

DISTRIBUTION AND ECOLOGY OF *ACHYRANTHES ASPERA* L. IN ALWAR DISTRICT OF RAJASTHAN

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The distribution and ecology of *Achyranthes aspera* L. (Amaranthaceae) which grows as a ruderal weed in wastelands in the Alwar district of Rajasthan have been evaluated. Three varieties of this weed have been identified, i.e. *Achyranthes aspera* var. *argentea* which grows on the Aravalli hills and in adjacent plain areas, *A. aspera* var. *porphyristachya* is found along hedge of agricultural fields and railway tracts only in Alwar tehsil whereas *A. aspera* var. *aspera* is widely distributed throughout the district chiefly in plain areas. The populations of *A. aspera* var. *aspera* growing in different parts of Alwar district exhibited considerable plasticity with respect to height, leaf area per plant, biomass production, seed production and biomass allocation pattern to root, shoot and reproductive structures.

Keywords: Aravalli hills; Biomass; Ecological amplitude; Seed production.

Introduction

Studies on the ecology of various weeds have been carried out, such as on the distribution of *Cassia tora* in India¹ and *Eupatorium adenophorum* in Australia²; the autecology of *E. adenophorum*³; the population regulation of *Eupatorium odoratum*⁴; the taxonomy and ecology of *Ipomoea carnea*⁵ and the biology of *Cytisus scoparius*⁶. Krishnan *et al.*⁷ studied the effect of season and altitude on the growth of *Acalypha indica* and concluded that the best growth was observed in rainy season and at the top of the hill slopes.

Achyranthes aspera L. (Amaranthaceae) is a plant of medicinal value⁸, grows as a ruderal weed in waste lands, along road sides and railway tracts, and in the forest areas of the Alwar district. Three varieties of *Achyranthes aspera*, i.e. *A. aspera* var. *aspera*, *A. aspera* var. *argentea* and *A. aspera* var. *porphyristachya* have been reported from the Sariska forest^{9,10}.

However, the review of literature indicated that scarce information is available about the ecology of *Achyranthes aspera* in general and particularly so far no attempt has been made to study the ecology of this weed in Rajasthan. Hence, the present study was carried out to investigate the distribution and ecology of *Achyranthes aspera* in Alwar district of Rajasthan.

Materials and Methods

The Alwar district is situated between 27°4' to 28°4' north latitude and 76°7' to 76°13' east longitude in the north-eastern part of Rajasthan. The Aravalli mountain range covers the most part of the Thanagazi, Rajgarh and Alwar tehsils and form important features in Bansur, Kishangarh and Tijara tehsils¹¹. The presence of hilly terrain provides a wide variety of habitats throughout the district. The hills and valleys enclose fertile land and are covered by tropical

dry deciduous thorn forests according to the classification of forests¹². A large part of these forests have been degraded by human disturbance. The plain areas of the district are subjected to intensive agriculture.

The climate is monsoonal type with three distinct seasons in a year. The summer season commences from mid March and extends upto June with maximum temperature approaching 45°C, the rainy season is from July to mid September when 90 percent of average annual rainfall (650 mm) occurs and the winter season extends from October to February with minimum temperature nearing 4°C in the month of December and January, and occasional low rainfall also occurs during this period. The annual rainfall of different locations of Alwar district has been presented (Table 1).

The soil is sandy loam mixed with gravel, small stones and shallow on the hill slopes, and sandy loam and deep in the valley and plain areas. The soil characteristics of different localities in Alwar district were observed to be highly variable (Table 1). The soil pH varies from 7.5 at Bala-fort forest to 7.97 at the Hasan Khan Mewat site. Total dissolved salts (TDS) were lowest at Laxmangarh (0.11 at 10 ppt) and highest in soils of Tijara (0.71 at 10 ppt). The soil salinity varies from 0.066 at Hasan Khan Mewat site to 0.259 at 2 ppt in Tijara soil. The percent organic carbon was lowest (0.22) in the soil of Thanagazi and highest (0.85) in soil of Tijara. Bala-fort forest soils were poor in phosphorus (27 kg ha⁻¹) as compared to the soils of other localities. Potassium was estimated to be lowest in the soil of Tehla while maximum in the soil of Ramgarh and Rajgarh.

