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Identification and Morph-metric Characterization of Powdery Mildew Infecting Diverse Host Plants of Southern Gujarat, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Powdery mildews are obligate biotrophic fungal pathogens that are responsible for disease on a wide range of host plants with white powdery patches on plant parts. An exhaustive survey in the Navsari region of south Gujarat was carried out to identify white powdery/floury circular to irregular spots, specks or patches either on the upper surface or lower surface or both the surface of the leaves. These powdery mildew symptoms were observed on leaves, stems and pods/fruits on 39 hosts of 22 families. For precise identification of the pathogen the morphological characteristics

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included mycelium, length and breadth of conidia, conidiophores, appressorium, conidial germ tubes foot cell and fibrosin bodies. Majorly the genera like *Erysiphe*, *Golovinomyces*, *Leveillula*, *Oidium*, *Phyllactinia*, *Podosphaera, Micro-oidium* and *Sphaerotheca* were found on different hosts in this region. The maximum number of hosts were infected by the genus *Oidium* followed by *Erysiphe*. The highest percent disease incidence was observed on the asthma plant, black gram, green gram and wild poinsettia between 75-100 per cent out of all the hosts.

Keywords: Powdery mildew; host range; per cent disease incidence.

1. INTRODUCTION

Powdery mildews are a group of fungal parasites belonging to order–*Erysiphales* under the class *Leotiomycetes*. They are obligate biotrophs responsible for powdery diseases. These fungi grow superficially or epiphytically on plant surfaces. They cause various disease symptoms including chlorosis, stunted growth, early leaf drop and flower bud deformation on different plant parts including leaves, young stems, buds, flowers and fruits [1]. The disease causes heavy losses to field crops and other plants. These fungi grow abundantly in dry and cool seasons. Leaves infected with powdery mildew may turn completely yellow, die, and fall off, which may expose fruit to sun burn. On some plants, powdery mildew may cause the leaves to twist, buckle, or otherwise distort. They are widespread on various hosts including agricultural crops, vegetables, trees, herbs, shrubs, grasses, ornamental plants and weeds [1].

Based on literature, throughout the world more than 7000 plant host species are attacked by powdery mildew [2]. However, powdery mildews are more common on cultivated crops than on other plant 2. The fungi infect almost every group of plants *i.e.* from grasses to higher angiosperms [3]. Powdery mildews are easily recognizable on infected plant parts. The initial symptom appears as white powdery spots that may occur on both surfaces of leaves, shoots and sometimes on flowers and fruits. These spots gradually spread over a large area of the leaves and stems. Disease symptoms usually appear with the onset of summer and begin to disappear during scorching heat and rainy season [4].

Identification of powdery mildew pathogen can also be done precisely by knowing its morphology on different growing season of the plants and it keeps on changing among different hosts. During the early growing season, hyphae of the powdery mildew are produced either on upper leaf surface or on lower leaf surfaces, although some species produce on both the surface of leaves, stems and flowers, or fruit. Specialized absorption cells called as haustoria which multiply into the plant epidermal cells to obtain nutrition. Conidia (asexual spores) are also produced on plant surfaces during the growing season. They grow either singly or in chains on specific hyphae called conidiophores. Conidiophores grow superficially or endophytically on variety of plant hosts [2].

Towards the end of the developing season, powdery mildew fungi produce sexual spores known as ascospores in a sac-like ascus (pl. asci) encased in a fruiting body called a chasmothecium (pl. chasmothecia) [3]. The chasmothecium is commonly round with no characteristic opening asci with ascospores when split creates the mass of the fruiting body. An assortment of appendages may occur on the outside of the chasmothecia.

The climatic conditions in Navsari district of south Gujarat encourage the initiation, growth and development of powdery mildew infection. The report of powdery mildews from the Navsari district is less explored therefore; an extensive survey of the area was carried out to study powdery mildew diversity and infection status of the disease on different hosts.

2. MATERIALS AND METHODS

2.1 Survey and Sampling

The 4-5 leaves samples from five individual plant showing white powdery symptom pattern were collected randomly using opportunistic survey from the Navsari region during March 2019 to March 2020 to know the diversity and incidence of powdery mildew on different hosts. These plants were tagged or marked to take observations regularly [5].

2.2 Morphological Characterization of Powdery Mildew Pathogen

The studies on morphological features like mycelium, conidia, conidiophores, foot cell, conidial germ tubes, appressorium were observed under 10x and 40x objective binocular light microscope measuring its length and the breadth with the help of microscopic camera using scope photo software at Department of Plant Pathology, N. M. College of Agriculture, Navsari Agricultural University, which is located at 20.95^0 North latitude (N) and 72.93^0 East longitude (E) under Agro climatic zone of South Gujarat, heavy rainfall zone, agroecological Situation-III.

Different methods were used to study the morphology of this pathogen such as for identifying mycelium, conidiophores and foot cell. Lactophenol (10CC) containing 1.0 per cent cotton blue was used. Cross section from the leaf using sharp blade found to be convenient for conidiophores and foot cell. Whereas to study the conidia, clear lactophenol solution was used. Glycerin was used to identify germ tube and appressorium. For identifying fibrosin bodies 3 and 10 per cent aqueous solution of KOH was mounted on glass slide along with fungal colonies [6] (Table 2) (Fig. 5).

