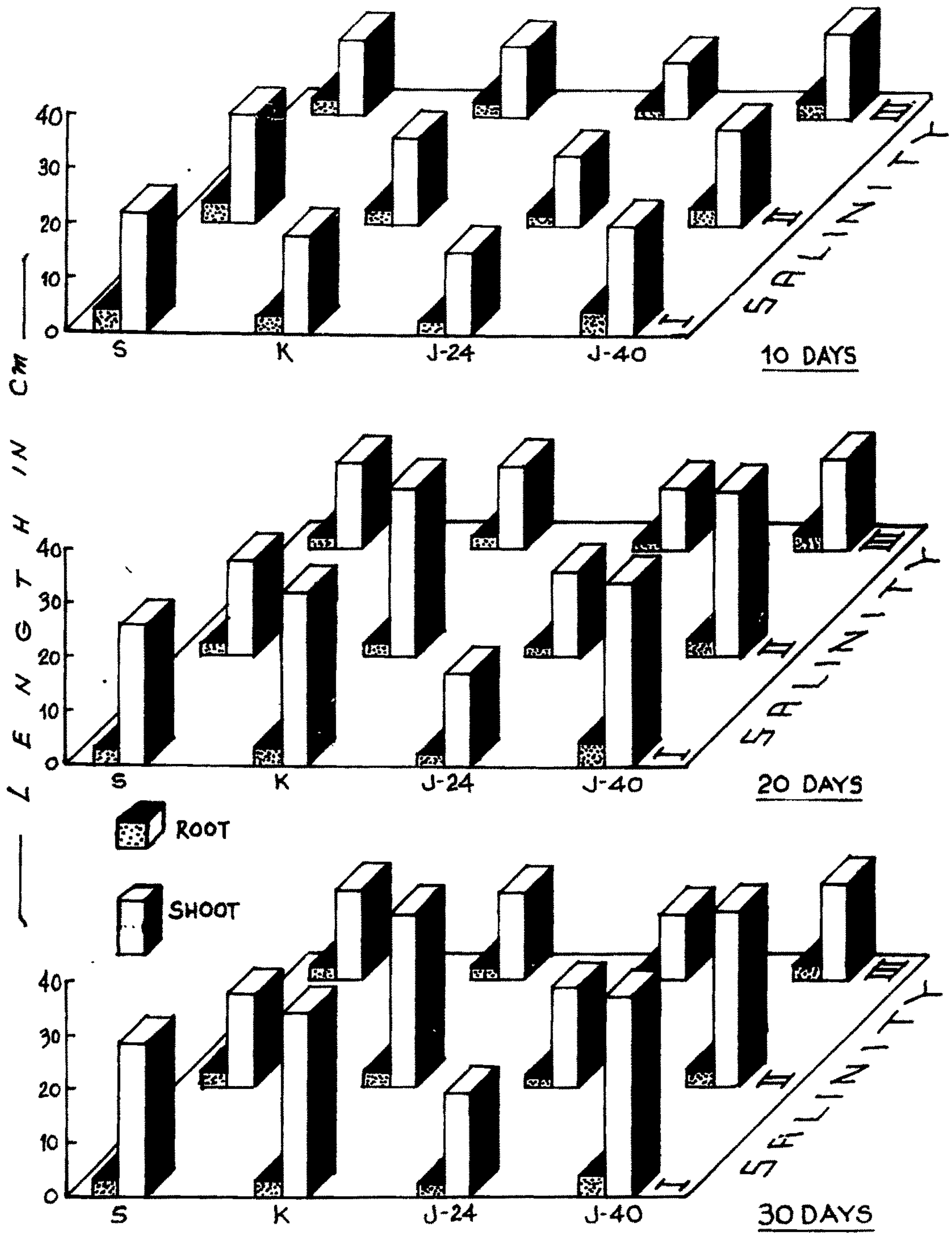
II. Root-Shoot Length Ratio :

There was no apparent deviation in the root-shoot length ratio in all the gradients of salinity and at almost all the three periods of observation. Fluctuations during twenty and thirty day periods were observed in J-40 and Kalyansona respectively in salinity gradient I, when shoot gained faster in length compared to the length of the root. Sonalika's bahaviour was comparable. J-24 had the poorest development of root and its shoot development was also slower. It, however, showed the same root/shoot ratio. Although the total length of root and shoot shows reduction in the salinity gradients II and III, the ratio remains nearly constant indicating the proportional compartmental increases in the two plant organs (Table 42).

Table 42 : Morphological behaviour. Root Length (RL) - Shoot Length (SL)- in cm.

	Days	Sonalika		Kalyansona		J-24		J-40	
		RL	SL	RL	SL	RL	SL	RL	SL
Salinity Gradient I	10	4.2	22.0	3.3	18.0	2.2	15.0	4.8	20.0
	20	3.5	26.3	3.2	32.0	2.1	17.0	4.3	34.0
	30	3.2	28.4	3.0	34.0	2.1	19.0	4.1	37.0
Salinity Gradient II	10	4.0	16.0	3.1	16.0	2.1	13.0	3.6	18.0
	20	3.3	18.0	2.9	31.6	2.1	16.0	3.4	31.0
	30	3.1	18.6	3.0	32.3	1.9	18.5	3.3	33.0
Salinity Gradient III	10	3.1	14.0	2.6	13.0	1.9	10.3	3.2	16.0
	20	2.7	16.0	2.5	15.3	1.7	11.6	3.1	17.2
	30	2.5	17.0	2.5	16.2	1.7	12.2	3.1	18.1

Plate - 51 : Variation in the root and shoot length in the three salinity gradients at the three growth periods (10, 20, 30 day period).



MORPHOLOGICAL BEHAVIOUR PATTERNS

PLATE-51

III. Leaf Area :

Leaf area is yet another morphological parameter which can serve as an indicator of the growth activity. It is the main surface for synthetic processes which are initiated by the solar flux incident upon this green area.

(i) Salinity Gradient I.

The experimental determination of leaf area showed increase in all the varieties from one growth phase to the other at this gradient of salinity. At 30 days the leaf area values (cm^2) were maximum for variety J-40 while Kalyansona fell next in the line. The values of variety J-24 at the thirty day period remained the lowest indicating the sensitivity of the plant at this level of salinity. In Kalyansona and Sonalika not much variation was found at all the periods of observation. The variety J-24 shows the same value to that of Sonalika at the twenty day growth period but later did not catch up and remained lower. J-40's performance was the best at this salinity level.

(ii) Salinity Gradient II.

It was very obvious that the higher salinity gradient had affected the size of the leaf and there were reductions in the leaf area of all the four varieties in this saline zone. The data indicated a slight increase in the leaf area from one growth period to the other. This increase was marginal in the case of J-24. Sonalika was not much superior. Kalyansona, however, performed a little better than these two varieties. From the data pattern it was clear that the variety J-40 showed higher values of the leaf area under the conditions compared to those of other three varieties.

(iii) Salinity Gradient III.

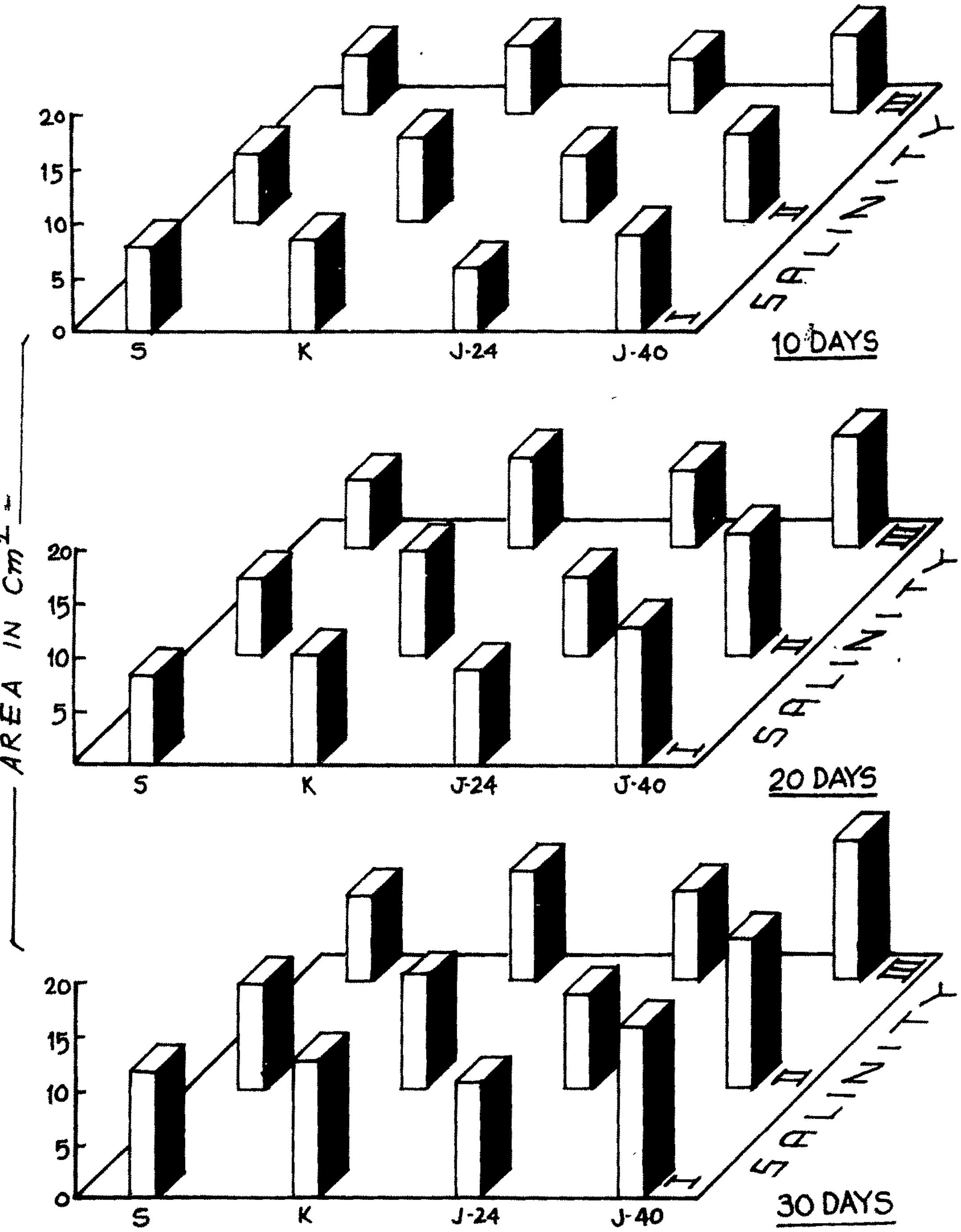
The varieties Sonalika, and J-24 were very much adversely affected at this salinity gradient. J-24 was, however, slightly more tolerant to salinity at this level than Sonalika. All varieties showed a trend towards reduction yet Sonalika and J-24 varieties were affected to a much greater extent than the other two varieties. It was noted that the J-40 kept up its superior performance even at this highest salinity gradient.

The evaluation of the data on leaf area at all the three salinity levels does show the decreasing trend but it was clearly seen that of all the varieties investigated J-40 maintained the upper values in all the three salinity gradients (PLATE 52) (Table 43).

Table 43 : Leaf area (cm^2).

	Days	Sonalika	Kalyansona	J-24	J-40
Salinity Gradient I	10	7.8	8.4	6.9	8.9
	20	8.2	10.1	8.8	12.6
	30	11.6	12.6	10.6	15.6
Salinity Gradient II	10	6.6	7.8	6.1	8.1
	20	7.1	9.8	7.3	11.3
	30	9.7	11.1	8.9	13.7
Salinity Gradient III	10	5.9	6.4	5.1	7.2
	20	6.3	8.3	7.1	10.3
	30	7.9	10.1	8.3	12.9

Plate - 52 : Changes in the leaf area due to salinity gradients at 10, 20, 30 day periods of growth.



LEAF AREA PATTERNS

PLATE-52

(c) Functional Behaviour :

I. Phytomass Production (Total and Compartmental)

Phytomass production is the outcome of various integrated physiologicalp processes of the plant and is dependent upon the assimilatory surfaces as well as processes. Phytomass measurements give an idea of the net sum total of dry matter accumulated at a given interval or within a given period.

(i) Salinity Gradient I.

The experimental determination of the phytomass (total and compartmental) as a measure of overall growth performance indicated the highest accumulation values for the variety J-40. Kalyansona came next but it showed only marginal increase over the other two varieties. J-40 was far superior in performance to all the other varieties.

The phytomass accumulation pattern from the ten day growth period to the subsequent growth periods showed but slight variation in all varieties except that there was remarkable increase in the case of J-40 from second to the third growth period.

