Powdery Mildews and Their Causal Fungi on Some Spice and Medicinal Plants

By
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Summary: Taxonomic examinations of five powdery mildew fungi found on two new host plants in Japan, rosemary (Rosmarinus officinalis, fam. Labiatae) and downy thorn apple (Datura metel, fam. Solanaceae), and on blue gum (Eucalyptus globulus, fam. Myrtaceae) on which the causal fungus is still indeterminate in Japan, were carried out.

Between two anamorphic types found on blue gum, the fungus of Euoidium type was identified to be Oidium state of Sphaerotheca aphanis var. aphanis. Another one, Pseudoidium type was regarded as a new Oidium species, O. eucalypti-globuli. The fungus of Euoidium type on downy thorn apple was identified with the anamorphic state of Erysiphe orontii, but it was not able to specify that of Pseudoidium type.

The anamorph on rosemary morphologically agreed well with that of Erysiphe galeopsidis observed on various plants of the Labiatae.

Key Words: powdery mildew, blue gum, downy thorn apple, rosemary, Oidium eucalypti-globuli

Introduction

Five powdery mildew fungi were found on three plants, viz. rosemary (Rosmarinus officinalis L., family Labiatae), downy thorn apple (Datura metel L., fam. Solanaceae) and blue gum (Eucalyptus globulus LABIL., fam. Myrtaceae). Among them, rosemary and downy thorn apple are new hosts of the fungi in Japan, and the taxonomic position of the causal fungus on blue gum has not been determined in our country. The identification of these powdery mildew fungi was conducted in the study.

Materials and Methods

1. The fungi and their host plants
   ①Oidium sp. (a) on blue gum (Locality and date collected: Seijo, Setagaya-ku, Tokyo, 10 Nov. 2001) (TUAMH 6129).
   ②Oidium sp. (b) on blue gum (Locality and date collected: The same place and date as ①Oidium sp.(a), TUAMH6129).
   ④Oidium sp. (a) on downy thorn apple (Locality and date collected: Tokyo Univ. of Agric., Atsugi-shi, Kanagawa Pref., 3 Dec. 2001) (TUAMH6109).
   ⑤Oidium sp. (b) on downy thorn apple (Locality and date collected: the same place and date as ④Oidium sp. (a), TUAMH6109).

In addition to the above five materials, many other fungous herbaria on different plants of families Labiatae and Solanaceae (Table 2, 3) were tested for comparison.

2. The observations of the causal fungi
The observations of the mycelial state on the affected plants and causal fungi conformed to the ones described by Tanda and Suga (2002)1.

Results and Discussion

1. Two powdery mildew fungi on blue gum
Recently, powdery mildew was found on seedlings of blue gum which were planted in pots at a nursery. Through microscopic observation of the causal fungi, their anamorphic states were discriminated between Euoidium and Pseudoidium types.
Though a powdery mildew on different Eucalyptus plants including blue gum has been reported in Japan, its taxonomic position has not been elucidated (TERASHITA, +3/141). The present fungus corresponding to the Euoidium type agreed well with the anamorph of Sphaerotheca aphanis (WALLR.) BRAUN var. aphanis which has been reported on various Eucalyptus plants from several other countries. The other one belonging to Pseudoidium type is highly distinct in the appearance of the conidia and conidiophores, and there is no allied fungus hitherto known on Eucalyptus and other genera of Myrtaceae. Therefore, it should be considered as a new, independent species of the genus Oidium.

i. Sphaerotheca aphanis (WALLR.) BRAUN var. aphanis (Fig. 1; Table 1; Photo 1•A, D, E).

Mycelia amphigenous, external appearance very similar to those of Oidium eucalypti-globuli which is described later, but evidently dense; conidiophores erect, branching from hyphae on the surfaces of the leaves, 2-or 3-septate, straight or remarkably curved near the middle, 90–320×9–11 (av. 191.9±24.9×10.1±0.23) μm, foot-cells slender cylindric, 30–135×9–11 (av. 62.8±13.5 ×10.0±0.24) μm; conidia catenulate, usually lemon shaped to doliform, often ellipsoidal, rarely oblong, vacuolate, fibrosin-bodies evidently present, 25–33 (~51) ×16–21 (~24) (av. 31.4±0.94×19.2±0.39) μm, length/width (l/w) ratio. 1.3–1.8 (~2.8) (av. 1.65±0.056).

ii. Oidium eucalypti-globuli TANDA, sp. nov. (Fig. 2; Table 1; Photo 1•A~C).

