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## Biocontrol fungi, *Trichoderma* spp. from Andaman and Nicobar Islands — their cultural and phenotypic characterization

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The present investigation revealed the presence of three species of *Trichoderma*, namely, *T. harzianum* (17 isolates), *T. viride* (10 isolates) and *T. hamatum* (11 isolates), in soil of Andaman and Nicobar Islands. The growth pattern of *Trichoderma* spp. were more or less same in all the media tested but there was relatively more fluffy mycelial growth in the OMA than PDA and MEA. The colour of colony of *Trichoderma* spp. in all media, were green to dark green and sometimes yellowish green to dark green with white tinge. There was more aggregated growth of *Trichoderma* spp. near the periphery region. The pigmentation in the reverse side of growth of *Trichoderma* spp. varied from white, yellowish or faint yellow to light green irrespective of *Trichoderma* species. The shape of phialides varied from ampulliform to subglobose or lageniform divergent or crowded whorls of 2-5, the middle of phialides were markedly swollen and abruptly tapered towards the tip. The shape of conidia were subglobose to ovoid. The conidiophores were highly branched pyramidally nearly at right angles in *T. harzianum* and *T. hamatum* and at nearly acute angles for *T. viride*. The intercalary or terminal chlamyospores were subglobose to ellipsoid or pyriform.

**Key words** : Andaman and Nicobar Islands, Biocontrol, *Trichoderma* spp.

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### INTRODUCTION

The *Trichoderma* spp. are the most commonly used biofungicides for the management of soil borne plant pathogens. The growing interest in non-chemical methods of pest and disease management are solely due to environmental and health hazards. It has been experienced that excessive use of chemical fertilizers and plant protection chemicals for maximizing crop yield and changes in traditional cultivation practices, resulted in deterioration of physical, chemical and biological health of the arable land (Paroda, 1997). This situation eliminates the ecologically beneficial microbes from soil and allowed groups of microorganisms which are otherwise improving the crop health. Biocontrol offers the chance of improving crop production within existing resources, avoiding the growing problems of build up of resistance of chemical pesticides to the target pathogen population (Dekker, 1976).

The *Trichoderma* spp. as potential biocontrol agents during past few decades have created a new

milestone in non-chemical plant disease management system and organic agriculture in particular. *Trichoderma* species, a filamentous soil borne mycoparasitic fungus, has been shown effective against many soil borne plant pathogens (Papavizas, 1985; Pan *et al.*, 2001; Pan and Bhagat, 2007). Therefore, present study has been undertaken to isolate the *Trichoderma* spp. from different agro-ecosystem of Andaman and Nicobar Islands, as these biocontrol fungi are generally found in almost all soils including forest humus layer, agricultural and orchard soils and to evaluate their antagonistic potential against some soil borne plant pathogens.

### MATERIALS AND METHODS

Altogether 315 soil samples from various locations of Andaman and Nicobar Islands with different agro-ecosystems were analyzed for the presence of *Trichoderma* spp. *Trichoderma* spp. were isolated by soil dilution technique (Dhingra and Sinclair, 1995) using *Trichoderma* specific medium (TSM)



(Elad and Chet, 1983) modified by Saha and Pan (1997). The isolates were identified up to species level based on taxonomic keys and monograph of Rifai (1969), Domsch *et al.* (1980) and Bissett (1991a, b).

#### **Cultural characteristics of *Trichoderma* spp.**

The cultural characteristics of 38 isolates of *Trichoderma* spp. were studied in three media, viz., potato dextrose agar (PDA), oat meal agar (OMA) and malt extract agar (MEA). Mycelial discs (6 mm diam) of young growing culture of respective isolates of *T. harzianum*, *T. viride* and *T. hamatum* were placed centrally into the Petriplates containing either solidified PDA or OMA or MEA medium and incubated at  $28 \pm 1^\circ\text{C}$  for one week. The growth pattern of isolates of all three species of *Trichoderma* was observed daily and all the distinguishing characters were recorded. The experiment was replicated five times. The characters recorded were colony, growth rate, presence or absence of pigments, hyphae and presence of any distinguishing odour.

#### **Anamorphic characters of isolates of *Trichoderma* spp.**

Morphological/ Anamorphic characterization of isolates of *T. harzianum*, were done by growing them in potato dextrose agar medium in order to unequivocally verify taxa and species. Morphological characteristics viz., conidiophores' length, width and branching pattern, phialides' width at tip, middle and base, phialides' length and shape, phialospores and chlamydo-spores' shape, length and width including colouration. For morphological characterization, slide culture technique was used and incubated at  $25^\circ\text{C}$  with alternating 12 h dark and 12 h cool white fluorescent light. The conidiophores, phialides, conidia and chlamydo-spores were measured following the methods of Lieckfeldt *et al.* (2001). At least 50 observations were randomly recorded while measuring the morphological characteristics of *Trichoderma* spp.

### **RESULTS AND DISCUSSION**

#### **Isolation and identification of *Trichoderma* spp.**

The results presented in Tables 1 and 2 indicated that the highest number of *Trichoderma* isolates

were obtained from South Andaman (14 isolates) soils, followed by Middle Andaman and North Andaman (9 isolates each), Great Nicobar (4 isolates) and least number were recorded in soils of Little Andaman (2 isolates). The soil pH, organic matter and nitrogen content are presented in Table 1, which indicated that the soil samples collected from Andaman and Nicobar Islands were of slightly acidic to nearly neutral in nature with relatively high organic matter and low nitrogen content. The C:N ratio of soil varied from 16:1 to 25:1 whereas soil reaction varied from 5.6-7.7. Three species of *Trichoderma* viz., *T. harzianum*, *T. viride* and *T. hamatum* were identified on the basis of their sporophore morphology and the taxonomic keys. All three species of fungal antagonists were isolated from the soils of Andaman Islands except little Andaman and Great Nicobar, where there was no *Trichoderma viride*. It was also suggested that there was strict specificity towards the distribution pattern of fungal antagonists with respect to the ecological habitat. *T. hamatum* was mostly obtained from the forest and fallow land soil, whereas *T. harzianum* and *T. viride* dominated in cultivated soils of vegetables and spices.