The root phytomass contributed somewhere between eight to eleven per cent in the case of Sonalika and between eight to ten per cent in the case of J-24. In the case of Kalyansona the root phytomass contribution was of the order of thirteen per cent as highest value. The variety J-40 showed the increasing values over Kalyansona and the root phytomass contribution values ranged from eight to fourteen per cent in this salinity gradient. However, it was marked with interest that the percentage contribution of root phytomass showed a decreasing trend from one growth period to the other while the percentage contribution of shoot showed an increasing though extremely marginal trend in this gradient.

(ii) Salinity Gradient II.

The data clearly indicated the lower values for total as well as the compartmental phytomass of all the varieties with increase in salinity. The adverse effect of salinity at this gradient was evidently noticed in all varieties. Like the results obtained for the other growth parameters at this saline gradient the values of phytomass of variety J-40 were higher compared to the other three varieties though reduction was evident at the higher salinity level.

The compartmental phytomass values for the root and shoot both followed the same trend as shown in the salinity gradient I. It was seen that the values of percentage contribution were slightly higher in the case of root compared to the gradient I though the total values for phytomass were comparatively lower. The root phytomass contribution in all the varieties ranged from nine per cent to twelve per cent. The highest per cent contribution value was noted for the variety J-40 at the first growth phase period.

(iii) Salinity Gradient III.

The varieties Kalyansona, Sonalika and J-24 were markedly affected due to salinization at this gradient. All these varieties show values for phytomass which quite lower compared to J-40. The variety J-24 showed the minimal level of values for phytomass. The variety Kalyansona performed comparatively better than Sonalika and J-24 but J-40 was way ahead in terms of absolute biomass. The variety J-40 again was observed to have maximum values at all the three periods of growth than rest of the three varieties.

The shoot phytomass contribution did not markedly differ from that of the saline gradient II or even I. The root phytomass contribution however showed fluctuations. Though it was certainly found that the trend of the percentage contribution remained more or less similar in the case of all the varieties and in all the three salinity gradients (PLATES 53, 54, 55) (Tables 44, 45).

II. Root and Shoot Phytomass Ratio.

The phytomass root and shoot ratio was calculated and it was found that no significant variation in the ratio occurred at all the gradients of salinity for the best variety J-40. In case of the poorest variety J-24 the root-shoot ratio showed a decreasing trend with increasing salinity.

III. Net Primary Productivity.

The success of any variety depends upon the efficiency of producing and accumulating the dry matter. The rate at which this is done gives an idea of the efficiency of the plant species to survive in the habitat complex.

(i) Salinity Gradient I.

Net Primary Productivity data of this salinity level did not show any significant variation for the first growth phase (10-20 day period) for the varieties except the variety J-24 for which the productivity values were lower than the rest. The data for the second growth phase (20-30 day period) showed a decrease in production rate by as much as fifty per cent.

Table 44 : Compartmental and Total Phytomass (mg $plant^{-1}$)

	Days	Sonalika			Kalyansona			J-24			J-40		
		R	S	T	R	S	T	R	S	T	R	S	T
Salinity Gradient I	10	4.1	31.2	35.3	6.0	39.3	45.3	3.1	28.1	31.2	7.9	48.3	56.2
	20	7.2	69.3	76.5	8.8	78.3	87.1	5.9	58.2	64.1	8.8	89.1	97.9
	30	8.3	88.2	96.5	10.1	98.4	108.5	6.8	79.1	85.9	12.6	136.4	149.0
Salinity Gradient II	10	3.2	22.2	25.4	4.1	28.2	32.3	2.7	18.3	21.0	6.2	39.3	45.5
	20	5.6	47.2	52.8	7.1	59.1	66.2	4.6	31.2	35.8	7.9	62.1	70.0
	30	6.2	69.3	75.5	8.3	77.2	85.5	6.1	53.2	59.3	10.3	103.2	113.5
Salinity Gradient III	10	3.0	19.1	22.1	3.5	23.3	26.8	2.5	15.2	17.7	5.6	32.2	37.8
	20	4.9	28.2	33.1	5.9	36.3	42.2	3.8	29.3	33.1	7.3	56.1	63.4
	30	5.6	39.3	44.9	6.2	53.1	59.3	4.9	36.1	41.0	9.4	93.5	102.9

R = Root Phytomass
S = Shoot Phytomass
T = Total Phytomass

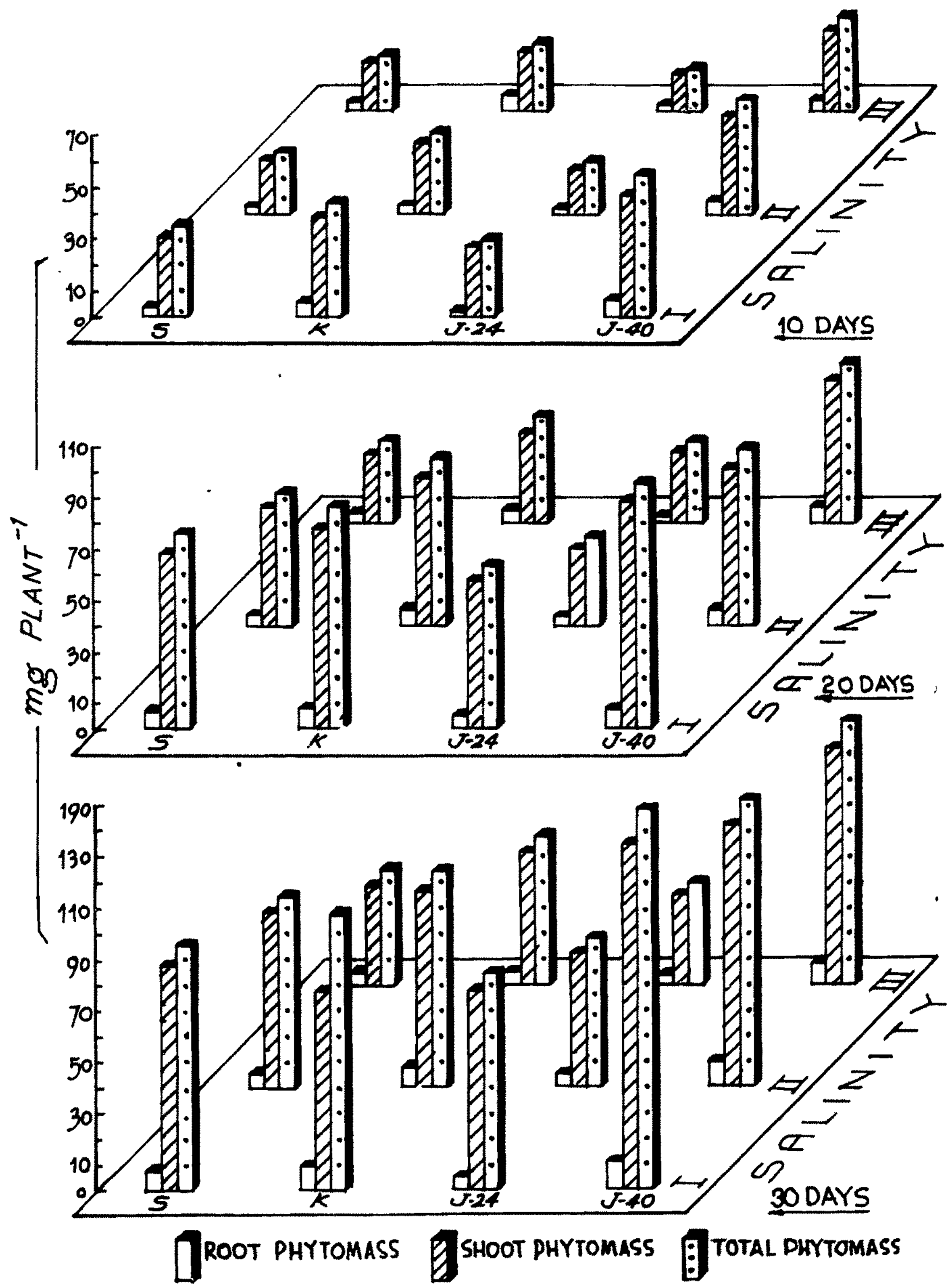
Table 45 : Percentage Contribution of Root and Shoot Compartment Phytomass.

	Days	Sonalika		Kalyansona		J-24		J-40	
		R	S	R	S	R	S	R	S
Salinity Gradient I	10	11.6	88.3	13.2	86.7	9.9	90.0	14.0	85.9
	20	9.4	90.5	10.1	89.8	9.2	90.7	8.9	91.0
	30	8.6	91.3	9.3	90.6	7.9	92.0	8.4	92.0
Salinity Gradient II	10	12.5	87.4	12.6	87.3	12.8	87.1	13.6	86.3
	20	10.6	89.3	10.7	89.2	12.8	87.1	11.2	88.7
	30	8.2	91.7	9.7	90.2	10.2	89.7	9.1	90.9
Salinity Gradient III	10	13.5	86.4	13.0	86.9	14.1	85.8	14.8	85.4
	20	14.8	85.1	13.9	86.0	11.4	88.5	11.5	88.4
	30	12.4	87.5	10.4	89.5	11.9	88.0	9.1	90.8

R = Root Compartment

S = Shoot Compartment

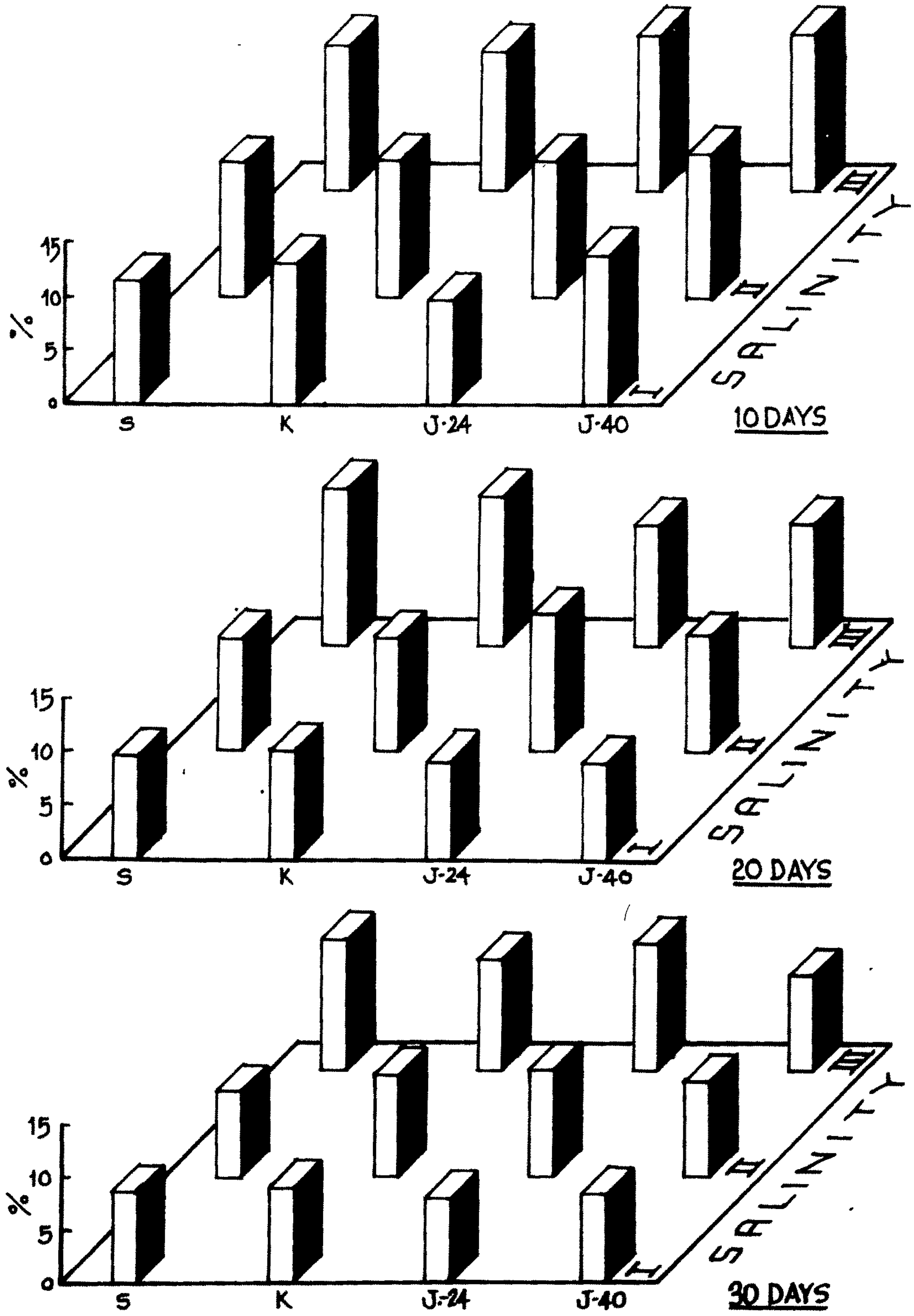
Plate - 53 : Phytomass (total and compartmental) accumulation trends in the four varieties in the three salinity gradients at 10, 20 and 30 day growth period.