Disease incidence on different hosts studied using the formula given by [7].

$$\text{Incidence \%} = \frac{\text{Number of infected plant units}}{\text{Total number (healthy and infected) of units assessed}} \times 100$$

3. RESULTS AND DISCUSSION

The present study data revealed that 8 genera and 24 species of powdery mildew were known to attack different hosts in Navsari region of south Gujarat. These were recorded on about 39 plant host species (Fig. 1) belonging to 36 genera and 22 families. The species richness of fungi was highest in *Oidium* (9 species), followed by *Erysiphe* (6 species), *Leveillula*, *Phyllactinia* and *Podosphaera* (2 each), *Golvinomyces, Sphaerotheca* and *Micro-oidium* (1 each). Eight hosts of family fabaceae were infected with powdery mildew followed by *Asteraceae* and *Cucurbitaceae* [8], *Malvaceae* [9], *Solanaceae* and *Euphorbiaceae* (2), *Rutaceae*, *Meliaceae*, *Brassicaceae*, *Convolvulaceae*, *Menispermaceae*, *Apiaceae*, *Boraginaceae*, *Oleaceae*, *Anacardiaceae*, *Moraceae*, *Phyllanthaceae*, *Apocyanaceae*, *Myrtaceae*, *Rosaceae*, *Pedaliaceae* and *Rhamnaceae* (1 each) (Table 1).

The powdery mildew symptoms were seen at different stages of the plant growth. Symptoms occurred in the initial stages in the case of jasmine, little gourd and ber; before flowering in gale of wind weed; between flowering and fruit setting stage in congress grass, okra, black gram and green gram (Table 1). The per cent disease incidence also varied among different hosts ranging from 10-88% during the period of survey.

3.1 Morphological Characterization of Powdery Mildew Pathogen

The collected samples were taken for identification of causal organism using morphological features. The observations on morphology of the powdery mildew pathogen included the mycelium, length and breadth of conidia, conidiophores (Fig. 2), appressorium (Fig. 3), conidial germ tubes (Fig. 4) and foot cell (Fig. 5). Morphological descriptions of powdery mildew pathogens collected from the different host are described in the Table 2.

Navsari, being a coastal area of south Gujarat with heavy rainfall and dense vegetation is favorable to powdery mildew fungi on various hosts [5]. Symptoms differed from hosts to hosts. Common symptoms were circular to irregular white powdery patches on the upper surface of leaves in crops like mustard, little gourd, neem *etc*. and on lower surface of leaves in crops like pigeon pea, chili, Indian rosewood, mulberry *etc*. or on both the surfaces of the leaves in wild poinsettia, field bindweed *etc*. High percent disease incidence *i.e*., 75-100 % was observed on different field crops such as okra, mustard, black gram, green gram, little gooseberry and little gourd and on weeds such as asthma plant, wild poinsettia *etc*.

Powdery mildew caused by genus *Erysiphe* infected crops like okra, mustard, black–gram [5,10,11]. The genus *Oidium* infected crops like neem, broom creeper, mango, congress grass, little gooseberry, tamarind and ber which were also in consonance with the studies of the [12] and [13]. The genus *Leveillula* infected crops like chili, pigeon pea and a weed wild poinsettia which were in accordance with [14].

Mulberry and Indian rose wood were infected by the genus *Phyllactinia* which was also reported by

[15] and [12], respectively. Powdery mildew pathogens infecting butternut squash, asthma plant, bitter gourd, bottle gourd, sesame and common cockle bur were infected with *Podospheara* genera which are in agreement with the findings of several workers [9,16,8,17,18,13].

