EFFECTS OF SALINITY ON RESOURCE ALLOCATION PATTERN OF *INDIGOFERA OBLONGIFOLIA* FORSK., A PALATABLE DESERT LEGUME

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Abstract

Resource allocation pattern of *Indigofera oblongifolia* Forsk., was studied in relation to salinity. The plant responded to salinity plastically and tended to enter the reproductive phase little earlier. Reproductive allocation (RA) declined progressively with increase of salts in the root zone. There was proportionate increase in vegetative allocation (VA). Net reproductive effort (NRE) of the treated plants declined to 0-4.5% in comparison to that of 0-12% in the control. Number of pods and seeds per plant declined with salinity. Number of seeds per pod remained unaffected and averaged four. The distribution of seeds among pods was distinctly normal. *I. oblongifolia,* with more vegetative growth, appears to be a K-strategist on the r-K-continum and to fall in the category of S-strategist on R-C- and S-strategy model.

Introduction

Quantitative pattern of resource allocation is an important aspect of life history patterns and reproductive strategies in plants. Different species expend different proportions of their biomass on reproductive or vegetative processes (Wilson, 1983). The life history strategies have been discussed in the context of r-and K-selection theory of MacArthur & Wilson (1967). Grime (1977) proposed a R-, C- and S- strategy model encompassing competitive (C-), ruderal (R-) and stress tolerant (S-) strategies. The relationship between environmental condition and the resource scheme expressed in plants has not been fully explored (Soule & Werner, 1981). In the present investigation, pattern of resource allocation in *Indigofera oblongifolia* Forsk., a perennial legume common in salt free to moderately saline soils, was followed under various salinity regimes.

Materials and Methods

Sea water diluted to simulate various salinity regimes was amended with calcium ammonium nitrate, single super phosphate and sulphate of potash to provide N:P:K ratio of 170: 40: 156, and micronutrients corresponding to half strength Hoagland's solution. Control culture solution was prepared by amending the tap water (Table 1).

Indigofera oblongifolia was sown in 40 cm diameter pots containing 20 Kg sandy soil @ 10 seeds per pot. The pots had basal perforation to ensure drainage of surplus water. After 15 days of emergence, plants were thinned to single seedling of more or less equal vigour per pot. The seedlings were pre-conditioned i.e., irrigated initially with 5%

Table 1. Analysis of different dillutions of sea water after chemical amendments. (Data are the mean of 5 replicates).

Irrigation medium	pH	EC (dS.m^{-1})	Na$^+$	K$^+$	Ca^{++}+Mg^{++}	SAR
			--------(meq/l)--------			
Control	7.35	1.2	3.26	1.27	32.43	0.63
10% Sea Water + Amendments	7.55	4.50	27.17	1.27	54.89	2.10
20% Sea Water + Amendments	7.45	9.50	32.82	3.19	69.86	6.04
30% Sea Water + Amendments	7.45	14.0	131.52	3.83	109.78	11.11
Sea Water (Arabian Sea)	7.50	40.0	328.80	8.00	162.17	36.51

amended sea water and then with gradually increasing concentrations up to the level in which plants were to be grown finally. The plants were weekly irrigated with 2.5 litres of 10, 20 or 30% amended sea water. Control plants were irrigated with control culture solution. The experiment was continued up to one year and 4 harvests of 3 plants per treatment taken at random from the replicates were made. The experiment was conducted in experimental field at the Department of Botany, University of Karachi.

The plants removed from the pots were washed in running water, separated into morphological components and weighed afresh as well as oven-dried at 100°C. Percentage allocation of biomass among different morphological units for each observation and treatment was followed with the help of dry weight data which is known to reliably reflect the calorific evaluation of the pattern of resource allocation (Abrahamson & Gadgil, 1973). Percent crude and net reproductive efforts (CRE and NRE) were determined following Abrahamson & Gadgil (1973) and Sarukhan (1976).

$$CRE = \frac{\text{Reproductive biomass}}{\text{Total Biomass}} \times 100$$

$$NRE = \frac{\text{Dry weight of seeds}}{\text{Total Biomass}} \times 100$$

The reproductive biomass was represented by sum of dry weights of inflorescence axes, flowers, pods and seeds. Since abscized parts were collected time to time from underneath the plants, the loss of unaccounted dry matter (if any) should be insignificant in influencing the overall dry weight of the plant.

For seed distribution pattern among the pods, number of seeds, from each of the 50 randomly selected pods for each treatment, were counted and their frequency histograms prepared. The location and dispersion parameters were calculated (Fisher, 1948).

