J. Phytol. Res. **21**(2) : 301-305, 2008

SEED DYNAMICS OF *INDIGOFERA TRITA* L. IN A PARTIALLY DISTURBED TROPICAL DRY DECIDUOUS FOREST

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Seed dynamics of *Indigofera trita* was studied by evaluating its seed production and the fate of buried seed under two depths in the soil over a two-year period in R R College campus, Alwar in north-east Rajasthan. The seed production was estimated in four study sites. *Indigofera trita* produced about 1707 seeds per m2 even in the highly disturbed Hajipur forest area, however, the seed production doubled in the partially disturbed R.R. college campus (3421) and tripled in the protected areas in R R college (4955) and the Bala-fort forest area (5751). Although it produces enormous seeds, about 740 seeds per m2 were collected only from the depth of 2.5 cm soil in R.R. college campus. The recovery of buried seeds declined constantly at 0.5 cm soil depth with 65 percent at the end of first year, however, it decreased rapidly to 27 percent in the second year of the study. On the contrary, the recovery of buried seeds was almost unchanged at 2.5 cm soil depth with 83 percent recovery at the end of two-year study period. The survivorship of viable seeds decreased constantly to 22 percent at 0.5 cm soil depth whereas it remained 87.33 percent under 2.5 cm soil depth at the end of two year of study. A large fraction of the viable seeds of *Indigofera trita* entered into enforced dormancy after their burial in the soil while a small fraction acquired induced dormancy. The fraction of buried seeds that acquired induced dormancy was higher at 2.5 cm soil depth as compared to those buried at 0.5 cm soil depth.

Keywords: Buried seeds; Enforced dormancy; Induced dormancy; Soil depth.

Introduction

Seed dynamics concerns with the study of seed input and output with reference to soil seed populations. The seed input to the soil seed pool depends upon the seed production by the growing plant populations every year. The enormous seed production by weeds helps them in maintaining their populations[1,2]. However, the number of seeds reaching the soil seed bank is limited by various environmental factors. A large fraction of the total seeds produced is carried away by wind and water to distant places. Predation and grazing of seeds also affect the number of seeds entering the seed pool[2-7]. Seeds in the seed bank acquire different types of dormancy to prevent germination as described by Harper[4].

Buried seed population of weeds in undisturbed areas showed exponential decrease when fresh input of seeds was stopped[5,8-10]. A large number of weedy species studied by Roberts and Feast[11] and Roberts[12] showed rapid loss of viability, and the seeds of only a few species could survive for more than five years. However, the seeds of certain species have been reported to remain viable for considerably long durations[13-15].

The composition of seed bank of several microhabitats has been studied in Central Monta Desert of Argentina[16]. Tobe *et.al*[17] observed that vertical distribution of seeds in sand determines the proportion of seeds that germinate after precipitation in Chinese desert. The literature reveals that no work has been done on the seed dynamics of *Indigofera trita* selected for the present study. The results obtained from field observations on the seed production of this species, the size of its seed bank in soil and the fate of the buried seeds over a two year period have been discussed in the present study.

Material and Method

Seed Production- The reproductive parameters like percentage of fertile plants, number of pods and seeds per plant, number of seeds per pod, and number of seeds per m^2 of *Indigofera trita* were estimated in the permanent quadrats fixed for the demographic studies at R R College campus. The reproductive measurements were also taken in October, November 2001 and 2002 on the study site at the Bala Fort and Hajipur village near Alwar.

Soil seed bank-For estimating the soil seed population five soil cores of 10x10x10 cm size including plant litter present on the surface were taken from five different places near the permanent quadrats from the study site at R.R.College campus. Soil samples were taken in the last week of November 2001 when the seed dispersal was over.

The soil cores were brought to the laboratory and sliced depth-wise in four equal parts. The soil was air-dried and then sieved carefully through a fine sieve to discard soil particles. The remaining material was washed thoroughly and air-dried. Now the seeds of *Indigofera trita* were sorted with the help of a bull lens. The sorting of any given lot was done twice to ensure accuracy in seed recovery. The seeds from various soil samples were recovered and counted separately. The germination of these recovered seeds was observed by putting seeds on moistened layer of cotton overlain by filter paper in the petriplates. Five replicates were taken. The germination experiment was carried out at 32°C temperature. The laboratory test indicated that this temperature was optimum for seed germination of *Indigofera trita* and therefore, in all the cases the germination was tested under this temperature. The observations were continued till the maximum germination was achieved. The seeds that failed to germinate in the petriplates were tested for viability by soaking them in 0.1% triphenyl tetrazolium chloride (TTC) solution and incubating them for 3 days at 25°C[18]. The seeds, which did not show pink colour after soaking in TTC solution, were considered as dead.