The ecological preference of *Trichoderma* is well known (Papavizas, 1985). The dry condition of soil for a long time period decreased the population of *Trichoderma* and *Gliocladium* as a group. He also concluded that certain strains of *T. hamatum* and *T. pseudokoningii* were adapted to excessive soil moisture and *T. viride* and *T. polysporum* were restricted to areas where low temperature prevails, whereas *T. harzianum* was most commonly found in warm climatic condition. The present findings corroborated with the remarks of Papavizas (1985) except the presence of *T. viride*. The possible reason of presence of *T. viride* in comparatively warm climate (Andaman and Nicobar Islands) may be due to presence of diverse climatic condition with high rainfall, dense forest and comparatively high organic matter content than normal soil with high soil microbial diversity and complex interactions between soil microorganisms, (Woo *et al.*, 2006). Noveriza and Quimio (2004) reported that the presence of organic matter in soil largely determines the presence of promising antagonistic fungi. Quimio and Cumagun (2001) successfully isolated the *Trichoderma* spp. including *T. viride*, *T. hamatum* and *T. harzianum* in Indonesia, which indicated that *T. viride* can also be obtained from warm regions instead of temperate regions only.



**Table 1:** Location, habitat, soil pH and organic matter of soil samples from which *Trichoderma* spp. were isolated from Andaman & Nicobar Islands.

Location	Code	Habitat	Soil pH	Organic matter (%)	Nitrogen content (%)	C: N ratio	<i>Trichoderma</i> spp.
Garacharma	Grm-3	Spices	6.2	0.72	0.045	16:1	TvAN-1, ThrAN-1
Garacharma	Grm-6	Vegetables	6.4	0.77	0.055	14:1	ThmAN-1, ThrAN-2
Chouldari	Cdr-2	Vegetables	6.9	0.75	0.053	14:1	TvAN-2
Chouldari	Cdr-5	Forest	7.3	0.93	0.058	16:1	ThmAN-2
Calicut	Cet-3	Vegetables/Spices	5.9	0.74	0.037	20:1	ThrAN-3
Makkapahad	Mkp-5	Fallow low land	5.4	0.87	0.034	25:1	ThrAN-4
Makkapahad	Mkp-1	Vegetables	6.2	0.76	0.047	16:2:1	TvAN-3
Burmanala	Bnl-4	Forest	5.7	0.95	0.047	20:1	ThmAN-3
Burmanala	Bnl-2	Vegetables	6.1	0.79	0.044	18.7:1	ThrAN-5
Guptapara	Gtp-2	Vegetables/Spices	6.8	0.85	0.06	14:1	TvAN-4
Guptapara	Gtp-5	Vegetables/Spices	6.5	0.89	0.06	15:1	TvAN-4
Sippighat	Spt-7	Vegetables/Spices	5.7	0.75	0.034	22:1	ThrAN-7
Wandoor	Wdr-0	Vegetables	7.4	0.70	0.06	12:1	ThmAN-4
Chiriatapu	Ctp-0	Forest	5.7	0.96	0.045	21:1	ThmAN-5
Sholebay	Slb-0	Forest	7.4	0.95	0.077	12.4:1	ThmAN-9
Neil Island	Nld-4	Vegetables	7.6	0.67	0.058	11.5:1	ThrAN-8
Neil Island	Nld-3	Vegetables	7.7	0.52	0.043	12:1	ThrAN-9
Mayabunder	Mbr-2	Forest land	6.1	0.99	0.058	16.8:1	ThmAN-7
Mayabunder	Mbr-9	Vegetables	5.9	0.84	0.046	18.2:1	ThrAN-10
Nimbudera	Nbd-1	Cultivated land	6.4	0.75	0.046	16:1	TvAN-5, TvAN-10
Nimbudera	Nbd-5	Garden soil	6.1	0.94	0.048	19.5:1	ThrAN-11
Diglipur	Dgr-6	Vegetables/Spices	6.8	0.78	0.045	17:1	ThrAN-12
Diglipur	Dgr-2	Vegetables/Spices	5.8	0.69	0.053	13:1	TvAN-6, TvAN-8
Diglipur	Dgr-7	Forest	6.0	0.91	0.041	11:1	ThrAN-13
Rangat	Rgt-2	Vegetables	5.6	0.80	0.040	20:1	ThrAN-14
Rangat	Rgt-3	Vegetables	6.1	0.79	0.052	15:1	ThrAN-15
Hut bay	Htb-4	Forest	5.8	0.98	0.040	14:1	ThmAN-8
Hut bay	Htb-1	Garden/Paddy soil	6.8	0.87	0.072	12:1	ThmAN-9
Campbell bay	Cmb-3	Garden/Forest	5.7	0.97	0.039	25:1	TvAN-7, TvAN-9
Campbell bay	Cmb-8	Vegetables	5.9	0.84	0.038	22:1	ThrAN-16
Campbell bay	Cmb-1	Forest	6.4	0.91	0.036	25:1	ThmAN-10
Garacharma	Grm-1	Fallow soil	5.8	0.89	0.055	16:1	ThmAN-11
Guptapara	Gtp-11	Vegetables	6.3	0.78	0.043	18:1	ThrAN-17
Havelock	Hvk-5	Forest/Garden	5.8	0.98	0.070	14:1	ThmAN-11

ThrAN-*T. harzianum*, ThmAN-*T. hamatum*, TvAN-*T. viride***Table 2:** Prevalence of *Trichoderma* spp. in Andaman and Nicobar Islands

Location	No. of soil samples	pH	Organic matter content(%)	Nitrogen content(%)	C:N ratio	Isolates of <i>Trichoderma</i> spp. identified			
						<i>T. harzianum</i>	<i>T. viride</i>	<i>T. hamatum</i>	Total
South Andaman	144	5.8-7.7	0.58-1.3	0.025-0.048	12:1-25:1	7.0 (50.0%)	3.0 (21.4%)	4.0 (28.6%)	14.0 (36.8%)
Middle Andaman	68	6.0-6.8	0.56-0.97	0.022-0.039	15:1-20:1	4.0 (44.4%)	2.0 (22.2%)	3.0 (33.3%)	9.0 (23.7%)
North Andaman	37	6.1-8.0	0.64-1.1	0.040-0.070	13:1-20:1	3.0 (33.3%)	5.0 (55.5%)	1.0 (11.1%)	9.0 (23.7%)
Little Andaman	29	5.6-7.0	0.65-0.95	0.043-0.063	12:1-24:1	1.0 (50.0%)	0.0 (0.0%)	1.0 (50.0%)	2.0 (5.3%)
Great Nicobar	37	5.6-6.4	0.61-0.99	0.024-0.040	22:1-25:1	2.0 (50.0%)	0.0 (0.0%)	2.0 (50.0%)	4.0 (50.0%)
Total	315					17.0 (44.7%)	10.0 (26.3%)	11.0 (28.9%)	38.0 (100%)



### Cultural characteristics of *Trichoderma* spp.

The results presented in Tables 3 to 5 indicated that there were clear differences in growth pattern and other cultural characters of antagonists when they were inoculated in three types of media stated. In general, there was dense mycelial growth of *Trichoderma* spp. in PDA than in MEA and OMA. The sporulation was first observed in PDA, followed by MEA and in OMA. The growth patterns of antagonists were more or less same in all the media tested but there was relatively more fluffy mycelial growth in the OMA. The colour of colony of *Trichoderma* spp. in all media, were green to dark green and sometimes yellowish green to dark green with white tinge. There was more aggregated growth of fungal antagonist near the periphery region. The pigmentation in the reverse side of growth of *Trichoderma* spp. varied from white, yellowish or faint yellow to light green irrespective of *Trichoderma* species.