Results

The dry matter yields of root, stem and leaf were significantly higher in plants irrigated with 10% amended sea water but significant reduction in growth occurred in higher levels of salinity (Figs. 1 & 2). The total reproductive biomass exhibited a declining trend with increasing salinity. The total biomass of a plant, at one year of age, related to the salinity (EC_{iw}: $dS.m^{-1}$) through following equation:

$$\text{Total Biomass} = 93.89 + \underset{\substack{(t=5.04)\\(p<0.008)}}{103.22\,EC_{iw}} - \underset{\substack{(t=5.56)\\(p<0.006)}}{17.93\,(EC_{iw})^2} + \underset{\substack{(t=5.36)\\(p<0.007)}}{0.748\,(EC_{iw})^3} \pm 21.95$$

per plant (g.DW)

$F = 31.42\ (p<0.004)$

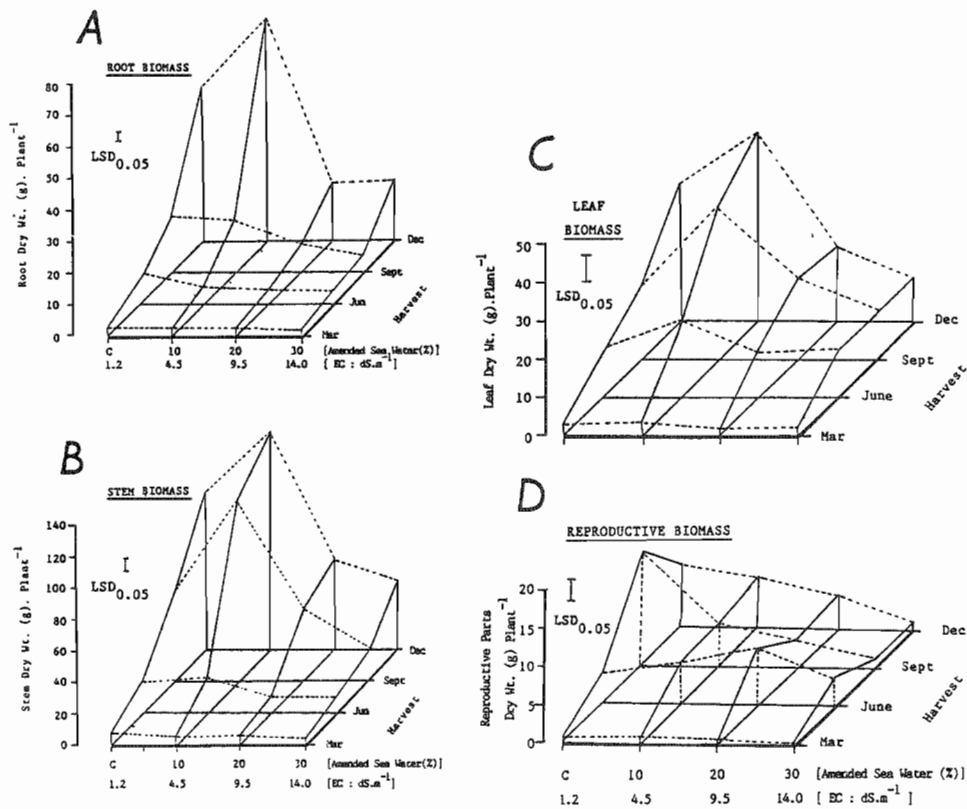$R = 0.9794{***}$

$R^2 = 0.9593{***}$

Fig. 1. Root (A), stem (B), leaf (C) and reproductive biomass (D) of *Indigofera oblongifolia* grown under irrigation with various amended dilutions of sea water on sandy soil.
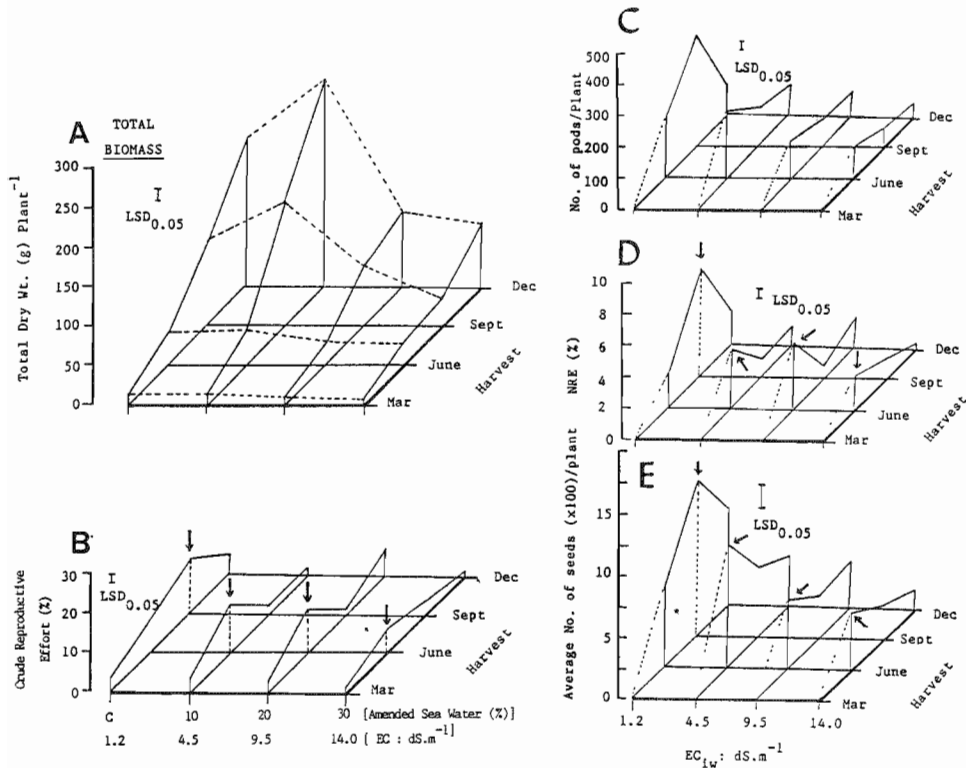
Fig. 2. Total biomass/plant (A), crude reproductive effort (B), number of pods/plant (C), net reproductive effort (NRE) (D) and average number of seeds/plant (E) of *Indigofera oblongifolia* grown under irrigation with various amended dilutions of sea water on sandy soil. Arrow indicates the relative shift of peak reproductive effort in time.