Survivorship of seeds in soil-Mature seeds of *Indigofera trita* were collected in October-November 2000 from the study site situated at Alwar. The seeds were air dried and stored in paper bags at 25°C. Sixty-six lots comprising 50 seeds each were counted. Thirty three lots of seed were kept at 0.5 cm depth and 33 lots at 2.5 cm depth in unglazed earthen pots (size 6.35 cm internal diameter and 8.9cm depth) which were filled with soil taken below the 4 cm soil depth where the occurrence of buried seeds was negligible. The soil was homogenously mixed and then filled in the pots. A small hole was made at the bottom of the pot for avoiding water logging and for allowing free movement of soil organisms. These pots were buried in soil in such a way that the seeds of one lot were at 0.5 cm depth and the other lot at 2.5 cm depth from the soil surface. The top of the pots was kept uncovered. Similarly, a control set of 33 pots was kept by filling the pots with the same soil but without seeds to account for the seeds already present in the soil. The experiment was started in January 2001 and observations were taken at bimonthly intervals from March 2001 to January 2002 and quarterly intervals from April 2002 to April 2003. At each observation period three replicate pots from two different depths and control treatment were dug up and brought to laboratory. The earthen pots were emptied and the soil collected and air-dried. The rest of the procedure was same as described under 'soil seed bank' study.

Result and Discussion

Seed production-The number of fertile plants per m² of *Indigofera trita* was maximum in the fenced area of R.R.College campus while it was minimum in Hajipur village. In the former case the fencing was done in the beginning of the experiment to exclude grazing animals completely whereas in Hajipur village the study site was heavily grazed area. The observations show that grazing is one of the important factors in determining the seed production of *Indigofera trita*. The other reproductive parameters such as number of pods per plant and number of seeds per plant was maximum in case of the Bala fort which is a protected area and all types of grazing is totally prohibited (Table 1). The number of seeds per m² was maximum in the Bala fort area followed by fenced area of R R College campus for the reason that plants in the Bala fort area were older and thus produced more pods as compared to the younger plants of fenced area of R.R.College campus. However, the results obtained also suggest that *Indigofera trita* produce sufficient number of seeds per m² even in grazed area for maintaining its population.

Germination and viability of seeds- The seeds of *Indigofera trita* are quite small in size and very light in weight. The average weight of a seed was found to be 0.0023 gms. The seeds have a tough seed coat. The

Table 2. Seed characteristics of *Indigofera trita* (±S.E.)

Average seed size (mm)	1.77X1.13
Average seed weight (g)	0.0023± .0006
Viability (%)	96.4 ±0.6
Germination (%) (Freshly collected seeds)	13.6 ±0.5
Germination (%) (Chemically scarified seeds)	91.2 ±0.6

Table 1. The seed production of *Indigofera trita* in relation to grazing and under different habitats in Alwar (S.E.)

	Hajipur	Balafort	R R College Fenced	R R College Grazed
Average number of fertile plants per m²	4.2±0.9	9.6±1.5	17.4±1.7	12.8±1.8
Number of pods per plant	61±11	72±5	33±2	34±0.8
Number of seeds per healthy pod	7.3±0.2	8.5±0.2	8.6±0.1	7.9±0.2
Number of seeds per plant	443±82	609±46	288±18	267±7
Number of seeds per m²	1707±383	5751±956	4955±419	3421±510

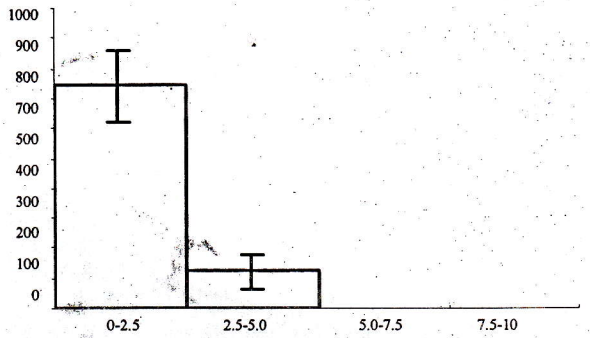

Fig. 1. Number of seeds of *Indigofera trita* present at different depths of soil after the dispersal of a fresh crop of seeds.

