Identification of powdery mildew fungus on Moroccan cucurbitaceous plants

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Summary

The identification of various plant pathogens is an important issue especially in breeding for resistant varieties and the use of fungicides. In Morocco, cucumber (Cucumis sativus L), melon (C. melo L.), pumpkin (Cucurbita maxima Duch.), squash (C. pepo L.) watermelon (Citrullus lanatus (Thunb.) Matsum. et Nakai), bottle gourd (Lagenaria sciceraria Standl. var. hispida Hara) which belong to the family of Cucurbitaceae are widely cultivated. These crops are often attacked by powdery mildew fungus which causes a lot of damage. Research on the identification of the causal agents of this disease is rare in Morocco. The objective of this study was to identify the species causing powdery mildew on the cucurbitaceous crops.

The identification was carried out based on the microscopic observation of the morphological characters of conidia, conidiophores, perithecial stage of the fungus, and the type of germination. 85 samples collected from different regions in the country were used confirming the existence of the characteristics of Sphaerotheca fuliginea; there was no instance of Erysiphe cichoracearum, E. polyphaga, or Leveillula taurica. Moreover, the morphological characteristics of perithecial stage, which was found on only one occasion, supported the idea that it was Sphaerotheca fuliginea.

In additional notes, 7 samples of sunflower (Helianthus annus L.) and one of tomato (Lycopersicon esculentum L.) showing powdery mildew symptoms were collected only in the Gharb area. From the morphological characteristics observed, the causal fungus of the powdery mildew on sunflower is Erysiphe cichoracearum. The symptoms and the results of the morphological observations of the causal fungus reveal that tomato powdery mildew in Morocco is caused by Leveillula taurica (Lév.) Arn.

Keywords: *Morocco, Cucurbitaceous crops, powdery mildew.*

تعريف فصائل الفطريات المسببة لمرض البياض الدقيقي للقرعيات بالمغرب

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ملخص

يقتضي التعريف بالطفيليات المسببة للأمراض عند النباتات أهمية كبرى خصوصا عند التحسين الوراثي للمقاومة عند النباتات أو عند إستعمال المبيدات الفطرية. في المغرب تعتبر زراعة القرعيات من أهم الزراعات نظرا لأهمية المساحات المزروعة. يعد مرض البياض الدقيقي أحد أهم الأمراض عند القرعيات التي تستدعي كل سنة عدة تدخلات كيميائية. الدراسات التعريفية لأنواع الفطريات المسببة لهذا المرض قليلة في المغرب لهذا كان الهدف الأساسي من هذه الدراسة معرفة فصائل الفطريات المسببة لهذا المرض. أجريت هذه الدراسة على 85 عينة مأخوذة من جل المناطق المنتجة لهذه الزراعات. ولقد تبين أن الفصيلة المسببة لهذا المرض هي . *Sphaerotheca fuliginea*

كلمات المفتاح : المغرب ، القرعيات، البياض الدقيقي.

Identification des champignons responsables des oïdiums des cucurbitacées au Maroc

Résumé

L'identification des agents causaux de maladies est très utile pour l'amélioration génétique des plantes et l'utilisation des fongicides. Au Maroc, le concombre (Cucumis sativus L.*), le melon (C. melo* L.*), la citrouille (Cucurbita maxima* Duch.*), la courge (C. pepo* L.*), la pastèque (Citrullus lanatus (*Thunb.*) Matsum. et Nakai), bottle gourd (Lagenaria sciceraria Standl. var. hispida Hara) appartenant à la famille des Cucurbitacées sont largement cultivées au Maroc et subissent des attaques sévères par les oïdiums. Les études sur l'identification des espèces liées à ces maladies sont rares. L'objectif de cette étude est d'identifier les espèces causant ces maladies au Maroc. L'identification de ces parasites obligatoires a été basée sur l'observation microscopique des conidies et leur type de germination, des conidiophores et les cleistothèces.*

85 échantillons ont été collectés de différentes régions du pays. L'espèce responsable de l'oidium des échantillons analysés est Sphaerotheca fuliginea. Les espèces, comme Erysiphe cichoracearum, E. polyphaga, ou Leveillula taurica n'ont pas été détectées.

Dans deux notes ajoutées à ce travail, sept échantillons de tournesol et un de tomate, collectés uniquement de la région du Gharb, ont montré que Erysiphe cichoracearum et Leveillula taurica (Lév.) Arn. sont respectivement les agents responsables de l'oïdium du tournesol et de la tomate

Mots clés : *Maroc, Cucurbitacées, Oïdium.*

Introduction

The identification of various plant pathogens is an important issue especially in breeding for resistant varieties and response to systematic fungicides.
In Morocco, cucumber (*Cucumis sativus* L), melon (*C. melo* L.), pumpkin (*Cucurbita maxima* Duch.), squash (C. pepo L.) watermelon (*Citrullus lanatus* (Thunb.) Matsum. et Nakai), bottle gourd (*Lagenaria sciceraria* Standl. var. *hispida* Hara) which belong to the family of Cucurbitaceae are widely cultivated. These plants are often attacked by powdery mildew fungus which causes a lot of damage. Research studies on the identification of the causal agents of this disease are rare in Morocco. Hirata (1968) says that Maire (*et al.)* and Werner (1937) reported that there is one species of powdery mildew fungus which attack cucurbitaceous plants in Morocco: *Sphaerotheca macularis*. Since Maire and Werner's report is not available, the writers cannot say anything about it now.
Salah (1988) says in his paper that there are three species of powdery mildew fungus on cucurbitaceous plants in Morocco: *E. cichoracearum*, *S. fuliginea* and *L. taurica* (and). Two of these species, *E. cichoracearum* and *S. fuliginea* are dominant and always found together on the same host plant. However, since in his report there is no figure describing the morphological characteristics. There are doubts about his findings.
Starting from December 2002, the writer had the opportunity to make observations of the fungus on cucurbitaceous plants in Morocco, while working at INRA Plant pathology laboratory in El Menzeh Research Station as a senior volunteer. In this report, the research results are described.

Review of the literature

Hirata (1969) stated that four species of powdery mildew fungus attacked cucurbitaceous plants: *Erysiphe cichoracearum*, *E. polyphaga*, *Sphaerotheca fuliginea* and *Leveillula taurica*. According to Khan (1983) who conducted a field research, there are three species: (, i.e .) *E. cichoracearum*, *S. fuliginea* and *L. taurica*. He named the powdery mildew of cucurbits a three pathogen disease.

