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Effect of good agricultural practice and organic methods on rice cultivation under the system of rice intensification in Cambodia

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Rice blast pathogen, *Pyriculria oryzae* was isolated from the rice lesion of Sen Pidao rice variety. *Chaetomium globosum* and *Chaetomium cupreum* mixed to CM product resulted to inhibit the tested the rice blast pathogen. Pot experiment was conducted at Khna Village,Chhhreav Commune, Siem Reap city, Siem reap Province, Cambodia. The organic method gave better rice straw weight than non-treated control, GAP and chemicals at 115 days of harvesting. The organic method could increase in plant height and tiller number per plant of 3.06 and 57.69 %, respectively at 60 days. GAP method increased in plant height and tiller number of 11.23 and 69.44 %, respectively while chemical method increased plant height and tiller number of 6.73 and 62.71 %, respectively. The grain weight (yield) increased in GAP, chemical and organic methods of 59.15, 55.38 and 44.23 %, respectively. It is shown that the naturally disease incidence of rice blast was significantly increased in non-treated control both in pot experiment. The disease index of rice blast in pot experiment of organic, GAP and chemical methods were 2.00, 2.50 and 3.25 respectively. The organic method was significantly decreased rice blast disease of 80 %, followed by GAP and chemical methods which were 50 and 40 %, respectively. The field experiment was conducted at Toeuk Wil Rice research Station, Siem Reap province. The organic method was also confirmed to be successfully applied the organic biofertilizer during soil preparation prior transplant of 10 days old of rice seedlings, then sprayed a mixture of liquid biofertilizer, Bioinsecticide (*Metarhizium* and *Beauveria*), and CM product (Chaetoimum-biofungicide plus Mycephyt-plant growth stimulant) every 15-20 days until harvest. As a result, organic method increased in yield of 28.57 %. The chemical method increased in grain yield of 33.33 %. It is concluded that the organic, GAP and chemical methods would be appropriated to the system of rice intensification (SRI) for integrating or combining these techniques with the principles of SRI to promote Cambodian farmers.

Key words: *Chaetomium globosum* and *Chaetomium cupreum* , CM product, *Metarhizium* and *Beauveria*

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Introduction

Rice belongs to the family of Gramineae and the genus *Oryza*. *Oryzae* contains about 20 different species of which only two are cultivated: *Oryza sativa* L. (Asian rice) and *Oryza glaberrima* Steud. (Africa rice). (Matsuo *et al,*. 1995). Rice is central to the lives of billions of people around the world. Possibly the oldest domesticated grain (10,000 years), rice is the staple food for 2.5 billion people (IRRI, 2002), and growing rice is the largest single use of land for producing food, covering 9 % of the earth's arable land. Rice provides 21% of global human per capita energy and 15% of per capital protein (IRRI, 2002). Calories from rice are particularly important in Asia, especially among the poor, where it accounts for 50-80% of daily caloric intake (IRRI. 2001). As expected, Asia accounts for over 90% of the world's production of rice, with China, India and Indonesia producing the most (International Year of Rice, 2004). Only 6-7% of the world's rice crop is traded in the world market. Thailand, Vietnam, China and the United States are the world's largest exporters. The United States produces 1.5% of the world's rice crop with Arkansas, California and Louisiana producing 80% of the U.S. rice crop (IRRI. 2002). 85% of the rice that is produced in the world is used for direct human consumption (IRRI. 2002). Rice can also be found in cereals, snack foods, brewed beverages, flour, oil, syrup and religious ceremonies to name a few other uses. Rice is grown under many different conditions and production systems, but submerged in water is the most common method used worldwide. Rice is the only cereal crop that can grow for long periods of time in standing water (International Year of Rice, 2004). The 57% of rice is grown on irrigated land, 25% on rainfed lowland, 10% on the uplands, 6% in deepwater, and 2% in tidal wetlands (Chopra and Prakash, 2002). The flooded rice paddy is a field of aquatic biodiversity, providing a home for fish, plants, amphibians, reptiles, mollusks, and crustaceans, which many of can be used as a means to incorporate protein into the diets of poor and malnourished people in low and middle income countries that farm rice (International Year of Rice, 2004). Just as rice can be grown in many different environments, it has many characteristics, making one variety more popular in one region of the world than another. Rice can be a short, medium or long grain size. It can also be waxy (sticky) or non-waxy. Some rice varieties are considered aromatic.

