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Chaetomium spp as Biological Fertilizer for Plant Growth

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Abstract *Chaetomium* spp is a saprophytic Ascomycetes which could produce cellulose to degrade cellulose materials and decay woods. There are many species of *Chaetomium* have been reported to produce antibiotic substances, especially ergostrol to increase soil fertility. *Chaetomium* spp. has been reported to increase plant growth parameters and yields of many kinds of plants eg kales, tomato, chilli, corn, citrus, potato etc. The natural products or fungal metabolites released from *Chaetomium* spp. also reported to increase plant growth, yield and induce plant immunity. *Chaetomium* spp. are proved to be safety for human being and environment. It can be developed as a biofertilizer to increase in plant growth and yield in several kind of economic plants.

Keywords: *Chaetomium* spp., biofertilizer

Introduction

The agricultural soil today becomes low fertility due to heavy application of only chemical fertilizer like 46-0-0, 15-15-15, 8-24-24 etc. leading to low pH, less organic matter, bad water drainage etc. Plants grow in this soil condition are low growth rate and low yield. There are some reports on microbial biotechnology can enhance the growth of plants (Soytong *et al*., 2001).

Chaetomium spp. are isolated from Guangxi to test for plant stimulator and supressed some phytopahtogens eg *Fusarium* sp., *Phythophthora* sp. especially in grape, citrus and some vegetables. (Personal Communication, Soytong, 2017). It found that *Chaetomium cochilodes* has one of a prominent species encountere (Fig. 1). There are reported that *Ch cochliodes* produces bis-spiro-Azaphilones and azaphilones as an active metabolite as reported by Phonkerd *et al*. (2008). Qian, Y., Mei, L. and Soytong, K. (2003) reported to find out the resiatent gene to some chemical fungicide. The research finding proved that *Chaetomium* sp. are safety for human being and environment (Soytong *et al.* 2001).

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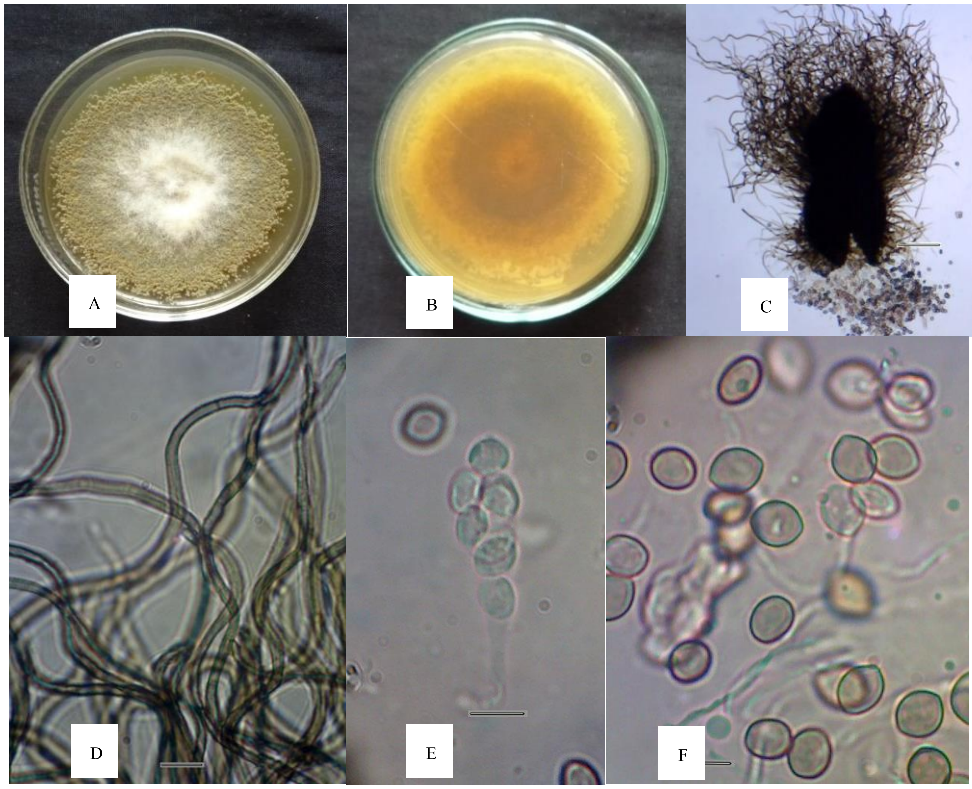
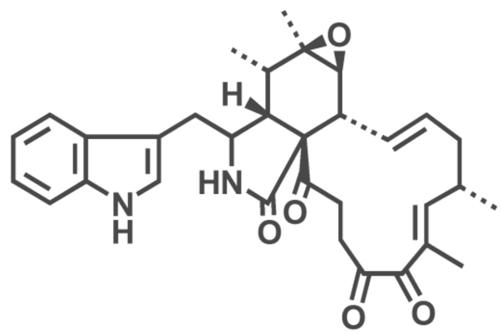