COMPARTMENTAL & TOTAL PHYTOMASS (mg PLANT^{-1})

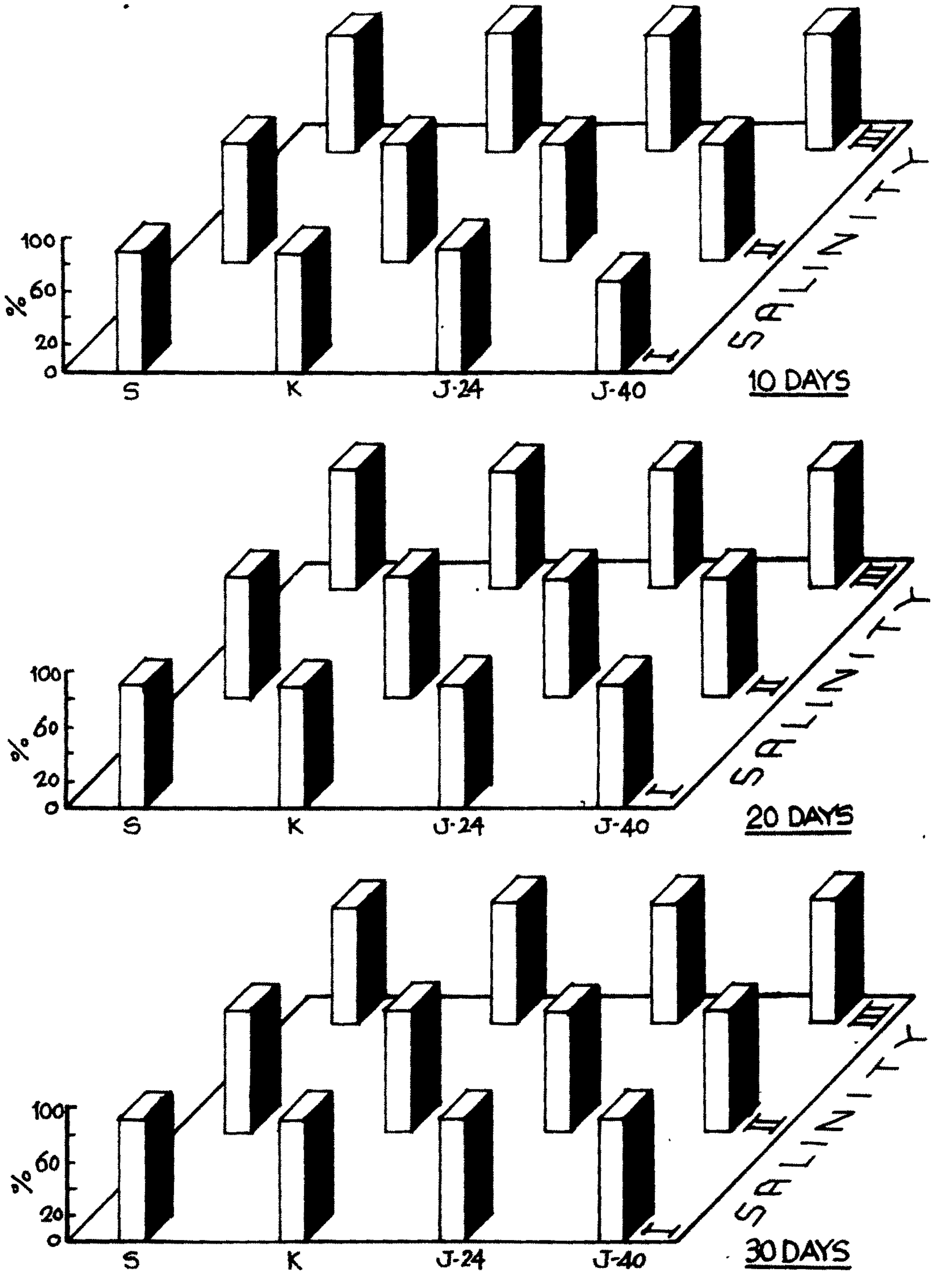
PLATE-53

Plate - 54 : Determination of the percentage of compartmental (Root) contribution to the total phytomass of the four varieties at the three growth periods.



% CONTRIBUTION OF ROOT PHYTOMASS PLATE-54

Plate - 55 : Determination of the percentage of compartmental (Shoot) contribution to the total phytomass of the four varieties at the three growth periods.



% CONTRIBUTION OF SHOOT PHYTOMASS PLATE-55

The efficiency of production decreased uniformly for all the varieties except the variety J-40 which exhibited a quite contrary anamolous behaviour to this general trend seen in the other three varieties. In this variety the values showed increase in the net productivity. The compartmental production viz. the net root productivity and the net shoot productivity followed the similar pattern as stated above.

(ii) Salinity Gradient II.

The effect of salinity on the production values was evident. The productivity values decreased for all the four varieties yet the temporal fluctuations were found. In the first growth phase the variety Kalyansona was found to show higher (3.5) value compared to the other three varieties and the variety J-24 showed the lowest value (1.5). The values for J-40 and Sonalika were found to be comparable (2.5 and 2.7 respectively). During the second growth phase the net productivity of Sonalika and Kalyansona showed reduction. J-40 and J-24 showed increased net productivity in the second growth period (20-30 days), but even at the increased rate J-24 could not attain the net productivity showed by other three varieties in the first period (10-20 days). J-40 showed the maximum increase in the net productivity during the second period; it exceeded the value for the first period by over 75% of the initial value.

The compartmental root and shoot production showed some variations in the two growth phases. While it was found that the values of root production decreased in the second growth phase compared to those of the first growth phase in the three varieties except the J-40. The shoot production of J-40 andJ-24 in the second growth phase increased while that of the other varieties decreased as per the trend.

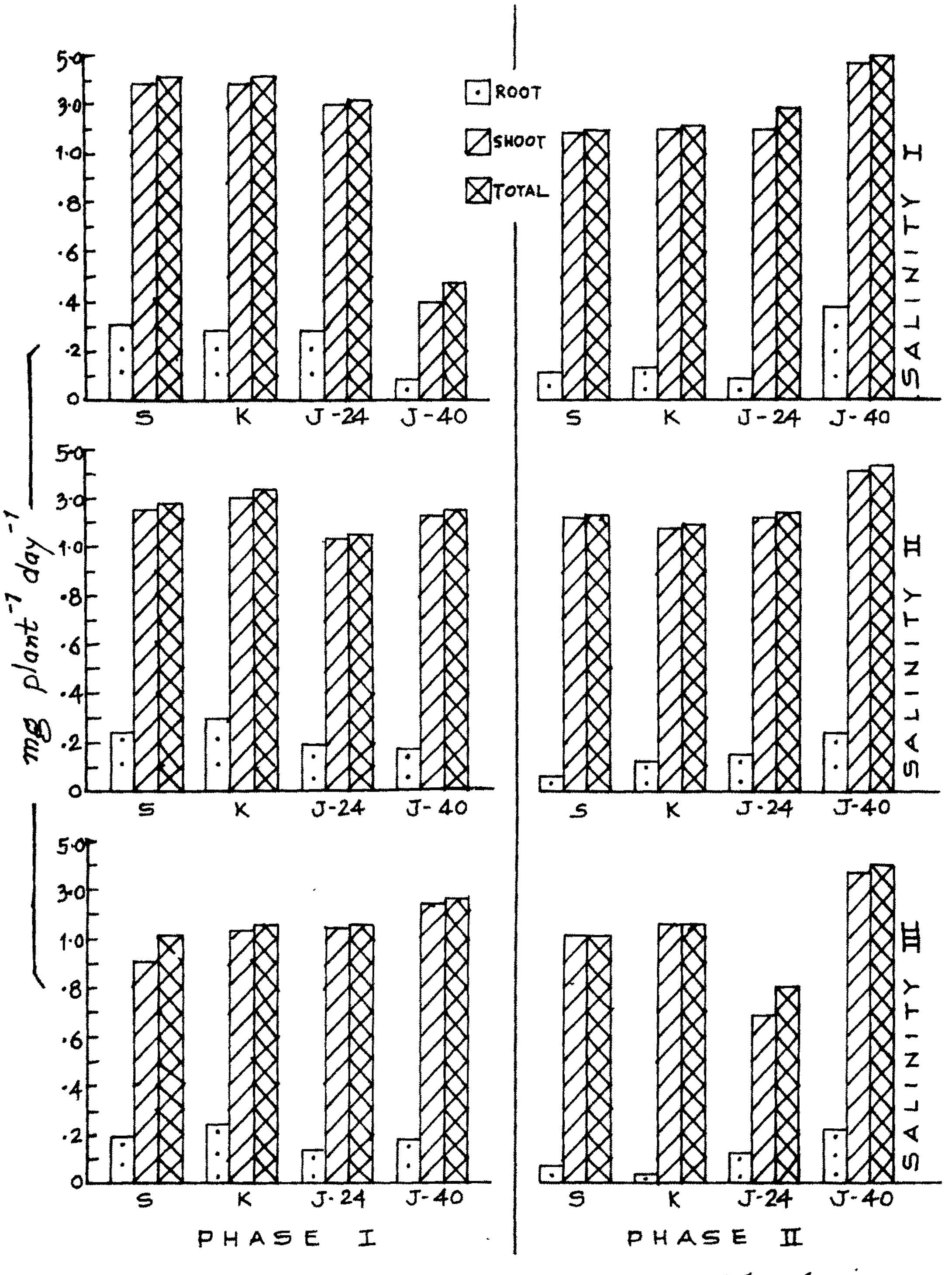
(iii) Salinity Gradient III.

In this salinity gradient the productivity was evidently reduced to a much lower level compared to the gradient I and II. The worst affected variety was J-24 wherein it was found that the net productivity in the second growth period was lowered. Sonalika and Kalyansona did not show any increase in net productivity in the second observation period, though they maintained the initial rate unlike J-24. J-40, however, showed a marked increase in net productivity in the second period (by over 75% over the initial period). The J-40 variety had the highest production value and this value was not much different from that for the salinity gradient II. It was found that J-40 always showed an increased net productivity during the second growth observation period at all the three salinity gradients (PLATE 56) (Table 46).

Table 46 : Net Primary Productivity (mg $plant^{-1}$ day^{-1})

	Growth phase	Sonalika			Kalyansona			J-24			J-40		
		R	S	T	R	S	T	R	S	T	R	S	T
Salinity Gradient I	I	0.31	3.8	4.1	0.28	3.9	4.1	0.28	3.0	3.2	0.09	4.0	4.09
	II	0.11	1.9	2.0	0.13	2.0	2.1	0.09	2.0	2.09	0.38	4.7	5.0
Salinity Gradient II	I	0.24	2.5	2.74	0.30	3.0	3.3	0.19	1.3	1.5	0.17	2.3	2.5
	II	0.06	2.2	2.31	0.12	1.8	1.9	0.15	2.2	2.4	0.24	4.1	4.3
Salinity Gradient III	I	0.19	0.91	1.1	0.24	1.3	1.5	0.13	1.4	1.5	0.17	2.4	2.6
	II	0.07	1.1	1.1	0.03	1.6	1.6	0.11	0.68	0.80	0.21	3.7	4.0

Plate - 56 : Functional performance of the four varieties in the salinity gradients in terms of the net primary productivity.



NET PRIMARY PRODUCTIVITY (mg plant^{-1} day^{-1})

PLATE-56

IV. Moisture structure.

The moisture structure was determined for all the four varieties and it was found that no great difference occurred in this parameter during the ten day and twenty day growth period in the salinity gradients I and II. However, slight reduction was found at the thirty day growth period in Sonalika and J-24 in salinity gradient III. The varieties J-40 and Kalyansona showed slight increase in the values (PLATE 57) (Table 47).

(d) Growth behaviour :

Growth is a biological phenomenon and is exhibited by structural changes and dry matter accumulation which involves fixation of energy and its storage in the organism. Growth behaviour depends upon the environmental factors as well as the internal set up of the plants which require habitat viability for optimal growth and development. Growth analysis presents the first step in the analysis of primary production being a link between merely recording plant production and analyzing it by means of physiological methods (Kvet, et al., 1971), NAR, LAR, RGR, LWR are some of the important growth analysis parameters by which production processes can be studied in the field conditions (Watson, 1952). A mathematical

Table 47 : Percentage of Moisture Content

	Days	Sonalika	Kalyansona	J-24	J-40
Salinity Gradient I	10	78	72	74	76
	20	82	76	77	79
	30	79	81	80.5	82
Salinity Gradient II	10	71	70.3	73	73
	20	74	73	78	77
	30	76	77	81	82
Salinity Gradient III	10	71	70	75	78
	20	76	78	77	80
	30	72	81	79	83

Plate - 57 : Comparative Moisture Content Structure in the four varieties in the three salinity gradients.