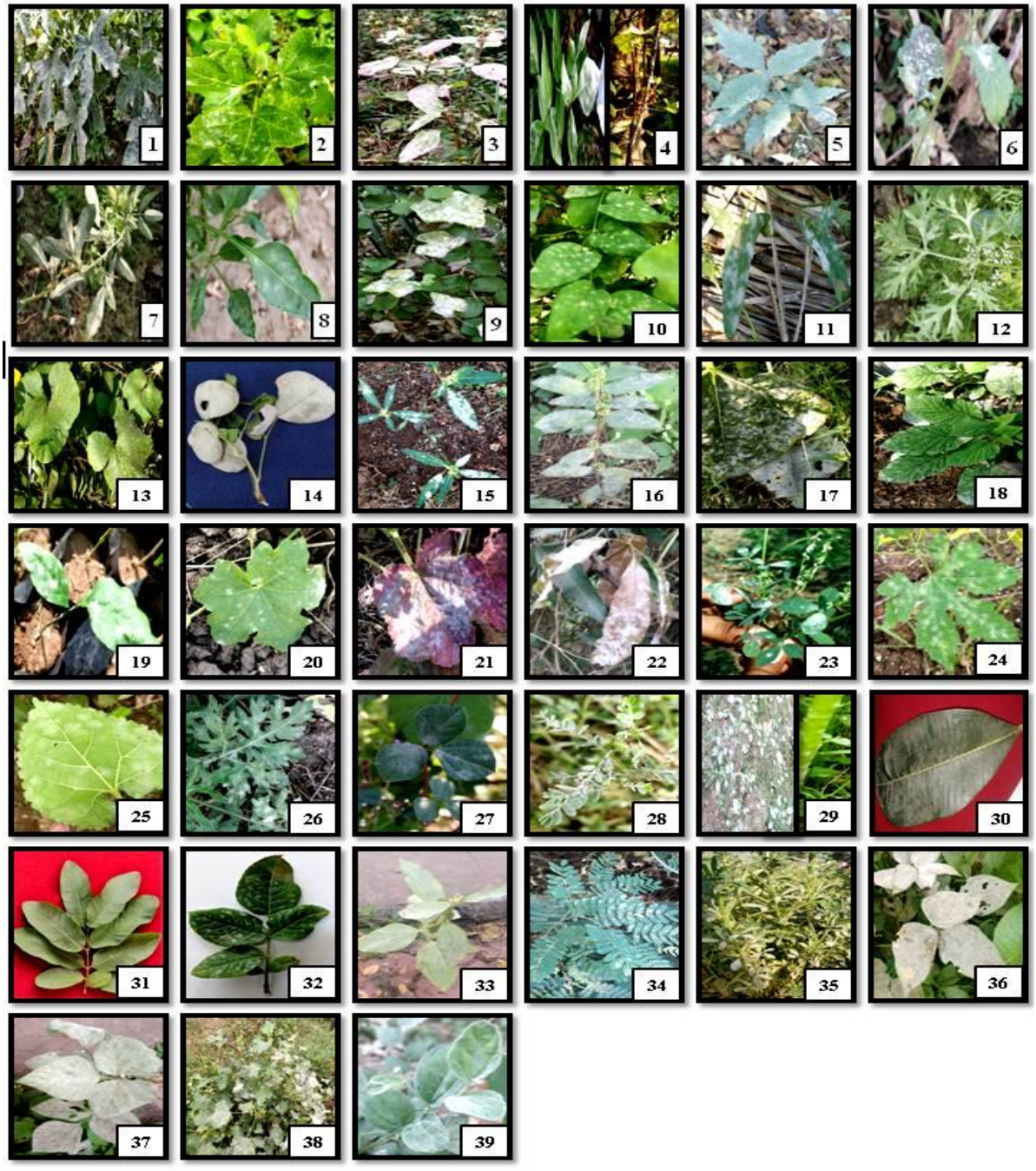

Fig. 1. Symptoms of powdery mildew on leaves of (1) Okra (2) wild bhendi (3) white spot flower (4) bael (5) neem (6) mustard (7) red gram (8) chilli (9) little gourd (10) broom creeper (11) Field bindweed (12) coriander (13) butternut squash (14) Indian rosewood (15) wild poinsettia(16) asthama plant (17) Sunflower (18) Indian heliotrope (19) jasmine (20) bottle gourd (21) vilayti bhendi (22) mango (23) white sweet clover (24) bittergourd (25) mulberry (26) parthenium (27) wild cocolmeca bean (28) gale of the wind (29) little gooseberry (30) Plumeria (31) guava (32) rose (33) sesame (34) tamarind (35) fenugreek (36) black gram (37) green gram (38) common cockle (39) ber

Table 1 Powdery mildew Symptoms and per cent disease incidence (PDI) on different hosts

Sl. No.	Host Range	Symptoms on plants	Stages of growth	Geographical co-ordinates		Year 2019-2020	
				Latitude	Longitude	Months	Incidence (%)
1.	Okra *Abelmoschus esculentus* L. Moench	Circular to irregular (CI) patches on the upper surface (US) of the leaves, on stem, flowers and pods	Flowering and fruit setting	20° 55′ 38″ N	72° 53′ 54″ E	October – November	74.50
2.	Wild bhendi *Abelmoschus* Medik.	Small white CI patches on the US of the leaves	Flowering and fruit setting	20° 55′ 38″ N	72° 53′ 54″ E	October – November	51.32
3.	White spot- flower *Acmella radicans* (Jacq.) R.K. Jansen	CI white patches on the leaves and stem	During flowering and pod setting	20° 55′ 38″ N	72° 53′ 54″ E	January – February	44.24
4.	Indian bael *Aegle marmelos* L.	Circular white patches on both the surface of leaves and on twigs and stem	Flowering and fruiting	20° 55′ 38″ N	72° 53′ 54″ E	December – January	47.33
5.	Neem *Azadirachta indica* A.Juss	Dirty white floury specks on US of leaves	Young plant	20° 55′ 38″ N	72° 53′ 54″ E	January	34.42
6.	Mustard *Brassica juncea* (L.) Czern.	CI patches on the US of older leaves	Flowering and fruiting	20° 55′ 38″ N	72° 53′ 54″ E	January-February	77.50
7.	Pigeon pea *Cajanus cajan* (L.) Millsp.	Creamish white circular powdery patches on lower surface (LS) of the leaves, US the leaves turned pale	Before flowering, during flowering and pod formation	20° 55′ 38″ N	72° 53′ 54″ E	January–February	50.25
8.	Chili *Capsicum annuum* L.	Off white circular powdery patches on LS of the leaves, coalesced to form large patches	During flowering and fruiting	20° 55′ 38″ N	72° 53′ 54″ E	January – February	46.66
9.	Little guard *Coccinia cordifolia* L	CI white powdery mycelial mat on US of the leaves and stem	Initial stage of the plant, during flowering and also during fruit formation	20° 56′ 42.36″ N	72° 56′ 3.84″ E	November, December, January	84.62
10.	Broom creeper *Cocculus hirsutus* (L.) Diels	White floury dust like pattern of mycelium on the US of the leaves	Before flowering and during flowering	20° 55′ 38″ N	72° 53′ 54″ E	November -December	49.82
11.	Field bindweed *Convolvulus arvensis* L.	White mat of dense mycelium on the LS of the leaves and on the US the circular white patches	Before flowering and during flowering	20° 55′ 38″ N	72° 53′ 54″ E	January-February	42.22
12.	Coriander *Coriandrum sativum* L.	White powder on older leaves and stem	At flowering and seed setting	20° 55′ 38″ N	72° 53′ 54″ E	February-March	38.50
13.	Butternut squash *Cucurbita maxima* Duchesne	White CI specks on LS of the leaves	Before flowering and fruit setting	20.9053° N,	72.9173° E	December-January	31.32
14.	Indian rosewood *Dalbergia sissoo* Roxb.	Dirty white circular powdery patches on the LS of the leaves	On older leaves of the tree	20° 55′ 38″ N	72° 53′ 54″ E	November-February	56.22
15.	Wild poinsettia *Euphorbia geniculata* Ortega	White circular small to large patches on both leaf surfaces	On leaves and post flowering	20° 55′ 38″ N	72° 53′ 54″ E	August-March	87.50
16.	Asthma-plant *Euphorbia hirta* L.	White powdery specks on the US of the leaves	Younger leaves to older leaves, stem, flowers and pod	20° 55′ 38″ N	72° 53′ 54″ E	November	76.00
17.	Sunflower *Helianthus annuus* L.	Specks of white powdery mycelium on the US of older leaves which coalesced to form large patch	During flowering and pod setting	21.3351°N	72.6225°E	January-February	45.72
18.	Indian Heliotrope *Heliotropium*	Small CI white spots on both leaf surfaces	Initial stages onwards	20° 55′ 38″ N	72° 53′ 54″ E	February	26.84

