INTRODUCTION

Fusarium species cause a huge range of diseases on an extraordinary range of host plants. In the Family of Cucurbitaceae (e.g. watermelons, muskmelon, pumpkins, and cucumber), it can cause diseases known as vascular wilt, root rot, and fruit rot (Vakalounakis & Chalkias, 2004). Fusarium is a genus of deuteromycetous fungi which are abundance in soils, whole parts of a plant, plant debris and other organic substrates (Summerell et al., 2003). It is found to be well and important genera living in the soils as free-living saprophytes, pathogens, and endophytes and known to produce a range of toxic compounds that can adversely affect livestock and humans (Summerell et al., 2001). Soil fertility is a main factor for the occurrence and virulence of Fusarium species. Meanwhile, Nik Mohd Izham et al. (2005) reported that Fusarium species are well distributed in soils planted with crops such as paddy, rubber, oil palm and vegetables compared to the unused
soils. A previous study by Lim (1971) was the first to report on the diversity of Fusarium species in Malaysian soils which had isolated 8 species with *F. solani* the widest spread species, and this was followed by *F. oxysporum*. It has been reported that various *F. oxysporum* pathotypes can survive successfully either in the soil or above ground by means of thick-walled chlamydospores that are either free or embedded in infected plant debris (Suarez-Estrella *et al.*, 2004). Thus, this study was undertaken to determine: (i) *Fusarium* species isolated from the soils by using morphological identification, and (ii) its diversity in east coast, Peninsular Malaysia, especially the areas that are highly cultivated with cucurbits such as in Bachok, Pasir Mas, Tok Bali (Kelantan district), as well as Besut and Setiu (Terengganu district).

**MATERIALS AND METHODS**

**Soil Samples**

In this study, the soil samples were collected from areas cultivated with cucurbits (watermelon, muskmelon, pumpkin and cucumber) around the east coast of Peninsular Malaysia (Kelantan and Terengganu). Field sampling was done between January 2009 and April 2009. The soil samples were air-dried at room temperature (27±1°C) for 5 days and ground. The ground soil was then sieved with 0.5 mm sieve to separate larger particles such as debris. Both the soil and debris were kept in paper envelopes.

**Isolation of Fusarium spp.**

The isolation was based on three methods; namely soil dilution plate, soil direct plating and debris plating, as described by Leslie and Summerell (2006).

**Soil Dilution Plate Technique**

One ml of the soil suspension that had been diluted from $10^{-2}$ to $10^{-4}$ was spread on the surface of peptone pentachloronitrobenzene (PPA) medium with 7 replicates for each dilution factor. The dilution plates were observed daily for 7 days for colony counting. *Fusarium* spp. colonies were counted based on the formula below for colony formation unit (CFU) (Nash & Snyder, 1962):

\[
\text{Colonies of } Fusarium_{spp./g \text{ soil}} = \left( \frac{\text{Means of } Fusarium_{spp. \text{colonies} \times \text{dilution factor}}}{\text{Weight of dried soil (g)}} \right)
\]

**Soil Direct Plating**

10 mg of the sieved soil were spread evenly on the surface of PPA medium and incubated. This was followed by observation within 7 days for colonies formation.

**Debris Isolation Technique**

After soil sieving, the collected debris was suspended in the running water for 24 hours with sieve as a separator to remove the soil particles that might be attached to debris. Then, the debris was air-dried on sterile paper and placed on the surface of PPA medium. Both direct plating and debris plating techniques were used for the qualitative data.

All *Fusarium* spp. that were isolated from those three techniques were then identified on PDA and CLA. The identification was based on the morphological characteristics from Leslie and Summerell (2006).