Present findings is in accordance with the findings of Bissett (1991a, b) who characterized the *T. harzianum*, *T. viride* and *T. hamatum*. Similar observations were made by other workers (Rifai, 1969; Samuel, 1996; Lieckfiedt, 2001; Joshi *et al.*, 2007; Pan and Bhagat, 2007) where they comprehensively reported that the *T. harzianum* and *T. viride* were fast growing green coloured mycoparasitic fungi with distinct coconut or faintly earthy aroma, whereas *T. hamatum* was with relatively slow growth and most of the isolates were with distinct coconut aroma with 4-5 days old culture in Petriplates.

### Characterization of Anamorphic characters

Anamorphic characteristics of Andaman Isolates of *T. harzianum* is presented in Table 6, which indicated that the shape of phialides varied from ampulliform to subglobose or lageniform divergent or crowded whorl of 2-5. The middle of phialides were markedly swollen and abruptly tapered towards the tip. The shapes of conidia were subglobose to ovoid, the conidiophores were highly branched pyramidally nearly at right angles and the intercalary or terminal chlamydo spores were subglobose to ellipsoid or pyriform. The size of phialides, phialospores and chlamydo spores of *T. harzianum* varied from 3.4 - 8.7 × 2.7 - 3.41 μm (ThrAn-9) to 7.8 - 9.7 × 3.3 - 4.3 μm (ThrAn-7); 1.7 - 5 × 1.2 - 1.5 μm (ThrAn-11) to

3.5 - 4.0 × 2.5 - 2.8 μm (ThrAn-7) and 7.5 - 12.1 × 6.8 - 7.9 μm (ThrAn-16) to 10.7 - 13.0 × 8.2 - 9.6 μm (ThrAn-4), respectively, whereas conidiophores sizes varied from 3.5 - 25 × 2.4 - 7.2 μm (ThrAN-8) to 6.0 - 39.7 × 3.1 - 4.5 μm (ThrAN-14).

The Anamorphic characteristics of *T. viride* isolates has been presented in Table 7. The data revealed that phialides were of lageniform to subglobose, sometimes ampulliform to lageniform, verticillate with divergent whorls of 2-4. The shapes of phialospores varied from globose to ellipsoid or oblong with distinctive rough episporium walled. The conidiophores were comparatively narrow and flexuous, with primary branches at regular internodes, typically pyramidally branched and flexuous. The shapes of chlamydo spores varied from ellipsoid to oval, pyriform or globose, borne intercalary and terminal. The sizes of phialides of *T. viride* isolates varied from 4.0 - 7.5 × 1.3 - 1.6 μm (TvAN-6) to 5.5 - 8.9 × 1.5 - 1.7 μm (TvAN-7) while the sizes of phialospores varied from 1.7 - 2.5 × 1.8 - 2.2 μm (TvAN-8) to 2.5 - 3.9 × 1.8 - 2.0 μm. The chlamydo spores sizes varied from 8.7 - 12.4 × 7.4 - 8.9 μm (TvAN-10) to 9.7 - 13.8 × 8.5 - 9.6 μm (TvAN-6).

The results presented in Table 8 reflected the anamorphic characters (shape, size and colour of phialides, phialospores, conidiophores and chlamydo spores) of *T. hamatum* which indicated that there were clear differences in their anamorphic characters among the eleven isolates of *T. hamatum*. The shape of phialides were subglobose to ellipsoidal or ampulliform with mostly crowded and relatively stout phialides. The phialospores were oblong to ellipsoidal, oblong to subglobose and conidiophores were relatively broad, main axis straight and stiff but hamate and curled sterile conidiophores end. The chlamydo spores were terminal or intercalary, subglobose to ellipsoid or pyriform. The sizes of phialides varied from 3.4 - 5.7 × 2.7 - 3.3 μm (ThmAn-1) to 5.0 - 6.8 × 2.7 - 2.9 μm (ThmAN-6). Similarly the sizes of phialospores, conidiophores and chlamydo spores of *T. hamatum* varied from 3.2 - 4.9 × 2.3 - 2.9 μm (ThmAN-I) to 4.7 - 7.5 × 2.6 - 3.2 μm (ThmAN-9), 2.8 - 4.9 × 2.1 - 3.3 μm (ThmAN-II) to 6.0 - 40.8 × 4.8-34.5 μm (ThmAN-5) and 9.0-15.0 × 8.2 - 10 μm (ThmAN-1) to 10.5 - 14.7 × 7.5 - 9.3 μm respectively.

Table 3 : Cultural characteristics of Andaman isolates of *Trichoderma harzianum*\*

Isolates	1			MEAs
	2	3	4	
Characters	PDA	OMA	MEA	
ThrAN-1	Whitish green coloured colony with concentric ring, more concentrated near the periphery of plate.	Whitish green colony, compact but sparsely distributed with concentric rings.	Green fluffy growth with concentric ring, aerial mycelium is floccose, white to yellowish green.	
Growth rate	Rapid	Rapid	Rapid	
Pustules	Flat, surface appearing granular or powdery owing to dense conidiation.	Flat, appears whitish green powdery mass.	Flat, dusky yellowish green or dull blackish green.	
Pigment	Lime green pigment	Whitish or pale yellowish pigment.	Yellow colour pigment.	
Odour	Indistinct	Indistinct.	Indistinct.	
Hyphae	Hyaline, smooth walled, submerged mycelium.	Hyaline, smooth walled, submerged mycelium.	Hyaline, submerged mycelium.	
ThrAN-2	Light greenish fluffy growth, concentric ring formation with dense growth at margin of the colony.	Compact light green at centre but greenish white margin with slow sporulation.	Greenish fluffy growth with slow sporulation, formation of concentric rings.	
Growth rate	Moderate	Moderate	Moderate	
Pustules	More	More	More	
Pigment	No pigmentation	No pigmentation	No pigmentation	
Odour	Indistinct	Indistinct	Indistinct	
Hyphae	Hyaline, submerged mycelial growth, smooth wall.	Hyaline, smooth wall.	Hyaline, smooth wall	
ThrAN-3	Dark green, granular, submerged mycelial growth with more growth at the margin.	Green, submerged and whitish colour at the margin of colony.	Dark green submerged, densely growth with slightly raised at the margin.	
Growth rate	Rapid	Rapid	Rapid	
Pustules	More	Moderate	More	
Pigment	Yellowish	Whitish yellow	Yellow	
Odour	Coconut like aroma	Coconut like aroma.	Coconut like aroma.	
Hyphae	Hyaline, submerged growth.	Hyaline, submerged growth.	Hyaline, submerged.	



