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LIFE HISTORY STRATEGIES OF *TEPHROSIA STRIGOSA* WILLD. – A DESERT SUMMER ANNUAL

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Abstract

Variation in demography and life-history patterns of *Tephrosia strigosa* Willd., a summer annual of dry habitat, was studied under field conditions during 1988 and 1990 growing seasons. Seasonal data on persistent seed bank showed a substantial loss of seeds in the seed bank after dispersal especially after rainfall where seeds either germinated or were washed deep into the soil. A high degree of similarity was observed between the buried seed bank flora and vegetation. There was a significant increase in mortality soon after recruitment followed by little change in population size during late vegetative phase. Mortality rate again increased at the time of flowering. Vegetative growth of plants increases significantly at the seedling stage but declined at the time of flowering. Biomass allocated to reproduction increased with the increase in the size of the seedlings which was shared by roots and shoots and later by root, stem and leaf. During flowering and fruiting time the reproductive allocations approached up to 30%.

Introduction

Tephrosia strigosa Willd. (Papilionaceae), is a summer annual commonly found in the Sindh desert. The seeds remain dormant in soil throughout the dry season and germinate soon after the monsoon rains completing their life span in 40 to 50 days time. Populations of *T. strigosa* are usually present in the low lying areas which receive run off water carrying top soil from the adjoining areas during monsoon rains. Soil profile in this area is relatively well developed and the vegetation is dominated by large shrubs like *Euphorbia caducifolia, Prosopis juliflora* and *Commiphora wightii.* After rains, annuals like *Eragrostis ciliaris, Indigofera cordifolia, Blepharis sindica* and *Aristida mutabilis* along with *T. strigosa* also appear.

The deserts have an environment characterized by low moisture which is irregularly distributed in space and time. The plants must have growth characteristics that are closely related to soil moisture (Goldsmith and Smart 1984, Guitierrez and Whitford 1987, Hegazy 1990). Annuals present in the desert environment usually avoid the drought period by seed dormancy and germinate in soil when conditions become more conducive for their germination and growth. The life history strategies of desert annuals are not properly understood. This paper reports the significance of seed bank, mortality and recruitment patterns and reproduction in regulating *T. strigosa* populations during 1988 and 1990 growing seasons.

Materials and Methods

The study area is adjacent to Karachi University campus, which was identified by Qadir *et al.* (1996) as *Euphorbia, Grewia, Acacia* community. This community is situated in a low lying area and has a relatively developed soil profile i.e. soil primarily azonal with rock outcrops could be seen everywhere. During the annual summer rainfall, the rain water from the adjacent areas accumulates and deposits a large amount of soil which is loamy with relatively high water-holding capacity as compared to sandy soils in nearby areas. The vegetation is closed as compared to other associated desert communities. Species associated with *Tephrosia strigosa* in the study area are *Blepharis sindica, Eragrostis ciliaris, Indigofera cordifolia, I. hochstetteri, Aristida mutabilis, Prosopis juliflora, Tribulus terrestris, Cynodon dactylon, Senna holosericea, Corchorus depressus* and *Calotropis procera.* Cattle grazing is the most frequent disturbance.

Forty soil cores were randomly collected using soil corer (2.5 cm diameter with a depth of 15 cm) before rainfall, after rainfall with completion of seedling recruitment and after dispersal of seeds from parent plants. Twenty soil samples of each collection were watered and the seeds allowed to germinate in the laboratory and monitored regularly for six weeks. As seedlings emerged they were identified later removed and the soil turned over to facilitate further germination. Seeds in the other three sets of 20 samples were manually extracted with the help of a binocular microscope and identified.

Twenty permanent quadrats (20 × 20 cm) were established subjectively to sample the population densities soon after the appearance of *T. strigosa* seedlings following substantial rainfall during 1988 and 1990 growing seasons. Quadrats were placed at regular intervals (5 ft) throughout the growing season. At each sampling date, ten seedlings randomly collected from the areas close to each quadrat were washed and the dry weight of root, shoot, leaf, flower were taken, and the number of fruit/seed were counted. At the end of growing season, prior to seed loss, all the plants surviving in quadrats were harvested, oven dried and weighed.

Statistical analysis of the data was carried out using the computer program of Statistical Package for Social Sciences (SPSS) on an IBM compatible 486/66 mhz computer. Data were analysed using Means and LSD ($P < 0.05$) procedures.

