Application of biological products for organic crop production of Kangkong (*Ipomoea aquatica*) in Thailand

P. Sibounnavong[1*], P. Sysouphanthong[1], Xay Ly[1], P. Phoutasay[1], K. Promrin[1], W. Pongnak[2] and K., Soytong[2]

[1]Department of Plant Science, Faculty of Agriculture, National University of Laos, Nabong Campus, Lao P.D.R.
[2]Faculty of Agricultural Technology, King Mongkut's Institute of Technology Ladkrabang (KMITL), Ladkrabang, Bangkok 10520, Thailand

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Results showed that biological products including biological fertilizers, bio-humus, Ketomium[@] and bot-f for disease control (certified by BioAgricert, International Federation of Organic Agriculture Movements, IFOAM) gave the greatest response for growth of Kangkong (water convolvulus: *Ipomoea aquatica*). Organic Kangkong production gave a higher yield per plot than the natural control method. Application of biological products for cultivation of organic Kangkong increased in yield by 45.83% when compared to the natural control method. It is clearly demonstrated that higher application rates of biological fertilizer could increase in plant height and yield than the lower application. It is suggested that these certified agricultural products could promote to other organic crop production.

Key words: biological products, organic crop production

Introduction

Application of chemical fungicides has been recognized to cause environmental pollution and leave chemical residues in the soil, water and agricultural products, and it is known that continuous use of chemical fungicides leads to the development of resistance in pathogens (Soytong and Soytong, 1996). Biological control of plant pathogens has provided a relatively recent strategy for integration with other control measures. This can reduce the heavy use of chemical fungicides, improving agro-ecosystems and maintaining a natural balance (Soytong *et al*., 1999). There are several reports on the potential use of biological control agents against plant pathogens. *Chaetomium*

[*]Corresponding author: P. Sibounnavong; e-mail: sone_lp@hotmail.com

spp. are strictly saprobic antagonists against several plant pathogens, e.g. *Venturia inegualis* (Heye and Andrews, 1983), *Botrytis cinerea* (Kohl *et al*., 1995) *Phytophthora parasitica* (Usawan and Soytong, 1998), *Phytophthora palmivora* (Pechprome and Soytong, 1996; Sodsa-art and Soytong, 1998), *Fusarium oxysporum* f. sp. *lycopersici* (Soytong *et al*., 1999), *Colletotrichum gloeosporioides* (Noiaium and Soytong, 1999). The biological control potential of *Chaetomium* species against plant pathogens has been screened in Thailand since 1989. Formulation of the biological products from *C. cupreum* CC1-10 and *C. globosum* CG1-12 have gradually been developed since 1992, and are produced in pellet and powder formulations and registered for a Patent Right No.6266, Intl. cl. ^{5} AO 1 N 25 / 12 in 1994 (Soytong and Soytong, 1996).

Soytong (2005) stated that Thailand is the one of the research leaders in biological products for agriculture producing good agricultural practices (GAP) of crop, pesticide-free production and organic crop using biological integrated pest management (Bio IPM). The aim is to decrease or stop the use of toxic chemical pesticides. Research and development has been performed with several outstanding scientists in the field of microbial biotechnology in agriculture to meet the philosophy as follows: high microbial activity, high organic matter, high natural resources, high environmental protection, high yield and safety food. There has been interest in biological control among scientists for over 20 years to seek new strategies for diseases and pest control to decrease the usage of toxic chemical pesticides.

Soytong (2004) noted that research and development of microbial products for bio-agriculture have been conducted for over 15 years. These are now successfully being applied to promote good agricultural practice (GAP), pesticide-free production (PFP), commercial scale organic farms, and in combined applications for integrated pest management (IPM). Microbial products have been used to reduce disease damage to several economic plants and to decrease toxic chemicals in agricultural products and the surrounding environment for sustainable development in Thailand, Vietnam and P.R. China. The microbial products used for bio-agriculture are biological organic fertilizers (microbial fertilizers), biological humus, liquid organic microbial fertilizer to improve soil fertility and promote plant growth, biological fungicide (Ketomium) and biologically active substances (Bot-f) for disease control.

These research findings aim to prove the effectiveness of microbial products used for organic crop production in the field. The project was to study the application of biological fertilizer and biological products applied to Kangkong (water convolvulus) for organic crop production in the field to meet

organic standard of the International Federation of Organic Agriculture Movement (IFOAM).