1	2	3	4	5
ThrAN-4	Colony	Greenish raised colony with profuse mycelial growth.	Greenish, scanty growth, whitish colour at the margin.	Greenish raised growth of mycelial growth, the colour is darker at margin than the centre.
	Growth rate	Rapid	Moderate	Rapid
	Pustules	More	Moderate	Rapid
	Pigment	Yellowish	No pigment	Yellowish
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Aerial mycelium is white to greyish white.	Aerial mycelium is whitish.	Yellow hyaline, mycelium.
ThrAN-5	Colony	Dark green, colony with concentric ring slightly white mycelium at the margin.	Dark green, colony with concentric rings, scanty growth at the centre and dense growth at or near the margin.	Dark green, colony with concentric ring slightly granular to powdery pustules.
	Growth rate	Rapid	Rapid	Rapid
	Pustules	Moderate	Moderate	Moderate
	Pigment	Lime green pigment	Light yellowish	Yellowish
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Hyaline	Hyaline	Hyaline
ThrAN-6	Colony	Light green colony sporulation throughout the plate and effuse conidiation.	Whitish green sporulation, more in margin than the centre	Light green with fluffy growth and sporulation throughout the plate, effuse conidiation
	Growth rate	Moderate	Slow	Moderate
	Pustules	No pustule	No pustule	No pustule
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hyphae	Hyaline	Hyaline	Hyaline
ThrAN-7	Colony	Colonies powdery to felty, white coloured became slightly green after sporulation, no concentric ring.	Whitish granular colony with no any concentric ring formation, later on turned light greenish.	Whitish colony, becomes light green or greyish green after sporulation.
	Growth rate	Moderate	Moderate	Moderate
	Pustules	No pustule	No pustule	No pustule
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled

1	2	3	4	5
ThrAN-8	Colony Growth rate Pustules Pigment Odour Hyphae Colony	Greenish colony with fluffy growth but slow sporulation. Slow Moderate No pigment Indistinct Hyaline mycelium with floccose. Green fluffy growth, more aggregated at the margin.	Greenish coloured colony at centre but whitish colour at the margin with slow sporulation. Slow Moderate No pigment Indistinct Hyaline mycelium Pale green to green, sparsely distributed in the plate but dense growth at the margin.	Greenish coloured colony with fluffy growth and whitish colour at the margin. Slow Moderate No pigment Indistinct Hyaline mycelium Green with profuse mycelial growth throughout the plate.
ThrAN-9	Growth rate Pustules Pigment Odour Hyphae Colony	Rapid Moderate No pigment Indistinct Hyaline Light green with submerged growth and sparsely distributed in the plate.	Moderate Moderate Creamy white to yellow Coconut like aroma Hyaline Green to dark green, submerged growth and very scanty growth at the centre but it is denser at margin.	Rapid Moderate Pale yellow Coconut like aroma Hyaline Light green to green with fluffy growth at the margin but scanty growth at centre.
ThrAN-10	Growth rate Pustules Pigment Odour Hyphae Colony	Moderate More Orange yellow Indistinct Hyaline Dark green, fluffy growth with profuse mycelial growth and white at the margin of colony.	Moderate Medium Creamy colour Indistinct Hyaline Dark green, fluffy but scanty growth and unevenly distributed on plate, white at the colony margin.	Rapid More Yellow Indistinct Hyaline Green to dark green with less fluffy but evenly distributed on the plate.
ThrAN-11	Growth rate Pustules Pigment Odour Hyphae	Rapid More Yellow Coconut like aroma Hyaline	Moderate Medium Yellow Coconut like aroma Hyaline	Rapid More Yellow Coconut like aroma Hyaline

1	2	3	4	5
ThrAN-12	Colony	Dark green, granular and submerged growth with typical whitish raised growth at the margin.	Dark green, submerged with flat growth at the colony margin.	Dark green, granular growth, evenly distributed on the plate, more dark green colour at the margin.
	Growth rate	Rapid	Moderate	Rapid
	Pustules	More	More	More
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hyphae	Hyaline	Hyaline	Hyaline
ThrAN-13	Colony	Whitish green coloured colony and uniform growth in the plate.	Greenish with no aerial hyphae, forming compact to loose growth and distributed in concentric rings.	Greenish coloured colony with compact growth and no aerial hyphae.
	Growth rate	Rapid	Moderate	Rapid
	Pustules	More	Medium	More
	Pigment	Yellow to brown	Yellow	Brown
	Odour	Indistinct	Indistinct	Indistinct
	Hyphae	Hyaline	Hyaline	Hyaline
ThrAN-14	Colony	Light green, sporulation is uniform and effuse condensation.	Light green colony, sporulation is slow but more at margin.	Light green to green, appressed colony with sporulation throughout the plate.
	Growth rate	Moderate	Slow	Moderate
	Pustules	Medium	Medium	Medium
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hyphae	Hyaline	Hyaline	Hyaline



1	2	3	4	5
ThrAN-15	Colony	Aerial mycelium is floccose, dark green with rapid sporulation, quickly turned dark green from pistachio green.	Dark green raised colony with whitish coloured margin.	Dark green, fluffy mycelial growth with rapid sporulation.
	Growth rate	Rapid	Rapid	Rapid
	Pustules	More	Medium	More
	Pigment	Yellow	Yellow	Brown
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hypphae	Hyaline	Hyaline	Hyaline
ThrAN-16	Colony	Green to dark green, compact growth with profuse mycelial growth and whitish border at the margin of colony.	Dark green, compact growth and evenly distributed in plate, white border at the colony margin.	Green to dark green with less fluffy but evenly distributed on the plate.
	Growth rate	Rapid	Moderate	Moderate
	Pustules	More	Medium	More
	Pigment	Yellow	Pale yellow	Pale yellow
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hypphae	Hyaline	Hyaline	Hyaline
ThrAN-17	Colony	Dark green, granular and submerged growth with typical whitish raised growth at the margin.	Pale green to dark green and submerged.	Green, granular growth, evenly distributed on the plate, darker green colour at the margin.
	Growth rate	Moderate	Moderate	Moderate
	Pustules	More	More	More
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline	Hyaline	Hyaline

\*Data are the means of five replications

Table 4 : Cultural characteristics of Andaman isolates of *Trichoderma viride* \*

