

POPULATION VARIATION IN *ACHYRANTHES ASPERA* VAR. *ASPERA* IN ALWAR DISTRICT OF RAJASTHAN

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Plasticity and genetic polymorphism was evaluated in *Achyranthes aspera* var. *aspera*, a plant of medicinal value and widely distributed in Alwar district in north-east Rajasthan. Ten populations of this variety growing in various locations in Alwar district were studied in field situations and in pot culture experiments in the Botanical garden. The observations taken on seed germination, vegetative characteristics, reproductive characteristics and biomass production exhibited considerable differences. The pink flowered and the greenish-white flowered populations were also identified in this taxa.

Keywords : Biomass production; Plasticity; Seed germination; Spatial heterogeneity.

Introduction

The study of natural populations is of considerable importance as these are recognised as fundamental units of a species¹. Species of great ecological amplitude occupy a wide range of environmental situations due to the existence of distinct populations adapted to each situation. According to Ramakrishnan¹, there are two distinct view points regarding the adaptability of individuals of a species to varying environmental influences : (i) the population is a stable unit implying thereby the existence of distinct populations evolved to suit distinct environmental situations, the ecotypes, and (ii) that the individual genotypes assume different characteristics showing both morphological and/or physiological manifestations. The temporary changes in forms of individuals of a population due to plasticity of the same genotype are known as ecads or ecophenes. Since the first demonstration of the presence of ecotypes^{2,3}, ecotypes have also been reported in several plant species in India⁴⁻¹⁰.

Achyranthes aspera var. *aspera* is a ruderal weed distributed in different environmental situations throughout the district of Alwar. Review of literature indicated that the population genetics of this species has not been studied. Hence, in the present study an attempt has been made to evaluate the population variation in *Achyranthes aspera* var. *aspera* growing in Alwar district of Rajasthan.

Materials and Methods

Study area - Alwar district which covers an area of about 8400 km² is situated in the north-eastern part of Rajasthan (27°4' to 28°4' N and 76°7' to 76°13' E). It comprises of various kinds of habitats due to the presence of Aravalli mountain range. There are three varieties of *Achyranthes aspera*, i.e. *A. aspera* var. *aspera*, *A. aspera* var. *argentea*

and *A. aspera* var. *porphyristachya*, which grow in the wastelands, along road sides and railway tracks and forest areas in Alwar district. *Achyranthes aspera* var. *porphyristachya* has been observed to grow only in Alwar sub-division, *A. aspera* var. *argentea* prefers to grow on hill slopes and foot hills of the Aravalli mountain range whereas *A. aspera* var. *aspera* exhibit luxurious growth throughout the Alwar district in the valley and plain areas¹¹. The climate and soil have been described by Agarwal and Yadav¹¹.

Ten study sites were selected in different regions of the district covering almost all the sub-division. Ten plant specimens were collected along with root at random from each study site and brought to the laboratory. The morphological characters such as height of plants, number of leaves per plant, the length of petiole, size of leaf were determined. The floral characters such as the length of spike, the number of fruits per spike, the length of flower and the length of tepals were estimated.

The mature fruits of *Achyranthes aspera* var. *aspera* were collected from each study site, air dried and kept in polythene bags separately for each population in the laboratory. Then 17 seeds of each species were sown in earthen pots in July 2005. Each earthen pot (diameter 23 cm) was filled with thoroughly mixed garden soil. After seedling establishment one plant of a population was allowed to grow in one pot. Nine such plants were grown for each population in pots. The pots were well labelled and kept in a net house. The pots were watered on alternate days in such a way that no water comes out of the hole present at the base of the pot. Three pots of each population were harvested at three week intervals. The vegetative and reproductive characters of each plant were determined. Then, the root, stem, leaf and inflorescence of

each plants were separated and kept at 80°C for 48 hours in a hot air oven to estimate the dry weight following Misra¹².

The rainfall data of various study sites from July 2004 to June 2005 was obtained from the Floods section Alwar, Govt. of Rajasthan, Alwar (Table 1).

Results and Discussion

(a) *Variations observed in field specimens*- The study of vegetative characters of *A. aspera* var. *aspera* specimens, collected from different locations in Alwar district, exhibited variation (Table 2). Petiole length varies from 1.13 cm in Bansur and Rajgarh populations to 1.43 cm in the Dewanji Ka Bag (DKB) specimens. Similar differences were observed in leaf size and leaf area per leaf among different populations of this variety. The variation in leaf apex and colour of bracteoles were also observed in specimens collected from different study sites. In most of the populations leaf apex was obtuse but it was acute in Thanagazi and Bansur populations. The texture of leaf was thick and leathery in all populations but Tehla population had thin and membranous leaves. The colour of bracteole was reddish in most of the populations whereas it was light pink in Hasan Khan Mewat (HKM) population and greenish-white in Bansur population. The spike length of *A. aspera* var. *aspera* populations growing in different sites also exhibited variations, however, other floral character showed almost negligible variations. The fruit weight was 0.003 gm in Thanagazi and Laxmangarh populations, 0.004 gm in Tehla, Dewanji Ka Bag (DKB), Bansur and Behror populations whereas it was 0.008 gm in Hasan Khan Mewat (HKM) population.