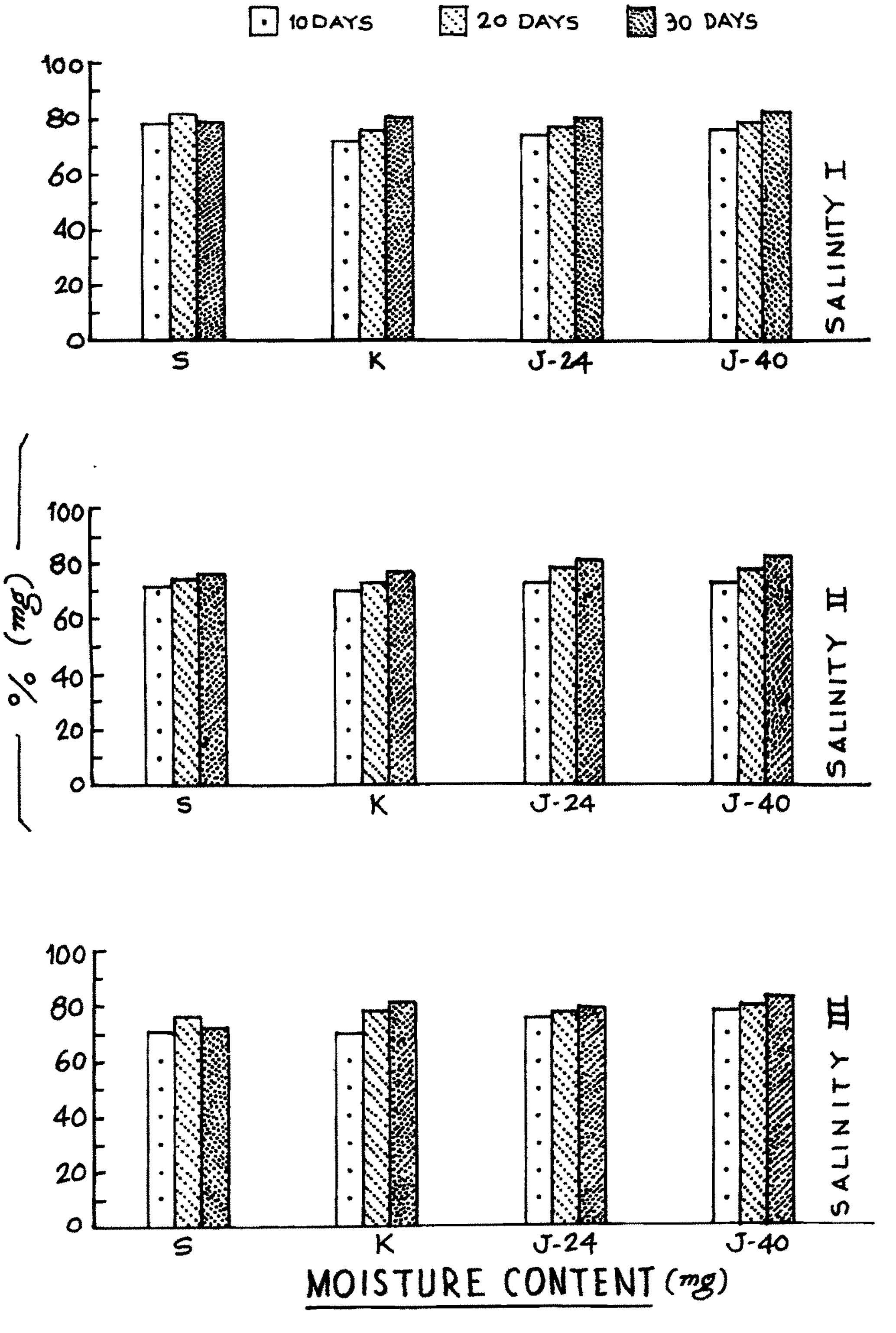

10 DAYS
20 DAYS
30 DAYS
SALINITY I
SALINITY II
SALINITY III
% (mg)
100
80
60
40
20
0
S
K
J-24
J-40
MOISTURE CONTENT (mg)

PLATE-57

correlation of RGR, NAR and LAR was established by Brigss *et al*. (1920) viz. RGR = NAR x LAR. While NAR is an index of physiological activity and is directly dependent on respiration and photosynthesis (Gregory, 1917), LAR is index ofm morphological activity. Effects on the growth rate can be interpreted either directly through RGR which is a measure of production efficiency or indirectly in terms of its components. Since many factors have opposite effects on NAR the final effect on RGR reflects the interaction of the two effects.

With this background in view the results of growth analysis are presented here :

I. RGR (Relative Growth Rate)

(i) Salinity Gradient I.

(a) Growth Phase I (10-20 day period)

The performance of Sonalika and J-24 was similar and slightly better compared to the Kalyansona and J-40. The varieties Sonalika and J-24 showed values slightly higher than those of Kalyansona and J-40. The values of RGR for root compartment were lower for variety J-40 while the those of Sonalika and J-24 were comparatively higher with Kalyansona falling next in the line.

Similar trend in the RGR values of shoot was also recorded in this growth phase.

(b) Growth Phase II (20-30 day period)

The variety J-40 performed much better compared to the other three varieties in this growth phase. The values for Sonalika, Kalyansona and J-24 were almost identical in this phase. J-40 showed the highest values for RGR.

The root compartment values for RGR in this growth phase showed the same trend. The J-40 variety showed the highest values while the values for Sonalika, Kalyansona and J-24 were identical.

Similar performance of J-40 was recorded in the shoot values also. The variety J-40 showed superior performance in the second growth phase.

(ii) Salinity Gradient II.

(a) Growth Phase I.

The varieties Sonalika and Kalyansona were found to perform better compared to the J-24 and J-40.

The root compartment values in this growth phase were almost identical for Sonalika, Kalyansona and J-24. The J-40 showed lower value in this growth phase.

The shoot compartment showed the similar trend in this growth phase.

(b) Growth Phase II.

The relative growth rate values for the varieties J-24 and J-40 were comparable but were higher than those of Sonalika and Kalyansona.

Similar trend was also indicated by the root and shoot compartment values.

(iii) Salinity Gradient III.

(a) Growth Phase I.

The values for the Sonalika and Kalyansona were lower compared to the J-24 and J-40. The highest values were recorded for variety J-40 in this phase.

The root values were higher for the Kalyansona and Sonalika with J-24 and J-40 falling next in the line respectively.

In the case of shoot, the J-24 showed better performance compared to the three varieties with J-40 being the next to the J-24 (PLATES 58, 59 and 60) (Table 48).

Table 48 : Relative Growth Rate (RGR)* – for Root and Shoot Compartments and the total.

	Growth Phase	Sonalika			Kalyansona			J-24			J-40		
		R	S	T	R	S	T	R	S	T	R	S	T
Salinity Gradient I	I	0.05	0.07	0.07	0.03	0.06	0.06	0.06	0.07	0.07	0.01	0.06	0.05
	II	0.01	0.02	0.02	0.01	0.02	0.02	0.01	0.03	0.02	0.03	0.04	0.04
Salinity Gradient II	I	0.05	0.07	0.07	0.05	0.07	0.07	0.05	0.05	0.05	0.02	0.04	0.04
	II	0.01	0.03	0.03	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.05	0.04
Salinity Gradient III	I	0.04	0.03	0.04	0.05	0.04	0.05	0.04	0.05	0.05	0.02	0.05	0.05
	II	0.01	0.03	0.03	0.01	0.03	0.03	0.02	0.02	0.02	0.03	0.05	0.04

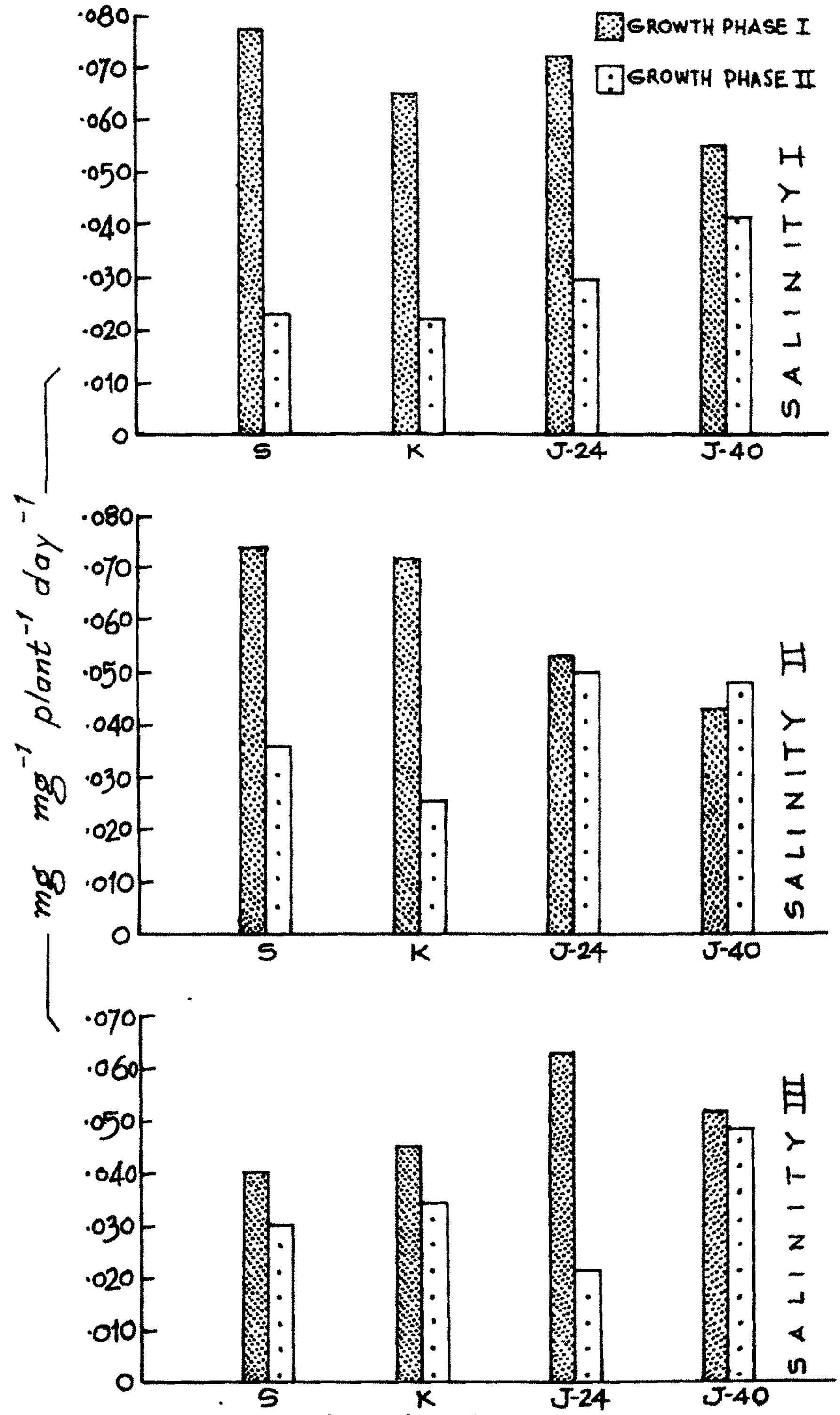
R = Root Compartment

S = Shoot Compartment

T = Total RGR for whole plant.