Isolates	Characters	4			5
		PDA	OMA	MEA	
TvAN-1	Colony	Dark green with light yellowish coloured tinge, dense mycelial growth and aerial mycelium is usually limited, floccose to arachnoids.	Green to dark green colony with relatively scanty mycelial growth and whitish green ring on the colony margin.	Pale yellowish or greenish fluffy growth more near the periphery region of plate, radial growth pattern with white boarder mark on the margin.	
	Growth rate	Rapid	Rapid	Rapid	
	Pustules	More, Dark green	More, Dark green	More, Dark green	
	Pigment	Yellowish green	Pale yellow	Yellow	
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma	
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled	
TvAN-2	Colony	Pale yellowish to dark green, aerial mycelium is usually floccose to arachnoids, whitish boarder in the colony margin with radial growth pattern.	Whitish green to green, mycelia are sparsely distributed in the plate with radial growth pattern and prominent whitish demarcation at the periphery.	Whitish or pale yellowish, highly fluffy growth with radial growth pattern, uniform distribution on the plate.	
	Growth rate	Rapid	Rapid	Rapid	
	Pustules	Compact dark green	Compact, dark green or brown	Dark green or brown	
	Pigment	Dull yellowish	Pale yellowish	Dull yellowish	
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma	
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled	
TvAN-3	Colony	Greenish fluffy growth with effuse conidiation and uniform distribution on the plate	Greenish colour colony with whitish margin and effuse conidiation,	Dark green, raised growth, effuse conidiation and whitish margin at the colony margin.	
	Growth rate	Rapid	Rapid	Rapid	
	Pustules	Greenish to dark green	Abundant, dark green to greyish brown	Abundant, dark green to brown	
	Pigment	Yellow	Yellow	Dull yellow	
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma	
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled	



1	2	3	4	5
TvAN-4	Colony	Whitish or pale green, dense with slight fluffy growth and uniformly distributed in the plate.	Whitish green to green, mycelium is sparsely distributed in the plate and whitish demarcation at the margin.	Pale green to dark green, mycelium is densely packed and uniformly distributed in the plate.
	Growth rate	Rapid	Slow	Moderate
	Pustules	Moderate, brownish	Low, dark green	Moderate, dark green
	Pigment	Colourless	Colourless	Colourless
	Odour	Indistinct	Indistinct	Indistinct
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
TvAN-5	Colony	Light yellowish to green colony, dense mycelial growth with uniform distribution and slight fluffy growth in the periphery region.	Green with pale yellow on the upper surface of growth slight fluffy growth and whitish border in the margin.	Pale yellowish or dark green, fluffy growth near the periphery region and radial growth pattern with whitish border at the margin.
	Growth rate	Rapid	Rapid	Rapid
	Pustules	Abundant, dark green	Abundant, dark green to brown	Abundant, dark green to brown
	Pigment	Dull yellowish	Dull yellowish	Dull yellowish
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Aerial mycelium is limited, hyaline and smooth walled	Aerial mycelium is limited, hyaline smooth walled	Hyaline, smooth walled
TvAN-6	Colony	Light green with effuse condition, uniformly distributed throughout the plate with whitish border.	Yellowish green, sparsely distributed with concentric ring formation and white border at the colony margin.	Dull green to green, fluffy growth with uniform distribution and whitish green border at the colony margin.
	Growth rate	Moderate	Moderate	Moderate
	Pustules	Abundant, dark green	Abundant, green	Abundant, brown
	Pigment	Dull yellowish	Dull yellowish	Pale yellowish
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
TvAN-7	Colony	Light green to green, effuse condition, uniform and compact growth and whitish border in the colony margin.	Green colour colony, scanty mycelial growth with radial growth pattern, and whitish border in the margin.	Light green, slight fluffy, dense growth, radial growth pattern and whitish border at the colony margin.
	Growth rate	Very rapid	Rapid	Very rapid
	Pustules	Abundant, dark green	Abundant, dark green	Abundant, dark green
	Pigment	Dull yellow	Dull yellow	Dull yellow
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled

1	2	3	4	5
TvAN-8	Colony	Green to dark green, effuse conidiation, uniform and radial growth pattern.	Green colour colony, compact mycelial growth with radial growth pattern, and whitish border in the margin.	Light green, dense growth, radial growth pattern and whitish border at the colony margin.
	Growth rate	Very rapid	Rapid	Very rapid
	Pustules	Pruinose, dark green to brown	Abundant, dark green	Abundant, dark green to brown
	Pigment	Pale yellow	Dull yellow	Pale yellow
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
TvAN-9	Colony	Light green to green, uniform and compact growth with radial growth pattern.	Pale green to dark green colony, scanty at the centre with radial growth pattern and greenish border in the margin.	Green to dark green, dense growth with radial pattern and whitish border at the colony margin.
	Growth rate	Very rapid	Rapid	Very rapid
	Pustules	Fairly abundant, brown	Abundant, dark brown	Abundant, brown
	Pigment	Dull yellow	Dull yellow	Dull yellow
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
TvAN-10	Colony	Yellow to green, effuse conidiation, uniform and compact growth and whitish border in the colony margin.	Green to dark green coloured colony, scanty mycelial growth with radial growth pattern, and whitish border in the margin.	Light green, slight fluffy, dense growth, radial growth pattern and whitish border at the colony margin.
	Growth rate	Very rapid	Very rapid	Very rapid
	Pustules	Dark green	Dark green	Fairly abundant, dark green
	Pigment	Yellow	Yellow	Light yellow
	Odour	Coconut like aroma	Coconut like aroma	Coconut like aroma
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled

\*Data are the means of five replications



Table 5 : Cultural characteristics of Andaman isolates of *Trichoderma hamatum*\*