1 - Asia and the Middle East

In Japan, Homma (1937), Uozumi *et al*. (1962) and Endo (1989) reported that *S. fuliginea* is found on cucurbitaceous plants. In India, firstly Rejendran (1965), says that it is *E. cichoracearum*. Jhooty (1964), Khan *et al.* (1970), however, state that it is *S. fuliginea*. After that, Shiradhana *et al.* (1972), Sharma (1973) and Khan (1976) say that both of the species are responsible for the cucurbit powdery mildew. In Israel, Rayss (1947) and Rudich *et al.* (1969) say that it is *S. fuliginea*. In Saoudi Arabia, Abul-Havia *et al*. (1981) report the same thing.

2 - Africa

In Egypt, El Kazzaz (1983) report that *S. fuligine* (was) is found on cucurbitaceous plants. El-Ammari (1983, 1985, 1986) says that three species: , (i.e .) *L. taurica*, *S. fuliginea* and *E. cichoracearum*, are found on cucurbits in Libya. In Sudan (Nour, 1958) and in South Africa (Gorter, 1966), agree that it is *S. fuliginea*. In Nigeria (Esenam, 1973) state that it is *E. cichoracearum*.

3 - Europe

In Sweden, Hammarland (1945) and Junell (1976) report that the causal fungus of cucurbit powdery mildery is *E. polyphaga*. In England (Zaracovitis, 1965), in Netherlands (Boerema *et al.*,1964) and in Italy (Marras *et al.,* 1977) say that it is *S. fuliginea*. In Germany; at first Rôder (1937) report that it is *E. cichoracearum*. Then, Schlôsser (1972) and Janke *et al.* (1977) say that *E. cichoracearum* and *S. fuliginea* are both responsible for disease. The same thing is reported by Nagy (1970, 1976) in Hungary and Lebeda (1983) in Czerchoslovakia.

4 - The ex-Soviet Union

Poretzky (1923) and Szembel (1926) say that it is *S. fuliginea*, but Deckenbach (1924), Deckenbach *et al* .(1927) and Rodigin (1936) say that there are two species: (i.e.) *E. cichoracearum* and *S. fuliginea*.

5 - South and North America

In America, Reed.(1907), Millet *et al.* (1931), Randal (1956) and Raabe (1966) say that it is *E. cichoracearum*. In an other report, Kable *et al.* (1936), Ellet (1966), (1937), Grand (1987), McGrath (1991) say that it is *S. fuliginea*. In Brazil, Reischeneider *et al.* (1985) report that the causal fungus of cucurbit powdery mildew is *S. fuliginea*. In this area, no researcher reported that two species at the same time are responsible for the disease.

6 - Oceania

In Australia, Clare (1985) and Ballentyne (1963, 1974) report that it is *S. fuliginea*. In New Zealand, Dingkery (1959) reports the same thing, but Boesewinkel (1979) describes three species in his report: *S. fuliginea, E. cichoracearum* and *E. polyphaga*.
In accordance to what Hirata (1968) said, the review of the literature that has been done reveals that, so far all over the world, there are four species of the fungus which attack the cucurbitaceous plants.

Table 1. Records of powdery mildew fungi on cucurbitaceous plants.

Country	Reference	Powdery mildew fugus
Asia and Middle East		
Japan	Homma (1937), Uozumi et Yoshii. (1952), Endo (1989)	*S. fuliginea*
India	Rajendran (1965)	*E. cichorcearum*
	Jhooty (1967), Khan *et al.* (1978)	*S. fuliginea*
	Siradhana, *et al* (1972), Sharma (1973), Khan (1976)	*E. cichorcearum* and *S. fuliginea*
Israel	Rayss (1974), Rudish, *et al*. (1969), Abul-Hayza *et al.* (1981)	*S. fuliginea*
AFRICA		
Egypt	El-Kazzaz (1983)	*S. fuliginea*
Libya	El-Ammari *et* Khan. (1983, 1985, 1986)	*L. taurica, S. fuliginea, E. cichorcearum* and *S. fuliginea*
Sudan	Nour (1959)	*S. fuliginea*
Nigeria	Esenam .(1973)	*E. cichorcearum*
South Sfrica	Gorter (1966)	*S. fuliginea*
EUROPE		
Sweden	Hammarland.(1945), Junell (1967)	*E. polyphaga*
United Kingdom	Zaracovitis (1965)	*S. fuliginea*
Netherlands	Boerema *et* You Kesteren. (1964)	*S. fuliginea*
Germany	Rôder (1937)	*E. cichorcearum*
	Schlôsser (1972), Janke *et al*. (1977)	*E. cichorcearum* and *S. fuliginea*
Italy	Marras and Corda (1977)	*S. fuliginea*
Hungary	Nagy (1970), Nagy (1979)	*E. cichorcearum* and *S. fuliginea*
Czechoslovakia	Lebeda (1983)	*E. cichorcearum* and *S. Fuliginea*
SOVIET UNION		
USSR	Poretzky (1923), Deckenbach (1924),Szembel (1926), Deckenbach, et Koreneff. (1927), Rodigin (1936), Rodigin (1936)	*S. fuliginea and E. cichorcearum*
NORTH AMERICA		
USA	Reed (1907), Miller et Barrett. (1931), Randall et Menzies (1956), Raabe (1966)	*E .cichorcearum*
	Kable et Ballantgne. (1963), Ellett (1966), Kontaxis (1979), Grand, (1987), McGrath (1991)	*S. fuliginea*
SOUTH AMERICA		
Brazil	Reifschneider *et al.* (1985)	*S. fuliginea*
OCEANIA		
Australia	Clare (1958),	*S. fuliginea*
	Ballantyne (1963), Ballantyne (1963), Ballantyne (1974), Ballantyne (1974)	*S. fuliginea*
	Boesewinkel (1979)	*E. cichorcearum, E. polyphaga* and *S. fuliginea*

*The Identification was based on the morphology of the conidial stage

Materials and methods

The identification of the species of powdery mildew fungus should be carried out by morphological observation of perithecial stage of the fungus. Since on cucurbitaceous plants perithecial formation is so rare, and Hirata (1942, 1955), Zaracovitis (1965) and Boesewinkel (1966) stated that morphological characteristics of conidial stage can help to identify the species of powdery mildew fungus, the following method are employed here.

1. Sampling and host plants collected

The area where the materials were collected is shown in Fig.1. The host plants collected are *Cucumis sativus* L. (4), *C. melo* L. (5), *Cucurbita maxima* Duch. (8), *C. pepo* L. (44), *Citrullus lanatus* (Thumb). Matsum et Nakai (8), and *Lagenaria siceraria* Standl. var. hispida Hara (16). The total is 85 samples. They were put into plastic bags immediately after they had been cut off and kept in a portable cooler. Once all the samples were collected, they were taken to the laboratory and observed during the following two days.