CRE and NRE were low and their magnitude declined with salinity and varied with plant age. Salinity induced a tendency of earlier entrance in reproductive phase as is evident by the relative occurrence of peaks of reproductive efforts (Fig. 2). Number of pods and seeds per plant also declined with salinity. However, the average number of seeds per pod remained unaffected and amounted to four. The distribution of seeds among pods was distinctly normal as shown by insignificant values of skewness and kurtosis (Fig. 3).

A relative instability of proportion of dry matter devoted to reproductive parts was evident under salinity (Fig. 4). Reproductive allocation declined under salinity and vegetative allocation increased proportionately. Slight adjustments among the vegetative parts were also evident. There was a trend of increase in leaf biomass and reciprocal decrease in stem biomass at second harvest but this trend gradually diminished in later harvests. The allocation to stem increased in 10% sea water but decreased in 20 and 30% sea water. Dry matter proportion allocated to leaves was relatively higher in treated plants.
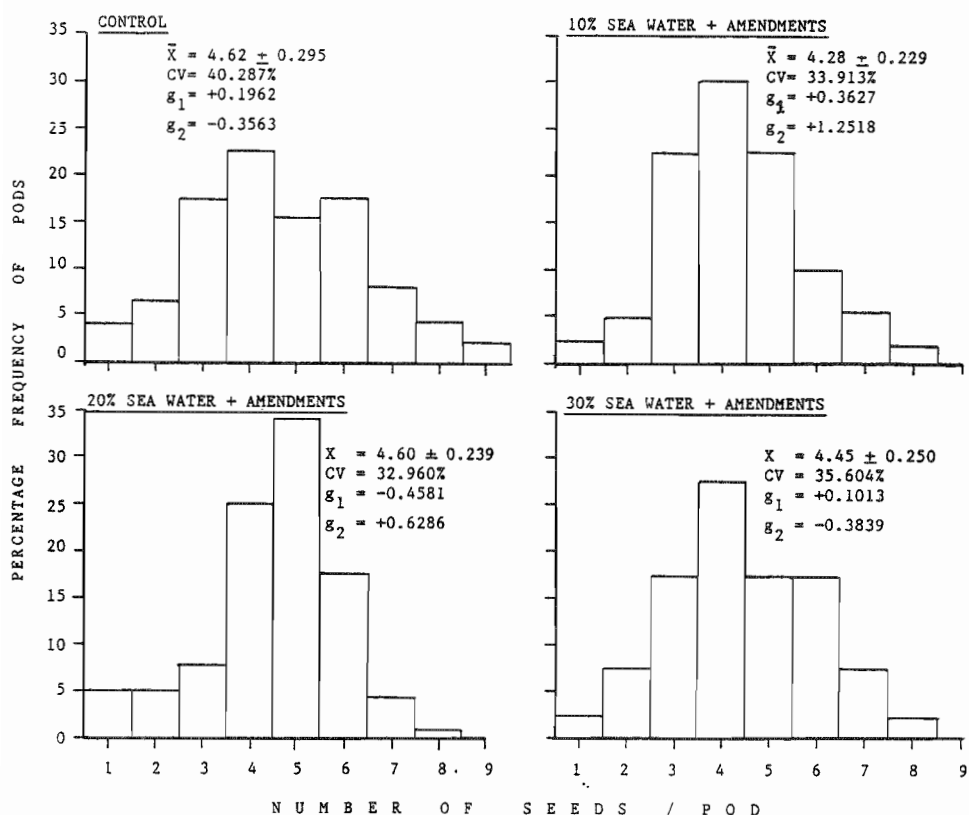
Fig. 3. Frequency distribution of seeds per pod of *Indigofera oblongifolia* under control and various salinity regimes. $\bar{x}$ = mean, CV = coefficient of variation (%), g_1 = skewness and g_2 = kurtosis as given by Fisher's (1948) statistics. Sg_1 and Sg_2 are the standard errors of skewness and kurtosis respectively. Sg_1 = 0.3366 and Sg_2 = 0.6619.