Mycelium amphigenous in foliis, pelliculas albas rotundas vel irregulariter, frequenter occupans tota superficiem; conidiophora recta ver interdum leviter curvata, (1–) 2 septata, cellulis ad basim cylindracea, 27–41×(6–) 8 (~9) μm; conidia singularia, doriformes vel ellipsoidea, vacuolata, (15–) 18–22μm.

Holotypos: in folis vivis Eucalypti globuli LABILL. (blue gum). Seijo, Setagaya-ku, Tokyo, Japan, 10 Nov. 2001, leg. S. TANDA (TUAMH6129). The type material of the fungus is kept in the Mycological Herbarium of the Tokyo University of Agriculture, Setagaya, Tokyo, Japan (TUAMH).

Mycelia amphigenous, conspicuous on the upper surface of the leaves, developing whitish powdery, round to irregular patches, margin obscure, often covering the whole surface of the leaves; conidiophores erect, branching from hyphae on the surfaces of the leaves,
usually 2-, rarely 1-septate, straight or slightly curved, 57–74×8–10 (av. 66.3±1.8×8.9±0.26) μm, foot-cells cylindrical, 27–41×(6–)8–18×22 (av. 34.1±1.6×7.8±0.28) μm; conidia solitary, doriform or ellipsoidal, vacuolate, fibrosin-body absent, 32–46 (52) × (15–)18–22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).

2. Taxonomic consideration of the two fungi

*Sphaerotheca aphanis* var. *aphanis* [syn.: *S. alchemilae* (STEN) ERIKSS., *S. macularis* (WALLR.: FR) LIND, and *S. pannonica* (WALLR.: FR) LEV.] and *Erysiphe orontii* CAST., of which the anamorphs are Euoidium type, have been recorded on different *Eucalyptus* species from other countries (AMANO, 1986; BRAUN, 1987). However, no Pseudoidium type on the plant of the same genus was found in any reliable references. Unfortunately we were unable to find the description of detailed anamorphic character of *Oidium* fungus (ROSTR) reported on *Eucalyptus* plants from Europe (SACCARDO, 1931; GRASSO, 1948). TERASHITA (1955) did not mention the formation manner of conidia and their fibrosin-body. Both the conidia and conidiophores of *Oidium* sp. found on five *Eucalyptus* spp. in Japan are evidently smaller than those of the present *Oidium* fungus (Table 1).

The hitherto known species on *Eucalyptus* plants are

### Table 1 Morphological characteristics of anamorph of powdery mildew fungi on *Eucalyptus* and other myrtaceous plants

<table>
<thead>
<tr>
<th>Fungus</th>
<th>Host plant (Genus)</th>
<th>Forming manner</th>
<th>Conidium</th>
<th>Size of foot-cell (μm)</th>
<th>Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Oidium eucalypti</em>-</td>
<td><em>Eucalyptus</em></td>
<td>solitary</td>
<td>doriform, elliptic</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
<td></td>
</tr>
<tr>
<td><em>Sphaerotheca aphanis</em></td>
<td>#</td>
<td>catemulate</td>
<td>lemon-shaped, doriform, elliptic</td>
<td>32-46 (52) × (15–)18–22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
<td></td>
</tr>
<tr>
<td><em>Erysiphe orontii</em></td>
<td>#</td>
<td>elliptic-doliform</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Oidium eucalypti</em></td>
<td>#</td>
<td>elliptic-doliform</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Uncinula australis</em></td>
<td>#</td>
<td>elliptic-doliform</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2 Dimension of conidia and foot-cells of conidiophore of *Erysiphe galeopsidis* on various plants of fam. Labiatae