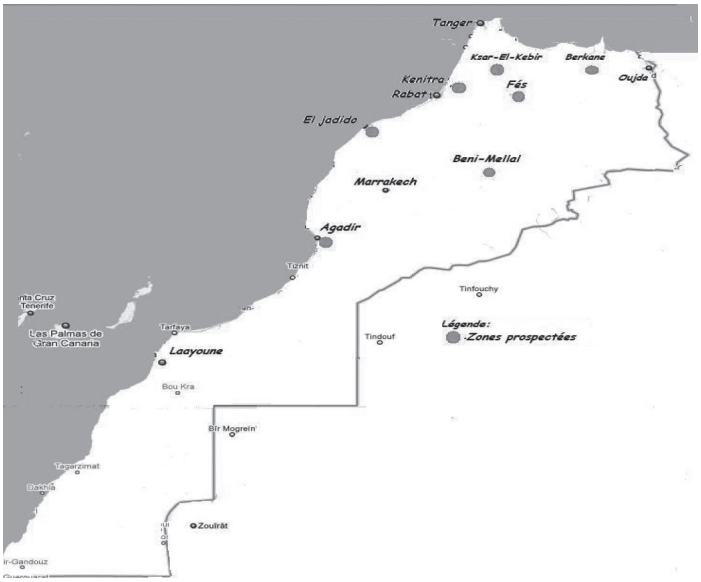

Figure 1: Areas explored

Morphological observations of conidial stage

Relatively, young powdery mildew colonies were taken off using a piece of Scotch tape and observed under the microscope. The observations were focused on the mode of conidial formation, absence or presence of fibrosin bodies and conidial size.

20 conidia were measured in each sample. The method used by Hirata (1942) was employed to observe the morphology of germ tubes. This method consisted in putting epidermis of onion bulb (15 X 15 cm) in 80 % alcohol, after washing it with water; it was used as a material for conidial germination. Conidia were put on the epidermis of onion bulbs that was floating on distilled water in Petri-dish which was kept at a temperature of 24°C. After 24 hours, germination type of conidia was checked.

Results

From the 85 samples collected, perithecial stage was formed on only one sample. The results of morphological observations of conidial stage are shown in Table 2 and Fig.2.

It is clear from Table 2 that all the materials observed have the same morphological characteristics, i.e. conidia are formed on conidiophores in chain, hyaline, ellipsoidal, more or less cylindrical in shape, and including conspicuous fibrosin bodies. As far as conidial size is concerned, there is no difference between the samples collected, and the average size is 34.5 x 20.O µm. The germ tubes of conidia, as indicated in Fig.2, are forked, simple and curved. These characteristics are similar to the description of *S. fuliginea* given by Hirata (1943, 1955).

The results of morphological observations of perithecial stage are given in Fig.3 and Fig.4. In table 3, there are comparisons between results found by different researchers.

Perithecia were found in relatively old mildew colony, forming groups, as illustrated in Fig.3. Perithecium is globous in shape, brown to dark brown, its diameter size is 90-113 µm5 (av. 99.3 µm). Perithecial wall cell is large and variable in shape, 35.8 x 22.5 µm , and it has appendages variable in number. The appendage is myceloid, hyaline but dark brown at the base, its length is variable and has 1 to 3 septa. Only one ascus is included in perithecium. Ascus is ovate in shape, hyaline, and its size is 71.3x 55.3 µm, including 8 ascospores when matured. Ascospore is ellipsoidal, single celled and hyaline, its size is 18.5 X 14.8µm.

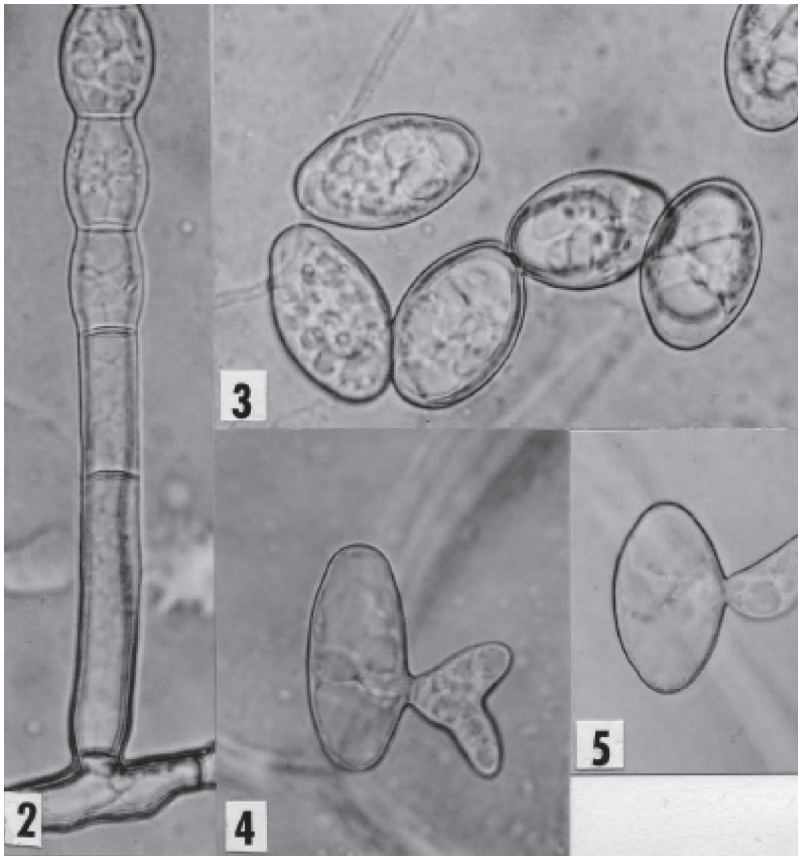

Fig.2. Morphology of conidial stage of powdery mildew fungus on cucurbitaceous plants.