$$Sg_1 = \sqrt{6N\ (N-1)/\ (N-2)\ (N+1)\ (N+3)} \qquad Sg_2 = \sqrt{24N\ (N-1)^2\ /\ (N-3)\ (N-2)\ (N+3)\ (N+5)}. \qquad N=50.$$

Root allocation was c. 20% of the total biomass. It declined up to third harvest i.e., till commencement of monsoon. It increased again in post-monsoon harvest. CRE of the control plants was not more than 18%. It declined in treated plants and remained less than 12%. NRE was much lower in magnitude and did not exceed 7% in the control, and 4.5% in the treated plants.

Discussion

Our studies indicate that the homeostatic processes that maintain the normal bionomic pattern of dry matter distribution among morphological structures of *I. oblongifolia* operate only within narrow range of salinity. Reproductive plasticity was evident un-

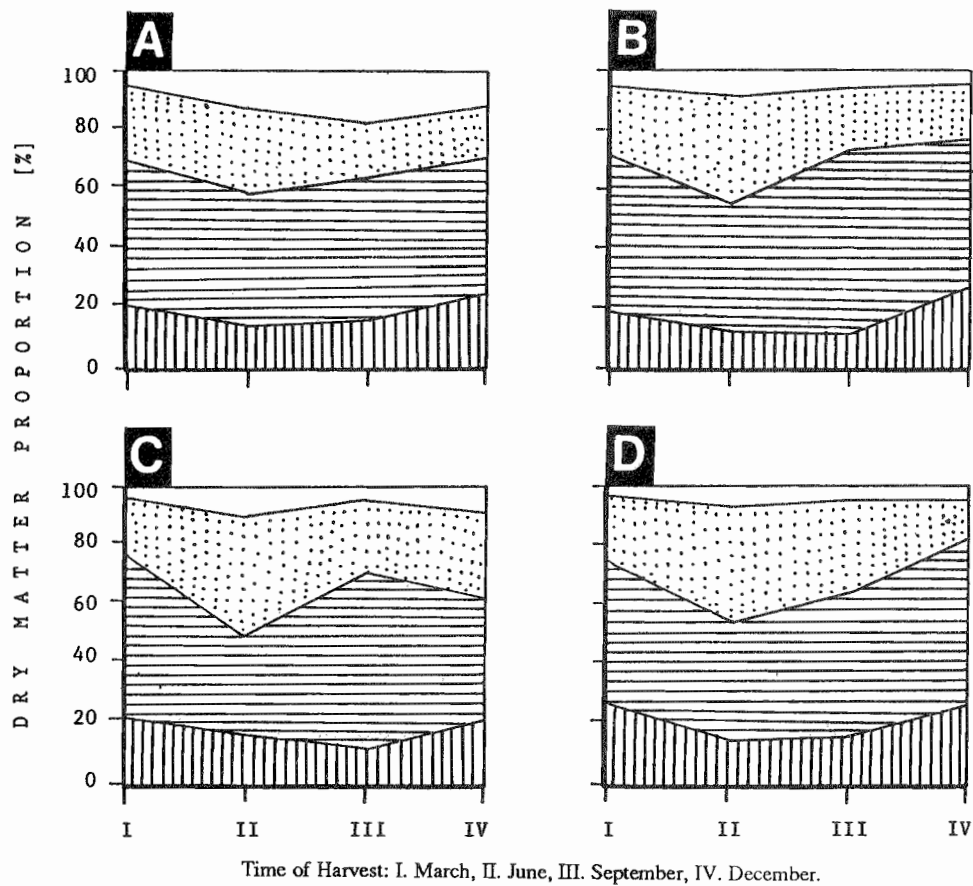Time of Harvest: I. March, II. June, III. September, IV. December.

