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# Comparative Study of Selected Luffa Cultivars Resistant to Powdery Mildew and Downey Mildew in Sri Lanka

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**Abstract:** Genetic resistance is one of the most suitable strategies to control cucurbit powdery mildew and downy mildew on *Luffa cylindrica* (L.), incited by *Podosphaera xanthii* and *Pseudoperonospora cubensis*. Annual surveys of the screening of germplasm for new sources of genetic resistance provide a vital support to Luffa breeding programs. The objective was to determine whether resistance to powdery mildew and downy mildew which has been bred into most commercial resistant Luffa cultivars, was continuing to provide suppression of the pathogen. In this study, the downy and powdery mildew resistance levels of a total of 24 cultivars were determined by using natural infection were evaluated for resistance to the pathogen by a visual scale for leaf lesions of disease symptoms. This study was conducted at Horticultural crop research and development Institute, Gannoruwa, Sri Lanka (Agro ecological zone $WU_1$) and Agriculture Research Station, Giradurukotte, Sri Lanka (Agro ecological zone $IL_2$). Powdery and downy mildew species differ in host range, ecological requirements, and geographic distribution. But, in here causal agent of the powdery mildew and downy mildew of *Luffa cylindrica* was identified as *Podosphaera xanthii* and *Pseudoperonospora cubensis* based on microscopic observations. These observations are compatible with published data. There was a considerable variation among *Luffa cylindrica* cultivars in terms of resistance to powdery mildew and downy mildew diseases. From 24 cultivars, In 17 x N5-2, N5-3 x N5-2, 542 x N1-1, N5-2 xN3-2, In 17 x N1-1, 9895 x N5-2, In 17 xN5-3, N3-4 xN1-1, N5-3 xN3-4, 9895 x N3-4, 804 xN3-4, 542 x N3-4, 542 cultivars were resistant for the powdery mildew disease and In17xN5-2, N5-2 xN3-2, 9895 x N5-2, In17 x N5-3, N3-4 x N1-1, N5-3 x N3-4, 9895xN3-4, N1-1, N5-2, N5-3, 2333, N3-2 cultivars were resistant for the downy mildew disease. Hence, the resistance rate identified in some cultivars In17xN5-2, N5-2 xN3-2, 9895 x N5-2, In17 x N5-3, N3-4 x N1-1, N5-3 x N3-4, 9895xN3-4, N1-1, N5-2, N5-3, 2333, N3-2 as resistant varieties for both diseases under open field condition would be reliable and applicable for powdery and downy mildew resistance breeding and growing purposes.

**Keywords:** *Luffa cylindrica*, Powdery mildew, Downy mildew, Resistant varieties.

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## 1. Introduction

*Luffa cylindrica* (L.) syn. *Luffa aegyptiaca* ,commonly called as sponge gourd, vegetable sponge or bath sponge gourd, is a member of Cucurbitaceae family. Luffa (*Luffa cylindrica* (L)) is popular vegetable belonging to the family cucurbitaceae and cultivated in different agro-ecological zones of Sri Lanka. Powdery mildew and downy mildew are two major constraints to profitable cultivation of Luffa (Anon. 1990). Powdery mildew is one of the most prevalent and aggressive diseases that affect leaves in cucurbits (McGrath, 2017). The infection is evident by the development of white mycelia and conidia, mainly on leaves and stems, but it can also affect fruits and floral structures. Severely infected leaves may become chlorotic, or even necrotic and brittle. Consequently, it decreases the photosynthetic potential, and concomitantly lower the fruit quality and yield (Stadnik and Bettiol 2001). *Podosphaera xanthii* [syn. *Sphaerotheca fuliginea* (Schlecht) Pollacci] and *Golovinomyces orontii* (syn. *Erysiphe cichoracearum* DC. Ex Mérat) are the most important CPM pathogen species of cucurbits (Kuzuya *et al.*, 2006).

*P. xanthii* occurs in a higher frequency in tropical and subtropical regions, whereas *G. orontii* is most observed in temperate climate (Cohen *et al.*, 2004, Naruzawa *et al.*, 2011). Physiological races and pathotypes are well documented for both species (Lebeda *et al.*, 2016).The chemical control of CPM may be ineffective due to development of resistance (insensitivity) of CPM to some fungicides (McGrath and Shishkoff, 2003; McGrath, 2006; Sedláková and Lebeda, 2008).