Materials and methods

Comparison between organic treatment and natural control methods to produce Kangkong

The experimental plots were prepared. Each plot was designed as 1.5 m × 1.5 m × 15 m (width:length:height) for the total of 8 plots. The organic fertilizer was mixed in each plot at a rate of 10 kg. Soil preparation in each plot was prepared and incubated for 7 days. Fifteen grams of Kangkong seeds were used per plot. The seeds were soaked with water overnight to stimulate seed germination before planting. Randomized Completely Block Design (RCBD) with 4 replicates and two treatments were used as follows:- T1 was interval spraying of liquid organic fertilizer at a rate of 50 cc, ketomium[@] 10 g, Bot-f 50 cc, Neem's extract 100 cc, bioinsecticide 10 cc and bio-humus 10 g/20 l of water and T2 was a natural control plot which only applying water and remove weeds.

Data collection:-plant height (cm) plant fresh weight (g) and yield/Rai. Per cent increase in growth and yield were calculated as follows: Organic treatment – control treatment /Organic treatment ×100. Mean comparison was computed by Duncan Multiple Range Test (DMRT) at P=0.05 and P=0.01.The experiments were repeated two times.

Application rate comparison of biological fertilizer to produce Kangkong

The experiment was conducted to compare application rates of biological fertilizer by using Randomized Completely Block Design (RCBD) with 4 replicates and 4 treatments as follows: T1 was the natural control which did not use organic agricultural inputs. Only watering and removal of weeds were carried out. T2, T3, and T4 were organic treatments which prepared by applying the pellet organic fertilizer at the rate of 1, 2, 3 kg per plot, respectively and liquid organic fertilizer were applied at the rate of 10 cc, 20 cc, and 30cc per 10 L of water per plot, respectively, every 3 days. Then, T2, T3 and T4 were applied a mixture of ketomium[@] 10g, bot-f 50cc, neem's extract 100 cc, bio-insecticide 10 cc, bio-humus 10g per 20 L of water by spraying every 7 days. The data were collected as follows: plant height (cm) and plant fresh weight (g), and then transformed to yield per Rai. Percentage increase in growth and yield were calculated as follows: Organic treatment – control treatment/Organic treatment ×100. Mean comparison was computed by

Duncan Multiple Range Test (DMRT) at P=0.05 and P=0.01. The experiments were repeated two times.

Results

Comparison between organic treatment and natural control methods to produce Kangkong

Plant height:-Results showed that plant height at 7 days was not significantly different (P=0.01) in organic treatment and natural control which were 6.62 cm and 5.73 cm, respectively. After planting for 14 days, there were highly significant differences in plant height for organic treatment and natural control of 14.20 cm and 11.16 cm. respectively. Organic treatment at 21 days was significantly higher in plant height than natural control. Plant height in organic treatment and natural control at 28 days were 40.72 cm and 28.32 cm respectively. Results showed that the biological product application such as biological fertilizer in powder and liquid formulations, bio-humus, ketomium and bot-f for disease control, neem's extract for insect control and liquid bio-fertilizer gave the highest response for growth of Kangkong as seen in Table 1 and Fig.1.

Table 1 Plant height of Kangkong in the field after planting for 28 days

Methods	Plant height (cm)			
	7 days	**14 days**	**21 days**	**28 days**
Organic treatment	6.62a[1]	14.20a	31.17a	40.72a
Natural Control	5.73a	11.16b	20.17b	28.32b
CV (%)	7.04	2.35	5.70	5.43

[1]Average of four replications. Mean follows by a common letter in the same column are not significantly different at P=0.01.

Plant fresh weight (yield) - Results showed that fresh weight per plant in organic treatment was significantly different (P=0.01) when compared to the natural control which was 24.37 g and 14.37 g, respectively. This showed that the organic treatment had significantly higher fresh weight per plot than the natural control method which was 17.20 kg and 3.90 kg, respectively.

As the result, the estimated yield per Rai (1600 m^2) in the organic treatment was 3,839 kg per Rai and in the natural control was 2,079 kg per Rai as seen in Table 2.

