J. Phytol. Res. 20(2) : 265-269, 2007

ECOLOGY OF *CASSIA TORA* L. IN THE SARISKA TIGER RESERVE FOREST IN RAJASTHAN

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Seed characteristics and growth behaviour of an invasive species, *Cassia tora* were studied in various micro-environmental situations in the Sariska reserve forest in north-east Rajasthan. Soil moisture content was observed to be the main factor which influences its different phenophases. It exhibited higher vegetative growth and seed production at the base as compared to the middle and top of the hill slopes. *Cassia tora* showed not only the plastic reduction in vegetative and reproductive growth but also in the number of seeds per pod and seed size even in the same plant.

Keywords : *Cassia*; Ecology; Sariska reseve forest.

Introduction

The preliminary ecological study of several weeds has been carried out in India[1]. The taxonomy and ecology of *Ipomoea carnea* have been reviewed[2]. Recently, Tripathi *et al.*[3] have reviewed the biology of *Eupatorium* spp. growing in India. The ecological studies have also been carried out on *Ruelia tuberosa*[4] and *Achyranthes aspera*[5,6].

Cassia tora is a dominant weed during rainy season in the semi-arid region of Rajasthan. It was introduced originally from Tropical America[1,7] and is a very common weed all over the area along roadsides and in the wastelands. Its autecology has been studied at Varanasi[8]. In last few decades it has been observed that *Cassia tora* has invaded the core area of the Sariska reserve forest and grows luxuriantly as a pure crop at the base of the hill slopes and in the valleys threatening the survival of indigenous herbaceous species. It is, therefore, imperative to study the biology of *Cassia tora* in this forest which may be valuable for the control of this weed. Hence, the present study was carried out to evaluate seed characteristics and growth behaviour of *Cassia tora* in the Sariska Tiger Project.

Materials and Methods

The study site: The ecology of *Cassia tora* was studied in the Sariska reserve forest which is located in Alwar district in the north-eastern part of Rajasthan (76°17' to 76°34'E and 27°5' to 27°33' N). It is a tropical dry deciduous thorn forest according to the criteria of classification of forest given by Champion and Seth[9]. The topography of the Sariska reserve is hilly with valleys at an altitude of 380m and the peak of hill slopes as high as 620m above sea level. The soil is deep and sandy loam in the valleys and shallow and mixed with gravel and small pebbles on the hill slope. It is slightly alkaline with pH varying from 7.5 to 8 (Table 1). The climate is monsoonal type with an average annual 650mm rainfall which mainly occurs during the rainy season from July to September. Summer season is from mid of March to June which is extremely hot and dry with maximum temperature rising to 45°c and winter season is from October to February with minimum temperature approaching 4°c in the month of December and January.

The biology of *Cassia tora* was studied in the Kalighati forest and the Slopka forest in the core area of the Sariska reserve forest. Mature fruits of *Cassia tora* were collected in October 2004 and seeds were taken out and stored in paper bags at room temperature in the laboratory. These seeds were used to determine various seed characteristics. Seed germination was studied by soaking the seeds in distilled water for 24 hours and then putting these on Whatman No.1 filter paper overlain by a thin cotton layer in petri dishes. The filter papers were moistioned with distilled water and placed in a BOD at 32°C. Seed polymorphism in *Cassia tora* was evaluated by collecting seeds from the fruits of individual plants.

The growth behaviour of *Cassia tora* was evaluated by laying 20 quadrats of 1m² each in the valley, at the base, middle and top of the hill slopes of various aspects in the study site. The east-facing and west facing hill slopes were selected in the Kalighati forest and north and south facing hill slopes in the Slopka forest as the hill ranges were running from north to south in the latter forest and east to west in the former forest. The density of *Cassia tora* was estimated for each micro-environmental situation.

Table 1. Soil depth, soil pH, soil organic carbon and available light intensity in different micro-environmental situations in the Sarsika reserve forest (±S.E.).