The distribution and ecology of the *Achyranthes aspera* was studied by selecting sites in each of the subdivisions of the Alwar district. In each selected study site, the wasteland areas were marked for taking observations

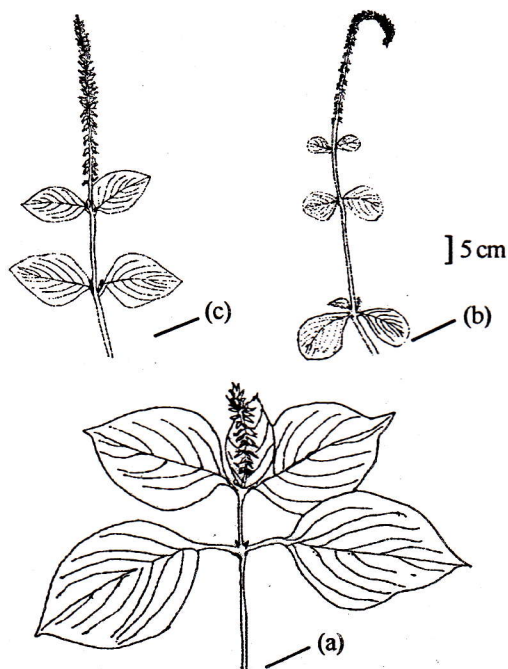


Fig.1. Flower and fruiting branch, (a) *Achyranthes aspera* var. *argentea*, (b) *A. aspera* var. *aspera* and (c) *A. aspera* var. *porphyristachya*.

where *Achyranthes aspera* was growing. Twenty quadrats of 1 m x 1 m were laid at random in each study site to evaluate the density of the population of *Achyranthes aspera*. Ten mature plants were uprooted along with roots from each study site and their height, number of leaves present and leaf area were recorded. Then the root, shoot and spike were separated and dried to constant weight for 48 hrs in a hot air oven for obtaining dry weight following Misra¹³. When the fruits were mature in December the number of fertile plants per m², the number of spikes per plant and the number of fruits per spike were estimated. Then the fruit/seed output per plant and m² area were calculated for each study site. *Achyranthes aspera* fruit contains only one seed, hence the fruit is mentioned as seed. These observations were taken from September 2004 to January 2005. Five soil samples were taken from 10 cm x 10 cm x 10 cm volume of soil from each study site. The soil of five samples for each site was mixed and then used to analyse the various soil characteristics in the laboratory¹⁴.

Results and Discussion

Physical description : Three varieties of *Achyranthes aspera* have been reported from Alwar district on the basis of the description of *A. aspera* var. *porphyristachya*¹⁵ and key given by Shetty and Singh¹⁰. *Achyranthes aspera* var. *argentea* (Thw.) Hook. f. is a small herb attaining a height of 58 to 104 cm in open deforested areas in the Aravalli

hills. Stem sparingly branched, quadrangular, flaccid with long internodes and pubescent (Fig. 1a). Leaves subsessile ovate lanceolate, entire, apex acuminate, silvery white below. Spike almost straight and flowers greenish white. *A. aspera* var. *aspera* L. is a robust perennial herb which is 35 to 86 cm tall (Fig. 1b). Stem stout, quadrangular becoming cylindrical when mature, tomentose. Leaves sessile or sub-sessile, obovate, almost rounded or obtuse at the apex, leathery and densely hairy. Spike long, penduncle thick, densely hairy, flowers reddish, fruits deflexed. *A. aspera* var. *porphyristachya* (Wall. ex Moq.) Hook. f. is a perennial herb growing 60 to 126 cm tall (Fig 1c). Stem is quadrangular, branched, purple in colour and almost glabrous when mature. Leaves petiolate, ovate or elliptic, acute, membranous, sub-glabrous or glabrous. Spike almost straight, penduncle slender, tomentose, flowers sparsely arranged, large size and pink coloured.

