



## Cultivation and Phenology of an antimalarial promising plant *Artemisia annua* in North India region at Agra

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**Abstract:** *Artemisia annua* Linn. is an antimalarial medicinal plant species producing bioactive compound artemisinin. The plant is native to China and North Asia and has been introduced to India since the 1980's. In Agra it is cultivated in semi desert area under extremes of temperatures (15-48°C). Saline soil is best suited for cultivation. It is a winter annual herb completed its life cycle in nine months from November to July. It requires early winter establishment by seeds. Germination of seeds takes place in the month of November-December at temperature (10-16°C) whereas maximum vegetative growth is retained by the plant during the time period February to last April. The yellow flowers appear in the summer (April- May) and a month later seed formation takes place. Maturation of seed is almost completed in June. Growth of the plant ceases in the month of July and the plant dies in the end of August. Dry plants and intact fruits remain on the ground and become brown in colour.

**Keywords-** *Artemisia annua*, Antimalarial drug, Cultivation, Phytophases, Phenogram, Phenology

### I. INTRODUCTION:

It is estimated that more than 80% of the world's population rely solely on indigenous systems of medicines, rely solely on indigenous systems of medicines, which are mainly plant-based. The World Health Organization (WHO) estimates some 20,000 spp. of higher plants are used medicinally throughout the world. Our country India and its neighborhood has inherited a very rich legacy of natural resources, particularly with respect to medicinal flora. In which a number of plant spp. belonging to the fifteen families reported to have antimalarial activities along with their principle constituent (Chalchat 1991). The drug from these plants used in prophylaxis or treatment of malaria in which *Artemisia annua* Linn. known as "SAGE BURSH" or "WORM WOOD", is a Chinese medicinal herb belonging to the Asteraceae family. This plant is native to China and North Asia and has been introduced from the seeds by Central Institute of Medicinal and Aromatic plant (CIMAP), Lucknow U.P., at its regional center at Bonera (Srinagar), in the Kashmir valley in 1984 from the Royal Botanical Gardens, Kew -England (Singh et al. 1986). This herb has been used since the ancient time in China against fever caused by malaria. In the early 1970's the research of *Artemisia annua* found of Artemisinin, a sesquiterpene lactone containing compound that is responsible for antimalarial properties (Wright, 2002.) The compound has been shown to have remarkably active against malaria parasites, including the resistant type of *Plasmodium falciparum* (WHO, 2008).

*Artemisia* is a large genus of small herbs or shrubs, comprising some 280 species found in temperate regions, in which 38 species are reported from India. This plant has become naturalized in many countries including Argentina, Bulgaria, France, Hungary, Romania, Spain, Italy, Yugoslavia and the United States. This plant has been introduced to India by Regional Research center of CIMAP at Srinagar. It is widely cultivated in the Kashmir valley and in the plains of North India at Lucknow to produce large quantities of antimalarial drug artemisinin.

India is a country with varied climate, soils, biotic interference and diversity of species requires detailed analysis. Expansion and cultivation of exotic medicinal plants in different regions of the country is very important from a commercial, economic and pharmaceutical point of view, because most of the medicinal plants are obtained from cultivated forms. It is experienced that the plant obtained from cultivated source yields more in all respects and hence the system of the systematic cultivation of medicinal plants should be thoroughly studied. The normal requirements for the systematic cultivation are to be studied with reference to the soil, rain, altitude and other climatic conditions. Different species differ in respect to their response to interacting climatic factors of their life cycles. Each species has a definite period (month, season) in the year during which it will germinate; its seedling will show growth and will flower and fruit. Study of all these periodic behaviors of a species is called its phenology. A study of the data and time of these events is known as phenology. In other words, phenology is the calendar of events in the life history of the plant. Since each species has a definite period for a particular stage of its life cycle, so, study of phenology is very important to know the biological clock of a species. The present investigation is to make a detailed investigation on cultivation and phenology of newly introduced broad spectrum antimalarial plant in the climatic condition of Agra of Uttar Pradesh in the North Indian region.