Micro environment	Light intensity (100xLux)	Soil depth (cm)	pH	Organic carbon (%)
Valley	1026 ± 105	>1 m	8.1 ± 0.01	1.31 ± 0.01
Base of hill slope	1093 ± 90	10.4 ± 0.8	7.5 ± 0.01	0.88 ± 0.01
Middle of hill slope	880 ± 113	11.0 ± 0.8	7.7 ± 0.02	0.7 ± 0.05
Top of hill slope	520 ± 215	4.4 ± 0.4	7.5 ± 0.01	0.1 ± 0.74

Table 2. Seed characteristics of *Cassia tora* (±S.E.).

Seed Characteristics	Seed Size		
	Category I	Category II	Category III
Seed length (mm)	4.33 ± 0.24	5.33 ± 0.19	6.25 ± 0.12
Seed width (mm)	1.45 ± 0.05	2.5 ± 0.016	2.25 ± 0.22
Seed shape	Cylindrical	Cylndrical one side flat with a prominent beak	Cylindrical one side flat with a small beak
Seed Colour	Brown	Greenish brown	Dark brown
Seed Surface	Smooth	Hairy	Hairy
Seed Weight (g)	0.11 ± 0.03	0.28 ± 0.05	0.30 ± 0.06
Dormancy	Seed coat dormancy	Seed coat dormancy	Seed coat dormancy
Viability (%)	100	100	100
Germination after scarification (%)	100	100	100

Ten plants of *Cassia tora* were uprooted along with roots from each micro-environmental situation in September, 2005. The vegetative and reproductive characters were estimated. Then, the root, shoot and reproductive parts of each plant were separated and dried in a hot air oven at 80°C for 48 hours to obtain the dry biomass following Misra[10]. The available light intensity was estimated at noon in different microenvironmental situations by portable luxmeter in the study site (Table 1).

Results and Discussion

(a) Seed characteristics : *Cassia tora* exhibits seed polymorphism as seed size and shape was highly variable among the seeds obtained from a single plant (Table 2). On the basis of size, seeds of *Cassia tora* were grouped into three categories: (1) the smallest seeds (4.3 x 1.5mm) were smooth, cylindical, brown colour and with 0.11 g weight,(2) the medium size seeds (5.3 x 2.5mm) were rough, cylindrical one side flat with a beak, greenish brown, hairy with 0.28 g weight, and (3) the largest seeds (6.3 x 2.3mm) were rough, cylindrical one side flat with a small beak, dark brown, hairy and with 0.30g weight. Despite great variation in the seeds obtained from the same

Table 3. Average density m^{-2} of the *Cassia tora* in different micro environmental situations in the Sariska reserve forest (±S.E.).

Sites	Kaligahti Forest		Slopka Forest	
	East facing	West Facing	South Facing	North facing
Valley of the hill slope	121.1 ± 17.2		72.5 ± 14.3	
Base of hill slope	135.47 ± 19.24	126.07 ± 19.9	70.42 ± 12.74	43.8 ± 4.64
Middle of hill slope	138.39 ± 16.18	23.67 ± 4.01	45.3 ± 10.98	25.2 ± 2.25
Top of hill slope	14.8 ± 3.24	8.57 ± 2.34	10 ± 3.8	3.08 ± 0.91

Table 4. Vegetative and reproductive characteristics, and biomass production of *Cassia tora* in different micro environmental situations in the Sariska reserve forest at the third harvest (±S.E.).

