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Phenology of *Adhatoda vasica* a multifarious useful medicinal plant

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Abstract
In the present study of phenology of *Adhatoda Vasica* has been done in which definite period, month, season in a year during which its seeds germinate, seedlings grow or show maximum vegetative growth, leaves fall (if it is deciduous), flushing of new leaves, flowering and then fruiting has been studied. Five sites have been selected from in and around Bhopal MP and the study was done and founded that the flowering starts in the month of October around the second week and is sparse. The normal flowering time in the mature bushes is from early September till the end of February. After the plants attain the age of two years the flowering and fruiting becomes regular. It has been observed that if the plants are raised from stem cutting flowering occurs in the first year of plant life itself. The fruit set starts in late December and lasts till April end. The peak fruit set period is February and March, seeds get matured during early February to March end. Fruit dehiscence and seed dispersal start at the end of March and peaks by the end of April when the temperature is over 40 ºC and humidity is low. The seeds are thrown by the elastically explosion of the fruit, which is a capsule to a distance of about two meters by a hook like structure known as retinaculum. No other seed dispersal mechanism is observed. The plant exhibits regular leaf fall in small numbers throughout the year which increase in the month of March but no time the plant becomes leafless. From April till September there is a period of high vegetative growth when new branches spring up and the plant increase in height and girth.

Keywords: Phenology, girth, retinaculum, elastically explosion

Introduction
India is quite rich in medicinal and aromatic plant resources and over 1,100 species of the flowering plants are described in the Materia Medica of ayurvedic and Unani medicines. Over 46 of these are in large and consistent demand, which is collected from their wild populations from forests.

Even so, over exploitation of our wild herbal wealth for pharmaceutical purposes is an age old practice. Over exploitation of many of these medicinal plants for economic use render them as endangered and vulnerable, whereas some others face regeneration problems due to mismanaged collection of the drug industry.

Adhatoda vasica Nees syn, Adhatoda zeylanica Medik, syn. Justicia Adhatoda Linn is one such important plant, belonging to family Acanthaceae. It is a gregarious species of multifarious use, distributed throughout India, up to an altitude of 1300 m in the Northwest sub Himalayan tracts. Commonly cultivated as a hedge plant, often grows wild near human inhabitations, found in dry and waste places. It thrives well where other vegetation fails to grow because of immunity from browsing by goats and other animals probably due to its fetid scent. Also elsewhere, it has almost gone as an escape to become naturalized.

In view of its common occurrence *Adhatoda vasica* has different vernacular names such as Hindi: Adosa, adalsa, vasaka

Sanskrit	:	Amalaka, bashika,
Bengali	:	Basak
Tamil	:	Adathodai
Marathi	:	Vasuka
Telugu	:	Adasaram
Malayalam	:	Ata-lotakam

It is a small evergreen, sub herbaceous bush. The leaves vary from 6-18 cms in length and are about 4 cms broad. They are opposite, entire, minutely pubescent, broadly lanceolate and shortly petiolate tapering towards both apex and base. When dry leaves are of a dull brownish green colour with fetid odour and bitter taste. They poses well marked histological features, which can easily be seen in fragments of the leaf, cleared by chloral hydrate. The stomata are elongated–oval in shape and surrounded by a crescent shaped cells, the long axis of which is at right angles to the ostiole. The epidermis bears simple one to three celled warty hairs and small glandular hairs with a Quadricellular secreting gland. Cystoliths occur beneath the epidermis of the under surface. All these characters of Leaf Help in the identification of the plant in the powder form and check for adulteration. The inflorescence is dense, short pedunculate spike, bracteates with long bracts and spike axial and terminal. The corolla is large and white with lower lip streaked purple or pink. The fruit is a 4, seeded non fleshy, dehiscent, a capsule which is longitudinally channeled. The seeds are globular, non-endospermic, born on minute hook like outgrowths, called" retinacula"

Adhatoda vasica has multifarious medicinal uses. Atta ur-Rahman *et al*. (1997) [1] conducted phytochemical studies on *Adhatoda vasica* and a new triterpenoid 3-alpha-hydroxy D Friedoolean-Zene along with epitaxol and peganidine was isolated for the first time from its aerial parts. X-ray diffraction studies on a bronchodilating and hypotensive principle of Adhatoda vasica-Vasicinone was also carried out. Also vasicine has been found to be promising uterotonic abortifacient (Gupta O.P *et al.* 1978, 1985 Nath. D., 1992, Gupta *et al*. 2000.) [2]. A herbal mixture containing *Adhatoda vasica* along with other medicinal plants like *Tinospora cordifolia*, *Hemidesmus indicus*, *Withania somnifera*, *Terminalia belerica* etc. has been found to be an effective treatment in advanced malignancies though not a total cure. (Kulkarni a. 2001) [3]. Its antiasthmatic properties were reported by Dorsch. (1991) *Adhatoda vasica* efficacy in cough (Farooq and Pathak, 1997) [5].

