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Morphoanatomy , Phenology and Palynology Of An Invasive Weed *Alternanthera ficoidea* (L.) P. Beauv

Reshma B. Patil [1] , Dr. Basavaraj A. Kore [2]
([1]*Research scholar, Department of Botany, Yashvantrao Chavan Institute of Science, Satara , Maharashtra, India ,415001.*
[2] *Associate Professor , Department of Botany, Maharaja Jivajirao Shinde College , Shrigonda , Dist. Ahmednagar, Maharashtra, India .413701)*
Corresponding Author: Reshma B. Patil

Abstract-
The present communication deals with morpho-anatomical , phenological and palynological characters of an invasive weed Alternanthera ficoidea . Investigation was carried out with highly populated weed habitats in and around Satara city during 2015-2017 and helps in proper identification , effective utilization as well as control of this noxious weed .
Keywords- *A . ficoidea , Invasive Weed , Morphoanatomy .*

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I. Introduction

Weeds are detrimental in arable lands since they cause great loss by competing with crop plants for nutrients , soil , moisture , sunlight and space . They have often been given special identity as a fast growing troublesome exotic and noxious plant . Weeds become useful to us if we learn to use them . The increasing demands for food with growing human population in a country like India looks for new plants as source of food. Throughout the world, thousands of plants are used for medicinal purposes . Rural people and particularly the tribals still depend on the indigenous system of medicine (Pawar and Patil, 2011) [1].

Alternanthera is a genus of about 80 herbaceous plants belonging to family Amaranthaceae . *Alternanthera ficoidea* (*A. tenella* Colla [2]) is an invasive alien weed native to Tropical America and well established all over India. The weed shows high abiotic stress tolerance capacity, which enables it to survive and reproduce successfully under extreme environmental conditions like drought , salinity , high temperature, nutrient scarcity etc. and has become influential, replacing the native plant species. It is an erect or prostrate evergreen perennial herb rooting at nodes with two lines of epidermal hairs and propagate vegetatively very rapidly [Plate.1 a , c , d] . Few specimens were observed infected by Alternanthera mosaic virus.

A. ficoidea is rich in minerals (Patil and Kore,2015) [3] . Phytochemical and G.C.M.S. analysis illustrates presence of medicinally active compounds in it (Patil and Kore ,2017) [4]. Secondary metabolites like tannins, flavonoids, polysaccharides, triterpenes and saponins are found in genus *Alternanthera* . Sandilyan and Klooster ,2016 [5] included this weed in a list of invasive alien plants of India having medicinal value . Immunomodulatory properties of this weed were studied by Guera *et al* (2003) [6] .

Investigation about it's ecology , morphology, phenology , reproductive biology, physiology and phytochemistry is essential for effective utilization and inturns management . The study was carried out with highly populated natural weed habitats in and around Satara city during 2015 - 2017.

I. Material And Methods

2.1.Morphological studies –

The morphological and phenological characters of randomly selected weed specimens from natural habitats were studied .

2.2. Epidermal studies –

Epidermal peels were removed from lower and upper epidermis of fresh leaves using nail varnish imprints and tearing leaf lamina technique .The epidermal peels were stained with dilute safranin for 1-2 minutes and washed with acidic water to remove excess stain and mounted in a drop of dilute glycerine . Frequency of stomata per unit area 1 mm^2 and stomatal indices were calculated as per Salisbury (1928) [7] . Druses, vein islet and vein termination numbers were studied by gently warming the leaf pieces with 80% alcohol , mounted in a drop of dilute glycerine and observed under light microscope (Lersten and Horner ,

2006) [8]. Epidermal outgrowths of arial plant parts were observed under stereoscopic microscope , light microscope and S.E.M. .

2.3.Anatomical studies -

Anatomical studies were carried out with fresh leaves, stems and petioles by cutting free hand sections following double stain technique (Johansen, 1940) [9] .