1 Isolates	2 Characters	3			5 MEA
		PDA	OMA		
ThmAN-1	Colony	White or pale yellow colony, radial growth pattern, highly fluffy growth with some pustules.	Light to dark green colony unevenly distributed throughout the plate. The mycelia are concentrating at the periphery region and thus an alternate ring of white and green in colour is formed. The growth is sparse and in radial pattern with light fluffy growth.	Whitish green to dark green with slight fluffy growth. The growth is sparse to compact and distributed throughout the plate.	
	Growth rate	Moderately rapid	Moderately rapid	Moderately rapid	
	Pustules	Cushion shaped or hemispherical pustules, surface is velvety to bluish green shade to porcelain green.	Hemispherical shaped pustules, dark green in colour	Cushion shaped or hemispherical, dark green to velvety.	
	Pigment	Colourless to pale green or yellow exudates usually lacking.	Colourless to pale green or yellow exudates rarely at margin.	Colourless to pale green or yellow exudates rarely at margin.	
	Odour	Indistinct	Indistinct	Indistinct	
	Hyphae	Mycelium mostly submerged, the limited aerial mycelium is floccose, white to greyish, hyphae smooth walled.	Submerged mycelium, aerial mycelium is floccose, white to greyish or hyaline and smooth walled, sporulation occurs at very late.	Submerged mycelium hyaline and smooth walled.	
ThmAN-2	Colony	Submerged mycelium with whitish colour colony, radial growth pattern with slight fluffy growth and whitish green ring at the periphery.	Whitish colony with fluffy growth and whitish green colour border at a colony margin.	Mostly submerged mycelium with slight fluffy growth, white to whitish green colony and prominent light greenish demarcation at the margin	
	Growth rate	Moderate	Moderate	Moderate	
	Pustules	Hemispherical pustules often distributed concentrically or aggregated near the colony margin, velvety to dark green.	Spherical, unevenly distributed, greyish colour.	Spherical to hemispherical, aggregated more near the colony margin.	
	Pigment	Colourless	Colourless	Colourless	
	Odour	Indistinct	Indistinct	Indistinct	
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled	
ThmAN-3	Colony	Whitish coloured colony with slow growth rate, light green sporulation at colony margin with compact growth.	Whitish colony, submerged mycelium, floccose aerial mycelium and sporulation occur at very late, sparsely distributed.	White colony with slow sporulation, submerged mycelium, aerial mycelium is floccose, white and compact growth.	
	Growth rate	Slow	Slow	Slow	
	Pustules	Absent	Absent	Absent	
	Pigment	No pigment	No pigment	No pigment	
	Odour	Indistinct	Indistinct	Indistinct	
	Hyphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled	

1	2	3	4	5
ThmAN-4	Colony	White to whitish green with highly fluffy growth uniformly distributed throughout the plate.	Whitish green coloured colony with moderately fluffy growth, sparsely distributed.	White to light green or green coloured colony with uniform distribution throughout the plate and slightly compact growth
	Growth rate	Rapid	Rapid	Rapid
	Pustules	Cushion shaped or hemispherical pustules, compact conidiation.	Conidiation is slightly raised, hemispherical pustules	Spherical to hemispherical pustules, conidiation is slightly compact and cushion shaped.
	Pigment	White to pale yellow	White to pale yellow	White to slight green
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
ThmAN-5	Colony	White or whitish green to green with highly fluffy growth.	White or whitish green colony with comparatively less fluffy growth.	White or whitish green to green with highly fluffy growth, distributed throughout the plate.
	Growth rate	Rapid	Moderately rapid	Rapid
	Pustules	Green pruinose pustules arising from curled sterile conidiophores.	Whitish green pruinose pustules.	Green pruinose pustules.
	Pigment	Pale yellow	Colourless	Pale yellow
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
ThmAN-6	Colony	Whitish green often distributed concentrically or aggregated more near the colony margin.	Whitish green often distributed concentrically or aggregated more near the colony margin.	White to whitish green aggregated more near the colony margin with concentric rings.
	Growth rate	Moderately rapid	Moderate	Moderately rapid
	Pustules	Spherical to hemispherical pustules due to numerous, flexuous, delicate sterile conidiophore apices.	Hemispherical, velvety or dark green pustules.	Spherical to hemispherical, dark green to velvety or greenish glaucous.
	Pigment	Whitish green	Whitish green	Whitish green
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
ThmAN-7	Colony	Whitish green, submerged mycelium, the aerial mycelium is floccose, white to greyish, aggregated more towards the colony margin.	White or whitish green or pale green, conidiation aggregation is more towards colony margin than the centre.	White or whitish green to green colony, distributed evenly throughout the plate.
	Growth rate	Moderately rapid	Moderately rapid	Moderately rapid
	Pustules	Green pruinose pustules	Whitish green pruinose pustules	Green pruinose pustules
	Pigment	Whitish green	Whitish green	Whitish green
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled



1	2	3	4	5
ThmAN-8	Colony	White to whitish green slow sporulation more aggregated towards the colony margin.	White to whitish green with slow sporulation more aggregated towards colony margin.	Whitish green to green colony with slow sporulation, more aggregated towards the colony margin.
	Growth rate	Slow	Slow	Slow
	Pustules	Velvety to green glaucous, hemispherical pustules.	Dark green, cushion shaped or hemispherical pustules.	Dark green, hemispherical pustules.
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth walled	Hyaline, smooth walled	Hyaline, smooth walled
ThmAN-9	Colony	White to greyish green, slow sporulation, aggregated more near the colony margin.	Whitish green, submerged mycelium, slow sporulation more aggregated near the colony margin.	White to whitish green, slow sporulation.
	Growth rate	Slow	Slow	Slow
	Pustules	Greyish green	Greyish green	Greyish green
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth wall and broad.	Hyaline, smooth walled.	Hyaline, smooth wall and broad.
ThmAN-10	Colony	Whit coloured, sporulation is very slow and fluffy growth	White to pale yellowish colour, sporulation is more aggregated towards the margin and slow sporulation.	White to whitish green, very slow sporulation, often aggregated towards the colony margin.
	Growth rate	Very slow	Very slow	Very slow
	Pustules	Velvety, hemispherical pustules.	Velvety, hemispherical pustules.	Velvety, spherical pustules.
	Pigment	No pigment	No pigment	No pigment
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth and broad.	Hyaline, smooth and broad.	Hyaline, smooth and broad.
ThmAN-11	Colony	Whitish colour with slight green, radial growth pattern and slight fluffy growth	Whitish colour with slight green in the centre, the mycelium is sparsely distributed throughout the plate.	Whitish colour, slightly fluffy and radial growth pattern, slight green condensation, more near the colony margin.
	Growth rate	Rapid	Rapid	Rapid
	Pustules	Pruinose green	Dark green	Dark green to pruinose green
	Pigment	Whitish green	Whitish green	Whitish green
	Odour	Indistinct	Indistinct	Indistinct
	Hypphae	Hyaline, smooth walled and broad.	Hyaline, smooth walled and broad.	Hyaline, smooth walled and broad.

