



A study of the diversity of Crassulacean acid metabolism (CAM) plants in the major districts of the Malwa region (M.P.) India

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Abstract

The present research works were undertaken to study the diversity of CAM plants in major districts of the Malwa region. Based on a field study, a total of 62 species, belonging to 29 genera and 13 families were collected from the different locations of the study area and were described along with botanical names, common name, families and uses. Euphorbiaceae was reported as the dominant family. Other main contributing families were Agavaceae, Cactaceae and Crassulaceae. The field study was carried out from January 2014 to December 2018 in major districts of the Malwa region (M.P.) India.

Keywords: Malwa region, CAM plants, Crassulacean acid metabolism, Diversity, M.P

Introduction

India is one of the 12 "mega-diversity" countries in the world and the country has a geographical area of 23.81% since ancient times man has been using plants for food, ornamental and medicinal purposes. Therefore various aspects of plants such as medicinal value, economic value, sustainable utility, conservation, floral assessment and documentation are necessary. The distribution of plants depends on various environmental factors such as temperature, water, and other food factors (Curtis and Cottom, 1956; Miskra, 1968). The diversity of plants is the most important feature, which plays an important role in the complexity of natural ecosystems.

The CAM Plants have Crassulacean acid metabolism, a form of photosynthesis in which carbon dioxide is taken only at night. CAM Plants use certain special compounds to gather carbon dioxide (CO₂) during photosynthesis. During night the CAM plants allow CO₂ to enter when stomata are open and fixed as organic acids that are stored in vacuoles. During the day the stomata are closed for preventing water loss and the carbon is released to the Calvin cycle so that photosynthesis may take place.

The CAM plants often show xerophytic features, such as thick, reduced leaves, thick cuticle, and the sunken stomata. Some CAM plants shed their leaves during the dry season and some store water in vacuoles (Cacti and orchids). CAM plants are good at retaining water and use nitrogen very efficiently. They are less efficient at CO₂ absorption when their stomata are being closed during the day. CAM plants are adapted to live in arid climates by conserving water. Crassulacean Acid Metabolism (CAM) was first discovered

in the late 1940s. The botanists Ranson and Thomas have observed Crassulacean Acid Metabolism in the succulents of the Crassulaceae family. Its name leads to acid metabolism in Crassulaceae. Succulent plants are popular among plant collectors, home gardeners and plant lovers for a number of reasons like their colorful leaves, flowers, structures, simple care and their beautifulness. CAM plants are ignored by workers in the Malwa region. Now succulent CAM plants are used in outdoor and indoor gardening at various places like malls, industries, colleges, hospitals, and gardens in the Malwa region. So, there is an urgent need to have documentation of such ornamental CAM plants. The present paper is an attempt to find out the distribution, abundance and diversity of CAM plant in major districts of the Malwa region.

Study area

The Malwa region occupies a plateau in western Madhya Pradesh and south-eastern Rajasthan with Gujarat in the west. Its lines between 21°10' N and 25°10' N latitudes and 73° 4' E and 79° 14' E longitudes. The region includes the districts of Madhya Pradesh Rajgarh, Shajapur, Dewas, Indore, Dhar, Jhabua, Ratlam, Mandsaur, Neemuch, Ujjain, Agar Malwa and parts of Guna and Sehore and the Rajasthan districts of Jhalawar and parts of Pratapgarh and Banswara. Of these, five districts of the Malwa region viz Rajgarh, Agar Malwa, Ujjain, Ratlam and Mandsaur were selected as the study sites for conducting a detailed Ecological survey of CAM plants gathering information (Fig. 1, 2).

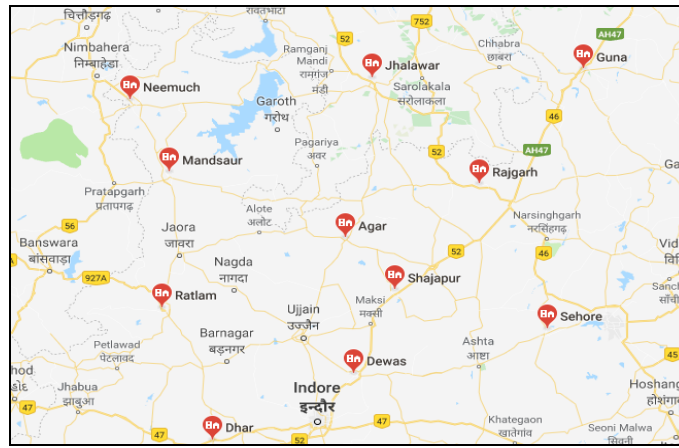


Fig 1: Showing location of the Malwa region (Red indications).