* mg mg^{-1} $plant^{-1}$ day^{-1}

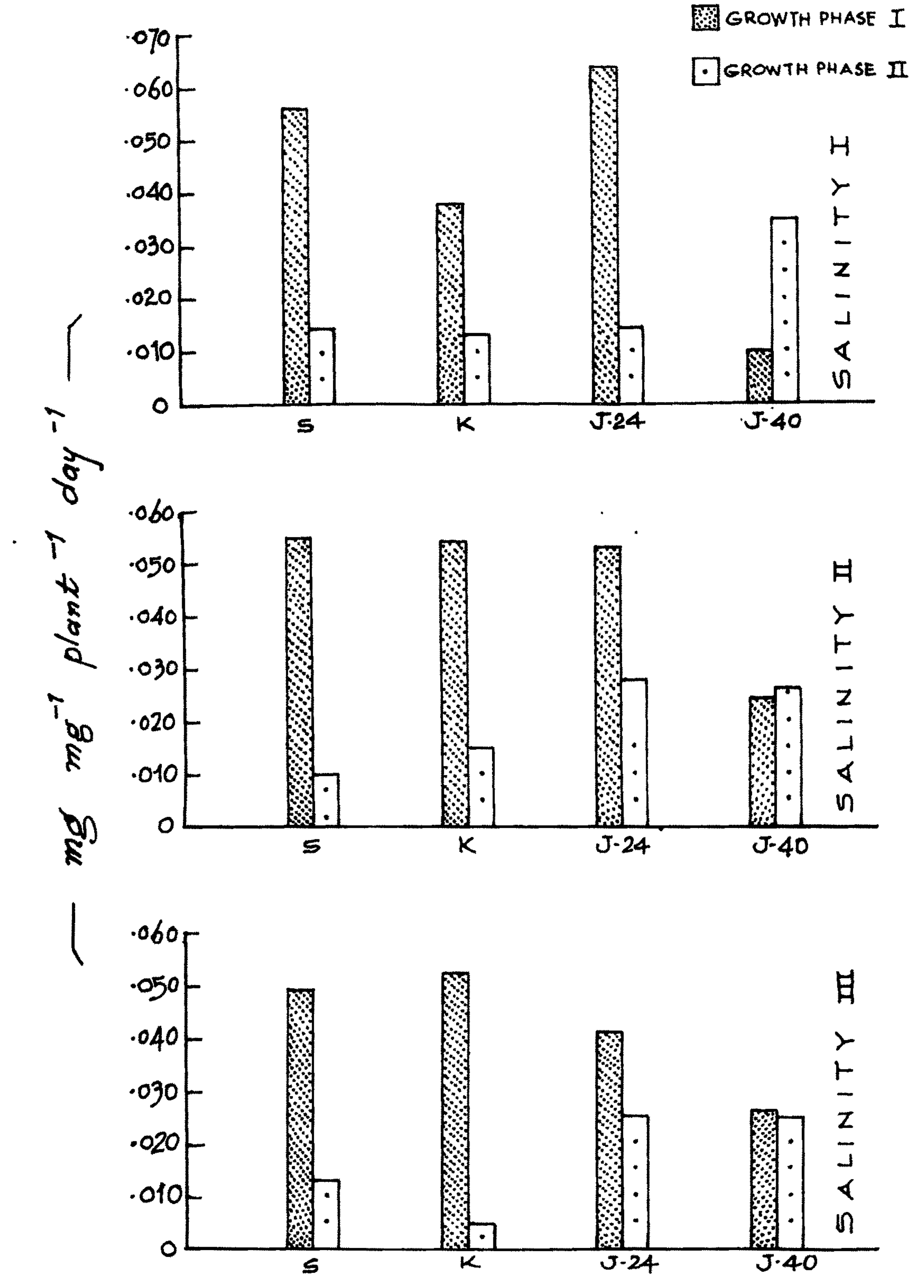
Plate - 58 : Relative Growth Rate (RGR) of the whole plant as affected by the salinity gradients. Comparison of the growth phase I and II is presented.



RGR (mg mg-1 plant-1 day-1)– WHOLE PLANT

PLATE-58

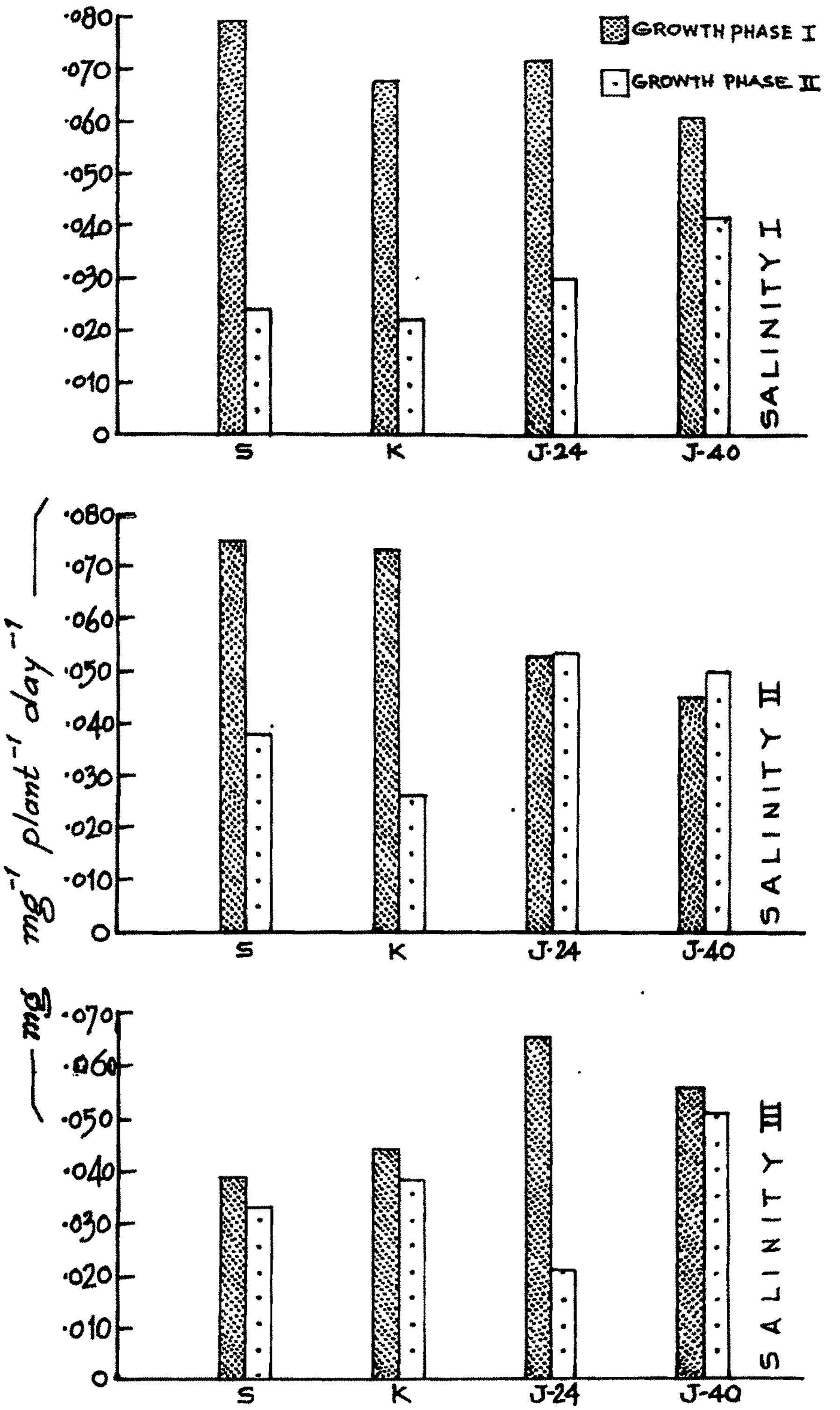
Plate - 59 : Root RGR in the growth phase I and II
showing variation in response to salinity.



RGR (mg mg⁻¹ plant⁻¹ day⁻¹) – ROOT COMPARTMENT

PLATE-59

Plate - 60 : Shoot RGR in the growth phase I and II showing variation in response to salinity.



RGR (mg mg^{-1} plant^{-1} day^{-1}) – SHOOT COMPARTMENT

PLATE–60

(b) Growth Phase II.

The variety J-40 superseded the rest three varieties in this growth phase and was the values were comparatively higher. The variety J-24 lagged behind comparatively. Even Sonalika and Kalyansona showed higher values for RGR than those of J-24 in this growth phase.

II. NAR (Net Assimilation Rate)

(i) Salinity Gradient I.

(a) Growth Phase I.

The net assimilation rate values were slightly higher for Sonalika while the Kalyansona, J-24 and J-40 showed decreasing trend compared to sonalika.

The root compartment values indicated the lowest performance of J-40. Sonalika, Kalyansona and J-24 remained almost identical.

Shoot compartment did not show much variation in the NAR values in this growth phase.

(b) Growth Phase II.

J-40 variety showed the highest values in this growth phase. The rest three varieties were slightly lower compared to J-40.

Similar trend was indicated by the root as well as shoot values. The superior performance of J-40 as a whole was noted in this growth phase.

(ii) Salinity Gradient II.

(a) Growth Phase I.

The varieties Sonalika and Kalyansona were identical and both of them showed higher values compared to J-24 and J-40. J-24 was very slightly lower in the value compared to J-40.

The same trend of values was found for both the shoot compartments. In the case of root compartment, J-40 showed minimum value

(b) Growth Phase II.

In this growth phase, the variety Kalyansona showed the lowest value. The performance of Sonalika and J-24 was comparable. The variety J-40 remained superior to the rest in this phase.

In the case of root compartment, J-40 and J-24 performed equally well while Sonalika and Kalyansona showed lower values.

The shoot compartment showed higher values for J-40 with J-24 and Sonalika coming next to it. The value for Kalyansona was comparatively low.

(iii) Salinity Gradient III.

(a) Growth Phase I.

In this gradient and the growth phase, J-40 performed better than the other three varieties. Sonalika and Kalyansona were almost comparable and J-24 showed marginal increase in the value.

Root compartment values indicated that Sonalika and Kalyansona roots performed better than those of J-24 and J-40 in this growth phase.

The shoot NAR was the highest in J-40. J-24 was slightly lower compared to J-40 but was marginally better compared to J-40 but was marginally better compared to Sonalika and Kalyansona. Both Sonalika and Kalyansona were identical.

(b) Growth Phase II.

J-40's performance was the best in this growth phase. The performance of Sonalika and Kalyansona was parallel but the value for J-24 was low comparatively.

The root compartment of Kalyansona showed the lowest value. J-24 and Sonalika showed similar performance. The highest value was of J-40 in this case.

The performance of J-24 shoot was the poorest. Sonalika and Kalyansona shoot values were comparable. J-40, however, maintained the highest shoot value record in this growth phase. (PLATES 61, 62 and 63) (Table 49).

IV. LAR (Leaf Area Ratio)

(a) Growth Phase I.

The varieties Sonalika, Kalyansona, and J-40 showed similar values. J-24 showed slight increase in the value.This trend was found in all the three gradients of salinity. The values of salinity gradients I and II did not show much variations. In the salinity gradient III the values were slightly lower.

(b) Growth Phase II.

The trend was comparable to that of first growth phase withJ-24 showing slightly increased value compared to the other three varieties. The trend was similar but the values in this growth phase were found to be comparatively lower than those of Growth Phase I (PLATE 64) (Table 50).

IV. a) SWR (Shoot Weight Ratio)

The shoot weight ratio values for, 10, 20 and 30 day period were found to remain similar in all the three salinity gradients.

Table : 49. Net Assimilation Rate (NAR)* - for Root and Shoot Compartments and the total.

	Growth Phase	Sonalika			Kalyansona			J-24			J-40		
		R	S	T	R	S	T	R	S	T	R	S	T
Salinity Gradient I	I	0.03	0.4	0.5	0.03	0.4	0.4	0.03	0.4	0.4	0.01	0.4	0.3
	II	0.01	0.2	0.2	0.01	0.2	0.2	0.01	0.2	0.2	0.02	0.3	0.4
Salinity Gradient II	I	0.03	0.3	0.4	0.03	0.3	0.4	0.02	0.2	0.2	0.02	0.2	0.3
	II	0.01	0.2	0.2	0.01	0.2	0.2	0.02	0.2	0.3	0.02	0.3	0.3
Salinity Gradient III	I	0.03	0.1	0.2	0.03	0.2	0.2	0.02	0.2	0.2	0.02	0.3	0.3
	II	0.01	0.1	0.2	0.003	0.2	0.2	0.01	0.08	0.1	0.02	0.3	0.3