Sl. No.	Host Range	Symptoms on plants	Stages of growth	Geographical co-ordinates		Year 2019-2020	
				Latitude	Longitude	Months	Incidence (%)
	indicum L.						
19.	Jasmine *Jasminum sambac* (L.) Aiton	White CI patches on US of the leaf and stem	At the flowering	20° 55′ 38″ N	72° 53′ 54″ E	April	11.42
20.	Bottle gourd *Lagenaria siceraria* (Molina) Standl.	White circular patches on US of the leaves	Flowering and fruit setting	20° 55′ 38″ N	72° 53′ 54″ E	December-February	34.22
21.	Vilayati Bhendi *Malachra capitata* L.	Dirty white CI white mycelial mat on US of the leaves and on stem	Initial stages of the plant to flowering and fruit setting	20° 55′ 38″ N	72° 53′ 54″ E	October-December	69.78
22.	Mango *Mangifera indica* L.	Grayish white powdery specks on the leaves	Post flowering and fruit setting	20° 55′ 38″ N	72° 53′ 54″ E	December	24.11
23.	White sweet clover *Melilotus albus* Medik.	White CI floury dust like patches on the US of the leaves	Flowering	20° 55′ 38″ N	72° 53′ 54″ E	April	15.65
24.	Bitter gourd *Momordica charantia* L.	White powdery specks on the US of the leaves	Flowering and fruit setting	20.9645°N,	72.9254° E	November-December	52.36
25.	Mulberry *Morus alba* L.	White circular powdery specks on the LS the leaves	Initial stages of the plant and during flowering and pod formation	20° 55′ 38″ N	72° 53′ 54″ E	December-January	32.44
26.	Parthenium grass *Parthenium hysterophorus* L.	White dusty mycelium on the leaves, stem and flowers	Flowering	21.3351°N	72.6225°E	December	26.89
27.	Wild Cocolmeca Bean *Phaseolus maculatus* Scheele	CI white spots on the US of the leaves	Flowering and pod formation	21.3351°N	72.6225°E	January-February	27.11
28.	Gale of the wind *Phyllanthus niruri* L.	White powdery mycelium on the leaves, stem, flowers and pods	Flowering and pod formation	20° 55′ 38″ N	72° 53′ 54″ E	October-December	82.65
29.	Little gooseberry *Physalis minima* L.	Dusty white powder like symptom on US of leaves, stem and fruits	Flowering And Fruit Setting	21.3351°N	72.6225°E	October-December	84.46
30.	Plumeria *Plumeria alba* L.	White dusty symptom was seen on US of leaves	Flowering	21.3351°N	72.6225°E	January	15.24
31.	Guava *Psidium guajava* L.	Circular powdery patches on the US of the leaves	Flowering and Fruiting	20° 55′ 38″ N	72° 53′ 54″ E	November-December	15.22
32.	Rose *Rosa indica* L.	Grayish white irregular spots on the US of the leaves, buds and flowers	Flowering	20° 55′ 38″ N	72° 53′ 54″ E	November-December	35.25
33.	Sesame *Sesamum indicum* L.	White powdery mycelial mat on the leaves and pods	Pod formation	20° 55′ 38″ N	72° 53′ 54″ E	December-January	27.48
34.	Tamarind *Tamarindus indica* L.	CI whitish specks on the US of the leaves	Before flowering	20° 55′ 38″ N	72° 53′ 54″ E	November-December	12.32
35.	Fenugreek *Trigonella foenum-graecum* L.	Dusty white powder on leaves and on stem	Flowering to seed setting	20° 55′ 38″ N	72° 53′ 54″ E	February-March	49.62
36.	Green gram *Vigna radiata* (L.) Wilczek	Irregular dirty white patches on the US of the lower leaves	During flowering and pod formation	20° 55′ 38″ N	72° 53′ 54″ E	November-December	78.22
37.	Black gram *Vigna mungo* (L.) Hepper	Irregular dirty white patches on the US of the lower leaves	During flowering and pod formation	20° 55′ 38″ N	72° 53′ 54″ E	November-December	77.84
38.	Common cocklebur *Xanthium*	White CI specks on the US of the leaves	On the leaves, pods	20° 55′ 38″ N	72° 53′ 54″ E	January-	69.32