<table>
<thead>
<tr>
<th>Host plant</th>
<th>TUAMH*</th>
<th>Occurring location of leaf</th>
<th>Conidium</th>
<th>Size of foot-cell (mean) μm</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Rosmarinus officinalis</em> var. <em>grandis</em></td>
<td>6102</td>
<td>Upper surface</td>
<td>(27–31)×(36–38)×(14–17)</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
</tr>
<tr>
<td><em>Cheloneis mossatarum</em></td>
<td>2988</td>
<td>Do.</td>
<td>24–32×(39)×(17–22)</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
</tr>
<tr>
<td><em>Lamium album</em> var. <em>arbatum</em></td>
<td>3492</td>
<td>Do.</td>
<td>30–32×(32–42)×(15–20)</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
</tr>
<tr>
<td><em>L. purpureum</em></td>
<td>5902</td>
<td>Do.</td>
<td>30–32×(32–42)×(15–20)</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
</tr>
<tr>
<td><em>Mentha viridis</em></td>
<td>5063</td>
<td>Do.</td>
<td>27–37×(41)×(14–17)</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
</tr>
<tr>
<td><em>Stachys japonica</em> var. <em>intermedia</em></td>
<td>2175</td>
<td>Upper surface</td>
<td>22–29×(37–44)×(13–16)</td>
<td>27-41×(6–)8–18×22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (2.6) (av. 2.06±0.044).</td>
</tr>
</tbody>
</table>

*TUAMH: Mycological Herbarium of Tokyo University of Agriculture.*

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*conidiophores*
II. Powdery mildew and its causal fungus on rosemary

Rosemary is an evergreen shrub native to the Mediterranean, which introduced into Japan early in the 19th century. No record of powdery mildew on this plant was found in any Japanese references although it is extensively planted throughout the country.

In October and December 2001, the disease was found on the plant in Hyogo and Kanagawa Prefectures. Though the observation was continued to the spring, no ascocarp of the causal fungus was detected. Therefore, the taxonomic position of the fungus was determined with morphologic characters of its anamorph and affinity to the host plant as follows.

1. The anamorph of Erysiphe galeopsidis DC. on rosemary (Fig. 3; Table 2; Photo 2 · F)

Mycelia amphigenous, also cauligenous, developing irregular, white, dense powdery patches, often covering the whole surface of the leaves and young treetops; conidiophores erect, branching from hyphae on the surfaces of the leaves and branches, 2–3 (–4)-septate, straight or loosely curved, 125–173×12–15 (av. 141.4±8.6×12.9±0.35) μm, foot-cells cylindric, 57–135 (av. 82.9±8.2) μm long, the width same as those of conidiophores; conidia catenate, ellipsoidal, often doliform, vacuolate, fibroin-body absent, (27–) 31–36 (–38)×(14–)17–21 (av. 33.1±0.49×18.4±0.34) μm, l/w ratio 1.5–1.9 (–2.4) (av. 1.80±0.043).

2. Taxonomic consideration of the fungus

Two powdery mildew fungi, Leveillula taurica (Lév.) Arnaud and E. galeopsidis have been reported on the rosemary from foreign countries (Amano, 198630; Braun, 198734). The anamorph of Japanese fungus is applicable undoubtedly to that of the latter taxon.

We have examined the anamorph of E. galeopsidis collected from seven species of the Labiatae with the fungus on the rosemary (Table 2). Among them, the conidia on Lamium album L. var. barbatum (Sieb. et Zucc.) Franch, et Savat., L. amplexicaule L., Mentha viridis L., Stachys japonica Miq. var. intermedia (Kudo) Ohwi and Glechoma hederacea L. var. grandis (A. Gray) Kudo. had considerable resemblance to those of the rosemary fungus although the foot-cells of their conidiophores were rather short. The foot-cell of some powdery mildew fungi is markedly variable in the length; e.g. usually the foot-cells of E. galeopsidis on under surface of the leaf of M. viridis are far longer than those on upper surface (Table 2). So we accepted the long foot-cells of rosemary fungus as a modification brought about by an environmental condition.