Distribution and Density : *Achyranthes aspera* is distributed throughout the Alwar district of Rajasthan. However, the species is represented by three varieties which grow in different habitats. *Achyranthes aspera* var. *aspera* is well distributed throughout the Alwar district in plain areas as well as in plateaus among the Aravalli hills. *Achyranthes aspera* var. *argentea* grows in the Aravalli mountain range on the hill slopes and at the base of hill slopes. *A. aspera* var. *porphyristachya* grows in Alwar tehsil along the hedge of agricultural fields.

The density of *Achyranthes aspera* var. *argentea* was 19 plants m⁻² at the Bala-fort forest whereas it was 0.3 plants m⁻² at Kotkasim (Table 2). The population density *Achyranthes aspera* var. *porphyristachya* was 16 plants m⁻² at Hasan Khan Mewat while that of *Achyranthes aspera* var. *aspera* varied from 10 m⁻² at the Bansur site to 39.8 m⁻² at the Dewanji ka bag site.

Height and leaf area : The height of *Achyranthes aspera* var. *argentea* was 58 cm on the hill slopes and 104 cm in the ungrazed plain area at Kotkasim (Table 2). The average number of leaves per plant was 19 and the leaf area per plant was 258 cm² in this variety. The height of plants of *A. aspera* var. *aspera* was maximum at Bansur (86 cm) and it was lowest (26 cm) at Diwanji ka bag. It suggests that height of plants is related to the density of *Achyranthes* in a given region. The number of leaves per plant in this variety was also 19 which is less variable character. The leaf area per plant was lowest 238 cm² at Hasan Khan Mewat and it was maximum 392 cm² at Tijara site. The average height of *A. aspera* var. *porphyristachya* was 126 cm and the number of leaves per plant were 54.

Fruit Production : The number of spikes per plant in *Achyranthes aspera* var. *asepra* were observed to be same in populations growing in various study sites (Table 3). However, the number of fruits per spike was lowest (75) in plants of *Achyranthes aspera* var. *aspera* growing at Behror

Table 1. Soil characteristics and annual rain fall of different localities in the Alwar district.

S.No.	Study Sites	pH	TDS at 10 ppt	Salinity at 2 ppt	Organic carbon (%)	P ₂ O ₅ kg/ha	K ₂ O kg/ha	annual rain fall mm
1	Bala-fort forest	7.55	0.15	0.073	0.67	27.00	450	584
2	Bansur	7.99	0.18	0.104	0.57	54.00	700	623
3	Behror	7.91	0.13	0.086	0.55	63.00	710	739
4	Diwan Ji ka Bagh	7.89	0.31	0.143	0.34	62.00	810	584
5	Hasan Kha Mewat	7.97	0.12	0.066	0.27	63.00	440	584
6	Ramgarh	7.92	0.13	0.078	0.74	135.00	1180	661
7	Rajgarh	7.85	0.23	0.132	0.45	63.00	1020	487
8	Laxmangarh	7.89	0.11	0.068	0.37	59.00	530	685
9	Thanagazi	7.59	0.24	0.128	0.22	61.66	450	682
10	Tehla	7.54	0.29	0.07	0.62	-	280	-
11	Tijara	7.69	0.71	0.259	0.85	65.00	300	804

Table 2. Density, height and leaf area per plant of *Achyranthes aspera* in various populations in Alwar district (\pm S.E.)