## II. RESEARCH METHODOLOGY:

For study and investigation purpose *Artemisia annua* is cultivated in the Botanical Garden of Dayalbagh Educational Institute, Dayalbagh, Agra by seed obtained from National Bureau of Plant and Genetic Resources (NBPGR)-ICAR, Regional station Bhowali, District-Nanital, Utrakand.

### II.I Situation :

Agra district is located in the upper Gangetic Plains of Uttar Pradesh, India. According to the Imperial Gazetteer (Repr.1985), Agra district is the division of Agra in the united provinces, lies between lat N 26° 45' and 27° 24' and long E 77° 26' and 78° 51'. It has a total area of 2,952 of km.

### II.II Physiography:

Agra is about 200 km. south east of Delhi. It is bounded on north by Mathura and Etah district, on east by Mainpuri and Etawah district, on south lies the native states of Gwalior and Dholpur, and on west Bharatpur. Agra district is divided into four distinct tracts by the rivers Jamna, Utangan or Banganga, and Chambal.

### II.III General Description of soil:

According to the Imperial Gazetteer of India (1985) , the entire district of Agra is occupied with fresh alluvium lying over the Pleistocene alluvium and the total depth of the two alluvia is around 155 meter prior to striking the base rock (Magma-Granite). Outcrops of Vindhyan sandstone at few places in the district and in the south-west of the city of Agra are prominent at Fatehpur Sikri, Tantpur, Jagner, where extensive quarrying of sandstone is done. The Vindhyan sandstone belong to lower Rewa and upper Bhandar group.

The obvious conclusion from the forgoing description and geological evidence of Agra district is that the soil deposits in the district is a two layered structure. The upper layer of varying depth (around 20 - 25 m) is a fresh alluvium brought down by the system of river Jamna and which is intermixed with quartz grain of Vindhyan sandstone. The deeper lower layer up to Magma is old alluvium. The water table occurs in the district in pouches at the depth of 25 - 30 m. Analysis of soils indicate that Agra old alluvium are sandy-silty loam. Following table gives the physical and chemical characters of old alluvial soil after Pandeya and Lieth, (1993).

### Physical and Chemical characters of a typical soil profile of old alluvium:

Name of the soil	Depth (cm)					
	0-15	15-30	30-60	60-80	80-120	120-150
Coarse sand %	0.42	0.48	0.47	0.35	0.54	0.47
Fine sand %	80.07	86.00	81.61	71.01	70.87	71.56
Silt %	10.75	9.75	9.50	22.50	20.50	21.50
Clay %	5.50	1.00	3.75	2.50	2.25	2.75
Loss on ignition %	1.24	0.97	0.97	1.46	1.50	1.48
Moisture %	1.22	1.17	1.60	2.07	2.67	2.91
Caronates	Nil	Nil	Nil	Nil	Nil	Nil
Total soluble salts	0.016	0.011	0.096	0.098	0.032	0.026
Nitrogen	0.067	0.049	0.035	0.020	0.012	0.009
Total K (mg/100g)	275.00	254.70	286.50	327.40	312.40	333.50
Exchanged K (mg/100g)	26.20	17.80	17.80	19.00	21.20	19.00
Base exchange capacity(mg/100g)	9.80	9.20	10.50	16.40	17.00	17.90
Total Mn(mg/100g)	49.10	48.30	48.80	45.40	44.80	46.80
Exchanged Mn (mg/100g)	0.78	0.59	0.70	0.58	0.54	0.50

Usually in the district at the depth varying from 1.5 - 3 m. there is a calcium concretion bed of 0.5 - 1 m thickness (locally called as 'Kankar' bed). It is a lime rich layer. pH value of soils of Agra range between 7.0 and 8.0. They are not base deficient. Soil colour is light yellow. Top soils are poor of humus.