(b) *Variations observed in culture experiments*

(i) *Seed germination*- The different populations of *A. aspera* var. *aspera* exhibited considerable variation in seed germination in culture pot experiment. Out of the 17 seeds sown in each of the 9 pots for a population, 70% seeds germinated in Behror population followed by 54% in Tijara and Tehla population, 43 % in Ramgarh population, 39% in Rajgarh population, 32% Laxmangarh and HKM population and 22-25 % in DKB, Bansur and Thanagazi populations (Table 3).

(ii) *Vegetative characteristics*- The populations of *A. aspera* var. *aspera* raised from the seed collected from various study sites in pots in the botanical garden also exhibited differences in vegetative characters (Table 3). The height of Bansur population was lowest, i.e. 82 cm. whereas it was maximum for Behror (107 cm) and Thanagazi (105) populations. Similar trends was observed with respect to number of leaves per plant and number of nodes per plant. The leaf size was 2.6 x 2.5 cm² for HKM, Tehla, Ramgarh and Rajgarh populations 3-6x2.5 cm² for Bansur, Thanagazi, Laxmangarh, Tijara and DKB populations whereas it was maximum (5-8x3-6 cm²) for Behror population. Similarly the maximum leaf area per leaf was

highest for Behror (19 cm²) and Thanagazi (22cm²) whereas it was lowest (9.0 cm²) for Rajgarh population.

(iii) *Reproductive characteristics* - The size of the flower and fruit was almost same (5.0 mm) in all the populations of *A. aspera* var. *aspera* raised in pots in the Botanical garden. However, the number of spikes per plant were lowest (6) in HKM population and highest (11) in Thanagazi, Rajgarh and DKB populations (Table 4). Similarly the length of spike was shortest (17 cm) in Bansur population and longest in Thanagazi (28 cm) and Rajgarh (29 cm). The number of flowers per spike was lowest (50) in Behror population and highest (98) for Thanagazi populations. The flower production per plant was lowest for HKM (8820) and Behror (9166) populations and highest for Thanagazi population (31164).

(iv) *Biomass production* - The biomass production per plant was highest (15 g) for Behror and Thanagazi populations whereas it was lowest (7 g) in Rajgarh and HKM populations (Table 5). The resource allocation pattern was almost similar in most of the populations, i.e. 65-70% biomass was allocated to vegetative parts and 30-35% biomass allocation to reproductive structures. However, the Behror population and Rajgarh population allocated 81% biomass to vegetative parts while it allocated 19% to reproductive structures.

(v) *Flower colour* - Two populations of *A. aspera* var. *aspera*, one with red flowers and the other with greenish-white flowers were collected from HKM, DKB and Company Garden sites which are situated in Alwar city. The pink flowered populations has a density of 29, 40 and 5 plants m⁻² in Company Garden, DKB and HKM respectively whereas the corresponding values for the greenish white flowered population were 5, 0.3 and 42 respectively (Table 6).

The various population of *Achyranthes aspera* var. *aspera* growing in different locations exhibited, considerable differences in seed germination in pot experiments. The variation in seed germination in the center and the periphery populations of *Veronica peregrina* has been observed by Linhart¹³, who further suggested that this difference in seed germination may be contributed to the micro-environmental conditions of the center and periphery of the temporary pools. Cohen¹⁴ has demonstrated quantitatively the advantage of delayed germination in areas of unpredictable rainfall. The various populations of *A. aspera* var. *aspera* representing different locations in Alwar district exhibited considerable variation in their vegetative characters and growth behaviour. The population of Behror region maintained its large leaf size as compared to that of other populations when grown in uniform environment in Botanical garden. The selection of large leaf size may be advantageous for the plant species when growing in intense competition with associated

Table 1. Soil characteristics and annual rain fall of different localities in the Alwar district. (source : Agarwal and Yadav¹¹)

S.N.	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 rainfall (mm)
1	Bansur	7.99	0.18	0.104	0.57	54.00	700	623
2	Behror	7.91	0.13	0.086	0.55	63.00	710	739
3	DKB*	7.89	0.31	0.143	0.34	62.00	810	584
4	HKM*	7.97	0.12	0.066	0.27	63.00	440	584
5	Ramgarh	7.92	0.13	0.078	0.74	135.00	1180	661
6	Rajgarh	7.85	0.23	0.132	0.45	63.00	1020	487
7	Laxmangarh	7.89	0.11	0.068	0.37	59.00	530	685
8	Thanagazi	7.59	0.24	0.128	0.22	61.66	450	682
9	Tehla	7.54	0.29	0.07	0.62	-	280	
10	Tijara	7.69	0.71	0.259	0.85	65.00	300	804

* The study sites, the Deewanji Ka Bag and the Hasan Khan Mewat are referred to as DKB and HKM respectively in the text and tables.