Fig 2: Showing location of major districts (study sites in red indications) in the Malwa region.

Materials and Methods

The field study was carried out from January 2014 to December 2018 in major districts of the Malwa region (MP) India.

The study was done in all parts of the study area and plants were collected to prepare herbarium. Herbaceous plant

specimens were dugout as a whole whereas, in the case of shrubs and trees, only the soft twigs with flowers and fruits were taken. The dried specimens were pasted on the herbarium sheets. The herbarium sheets were protected against damage from insect and fungal pathogens by poisoning the sheets with naphthalene balls and, 1% mercuric chloride. After field survey and herbarium preparation, all plants were identified with the help of available literature and BSI Jodhpur. The collected plants' materials have been deposited in the herbarium of the Department of Botany, Govt. Madhav PG College Ujjain. The methodology was covered in two stages as follows. The first is the Field survey and the second is Literature study. The field survey was conducted to collect information about the plant species like their identification and documentation. The whole study area was visited many times for the collection of plants specimen. The identification was also done based on a literature study (Bhandari, 1978; Hooker, 1875; Jain, 1968 Maheshwari 1963). Maximum plant specimens were identified by BSI Jodhpur.



Fig 3: View of study site in the field during survey period.



Fig 4: Photograph of BSI Jodhpur Campus, Where I meet to senior scientist Shri Vinod Maina, Head of office and Scientist 'D' and Dr. M. K. Singhadiya Botanist.



Fig 5: A photograph of preparing herbarium file.



Photo plate 1: Some important CAM plants species reported in different districts of the Malwa region.

Results and Discussion

Plant diversity is the structural and functional unit of the biotic components of the ecosystem. Based on a field study, a total of 62 species, belonging to 29 genera and 13 families were collected from the different locations of the Malwa region and were described along with botanical names, common names, genus and families. All plant species were listed as shown in Table-2. Out of these plant species, 4 species were of trees, 39 species were of shrubs, 16 species were of herbs and 1 species was of epiphyte (Table-1).

Euphorbiaceae was reported as the dominant family. Other main contributing families were Agavaceae, Cactaceae and Crassulaceae (Table-3, 4). The dominance of plants from the Cactaceae and Euphorbiaceae family in the study area indicates the harsh environmental conditions especially the water stress because the species of Cactaceae and Euphorbiaceae have made morphological, anatomical and physiological adaptations to overcome the drought conditions (Vasistha et al., 2010). There are 62 species of CAM plants belonging to 13 families that were observed and scientifically documented. Out of recorded plants, the maximum number of plants (13) belonging to the family Euphorbiaceae, followed by Agavaceae (12), Crassulaceae

(11) and Cactaceae (11). The members of the family Xanthorrhoeaceae, Portulacaceae, Asteraceae, Vitaceae, Orchidaceae, Commelinaceae and Asclepiadaceae showed their species range 1-5 in number (Table-3, 4). The recorded plants is of value for much purpose. The researchers can utilize this information in the planning of sustainable utilization and conservation of these resources in the Malwa region. Medicinal and ornamental CAM plants diversity with herbaceous, shrubs and some trees were assessed and documented in this study. Available literature was consulted for documentation of present research work. The study was done to know the eco-taxonomical position of the CAM plants. There are no specific reports on such details of Ecological survey and diversity of CAM plants in the Malwa region. However, Patel R.M. et al. (2016) A checklist of succulent plants of Ahmedabad, Gujarat, India and reported 45 genera and 73 species with 1 sub sp., 5 varieties and 2 cultivated varieties belonging to 15 families. Similarly, Aditya Kumar et al. (2015) Survey of Some Important Ornamental Flowering Plants of Solan, Himachal Pradesh with Enumeration, Fifteen ornamentally important plant species belonging to 15 genera and 11 families were studied. Ornamental CAM plants are produced mainly for their aesthetic value. Conservation of ornamental flowering species is essential to maintain their diversity.