Fig. 4. Percentage allocation of total biomass (Dry wt.) among various structural components of *Indigofera oblongifolia* grown under various salinity regimes. A = Control: EC_{iw}: 1.2 dS.m^{-1},   b = EC_{iw}: 4.5 dS.m^{-1}, C = EC_{iw}: 9.5 dS.m^{-1}, D = EC_{iw}: 14.0 dS.m^{-1}.

|||||||||| Root; ≡≡≡ Stem; ☐ Leaves; ☐ Reproductive parts.

der salinity in this plant. Hickman (1975) reported reproductive plasticity in an annual, *Polygonum cascadense* under moisture stress. CRE of *Plantago major,* a perennial, is also substantially reduced under stress (Trivedi & Tripathi, 1982). Such a plastic response has also been shown in halophytic *Atriplex triangularis* when grown in high salinity (Khan, 1987). In *I. oblongifolia* salinity stresses substantially changed the growth rate of different organs to different extent, so that the overall pattern of dry matter distribution among various parts was substantially altered. The plastic reproductive response resulted in increased vegetative allocation that was also associated with some adjustments among

the vegetative parts themselves in form of decreased root allocation and deviation of resources to leaves in relatively larger magnitude, though after rainfall some increase in root growth occurred. Reduction in root growth under saline conditions is well known (Greenway, 1968; Okusanya & Fawole, 1985). Some improvements in root growth during post-monsoon period may be attributed to the leaching of salts from the root zone due to 69.1 mm rain. The overall reduction in plant growth may, however, be primarily related with the limited supply of metabolic energy for maintenance of growth under salinity which increases the amount of energy necessary to combat with the ionic and osmotic effects (O'Leary, 1986).

The relative occurrence of peaks of reproductive efforts showed that salinity hastened the flowering initiation and seed maturation processes but reduced the reproductive yield of the plant in terms of number of pods and seeds per plant. The number of seeds per pod, however, did not vary and followed a normal distribution curve. In this respect, *I. oblongifolia* resembled a leguminous perennial, *Leucaena leucocephala*, in which decrease in reproductive yield at high salinity was observed (Ahmad *et al.*, Unpublished). In contrast, in *Sesbania sesban*, another leguminous perennial, salinity increased the number of seeds as well as the total seed weight (Ahmad *et al.*, Unpublished). The reproductive responses of plants to salinity, even among legumes, are thus species-specific. It may be the result of some specific metabolic changes causing hormonal imbalance (O'Leary, 1971).

As regards the bionomic strategy of the plant, on the basis of its greater emphasis on vegetative growth and tendency of perennation, it appears to be a K-strategist on r-K continum proposed by MacArthur & Wilson (1967). Reviewing in terms of R-, C- and S-strategy model of Grime (1977, 1979), the plant is a S-strategist capable of tolerating high stress and some disturbance also. It is characterized by the features that maximize the capture of resources. It possesses high regenerative capability even after repeated clippings under saline conditions (Khan, 1987). Unlike most of the legumes, it responds to salinity in a halophytic manner accumulating salts throughout its vegetative body but excluding salts from the seeds by retaining them in fruit wall (Khan, 1987). Perennials are known to generally have low reproductive allocation (Wilson, 1983). Further lowering of reproductive allocation under saline conditions in this species may, however, be not only due to high metabolic costs involved in producing the reproductive structures under salinity but also due to greatly enhanced energy expenditure needed to check the entry of ions into seeds. Green fruits may also have provided some energy towards their own maintenance and growth. Besides, age-related fecundity measurements could also be important to further elucidate the reproductive strategy of the plant.

Acknowledgement

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