2.4 . Reproductive biology

2.4.1.Phenology and floral biology -

Phenological events like bud break, flowering, fruiting, fruit dispersal and seed germination were recorded over a period of two flowering seasons 2015-16 and 2016-17.The average number of flowers borne on an inflorescence were recorded from a set of randomly tagged 30 flowering branches . Flowering phenology was observed on a day - to – day basis in the natural habitat according to method suggested by Dafni (1992) [10] . 30 plants were marked for detailed study of floral biology and pollination ecology at the study site.

2.4.2. Pollen and stigma biology -

For study of pollen morphology, pollen grains from the flowers were collected in fresh water . The pollen samples were acetolysed as per technique of Suryanarayanan (1975) [11] . Also pollens were studied by following S.E.M. technique . For estimation of average pollen production per flower, mature but undehisced anthers (n = 100) were squashed in a mixture of two or three drops of 10 % glycerol and 1% acetocarmine (3:1) . Pollen viability and viability period were tested by staining with 1% TTC (2, 3, 5 triphenyl tetrazolium chloride solution) .

2.4.3. Pollination -

Since the flowers are very minute, in vitro and in vivo pollination studies were carried out using stereoscopic microscope by routine methods .

2.4.4.Phenological events -

Phenological events on single flower like time of anthesis, stigma receptivity, anther dehiscence, duration of flower were recorded as per Dafni (1992) .

2.5 . Seed biology and nursery techniques -

The mature weeds were harvested and seeds were isolated from fruits ,air dried in shade and stored in plastic bags. Seed attributes like seed output , seed index , moisture content ,weight of 100 seeds , germination % , seed dormancy and viability were recorded . Air dried seeds were used for germination tests and the germination percentage was expressed on the basis of number of radical emergence. Seed germination , dormancy and viability experiments in triplicates were carried out in petriplates by sowing seeds on sterilized moist blotting papers every month for a period of 2 years . Seed dimensions were measured with scale. For seed viability period 2 year old , air dried seeds were periodically tested for germination up to 20 days . Characters like Seed output, reproductive capacity and seed moisture content were calculated (Misra, 1968) [12] . Seed coat characters were studied under S.E.M.

II. **Result**

TABLE NO. 3. 1 . Observation

Sr. No	Character	Observation
1	**External morphology** [Plate 1a , 1c and 1 d]	It is an erect or prostrate perennial herb rooting at nodes with two lines of root hairs and propagate vegetatively very rapidly . Whole plant's fresh weight = 46.66 ± 26.48 gm Dry weight of whole plant =14.16 ±7.0 gm Moisture % = 69.65 ± 7.3
	Plant development Stages Duration	Vegetative stage - flowering stage - post flowering stage 2 months 3 months 4 months (June –July) (August-October) (November to February)
	Root System [Plate 1 b]	Well developed tap root systems . Root length = 5.76 ± 3.1 cm.
	Shoot System	Prostrate, cylindrical but slightly ridged, branched, solid, green, rooting at nodes , stem clothed with trichomes .Shoot length = 22.31 ± 9.8 cm .
	Root / Shoot	Root Shoot Ratio = 0.25
	Leaves	Opposite, linear – lanceolate, oblong or ovate, sessile, exstipulate , margin entire . Amphistomatic , 8 ± 1 cm long and 1.25 ± 0.25 cm broad.