Figure 1. *Chaetomium cochliodes* 10-day-old culture on PDA, upper surface (A) and lower surface (B), ascomata (C), ascomatal hairs (D), ascus (E) and ascospores (F). Bar. C = 100 μm, D, E, F = 10 μm.

Metabolites produced from *Chaetomium* spp. for disease control

Soytong (1992) and Kanokmedhakul *et al*. (1993) reported that crude extract of *Chaetomium cupreum* KMITL-N 4320 can increase the growth parameters of tomato and inhibited *Fusarium oxysporum* f. sp. *Lycopersici* causing wilt. It is reported that *Chaetomium* can produce ergosterol that can be promoted to increased soil fertility and high organic matter.



Chaetoglobocin C

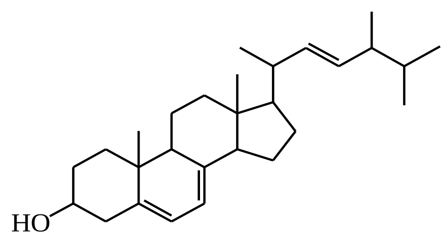


Figure 2. Ergosterol produced by *Chaetomium* sp.

Moreover, there are many reports on bioactive compounds which extracted from fungi such as trichotoxin A50 extracted from *Trichoderma harzianum* PC01, and chaetoglobosin C extracted from *Chaetomium globosum* KMITL-N0802 have been reported to elicit the resistant or immunity in plants and increased in plant growth and yield (Soytong, *et al*., 2001).

Soytong *et al*. (2001) reported that chaetoglobosin C expressed as an alien substance which induce a localized and sub-systemic oxidative burst in carrot, potato, tomato and tobacco implied plant immunity. Soytong *et al.* (2001) reported that *Chaetomium* has been developed from 22-strains of *Chaetomium globosum* and *Chaetomium cupreum* in the form of pellet and powder formulation successfully applied to infested field-soils with integrated with cultural control measures and organic amendments for the long-term protection of Durian and Black pepper caused by *Phytophthora palmivora*, Tangerine caused by *P. parasitica* and Strawberry caused by *P. cactorum*, Wilt of Tomato caused by *Fusarium oxysporum* f. sp. *lycopersici* and Basal rot of Corn caused by *Sclerotium rolfsii*. All experiments gave significantly better plant growth parameters and better yield than the non-treated control.

Chaetomium as biofertilizer

Kaewchi *et al* (2000) reported that fungal biofertilizers and biofungicides have been stimulated for agricultural use due to their ability to supress plant diseases and increase crop production. Fungal biofertilizers including Chaetomium species has been registered for application in crop production. Several fungal biofertilizers have been formulated for commercial production eg *Chaetomium* sp. was registered as biofertilizer in China (1989). It is stated that the fungal biofertilizers play an important role in promoting plant growth, productivity and improving soil fertility. Kowapradit *et al.* (2007) reported that fermented ash mixed with *Chaetomium lucknowense* increased in plant height, number of tillers, number of grains per panicle, number of panicle per tiller and grain weight per panicle. It was indicated that the bio-ash with *Chaetomium* sp. has affected to higher soil fertility, which increased in plant nutrients available for the growth of rice var Prathumthani 1. The bio-ash with *Chaetomium* sp. at 25, 50 and 75 kg/rai were notsignificantly differed and increased the yield of 52.38, 49.05 and 56.59 %, respectively. It was significantly higher when compared to the non-treated one. It recommends that the biological ash mixed to *Chaetomium* sp. may possible to develop for using to increase yield and to reduce the chemical use (Table 1).

Table 1. Growth parameters of rice after application bio-ash mixed with *Chaetomium* sp.

	Grain weight/panicle (g)	**Grain weight/panicle(g)**	**green yellow Total(g)**	**Increase (%)**
Control	0.00b[1]	152.44b	152.44b	-
ash 50 kg/rai	00.00b	111.32b	111.32b	-
Bio-ash 25 kg/rai	20.66a	292.91a	313.57a	51.38
Bio-ash 50 kg/rai	20.08a	279.17a	299.25a	49.05
Bio-ash 75 kg/rai	35.02a	316.16a	351.18a	56.59

[1]Mean of four replications. Means followed by a common letrer in each column are not significanty differed by DMRT at P=0.01.