2) Conidiophores with chain of conidia, 3) Mature conidia including fibrosin bodies in mature conidia, 4 &5) germinating conidia

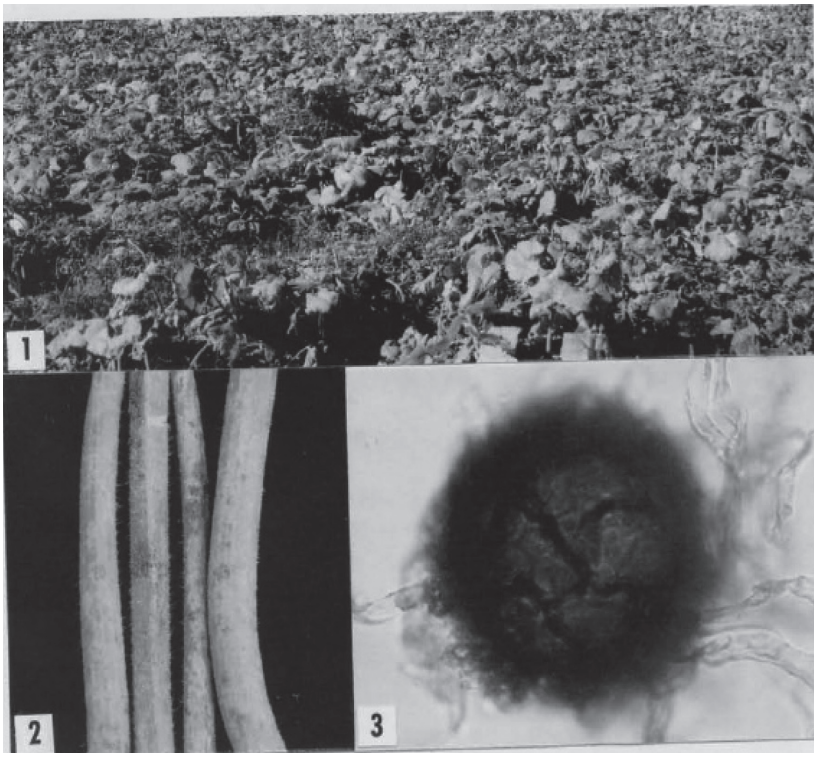

Fig.3. Perithecial formation of powdery mildew on cucubitaceous plant.
1) Pumkin field where perithecia were found, 2) perithecia formed on stem and petiole of host plant, 3) Perithecia enlarged

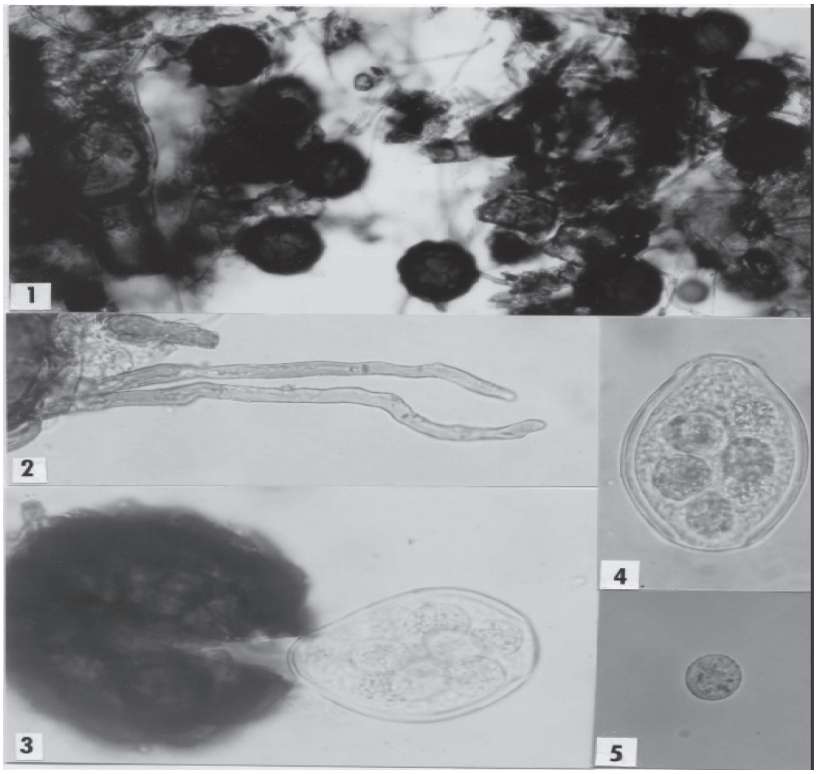

Fig.4. Morphology of perithecial stage of powdery mildew fungus on cucurbitaceous plants
1) Perithecia, 2) appendage, 3) perithecia and discharged ascus 4) Ascus including 8 ascospores, 5) ascospore

Table 2. Morphological characteristics of conidial stage of powdery mildew fungus on cucurbitaceous plants in Northern parts of Morocco.

Localities	Date of collection	Host plants	Characteristics of conidial stage			
			Type of conidial formation	Fibrosin bodies	Size of conidia (µm)	Germination types
1-Moulay Bouselham	16/05/2003	*Lagenaria siceraria*	In chain	+	34.8 X 19.0	*S. fuliginea*
2-Ouled Khalifa	16/5/2009	*Cucurbita pepo*	In chain	+	38.0 X 22.5	*S. fuliginea*
3-Douar Ouled zian	16/5/2009	‘	In chain	+	32.3 X 18.3	*S. fuliginea*
4-Allal Tazi	25/06/2003	*Citrullus lanatus*	In chain	+	33.0 X 18.0	*S. fuliginea*
5-Douar Ouled Aissa	25/06/2003	‘	In chain	+	33.0 X 18.0	*S. fuliginea*
6-Tazi (Jamaat Ghrabel)	25/06/2003	‘	In chain	+	32.8 X 17.3	*S. fuliginea*
7-Moulay Bouselham	25/06/2003	‘	In chain	+	33.0 X 18.0	*S. fuliginea*
8- Moulay Bouselham	25/06/2003	*Cucumis melo*	In chain	+	32.0 X 19.3	*S. fuliginea*
9-Allal Bahraoui	25/06/2003	*Cucurbita pepo*	In chain	+	31.8 X 17.3	*S. fuliginea*
10- Allal Bahraoui	25/06/2003	*Citrullus lanatus*	In chain	+	31.3 X 17.5	*S. fuliginea*
11-Tifelt	25/06/2003	*Cucurbita maxima*	In chain	+	31.5 X 17.5	*S. fuliginea*
12-Kénitra	02/07/2003	*Cucurbita pepo*	In chain	+	30.5 X 17.3	*S. fuliginea*
13-Mnasra	02/07/2003	‘	In chain	+	30.5 X 17.5	*S. fuliginea*
14- Mnasra	02/07/2003	*Cucumis sativus*	In chain	+	31.3 X 17.5	*S. fuliginea*
15- Mnasra	08/07/2003	*Lagenaria siceraria*	In chain	+	32.0 X 17.5	*S. fuliginea*
16- Mnasra	08/07/2003	*Cucurbita pepo*	In chain	+	31.0 X 17.3	*S. fuliginea*
17- Mnasra	08/07/2003	‘	In chain	+	30.5 X 17.0	*S. fuliginea*
18-Kénitra	27/07/2003	*Cucurbita maxima*	In chain	+	31.8 X 17.5	*S. fuliginea*
19- Kénitra	27/07/2003	*Lagenaria siceraria*	In chain	+	32.8 X 17.3	*S. fuliginea*
20- Kénitra (INRA)	29/07/2003	*Cucurbita maxima*	In chain	+	30.5 X 19.5	*S. fuliginea*
21-Ksar El Kbir	24/09/2003	*Lagenaria siceraria*	In chain	+	35.0 X 20.5	*S. fuliginea*
22-Ksar El Kbir	24/09/2003	*Cucurbita pepo*	In chain	+	34.5 X 21.8	*S. fuliginea*
23-Ksar El Kbir	24/09/2003	*Lagenaria siceraria*	In chain	+	36.0 X 20.3	*S. fuliginea*
24-Moulay Bouselham	24/09/2003	*Cucurbita pepo*	In chain	+	36.5 X 20.0	*S. fuliginea*
25-Souk Larbaa	24/09/2003	*Lagenaria siceraria*	In chain	+	36.3 X 19.5	*S. fuliginea*
26-Souk Larbaa	24/09/2003	*Cucurbita pepo*	In chain	+	34.0 X 20.0	*S. fuliginea*
27-Ras Ain chkaf	14/10/2003	*Cucurbita maxima*	In chain	+	35.5 X 19.3	*S. fuliginea*
28-Ras Ain chkaf	14/10/2003	*Cucurbita pepo*	In chain	+	35.3 X 20.8	*S. fuliginea*
29-Ras Ain chkaf	14/10/2003	*Cucumis melo*	In chain	+	35.8 X 20.3	*S. fuliginea*