Adhatoda Ether Extract of the leaves yields a resin which is toxic to grain insects, but nontoxic to human beings, the leaves give a yellow dye which is capable of killing aquatic weeds, white ants flies and mosquitoes etc. (Gamble 1902) has reported its usefulness in combination with neem cake in bringing biological control of root knot nematode Meloidogyne incognita on black Henbane, Hyoscyamus niger. Very little work has done in this field for *Adhatoda Vasica* although Dhuria (1990) [6] has worked on macropropagation of *Adhatoda vasica* under mist conditions. Barman. D (2014) [7] Studied phenology of some medicinal plants of Goalpara Dist Assam. It is therefore very imperative to understand phenology of this multifariously useful medicinal plant. A plant phenological study has great significance because it not only provides knowledge about the plant growth pattern, but it also provides the idea on the effect of environment and selective pressure on flowering and fruiting behavior. Phenological events are used variously for characterization of vegetation type. Climate change forced deviations in the length of growing period.

Materials and Methods

Distribution in Study Area

Adhatoda vasica has been found distributed in tropical regions of the world. It has been reported distributed in tropical regions of the world. It has been reported distributed in tropical Africa. In Asia it has been reported from all over India, Sri Lanka, Singapore and Malaysia. In Madhya Pradesh it is found distributed in Rewa, Satna Chhatarpur, Damoh, Sagar, Vidisha, Raisen, Bhopal, Hoshangabad, Seoni, Indore, Raigarh and in Chhattisgarh in Bilaspur, Raipur, Bastar etc.

In Bhopal *Adhatoda vasica* is found growing wild in Van Vihar National Park, Shyamla Hills, by the lakeside of the upper lake, Motilal Vigyan Mahavidyalaya Campus by the side of nallah adjoining lower lake, near Khajuri village along Raisen highway. In Vidisha it is growing along the highway about 2 Km near Sanchi, On Raisen fort hill slopes, and at the foothills. An interesting feature noticed regarding its distribution is its occurrence near Mazars where it is revered. It was found growing near a Mazar in Motilal Vigyan Mahavidyalaya Campus area, as also growing luxuriantly around Raisen Mazar, besides the plant is found growing on waste lands, as a hedge plant in the boundaries of houses, fields, along railway tracks, by highway sides or growing as an escape and almost naturalized in the habitat in this area.

For the present study area in and around Bhopal was thoroughly surveyed for recording occurrence of *Adhatoda vasica* and selection of sites where it was growing in wild conditions. Five sites were finally selected based on the consideration that they represented all types of area where *Adhatoda Vasica* grew naturally. The five sites so selected are:

Site -1: Motilal Vigyan Mahavidyalaya Campus, Bhopal.
Site-2: Lake View area along upper Lake Bhopal.
Site-3: Islam Nagar Fort, Islam Nagar.
Site-4: Raisen Fort, Raisen.
Site-5: Vidisha along state Highway at about 2Km towards Sanchi.

The sites identified were marked and voucher specimens have been deposited in the herbarium, Department of Botany, M.V.M Bhopal. Their Accession Number, along with locality is given in Table-1. Data on temperature, rainfall and relative humidity covering the months during which the observations were made are presented in Tables on the fortnight basis.

Due to typical fruit dehiscence and seed dispersal mechanism, it was difficult to collect seed in large amounts. Hence, at each site 25 bushes were selected randomly and on them 100 inflorescence (4 per bush) were bagged using muslin cloth. Young buds and unopened flowers were removed from the inflorescence before bagging to ensure uniformity in seed size. The seed lots so collected were numbered and stored in bulk. From it working samples were taken for various studies.

Fruit Setting

Initiation of fruit setting was observed and mid of fruit setting with 50% fruit set is referred as peak of fruit setting. The percentage of fruit setting was determined by marking 50 spikes in each site and counting the number of flowers present and involved in fruit setting.

Fruit dehiscence

For the study of dispersal of fruits/seeds observations were made during peak season of fruit maturation. The subsequently emergence of seedling in areas away from the shrubs was also studied to record the effectiveness of dispersal mechanism.

Seed Setting

Three samples, each having 25 randomly selected fruits from each site were examined for seed setting, viz number of seeds per fruit, seed abortion frequency, and variation in the incidence of seed setting.

Observations & Results

In nature the seeds of *Adhatoda Vasica* start to germinate during monsoon rains usually during July to September. Germination is epigeal, it takes about 10 days for the cotyledonary leaves to come up and turn green after sprouting. It takes usually four weeks' time for the first pair of foliar leaves to get fully developed. At this stage the seedling attains a height of 14-15cms and gets almost established in the soil.