The rice growing appeared significantly different in plant height after transplanting. It was showed that in non-treated control and biofertilizer mixed *Chaetomium* sp. at 45 days, the plant height were 33.15 cm and 30.46 cm, respectively. There was highly significant in plant height in bio-fertilizer mized *Chaetomium* sp. applied at 25, 50 and 75 kg/rai which were 35.59, 35.62 and 39.54 cm, respectively (Table 2). The number of tillers/plant was not significantly differed at early stage of 15 d in all treatments but number of tillers at 45 days significantly differed in bio-fertlizer mixed *Chaetomium* sp. when applied at the rate of 25 kg/rai, 50 kg/rai and 75 kg/rai (6.49, 7.14 and 7.05 tillers) when compared to the control (6.18 tillers) as seen in Table 3.

Table 2. Plant heights of rice after application of biofertilizer mixed to *Chaetomium* sp.

Treatments	Plant height (cm)		
	15 d	30 d	45 d
Control	15.25b1	19.44b	33.15bc
ash 50 kg/rai	15.84ab	19.66b	30.46c
Bio-fertilizer 25 kg/rai	15.67ab	19.41b	35.59ab
Bio-fertlizer 50 kg/rai	15.29b	19.83ab	35.62ab
Bio-fertilzer 75 kg/rai	16.70a	20.88a	39.54a

1Mean of four replications. Means followed by a common letters in each column are not significantly different by DMRT at P=0.05.

Table 3. Number of plant per tiller of rice after application of biofertilizer mixed to *Chaetomium* sp.

Treatments	**Number of tiller/plants**		
	15 d	30 d	45 d
Control	2.38a[1]	5.44ab	6.18bc
ash 50 kg/rai	2.14a	4.93b	5.55c
Bio-fertilizer 25 kg/rai	2.53a	5.53ab	6.49ab
Bio-fertilizer 50 kg/rai	2.01a	5.59ab	7.14a
Bio-fertlizer 75 kg/rai	2.51a	6.27a	7.05a

[1]Mean of four replications. Means followed by a common letters in each column are not significantly different by DMRT at P=0.05.

Biofertilizer mixed *Chaetoimum* sp. showed significantly different in number of grain per panicle 45 days. It was shown that in control treatment and ash treatment at 45 days, the total number of grain/panicle were 108.50 and 100.75 grains, respectively. It was highly significant in total number of grain/panicle at 45 days in bio-fertilizer treatments applied at 25, 50 and 75 nkg/rai which were 259.50, 227.25 and 265.75 grains, respectively (Table 4).

Table 4. Number of grain per panicle of rice from the experimental plots.

Treatments	No of grain/panicles		
	green	yellow	Total
Control	0.00b1	108.50b[1]	108.50b
ash 50 kg/rai	0.00b	100.75b	100.75b
Bio-fertilizer 25 kg/rai	68.75a	190.25a	259.00a
Bio-fertilizer 50 kg/rai	64.00a	163.25a	227.25a
Bio-fertlizer 75 kg/rai	69.75a	196.00a	265.75a

[1]Mean of four replications. Means followed by a common letters in each column are not significantly different by DMRT at P=0.05.

The rice growing revealed significantly different in total grain weight/panicle at 45 days after transplanting. It was shown that in control treatment and ash treatment at 45 days, the total number of grain weight/panicle were 152.44 and 111.32 g, respectively. It was highly significant differed in total number of total grain weight/panicle at 45 days in bio-fertilizer treatments at 25, 50 and 75 kg/rai (313.57, 299.25 and 351.18 g, respectively) as seen in Table 5. Soytong and Quimio (1989) stated that *Chaetomium globosom* could give the better plant starnds of rice var IR44 in the Philippines. Tann, *et al*. (2011, 2012) stated that the evaluation of organic rice cultuvatuon in Cambodia was applied bioproducts as agricultural inputs especially Chaetomium-bioproduct that gave the better yield than the non-treated control. Soytong (2014) reported that bio-formulation of *Chaetomium cochliodes* applied to rice cultivation gave better plant strand than the non-treated control for controlling brown.