Cucurbit downy mildew, caused by *P. cubensis* (Berk. and Curt.) Rostov is one of the most important diseases affecting field and glasshouse cucumbers, and other cucurbits around the world (Lebeda and Widrlechner, 2003). Although cucurbit downy mildew most often occurs in tropical, subtropical and warm, temperate areas of the world (Lebeda and Widrlechner, 2003). Interactions and host-parasite specificity between Cucurbitaceae and *P. cubensis* are very heterogeneous and complex.

The existence of *P. cubensis* pathogenicity variation on the level of pathotypes and races has been confirmed in different countries around the world (Lebeda and Widrlechner, 2003; Lebeda *et al.*, 2006). Infection by *P. cubensis* is strongly influenced by environmental conditions. For that reason, it is necessary to ensure stable microclimate conditions during *in vitro* incubation. In field conditions, incubation of *P. cubensis* takes 4-12 days, and the shortest incubation occurs at 25°C (day) and 15°C (night). The production of spores requires high air humidity and a dark period of approximately six hours, and is inhibited by water drops on the surface of the leaves (Cohen, 1981).

However, according to the terminology of McDonald and Linde (2002), *P. cubensis* belongs to the group of “the highest risk pathogens” with high evolutionary potential (Lebeda and Urban, 2004a; Lebeda *et al.*, 2006; Urban and Lebeda, 2006) and, thus, the use of resistance genes has to be combined with other practices of an integrated management system to minimize the risk of the pathogen attack.

Breeding and application of powdery mildew and downy mildew resistant germplasm are among the best methods used to control these diseases (Zhang et al., 2015) because of avoiding the use of environmentally unsafe chemicals and other costly methods. In this study, the downy and powdery mildew resistance levels of a total of 24 cultivars were determined by using natural infection. The most resistant cultivars were identified and can be used as resistant donors in later breeding programmes.

## 2. Methodology

### 2.1 Identification of powdery mildew pathogen

*Podosphaera xanthii* [syn. *Sphaerotheca fuliginea* (Schlecht) Pollacci]and *Golovinomyces orontii* (syn. *Erysiphe cichoracearum* DC. Ex Mérat) are the most important CPM pathogen species of cucurbits (Kuzuya, 2006). Powdery mildew affected luffa leaves were collected from the field of Horticultural Crop Research and Development Institute, Gannoruwa, (upcountry wet zone) in different locations and mycelia parts and conidia of all diseased samples were microscopically observed to identify the morphological features of pathogen.

### 2.2 Identification of downy mildew Pathogen

Several plants of *L. cylindrica* exhibiting yellow angular spots on upper side and greyish-to-black efflorescence on lower side of the leaves were observed in different cultivation fields of Agriculture Research Station, Giradurukotte, Sri Lanka. Infected leaves were collected from fields and the abaxial surface of the symptomatic portion was observed under the microscope.

### 2.3 Variety evaluation of Luffa under open field condition for powdery and downy mildew

Twenty four different luffa cultivars were used in this study. The field of Agriculture Research Station, Girandurukotte was used for downey mildew screening and the field of Horticultural Crop Research and Development Institute, Gannoruwa was used for powdery mildew screening.

The test genotypes were screened under natural epiphytotic conditions during the Maha season (January to March, 2019), when the climatic conditions were favourable for severe development of the diseases.

The experiment was conducted in randomized complete block design with two replications and 15 plants per replication. Seedlings of each genotype were transplanted in raised beds spacing 150 cm apart with plant to plant distance of 50 cm following recommended package of practices (Anon, 1990). The plants developed under natural infection of powdery mildew in Gannoruwa field (agro ecological zone $WU_1$) and downy mildew in Girandurukotte (agro ecological zone $IL_2$).

### 2.4 Disease assessment and statistical analysis

Each plants were selected in each replication for disease scoring based on per cent leaf area infected and 0–9 rating scale for powdery mildew (0 - No symptoms, 1- >1% symptoms, 3-1-10% symptoms, 5-11-25% symptoms, 7-26-50% symptoms, 9– 51% < symptoms) was followed for disease ratings as suggested by Jenkins and Wehner (1983) and 0-5 visual rating scale for downy mildew (0– no foliar symptoms, 1–1-20 % symptoms, 2–21-40 % symptoms, 3– 41- 60 % symptoms, 4–61-80 % symptoms, 5– 81-100 % symptoms) was used to calculated percent diseases index (PDI) (Thompson and Jenkins, 1985).