Conclusion

The field study was carried out from January 2014 to December 2018 in major districts of the Malwa region (MP) India. In the present research work, total of 62 species, belonging to 29 genera and 13 families were collected from the districts of the Malwa region. Euphorbiaceae was reported as the dominant family. Other main contributing families were Agavaceae, Cactaceae and Crassulaceae. The dominance of plants from the Cactaceae and Euphorbiaceae family in the study area indicates the harsh environmental conditions especially the water stress because the species of Cactaceae and Euphorbiaceae have made morphological, anatomical and physiological adaptations to overcome the drought conditions (Vasistha et al., 2010). The recorded plants are of value for much purpose. The researchers can utilize this information in the planning of sustainable utilization and conservation of these resources in the Malwa region. The study was done to know the eco-taxonomical position of the CAM plants. Ornamental CAM plants are produced mainly for their aesthetic value. Conservation of ornamental flowering species is essential to maintain their diversity. Succulent plants are popular among plant collectors, home gardeners and plant lovers for a number of reasons like their colorful leaves, flowers, structures, simple care and their beautifulness. CAM plants are ignored by workers in the Malwa region. Now succulent CAM plants are used in outdoor and indoor gardening at various places like malls, industries, colleges, hospitals, and gardens in the Malwa region. The ornamental CAM herbs, shrubs and climber do not require much space and they can be planted even in small pots at houses and offices garden. We can retain biodiversity in CAM plants only if we maintain CAM phytodiversity. We can make special efforts to grow some of the endangered CAM plant species for conserved and propagation in our botanical gardens, nurseries, residential campuses, and houses. We can also make artificial "Green roof". CAM plants are cultivated in different pots and transfer in the roof of our house and used for the formation of artificial "Green roof". So, there is an urgent need to have documentation of such ornamental CAM plants.

Table 1: Number and percentage of families, genus and species in each community (life form)

Communities	Families		Genus		Species	
	No.	%	No.	%	No.	%
Herbs	5	38	8	28	16	26
Shrubs	8	62	18	62	39	63
Trees	2	15	4	14	4	6
Epiphyte	1	8	1	3	1	2
Ball cactus	1	8	2	7	2	3
Total					62	100

Table 2: List of CAM plants species observed in the different study sites of the Malwa region is as follows.

S.N.	Botanical Name	Common Name	Family	Habit
1	<i>Agave americana</i> L.	Century plant, Rambans	Agavaceae	Shrub
2	<i>Agave americana</i> var. 'marginata' Trel.	Yellow margin century plant	Agavaceae	Shrub
3	<i>Agave angustifolia</i> Haw.	Narrow leaved century plant	Agavaceae	Shrub
4	<i>Agave attenuata</i> salm-dyck	Fox tail agave	Agavaceae	Shrub
5	<i>Aloe abyssinica</i> lam.	Gvarapatha, Ghigavar	Xanthorrhoeaceae	Herb
6	<i>Aloe vera</i> (L.) Burm. f.	Gvarapatha, Ghigavar	Xanthorrhoeaceae	Herb
7	<i>Aloe 'sean red'</i> hybrid	Bright star	Asphodelaceae	Herb
8	<i>Ananas comosus</i> (L.) Merr.	Pineapple	Bromeliaceae	Herb
9	<i>Bryophyllum daigremontianum</i> (Raym.-Hamet & Perrier) A. Berger	Mother of Thousands	Crassulaceae	Herb
10	<i>Bryophyllum delagoense</i> (Eckl. & Zeyh.) Druce	Finger plant	Crassulaceae	Herb
11	<i>Bryophyllum pinnatum</i> (Lam.) Kurz.	Miracle plant	Crassulaceae	Herb
12	<i>Carnegiea gigantea</i> (Engelm.) Britton & Rose	Saguaro Cactus, Giant Cactus	Cactaceae	Tree
13	<i>Cereus uruguayanus</i> R. Kiesling	Spiny hedge cactus, Peruvian apple	Cactaceae	Tree