<table>
<tr><td></td><td>Flowers
[Plate 3]</td><td>Bracteoles scarious . Flowers in axillary and terminal dense clusters of 2-5 spikes . Autogamous and bisexual.
Tepals 5 , white or pale yellow , 3-nerved , alternating with stamens , staminodes, 5, toothed or lobed at apex.
Stamens-5 , dorsifixed and introrsely dehiscent , filaments connate at the base.
Pollination – Autogamous or self pollinated flowers.</td></tr>
<tr><td></td><td>Fruit</td><td>Utricle, acute and pointed at apex , brown to dark brown . Animals and vehicles seems to be responsible for the dispersal of Alternanthera fruits because of hairiness of the persistent perianth , which bears long trichomes .</td></tr>
<tr><td></td><td>Seeds
[Plate 4 a and 4 b]</td><td>Brownish discoid dicot seeds pointed at apex . Slightly rough in texture because ridges and furrows observed on outer surface of seeds in SEM . Lack of seed dormancy leads to germinate seeds very easily. Seeds remain viable during study period .
Seed output = 513.14 ±104.
Reproductive capacity = 334.82 ± 21.45 .
Type of germination – Epigeal germination .
Maximum seed germination % = 96.6 ± 3.3 % / month.
Minimum seed germination % =10 % /month.
Average seed germination % = 65.25 ± 26.14 / month
Diameter of the seed ≤ 0.1 mm. Weight of 100 air dried seeds = 4 ± 0.1 mg
Moisture % of seeds = 22.8 % .</td></tr>
<tr><td>2.2</td><td>Epidermal study</td><td>Uniseriate layer of epidermis on both leaf surfaces. Stomata, trichomes and druses were observed .</td></tr>
<tr><td></td><td>Stomata [Plate 2 c and 2 d]</td><td>Dicytic stomata observed on both leaf surfaces
<table>
<tr><td>Surface</td><td>Stomatal density</td><td>Stomatal index</td><td>Stomatal pore(µm)</td></tr>
<tr><td>Adaxial</td><td>40.9±13.2</td><td>20.5±2.3</td><td>6.56±0.31</td></tr>
<tr><td>Abaxial</td><td>96.4±8.4</td><td>25.9±1</td><td>5.2 ± 0.4</td></tr>
</table></td></tr>
<tr><td></td><td>Trichomes [Plate 2 b , 4 c and 4 d]
Druses [Plate 2 e]</td><td>Nonglandular uniseriate to multicellular trichomes with characteristic interlocking cells as illustrated in SEM . In trichome basal cells are nearly isodiametric, the other cells of the series are long and the apical cell is slender .Only one type of trichome observed on stem , leaves and petioles .Trichomes were absent on androecium and gynoecium.
Druses or idioblasts - A large number of calcium oxalate crystals called as druses were observed in leaf , stem and petiole .</td></tr>
<tr><td></td><td>Palisade cells / epidermal cell.</td><td>4-7 palisade cells / epidermal cell .</td></tr>
<tr><td></td><td>Vein islet no.& termination no.</td><td>4-7 / mm^2
6-9 / mm^2</td></tr>
<tr><td>2. 3</td><td>Anatomy
[plate 2]</td><td>1] T.S.of Stem - [Plate .2 f]
Single layered epidermis consists of polygonal cells. Cortex made up of 4-5 layered loosely arranged parenchymatous cells and alternately arranged collenchyma . Vascular bundles are conjoint, collateral , arranged in a ring. Phloem cells are comparatively smaller and situated towards cortical region while xylem cells are towards pith region . Pith is wide and consists of thin-walled large parenchymatous cells. Idioblast or druses are observed scattered in the section.
2] T.S . of Leaf- [Plate 2 a]
Leaf is dorsi-ventral and has reticulate venation. Thin sections of leaves shows following arrangement of tissues .
Epidermis-There are two epidermal layers, upper and lower epidermis. Each layer is uniseriate , being composed of row of compactly arranged cells followed by palisade cells on adaxial surface .
Mesophyll tissue- Mesophyll tissue is differentiated into palisade and spongy layers. It contains chloroplast performing photosynthetic function .
The palisade layer occurs towards the upper epidermis and composed of columnar cells. The spongy layer occurs towards the lower epidermis and composed of loosely arranged rounded cells.
Vascular bundles –Vascular bundles are collateral and closed, located in mesophyll tissue. The bundle is composed of xylem and phloem .
3] T. S . of petiole – [Plate 2 g] T.S. shows variable number of vascular bundles</td></tr>
<tr><td>2.4 and 2.5</td><td>Phenological, palynological characters</td><td>[Plate 3] Flowering and fruiting carried out throughout the year as weed grows along the road sides, at moist places. Regeneration of weed carried out again and again. But main lifecycle from rainy season to late winters (June to February).</td></tr>
<tr><td></td><td>Bud to flower development time period</td><td>Duration of developmental stages observed from budding to fruiting .
Bud initiation - Flowering stage - Fruiting
5±1 days 30±2 days</td></tr>
<tr><td></td><td>Average flowers</td><td>Average flowers / plant / month =1014.7 ± 436.4</td></tr>
<tr><td></td><td>Time of Anthesis [Plate .3 b]</td><td>Anthers dehisces longitudinally dispersing pollens by wind . At the time of anthesis yellow shower of pollens observed in the flowers.
Time of anthesis = 12.30 p.m.to 3.30 p.m.</td></tr>
</table>