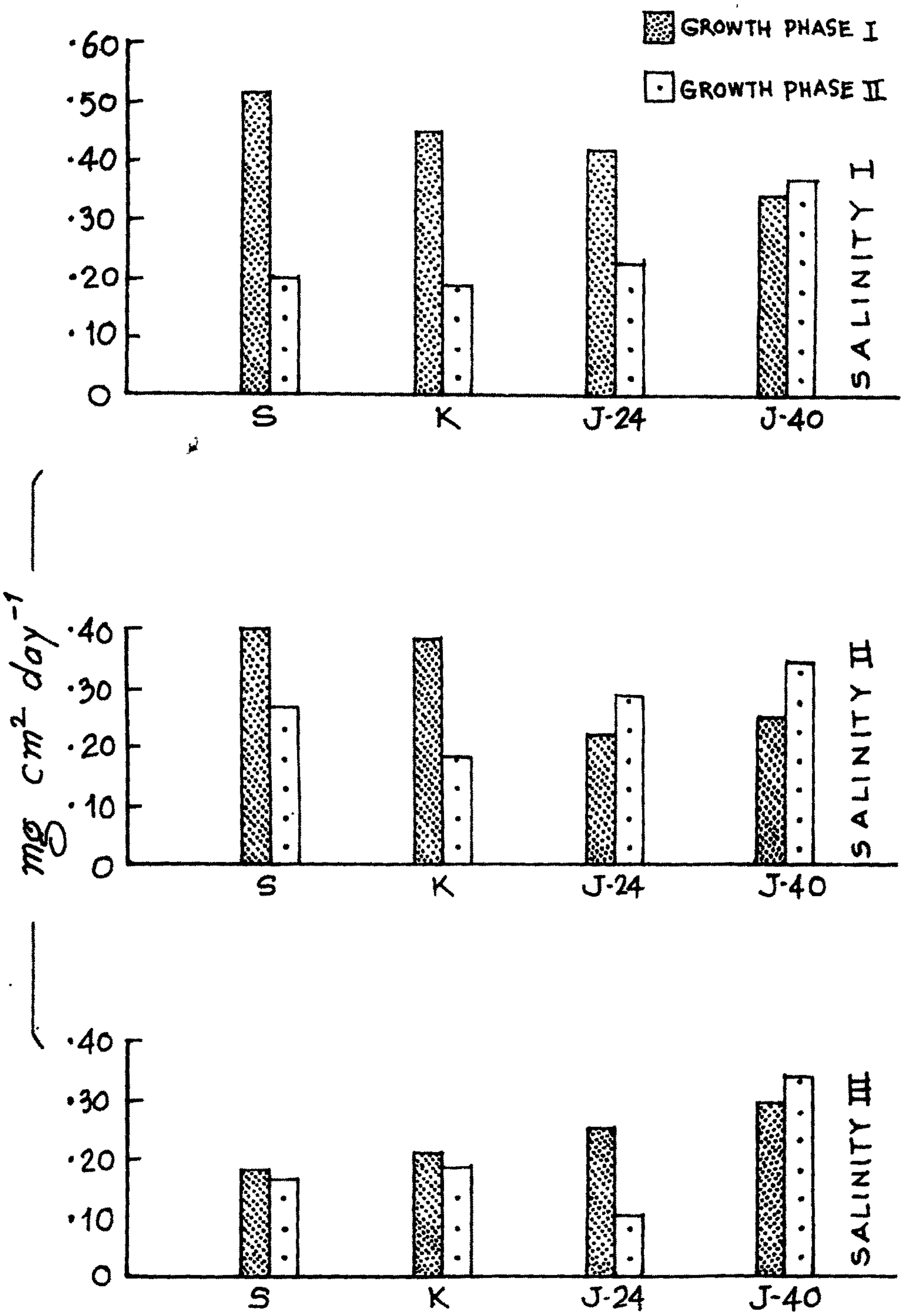
R = Root Compartment

S = Shoot Compartment

T = Total NAR for whole plant.

* mg cm^{-2} day^{-1}

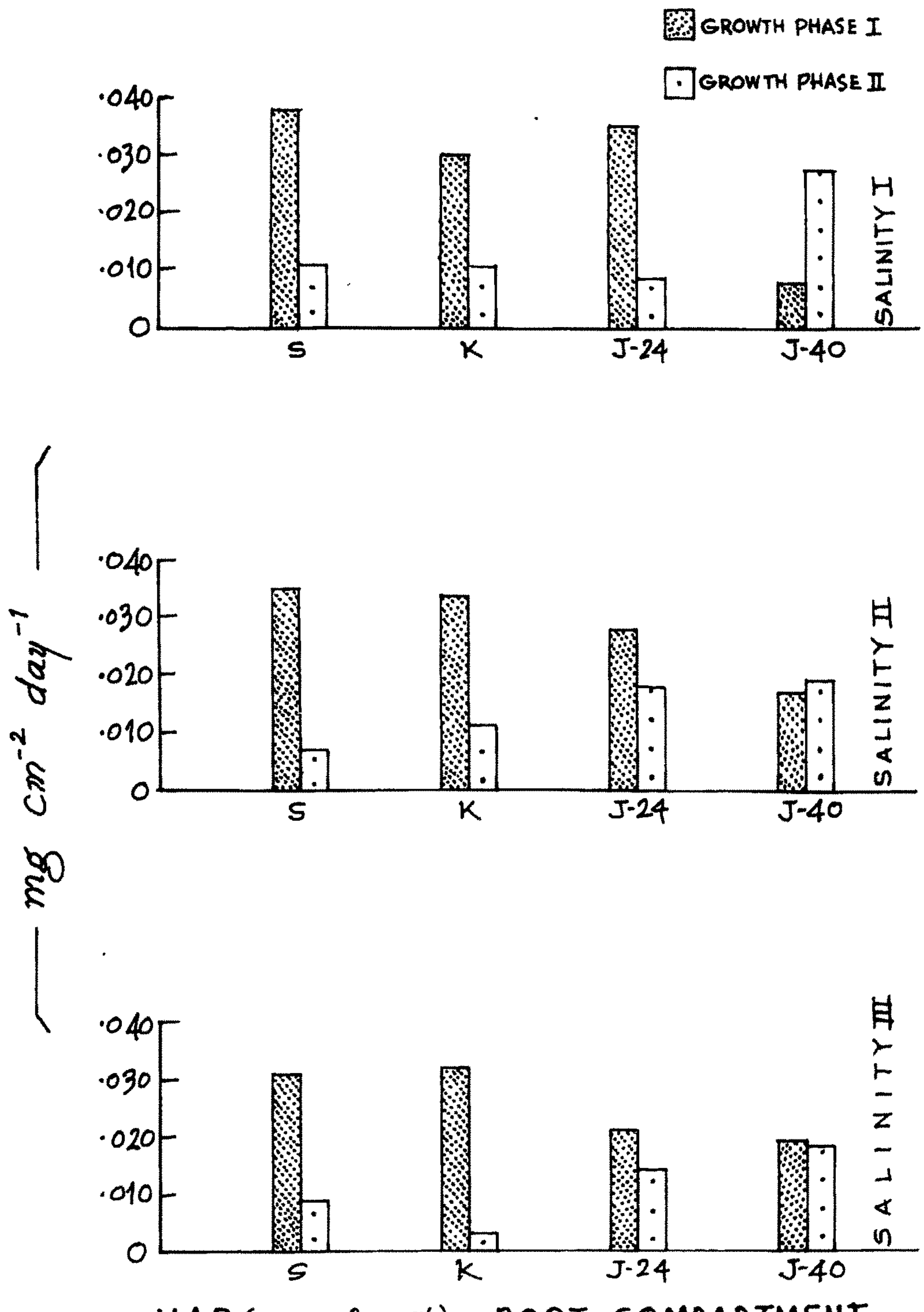
Plate - 61 : Total Net Assimilation Rate (NAR) patterns in the growth phase I and II as influenced by the salinity gradients.



NAR ($mg\ cm^{2}\ day^{-1}$) — WHOLE PLANT

PLATE-61

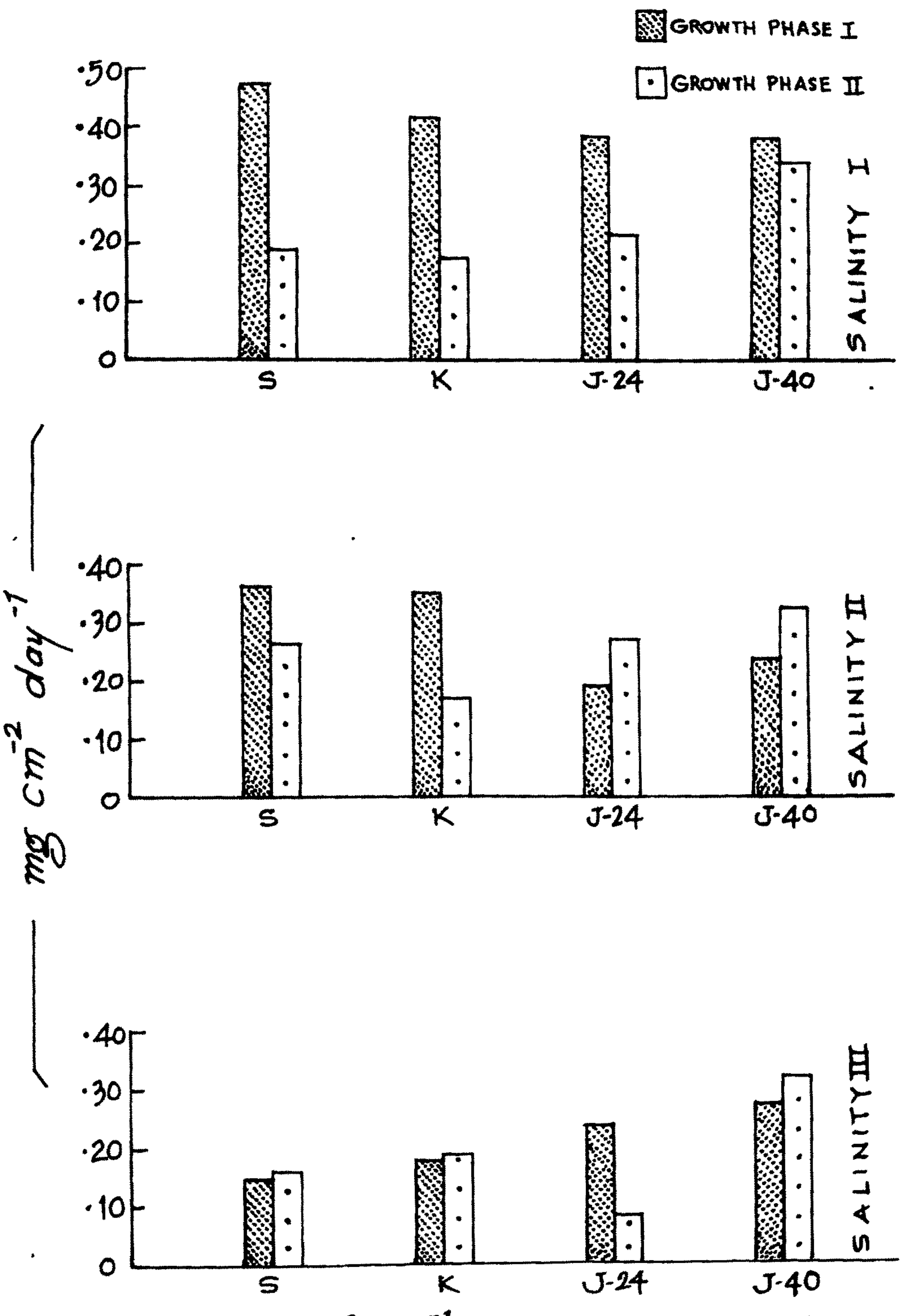
Plate - 62 : Root NAR variations in the growth phase I and II in the three salinity gradients.



NAR (mg cm^{-2} day^{-1}) — ROOT COMPARTMENT

PLATE-62

Plate - 63 : Shoot NAR variations in the growth phase I and II in the three salinity gradients.



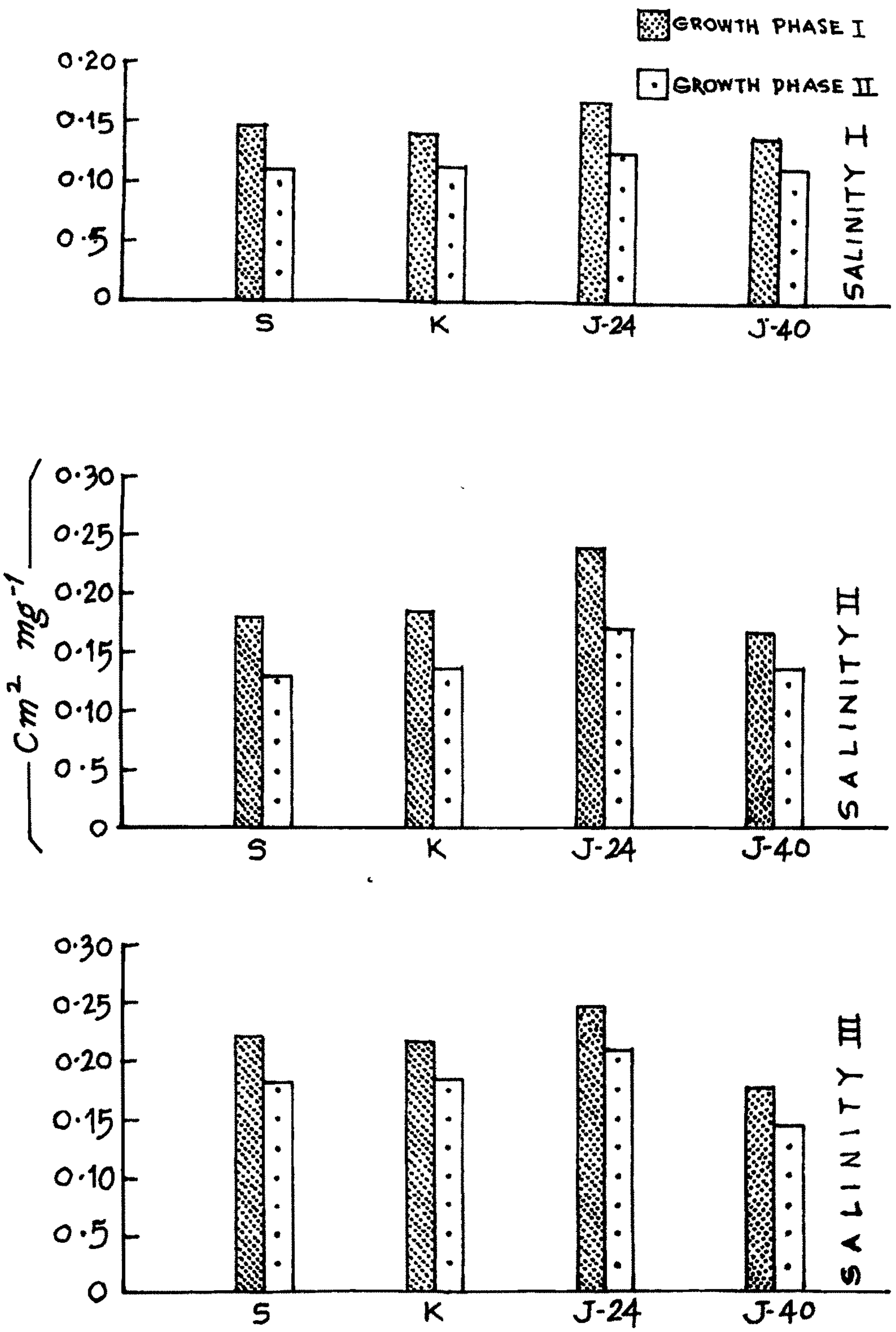
NAR (mg cm^{-2} day^{-1})—SHOOT COMPARTMENT