14	<i>Cissus quadrangularis</i> L.	Hadjod, Devil's back bone	Vitaceae	Shrub
15	<i>Cleistocactus strausii</i> (Hesse) Backeb.	Silver Torch	Cactaceae	Shrub
16	<i>Corynopuntia vilis</i> (Rose) F.M. Knuth.	Sagebrush cholla	Cactaceae	Shrub
17	<i>Crassula subacaulis</i> subsp. <i>erosula</i> (N.E.Br.)Toelken	Campfire	Crassulaceae	Herb
18	<i>Cylindropuntia tunicata</i> (Lehm.) F.M.Khuth	Desert cholla	Cactaceae	Shrub
19	<i>Echinocactus platyacanthus</i> Link and Otto	Golden barrel cactus	Cactaceae	Barrel cactus
20	<i>Euphorbia canariensis</i> L.	Canary Candelaber Spurge	Euphorbiaceae	Shrub
21	<i>Euphorbia grandicornis</i> Goebel ex N.E.Br.	Zig-zag Cactus	Euphorbiaceae	Shrub
22	<i>Euphorbia lactea</i> f. <i>cristata</i>	Crested euphorbia, coral cactus	Euphorbiaceae	Shrub
23	<i>Euphorbia milii</i> Des moult. 'Breonii'	Crown of thorns	Euphorbiaceae	Shrub
24	<i>Euphorbia milii</i> Des Moul. 'Cristata'	Crested crown of Thorns	Euphorbiaceae	Shrub
25	<i>Euphorbia milii</i> Des Moul.	Crown of thorn	Euphorbiaceae	Shrub
26	<i>Euphorbia royleana</i> Boiss	Danda thor	Euphorbiaceae	Shrub
27	<i>Euphorbia tirucalli</i> L.	Pencil tree, milk bush	Euphorbiaceae	Shrub
28	<i>Euphorbia trigona</i> Mill.	African milk tree, cathedral cactus	Euphorbiaceae	Shrub
29	<i>Euphorbia xylophyloides</i> Brongn.ex Lem.	Milk-bush	Euphorbiaceae	Tree
30	<i>Furcraea foetida</i> (L.) Haw.	Green agave	Agavaceae	Shrub
31	<i>Furcraea gigantea</i> var. <i>mediopicta</i> Trel.	Mauritius hemp	Agavaceae	Shrub
32	<i>Gasteria carinata</i> var. <i>verrucosa</i> (Mill.) Van Jaarsv.	Deer's Tongue, Ox Tongue	Xanthorrhoeaceae	Shrub
33	<i>Graptopetalum paraguayense</i> (N. E. Br.) E. Walther	Ghost plant	Crassulaceae	Shrub
34	<i>Haworthia attenuata</i> (Haw.) Haw.	Zebra plant	Xanthorrhoeaceae	Shrub
35	<i>Howorthia fasciata</i> (Willd.) Haw.	Zebra plant	Xanthorrhoeaceae	Shrub
36	<i>Kalanchoe blossfeldiana</i> Poelln.	Flaming Katy	Crassulaceae	Herb
37	<i>Kalanchoe fedtschenkoi</i> f. <i>variegata</i> hort	Rainbow kalanchoe	Crassulaceae	Herb
38	<i>Kalanchoe pumila</i> Baker	Flower dust plant	Crassulaceae	Herb
39	<i>Kalanchoe thyrsiflora</i> Harv.	Desert Cabbage, paddle plant	Crassulaceae	Herb
40	<i>Opuntia cylindrica</i> (Lam.) Dc.	Prickly Pear	Cactaceae	Shrub
41	<i>Opuntia falcata</i> Ekman & Werderm.	Tree opuntia	Cactaceae	Tree
42	<i>Opuntia ficus-indica</i> (L.) Mill.	prickly pear	Cactaceae	Shrub
43	<i>Opuntia microdasys</i> (Lehm.) Lehm. ex Pfeiff.	Polka-dot Cactus, Bunny Cactus	Cactaceae	Shrub
44	<i>Parodia haselbergii</i> (F.Haage) F.H.Brand.	<i>Notocactus</i> , small ball cacti	Cactaceae	Ball Cactus
45	<i>Pedilanthus tithymaloides</i> (L.) poit.	Devil's backbone, redbird-cactus	Euphorbiaceae	Shrub
46	<i>Pedilanthus tithymaloides</i> (L.) poit. 'Nanus'	Zigzag plant, Devil's backbone	Euphorbiaceae	Shrub
47	<i>Pedilanthus tithymaloides</i> (L.) poit. "variegatus"	redbird-cactus	Euphorbiaceae	Shrub
48	<i>Portulaca grandiflora</i> Hook.	Eleven-o'clock, Sun plant, Rose moss	Portulacaceae	Herb
49	<i>Portulaca oleracea</i> L.	Green purslane	Portulacaceae	Herb
50	<i>Portulacaria afra</i> Jacq	Elephant food	Portulacaceae	Shrub
51	<i>Sansevieria cylindrica</i> Bojer ex Hook	Cylindrical snake plant	Agavaceae	Shrub
52	<i>Sansevieria suffruticosa</i> N.E.Br.	Cylindrical snake plant	Agavaceae	Shrub
53	<i>Sansevieria trifasciata</i> 'Hahnii'	Bird's Nest, Snake plant	Agavaceae	Shrub
54	<i>Sansevieria trifasciata</i> prain	Mother-in-Law's tongue	Agavaceae	Shrub
55	<i>Sansevieria trifasciata</i> var. <i>laurentii</i> (De Wild.) N.E.Br.	Snake plant, Good luck plant	Agavaceae	Shrub
56	<i>Sedum nussbaumeria</i> Bitter	Golden sedum, stonecrops	Crassulaceae	Shrub
57	<i>Sedum spectabile</i> Bor.	Stonecrops	Crassulaceae	Herb
58	<i>Senecio radicans</i> (L.f.) Sch. Bip.	String of bananas	Asteraceae	Shrub
59	<i>Stapelia glanduliflora</i> Masson	Starfish flowers	Asclepiadaceae	Shrub
60	<i>Tradescantia pallida</i> (Rose) D.R. Hunt	Purple Heart, Purple Queen	Commelinaceae	Herb
61	<i>Vanda roxburghii</i> R.Br	Rasna, Vandaka	Orchidaceae	Epiphyte
62	<i>Yucca aloifolia</i> L.	Dagger Plant	Agavaceae	Shrub