III. Two powdery mildew fungi on downy thorn apple

In late autumn, a powdery mildew was found on the leaves of downy thorn apple, which was planted in the sample garden of medicinal and spice plants of the university. The disease was not so serious, and ascocarp of the causal fungus was not found on any affect-
ed leaves up to early winter.

Two conidial types, viz. the solitary and catenulate conidia were distinguishable on the separate leaves of one plant. One of them, the fungus having solitary conidia (Pseudoidium type) agreed well with those of Oidium sp. on common thorn apple (Datura stramonium L. var. tatula (L.) Torr.) which has been recorded by Sato et al. (1996)\(^7\). The another one, the catenulate conidia (Euoidium type) resembled closely those of Erysiphe orontii Cast. obtained from Chinese-lantern (Physalis alkekengi L. var. franchetii (MaSt.) Hort.) and a few other solanaceous genera.

1. Two causal fungi

i. Oidium sp. (Fig. 4.)

Mycelia amphigenous, external appearances resembling closely those of E. orontii; conidiophores erect, branching from hyphae, slightly curved, 1- or 2-septate, 57-80×10-12 (av. 68.4±2.3×10.6±0.24) μm, foot-cells cylindrical, somewhat slender, 28-40×9-12 (av. 34.6±1.0×10.3±0.33) μm; conidia solitary, ellipsoidal to ovoid, often doliform, vacuolate, 27-42×14-21 (av. 34.2±0.84×17.4±0.41) μm, l/w ratio 1.5-2.3 (~2.5) (av. 1.95±0.095).

ii. The anamorph of Erysiphe orontii Cast. (Fig. 5; Table 3; Photo 2-G, H).

Mycelia amphigenous, developing thin, grayish white, round to irregular patches, margins obscure; conidiophores erect, branching from hyphae creeping on the surfaces of the leaves, straight or loosely curved, usually 1-, rarely 2-septate or aseptate, 65-102×12-13 (av. 81.1±4.0×12.6±0.18) μm, foot-cells cylindrical, 43-73×12-13 (av. 58.4±4.1×12.6±0.18) μm; conidia catenu-

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**Table 3** Dimension of anamorphs of two powdery mildew fungi (Erysiphe orontii and Oidium sp.) on Datula and other solanaceous plants

<table>
<thead>
<tr>
<th>Fungus</th>
<th>Conidial formation</th>
<th>Host plant (Solanaceae)</th>
<th>TUAMH</th>
<th>Conidium Size (mean) μm</th>
<th>Conidium Length/width (mean)</th>
<th>Size of foot cell of conidiophore (mean) μm</th>
<th>Investigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. orontii</td>
<td>Catenate</td>
<td><em>Datula metel</em></td>
<td>6109</td>
<td>(28.3±3.0-39.3) × 18.22</td>
<td>1.4±1.9</td>
<td>43.73 ± 12.13</td>
<td>The authors</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Physalis alkekengi</em></td>
<td></td>
<td>(33.6±2.47×20.6±0.22)</td>
<td>(1.63±0.033)</td>
<td>(58.4±4.12×12.6±0.18)</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Physalis japonicum</em></td>
<td>0985</td>
<td>28.35 ± 13.20</td>
<td>1.4±2.0(±2.0)</td>
<td>57.75 ± 9.10</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Solanum mammosum</em></td>
<td>5065</td>
<td>(30.1±16.73×10.6±0.72)</td>
<td>(1.84±0.091)</td>
<td>(65.5±4.2×9.8 ±0.25)</td>
<td>Do.</td>
</tr>
<tr>
<td>O. sp.</td>
<td>Solitary</td>
<td><em>Datula metel</em></td>
<td>6109</td>
<td>(25.4±4.2±14.18)</td>
<td>1.4±2.1(±3.1)</td>
<td>45.73 ± 9.10</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>D. stramonium</em></td>
<td></td>
<td>(32.0±1.0×16.4±0.29)</td>
<td>(1.98±0.083)</td>
<td>(54.0±6.5×9.5±0.29)</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>S. aculeatissimum</em></td>
<td>2062</td>
<td>(35.0±51.6×18.7±0.24)</td>
<td>(1.89±0.037)</td>
<td>(43.8±0.33×11.4±0.24)</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>S. carolinensis</em></td>
<td>3968</td>
<td>(24.2±4.1-15.24)</td>
<td>1.3±2.4(±2.7)</td>
<td>30.77 ± 7.13</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>S. lycopersicum</em></td>
<td>0039</td>
<td>(35.0±51.6×18.7±0.24)</td>
<td>(1.89±0.037)</td>
<td>(43.8±0.33×11.4±0.24)</td>
<td>Do.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>S. americanum</em></td>
<td>5728</td>
<td>(27.37±4.1-17.9±19.23)</td>
<td>1.3±1.9(±2.1)</td>
<td>31.62 ± 9.10</td>
<td>Do.</td>
</tr>
</tbody>
</table>