### II.IV General Climate of district:

According to the Imperial Gazetteer of India, (Repr. 1985) owing to its proximity to the sandy deserts on the west, Agra District is very dry and suffers from greater extremes of temperature than the country further east. Though cold in winter, and exceedingly hot in summer, the climate is not unhealthy. The mean annual temperature is about 23.65°C and 32.50°C during the months of May and June.

The annual rainfall averages about 70.04cm. There is not much variation in different parts, but the tract near the Jamna receives the largest rainfall. Great variations occur from year to year, the amount ranging from 27.94 cm to 91.44 cm. General climate of Agra is of extremes, with severe summer and winter and medium erratic rains.

#### 1. Summer Season

Summer starts from the month of April when the day becomes of exactly twelve hours (23 April) . Summer continues upto the month of June when the day is longest. During the year 1997-98 an absolute maximum temperature of 46.7 °C was recorded in the first week of June and then again in 18 June (49.5°C). This was the highest temperature in the entire Upper Gangetic Plains. During the summer minimum absolute temperature varied between 20.0 and 36.3°C.

#### 2. Monsoon Period

Normally, Agra receives south-east monsoon from Bay of Bengal. This is followed by easterly winds. However, wind direction has been changing at Agra during the monsoon period. Easterly winds are many times intercepted by westered winds. The post monsoon rains occur during the month of October to January/February.

#### 3. Winter Season

In general winter at Agra is severe and retreat monsoon is received during the month of December and January (this rainfall is very important for Rabi crops). Serve winter is experienced during the month of December and January. October is the transitional period after the close of monsoon at the end of the month of September.

Fig.1- *Artemisia annua* Linn.-in cultivated fieldFig.2- Flowering twig of *Artemisia annua* Linn.

### III. RESULT AND DISCUSSION:

#### Cultivation of *Artemisia annua* Linn.

It has been grown successfully in the garden in the climatic condition of Agra as a good start to understand the cultivation related heads.

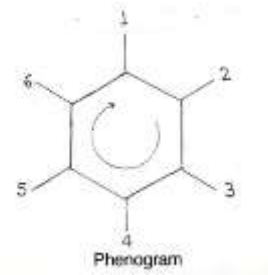
- **Time of establishment** -Accordingance to Agra climate *Artemisia* requires early winter. In Agra, the cool period of mid-December was chosen for cultivation from seeds.
- **Propagation** – *Artemisia annua* established through seeds. The seeds of *Artemisia* are very small and light. Direct sowing in the main field does not give good results. Hence, seedlings are first raised in nursery beds and then transplanted to the main field. The small seed-beds are prepared and seeds are sown, supplemented with sand to keep them in position.
- **Raising of seedlings**- The beds are kept moist by frequent watering with the help of sprinkler or rose can. Seeds germinate in about 5-8 days. The seedlings would be ready for transplanting after 6-8 weeks.
- **Land preparation**- The land is ploughed 2-3 time to produce a fine tilth before the seedlings are transplanted. For better management, the land is laid into beds of convenient size after applying the recommended dose of fertilizer.
- **Crop nutrition**- The crop response well to the application of manures and fertilizers well decomposed farm yard manure / compost should be applied before planting.
- **Plant population density**- The seedlings are transplanted in plots at height of 6 -10 cm with distance one plant per m.<sup>2</sup>, because it require low population density to maximize leaf yield. The plants are kept free of weeds and occasional hoeing is also done.
- **Irrigation**- Crop field is to be frequently irrigated from transplanting to the establishment of the crop. After establishment only 3-4 irrigation will be required up to harvest period.
- **Time of harvest**- It has been established that, just before flowering of the total plant artemisinin was 89% in the leaves with only 11% in aerial branch shoots. There were only trace amount in the main stem and none in the roots. The highest content of 0.53% volatile oil was found at the beginning of flowering. So, crude drug leaf became harvest after the bud stage of plant to give maximum artemisinin yield at full bloom.
- **Method of harvest and processing** - The leaves of *Artemisia annua* could be machine harvested by some process of leaf stripping or possible forage harvesting. One of the problems in machine harvesting would be the large, bulk involved in forage harvesting and the necessity to lower the moisture content of the plant in order to reduce the cost of kiln drying. Cutting the required length the plant and drying it in windrows could reduce the moisture content by fifty percentages (50%).