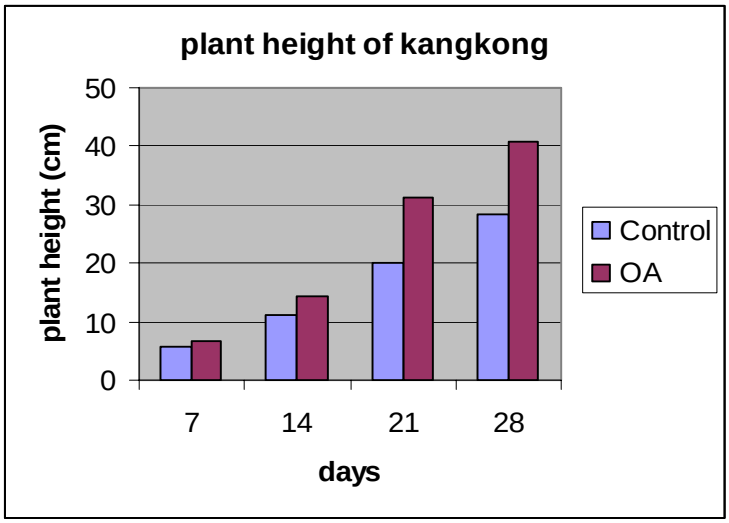

Fig. 1. Plant height of Kangkong at 7, 14, 21 and 28 days

Table 2. Plant fresh weight or yield of Kangkong in the field after planting for 28 days

Methods	Per plant (g)	Per plot (kg)	Estimated yield/Rai(kg)
Organic treatment	24.37a[1]	7.20a	3839a
Natural control	14.37b	3.90b	2079b
CV(%)	11.54	10.50	10.51

[1]Average of four replications. Mean follows by a common letter in the same column are not significantly different at P=0.01.

Increase in plant height or growth

All plant growth parameters such as plant height (growth) and plant fresh weight (yield) significantly increased in organic treatment when compared to the natural control. Results show a clear increase in plant height or growth with organic treatment at 7, 14, 21, and 28 days after planting which were 13.44, 21.40, 35.29, and 30.45%, respectively. It is demonstrated that the organic treatment which interval spray of a mixture of liquid organic fertilizer at the rate of 50 cc, ketomium@ 10 g, Bot-f 50 cc, Neem's extract 100 cc, bioinsecticide 10 cc and bio-humus 10g/20L of water gave a higher yield than the natural control (Table 3). The organic treatment increased in yield or plant

fresh weight at 28 days after planting when compared to the natural control as seen in Table 4.

Table 3 Percentage increase in plant height of Kangkong in the field after planting for 7, 14, 21, and 28 days

Methods	Percent of increasing in plant height (cm)			
	7 days	14 days	21 days	28 days
Organic treatment	13.44	21.40	35.29	30.45
Natural Control	00.00	00.00	00.00	00.00

Percent of increasing in plant height or growth were also calculated as follows: Organic treatment – control treatment /Organic treatment x100.

Table 4. Per cent of increasing in yield or plant fresh weight of Kangkong in the field after planting for 28 days

Methods	Per plant	Per plot	Estimated yield/Rai
Organic agriculture	41.03	45.83	45.84
Natural control	00.00	00.00	00.00

Percent of increasing in yield were also calculated as follows: Organic treatment – control treatment /Organic treatment x100.

Application rate comparison of biological fertilizer to produce Kangkong

No significant differences in plant height at 7 days were observed after planting, as the natural control (T1) was 6.02 cm and the organic treatments were 6.7, 6.06, and 6.31 cm, respectively (Table 5). After planting for 14 days, the organic treatments showed significantly higher plant height which were 12.56, 12.67, and 13.25 cm, respectively than the natural control (11.32 cm). At the same trend, the organic treatments at 21 days also showed significantly higher in plant height were 26.12 cm, 26.87 cm and 28.10 cm, respectively when compared to the natural control (20.05 cm). The organic treatment for Kangkong cultivation at 28 days harvesting showed highly significantly different in plant height when compared to the natural control method as seen in Table 5 and Fig. 2.

Plant fresh weight (Yield)

Results showed that the organic treatments were significantly different (P=0.05) in plant fresh weight when compared to the natural control. With this,

plant fresh weight or yield per plot in natural control (T1) was 2.4 kg, and in organic treatments were 3.30, 3.05, and 4.25 kg, respectively. However, the organic treatments estimated yield per Rai were 1759, 1626, and 2266 kg, respectively when compared to the natural control which was 1,279 kg per Rai (Table 6).