PLATE-63

Table 50 : Leaf Area Ratio ($cm^2 mg^{-1}$)

	Growth Phase	Sonalika	Kalyansona	J-24	J-40
Salinity Gradient I	I	0.1497	0.1442	0.1709	0.1416
	II	0.1138	0.1160	0.1298	0.1154
Salinity Gradient II	I	0.1828	0.1854	0.2408	0.1689
	II	0.1312	0.1383	0.1733	0.1384
Salinity Gradient III	I	0.2239	0.2154	0.2457	0.1748
	II	0.1826	0.1824	0.2081	0.1416

Plate - 64 : Leaf Area Ratio (LAR) for the four varieties as affected by the salinity gradient.



LAR ($cm^2\ mg^{-1}$) — WHOLE PLANT

PLATE-64

b) <u>RWR</u> (Root Weight Ratio)

The ratio value was found to decrease with the growth age in all the three salinity gradients in all the four varieties. Slight fluctuations were observed in case of J-24 in Salinity gradients I and II and for Sonalika and Kalyansona in salinity gradient III.

c) <u>SLW</u> (Specific Leaf Weight)

Sonalika showed slightly better performance in all the three salinity gradients. The performance of the other three varieties was comparable.

d) <u>SLA</u> (Specific Leaf Area)

The values for J-40 were comparatively higher in salinity gradient I than those of the other three varieties. J-40 maintained this trend in all the three gradients of salinity but J-24 was comparable to J-40 in gradients II and III.

e) <u>LWR</u> (Leaf Weight Ratio)

There was no great difference in the values of the four varieties in all the three salinity gradients. (PLATE 65, 66) (Tables 51, 52).

Table 51 : Root Weight Ratio (RWR) and Shoot Weight Ratio (SWR).

	Days	Sonalika		Kalyansona		J-24		J-40	
		RWR	SWR	RWR	SWR	RWR	SWR	RWR	SWR
Salinity Gradient I	10	0.11	0.88	0.13	0.86	0.09	0.90	0.14	0.85
	20	0.09	0.90	0.10	0.89	0.09	0.90	0.08	0.91
	30	0.08	0.91	0.09	0.90	0.07	0.92	0.08	0.91
Salinity Gradient II	10	0.12	0.90	0.12	0.87	0.11	0.87	0.13	0.86
	20	0.10	0.90	0.10	0.89	0.12	0.87	0.12	0.88
	30	0.08	0.91	0.09	0.90	0.10	0.89	0.09	0.90
Salinity Gradient III	10	0.13	0.86	0.13	0.86	0.14	0.85	0.14	0.86
	20	0.13	0.85	0.13	0.85	0.11	0.88	0.12	0.88
	30	0.12	0.89	0.10	0.89	0.10	0.88	0.09	0.90

Table 52 : Specific Leaf Weight (SLW)*, Specific Leaf Area (SLA)** and Leaf Weight Ratio (LWR) at 30 days of growth.

		Sonalika	Kalyansona	J-24	J-40
Salinity Gradient I	SLW	0.96	0.81	0.90	0.76
	SLA	1.03	1.2	1.1	1.3
	LWR	0.11	0.09	0.11	0.08
Salinity Gradient II	SLW	1.0	0.86	0.91	0.81
	SLA	0.93	1.2	1.1	1.2
	LWR	0.13	0.11	0.13	0.09
Salinity Gradient III	SLW	1.1	0.83	0.86	0.84
	SLA	0.84	1.2	1.1	1.2
	LWR	0.20	0.14	0.17	0.10

* $mg\ cm^{-2}$

** $cm^{2}\ mg^{-1}$

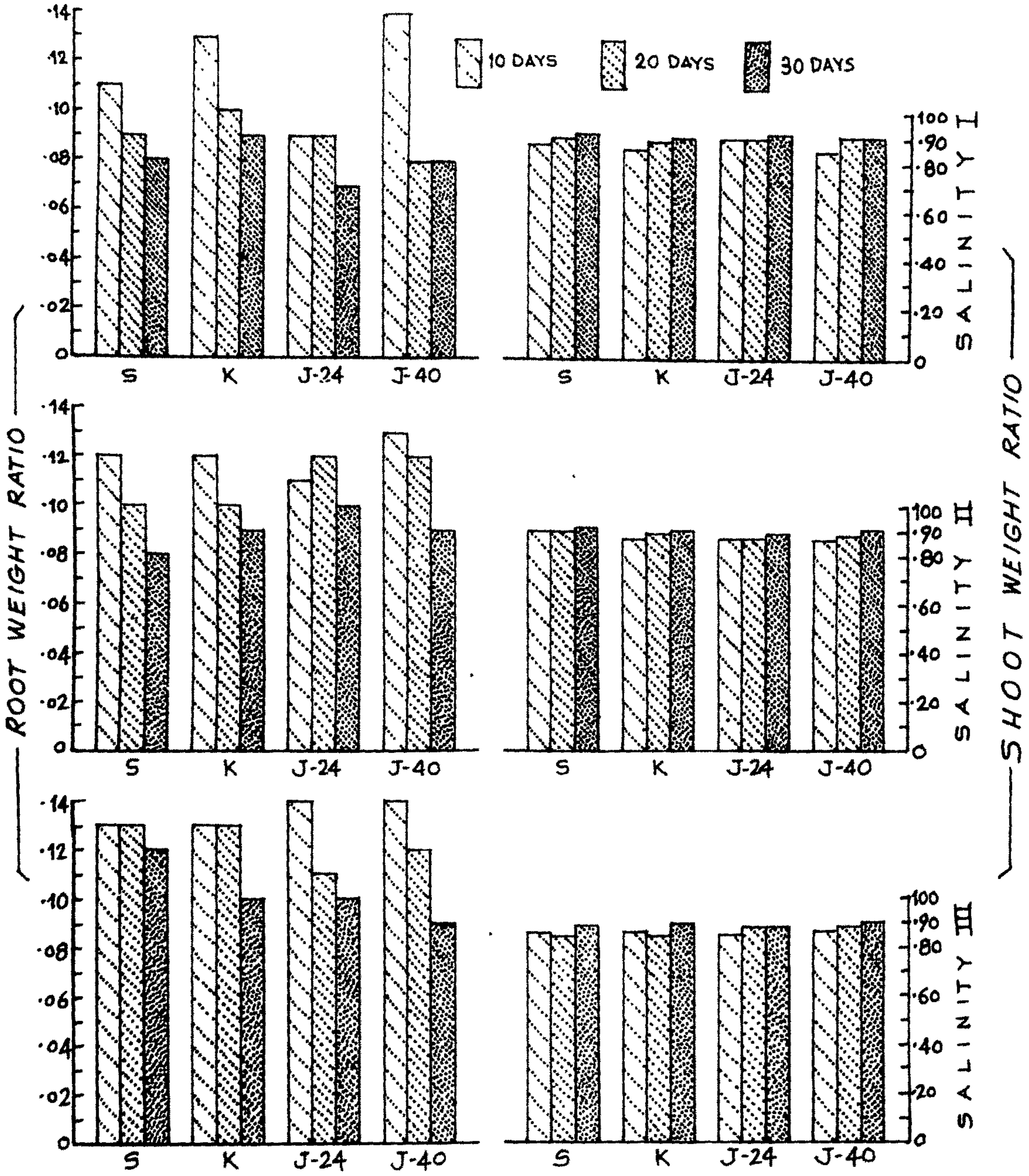
Table 53 : Root and Shoot Length Ratio and Root and Shoot Phytomass Ratio

	Days	Sonalika		Kalyansona		J-24		J-40	
		P	L	P	L	P	L	P	L
Salinity Gradient I	10	0.13	0.19	0.15	0.18	0.11	0.14	0.16	0.24
	20	0.10	0.13	0.11	0.10	0.10	0.12	0.09	0.08
	30	0.09	0.10	0.10	0.08	0.08	0.11	0.09	0.11
Salinity Gradient II	10	0.14	0.2	0.14	0.19	0.14	0.16	0.15	0.2
	20	0.11	0.18	0.15	0.09	0.14	0.13	0.12	0.10
	30	0.08	0.17	0.10	0.09	0.11	0.10	0.09	0.10
Salinity Gradient III	10	0.15	0.2	0.15	0.2	0.16	0.18	0.17	0.2
	20	0.17	0.16	0.16	0.16	0.12	0.14	0.13	0.18
	30	0.14	0.14	0.11	0.15	0.13	0.13	0.13	0.17

P = Phytomass Ratio

L = Length Ratio

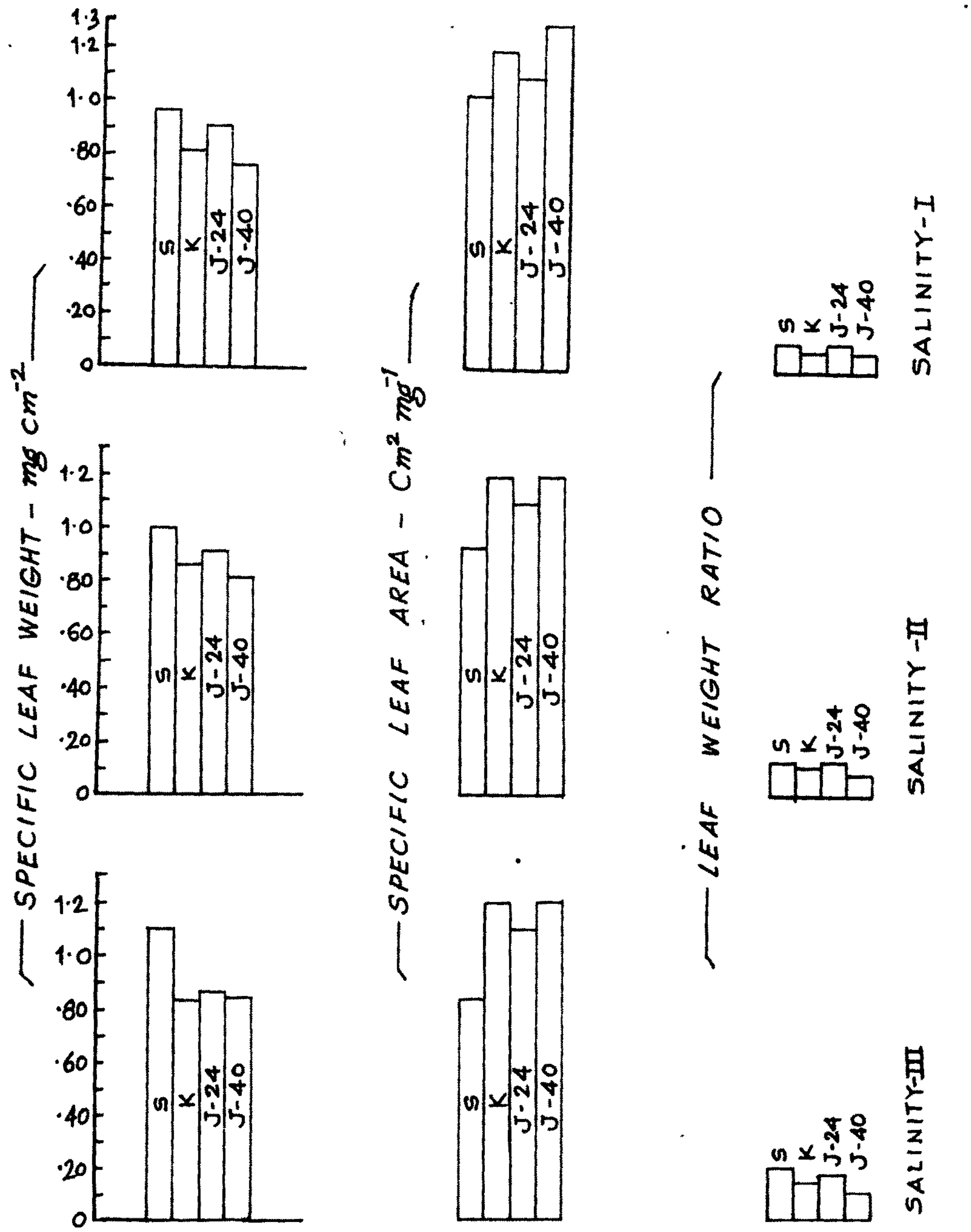
Plate - 65 : Graphic record of Root Weight Ratio (RWR) and Shoot Weight Ratio (SWR) of the four varieties in the three salinity gradients.