Scoring was done primarily to determine the response of plants to the two pathogens causing downy and powdery mildew during Maha season (Table. 1). Disease severity was estimated as the percentage of affected leaves.

Disease severity (infection degree, ID) was computed using a scale of total number of classes with the Townsend–Heuberger formula (Townsend and Heuberger, 1943): $ID\ (\%) = \Sigma i1(ni \times vi) / N \times V$, where vi is the damage class, ni is the number in one class, N is the total number, V is the highest class, and i is the number of classes.

**Table 1. Disease Scoring Index for Powdery and Downy Mildew**

| | |
|---|---|
| The resistance level of each cultivar to downy mildew was rated based on its Percent disease Severity Index (DSI) (Boso *et al.*, 2006):<br><br>ER – Extremely resistant, SI: 0 to 5.0<br>HR – Highly resistant, SI: 5.1 to 25<br>R – Resistant, SI: 25.1 to 50<br>S – Susceptible, SI: 50.1 to 75<br>HS – Highly susceptible, SI: > 75.1 | The resistance level of each cultivar to powdery mildew was rated based on its Percent Disease Severity Index (DSI) (Wang *et al.*, 1995):<br><br>ER – Extremely resistant, SI: 0<br>HR – Highly resistant, SI: 0.1 to 5.0<br>R – Resistant, SI: 5.1 to 25 .0<br>S – Susceptible, SI: 25.1 to 50<br>HS – Highly susceptible, SI: = 50.1 to 100 |

## 2.5 Data Analysis

The data obtained were tabulated and analyzed subjected to the Analysis of Variance (ANOVA) procedure of Statistical Analysis System (SAS) 9.1 software. Duncan's New Multiple Range Test (DNMRT) was performed to compare the differences among treatment means at p=0.05.

## 3. Results and Discussion

### 3.1 Pathogen identification of Powdery mildew

The powdery mildew fungi of *Luffa cylindrica* was found on the living leaves, on the upper side and underside. Colonies were white to brown, irregular. Hyphae were hyaline, septate. Conidiophores hyaline, straight, unbranched. Conidia formed singly at the apex of the conidiophores. Based on the morphological characteristics especially on the presence of fibrosin bodies in conidia, the identity of powdery mildew fungi was *Podosphaera xanthii*. Fibrosin bodies in conidia were an important characteristic for identification of *Podosphaera xanthii* (Zheng and Chen, 1981) and were found in this study.

### 3.2 Pathogen identification of Downy mildew

A fungus-like was consistently observed from symptomatic portion which showed hyaline, monopodially branched with 3–5 orders, straight, slightly swollen at the bases like sporangiophores. Each sporangium was found to be lemon shaped, ellipsoidal, black and measured 25 to 30 µm in length and 15 to 20 µm in width. Based on the microscopic measurements and morphological characteristics the fungus was identified as *Pseudoperonospora cubensis* (Waterhouse and Brothers, 1981).

### 3.3 Variety evaluation of *Luffa cylindrica* in open field condition for powdery and downy mildew under natural infection

**Table 2. Percent Disease severity index for powdery mildew and Downy Mildew of *Luffa cylindrica* at the fruiting stage under natural infection**

| Variety | Percent Disease Severity Index of Powdery Mildew | Disease Severity of Powdery Mildew | Percent Disease Severity Index of Downy mildew | Disease Severity of Downy Mildew |
|---|---|---|---|---|
| In 17 x N5-2 | 5 $^{cd}$ | Highly Resistant | 45 $^{de}$ | Resistant |