Results and Discussion

Soil seed reserve : Seed bank study was conducted at three phenological states. The Sindh desert normally receives rainfall during monsoon period and winter rains are rare. Seeds usually germinate after relatively heavy rainfall during the monsoon. Little or no germination was observed after winter rains. Seeds of seven desert annuals were located in the seed bank (Table 1) with *Tephrosia strigosa* showing the highest density followed by *Indigofera hochstetteri* and *Aristida mutabilis.* Size of the seed bank significantly reduced after the germination following rainfall. All the annuals maintained a few seeds in the seed bank, indicating the persistent nature of the seed bank. After dispersal the number of seeds in the seed bank showed an increase. In the laboratory test when the soil samples were watered ten species showed germination (Table 2) which is similar to the results given in Table 1.

Table 1. Seeds extracted from the soil samples collected at three different phenological states. (Mean m^{-2} ± standard error of mean from twenty samples).

Name of the species	Before rainfall	After rainfall	After dispersal	LSD ($P < 0.05$)
Tephrosia strigosa	28.1 ± 2.1	7.7 ± 1.4	26.7 ± 2.2	3.3
Aristida mutablis	14.0 ± 1.6	3.5 ± 0.9	17.0 ± 1.2	2.4
Eragrostis ciliaris	5.3 ± 0.7	2.6 ± 0.5	8.3 ± 1.5	2.2
Indigofera cordifolia	12.9 ± 1.7	4.7 ± 0.8	10.1 ± 1.1	4.3
Indigofera hochstetteri	16.8 ± 1.9	2.4 ± 0.4	11.3 ± 1.0	3.0
Blepharis sindica	2.0 ± 0.5	3.4 ± 0.5	1.3 ± 0.3	1.4
Calotropis procera	1.0 ± 0.0	-	-	0.5

The seed bank of *T. strigosa* persists in the soil with a large number of dormant seeds. The size of seed bank relies of the dispersal of seeds from the overlying vegetation. More species germinated in the soil samples than were found by manual extraction. Annual plant species in all soil samples germinated more than perennials or biennials presumably the perennial species produce dormant seeds (Hill *et al.* 1989) or reproduce by vegetative methods.

Most seeds germinated in the samples collected before rain, followed by the samples collected after seed dispersal. Minimum number of seeds germinated in the second collection (after rainfall) suggested that a large fraction of seeds were washed deep down so that they could not emerge or their numbers declined due to rapid germination after the monsoon showers. The seed bank flora showed a high similarity to that of existing vegetation. A close relationship of the seed bank and overlying vegetation was also reported by McIntyre *et al.* (1989) and Leck and Simpson (1987) of fresh water tidal wetlands. *T. strigosa* possesses a persistent seed bank in the soil, a large fraction of which germinate each year after monsoon showers. But synchronous germination of all annual species in an area leads to interspecific competition and increases the probability of density-dependent mortality in juveniles. It is likely that timing of germination has a greater impact on plant survival than buried seed reserves.

Demography : Emergence of *T. strigosa* after rains during 1988 and 1990 growing season is presented in Fig. 1. Mean plant density per quadrat was higher (33.7 ± 4.90 plant m^{-2}) in 1988 than in 1990 (17.3 ± 0.02 plant m^{-2}). After initial recruitment during first five days there was a substantial decrease after ten days and the population density remained unchanged until seed set started and at this period a significant ($P < 0.05$, LSD = 4.4) reduction in density was recorded. More or less similar patterns were observed during 1990 growing season.

Table 2. Germination of seeds in soil samples collected at three different phenological states (Mean m^{-2} ± standard error of mean for twenty samples).

Name of the species	Before rainfall	After rainfall	After dispersal
Tephrosia strigosa	20.2 ± 1.1	16.2 ± 2.4	19.4± 1.5
Aristida mutablis	7.5 ± 0.7	2.4 ± 1.5	6.6 ± 1.1
Eragrostis ciliaris	6.7 ± 1.4	3.2 ± 1.1	5.6 ± 0.7
Indigofera cordifolia	3.0 ± 0.6	2.2 ± 0.1	2.7 ± 0.5
Indigofera hochstetteri	3.5 ± 0.5	3.0 ± 2.2	3.0 ± 1.4
Corchorus depressus	1.9 ± 0.6	1.0 ± 1.4	1.9 ± 1.2
Blepharis sindica	1.5 ± 0.5	1.8 ± 1.2	2.5 ± 0.2
Calotropis procera	-	1.0 ± 0.0	-
Prosopis juliflora	-	-	1.2 ± 0.1
Semma holosericea	-	1.0 ± 0.0	-

The buried seed pool gives rise to a large seedling population. Seedlings of both the years had high mortality. With the passage of time, the plants grow, mature and produce large number of seeds. After seed set, the population of *T. strigosa* was reduced to the seed bank until another summer rainfall.