Parameters	Valley	Base of hill slope	Middle of hill slope	Top of hill slope
Plant height (cm)	86.6 ± 12.40	85.2 ± 10.64	94 ± 9.41	37.6 ± 3.51
Basal area per plant (mm^2)	4.48 ± 0.61	5.28 ± 0.98	4.21 ± 1.1	2.57 ± 0.35
Number of leaf per plant	71.8 ± 13.88	96.6 ± 50	22.6 ± 6.6	21.8 ± 7.76
Leaf area per plant (cm^2)	2757.12 ± 533	3129.84 ± 1619	969.54 ± 282	483.96 ± 172
Number of pods per plant	33.5 ± 2.5	46.75 ± 9	36 ± 1.67	7.3 ± 0.97
Number of seeds per pod	19.2 ± 1.4	17.5 ± 1.20	16.3 ± 0.66	14.4 ± 1.33
Number of seeds per plant	643.2 ± 29.5	818.12 ± 31.2	586.8 ± 2.3	105.12 ± 2.2
Shoot biomass per plant (gm)	15.08 ± 3.9	17.7 ± 8.2	9.94 ± 4.65	2.31 ± 0.53
Root biomass per plant (gm)	2.42 ± 0.65	2.05 ± 0.86	1.28 ± 0.59	0.25 ± 0.1
Biomass per plant (gm)	17.5 ± 4.1	19.75 ± 9.14	11.22 ± 5.2	2.56 ± 0.69

plant, all type of seeds exhibited seed coat dormancy and 100 percent viability and germination at room temperature in rainy season after scarification treatment.

(b) Phenology: Seed germination commenced in the month of June with the arrival of pre-monsoon rains. The vegetative growth continued through July. Flowering initiation occurred in the first week of August and attained peak by end of August. Fruit initiation began at the end of August and attained peak in September. The pods were mature by October. The senescence of plants occurred in October and November. The pods remained attached to the dried plants. Dehiscence of pods occurred slowly in the next summer season.

(c) Population density : The average population density of *Cassia tora* was 121 plants m^{-2} in the Kalighati forest and 73 plants m^{-2} in the Slopka forest (Table 3). The low density in the Slopka forest may be due to more vigorous growth of *Cassia tora* as compared to the valley of the Kalighati forest which led to thinning of population in the former site, It may be attributed to high soil moisture content in the narrow Slopka forest valley. The population density of *Cassia tora* was 135 plants m^{-2} at the base whereas 15 plants m^{-2} at the top of the east facing hill slope. Similarly, the decrease in population density of the weed from the base of the hill slopes with increase in altitude was also observed on the rest of the three aspects of the slope. This decline in the population density may be attributed to decrease in soil depth and loss of seeds due to run off water along the elevation of hill slopes. The low population density at the top of hill slopes also contribute to less seed production which in turn resulted in less seedling recruitment. The aspects of hill slope also influenced the density of *Cassia tora* with low density on the north-facing slope and high density on other aspects of hill slopes (Table 3). The low density of *Cassia tora* on north facing hill slope may be due to availability of less light intensity.

(d) Vegetative Characters : The height of *Cassia tora* plants was 87cm in the valley whereas it was 85, 94 and 38 at the base, middle and top of the hill slope respectively

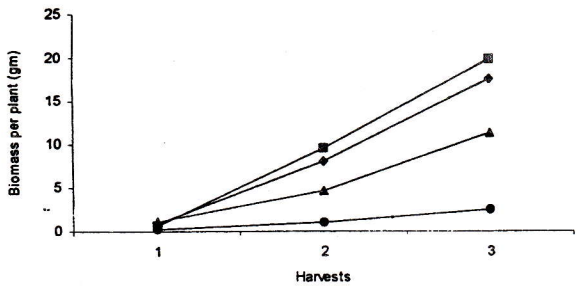

Fig.1. Biomass per plant of *Cassia tora* in different micro-environmental situations in the Sariska reserve forest ; Valley (♦), base of hill slope (■), middle of hill slope (▲) and top of hill slope (•)

(Table 4). Similar trend was observed with respect to basal area per plant. This also suggests that the growth of *Cassia tora* decreased along the elevation of hill slope.