Table 5: Plant height of Kangkong in the field after planting for 28 days

Methods	Plant height (cm)			
	7 days	14 days	21 days	28 days
Treatment 1	6.02 a[1]	11.32 b	20.05 b	26.92 b
Treatment 2	6.70 a	12.56 a	26.12 a	34.60 a
Treatment 3	6.06 a	12.67 a	26.87 a	35.30 a
Treatment 4	6.31 a	13.25 a	28.10 a	38.60 a
CV (%)	5.21	4.22	6.05	7.08

[1]Average of four replications. Mean followed by a common letter are not significantly different by DMRT at P=0.01.

Table 6. Plant fresh weight or yield of Kangkong in the field after planting for 28 days

Methods	Per plot (kg)	Estimated yield/Rai(kg)
Treatment1	2.40b	1279b
Treatment 2	3.30ab	1759ab
Treatment 3	3.05ab	1626ab
Treatment 4	4.25a	2266a
	P=0.05	P=0.05
CV (%)	24.51	24.52

[1]Average of four replications. Mean follows by a common letter in the same column are not significantly different at P=0.05.

Increase in plant height or growth:

Results showed that the tested biological products which have been certified to be agricultural inputs by IFOAM applied in organic treatments gave the highest plant height. The organic treatments had significantly increased in plant height after planting for 28 days were 28.52, 23.94, and 30.25%, (Table 7 and Fig. 3).

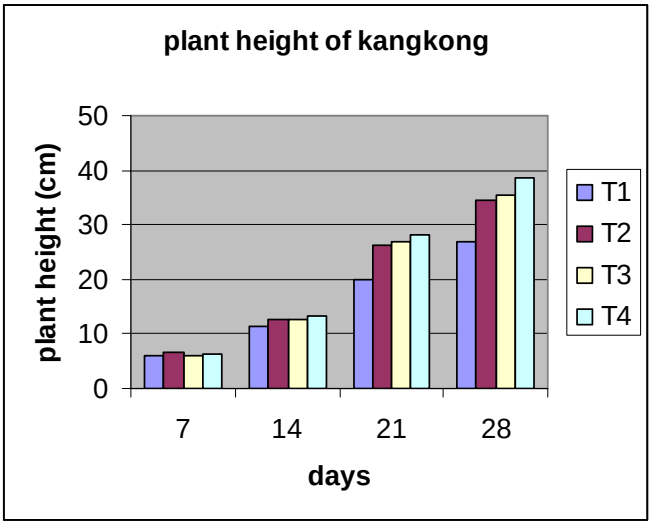

Fig. 2. Plant height of Kangkong at different application rates of biological fertilizers

Table 7 Per cent of increase in plant height of Kangkong in the field after planting for 7, 14, 21, and 28 days

Methods	Per cent of increasing in plant height			
	7days	14 days	21 days	28 days
Treatment1	0	0	0	0
Treatment 2	10.14	9.87	23.23	28.52
Treatment 3	0.66	10.65	25.38	23.94
Treatment 4	4.59	14.56	28.75	30.25
P	0.05	0.01	0.01	0.01
C.V.(%)	5.21	4.22	6.05	7.08

Percent of increasing in plant height or growth were calculated as follows: Organic treatment – control treatment /Organic treatment ×100.

Increasing in yield or plant fresh weight

The organic treatments had significantly increased plant yield when increased the application rate of biofertilizer. It is clearly demonstrated that yield per plot increased in organic treatments which were 27.27, 21.31, and 43.5%, respectively when compared to the natural control method. The estimated yield per Rai (1600 m^2) increased in organic treatments which were 35.52, 21.34, and 43.55%, respectively as shown in Table 8.