Table 2. Morphological characteristics of conidial stage of powdery mildew fungus on cucurbitaceous plants in Northern parts of Morocco

30-Ras Ain chkaf	14/10/2003	*Cucurbita pepo*	In chain	+	35.5 X 19.8	*S. fuliginea*
31-Ras Ain chkaf	14/10/2003	*Cucumis sativus*	In chain	+	34.8 X 19.3	*S. fuliginea*
32-Moulay Yacoub	14/10/2003	*Cucumis sativus*	In chain	+	34.8 X 20.0	*S. fuliginea*
33-Moulay Yacoub	14/10/2003	*Cucurbita pepo*	In chain	+	34.3 X 20.5	*S. fuliginea*
34-Moulay Yacoub	14/10/2003	*Lagenaria siceraria*	In chain	+	34.8 X 19.8	*S. fuliginea*
35- Dokarate	14/10/2003	*Cucurbita pepo*	In chain	+	35.3 X 20.5	*S. fuliginea*
36-Marjate Oued Allal	14/10/2003	*Cucurbita pepo*	In chain	+	33.3 X 20.3	*S. fuliginea*
37-Agadir, Ait Melloul	22/10/2003	*Lagenaria siceraria*	In chain	+	35.5 X 20.3	*S. fuliginea*
38-Agadir, Ait Melloul	23/10/2003	*Cucumis sativus*	In chain	+	34.8 X 20.5	*S. fuliginea*
39-Taroudant	23/10/2003	*Lagenaria siceraria*	In chain	+	36.3 X 20.5	*S. fuliginea*
40-Sebt Guerdane	23/10/2003	*Cucurbita pepo*	In chain	+	36.0 X 19.8	*S. fuliginea*
41- Chichaoua	24/10/2003	*Lagenaria siceraria*	In chain	+	35.0 X 20.1	*S. fuliginea*
42- Chichaoua	24/10/2003	*Cucurbita pepo*	In chain	+	36.0 X 20.3	*S. fuliginea*
43-Sidi Bou Othmane	24/10/2003	*Lagenaria siceraria*	In chain	+	34.0 X 19.8	*S. fuliginea*
44- Sidi Bou Othmane	24/10/2003	*Cucurbita pepo*	In chain	+	36.8 X 20.1	*S. fuliginea*
45-Benguerir	24/10/2003	*Cucurbita pepo*	In chain	+	35.3 X 20.5	*S. fuliginea*
46-Marrakech, Tferiat	18/11/2003	*Cucurbita pepo*	In chain	+	36.5 X 20.4	*S. fuliginea*
47-El Jadida, Walidia	02/12/2003	*Cucurbita pepo*	In chain	+	34.3 X 19.5	*S. fuliginea*
48-El Jadida, Walidia	02/12/2003	*Cucurbita pepo*	In chain	+	35.5 X 20.3	*S. fuliginea*
49-El Jadida, Walidia	02/12/2003	*Cucurbita pepo*	In chain	+	34.8 X 20.3	*S. fuliginea*
50-El Jadida, Walidia	02/12/2003	*Cucurbita pepo*	In chain	+	35.0 X 21.0	*S. fuliginea*
51-El Jadida, Walidia	02/12/2003	*Cucurbita pepo*	In chain	+	34.8 X 20.5	*S. fuliginea*
52-El Jadida, Walidia	02/12/2003	*Lagenaria siceraria*	In chain	+	36.8 X 21.3	*S. fuliginea*
53-El Jadida, Walidia	02/12/2003	*Cucurbita pepo*	In chain	+	35.8 X 20.5	*S. fuliginea*
54-El Jadida, Walidia	02/12/2003	‘	In chain	+	35.3 X 21.5	*S. fuliginea*
55-El Jadida, Walidia	02/12/2003	*Cucurbita maxima*	In chain	+	36.8X21.5	*S. fuliginea*
56-El Jadida, Walidia	02/12/2003	*Lagenaria siceraria*	In chain	+	34.8 X 21.0	*S. fuliginea*
57-Ahfir	11/12/2003	*Cucurbita pepo*	In chain	+	35.5 X 20.3	*S. fuliginea*
58-Nador	11/12/2003	*Cucurbita maxima*	In chain	+	37.0 X 21.8	*S. fuliginea*
59-Nador	11/12/2003	*Cucurbita pepo*	In chain	+	36.3 X 21.0	*S. fuliginea*
60-Saidia	11/12/2003	*Cucurbita pepo*	In chain	+	36.5 X 20.4	*S. fuliginea*
61-Taourirt	13/12/2003	*Cucurbita pepo*	In chain	+	37.8 X 21.5	*S. fuliginea*

Table 2. Morphological characteristics of conidial stage of powdery mildew fungus on cucurbitaceous plants in Northern parts of Morocco