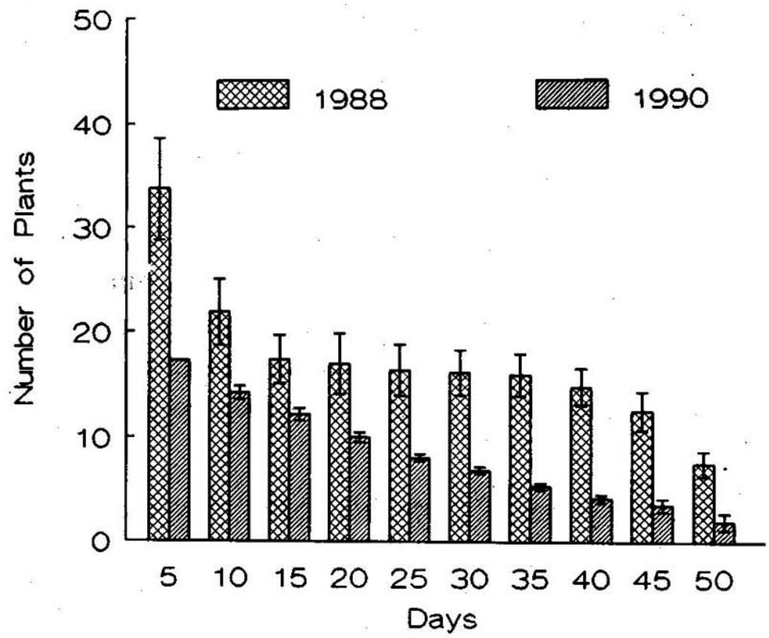


Fig. 1. Survivorship curve of *Tephrosia strigosa in* 20 × 20 cm quadrats during 1988 and 1990 growing seasons.

T. strigosa was observed to complete its life cycle from germination to seed production in 50 days in both dry and wet seasons during 1988 and 1990. The rate of mortality in *T. strigosa* was high in the seedling stage of plant growth. Similar patterns were also reported in *Rubus* *idaeus* and *R. pubescens* (Whitney 1986), *Cakile edentula* (Payne and Maun 1984) and *Floerkea proserpinacoides* (Smith 1983). Death risk of *T. strigosa* may also be associated with some grazing or trampling in the study area. Germination in both the dry and wet seasons began soon after the monsoon showers. Significantly higher germination percentages were recorded during 1988 and a large number of seedlings died before reproduction or had low fecundity.

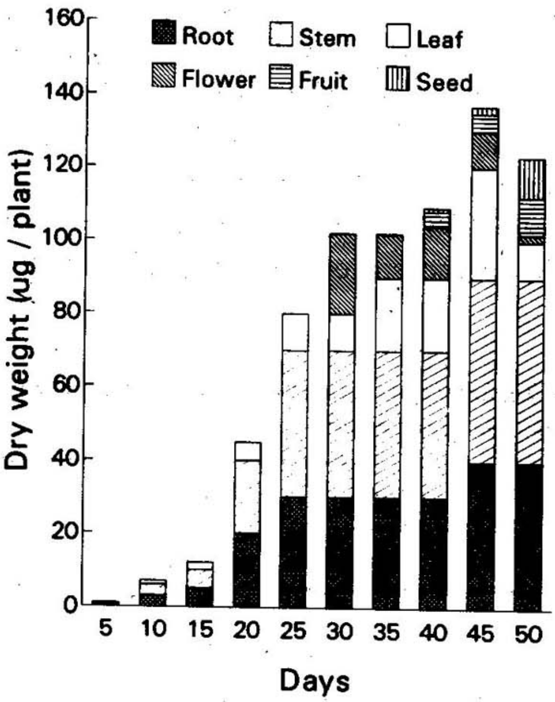
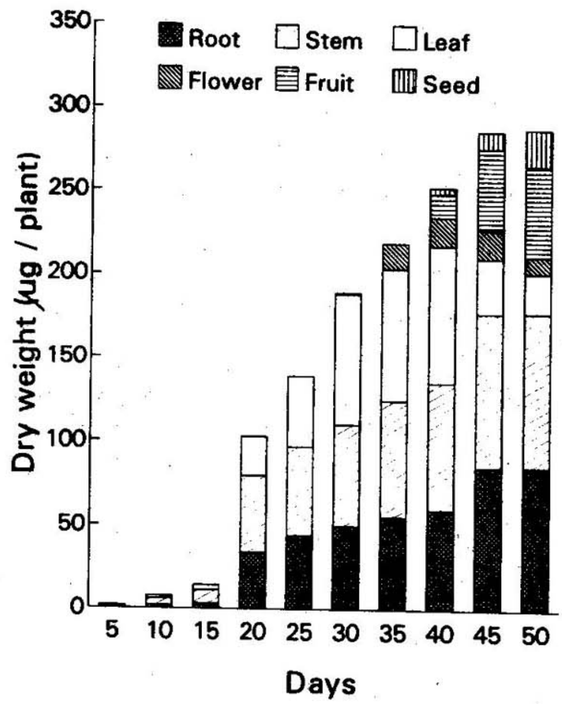


Fig. 2 (a): The vegetative and reproductive performance of *Tephrosia strigosa* during 1988 growing seasons.