	Pollen / stigma	[Plate 3 c] 40.56 ± 20.45
	Pollen polarity	Isopolar,
	Symmetry of pollen grain.	Radially symmetrical .metareticulate pollen grains . [Plate 3 e] According to NPC System pollen grains are classified as polytreme pentaporate, pentaporate or polyporate NPC 764 . Number of apertures- 12 (N 7) ,position- pentotreme (P 6) and character- porus (C4). Shape -Oblate spheroidal ,microspines are distally and usually regularly arranged.[Plate 3f]
	Placentation Gynoecium [Plate 3 d]	Basal placentation. Ovary bicarpellary, suborbicular ,glabrous,with a solitary single pendulous ovule attached at the upper micropylar end. Ovule camphyllotropous ,suspended from the apex of a long basal funicle. Stigma bifid,capitellate with uniseriate papillae ,style very short .Gynoecium size ≠ 1.5 mm

III. **Discussion**

The reproductive biology of the genus *Amaranthus* is more extensively studied as compared with the genus *Alternanthera*. The breeding system of *Amaranthus* is autogamy with self pollinated flowers. The flowers are small, unattractive to pollinators, odourless and lack nectar. Costea *et al*., 2004 [13]. Our observations in *A. ficoidea* were similar to that of *Amaranthus* flowers . *A.ficoidea* flowers are with 5 stamens while *A.sessilis* with 3 stamens.That is the main difference between these two closely related species.

The mesophyll of a leaf is divided into small portions of photosynthetic tissue by the veins and veinlets, such small portions of areas are termed veinislets . The number of vein islets / mm^2 is termed as veinislet number. This value has been shown to be a constant for any given species and full grown leaves, to be unaffected by the age of the plant or the size of the leaves. This number has proved useful for the critical distinction of certain nearly related species . Large number of idioblasts or druses are also observed in leaf , stem and petioles. Various functions have been attributed to plant crystal idioblasts. Some evidences have pointed out to the ionic balance, which avoids the oxalate toxic accumulation, to the storage of calcium, to do protective function against herbivorous animals and even to mechanical support Franceschi, Horner Jr., 1980 [14].

IV. **Conclusion**

Present investigation throws light on phenology , palynology and morpho-anatomical characters of *A . ficoidea* which helps in proper identification and effective utilization as well as control of the invasive weed .

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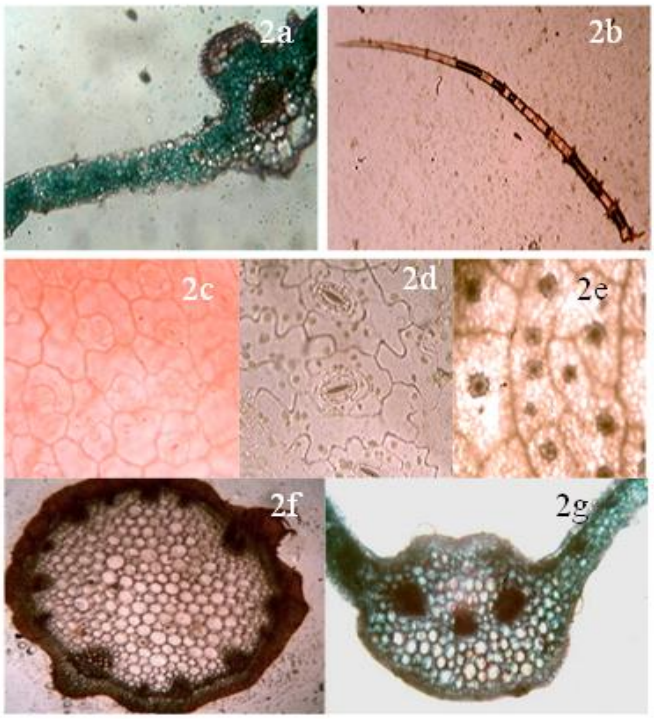
Plate – 1 – Morphology of weed
A. ficoidea