**Measurement of Species Diversity**

*Fusarium* species diversity within the east coast of Peninsular Malaysia was calculated by using the Shannon-Weiner Index (Spellerberg, 2008):

\[
H' = - \sum_{i=1}^{s} p_i \ln p_i
\]

where: $\sum$ refers to “the sum of” there are $s$ species in the community $p_i$ = is the relative abundance (proportion) of the $i$ species in the community $\ln$ = natural log
Diversity of *Fusarium* species Isolated from Soil Cultivated with Cucurbit within East Coast, Peninsular Malaysia

**Fig. 1:** (A) Colonies of *Fusarium* species from soil dilution plate technique on PPA medium; (B) *Fusarium* species from debris on PPA medium (arrow)

**Fig. 2:** The thick-walled chlamydospores of *F. oxysporum* (arrow) that is either free or embedded in infected plant debris
TABLE 1
Number of *Fusarium* species colonies isolated per gram soils (CFU/g soil) by using soil dilution plate (10\(^{-2}\)) technique and species diversity (Shannon-Weiner Index)

<table>
<thead>
<tr>
<th>Soil Locality</th>
<th>Fusarium species colonies</th>
<th>p, ln p,</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>¹F. chl</td>
<td>²F. oxy</td>
</tr>
<tr>
<td>Bachok, Kelantan</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>Pasir Mas, Kelantan</td>
<td>0</td>
<td>146</td>
</tr>
<tr>
<td>Tok Bali, Kelantan</td>
<td>24</td>
<td>101</td>
</tr>
<tr>
<td>Besut, Terengganu</td>
<td>18</td>
<td>190</td>
</tr>
<tr>
<td>Setiu, Terengganu</td>
<td>1</td>
<td>195</td>
</tr>
<tr>
<td>Total</td>
<td>43</td>
<td>687</td>
</tr>
</tbody>
</table>

¹F. chlamydosporum, ²F. oxysporum, ³F. proliferatum, ⁴F. semitectum, ⁵F. solani, ⁶F. subglutinans
RESULTS AND DISCUSSION

Only the number of colonies from the dilution factor $10^{-2}$ was chosen as an optimum concentration of soil dilution for CFU counting on PPA medium. After five days, more Fusarium spp. colonies appeared in the PPA medium from soil dilution plate technique (Fig. 1a) and also debris (Fig. 1b). A total of 2,624 Fusarium colonies with 26.2% $F. oxysporum$ was isolated, and this was followed by $F. semitectum$ (24.0%), $F. solani$ (21.3%), $F. proliferatum$ (17.0%), $F. subglutinans$ (9.8%) and $F. chlamydosporum$ (1.7%).

The highest number of Fusarium species colonies isolated from the soil cultivated with cucurbits was $F. oxysporum$, with a total of 687 colonies (Table 1). Based on the Shannon-Weiner Index, even though all five locations in the east coast of Peninsular Malaysia had the same species richness, the Fusarium species diversity was found to be much higher in Besut, Terengganu ($H' = 1.59$), followed by Pasir Mas, Kelantan ($H' = 1.57$), Bachok, Kelantan ($H' = 1.52$), Tok Bali, Kelantan ($H' = 1.50$) and Setiu, Terengganu ($H' = 1.49$) (Table 1).

The survival of $F. oxysporum$ in soil and debris has been proven by Vakalounakis and Chalkias (2004), whereby it was found that $F. oxysporum$ f. sp. radicis-cucumerinum could survive as a successful soil-inhabiting fungus for more than 13 months and cause root and stem rot of cucumber. $F. oxysporum$, $F. semitectum$, $F. solani$ and $F. chlamydosporum$ produced chlamydospores (Fig. 2) that may survive successfully in plant debris and could act as inoculums source when the environment is suitable for dispersion from one growing season to the next. Cucurbits fruits attached to the soil were easily infected with Fusarium fruit rot (FFR) disease; a recent study showed that 54% of $F. solani$ and 46% of $F. oxysporum$ were isolated from the east coast of Peninsular Malaysia, i.e. from the samples with FFR disease (Siti Nordahlawiwe et al., 2009).

Meanwhile, some research has focused on the survival of various $F. oxysporum$ pathotypes in soils. Among other Roncero et al. (2003) used Fusarium as a model system to understand the process of root infection and disease development in soil-borne plant pathogens. Their ubiquitous distribution in soil may contribute as saprophytic decomposition in the process of nutrients cycling, while some species such as $F. oxysporum$ have been found to beneficial in soil denitrification (Takeya et al., 2002; Steven et al., 2008). These studies would become a platform for researchers and students to understand the importance of Fusarium species as a soil-borne microorganism that might contribute to the economically important cucurbit disease in the east coast of Peninsular Malaysia. In addition, soil treatments, crop rotation and other measure controls can be considered to control the diseases caused by Fusarium species, specifically at the highest inoculums area.

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REFERENCES