(b): The vegetative and reproductive performance of *Tephrosia strigosa* during 1990 growing seasons.

Growth : Density has its most striking influence on plant size. The size of the seedlings was more or less similar in the beginning of 1988 and 1990, but as the intraspecific competition increased, the growth of *T. strigosa* individuals slowed down considerably. Lower mean plant size of summer annuals when subjected to high density was also reported for *Erucastrum gallicum* (Klemow and Raynal 1983), *Viola* (Newell 1982) and *Solidago semperivens* (Cartica and Quinn 1982).

Leaf emergence in *T. strigosa* was observed after six or seven days of germination (Table 3). At the initial stage of the life cycle leaf production was slow. However, around 40 days of growth a significant increased in number of leaves was noted. This increase was more in 1990 populations which could be attributed to higher rainfall, 86 mm, during August 1990 as compared to 8 mm in 1988.

Growth of *T. strigosa* seedlings as a function of increase in dry weight is presented in Fig. 2. The data indicate a substantial increase in dry weight during initial stage of the life cycle with slow growth at flowering and fruiting after 30 days of growth. Total biomass producd by the plants was much higher during 1990 growing season than 1988 which could be attributed to higher rainfall during 1990. The increased productivity during 1990 growing season also resulted in the greater allocation to the reproductive part of the plant.

During each season, leaf production and growth continued till the plants were 45 days old, where leaf emergence and vegetative growth of plants ceased. At the end of the experiment, the number of leaves per plant in 1990 was far more than in 1988, probably due to higher plant density which is inversely proportional to plant growth. The decrease in number of leaves and tillers due to high plant densities has also been reported by Langer (1956), Kays and Harper (1974), and Granier and Roy (1988), Lower number of leaves could also be attributed to low rainfall during the 1988 growing season or could be the function of drought and density.

Table 3. The vegetative and reproductive performance of *Tephrosia strigosa* individuals during 1988 and 1990 growing seasons (Mean number /plant ± standard error).

Days	Leaves		Flowers		Fruits		Seeds	
	a	b	a	b	a	b	a	b
5	-	-	-	-	-	-	-	-
10	1.1	1.0	-	-	-	-	-	-
15	1.5	1.7	-	-	-	-	-	-
20	2.5	3.8	-	-	-	-	-	-
25	3.2	4.0	-	-	-	-	-	-
30	4.2	4.3	1.0	1.0	-	-	-	-
35	4.5	4.8	2.0	2.2	-	-	-	-
40	5.7	5.9	2.0	3.1	0.3	1.9	5.0	11.8
45	7.8	11.0	1.4	1.8	1.1	5.6	7.5	28.3
50	7.5	10.3	1.1	1.0	2.4	5.9	25.3	5.4
LSD ($P < 0.05$)	1.0	0.9	0.4	0.4	1.7	0.8	2.0	2.4

a = 1988, b =1990.

Reproduction : During both the growing seasons onset of flowering occurred after about 30 days and continued up to the last days of the life cycle. Flowers were produced singly in the axil of leaf. The number of flowers produced per plant, was hardly more than two. The flowering data of the two seasons showed a similar pattern. Fruit formation started after around 40 days of growth and number of fruits produced were found significantly ($P < 0.05$, LSD = 0.85) higher in 1990 which could be attributed to the better vegetative performance of the palnts.

Seed production commenced around 40 days of growth (Table 3). High seed production during 1990 growting season could be attributed to high vegetative performance in response to high moisture availability due to rainfall.

Timings of flowering and fruiting were same in both 1988 and 1990 growing seasons, but the amount allocated to reproduction was higher during 1990 growing season. Lower number of flowers and fruits during 1988 growing season could be due to low moisture. Similar results were reported in *Urtica urens* (Boot *et al.* 1986) and *Tusdalia nudicaulis* (Newman 1965).

Populations of *T. strigosa* maintain a persistent seed bank in which seed number substantially increased after seed dispersal and decreased after rainfall. During the wetter season, a large number of seeds germinate and there was a high mortality of seedlings. The growth of remaining seedling was dependent on the availability of moisture. More moisture results into healthier and larger seedlings with higher reproductive allocations and fecundity. Reproductive allocations could be as high as 30% of the total biomass.

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