Table 5. Grain weight per panicle of rice from the experimental plots

Treatments	panicle (g)	green (g)	yellow(g)	Total Increase (%)
Control	0.00b1	152.44b	152.44b	-
ash 50 kg/rai	0.00b	111.32b	111.32b	-
Bio-fertilizer 25 kg/rai	20.66a	292.91a	313.57a	51.38
Bio-fertilizer 50 kg/rai	20.08a	279.17a	299.25a	49.05
Bio-fertlizer 75 kg/rai	35.02a	316.16a	351.18a	56.59

1Mean of four replications. Means followed by a common letters in each column are not significantly different by DMRT at P=0.05.

Soytong and Quyet (2013) stated that the organic compost mixed with *Chaetomium* sp. was analyzed to get pH 7.79, EC 95553 us/cm, organic matter 45 %, P 3,008 ppm, K 14,195 ppm, Ca 5860 ppm, Mg 2834 ppm, Fe 48.53 ppm, Mn 55.63 ppm, Zn 53 ppm. The organic compost mixed *Chaetomium* sp. was tested and resulted to promote the growth of kangkong in the field at 23 days. The total yield showed that organic compost mixed *Chaetomum* sp. in formula 1 gave significantly highest yield of 10.43 kg and followed by F2, F3, F4, F5 and F6 in different application rates which were 8.87, 8.80, 7.53, 9.57 and 9.17 kg, respectively when compared to non-treated, the yield was only 6.40 kg. It is concluded that the organic compost mixed *Chaetomium* in using in formula F1, F2, F3, F4, F5 and F6 increased in yield of 38.63, 27.84, 25.58, 15.00, 33.12 and 30.20 %, respectively (Table 6).

Table 6. Yields of kangkong after application of bio-fertilizer F1-F6 mixed with *Chaetomium* spp.

Treatments	Yield(g)	Increased yield (%)	Total yield of 4 square meter (kg)	Total increased yield (%)
F1	13.03 a[1]	70.67	10.43 a	38.63
F2	10.27 ab	67.47	8.87 ab	27.84
F3	12.37 a	72.27	8.60 ab	25.58
F4	6.77 bc	50.66	7.53 ab	15.00
F5	14.13 a	75.75	9.57 ab	33.12
F6	10.70 ab	67.94	9.17 ab	30.20
Control	3.43 c	-	6.40 b	-
C.V.(%)	16.79	-	15.07	-

Potato growing areas were cultivated by applying bio-technique 1, 2 and 3 treatments which mixed different concentration of *Chaetomium* sp. gave tuber potato yields of 12, 12.5 and 16.75 tubers, respectively which the tuber weighed were 1,718.75, 1,103.75 and 1,450 g , respectively. It was significantly differed at P = 0.01 when compared to non-treated control which yielded 9.63 tubers and 732.50 g. The chemical method produced 19.63 tubers (1,726.25 g) and not significantly differed when compared to bio-techniques (Table 7). Potato yields were randomly collected from 3 × 0.6 meter plots (18 m^2).

Table 7. Application of bio-techniques mixed with *Chaetomium* sp. for potato cultivation

Treatments	Plant number	Tuber number	big tuber (g)	medium tuber(g)	small size tuber (g)
Control	8.25 ab1	9.63 b	732.5 b	8.5 ab	221.25 a
Bio-technique1	8 ab	12ab	1718.75 a	6.25 b	155 b
Bio-technique2	7.63 b	12.50 ab	1103.75 ab	8.63 ab	238 ab
Bio-technique 3	9.88 a	16.75 ab	1450 a	10.13 a	295 a
C.V.(%)	9.83	33.92	28.30	24.92	30.13

[1]Avearage of four replications. Means followed by a common letter were not significantly different by DMRT.

Soytong and Ratancherdchai (2005) reported that the potato tubers planted with biotechnique 1,2,3 mixed *Chaetomium* sp. produced larger tubers of 8.1, 7.4 and 7.5 kg, respectively that significantly higher than the non-treated control (5.9 kg). The chemical method gave a yield of 13.9 kg which was not significantly differed when compared to all bio-techniques including *Chaetomium* sp. (Table 8). The bio-techniques mixed *Chaetomium* sp. gave a high yield quality averaging 18.7% starch can control late blight.

Table 8. Potato yield

Treatments	Big size (kg)	Small size (kg)	Total yield (kg)
Control	5.9 b1	2.5 a	8.4
Pesticides	13.9 a	2.8 a	16.7
Bio-technique1	8.1 ab	2.1 a	10.2
Bio-technique2	2 7.4 ab	2.4 a	9.8
Bio-technique3	3 7.5 ab	2.6 a	10.1
C.V.(%)	53.65	38.29	NS

[1]Average of four replications. Means followed by a common letters were significantly different by DMRT.