The new plants are produced every year through the germination of seeds lying on the ground of the previous year's crop. The details of phonological events in the five habitats from where the plant was studied.

Phenological Events in Adhatoda Vasica					
Phase	**M.V.M Area**	**Lakeview Area**	**Islam Nagar**	**Raisen Area**	**Vidisha Area**
Seed Germination	Mid July-Mid September	Early July -Mid September	Mid July- Late September	July End - September	Early July-September Mid
Vegetative phase*	Late April-December End	May- December End	May-December End	April- December End	May-December
Flowering	Early September-Late February	Mid-September-February End	Early September-Late February	Early September-Mid February	Mid-September-Late February
Fruiting	From Late December-Early April	From December End-Mid April	From Early February-Mid March	From Mid-February-Early March	From Early February -Mid March
Seed Maturation	Early February-March End	From Mid-February-Late March	From Early February-Mid March	From Mid-February-Early March	From Early February -Mid March
Fruit Dehiscence**	March-April	March-April	March-April	March-April	March-April
Leaf Shedding***	Early March-April	Mid-March-April	From Early March-April	Early March-April	From Early March-Late April

*First year of life has no vegetative phase

**In this period maximum fruit dehiscence occurs

*** The plant is never leafless leaf shedding rate is increased during this time.

Flowering and Fruit Set

Flowering in mature bushes (2 year and above) starts in early September and lasts till the end of February. The peak flowering period is in the months of December when about 50% branches of all bushes are in bloom. The average number of spikes per branch is 2-3 pairs and number of flowers per spike range between 3-15, while the average number of flowers / spike is 8 (8.09). The data are presented in table No.: 2 and Fig. No.:1.

No. of Flowers/Spike in Adhatoda Vasica			
S. No.	**No. of Flowers/spike**	**Frequency**	$\overline{X}$
1	1-Mar	4	8.090 $\pm$ 1.42 $\pm$ 0.14
2	4-Jun	19	
3	7-Sep	50	
4	10-Dec	24	
5	13-15	3	

The fruit set starts in late December and lasts till April end. The number of fruits, set per Inflorescences vary between one to ten. The average fruit-set/spike is about 4(4.08). It takes about 30-35 days for the fruit set to occur since the anthesis. Maturation of fruit takes about 40-45 days. Fruit and seed set are two important indicators of reproductive success of any plant. The seed set starts along with the fruit set i.e. late November and lasts till April end. Te peak seed set period is February. When half of all the bloomed spikes show seed set. A sample of 25 bushes in the replicate of four was observed in determining seed set percentage and seed abortion frequency

Fruit set in Adhatoda Vasica			
S. No.	**No. of Fruits/Spike**	**Frequency**	$\overline{X}$
1	1-2	24	4.080 $\pm$ 1.27 $\pm$ 0.127
2	3-4	41	
3	5-6	21	
4	7-8	10	
5	9-10	4	

Result & Discussion

Phenology involves the genetically conditioned and environmentally influenced events in the life cycle of a plant. It deals with the time of appearance of characteristics periodic biological events in the lifecycle of organisms in nature, in relation to climatic and other environmental factors, especially temperature, altitude and latitude etc. The phonological events through characteristic of an organism, variety or species are altered by environmental interactions therefore it is desirable to describe these events in plant populations growing in natural habitats under wild conditions. In the first year of life *Adhatoda Vasica*, only vegetative growth takes place, which constitutes an increase in height, number of leaves and some branching. The leaves are simple, opposite and decussate, after one year's vegetative phase, i.e. during the second year, after monsoon a number of branches spring up from the main stem, from near the base. The onset of reproductive phase is delayed in one year old plant. The flowering starts in month of October around the second week and is sparse. The normal flowering time in the mature bushes is from early September till the end of February. After the plants attain the age of two years the flowering and fruiting becomes regular. It has been observed that if the plants are raised from stem cutting flowering occurs in first year of plant life itself. The fruit set

starts in late December and lasts till April end. The peak fruit set period is February and March; seeds get matured during early February to March end. Fruit dehiscence and seed dispersal starts at the end of March and peaks by the end of April when the temperature is over 40 ^{o}C and humidity is low. The seeds are thrown by the elastically explosion of the fruit, which is a capsule to a distance of about two meters by a hook like structure known as retinaculum. No other seed dispersal mechanism is observed. The plant exhibits regular leaf fall in small numbers throughout the year which increase in the month of March but no time the plant becomes leafless. From April till September there is a period of high vegetative growth when new branches spring up and the plant increase in height and girth.

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