\(^1\)\(^2\)\(^3\)

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**Fig. 4** Oidium sp. on Datula metel (A: Conidia and conidiophores; B: Mature conidia)
late, ellipsoidal to ovoid, vacuolate, fibrosin-body absent, (28-31-36  (-39) × 18-22 (av. 33.6±0.47×20.6±0.22) μm, l/w ratio 1.4-1.9 (av. 1.63±0.033).

2. Taxonomic consideration of the two fungi

*Erysiphe cichoracearum* DC. has been described on downy thorn apple from India (Amano, 1986). Braun (1987) has listed *Datula* as a host of *E. orontii* and included *E. cichoracearum* among the synonyms of *E. orontii*. As compared with the foot-cells of the conidiophore of *E. orontii* described by Braun, although those of the present fungus of Euoidium type are more or less short, other morphological characteristics agreed mutually.

The conidia of *Oidium* sp. were not only solitary but also the conidiophores were rather short and more slender than those of *E. orontii*. Moreover, there were some morphological differences between the conidial shape of both the fungi on downy thorn apple.

References

Photo 1  Two powdery mildews and their causal fungi occurred on *Eucalyptus globulus* (A: Mycelial patches of *Oidium eucalypti-globuli* (O) and *Sphaerotheca aphanis* var. *aphanis* (S); B: Conidium and conidiophore of *O. eucalypti-globuli*; C: Mature conidia of *O. eucalypti-globuli*; D: Anamorph of *S. aphanis* var. *aphanis*; E: Conidia and conidiophore of *S. aphanis* var. *aphanis*). Bars B, C, E 20μm; D 40μm
Powdery Mildews and Their Causal Fungi on Some Spice and Medicinal Plants

Photo 2  Powdery mildews and their causal fungi on two plants (F: Diseased plant of Rosmarinus officinalis; G, H: Diseased leaf of Datura metel by Oidium sp., I: Conidia and conidiophore of Oidium sp. on D. metel; J: Mature conidia of O. sp.). Bars I, J 20μm
２種の香料植物と薬料植物１種に発生したうどんこ病とその病原菌

丹田誠之助*・廣瀨友二*
（平成14年8月20日受付／平成14年12月11日受理）

要約：ローズマリー（シソ科）とチョウセンアサガオ（ナス科）にわが国では未記録のうどんこ病の発生がみられた。さらに、ユーカリノキ（フトモモ科）に未同定菌による同病の発生が観察されたので、それらの菌の同定を試みた。宿主植物上の菌はすべてアナモルフのみであったが、ユーカリノキとチョウセンアサガオでは分生子の形成状態で容易に識別できる Euoidium 型と Pseudoidium 型の 2 菌が認められた。

形態的特徴よりユーカリノキ上の Euoidium 型菌は Sphaerotheca aphanis var. aphanis と同定され、Pseudoidium 型菌は新種とみなされ、Oidium eucalypti-globuli と命名された。ローズマリーのアナモルフは Euoidium 型で、他のシソ科植物に発生する Erysiphe galeopsidis の分生子世代によく一致した。チョウセンアサガオ上の Euoidium 型菌は Erysiphe orontii のアナモルフと判定されたが、Pseudoidium 型菌の所属は特定できなかった。

キーワード：うどんこ病、ユーカリノキ、チョウセンアサガオ、ローズマリー、Oidium eucalypti-globuli