(e) Seed production : Cassia tora produced 643 seeds per plant in the valley whereas 818, 587, and 105 seeds per plant at the base, the middle and the top of the hill slope respectively (Table 4). Similar, trend was observed with respect to the number of pods per plant and the number of seeds per pod. These observations indicate that reproductive potential of *Cassia tora* declines with increase in altitude of the hill slope. The decrease in number of seeds per pod also suggests that it exhibits high plasticity with change in environmental conditions.

(f) Biomass production : Biomass production per plant was 18 g in the valley whereas 20, 11 and 3 g at the base, middle and top of the hill slope respectively (Table 4). Shoot biomass and root biomass also exhibited similar trend. The high biomass production at the base of slope suggests that *Cassia tora* exhibits better growth at the base of hill slopes as compared to other microenvironmental situations which may be attributed to the high light intensity available at the base of slope. However, the root biomass production was highest in the valley and lowest at the top of the hill slope. The biomass production per plant suggest that the growth rate of *Cassia tora* was maximum in valley in the first month of growth whereas it became more at the base of the hill slope in the second and third month of growth (Fig. 1).

Seeds of *Cassia tora* obtained from a single plant exhibited variations in different seed characteristics, although seed viability and germination after scarification were 100 percent in all different categories of seeds. Seed polymorphism with individuals producing either tubercled or smooth seeds has been observed in three species of *Silene* of the Nordic region[11]. Seeds of various sizes and colours with differences in germination percentage of *Atylosia scarabaeoides*, a legume has also been reported[12]. Similarly, Thakur and Thakur[13] reported seed polymorphism in *Robinia pseudoacacia* producing black, brown and grey coloured seeds, in which black seeds showed higher germination and emerging seedlings showed best growth performance. Incase of *Cassia tora* individual plant and even individual pod produced seeds of variable shape, size and colour which donot exhibit variation in viability and germination. However, the number of seeds per pod was observed to be a constant character in *Indigofera trita*[14]. Thus, the variation in the characteristics of seeds obtained from the same plant in *Cassia tora* may be due to plastic reduction in growth under unfavourable conditions at the end of the growing season. The decrease in number of seeds per pod and also variation in the size, shape and weight of seeds even in one individual plant indicate that this weed exhibits considerable plasticity under different environmental situations. Seeds of *Cassia tora* exhibited hard seed coat dormancy which was broken by chemical and mechanical scarification. Hard seed coat dormancy has also been reported in seveal leguminous species[15-17].

Cassia tora completes its life cycle during the rainy season, therefore, its various phenophases are mainly influenced by the soil moisture content. Population density of *Cassia tora* was maximum at the base of hill slopes and decreased with increase in elevation. Similarly it showed normal growth at the base of hill slopes and valleys, although the vegetative growth and seed production also decreased with elevation of hill slopes. This is in conformity with Yadav[18] who also observed that *Cassia tora* exhibited high density and basal area at the base as compared to the middle and top of the hill slope in the Balafort forest in Alwar district of Rajasthan. However, Krishnan *et al.*[19] reported that *Acalypha indica* showed the best growth at the top of the hill slopes in rainy season in Alagar hills, South India, and attributed it to higher width of top soil, natural reserve of nutrients and higher soil moisture at the top as compared to middle and base of hill slope. Yadav and Yadav[20] reported that different herbaceous plant species show normal growth performance at different elevations of hill slopes in the Balafort forest. The reduced growth of *Cassia tora* on the hill slopes may be attributed to decrease in light intensity due to thick tree canopy and also decrease in thickness of soil with increase in height of the slope in Aravali hills. It may be suggested that *Cassia tora* showed plastic reduction in vegetative and reproductive growth and exhibits considerable plasticity with respect to variation in the size, shape and weight of seeds produced by the same plant under

different micro-environmental situations.

Acknowledgements

The authors are grateful to the Chief Wild Life Warden, Rajasthan, Jaipur and the Field Director, Sariska Tiger Project for granting permission for doing field work in the Sariska Tiger Project. The financial assistance received by Ved Prakash Gupta in the form of SRF from University Grant Commission, New Delhi is gratefully acknowledged.

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