(Alford and Duguid, 1998 and Chaudhary *et al.,* 2001). Rice also comes in many different colors including brown, red, purple and black (International Year of Rice, 2004). The main problem associated in rice production is high agricultural inputs including chemical fertilizer and pesticide leading to high production cost but gain low yield. These problems faced from low soil fertility, insect and pathogen become resistant to chemical pesticides. The research finding is to compare the application methods between Chemicals, GAP (good agricultural practices) and Organic methods of rice varieties from Cambodia (Tann *et al.*, 2011).

Rice production in Cambodia has passed through a series of development over the past. Cambodia becomes one of the major rice exports of the world which planted in rainfed lowland areas without irrigation. Total cultivated area for rice production in 24 provinces in 2009 was 2,719,080 ha and in 2010 was 2,795,892 ha. The total yield production of rice in 2009 was 7,175,473 tons, and average yield was 2.84 t/ha and the total yield production of rice in 2010 was 8,249,452 tons, and average yield was 2.97 t/ha (MAFF, 2010). The problem of rice production has been increasingly faced for the used of chemical fertilizers and chemical pesticides. The main problem has faced on decreased in soil fertility, low yield due to soil acidity, bad air and water drainage and low organic matter, and also faced the insects and pathogens become resistant to chemical pesticides. All chemicals increase production cost and toxic residues that risk for human being. System of rice intensification (SRI) is designated in 1983 after two decades of experimenting Fr. Henri de Laulaníe. It is under the pressures from a drought and shortages of rice seeds which focused on transplanting young rice seedlings of 10-15 days old in a spacing (25x25 cm^2) of single seedlings. The rice was not grown in flooded paddies, but in moist soil with intermittent irrigation. SRI become in other major rice growing areas in particular Asia, leading to a serious controversy with scientists of some established rice research institutes (Stoop *et al.,* 2006). The conventional weeding and limited irrigation would substantially increase the profitability of SRI. Crop management followed standard SRI and conventional practices which seedlings were transplanted with 2.5 leaves (8-12 days old) (Inagaki, 1898). The alternative method is challenging to find the safety agricultural inputs e.g. bio-fertilizer and bio-pesticides instead of toxic chemicals in rice production in term of good agricultural practice (GAP) and organic methods (Soytong *et al.,* 2001). There are several reports on the potential use of biological control agents against plant pathogens. *Chaetomium* spp. is one of the strictly saprophytic antagonists against several plant pathogens (Soytong and Quimio, 1989) e.g. *Phytophthora palmivora* (Pehprome and Soytong, 1996) and *Colletotrichum gloeosporioides* (Noiaium and Soytong, 1999) and *Pyricularia oryzae* (Soytong and Quimio, 1989) . The biological products have been developed as biofetilizer, biohumus, bioinsecticide according to research findings as reported by Soytong *et al.* (2001). 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 are now used to reduce damage to several economic plants in Thailand, Vietnam and P.R. China., and to decrease toxic chemicals in agricultural products and surrounding environment for sustainable development. The microbial products used for bio-agriculture are biological organic fertilizers (microbial fertilizers), biological humus, liquid organic microbial fertilizers to improve soil fertility and promote plant growth, biological fungicides (Ketomium) and biologically active substances (Bot-f) for disease control as certified agricultural inputs from the International Federation of Organic Agriculture Movement (IFOAM) for organic vegetable production of water convolvulus (*Ipomoea aquatica*), Kale (*Brassica oleracea* var *albograbra*), Pakchoi (*Brassica chinensis* var. *parachinensis*) and Chinese cabbage (*Brassica pekinensis*) in the fields (Sibounnavong *et al.,* 2006).

The research finding was conducted to test antagonism of rice blast pathogen (*Pyricularia oryzae*) in laboratory and to compare the application methods between chemicals, GAP (good agricultural practices) and organic methods of rice var Sen Pidao under the system of rice intensification (SRI) in Cambodia.