\*Data are the means of five replications

1	2	3	4	5	6	7	8	9
ThrAN-10	Ampulliform to subglobose or lageniform with strongly swollen in the middle.	3.6-7.9 x 2.8-3.5	More obvoid, smooth walled.	1.9-3.0 x 1.4-1.8	Hyaline, smooth wall, straight or flexuous, highly branched and primary branch arises at nearly right angles.	5.5-34.2 x 3.0-6.9	Fairly abundant, intercalary and terminal, subglobose or pyriform, brownish in colour.	10.2-13.0 x 7.5-9.3
ThrAN-11	Subglobose or lageniform with divergent whorls of 4-5.	4.0-7.5 x 3.1-3.8	Subglobose to obvoid.	1.7-2.5 x 1.2-1.5	Straight or flexuous highly branched in a pyramidal form.	4.7-28.8 x 2.5-5.8	Intercalary and terminal, subglobose, pale yellow to brownish colour.	9.2-12.6 x 7.4-9.5
ThrAN-12	Ampulliform to subglobose, markedly constricted at base but broadly swollen at middle.	3.9-6.8 x 2.6-3.4	Subglobose to obvoid.	1.7-2.5 x 1.3-1.4	Straight, highly branched with primary branches arising at nearly right angles.	6.0-36.2 x 2.4-4.9	Subglobose to ellipsoidal or pyriform. Solitary contents subhyaline to pale yellow.	9.4-13.2 x 7.5-9.4
ThrAN-13	Subglobose to ampulliform with divergent whorls of 4-6.	4.0-7.4 x 2.5-3.5	Subglobose.	1.9-2.8 x 1.4-1.6	Smooth walled, straight or flexuous, macro-nematous conidiophores, highly branched, primary branches arising nearly at right angles or slightly bent towards the apex. usually in whorls of 2 or 3.	5.8-33.9 x 2.6-4.4	Ellipsoid, intercalary and terminal, brown in colour.	9.5-12.0 x 7.2-9.3
ThrAN-14	Ampulliform, narrow at the base but attenuate abruptly and sharp pointed neck.	4.9-7.4 x 3.0-3.4	Subglobose to obvoid.	1.8-2.9 x 1.2-1.5	Smooth walled, loose tuft, numerous branches arises nearly at right angles from the main branches especially from or near the base.	6.0-39.7 x 3.1-4.5	Intercalary and terminal, dark green to brown in colour.	8.9-12.6 x 7.5-9.1
ThrAN-15	Lageniform or ampulliform and strongly swollen in the middle.	4.5-6.9 x 2.6-3.2	Subglobose smooth walled.	2.0-3.0 x 1.6-1.8	Smooth walled, straight or flexuous, highly branched, primary branch arises at right angles.	5.1-36.2 x 3.1-4.5	Subglobose or Pyriform, intercalary and terminal, light brown.	9.2-14.2 x 8.0-9.5
ThrAN-16	Ampulliform to subglobose, more swollen in middle than base or tip.	5.8-8.0 x 3.5-5.0	Subglobose to obvoid smooth walled.	3.5-4.0 x 2.5-2.8	Smooth walled, flexuous and highly branched.	4.9-30.5 x 2.9-3.7	Pyriform, intercalary and terminal, dark green.	7.5-12.1 x 6.8-7.9
ThrAN-17	Ampulliform or lageniform, more swollen in middle and abruptly tapered towards the tip.	4.9-6.7 x 2.5-4.9	Subglobose to obvoid smooth walled.	2.0-3.5 x 1.2-1.4	Smooth walled, straight or flexuous, highly branched with primary branch arises at or nearly at right angles.	4.5-28.9 x 3.0-3.8	Subglobose, fairly abundant and dark brown	9.5-13.2 x 7.2-9.1

\*Data are the means of five replications



Table 7: Anamorphic characteristics of Andaman isolates of *T. viride*\*

Isolates	Phialides		Phialospores		Conidiophores		Chlamydospores	
	Shape	Size ( $\mu\text{m}$ )	Shape	Size ( $\mu\text{m}$ )	Shape	Size ( $\mu\text{m}$ )	Shape	Size ( $\mu\text{m}$ )
TvAN-1	Phialides mostly in verticilloid of 3 or 4, lageniform to subglobose.	5.3-8.2 X 1.2-1.6	Rough spores globose to ellipsoid or oblong	1.9-2.8 X 1.7-2.1 at regular intervals.	Comparatively narrow and flexuous, with primary branches at regular intervals.	5.6-35.0 X 2.0-3.5	Abundant, ellipsoid to oval, intercalary and terminal, dark brown colour.	9.5 - 12.7 X 7.5-8.9
TvAN-2	Lageniform, arranged in divergent whorls of 2-4, slender, sometime irregularly bent.	4.1 - 7.9 X 1.3 - 1.6	Rough spored globose	1.7-2.5 X 1.8-2.2	Typically pyramidally branched and flexuous.	4.7-28.8 X 3.0-4.2	Oval shaped, terminal and intercalary and dark green.	9.1 - 12.2 X 7.2-8.9
TvAN-3	Regularly paired phialides, slender irregularly bent.	4.7-7.8 X 1.5 - 1.7	Rough spored, globose to oval.	2.0-2.4 X 1.8-2.0	Short branches near the tip and longer ones with repeated branching at the base, without sterile hypha at the tip.	5.1 -35.0 X 3.1 -4.8	Ellipsoid to globose, both intercalary and terminal, dark green.	9.7 - 13.2 X 7.5-9.3
TvAN-4	Verticillate, slender with open fingers, abruptly tapered towards the apices.	4.5-8.5 X 1.3 - 1.5	Rough spored, ellipsoid.	2.2-3.0 X 1.8-2.2	Irregularly branched, broad, non-flexuous branches, smooth walled.	4.9-33.4 X 2.9-3.7	Ellipsoid or pyriform, intercalary and terminal, dark brown.	8.7 - 12.4 X 7.4-9.6
TvAN-5	Ampulliform or lageniform	5.5-8.4 X 1.4-1.7	Subglobose, rough walled.	1.6-2.7 X 1.8-2.1	Narrow and flexuous conidophores, pyramidally branched with paired or three, primary branches not arises at or nearly right angles.	5.6-37.0 X 3.4-5.2	Abundant, intercalary and terminal or at short branches, subglobose to pyriform.	9.1 - 13.5 X 7.5-9.0
TvAN-6	Bottle shaped with rather slender and divergent whorls of 3-4.	4.0-7.5 X 1.3 - 1.6	Subglobose, rough spores.	2.1 -3.5 X 1.6-2.0	Flexuous with pyramidally branched at regular intervals.	7.2-39.7 X 3.0-4.1	Fairly abundant, subglobose to elliptical, intercalary and terminal at short branches.	9.7 - 13.8 X 8.5-9.6
TvAN-7	Lageniform to bottle shaped with divergent phialides.	5.5 - 8.9 X 1.5-1.7	Globose to oval, rough spores.	2.5-3.9 X 1.8-2.0	Pyramidally branched, smooth walled.	5.7-36.2 X 3.2-4.2	Oval shaped, terminal and intercalary, dark green.	9.1-12.2 X 7.2-8.9
TvAN-8	Bottle shaped, arranged in divergent whorls of 3-4, slender, often irregularly bent.	4.1 -7.9 X 1.3-1.6	Rough spored oval.	1.7-2.5 X 1.8-2.2	Typically pyramidally branched and flexuous.	4.7-28.8 X 3.0-4.2	Oval shaped, terminal and intercalary and dark green.	9.1 - 12.2 X 7.2-8.9
TvAN-9	Lageniform, regularly paired phialides, slender irregularly bent.	4.7-7.8 X 1.5-1.7	Rough spored, globose to oval.	2.0-2.4 X 1.8-2.0	Short branches near the tip and longer ones with repeated branching at the base, not nearly or at right angles.	5.1 -35.0 X 3.1 -4.8	Ellipsoid, both intercalary and terminal, dark green.	9.7 - 13.2 X 7.5-9.3
TvAN-10	Verticillate, slender with open phialides, slender, abruptly tapered towards the apices.	4.5-8.5 X 1.3-1.5	Rough spored, ellipsoid.	2.2-3.0 X 1.8-2.2	Flexuous, irregularly branched, smooth walled.	4.9-33.4 X 2.9-3.7	Ellipsoid, intercalary and terminal, dark brown.	8.7 - 12.4 X 7.4-9.6