Table 2. Characteristics of *Achyranthes aspera* var. *aspera* population collected from different study sites in Alwar district. (± S.E.)

Study site	Length of the width (cm)	Weight of fruit spike (cm)	Length of the (gm/fruit)	Leaf size Length x petiole (cm)
		Behror	47.0 ± 5.7	0.004 1.35 ±
0.06	5-8 x 3-7			
Bansur	47.6 ± 3.6	0.004	1.13 ± 0.05	5-8 x 3-7
Rajgarh	30.2 ± 4.4	0.003	1.33 ± 0.05	4-5 x 3-4
Laxmangarh	34.3 ± 7.3	0.003	1.33 ± 0.05	3-6 x 3-4
Thanagazi	46.5 ± 12.5	0.003	1.23 ± 0.09	4-6 x 3-4
Ramgarh	22.5 ± 3.2	0.003	1.13 ± 0.05	5-6 x 3-4
Deewanji Ka Bag	17.8 ± 1.0	0.004	1.43 ± 0.09	4-6 x 3-7
Hasan Khan Mewat	11.8 ± 2.0	0.005	1.35 ± 0.06	3-6 x 3
Tehla	20 ± 1.8	0.004	1.35 ± 0.06	3-6 x 3-4

Table 3. Vegetative characteristics of various populations of *A. aspera* var. *aspera* in Alwar district grown in culture pots in the Botanical garden (± SE).

Sites	Height of Plant (cm)	Number of leaves per plant	Number of nodes per plant	Leaf length x width (cm)	Leaf area (cm ²)	Seed germination (%)
Behror	107 ± 2.31	66.0 ± 5.03	9.33 ± 0.33	5-8 x 3-6	19.1	70
Bansur	82.33 ± 3.18	31.33 ± 3.71	7.0 ± 0	3-6 x 2-5	12.4	23
Thanagazi	105.33 ± 8.17	57.0 ± 3.21	7.33 ± 0.33	3-7 x 2-5	21.7	24
Rajgarh	87.62 ± 6.36	33.0 ± 3.27	6.33 ± 0.33	2-6 x 1-4	9.3	38
Laxmangarh	99.25 ± 1.75	36.5 ± 9.5	7.0 ± 0	3-6 x 2-5	10.1	32
Ramgarh	87.67 ± 6.36	36.0 ± 3.06	7.3 ± 0.33	2-6 x 2-5	10.5	43
Tijara	91.33 ± 6.98	51.0 ± 6.66	7.67 ± 0.33	3-7 x 2-6	12.3	67
DKB	91.0 ± 2.31	30.0 ± 2.6	6.67 ± 0.67	3-6 x 2-5	11.8	22
HKM	93.67 ± 5.46	27.0 ± 1.44	8 ± 0	2-6 x 2-5	12.8	38
Tehla	102.67 ± 6.69	43.0 ± 2.65	7.33 ± 0.33	2-5 x 2-4	9	54

Table 4. Reproductive characteristics of various population of *A. aspera* var. *aspera* in Alwar district in culture pots in the Botanical garden (\pm SE).

Sites	Length of the spike (cm)	Number of Spike per plant	Number of flower/spike	Number of Flower/plant	Seed weight (g)
Behror	18.9 \pm 4.5	9.67 \pm 0.88	50.0 \pm 1.9	9166.5	0.005
Bansur	17.20 \pm 8.3	10.33 \pm 0.67	60.53 \pm 2.79	10718.18	0.006
Thanagazi	28.23 \pm 3.19	11.33 \pm 0.33	97.79 \pm 7.26	31164.95	0.0035
Rajgarh	28.85 \pm 6.48	11.33 \pm 0.67	79.19 \pm 17.38	25774.85	0.004
Laxmangarh	23.5 \pm 0.3	9.5 \pm 1.5	64.40 \pm 1.20	14377.3	0.0028
Ramgarh	18.5 \pm 3.75	9.67 \pm 1.45	59.37 \pm 14.21	10659.3	0.0031
Tijara	23.33 \pm 2.45	7 \pm 2.08	65.13 \pm 7.16	10699.36	0.006
DKB	22.69 \pm 3.72	11.0 \pm 1.15	72.98 \pm 7.96	18228.1	0.0045
HKM	22.9 \pm 1.16	6 \pm 1.15	64.15 \pm 4.17	8821.08	0.004
Tehla	24.93 \pm 1.01	8.67 \pm 0.67	60.13 \pm 14.2	13025.61	0.005

Table 5. Biomass production (g per plant) by different populations of *A. aspera* var *aspera* in Alwar District in the culture pots in the Botanical garden (\pm SE).