Materials and methods

Antagonism of rice blast pathogen

Isolation of pathogen-the blast symptom of rice var. Sen Pidao was corrected and isolation to pure culture by tissue transplanting technique followed the method of Soytong and Quimio (1989). Pathogenicity test, the blast pathogen, *Pyricularia oryzae* was then tested for pathogenicity by Koch's Postulate. Bi-culture antagonistic test:- Cultures of *Chaetomium globosum* and *Chaetomium cupreum* were offered by Assoc. Prof. Dr. Kasem Soytong from King Mongkut's Institute of Technology Ladkrabang (KMITL), Bangkok, Thailand. Agar plug of each antagonist was cut at peripheral colony and moved onto the potato dextrose agar in Petri dish in one side and the other side was transferred an agar plug of pathogen. The experiment was conducted by using Completely Randomized Design (CRD) with four replications. Data were collected as colony diameter (cm) and statistically computed analysis of various (ANOV), then treatment means were compared using Duncan's Multiple Range Test (DMRT) at P=0.05 and 0.01.

Application of agricultural inputs for GAP and Organic for Rice production var Sen Pidao in pot experiment

Sen Pidao rice variety was tested in pot experiment at Khna Village, Chhhreav Commune, Siem Reap city,Siem reap Province. The experiment was conducted in a Randomized Complete Block Design (RCBD) with 4 replications and 4 treatments. The experimental plot was 1 meter in diameter and 50 cm high. There were 16 experimental plots. Each experimental pot was transplanted 21 seedlings which approximately plant spacing of 20×20 cm. Treatments were arranged as follows:-T1 = non treated control, T2= Organic method was applied organic biofertilizer 0.2 kg/pot during soil preparation prior transplant, filled in water to the plot until water level was about 10 cm above soil. For disease and insect control, sprayed a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (*Chaetoimum*-biofungicide plus Mycephyt-plant growth stimulant) 10 g/20L, every 15-20 days until harvest. T3= Good Agriculture Practice (GAP) was applied chemical-biofertilizer (9-3-4) at 0.1 kg /plot before transplanting, filled in water to the plot until water level was about 10 cm above soil, chemical biofertilizer (8-3-8 at) 0.1 kg/plot after flowering. For disease and insect control: alternative spraying a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (*Chaetoimum*-biofungicide plus Mycephyt-plant growth stimulant) 10 g/20L and chemical insecticide (abamectin 20 cc/20L) and chemical fungicide (benomyl 5 g/20L) every 15-20 days until harvest.
T4: Chemical method was applied urea (46-0-0) at 0.1 kg /plot after transplanting, filled in water to the plot until water level was about 10 cm above soil, applied 15-15-15 formulation at 0.1 kg /plot after flowering and sprayed chemical insecticide (abamectin) 20 cc/20L and chemical fungicide (benomyl) 5 g/20L every 15-20 days until harvest.

Data were collected as plant height (cm) at every 30 days, number of tiller per plant, number of panicles, fresh and dried weight (g) of plant, grains (seeds) rice straw and harvest index (HI). All data were statistically analyzed for analysis of variance (ANOVA) and treatment means were compared using Duncan's Multiple Range Test (DMRT) at P=0.05 and P=0.01. Disease Index was evaluated from nationally infection of rice blast disease caused by *Pyricularia oryzae* and rated to 5 levels which modified from Jitra (2010) as follows:- 1= no symptoms, 2= small blighted spot and still healthy tissue, 3= dead cells in the are of blighted spot 1-2 mm and turn brown color, 4= expanded lesion in oval shape 1-2 cm and cell death in the center of lesion and 5= diseased area over 20 % and finally death.

Application of agricultural inputs for GAP and Organic for Rice production var Sen Pidao in the field