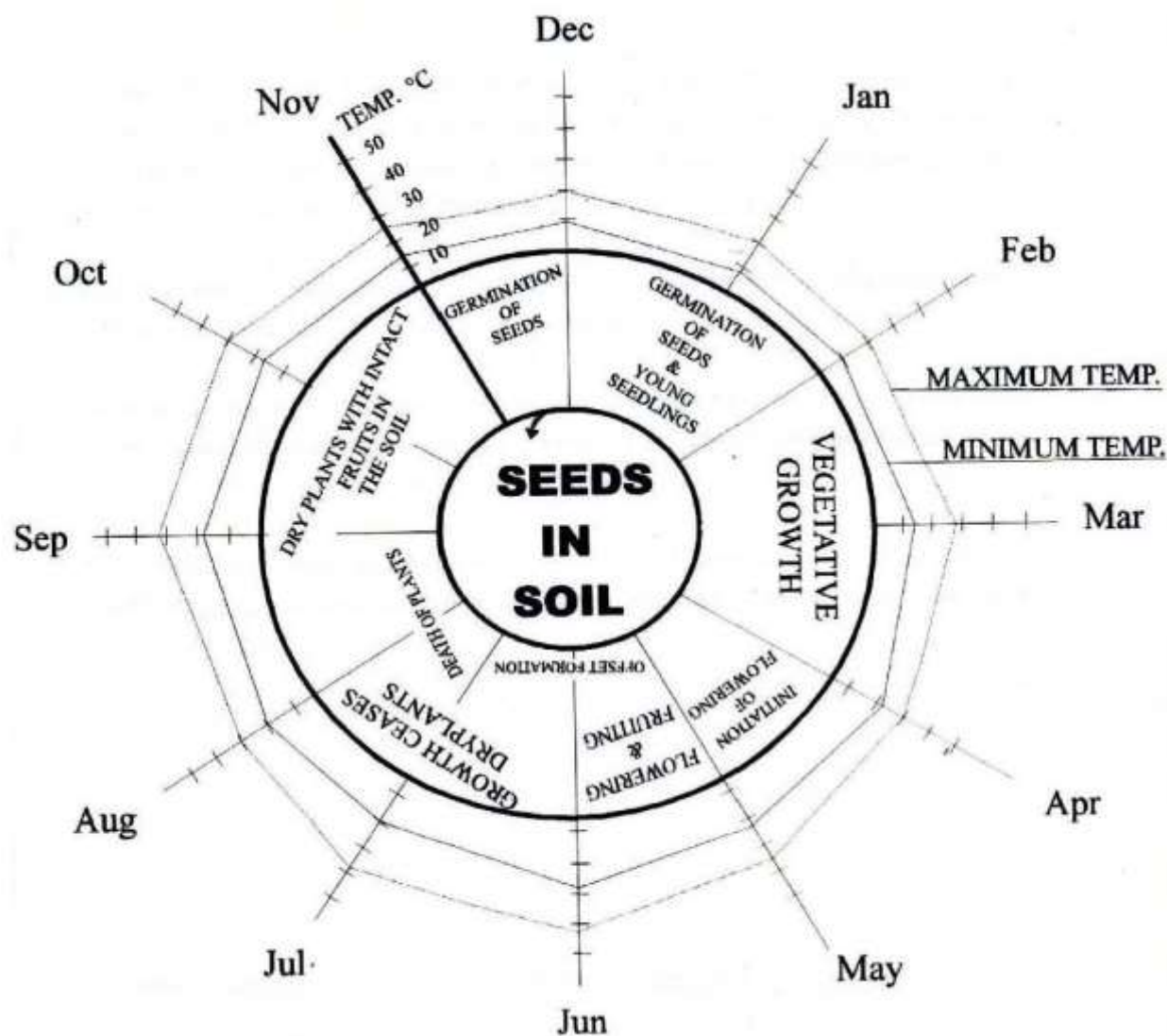
**Phenology of *Artemisia annua* Linn.**

*Artemisia annua* is a winter annual species complete their life cycle events within 8 to 9 months. The periodicity of it completed with main six phytophases.