| | | | | |
|---|---|---|---|---|
| N5-3 x N5-2 | 22$^{abc}$ | Resistant | 59 $^{abc}$ | Susceptible |
| 542 x N1-1 | 17$^{abcd}$ | Resistant | 59 $^{ab}$ | Susceptible |
| N5-2 xN3-2 | 20 $^{abc}$ | Resistant | 47 $^{cde}$ | Resistant |
| In 17 x N1-1 | 0 $^{d}$ | Extremely Resistant | 53 $^{abcd}$ | Susceptible |
| 9895 x N5-2 | 17 $^{abcd}$ | Resistant | 45 $^{de}$ | Resistant |
| In 17 xN5-3 | 17 $^{abcd}$ | Resistant | 49 $^{bcde}$ | Resistant |
| N3-4 xN1-1 | 16 $^{abcd}$ | Resistant | 29 $^{f}$ | Resistant |
| N5-3 xN3-4 | 12 $^{abcd}$ | Resistant | 49 $^{bcde}$ | Resistant |
| 9895 x N3-4 | 14 $^{abcd}$ | Resistant | 44 $^{de}$ | Resistant |
| 804 xN3-4 | 17 $^{abcd}$ | Resistant | 61 $^{a}$ | Susceptible |
| 542 x N3-4 | 18 $^{abcd}$ | Resistant | 56 $^{abc}$ | Susceptible |
| 542 | 15 $^{abcd}$ | Resistant | 54 $^{abcd}$ | Susceptible |
| 804 | 30 $^{a}$ | Susceptible | 54 $^{abcd}$ | Susceptible |
| N1-1 | 17 $^{abcd}$ | Resistant | 42 $^{e}$ | Resistant |
| In17 | 10 $^{abcd}$ | Resistant | 52 $^{abcd}$ | Susceptible |
| 9895 | 10 $^{abcd}$ | Resistant | 54 $^{abcd}$ | Susceptible |
| N5-2 | 17 $^{abcd}$ | Resistant | 49 $^{bcde}$ | Resistant |
| N5-3 | 25 $^{abc}$ | Resistant | 49 $^{bcde}$ | Resistant |
| 2333 | 20 $^{abc}$ | Resistant | 50 $^{bcde}$ | Resistant |
| N3-2 | 18 $^{abcd}$ | Resistant | 48 $^{cde}$ | Resistant |
| N5-4 | 25 $^{abc}$ | Resistant | 52 $^{abcde}$ | Susceptible |
| Gannoruwa Ari | 19 $^{abcd}$ | Resistant | 52 $^{abcde}$ | Susceptible |
| NAGA | 9 $^{bcd}$ | Resistant | 59 $^{ab}$ | Susceptible |

***Note:*** Means followed by the same letter/s along the column are not significantly different at p=0.05 level. (Values within parenthesis are Arcsine values)

The resistance rate of the cultivars for the powdery mildew at the stage of fruiting was higher than that of the cultivars resistant for the downy mildew (Boso et al., 2006; Wang et al., 1995). From 24 cultivars, In 17 x N 5-2 cultivar was highly resistant, In 17 x N 1-1 cultivar was extremely resistant, 804 cultivar was susceptible and other 21 cultivars were resistant to the powdery mildew disease.

From 24 cultivars, 12 cultivars were resistant and 12 cultivars were susceptible to the downy mildew disease. Hence, the resistance rate identified in some cultivars In17xN5-2, N5-2 xN3-2, 9895 x N5-2, In17 x N5-3, N3-4 x N1-1, N5-3 x N3-4, 9895xN3-4, N1-1, N5-2, N5-3, 2333, N3-2 as resistant varieties for both diseases under open field condition would be reliable and applicable for powdery and downy mildew resistance breeding and growing purposes.

## 4. Conclusion

The powdery mildew of *Luffa cylindrica* of agro ecological zone $WU_1$ isolated in the present study was confirmed to be caused by *Podosphaera xanthii* and Downy mildew of agro ecological zone $IL_2$ caused by *Pseudoperonospora cubensis* based on microscopic observation and characteristics of pathogen. These observations are also compatible with published data. In conclusion, there was a considerable variation among *Luffa cylindrica* cultivars in terms of resistance to powdery mildew and downy mildew resulting in the identification of twelve resistant cultivars (In17xN5-2, N5-2 xN3-2, 9895 x N5-2, In17 x N5-3, N3-4 x N1-1, N5-3 x N3-4, 9895xN3-4, N1-1, N5-2, N5-3, 2333, N3-2) belonging to open

field condition under natural infection. In contrast growing of the susceptible cultivars should be avoided or be done with high attention, especially in these areas.

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