Localities	Density	Height of plant (cm)	No. of Leaf per plant	Average leaf area (cm ²)	Leaf area per plant (cm ²)
<i>A. aspera</i> var. <i>aspera</i>					
Behror	33.6 \pm 3.2	65.5 \pm 2.2	18 \pm 1.3	19.8 \pm 2.7	356
Bansur	9.9 \pm 0.9	86 \pm 1.7	1.5 \pm 1.3	16 \pm 1.3	296
Rajgarh	27.7 \pm 3.12	61.8 \pm 3.1	18.7 \pm 1.2	12. \pm 1.9	239
Ramgarh	24.6 \pm 2.3	67.5 \pm 12.5	17 \pm 0.7	18.2 \pm 1.6	306
Laxmangarh	28.2 \pm 4.5	52.7 \pm 5.9	20 \pm 2.8	14.2 \pm 2.0	284
Thanagazi	14.5 \pm 2.7	-	21 \pm 0.8	18.8 \pm 3.1	394
Deewanji Ka Bagh	39.8 \pm 3.7	26.2 \pm 3.2	17.2 \pm 0.8	15.2 \pm 1.8	261
Hasan Khan Mewat	42.9 \pm 3.3	48.5 \pm 2.9	19.5 \pm 1.0	12.2 \pm 0.9	238
Tehla	14.5 \pm 2.2	51.2 \pm 4.9	18.2 \pm 1.3	14.6 \pm 0.5	265
Tijara	23.6 \pm 1.5	48 \pm 8.2	17.7 \pm 1.2	22.2 \pm 1.8	392
Kotkasim	21.6 \pm 2.8	46.6 \pm 20	16 \pm 0.6	*	*
<i>A. aspera</i> var. <i>argentea</i>					
Bala-fort forest	19.4 \pm 4.8	58 \pm 4.4	19 \pm 1.8	13.6 \pm 1.3	258
Kotkasim	0.3 \pm 0.3	104 \pm 2.02	36.3 \pm 5.5	*	*
Hasan Khan Mewat	3.9 \pm 1.5	51.6 \pm 2.0	4.5 \pm 1.1	*	*
<i>A. aspera</i> var. <i>porphyristachya</i>					
Hasan Khan Mewat	15.6 \pm 0.4	126 \pm 12.2	54.4 \pm 3.0	*	*

* Leaf area could not be estimated.

Table 3. Reproductive features of various populations of *Achyranthes aspera* in Alwar district (\pm S.E.).

Study Site	No. of Spikes per plant	No. of fruits per spike	No. of fruits per plant	No. of fruits per m ²
<i>A. aspera</i> var. <i>aspera</i>				
Behror	6.5 \pm 0.6	75.1 \pm 6.8	488.15	16402
Bansur	5.8 \pm 0.8	100 \pm 6.6	580	5742
Rajgarh	7.5 \pm 0.6	92.0 \pm 13.8	690	19113
Ramgarh	8.5 \pm 0.6	84.0 \pm 12.1	714	17564
Laxmangarh	7.7 \pm 1.1	77.2 \pm 10.2	594	16763
Thanagazi	6.5 \pm 0.6	89.1 \pm 5.0	579	8398
Deewan Ji ka Bag	7.5 \pm 0.6	93.9 \pm 9.5	704	28029
Hasan Khan Mewat	7.2 \pm 0.8	88.0 \pm 9.4	634	27181
Tehla	7.0 \pm 0.9	86.9 \pm 7.4	608	8820
Tijara	6.7 \pm 0.6	107 \pm 9.8	717	16921
Kotkasim	1	44.3 \pm 2.0	44	950
<i>A. aspera</i> var. <i>argentea</i>				
Bala-fort forest	7.3 \pm 0.6	40.0 \pm 4.3	292	5664
Kotkasim	12.66 \pm 0.3	52 \pm 2.3	658	197
Hasan Khan Mewat	1	21.96 \pm 2.2	22	86
<i>A. aspera</i> var. <i>porphyristachya</i>				
Hasan Khan Mewat	5.2 \pm 0.6	74.5 \pm 18.2	387	6043

Table 4. Biomass (gm) allocation to different parts of *Achyranthes aspera* plants in various localities in Alwar district (\pm S.E.).