Sites	Root	Stem	Leaves	Inflorescence	Biomass per plant (g)
Behror	2.53 \pm 0.14	6.24 \pm 1.18	3.13 \pm 0.26	2.74 \pm 0.72	14.64
Bansur	1.77 \pm 0.4	3.95 \pm 0.34	.99 \pm 0.27	3.02 \pm 0.27	9.73
Thanagazi	2.11 \pm 0.14	6.13 \pm 0.85	1.72 \pm 0.09	5.36 \pm 0.35	15.32
Rajgarh	1.15 \pm 0.27	3.85 \pm 0.39	.53 \pm 0.27	1.27 \pm 0.74	6.8
Laxmangarh	1.74 \pm 0.2	5.28 \pm 0.77	1.28 \pm 0.33	3.27 \pm 0.59	11.57
Ramgarh	1.19 \pm 0.29	4.09 \pm 0.91	1.79 \pm 0.29	2.76 \pm 0.85	9.83
Tijara	2.16 \pm 0.08	3.31 \pm 0.76	1.63 \pm 0.14	2.15 \pm 0.35	9.25
DKB	2.30 \pm 0.25	4.48 \pm 0.29	1.42 \pm .09	4.10 \pm 0.68	12.3
HKM	2.55 \pm 0.6	2.68 \pm 0.81	.63 \pm 0.11	1.53 \pm 0.53	7.39
Tehla	1.42 \pm 0.05	4.58 \pm 0.28	1.31 \pm 0.07	4.01 \pm 0.36	9.89

Table 6. Density of pink and white flower population of *A. aspera* var. *aspera* in Alwar City.

Populations	Density (m ²)	
	Pink	White
HKM	5.1 \pm 8.72	41.6 \pm 4.54
Company Garden	29.1 \pm 3.89	5.2 \pm 3.17
DKB	39.8 \pm 4.01	0.3 \pm 0.22

grasses¹³. Such selection of large size leaves was also observed by Snaydon and Davies¹⁵ in populations of *Anthoxanthum odoratum* growing under intense competition from tall vegetation. The variation observed in fruit weight of different specimens collected from various study sites were maintained by the respective population when grown in culture pots in Botanical garden. Biomass production and resource allocation pattern to reproductive and vegetative structures also exhibited considerable variation in different population of *A. aspera* var. *aspera* growing in different regions of Alwar District. The vegetative growth and biomass production per plant was highest in Behror and Thanagazi population as compared to other population. However, the seed production per plant was lowest in Behror population and highest in Thanagazi population when grown in culture experiments. This again confirms that the Behror population allocates higher proportion of resources to vegetative parts to enhance its competitive ability and therefore, has a tendency towards K-selection strategy. In contrast, the Thanagazi population exhibit good vegetative growth and biomass yield but allocates considerable proportion of biomass to reproductive structures indicating its r-selection strategy. Although the Rajgarh population produced less biomass per plant, it also allocated 80 percent resources to vegetative structures indicating its k-selection strategy. The other populations of *A. aspera* var. *aspera* exhibited the tendency towards r-selection strategy.

The differences in the vegetative and reproductive characteristics, and biomass production in the field specimens and culture pot experiments of populations growing in different locations in Alwar district exhibit considerable plasticity and gene polymorphism in the populations of *A. aspera* var. *aspera*. The soil characteristics and annual rainfall indicate that spatial and temporal heterogeneity exist in Alwar district. The theory of population variability states that populations in variable environments will themselves be more variable¹⁶. This is also supported by Snaydon¹⁷ who observed correspondence between genetic variability and environmental variability as indicated by pH and plant response in *Anthoxanthum odoratum*. These observations are also in agreement with Zangerl *et al.*¹⁸ who proposed relationship between stress, spatial heterogeneity and temporal heterogeneity and standing variations in plants. This is also in conformity with Pandeya and Pandeya¹⁹ who reported variations in vegetative and reproductive characters of *Desmostachya bipinnata* growing in four selected localities representing different environmental conditions in the Western India. The two flower colour populations of *A. aspera* var. *aspera* are being reported from three locations of Alwar city. Hence, it may be inferred

that the populations of *Achyranthes aspera* var. *aspera* exhibit considerable plasticity and genetic polymorphism in Alwar district of Rajasthan.

Acknowledgement

The authors are grateful to Dr. G.K. Rustagi, Principal, R.R. College, Alwar for providing necessary facilities and encouragement. The financial assistance received from Council of Scientific and Industrial Research, New Delhi by Teena Agarwal in the form JRF is gratefully acknowledged.

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