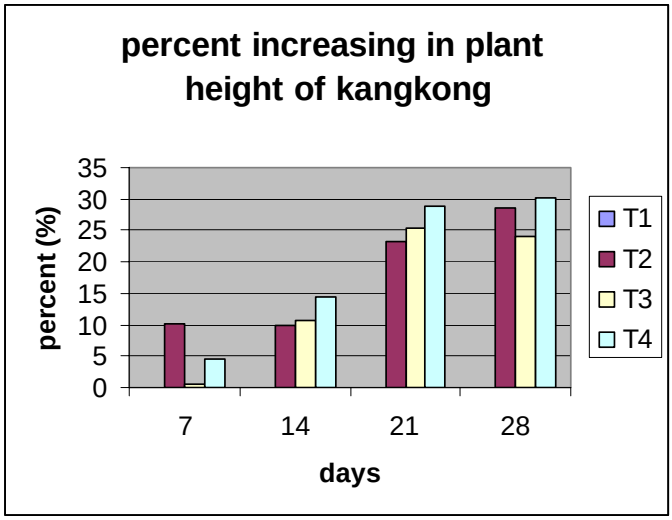

Fig. 3. Percent increasing in plant height of kangkong at different application rates of biological fertilizers

Table 8. Per cent of increasing in yield or plant fresh weight of Kangkong in the field after planting for 28 days

Methods	Per plot	Estimated yield/Rai
Treatment1	0.00	0.00
Treatment2	27.27	35.52
Treatment3	21.31	21.34
Treatment4	43.52	43.55
	P = 0.05	P =0.05
C.V.(%)	24.5	24.52

Percent of increasing in yield were calculated as follows: Organic treatment – control treatment /Organic treatment x100.

Discussion

Comparison between organic treatment and natural control methods to produce Kangkong

It is explained that the organic treatments for Kangkong gave significantly higher plant height at 7, 14, 21, and 28 days than the natural control method. This research finding was similar results to the work of Sripai

(2000) and Charee (2005) who stated that the organic method had resulted to higher plant height than non-treated ones.

The result showed that the biological product application such as biological fertilize, bio-humus, ketomium[@] and bot-f for disease control, neem's extract for insect control and liquid bio-fertilizer successfully gave the highest response for the growth of Kangkong. The highest response for stimulating plant growth after apply agricultural inputs resulted with the addition of liquid biofertilizer. Soytong (2004) stated that liquid organic microbial fertilizer is extracted from complete fermentation of fish, crab and some kind of shell and directly applied into soil for plant growth. It includes the screened-microorganisms as follows: *Actinomyces* K, *Bacillus subtilis* WC-1, *Saccharomyces cerevisiae* RT, *Bacillus subtilis* BSP, *Bacillus subtilis* BA-1, *Bacillus subtilis* WP, *Bacillus subtilis* HB2.

In this study, the organic treatments gave significantly higher fresh weight per plant or yield when compared to the natural control either yield per plot and estimated yield per Rai (1600 m^2). It is observed that all plant growth parameters such as plant height (growth) and plant fresh weight (yield) had increased in organic treatments when compared to the natural control as similar result to the work of Chaiwat (2004). The result was also similar to the work of Pumsing (2005) which applied the above mentioned agricultural inputs to produce organic plant resulted to increase in yield of Kale. The result also supports Inmark (2000) who stated that *Trichoderma* sp. could increase in yield about 36% when compared to the control. The reasons why the yield could increase that can be explained by the scientific reason's work of Suwan *et al.* (2003) who reported that *T. harzianum* stain PC01 could elucidate to produce *Trichotoxin*s promoting plant growth which *T. harzianum* PC01 was mixed to bio-fertilizer.

Application rate comparison of biological fertilizer to produce Kangkong

The proper application rate of agricultural inputs for plant growth showed that plant height in organic treatment of 1 kg of pellet bio-fertilizer, 10 cc of liquid bio-fertilizer, 2 kg of pellet bio-fertilizer, 20 cc of liquid bio-fertilizer and 3 kg of pellet bio-fertilizer, 30 cc of liquid bio-fertilizer for Kangkong cultivation had highly significantly increased in plant height when compared to the natural control. This was similar result to the works of Phuwiwat and Soytong (1999a, b) and Soytong (2004), they explained that the high response for increasing the growth of Chinese radish due to the effective isolate of *T. harzianum* and *T. hamatum*. Those isolates were mixed to biological humus product.

Finally, in both experiments were observed for disease prevalence of white rust of Kangkong (*Ipomoea aquatica*) which caused by obligate parasitic fungus namely *Albugo ipomoeae-pandurat*. With this, the disease was observed more invasion on leaves in the natural control than the organic treatments.

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