\*Data are the means of five replications

Table 8 : Anamorphic characters of Andaman isolates of *Trichoderma hamatum*\*

Isolates	Phialides		Phialospores		Conidiophores		Chlamydospores	
	Shape	Size (µm)	Shape	Size (µm)	Shape	Size (µm)	Shape	Size (µm)
ThmAN-1	Subglobose to ellipsoidal or ampulliform. crowded whorls of 3-6.	3.4-5.7 x 2.7-3.3	Oblong to ellipsoidal, apex broadly rounded and base narrower or slightly pointed.	3.2-4.9 x 2.3-2.9	Smooth walled, main axis appearing straight and stiff, regularly branched, primary branches relatively short, usually in whorls of 2-5.	4.1-20.5 x 3.5-7.8	Terminal or intercalary, solitary, subhyaline, subglobose to broadly ellipsoid.	5.0-15.0 x 8.2-10.0
ThmAN-2	Subglobose or ampulliform, crowded whorls.	3.6-5.9 x 2.6-3.5	Oblong to ellipsoid, apex rounded.	3.5-5.0 x 2.2-3.2	Smooth, hyaline, upper part of conidiophore is sinuous or more often strongly undulated or hamate.	5.0-25.2 x 4.0-6.5	Subglobose to ellipsoid.	10.2-14.5 x 8.2-11.5
ThmAN-3	Ampulliform.	4.0-6.2 x 2.4-3.2	Ellipsoid, apex with more rounded.	3.7-5.6 x 2.1-3.0	Smooth, hyaline, main axis is straight, highly branched and rebranched with sterile conidiophore apices.	4.8-27.4 x 3.5-5.7	Subglobose.	10.4-14 x 8.6-10.0
ThmAN-4	Ellipsoid.	4.4-6.2 x 2.3-2.9	Oblong with more rounded apex.	3.9-4.5 x 2.5-2.9	Hyaline, smooth walled or occasionally irregular thickening at the base. Main axis is straight, primary branches are relatively short, in whorls of 2-5.	5.1-24.8 x 3.5-5.5	Subglobose.	10.0-14.6 x 7.8-10
ThmAN-5	Ellipsoidal to ampulliform.	4.9-7.0 x 2.5-2.8	Oblong, apex broadly rounded and base narrower or slightly pointed.	4.1-5.5 x 1.8-2.5	Hyaline, smooth walled, main axis straight and stiff but hamate in upper part.	6.0-40.8 x 4.0-34.5	Subglobose.	9.4-12.6 x 8.0-9.2
ThmAN-6	Subglobose to ellipsoidal or ampulliform.	5.0-6.8 x 2.7-2.9	Oblong to ellipsoidal.	4.1-5.3 x 1.9-2.8	Hyaline, broad conidiophore, main axis is straight with curled sterile conidiophore ends.	5.9-36.7 x 3.2-38.0	Pyriform.	11.4-15.2 x 9.2-9.7
ThmAN-7	Ampulliform or ellipsoidal.	4.4-6.8 x 2.5-3.3	Oblong to subglobose.	4.0-4.9 x 1.7-2.9	Broad conidiophore, hyaline, highly branched nearly at right angles to slightly bent inwards, curled sterile conidiophore ends are abundant.	5.5-38.2 x 2.9-3.5	Subhyaline, subglobose to broadly ellipsoid.	10.4-12.5 x 7.8-9.2
ThmAN-8	Subglobose to ellipsoidal or ampulliform.	4.5-7.4 x 2.7-3.5	Subglobose.	3.9-4.8 x 1.5-3.0	Broad, conidiophore, hyaline, straight, main axes with curled sterile conidiophore end with no conidia	5.0-32.7 x 2.8-3.2	Subglobose to ellipsoid.	10.5-14.7 x 7.5-9.3
ThmAN-9	Ampulliform.	4.7-7.5 x 2.6-3.2	Oblong to subglobose.	4.2-5.6 x 1.8-3.5	Smooth walled, broad conidiophore highly branched pyramidally with curled sterile conidiophores end at the main axis.	5.2-30.8 x 3.0-3.5	Subglobose to pyriform.	9.5-14.7 x 7.9-9.3
ThmAN-10	Subglobose to ellipsoidal or ampulliform, constricted at the base, narrowing abruptly at the apex to a very short conidia.	3.5-5.9 x 2.5-3.4	Ellipsoid.	3.2-4.9 x 2.2-3.3	Hyaline, smooth walled broad conidiophores with straight and stiff pyramidally branched.	6.0-30.8 x 3.0-3.5	Broadly ellipsoid.	10.1-13.9 x 7.8-9.2
ThmAN-11	Subglobose or ampulliform.	3.9-5.7 x 2.6-3.8	Oblong.	2.8-4.9 x 2.1-3.3	Broad, smooth walled highly branched with sterile conidiophores apices.	5.2-30.5 x 2.8-5.0	Subglobose or pyriform.	

\*Data are the means of five replications



Cultural and anamorphic characteristics are the major determinants for morphological identification of *Trichoderma* spp. at species level. Present findings suggested that *T. harzianum*, *T. viride* are fast growing green coloured fungi whereas *T. hamatum* is relatively a slow grower species. These findings support the earlier observations (Rifai, 1969; Domsch *et al.*, 1980, Bissett, 1991a, b; Samuel, 1996; Samuel, 2006) where they characterized different species of *Trichoderma*. They have also reported that *T. viride* and its related species are able to secrete  $\alpha$ -pyrone, a sweet coconut like aroma. Pan and Bhagat (2007) have reported that the conidiophores branching are at nearly right angle or less for *T. harzianum*, while at nearly acute angles in case of *T. viride*. Present findings also suggest that the conidiophores of *T. hamatum* is comparatively broader and short but with stout phialides. These findings are in agreement with earlier findings (Domsch *et al.*, 1980; Bissett, 1991 a, b).

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