63-Taourirt	11/12/2003	*Cucurbita pepo*	In chain	+	36.5 X 20.5	*S. fuliginea*
64-Beni Mellal	26/12/2003	*Lagenaria siceraria*	In chain	+	37.3 X 21.5	*S. fuliginea*
65- "Beni Mellal	26/12/2003	*Cucurbita pepo*	In chain	+	36.0 X 20.8	*S. fuliginea*
66-Dar Bouazza	16/03/2004	*Cucurbita pepo*	In chain	+	36.0 X 21.3	*S. fuliginea*
67- Beni Mellal	16/03/2004	*Cucurbita pepo*	In chain	+	36.3 X 21.3	*S. fuliginea*
68-Had Soualem	16/03/2004	*Cucurbita pepo*	In chain	+	37.3 X 21.8	*S. fuliginea*
69-Tnine Chtouka	16/03/2004	*Cucurbita pepo*	In chain	+	35.8 X 21.3	*S. fuliginea*
70-Ouled Daoud Bir Jdid	16/03/2004	*Cucurbita pepo*	In chain	+	35.5 X 22.0	*S. fuliginea*
71-Mnasra	22/06/2004	*Cucumis melo*	In chain	+	33.5 X 20.5	*S. fuliginea*
72-Mnasra	22/06/2004	*Cucurbita pepo*	In chain	+	35.3 X 19.5	*S. fuliginea*
73-Mnasra	22/06/2004	*Cucurbita maxima*	In chain	+	35.0 X 20.5	*S. fuliginea*
74-Mnasra	22/06/2004	*Citrullus lanatus*	In chain	+	33.0 X 20.1	*S. fuliginea*
75-Mnasra	22/06/2004	*Lagenaria siceraria*	In chain	+	34.3 X 19.3	*S. fuliginea*
76-Mnasra	22/06/2004	*Citrullus lanatus*	In chain	+	32.0 X 20.3	*S. fuliginea*
77-Mnasra	22/06/2004	*Cucurbita pepo*	In chain	+	32.6 X 21.3	*S. fuliginea*
78-Mnasra	22/06/2004	*Cucurbita maxima*	In chain	+	35.8 X 21.0	*S. fuliginea*
79-Mnasra	22/06/2004	*Cucumis melo*	In chain	+	32.8 X 21.3	*S. fuliginea*
80-Ouezzane	10/11/2004	*Cucurbita pepo*	In chain	+	34.8 X 21.3	*S. fuliginea*
81-Ouezzane	10/11/2004	*Lagenaria siceraria*	In chain	+	35.1 X 9.0	*S. fuliginea*
82-Ouezzane	10/11/2004	*Cucurbita pepo*	In chain	+	34.0 X 20.0	*S. fuliginea*
83-Ouezzane	10/11/2004	*Cucumis melo*	In chain	+	33.0 X 22.0	*S. fuliginea*
84-Ouezzane	10/11/2004	*Citrullus lanatus*	In chain	+	32.3 X 20.8	*S. fuliginea*
85-Taroudant	14/11/2004	*Cucurbita pepo*	In chain	+	34.5 X 22.0	*S. fuliginea*

*) From Hirata (1942, 1955)

**) These are *Lagenaria siceraria var. hispida*

***) Perithecial stage of the fungus is found

Table 3. Morphological characteristics of perithecial stage of powdery mildew fungus on *Cucurbita pepo* L.

Author	Diameter of perithencium (µm)	Size of perithecial wall cell (µm)	Appendage	Ascus		Ascospores	
				Number	Size (µm)	Number	Size (µm)
Present Fungus	90-113 av.99.3	30-48x20-28 av.35.8x22.5	Myceloid	1	56-76x53-61 Av.71.3x55.3	8	16.21x13-16 av.18.5x14.8
Homma (1937)	84-98	27-31x16-17	Flexuous	1	65-71x55-58	6-8	16-21x11-14
Uzomi et Yoshii (1952)	80-130	24-25x12-36	myceloid	1	54-72x42-60	6-8	14-22x12-17
Khan *et* Khan (1970)	86-140		Hypha-like	1	55-77x43-63	8	18-22x12-18
Siradhana et Chandhari (1972)	90-180 av.123.6		Myceloid	1	51-75x50-68 av.61.8x57.9	6-10	11-20x9-16 av.14.6x11.2
Sharma (1973)	87-109		Hypha-like	1	59-75x47-56	8	16-22x13-16
Marras et Corda (1977)	74-117 av.95.8	Rather great	Flexuous	1	80-93x44-59 av.76.2x62.6	8	19-24x10-14 av.18.8x14.4
Endo. (1989)	80-116 av.99.3	15-50x13-32 av.31.7x21.0	myceloid	1	64-102x53-75 av.81.2x62.6	8	13.23x11.19 av.18.7x14.9

*Shown in the figure in the report

Discussion and conclusion

Homma (1937) said that it is possible to recognize conspicuous fibrosin bodies in conidia of *Sphaerotheca fuliginea*, but it is impossible in *Erysiphe cichoracearum*. Hirata (1942, 1955) stated that the germ tubes of conidia of *S. fuliginea* have a shape which characterizes the species. It is forked, simple and curved. In contrast, the germ tubes of conidia of *E. cichoracearum* are always simple. Therefore, it is easy to distinguish between *S. fulignea* and *E. cichoracearum* from the shape of the germ tubes of conidia. Boesewinkel (1980) reported that it is possible to identifity the species of powdrey mildew fungus from the morphological charcteristics of conidial stage and described how to identify the species of Erysphaceae based on the morphology of the imperfect states. According to this report, the size of conidia of *E. cichoracearum* is 32-40 X 15 X 18µm, whereas that of *Erysiphe polyohaga* is 25.8-26.7 X 16.5 µm, and its germ tubes develop conspicuous appressorium.

The present survey will focus on the conidial stage of the fungus to identify the species, since it is difficult to out the perithecial stage. In accordance with the literature above mentioned, the following four points will be checked :

(1) Production of conidial singly or in chain

(2) Presence or absence of conspicouous fibrosin bodies

(3) S. fuliginea germination type of conidial and appressorial formation

(4) Size and shape of conidia

Observations of all the used materials (used) confirmed the existence of the characteristics of *S. fuliginea* ; there was no instance of *E. cichoracearum*, *E. polyphaga*, or *L. taurica*. Moreover, the morphological characteristics of perithecial stage, which was found on only one occasion, supported the idea that it was *S. fuliginea*.

To conclude, it has been found out that in Morocco only one species of fungus, *S. fuliginea* , occurred on cucurbitaceous plants, e .g. cucumber, melon, watermelon, pumpkin, etc. Earlier report in Russia by Poretzky (1923), Deckenbach.(1924), Szembel (1926), Deckenbach *et* Koreneff. (1927) and Rodigin (1936) stated that the powdery mildew fungus which attacks cucurbitaceous plants is *S. fuliginea*. In these reports, identifications were always based on the morphological characteristics of perithecial stage. The same findings were reached by Homma (1937) in Japan and Rayss (1947) in Israel.