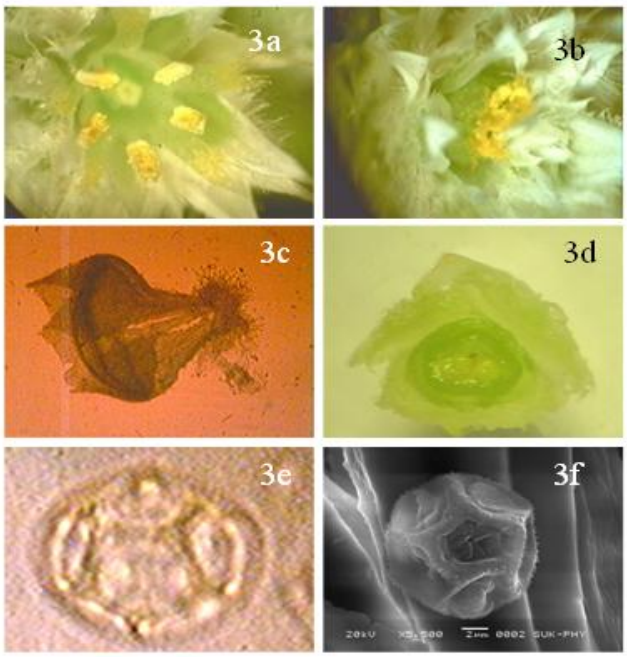
1a- Habitat 1b- Long tap root , 1 c – Habit
1d- At flowering stage

Plate -2- Anatomy of *A ficoidea*



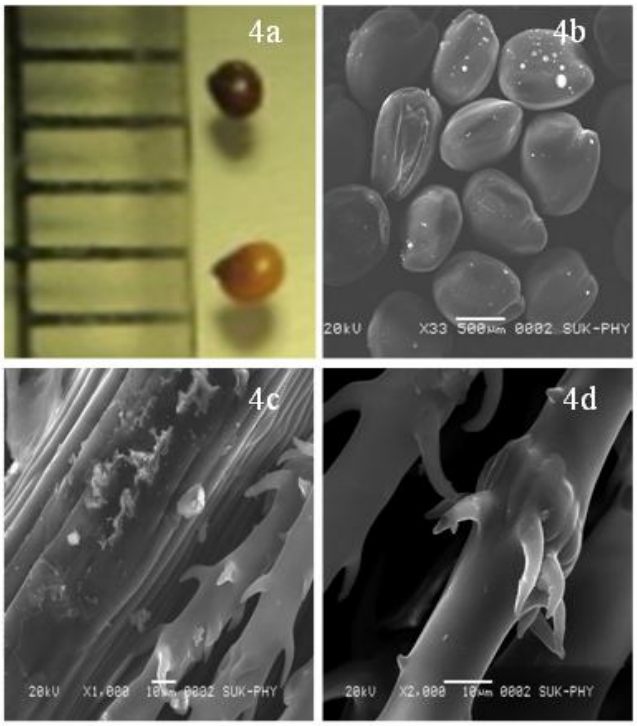
2 a-T..S.of leaf
2 b-Trichome,
2c -Upper epidermis,
2d-Lower epidermis,
2e -Druses on plant parts
2f -T.S. of stem,
2g -T. S . of petiole,

Plate – 3 - Phenology and palynology of *A. ficoidea*



3 a- Single flower , 3 c- Receptive stigma, 3e -Single pollen,
3 b - Anthesis of flower , 3d –T.S. of ovary, 3f –SEM of pollen

Plate – 4 - Seed of *A. ficoidea*



4 a – Seed ,
4 b– SEM of seed

4 c and 4 d – SEM of trichome

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