Sl. No.	Host Range	Symptoms on plants	Stages of growth	Geographical co-ordinates		Year 2019-2020	
				Latitude	Longitude	Months	Incidence (%)
	strumarium L.					December	
39.	Ber *Zizyphus mauritiana* Lam.	White dusty powder on the US of the leaves and on stem	Early stage of the plant and fruit formation	20° 55′ 38″ N	72° 53′ 54″ E	November-March	38.80

** CI - Circular to irregular LS- lower surface US- upper surface*

Table 2. Description of powdery mildew genera identified from different hosts with their morphological features

Sl. No.	Genera	Hosts	Mycelia	Conidia and conidiophores (Cp) morphology	Germ tube and appresorium	Fibrosin bodies	Conidial size(µm)			Conidiophore L(µm)	Foot cell Length
I	***Oidium***						**Length (L)**	**Breadth (B)**	**L/B index**		
a	*O. azadirachte*	Neem	Epiphytic	Conidia long ovoid, cylindrical in shape, borne singly on conidiophores(Cp).Cp erect, foot cells straight, curved to flexuous, followed by 2-3 smaller cells	simple with slightly swollen appressoria	-	38.03	12.42	3.06	112.32	37.44
b	*Oidium sp.*	White spot flower	White amphigenous	Ellipsoidal-cylindrical long conidia, borne singly. Cps were simple, slightly curved	simple slightly swollen nipple shaped appressorium.	-	30.71	16.05	1.91	90.07	39.63
c	*O. cocculus*	Broom creeper	White amphigenous	Conidia ovoid, ellipsoid borne singly or in short chains .Cp straight on foot cell composed of 3-4 cells	simple, slightly swollen appressorium	-	35.28	16.88	2.08	73.01	32.13
d	*O. mangiferae*	Mango	Superficial	Elliptical barrel shaped conidia borne singly or in chains. Slightly long with two to more basal cells Cp	simple	-	33.44	15.17	2.20	80.30	20.62
e	*o. ziziphin*	Ber	Septate white	Cylindrical to barrel shaped conidia. Upright and short Cp	simple	-	34.62	11.40	3.03	86.36	36.56
f	*O. tamarindii*	Tamarind	White cylindrical	Conidia cylindrical, formed singly or in chains. Cp Short and erect	arose from the end of conidia	-	30.02	14.60	2.05	52.23	32.72
g	*O. heliotropeindici*	Indian heliotrope	Ectophytic	Ovoid to ellipsoid in shape formed singly or in short chains. Cp erect, straight, slightly curved and cylindrical	produced from the lateral sides of the conidia. Appressorium was nipple shaped.	-	28.92	18.44	1.56	54.20	20.62
h	*O. malachaera*	Vilayati bhendi	White amphigenous mycelium	Ellipsoid to ovoid in shape, borne singly or in chains. Cp curved 6-8 celled, foot cell was straight	simple	-	35.70	17.75	2.01	97.98	42.65
i	*O. parthenii*	Parthenium grass	Amphigenous	Barrel shaped conidia, Cp slightly swollen at the base and branched made up of 3-4 cells followed by foot cell	simple	-	22.77	13.93	1.63	85.05	39.60

Sl. No.	Genera	Hosts	Mycelia	Conidia and conidiophores (Cp) morphology	Germ tube and appresorium	Fibrosin bodies	Conidial size(µm)			Conidiophore L(µm)	Foot cell Length
j	*Oidium sp.*	Indian bael	White amphigenous mycelium persistent, effuse or patches	Conidia obovoid-ellipsoid to doliform subcylindrical borne singly, Cp simple, erect foot cells cylindrical 1–3 shorter cells	slightly swollen lobed or hooked appressorium	-	27.11	25.5	1.063	56.70	28.64
k	*Oidium sp.*	Plumeria	White, dense, superficial masses of mycelium,	Ellipsoid to oblong-elliptical conidia, produced singly, Cp unbranched, foot cells were cylindric, nearly straight and long, followed by 2-3 shorter cells	formed at the terminal position of the conidium.	-	25.6	18.23	1.40	72.47	18.68
l	*Oidium sp.*	Guava	White ectophytic	Conidia cylindrical, oblong-elliptical in shape. Cp straight and slightly swollen at the base	simple	-	15.30	14.93	1.02	66.67	29.80
m	*Oidium sp.*	Little gooseberry	Ectophytic branched and septate mycelium	Conidia ovoid-ellipsoid and formed in short chains. Cp branched, short composed of 3-4 cells followed by foot cell	simple, appressorium slightly swollen or lobed	-	26.27	13.76	1.90	87.52	28.70
II	***Erysiphe***										
a	*E. cichoracearum*	Okra	Epiphytic hyaline, whitish, slightly flexuous and profuse	Conidia ellipsoidal-cylindrical (oblong/ barrel) long in shape borne singly or in short chains on slightly straight Cp	simple (non-forked) emerging apically or basally and it formed unlobed appressorium	-	47.22	20.88	2.26	112.26	35.40
b	*E. cichoracearum*	Wild bhendi	-do-	-do-	-do-	-	29.61	16.48	1.79	94.74	30.29
c	*E. polygoni*	Coriander	Amphigenous dirty white hyaline	Conidia borne singly or in chains which were barrel or cylindrical in shape. Cp slightly straight, foot cells were straight followed by 5-6 cells	simple (non-forked) emerging apically or basally and it formed unlobed appressorium.	-	26.14	15.65	1.67	87.63	16.95
d	*E. polygoni*	Fenugreek	-do-	-do-	-do-	-	27.42	16.23	1.68	88.32	18.04
e	*E. polygoni*	Black gram	-do-	-do-	-do-	-	25.7	16.1	1.59	62.27	38.00
f	*E. polygoni*	Green gram	-do-	-do-	-do-	-	28.97	17.54	1.65	102.16	13.74
g	*E. polygoni*	Wild cocolmeca bean	Epiphytic white	-do-	-do-	-	27.57	16.45	1.67	80.74	12.56
h	*E. cruciferarum*	Mustard	Amphigenous	Oblong to cylindrical or oval borne conidia	simple (non-	-	38.90	14.90	2.60	114.25	40.20