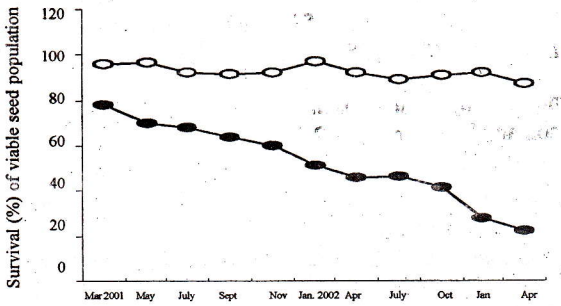

Fig. 2. Survival of the viable buried seed population of Indigofera trita at two different depths; seeds at 0.5 cm depth (-•-) and at 2.5 cm depth (-o-).

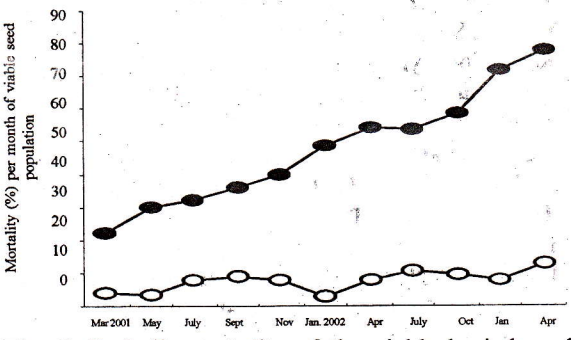

Fig. 3. Periodic mortality of the viable buried seed population of Indigofera trita at two different depths; seeds at 0.5 cm depth (-•-) and at 2.5 cm depth (-o-).

viability of seeds was found to be 96.4 percent. When freshly collected seeds were kept at 32°C for germination, it was found to be only 13.6 percent (Table 2). The seeds were chemically scarified with conc. H_2SO_4 for 10 minutes and then the germination was observed to be 91.2 percent. Hence seeds of *Indigofera trita* exhibited 96 percent viability, and dormancy due to hard seed coat.

Soil seed bank- The number of seeds of *Indigofera trita* present in soil was low, out of which most of the seeds were present in the topsoil layer (uppermost 2.5 cm) and a small fraction of seeds were also present in deeper layer (2.5-5 cm depth). No seed was found to be present below the 5 cm depth of soil (Fig 1). The less number of seeds in the soil may be attributed to grazing and low rainfall, which reduces seed rain in this species.

The percentage of viable fraction and seed germination of recovered seeds was higher as compared to freshly collected seeds. The higher germination of seeds recovered from soil as compared to that of fresh seeds may be attributed to the breakage of seed coat dormancy due to the influence of rainfall and temperature and the action of soil microbes.

Fate of seeds in soil-The survivorship of viable seed population of *Indigofera trita* decreased constantly at 0.5 cm soil depth throughout the study period. This is in conformity with observations made by the other workers[2,5,8,9,19]. However, Bell and Clarke[20] reported consistently high viability and very low decomposition rates in buried seeds in *Eleocharis* spp. The buried viable seed population exhibited almost constant death rate throughout the study period (Fig 2). Although percent mortality had been very high in the seeds buried at 0.5 cm depth as compared to the seeds at 2.5 cm depth. In contrast to seeds buried at 0.5 cm soil depth, the seeds buried at 2.5 cm depth exhibited higher viability over a two-year study period (Table 3). This indicates that decrease in number of viable seeds with time at 0.5 cm soil depth may be due to germination of seeds. This finds support from Bonis *et al.*[21] who reported the decrease in number of seeds in soil seed bank due to germination and seeds present on soil surface exhibited high germination.

The mortality of buried viable seeds was observed continuously over a two-year study period, although it was relatively higher in June and July at 0.5 cm soil depth and July to November at 2.5 cm soil depth (Fig 3). However, the mortality of seeds was very low at

Table 3. Fraction of germinable, viable but dormant and non-viable seeds of the total seed population of *Indigofera trita* recovered from 0-2.5 cm and 2.5-5.0 cm soil depth in natural field conditions. (± S.E.).