After 1950, Uozumi et Yoshii. (1952), Dingley (1959), Nour (1959), Nagy (1970), Khan and Khan. (1970), Siradhana et Chandhari. (1972), Sharma (1973), Khan (1976), Marras et Corda. (1977), Kontaxis (1979), Abul-Hayia et Trabulsi. (1981), El-Ammari et Khan. (1985), Grand (1987), Endo (1989) and Mc Grath (1991) reported the same results as the above mentioned.

Fourthermore, although *S. fuliginea* and *E. cichoracearum* are different species, they are found together at the same time. This finding has been reported by Deckenbach (1924), Deckenbach *et al*. (1927) and Rodigin (1936) in Russia and by Nagy (1970, 1975) in Hungary, Schlôsser (1972) and Janke (1977) in Germany, Siradhana *et al*. (1972), Sharma, (1973) and Khan (1976) in India, Lebeda (1983) in Czechoslovakia, El-Ammari *et al.* (1986) in Libya. From the reports cited above, the evidence is not rare that *S. fuliginea* and *E. cichoracerarum* are found together on cucurbitaceous plants.

In addition, El-Ammari *et al.* (1983) reported that *Leveillula taurica* attacks cucurbitaceous plants in Libya, which is a country near Morocco. Khan (1983) stated that there are (theree) three species as cusal fungus of cucurbit powdery mildew, *S. fuliginea*, *E. cichoracearum* and *L. taurica*. (and) The latter (last) one may become a major pathogen in the future, but the scope of its damage cannot be prediticted yet. So far, the evidence reached from this research is that only one species of powdery mildew fungus attacks cucurbitaceous plants in Morocco. However, other species may be found out if the research is carried on.

References

Abul-(Hayia) Hayja,Z.M and I.Y. Trabulsi (1981). Sphaerotheca fuligenea on cucurbits is (Sausi) Saudi-Arabia. Jour. Trans. Brit. Mycol. Soc .76 :5506-507.

Ballantyne, B. (1963). A preliminary note the identity of cucurbit powdery (milews) mildews. Aust. Jour. Sci. 25-360-361.

(Ballantyne) Ballentyne, B. (1974). Powdery mildew on Cucurbitaceae: Identity, distribution, host range and sources of resistance. Proc. Linn. Soc. (N.S.W) New South Wales, 99: (1006120) 100-120.

Boerema,G.H. and H.A. Van Kesteren (1964). De identiteit van de echte meeldauw bij cucurbitaceae. Neth .Jour. Plant Path. 70 :33-34. (Rev.Appl. Mycol. 43 :449.1964).

Boesewinkel,H.J.(1979). Erysiphaceae of New Zealand. Sydowia 32 :13-56.

Boesewinkel,H.J.(1980) . The morphology of the imperfect (states) stages of powdery mildews (Erysiphaceae). Bot. Rev. 46:167-224.

Clare, B.G.(1958). The identity of the cucurbit powdery mildew of South-Eastern Queensland. Aust. Jour. Sci. 20 :273-274.

Deckenbarch,K.N.(1924). On mildew fungi parasitizing Cucurbitaceae and tabacco on the south coast of the Crimea (in Russian with German summary). Morbi Plantarum, (Leningrad), 13 :98- 103 (102) (Rev.Appl .Mycol. 5 :70-71.1926)

Deckenbach, K. N. and M. S.Koreneff (1927). Contribution to the study of the mildew fungi of (plantaion) plantation crops in (Grimea) Crimea (in Russian). Morbi Plantarum, Leningrad, 16: 155-160. (Rev.Appl.Mycol. 7 :273-274. (1928)

Dingley, J.M.(1959). New records of fungus diseases in New Zealand, 1957-58. New Zealand Jour. Agr.Res. 2 :380-386.

El-Ammari,S.S. and M.W.Khan (1983). Leveillula (tarica) taurica powdery mildew on (grrenhouse) greenhouse cucumbers in Libya. Plant Dis. 67 :553-555.

El-Ammari, S.S. and M.W.Khan (1985). Sphaerotheca neafuligi (perithecial stage) on cucurbits. FAO Plant Prot. Bull. 33:42-43.

El Ammari,S.S, and M.W.Khan (1986). Sphaerotheca fuliginea (Schlecht) Poll. and Erysiphe cichoracearum DC. (C) causing powdery mildews in Libya. Libyan Jour. Agr. 12 :43-48.

El-Kazzaz,M. K.(1983) (1981). Sphaerotheca fuliginea (Schlecht. ex Fr.) Poll. The causal agent of powdery mildew on many of cucurbits in Egypt. Egyptian Jour. Phytopath 13 :65-66. (5Rev. Plant Path. 63 :295.1984)

Ellett,C.W.(1966). Host range of the Erysiphaceae of Ohio. Ohio Jour. Sci. 66-570-581.

Endo,T. (1989). Studies on the Life-cycle of cucurbit powdery moldew fungus Sphaerotheca fuliginea (Schkecht). Poll. (in Japanese with English summary). Spec. Bull. Fukushima Pref. Agr. Exp. Stn. (a). 5:16106.

Esenam,E.V.(1937). Occurrence of cucurbits powdery mildew (Erysiphe cichoracearum

DC) on Acalypha ciliata Forsk. Nigerian Agr. Jour. 10 :258-259.

Gorter,G.J.M.A.(1966). Powdery mildew fungus on cucurbits in the Transvaal province of South Africa. Nature 209: 938.

Grand, L. F.(1987). Perithecia of Sphaerotheca fuliginea on cucurbits in North Carolina. Plant Dis. 71: 761.

Hammarl(a)und, C.(1945). Beitrage zur Revision einiger imperfekten Mehltau-Arten, Erysiphe polyphaga nov.sp. Bot. Notis. 1945 :1016108.

Hirata,K.(1942).On the shape of the germ tubes of Erysipheae (in Japanese with Englich summary). Bull. Chiba College. Hort. 5: 34-49.

Hirata,K.(1955). On the shape of the germ tubes of Erysipheae II. (in Japanese with English summary). Bull. Fac Agr. Niigata Univ. 7: 24-36.

Hirata, K. (1986). (Notes on) Host range and geographi(e)cal distribution of the powdery mildew fungi. Trans. Mycol. Soc. Japan 9: 73-88.

Homma,Y.(1937). Erysiphaceae of Japan. Jour. Fac. Agr. Hokkaido Imp. Univ. 38 :183-461.