Sl. No.	Genera	Hosts	Mycelia	Conidia and conidiophores (Cp) morphology	Germ tube and appresorium	Fibrosin bodies	Conidial size(µm)			Conidiophore L(µm)	Foot cell Length
			white	borne singly or in short chains. Cp cylindrical composed of 3-4 cells	forked) emerging apically or basally						
i	*E. convolvuli*	Field bindweed	White dense	Conidia cylindrical to ellipsoid borne either singly or in chains. Cp with cylindrical foot cells, slightly curved composed of 3-4 cells	Arises laterally, with lobed appressorium	-	34.62	17.52	1.95	79.42	29.35
j	*E. trifoliorum*	White sweet clover	Epiphytic	Conidia solitary, cylindrical to doliiform, borne singly or in chains and Cp were single, hyaline and erect	terminal or subterminal with well-developed lobed appressoria	-	30.65	18.64	1.64	68.92	37.80
k	*Erysiphe sp.*	Jasmine	White ectophytic	Conidia ellipsoid-ovoid to subcylindrical in shape and formed singly. Erect and unbranched Cp with cylindrical foot-cells	arises laterally, with lobed appressorium	-	33.22	18.64	1.78	65.71	25.64
III	***Podosphaera***										
a	*P. xanthii*	Butternut squash	Mycelium flexuous to straight branched and septate	Ellipsoid-ovoid to barrel shaped conidia, formed in chains and straight Cp, foot-cells were cylindrical with slightly swollen base	simple to forked laterally, appressoria on the mycelium were nipple-shaped.	+	30.99	18.53	1.67	86.20	47.95
b	*P. xanthii*	Bottle gourd	Mycelium flexuous to branched and septate.	Conidia ellipsoid-ovoid to sub-cylindrical in shape, borne in chains. Cp were unbranched, erect and cylindrical	simple, nipple-shaped to almost absent with appressoria.	+	26.14	18.31	1.49	101.79	47.58
c	*P. xanthii*	Bitter gourd	Amphigenous	Ellipsoid to ovoid, doliform to sub-cylindrical in shape.Cp were erect, straight and cylindrical to flexuous, foot-cell followed by 1 to 4 shorter cells	simple germ tube, appressoria were indistinct to slightly nipple-shaped, and solitary.	+	27.89	15.63	1.78	104.86	49.20
d	*P. xanthii*	Sesamum	Amphigenous white mycelium	Conidia ovoid to dolliform, formed in short chains. Cp were simple, erect, foot-cells straight, followed by 1-3 short cells	arises from the end of the conidium	+	25.08	15.04	1.66	90.86	38.65
e	*P. xanthii*	Common cocklebur	Mycelium was flexuous to straight branched and septate	Conidia ellipsoid-ovoid to sub-cylindrical in shape, borne in chains. Unbranched, erect and cylindrical Cp.	simple, nipple-shape	+	33.00	16.4	2.01	71.74	45.23
f	*P. fusca*	Asthma plant	Hyphae were	Conidia ellipsoid to ovate in shape formed	produced	+	25.10	18.53	1.34	84.62	42.22