Parameter	Seeds recovered from 0-2.5 cm depth	Seeds recovered from 2.5-5 cm depth
Number of seeds per m^2	740±121	120±58
Germinable fraction (%)	29.7±0.6	33.3±0.3
Viable but dormant fraction (%)	67.6±0.8	66.7±0.9
Nonviable fraction (%)	2.7±0.2	0

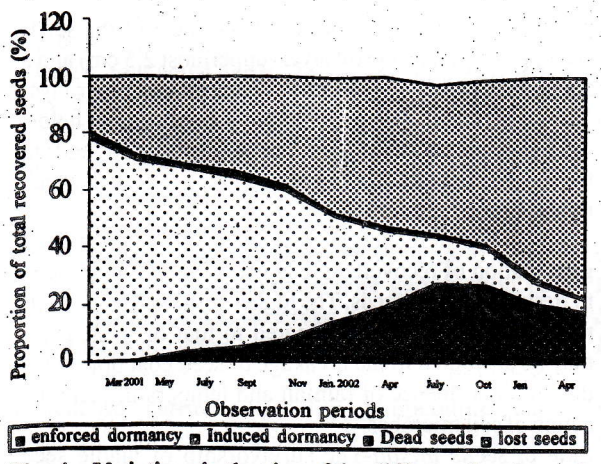

Fig. 4a. Variations in the size of the different fractions of the buried seed population of *Indigofera trita* (at 0.5 cm depth) under field conditions.

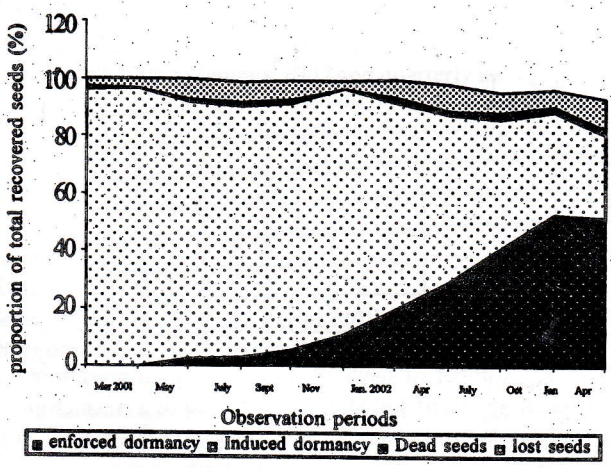

Fig.4b. Variations in the size of the different fractions of the buried seed population of *Indigofera trita* (at 2.5 cm depth) under field conditions.

2.5 cm soil depth, which exhibit that pathogens and other soil microbes do not destroy seeds of *Indigofera trita* at least for over more than two years. The recovery of buried seeds of *Indigofera trita* declined constantly during the two-year study period; however, it decreased rapidly in the second year of study (Fig 4a and b). After two years of study period 83 percent of seeds were recovered from 2.5 cm depth while only 23 percent from the seeds buried at 0.5 cm depth. This may be attributed to the loss through run-off water and impact of seed predators, which is more intense at the surface of the soil. These observations suggest that at 0.5 cm soil depth the seed germination was high due to availability of sufficient light whereas the seeds buried at 2.5 cm soil depth might have undergone enforced dormancy in the absence of light. This is in conformity with Yadav and Tripathi[2] who suggested that seeds of *Eupatorium* sp. might acquire enforced dormancy at 2cm soil depth due to the non-availability of light. This is also in agreement with Wesson and Wareing[22] and Black[23] who suggested that seeds might acquire dormancy in the absence of light when buried in soil. A large fraction of seeds buried in soil acquired enforced dormancy, however, the number of seeds under induced dormancy increased while those under enforced dormancy declined constantly with time. On the contrary, the recovery of buried seeds was almost unchanged at 2.5 cm soil depth over a two-year study period. However the number of buried seeds that acquired induced dormancy was higher at 2.5 cm soil depth as compared to those buried at 0.5 cm soil depth. Further, the seeds buried at 2.5 cm soil depth acquired more induced dormancy than enforced dormancy. The reason for which *Indigofera trita* seeds acquire dormancy may be the absence of light as suggested by Wesson and Wareing[22] and Black[23] or may be in response to relative concentration of CO_2 and O_2 in soil atmosphere[4].

Acknowledgement

The financial assistance received from University Grants Commission, New Delhi by V N Dey is gratefully acknowledged.

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