-ROOT & SHOOT-RATIOS

PLATE-65

Plate - 66 : Specific Leaf Weight (SLW), Specific Leaf Area (SLA) and Leaf Weight Ratio (LWR) at 30 day growth period in the three salinity gradients.



SPECIFIC LEAF WEIGHT, AREA & RATIO AT 30 DAYS OF GROWTH

PLATE-66

Discussion :

Strognov (1964) after a serious and continuous study of the salt tolerance of several crop plants produced a treatise on the subject and made a generalization therein - 'As the salinity increases the crop growth decreases'- This generalization of Strognov (1964) is supported by the present investigation. The increase in salinity gradient resulted in the overall decrease in the plant performance in the estuarine agro-ecosystem. The ecophysiological parameters of plant growth (Kvet, 1971) showed a trend ofd decreasing values which is explained by the work of Strognov (1964) and several other workers. The adverse effect of increasing salinity has been shown not only on the crop plants but on several other plant species (Joshi, 1977). The greater the salinity, the more marked is the adverse effect (Strognov, 1964; Ayers, 1952). The dwarfed plants due to salinity give low yields of poor quality (Strognov, 1964; Bernstein, 1952; Haywood, 1948; Richards, 1954). The results of the present investigation on all the four wheat varieties fall in line with the observations made by these workers with respect to the increase in salinity.

It was, however, the aim of this investigation to study the effect of salinity gradients on the ecological behaviour in order to assess the halophytic potential of the wheat varieties for optimization of the production strategy. Each behavioural pattern is discussed in detail below :

The adverse effect of salinity on the plant is first expressed during the germination phenophase. The stands of crop plants appear to be thin and some spots appear barren due to the effect of salinity on germination (Bernstein, 1952; Ayers, 1958; Strognov, 1964; Maliwal, 1967; Paliwal, 1968). Similar reduction in the pattern of germination was also observed by Asana (1965) in wheat varieties. The results of the present investigation also fall in line with the above findings. The reduction trends of germination are supported by Ayers (1952) in his studies on several crop plants. Maliwal (1967) in his extensive work on the germination of about a dozen crops observed similar results. Donovan (1969) in his study of the germination of barley with respect to salinity came to the conclusion that salinity in general reduced the percentage of germination and that quantity of the reduction depended on the type of salinity.(Janardhan, et al. (1970) studied the effect of Sodium chlorode on rice seedlings and supported the findings of the earlier workers. Kurian and Iyengar (1971) attempted an evaluation of the use of sea water in seedling growth of some crop plants and came to similar conclusions. Maliwal (1967) and Paliwal (1968) studied various aspects of seed germination in relation to salinity and determined the inter- and intra-varietal differences in over all reduction pattern.

The physiologists consider the sensitivity of crop plants, during germination phenophase to be due to the absence of osmotic forces responsible for absorption of water from the soil. The adult plants absorb water by means of an adequate suction potential in the cells of the root (Richard, 1954; Hayward, 1958; Strognov, 1964; Larcher, 1975). The performance of the four varieties evaluated in the present work fell in line with these observations. However, the intra-varietal differences were observed and J-40 variety was found to be quite tolerant at this phenophase in all the gradients of the salinity in the estuarine edaphic complexes.

The seedling mortality has not been worked out by many workers in saline conditions. It was essential to determine this parameter as the crop density is ultimately determined by the cumulative effect of the percentage germination and the seedling mortality. The observations suggest that the mortality percentage is not very high due to salinity though differences within varieties are visible. Uprety (1971) investigated the mortality of Pea seedlings in relation to the artificial salinization and came to similar conclusions. The variety J-24 is quite susceptible to salinity in this respect also; it showed higher percentage of seedling mortality.

The effect of salinity on the overall and organ morphology has been investigated by Ayers (1952), Chaudhuri (1964), Narale (1969) and Nieman (1965). It is observed that the dwarfing of the organ length is a common feature wherein the adverse effect of salt is expressed. These observations support the findings reported here. Strognov (1964) is of the view that length reduction of root or shoot is indicative of the overall poor performance of metabolic machinery as far as the growth or synthetic processes of the plant are concerned. The effects of salinity are more pronounced on the shoot length compared to the root length in the varieties investigated in the present work. This observation is supported by Strognov (1964) who found similar trend in cotton.

In all varieties under investigation there is seen a persistent trend towards decrease in the length of root and shoot but, it was found that ratio of root/shoot length remains more or less unaffected in all the four varieties in the three salinity gradients.

The reports of Strognov (1964) and several other workers support the findings in the present investigation on the leaf area reduction due to salinity. The leaf area decreased inversely with the salinity gradient. The variety J-40 showed less reduction compared to the other three varieties. The leaf being an essential functional surface, the reduction in its area results in fall in performance (Nieman, 1965). Similar findings were obtained in rice seedlings by Narale (1969). The observations of Strognov (1964) and Nieman (1965) show that under saline conditions the initiation of leaf primordia is less inhibited than their expansion thus affecting the leaf area. Strognov further established that the process of formation of leaf initials is disturbed in the stem apex by increasing salinity.

The phytomass accumulation is determined by the outcome of the net assimilation in the plant body. The increasing salinity is found to decrease the phytomass accumulation in all the varieties investigated. Uprety (1973) has observed the same trend in pea seedlings. Similar findings on the dry weight and fresh weight have been reported by Bhardwaj (1960), Donovan (1969) and Dumbroff (1974). Similar observations on the overall plant growth have been made by several workers (Sarin, 1963; Francois, 1964; Maliwal, 1967; Paliwal, 1968; Narale, 1969; Janardhan, 1970).

The reduction in the phytomass values is seen in the root as well as the shoot. These findings are supported by

Strognov (1964) who observed that the root and shoot have differential response to salinity though the trend of reduction is obvious.

The moisture status of the rice crop plants under saline conditions has been found to the tune of sixty to seventy five per cent (Narale, 1969). The observations with regard to the moisture structure and the effect of salinity on it in the four wheat varieties made during the present work fall in line with this finding. Strognov (1964) reports that the rate of loss of water from the surface of the plant body markedly decreases with salinity.

It is to be noted that production ecology has received great attention of ecologists yet Net Primary Productivity as affected by salinity has not been extensively worked out under Indian conditions though some references are available (Asana, 1965; Narale, 1969). Some production studies may be mentioned here. Weighing (1935) found increase in shoot biomass during the early phase of growth and he correlated it with the root biomass. Since then a spurt has been recorded in production ecology research (Bray, et al., 1959; Ovington, 1963; Westlake, 1963; Odum, 1965; Misra, 1970; Vyas, 1972; Singh, 1974; Wahi, 1976). Bhardwaj (1966) studied Sonara 64 - Lerma Rojo with irrigation pattern. Raza (1971) worked on the production ecology of maize, bajara and wheat. Sen (1976) studied production ecology of Bajara; Amritphale (1976) studied Saccharum spontaneum.

It is seen that clear cut relationship between salinity and productivity is not determined. The present investigation dealing with the seedling productivity of four wheat varieties reports decreasing trend in the production values. The net primary production is the outcome of the cumulative effect of all the metabolic processes occurring in the plant body. The findings of Strognov (1964) and other workers indirectly support the experimental results on net primary production reported in this thesis. Strognov (1964) found that the metabolism of the plants in saline soils undergoes a drastic change. There is also considerable disturbance in the transport and translocation metabolism (Strognov, 1964). The photosynthesis - the process at the base of production, is altered under the influence of salinity gradients. The bleaching of chlorophyll tissue is also reported in the case of cotton and vegetable crops (Hayward, 1958). The biochemical studies revel revealed that the bond between the green pigment and the protein of the chloroplast shows the decrease of strength. (Strognov, 1964; Larcher, 1975). The enzymatic studies have shown that RuDP-ase cannot function in the saline medium (Joshi, 1977). Joshi (1977) further reports that high salinity inhibits sugar formation stimulating at the same time amino acid synthesis. Strognov (1964) suggests that amino acids are metabolized which result in the disappearance of some essential amino acids and accumulation of some others in excessive amounts. These arguments may explain the decreasing pattern of productivity as seen in our data on the seedling net primary productivity of wheat varieties. It is, however, pointed out that the crop plants adapted for saline soils show a mixed C_3 and C_4 pathway though the crop may be of C_3 type under normal agronomic conditions (Joshi, 1977). This may well be the case with J-40 which would explain its superiority over other varieties under saline condition.

The RGR, NAR, LAR, SLW, SLA are investigated with two fold objective - one is to study these rates in relation to the growth age and secondly to assess the impact of salinity on these analytical parameters : Relative growth rate, net assimilation rate and leaf area ratio declined with time. This has also been observed by numerous workers (Watson, 1936; Thorne, 1960; Friend, 1969). Heath and Gregory (1938) and Gregory (1950) have shown that NAR is not a very variable quantity in nature, while others (Watson, 1952; Thorne, 1960; Cline, 1966; Power et al., 1967), have shown that NAR varies with age, mineral nutrition, water supply, light, and season of growth. However, it was claimed that (Gregory, 1926, 1938) that NAR on leaf dry weight basis is independent of age to the time of maximum leaf area and that on area basis declines with advancing age except brief early growing phase (Willima, 1946), Kothari (1974) also found the effect of aging on RGR and its components in Dichanthium. Singh (1974) also came to similar conclusions on Oryza sativa during dry land farming experiments. Thorne (1960) evaluated NAR in sugarbeet, potato and barley under controlled environment and found a decreasing trend of NAR when calculated on leaf area, leaf weight basis with advancing age.

SLW varies with age, stage of plant (phenophasic) environmental factors as well as inherent make up of the plant (Barnes, et al., 1969; Singh, 1974). Since LAR is the product of SLA, and LWR, the ultimate effect can be observed through changes in the leaf area per unit plant dry weight. Coombe (1966) however points out that though thick leaves have a high efficiency of assimilation, they are poor in conserving energy.

Positive association of SLW and NAR have also been reported by Okubo, et al., (1970) and Pearce (1969). This association is however, not significant in determining the photosynthetic rates of the plants (Friend, 1969).

These ecophysiological parameters are dependent upon the whole physiology of the plant. The metabolic changes alter the overall growth pattern and thus reflect the interaction with the environmental influences - both - edaphic and physical. Strognov (1964) opines that the metabolic changes under salinity stresses especially the nitrogen metabolism is not well worked out. Disturbance in this metabolism is reported by Strognov (1964) with a comment that these disturbance alter the growth rate and assimilation patterns in saline conditions.

Salinity decreases these ecophysiological ratios of the four wheat varieties as found by Strognov (1964) in the case metabolic studies on cotton and Narale (1969) in young rice seedlings.

The discussion above is concerned with the adverse effect of salinity on the eco-behavioural patterns and for the explanation of the trend of decreasing plant growth values with the concomitant increase in the salinity level of the edaphic complexes.

For the purposes of ecosystem optimization, the experimental results and the discussion trend indicates that the performance of the varieties follows same pattern of decrease due to increased salinization but the performance of individual variety with respect to the parameters discussed above is at variance due to genetic makeup. It is observed that varieties J-24 and Sonalika do not perform as good as the varieties Kalyansona and J-40, which can be due to their genetic potential for adaptability. The variety J-40 is seen to perform better when compared to Kalyansona at this seedling phenophase. The genetically based varietal differences in the performance of all the varieties need reappraisal from time to time in the fluctuating estuarine agro-ecosystems of Chokari rural ecosystem.