Janke,C., C. Peter and A. Hellwing (1977) (à). Uber das Auftreten der Mehltaugattungen Erysiphe und Sphaerotheca an Gruken in der DDR. Archiv Phytopath. U.P. flanzensch. Berlin 13 (4): 263-269.(Rev. PI. Path. 57 :140.1978)

Jhooty, J. S.(1967). Identity of powdery mildews of cucurbits in India. Plant Dis Reptr. 51 :1079-1080.

Junell, L.(1967). Erysiphaceae of Sweden. Symb. Bot. Upsal. XIX, 19 :1-117.

Kable, P. F. and B.J.Ballantyne (1963). Observations on the cucrbit powdery mildew in the Ithaca district. Plant Dis. Reptr. 47 :482.

Khan, M.W. and A.M. Khan (1970). Studies on the cucrbit powdery mildew I. Perithecial production in cucrbit powdery mildew in Northem India. Indian Phytopath. 23: 497-502.

Khan,M.W.(1976). Studies on the cucurbit powdery mildew IV. Intensity and identity of cucurbit powdery mildew in Bihar. Indian Phytopath. 29: 314-315.

Khan, M.W. (1983). The identity of powdery mildew of cucrbits – A critical appraisal. Acta (;) Bot. Indica 11: 97-126.

Khan,M.W.(1989).Powdery mildew of cucrbits- A three pathogen disease. Int .Jour. Tropical Plant Dis. 7 : 107-123.

Kontaxis, D.G. (1979). Cleistothecia of cucurbit powdery mildew in California (;) - A new record. Plant Dis. Reptr. 63: 278.

Lebeda, A. (1983). The genera and species spectrum of cucumber powdery mildew in Czechoslovakia. Phytopath. Z. 108 :71-79.

Marras, F . and P.Corda (1977). About the powdery mildew of cucurbit(y)ts in Sardinia (Ita(r)ly). International symposium on vegetable crops under glass protection .Acta. Horticulturae, 58 :42-428.

McGrath,M.T.(1991). Cleistothecia of the powdery mildew fungus Sphaerotheca fuliginea

observed on pumpkin in New York. Plant Dis. 75 :1075.

Miller, P. A. and J.T. Barrett (1931). Cantaloupe powdery in the Imperial Valley. Calif. Agr. Exp. Sta., Bull. 507:1-36.

Nagu G.S (z).(1970). Die Identifi(s)zeierung des mehltaus der Kürbisgewächse auf Grund der Konidienme(l)rkmale. Acta. Phytopath. Acad. Sci. Hung. (5) (2-4): 231-248.

Nagy,G .S (z.) (1975). Revision of the powdery mildew species Erysiphe polyphaga Hamm. Acta. Phytopath.Acad. Sci. Hung. 10: 377-388.

Nour,M.A.(1959).Studies on the specialization of Sphaerotheca fuliginea (Sc(k)hlecht.) (Poll). And other powdery mildews. Trans. Brit. Mycol. Soc. 42: 90-94.

Poretzky,V.S.(1923) A new record of the ascus stage of Sphaerotheca fuliginea (Schlec(h) t) Poll. on melon (in Russian). (Plant Disecases) x ii, 3 :86-88.(Rev. Appl. Mycol. 3: 665. 1924)

Raabe, R. D.(1966). Check list of plant diseases previously unreported in Hawaii. Plant Dis. Reptr. 50: 411-414.

Rajendran,V.(1965). A note on the occurrence of perfect stage of Bottle Gourd powdery mildew in Mysore. Indian Phytopath . 18: 389-390.

Randall, T. E. and J. D. Menzies (1956). (Y)The perithecial state of the cucurbit powdery mildew. Plant Dis. Reptr. 40: 255.

Rayss, (P.) T. (1947). Nouvelle contribution à l'étude de la mycoflore de Palestine. Palestine Jour. Bot. Jour. Series, 4: 59-76.

Reed,G. M. (1907). Infection experiments with the mildew on cucurbits, Erysiphe cichoracearum DC. Trans. Wisc. Acad. Sci., Arts. Ltrs. 15 :527-547.

Reifschneider,F.J.B., L.S.Boiteux and E.M.Occhiena (1985) . Powdery mildew of melon (Cucumis melo) caused by Sphaerotheca fuliginea in Brazil. Plant Dis. 69: 1069-1070.

Röder, K. (5) (1937). Perithecien von Erysiphe cichoracearum DC.em. Salm. an Freilandgurken (Cucumis sativus L.). Angew. Bot. 19:161-163.

Rodigin, M. N.(1936). Note on the powdery mildews of cucrbits (Sphaerotheca fuliginea (Schl.) Poll. (A) and Erysiphe cichoracearum Fr.) (in Russian). Sovetsk. Bot. (1936) 5:120-123. (Rev.Appl.Mycol. 16 :364-365.1937)

Rudich, J., Z.Karchi and N. Eshed (1969) Evidence for two races of the pathogen causing powdery mildew of muskmelon in Israel Jour. Agr. Res. 19: 41-46.

Salah, R.(1988). Les oïdiums des cucurbitacées : identification, gamme d'hôtes et méthodes de lutte, Mémoire de 3eme cycle, phytopathologie, IAV, Hassan II, Rabat, Maroc, (pp.) 111p

Schlösser, E.(1972). Cleistothecia of Erysiphe cichoracearum DC. ex Merat. (A)and conidia of Sphaerotheca Schl. (E)ex Fr. concomitantyl on cucumber. Meded. Fac.Landb.Wetensch. Gent. 37: 553-558.

Sharma, P.D. (1973). Occurrence of perfect states of two cucurbit powdery mil(i)dews in northen India. Curr . Sci. 42: 871-872.

Siradhana, B. S.and S.L. Chaudhari(1972). Occurre ce of Erysiphe cichoracearum and

Sphaerotheca fuliginea at Udaipur, Rajasthan (India). Indian Jour. Mycol. Plant Pathol. 2: 76-79.

Szembel, S. J.(1926). A new record of Sphaerotheca fuliginea (Schlecht) Poll. on melon (in Russian). Morbi Plantarum, Lening(a)rad, 15 :51-52. (Rev.Appl. Mycol. 7 :219.1927)

Uozumi,T. and H.Yoshii (1952). Some observations on the mildew fungus affecting the cucurbitaceous plants (in Japanese with English summary). Ann. Phytopath. Soc. Japan 16:123-126

Zaracovitis ,C.(1965). Attempts to identify powdery mildew fungi by conidial characters. Trans. Brit. Mycol. Soc. 48 :553-558.