Table 3: Total numbers of CAM plant species in the different families observed from major districts of the Malwa region

S.N.	Family	Botanical Name	Total No. of Species
1.	Agavaceae	1. <i>Agave americana</i> L. 2. <i>Agave americana</i> var. 'marginata' Trel. 3. <i>Agave angustifolia</i> Haw. 4. <i>Agave attenuata</i> salm-dyck 5. <i>Furcraea foetida</i> (L.) Haw. 6. <i>Furcraea gigantea</i> var. <i>mediopicta</i> Trel. 7. <i>Sansevieria cylindrica</i> Bojer ex Hook 8. <i>Sansevieria suffruticosa</i> N.E.Br. 9. <i>Sansevieria trifasciata</i> 'Hahnii' 10. <i>Sansevieria trifasciata</i> prain 11. <i>Sansevieria trifasciata</i> var. <i>laurentii</i> (De Wild.) N.E.Br. 12. <i>Yucca aloifolia</i> L.	12
2.	Asclepiadaceae	1. <i>Stapelia glanduliflora</i> Masson	1
3.	Asphodelaceae	1. <i>Aloe 'sean red'</i> hybrid	1
4.	Asteraceae	1. <i>Senecio radicans</i> (L.f.) Sch. Bip.	1

5.	Bromeliaceae	1. <i>Ananas comosus</i> (L.) Merr.	1
6.	Cactaceae	1. <i>Carnegiea gigantea</i> (Engelm.) Britton & Rose 2. <i>Cereus uruguayanus</i> R. Kiesling 3. <i>Cleistocactus strausii</i> (Hesse) Backeb. 4. <i>Corynopuntia vilis</i> (Rose) F.M. Knuth. 5. <i>Cylinropuntia tunicata</i> (Lehm.) F.M. Khuth 6. <i>Echinocactus platyacanthus</i> Link and Otto 7. <i>Opuntia cylindrica</i> (Lam.) Dc. 8. <i>Opuntia falcata</i> Ekman & Werderm. 9. <i>Opuntia ficus-indica</i> (L.) Mill. 10. <i>Opuntia microdasys</i> (Lehm.) Lehm. Ex Pfeiff. 11. <i>Parodia haselbergii</i> (F.Haage) F.H.Brand.	1
7.	Commelinaceae	1. <i>Tradescantia pallida</i> (Rose) D.R. Hunt	1
8.	Crassulaceae	1. <i>Bryophyllum daigremontianum</i> (Raym.-Hamet & Perrier) A. Berger 2. <i>Bryophyllum delagoense</i> (Eckl. & Zeyh.) Druce 3. <i>Bryophyllum pinnatum</i> (Lam.) Kurz. 4. <i>Crassula subacaulis</i> subsp. <i>erosula</i> (N.E.Br.)Toelken 5. <i>Graptopetalum paraguayense</i> (N. E. Br.) E. Walth. 6. <i>Kalanchoe blossfeldiana</i> Poelln. 7. <i>Kalanchoe fedtschenkoi</i> f. <i>variegata</i> hort 8. <i>Kalanchoe pumila</i> Baker 9. <i>Kalanchoe thyrsiflora</i> Harv. 10. <i>Sedum nussbaumeria</i> Bitter 11. <i>Sedum spectabile</i> Bor.	11