Locality	Root	Stem	Leaf	Inflorescence	Biomass Per Plant
<i>A. aspera</i> var. <i>aspera</i>					
Behror	0.26 \pm 0.08	1.57 \pm 0.17	0.54 \pm 0.18	0.33 \pm 0.08	2.7
Bansur	0.26 \pm 0.13	1.87 \pm 0.29	0.73 \pm 0.3	0.84 \pm 0.24	4.01
Rajgarh	0.6 \pm 0.11	2.16 \pm 0.65	1.28 \pm 0.36	1.46 \pm 0.67	5.5
Ramgarh	0.91 \pm 0.01	3.71 \pm 0.85	1.84 \pm 0.21	1.51 \pm 0.02	7.97
Laxmangarh	1.19 \pm 0.18	2.03 \pm 0.08	1.35 \pm 0.48	1.35 \pm 0.32	5.92
Thanagazi	1.69 \pm 1.11	1.86 \pm 0.51	1.03 \pm 0.32	0.6 \pm 0.11	5.18
Dewan Ji Ka Bag	2.96 \pm 0.66	2.90 \pm 0.47	1.72 \pm 0.25	0.61 \pm 0.24	8.19
Hasan Khan Mewat	1.94 \pm 0.62	5.78 \pm 2.08	0.29 \pm 0.11	0.47 \pm 0.17	8.48
Tehla	1.51 \pm 0.99	2.71 \pm 1.24	0.91 \pm 0.18	0.39 \pm 0.10	5.52
Tijara	1.17 \pm 0.17	2.05 \pm 0.57	1.51 \pm 0.5	1.36 \pm 0.31	6.08
Kotkasim	0.65 \pm 0.4	5.37* \pm 3.4	-	0.37 \pm 0.2	6.39
<i>A. aspera</i> var. <i>argentea</i>					
Bala-fort forest	0.27 \pm 0.06	1.10 \pm 0.21	0.33 \pm 0.05	0.68 \pm 0.21	2.38
Hasan Khan Mewat	0.58 \pm 0.1	3.78* \pm 0.4	-	0.45 \pm 0.1	4.81
Kotkasim	1.63 \pm 0.5	5.48* \pm 2.0	-	0.82 \pm 0.1	7.93
<i>A. aspera</i> var. <i>porphyristachya</i>					
Hasan Khan Mewat	-	23.17* \pm 6.6	-	1.87 \pm 0.3	29.97

* The biomass of stem and leaf is estimated together.

site while it was maximum (107) in those growing at Tijara. Consequently, the fruit production per plant in this variety was lowest at Behror (488) whereas highest (717) at Tijara. Fruit production per plant in this variety was moderate (600) at Tehla and Hasan Kha Mewat sites. However, the fruit production m^{-2} was highest at Dewanji ka bag (28000) followed by Hasan Khan Mewat site (27100) while lowest fruit production was at Kotkasim site (950) which may be attributed to heavy grazing by cattle and goats in this site. The fruit production of *A. aspera* var. *porphyristachya* was 387 per plant and $6043m^{-2}$ at the Hasan Khan Mewat site. *Achyranthes aspera* var. *argentea* produced 290 fruits per plant and 5660 seeds m^{-2} on hill slopes at the Balafort forest site whereas the fruit production was low at Kotkasim and Hasan Khan Mewat sites in plain areas.

Biomass : The maximum biomass per plant in *A. aspera* var. *aspera* was recorded at Hasan Khan Mewat site (8.48 gm) followed by Diwanji ka bag and Ramgarh site (8 gm). The lowest biomass was observed at Behror (2.7 gm) (Table 4). *A. aspera* var. *perphyristachya* produced 30gm per plant biomass which was highest whereas it was lowest 2.38 gm per plant in *A. aspera* var. *argentea* at Bala-fort forest among all the populations studied. However, *A. aspera* var. *argentea* produced 4.8 gm biomass per plant under grazed conditions at Hasan Khan Mewat site whereas about 8 gm biomass per plant at the ungrazed Kotkasim site. It was also observed that almost all the plants of *A. aspera* var. *argentea* have been damaged by grazing at the Hasan Khan Mewat site.

The allocation of biomass to different parts of the plant was quite variable in different populations of *Achyranthes aspera* (Table 4). In general, *Achyranthes* allocated higher biomass to vegetative parts as compared to reproductive structures indicating its perennial habit. However, plants of *A. aspera* var. *aspera* growing at Tehla, Hasan Kha Mewat and Dewanji ka bag sites allocated merely 7 percent of the total biomass to reproductive structures whereas those growing at Laxmangarh and Rajgarh allocated about 23 and 26 percent respectively to fruit production. The plants growing at Behror allocated lowest biomass to roots (10 percent) while those growing at Deewanji ka bag site allocated highest biomass to roots (36 percent). The plants growing at Tehla, Thanagazi and Laxmangarh sites allocated 23-33 percent biomass to roots. Plant of *A. aspera* var. *porphyristachya* growing at Hasan Khan Mewat site allocated only 6 percent of above ground biomass to reproductive structures. On the contrary, *Achyranthes aspera* var. *argentea* growing on hill slopes at Bala-fort site allocated sufficient biomass (28 percent) to fruit production whereas 9 percent and 10 percent respectively at Hasan Khan Mewat and Kotkasim sites in plain areas. It allocated only 10-20 percent biomass to

roots in plains as well as on hill slopes (Table 4).