Sl. No.	Genera	Hosts	Mycelia	Conidia and conidiophores (Cp) morphology	Germ tube and appresorium	Fibrosin bodies	Conidial size(µm)			Conidiophore L(µm)	Foot cell Length
			branched, septate and straight	in 5-6 chains. Cp unbranched, long and straight	laterally, formed nipple-shaped to almost absent appressoria						
IV	***Leveillula***										
a	*L. taurica*	Pigeon pea	Endophytic	Conidia pyriform, long, borne singly. Cp were long, slender, erect, unbranched, composed of 3- 4 cells followed by foot cell	long erect tail-like arising at the end of the conidia	-	59.10	19.88	2.97	130.99	33.21
b	*L. taurica*	Chili	-do-	-do-	-do-	-	61.19	15.79	3.87	104.40	47.89
c	*L. clavata*	Wild poinsettia	Endophytic	Clavate, long conidia, borne singly at the apex. Long and slender Cp composed of 5-6 cells	formed near the end of conidium	-	72.8	16.6	4.38	135.64	40.84
V	***Golvonomyces***										
a	*G. orontii*	Little gourd	Amphigenous	Long cylindrical conidia, borne in chains. Cp erect composed of 4-5 cells followed by foot cell	simple and formed apically or basally at the end of the conidia; appressoria was bilobed	-	32.98	14.81	2.22	103.24	41.42
b	*G. orontii*	Sunflower	Amphigenous mycelium	Ellipsoid to round conidia formed in chains. Cp mostly erect containing a foot cell followed by 2 or 3 shorter cells	erect and long arising from the side with well developed nipple-shaped appressoria	-	32.22	18.44	1.74	65.41	25.62
VI	***Phyllactinia***										
a	*P. dalbergiae*	Indian rose wood	Endophytic mycelium	Pyriform, long conidia borne singly. Cp were long, erect, unbranched and composed of 5-6 cells followed by foot cell	long erect tail-like arising at the end of the conidia	-	75.05	16.06	4.67	141.25	50.72
b	*P. corylea*	Mulberry	Andophytic unbranched hyaline, erect	-do-	-do-	-	61.66	17.61	3.50	159.50	52.34
VII	***Microidium***										
a	*Microidium phyllanthi*	Gale of the wind	Amphigenous	Conidia were small, doliiform, ellipsoid to cylindrical in shape, produced in chains. Catenescent Cp; foot-cells were curved with a twist at the base.	microidium type on conidia. Appressoria on mycelium was lobed or nipple shaped	-	19.81	8.45	2.34	49.95	15.26

Sl. No.	Genera	Hosts	Mycelia	Conidia and conidiophores (Cp) morphology	Germ tube and appresorium	Fibrosin bodies	Conidial size(µm)			Conidiophore L(µm)	Foot cell Length
VIII	***Sphaerotheca***										
a	*S. pannosa*	Rose	Epiphytic mycelia.	Ellipsoid-ovoid to doliiform conidia and produced in chains. Cp were erect, septate, hyaline and unbranched	appressoria in mycelia were simple and nipple-shaped	+	26.32	17.39	1.51	90.40	36.24

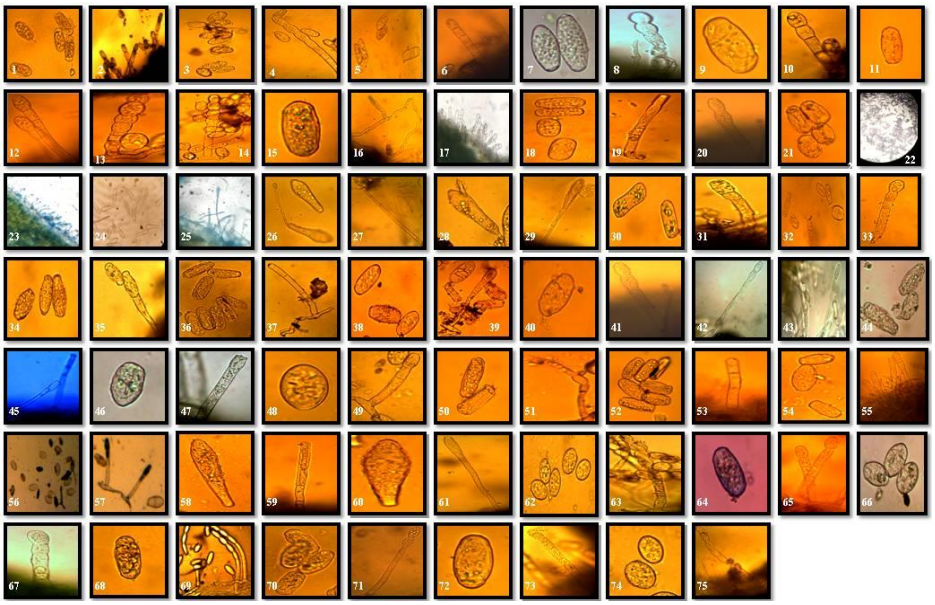

Fig. 2. Conidia and conidiophores of (1&2) *E. cichoracearum* (Source: okra); (3&4) *E. cichoracearum* (Source: wild bhendi); (5 & 6) *E. convolvuli* (Source: field bindweed); (7 & 8) *E. cruciferarum* (Source: mustard) (9 & 10) *E. polygoni* (Source: coriander); (11 & 12) *E. polygoni* (Source: wild cocolmeca); (13) *E. polygoni* (Source: fenugreek); (14) *E. polygoni* (Source: black gram); (15 & 16) *E. polygoni* (Source: green gram); (17) *Erysiphe sp.* (Source: jasmine); (18 & 19) *E. trifolium* (Source: white sweet clover); (20 & 21) *G. orontii* (Source: little gourd); (22 & 23) *G.cichoracearum* (Source: sun flower); (24 & 25) *L. clavata* (Source: wild poinsettia); (26 & 27) *L. taurica* (Source: pigeon pea); (28 & 29) *L. taurica* (Source: chili); (30 & 31) *M. phyllanthi* (Source: gale of the wind); (32 & 33) *Oidium sp.* (Source: white spot flower); (34 & 35) *Oidium sp.* (Source: bael); (36 & 37) *O. azadirchtae* (Source: neem); (38 & 39) *Oidium sp.* (Source: broom creeper); (40 & 41) *O. heliotrope-indicum* (Source: Indian heliotrope); (42 & 43) *O. malachaera* (Source: vilayti bhendi); (44 & 45) *O. mangiferae* (Source: mango); (46 & 47) *O. parthenii* (Source: parthenium grass); (48 & 49) *Oidium sp.* (Source: little goose berry); (50 & 51) *Oidium sp.* (Source: plumeria); (52 & 53) *Oidium sp.* (Source: guava); (54 & 55) *O. tamarindi* (Source: tamarind); (56 & 57) *Oidium ziziphi* (Source: ber); (58 & 59) *P. corylea* (Source: mulberry); (60 & 61) *P. dalbergiae* (Source: Indian rosewood); (62 & 63) *P. fusca* (Source: asthma plant); (64 & 65) *P. xanthii* (Source: butternut squash); (66 & 67) *P. xanthii* (Source: bottle gourd); (68 & 69) *P. xanthii* (Source: bitter gourd) (70 & 71) *P. xanthii* (Source: sesame); (72 & 73) *P. xanthii* (Source: common cockle bur); (74 & 75) *Sphaerotheca pannosa* (Source: Rose)