9.	Euphorbiaceae	1. <i>Euphorbia canariensis</i> L. 2. <i>Euphorbia grandicornis</i> Goebel ex N.E.Br. 3. <i>Euphorbia lactea</i> f. <i>cristata</i> 4. <i>Euphorbia milii</i> Des moul. 'Breonii' 5. <i>Euphorbia milii</i> Des Moul. 'Cristata' 6. <i>Euphorbia milii</i> Des Moul. 7. <i>Euphorbia royleana</i> Boiss 8. <i>Euphorbia tirucalli</i> L. 9. <i>Euphorbia trigona</i> Mill. 10. <i>Euphorbia xylophylloides</i> Brongn.ex Lem. 11. <i>Pedilanthus tithymaloides</i> (L.) poit. 12. <i>Pedilanthus tithymaloides</i> (L.) poit. 'Nanus' 13. <i>Pedilanthus tithymaloides</i> (L.) poit. "variegatus"	13
10.	Orchidaceae	1. <i>Vanda roxburghii</i> R.Br	1
11.	Portulacaceae	1. <i>Portulaca grandiflora</i> Hook. 2. <i>Portulaca oleracea</i> L. 3. <i>Portulacaria afra</i> jacq	3
12.	Vitaceae	1. <i>Cissus quadrangularis</i> L.	1
13.	Xanthorrhoeaceae	1. <i>Aloe abyssinica</i> lam. 2. <i>Aloe vera</i> (L.) Burm. f 3. <i>Gasteria carinata</i> var. <i>verrucosa</i> (Mill.) Van Jaarsv 4. <i>Haworthia attenuata</i> (Haw.) Haw. 5. <i>Howorthia fasciata</i> (Willd.) Haw.	5
Total	13 families	62 species	62 species

Table 4: The dominant position of the families according to their total number of CAM plant species in the Malwa region

S.N.	Family	Total number of genus	Total number of Plant Species	Position of the Families
1.	Euphorbiaceae	2	13	1
2.	Agavaceae	4	12	2
3.	Cactaceae	8	11	3
4.	Crassulaceae	5	11	3
5.	Xanthorrhoeaceae	3	5	4
6.	Portulacaceae	1	3	5
7.	Asclepiadaceae	1	1	6
8.	Asphodelaceae	1	1	6
9.	Asteraceae	1	1	6
10.	Bromeliaceae	1	1	6
11.	Commelinaceae	1	1	6
12.	Orchidaceae	1	1	6
13.	Vitaceae	1	1	6
Total	13	29	62	1-6

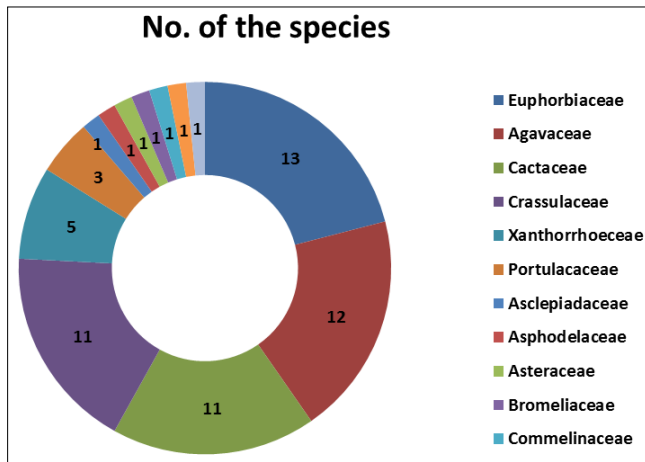


Fig 6: Showing the dominant position of the families according to their total number of CAM plant species in the Malwa region.

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