Discussion

There are three varieties of *Achyranthes aspera* which grow in Alwar district of Rajasthan. *A. aspera* var. *aspera* is distributed throughout the district in plain areas whereas *A. aspera* var. *argentea* is found on the hill slopes and adjacent plain areas in the Aravalli hills, and *A. aspera* var. *porphyristachya* is restricted to Alwar tehsil. The variety *A. aspera* var. *aspera* is distributed in various edaphic conditions throughout the district, however, it does not grow on the hill slopes.

The observations made on the various population of *Achyranthes aspera* var. *aspera* and *A. aspera* var. *argentea* growing in different parts of Alwar district exhibited plasticity with respect to stem height, leaf area, biomass productions and fruit production which may be in response to varying edaphic conditions, soil moisture content and biotic factors. Despite variation in growth behaviour in different study sites in Alwar district, *A. aspera* var. *aspera* produced enormous number of seeds/ fruits per unit area in all the study sites for the perpetuation of its population. On the contrary, *A. aspera* var. *argentea* exhibited high biomass and fruit production per plant in ungrazed Kotkasim site, the fruit production per unit area was very less because of its low population density. Biomass and fruit production in this variety was further reduced at the grazed Hasan Khan Mewat site. Hence, it may be suggested that the poor growth of *A. aspera* var. *argentea* in plain areas may be attributed to its low reproductive capacity and grazing by animals. *A. aspera* var. *aspera* populations growing at Tehla, Hasan Khan Mewat and Deewanji ka bag sites allocated more than 90 percent biomass to vegetative parts and merely 8 percent to reproductive structures indicating its perennial nature. However the populations of Bansur, Laxmangarh, Rajgarh and Tijara sites allocated 75 percent biomass to vegetative parts and 25 percent to reproductive structures. The availability of sufficient soil moisture at the Hasan Khan Mewat being near to irrigated agricultural fields and Tehla site due to proximity of Mangalsar dam may be the reason for less reproductive effort by *A. aspera* var. *aspera*. In the Bansur, Rajgarh and Laxmangarh sites it may allocate more resources to fruit production in response to high salinity of soils and limited soil moisture availability after the departure of monsoon. This is in agreement with Hickman¹⁶ and Yadav and Tripathi¹⁷ who observed increased allocation to reproductive parts in *Polygonum cascadenense* and *Eupatorium adenophorum* with increasing stress conditions.

A. aspera var. *porphyristachya* exhibited similar pattern of biomass allocation indicating its perennial habit. Reddy and Aruna¹⁸ also reported that *Ruelia tuberosa*

purple form allocates major proportion of biomass to above ground parts (73 percent) whereas the green form allocates 62 percent biomass indicating their perennial habit. *A. aspera* var. *argentea* growing on hill slopes at the Bala-fort forest produced vary less biomass per plant and out of which allocated 72 percent biomass to vegetative parts and 28 percent to reproductive structure. However, it allocated only 10% biomass to reproductive structure in plain areas indicating its tendency to acquire perennial habit.

Hence, *Achyranthes aspera* var. *aspera* exhibits considerable plasticity with respect to morphological characters and growth behaviour in various habitats which indicates its wide ecological amplitude and distribution throughout the Alwar district. The wide ecological amplitude of *Ipomoea carnea* has been observed as it can grow from hydric to xeric situations¹⁹. *Ipomoea carnea* has also been reported to grow in the sandy and silty soils, organic or nutrient poor soils and hydric to xeric conditions⁵. Singh and Singh²⁰ also attributed the wide distribution of *Cassia tora* and *Anagallis arvensis* to occurrence of distinct local populations. The reasons for the restricted distribution of *A. aspera* var. *porphyristachya* to the Hasan Khan Mewat site are still obscure.

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