Chaetomium as a bio-agent formulation tested in tomato resulted in increased in yields as seen in Table 9 (Charoenporn *et.al*, 2010) and Soytong, K. and Yang Qian (2000) also reported to test *Chaetomium* spp. in tomato cultivation that gave better plant parameter than the non-treated control. Soytong, *et al* (1999) reported that the evaluation of *Chaetomium* spp. in tomatoes in P.R. China that gave better tomato plants stand than the non-treated control and also suppressed for biological Fusarium wilt of tomato. Moreover, Sibounnavong, *et al* (2011) tested fungal metabolite from Chaetomium treated to tomato plants resuted to increase in yield. Sibounnavong, *et al* (2012) reported that the efficacy test for organic tomatoes that was done using bioproducts, especially Chaetomium-bioproduct also increased in tomato yield when compared to the non-treated control. However, Soytong, *et al* **(**2013) stated that application of microbial elicitors produced from *Chaetomium* sp. could increase in tomato yield and induced immunity for tomato. Soytong (2014) stated that *Chaetomium* spp. as biformulations can be given the better plant strand than the non-treated control in rice cultivation. It is reported bioproducts produced from *Chaetomium cochliodes* tested for rice production gave better plant height, number of tillers, fresh weight of plants than the non-treated control as seen in Table 10. Sibounnavong, *et. al.* (2006) reported that the application of biological products including Chaetomium product for organic crop production of kangkong (*Ipomoea aquatica*) that can be increased in yield.

Table 9. Testing bio-agent formulations to control Fusarium wilt of tomato *in vivo* for 60 days.

Treatments[1]	**DSI**	**DR[3] (%)**	**Plant height(cm)**	**Plant fresh weight (g)**	**Plant dry weight (g)**	**Yield/plant (g)**	**Increase in yield4 (%)**
N0802	2.60b	44.68a	37.40b	67.55a	11.53a	133.81a	88.53a
CLT	3.00b	36.28a	35.65b	54.90ab	8.68a	94.40ab	83.74a
PC01	2.80b	41.01a	40.20ab	54.90ab	12.11a	120.32ab	87.24a
prochoraz	3.70ab	21.95b	21.10c	32.5bc	4.90b	26.27c	41.57b
Fol	4.70a	-	14.80c	22.20c	3.80b	15.35c	-
No-Fol	1.00c	-	49.50a	50.35ab	9.89a	82.47b	81.39a

[1] N0802 = *C. globosum* N0802, CLT = *Chaetomium lucknowense* CLT, PC01 = *Trichoderma harzianum* PC01, Fol = inoculated with *Fusarium oxysporum* f sp *lycopersici* only, No-Fol= non-inoculated with pathogen and non-treated bio-agent formulation. 2Average of four replications (5 plants/rep.). Means with the same common letters in each column are not significantly different according to Duncan's multiple range test at P = 0.05. 3% disease reduction (DR) = disease severity index (DSI) of control – disease severity index of treatment/ disease severity index of control x 100. 4% increase in yield = Yield per plant of treatment – Yield per plant of control/ Yield per plant of treatment x 100.

Table 10. Plant height of rice var Pitsanulok 2 after applying bio-formulation of *Chaetomium cochliodes*

Treatment	40 d /	Increased (%)2/	55 days	Increased (%)2/	70 days	Increased (%)2/	85 days	Increased (%)2/	100 days	Increased (%)2/
Inoculated Control	8.00c	-	15.58 c	-	21.00 b	-	33.91 b	-	47.66 e	-
Non-Inoculated Control	10.33 b	22.56	20.16 b	22.72	21.58 b	20.60	36.24 b	6.43	50.83 d	6.24
Spore suspention , *Ch. cochliodes*	11.83 ab	26.65	21.08 ab	26.09	29.25 a	28.21	47.66 a	28.85	59.91 c	20.45
Bio-powder *Ch. cochliodes*	13.41 a	40.34	22.50 a	30.76	30.91 a	32.06	50.83 a	33.29	70.83 a	32.71
Crude extract ofCh.cochliodes	13.16 a	39.21	22.33 ab	30.22	30.58 a	31.32	50.33 a	32.62	68.25 b	30.17
Benlate	12.00 ab	33.33	20.58 ab	24.29	29.91 a	29.79	48.91 a	30.67	59.50 c	19.90
C.V. (%)	9.40%		4.93%	-	3.40%	-	5.58%	-	1.58%	-

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