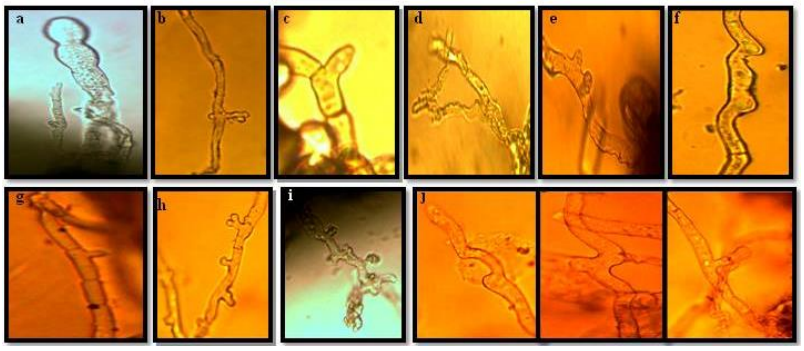

Fig. 3. Appressorium formation in (a) *E. cruciferarum* (Source: mustard); (b) *G. orontii* (Source: little gourd); (c) *M. phyllanthi* (Source: gale of the wind); (d) *O. azadirachtae* (Source: neem); (e) *Oidium* sp. (Source: white spot flower); (f) *Oidium* sp. (Source: little goose berry) (g) *Oidium* sp. (Source: plumeria) (h) *P. corylea* (Source: mulberry); (i) *P. dalbergiae* (Source: Indian rosewood) ; (j) *P. xanthii* (Source: butternut squash)

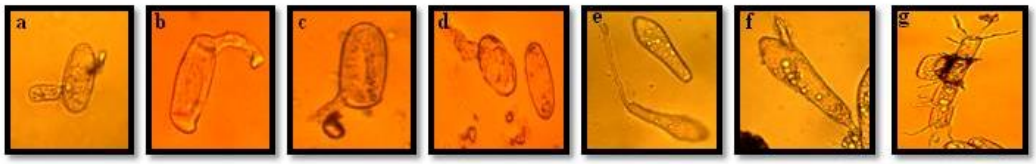

Fig. 4. Conidial germination of (a) *E. cichoracearum* (Source: okra); (b) *Oidium* sp. (Source: white spot flower); (c) *G. orontii* (Source: little gourd); (d) *P. xanthii* (Source: butternut squash); (e) *L. taurica* (Source: pigeon pea);(f) *L. clavata* (Source: wild poinsettia); (g) *M. phyllanthi* (Source: gale of the wind

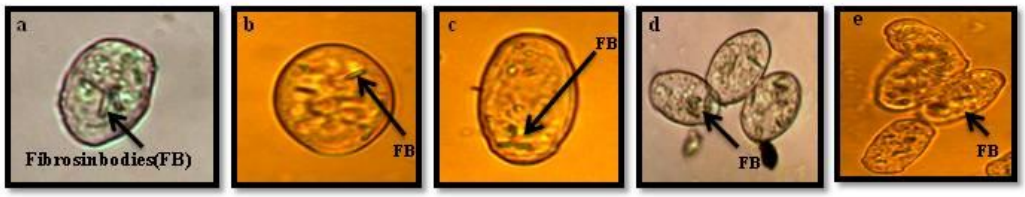

Fig. 5. Fibrosin bodies of (a) *O. parthenii* (Source: congress grass); (b) *Oidium* sp. (Source: little goose berry; (c) *P. xanthii* (Source: bottle gourd); (d) *P. xanthii* (Source: sesame); (e) *P. xanthii* (Source: common cockle bur)

4. CONCLUSION

Survey showed variety of host plants belonging to different family are infected by powdery mildew disease. Huge morphological variability exists among the genus of powdery mildew on different hosts. Morphological studies on the powdery mildew pathogen showed that Navsari region is present with the anamorphic stage of the genus like *Erysiphe*, *Golovinomyces*, *Leveillula*, *Microidium*, *Oidium*, *Phyllactinia* and *Podospheara*. The genus *Erysiphe* and *Oidium* were mostly dominated in Navsari region. The highest percent disease incidence was observed on the asthma plant, black gram, green gram and wild poinsettia between 75-100 per cent out of all the hosts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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