S.No.	Phytophase	Period	Season
1.	Seed Germination	Nov. - Dec.	Winter
2.	Veg. growth	Feb. – March	Winter
3.	Flowering	April - May	Summer
4.	Fruit formation	May	Summer
5.	Seed maturation	June	Summer
6.	Death	July	Monsoon



- **Seed germination-** Germination of *Artemisia annua* seeds take place in nature soon after a few showers during November and December. It may continue even later. The optimum growth taken place in January. During The month of November maximum temperature, was recorded in the first week being (26°C) which gradually decrease to (15°C) during the last week of the month.
- **Vegetative growth-** The vegetative growth rate gradually increases during February to last of March. So, maximum biomass taken by plant up to end of March during winter season.
- **Flowering-** The plant start flowering in month of April and end to the start of May with the advent of summer starts from the month of April, where the day becomes of exactly twelve hours and continuous up to the month of June. During the period of April and May the temp is extremely high (33-35°C).
- **Fruit formation-** Formation of offset and fruiting in *Artemisia annua* take place in month of May followed by flowering. Maturation completed in last of May month.
- **Seed maturation-** Maturation of seed almost completed in June. During this time an absolute maximum temperature of (46.8°C) was recorded in the first week of June and the minimum absolute temperature varies between (19 and 31°C).
- **Death-** Growth of plant ceases in month of July and plant goes to death up to end of August. But dry plants with in fact fruits remain on the soil later. On the death green plant become brown in colour.



**Phenological clock of *Artemisia annua* Linn.  
Monthly mean, Maximum and Minimum Temperature (Line)**

In the climatic condition of Agra, *Artemisia annua* require early winter establishment (November-December) by seeds. The seedlings are transplanted in plots for maximum leaf yield at height 6-10 cm with distance one plant / m<sup>2</sup>. The leaves for crude drug purpose, become harvest after the bud stage of plant to give maximum artemesin yield (not less than 0.12% by hexane extract technique). Dry weather with minimum humidity is ideal for picking of the leaves.

Thus, winter annual herb completes its life cycle in nine months from November to July. Germination of seeds taken in month of November-December, at temperature (10-16°C) whereas maximum vegetation growth (up to 7 feet) retained by plant during time period February to last April. The yellow flowers appear the summer (April-May) and a month later seed formation take place. Maturation of seed almost completed in June. Growth of plant ceases in month of July and plant dies in the end of August. The leaves are harvested on maturity during month of February for preparation of crude drug and extraction of essential oils and terpenoids. The plant is also of great economic in perfumery, cosmetics and dermatology.

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**References**

1. W. Wright, *Artemisia* first Edition (Taylor and Francis, London 2002) pp. 149-248
2. WHO, *World Malaria Report* (World Health Organization, Geneva, Switzerland, 2008).
3. Chalchat J.C. , Garny R.P. Michet A. (1991) Chemical composition of essential oil of *Calendula officinalis* L. *Flavour and fragrance journal*, vol. 6 (930) pp. 189-192.
4. Pandya S.C. , Leith H. (1993) *Western India- The Physical Environment, the land and the people*. eds Pandya S.C. , Leith H., *Ecology of Cenchrus grass complex*. Pub. Springer Nature, Switzerland.
5. Singh A., Kaul V.K., Mahajan V.P., Singh A., Mishra L.N., Thakur R.S. and Hussain A. (1986) Introduction of *Artemisia annua* in India and isolation of Artemisinin , a promising antimalarial drug. *Indian Journal of Pharmaceutical Sciences*, Vol. 48, pp. 137-138.