Rice variety used in the experiment was Sen Pidao variety. The experiment was done at Toeuk Wil Rice research Station ,Siem Reap province. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 4 replications and 4 treatments. The dimensions of the individual plot were 10 m length and 7 m width. One experimental plot was 70 m^2. There was a bund accounting to 0.5 m width between plots and a border having 1 m width. Each replication was separated by 1 m bund. The plant spacing was 20×20 cm^2 (hill to hill and row to row spacing) with one seedling per hill and 12 rows in each plot having 50 seedlings in each row. Treatments were as follows:- T1 = non treated control, T2= Organic methods was applied organic biofertilizer 0.7 kg/plot during soil preparation prior transplant of 10 days old of rice seedlings, filled in water to the plot until water level was about 10 cm above soil. For disease and insect control- sprayed a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (*Chaetoimum*-biofungicide plus Mycephyt-plant growth stimulat) 10 g/20L, every 15-20 days until harvest. T3= Good Agriculture Practice (GAP) was applied chemical-biofertilizer (9-3-4) at 0.7 kg/plot before transplanting of 10 days old of rice seedlings, filled in water to the plot until water level was about 10 cm above soil, chemical biofertilizer (8-3-8 at) 0.7 kg/plot after flowering. For disease and insect control: alternative spraying a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (*Chaetoimum*-biofungicide plus Mycephyt-plant growth stimulat) 10 g/20L and chemical insecticide (abamectin 20 cc/20L) and chemical fungicide (benomyl 5 g/20L) every 15-20 days until harvest. T4: Chemical method was applied urea (46-0-0) at 0.35 kg/plot (approx. 1 tons/hectare) after 15 days transplanting of 10 days old of rice seedlings, filled in water to the plot until water level was about 10 cm above soil., applied 15-15-15 formulation at 0.35 kg/plot (approx. 1 tons/hectare) after flowering and sprayed chemical insecticide (abamectin) 20 cc/20L and chemical fungicide (benomyl) 5 g/20L every 15-20 days until harvest. The rice yield was harvested manually with the help of sickle. Harvested rices were left in the field for 5 days sun dry. Threshing was done manually, and seeds (grains) were obtained and weighed at 14% moisture content.

Data were collected as plant height (cm) at every 30 days, number of tiller per plant, number of panicles, fresh and dried weight (g) of plant, grains (seeds) rice straw and harvest index (HI). All data were statistically analyzed for analysis of variance (ANOVA) and treatment means were compared using Duncan's Multiple Range Test (DMRT) at P=0.05 and P=0.01.

Gain yield (kg/ha) at 14% moisture = (100) x Plot yield (kg) x 10000 (m^2) /(100-14) x net plot area (m^2). Where, MC is the moisture content in percentage of grains. Harvest index (HI) was computed by dividing grain yield with the biological yield (total dry matter yield) as per the following formula. HI (%) = (grain yield × 100)/ (grain yield + straw yield).

Results and discussion

Isolation of rice blast pathogen

Rice blast pathogen, *Pyricularia oryzae* was isolated from the rice lesion of Sen Pidao rice variety. The lesion started small blighted spot, expanded to large lesion in oval shape with surrounding brown color and spread on to more areas on leaves, stem, panicles and grains. The colony on potato dextrose agar was whitish gray, conidia two cell. The characteristic of fungi was similar to the report of Soytong and Quimio (1989).

Antagonism of rice blast pathogen

Result showed *C. cupreum* inhibited the colony growth of *P oryzae* at 64.85 % which significantly better than *C. globosum* to inhibit the tested pathogen of 49.92 %. The colony diameter of pathogen in control plate was 9.00 cm which significantly differed from pathogen colony in bi-culture plate of *C. globosum* and *C. cupreum* were 4.38 and 3.16 cm, respectively (Table 1). This was similar to the work of Soytong (1992 a,b) who reported that *C. globosum* and *C. cupreum* inhibited *P. oryzae* causing rice blast disease in bi-culture antagonistic test and *Chaetomium* spp could grow over the colony of rice blast pathogen over 80 % within two week, then lead to the pathogen become weak. Moreover, Kanokmedhakul *et al.* (2001, 2006) reported that *C. globosum* and *C. cupreum* coud produce antibiotic substances namely chaetoglobosin-C and rotiorinol that not only suppress human pathogen but also active against several plant pathogens (Soytong *et al.,* 2001).

Application of agricultural inputs for GAP and Organic for Rice production var Sen Pidao in pot experiment

GAP method was the highest in plant height of 106.80 cm, followed by chemical method and organic method which were 101.65 and 97.80 cm, respectively which significantly different by DMRT at P=0.01 when compared to the non-treated control (94.80 cm). This is similar to previous report of Tann *et al.* (2011) which done with the different varieties of Neang Kong and Neang

Kang. It is showed that GAP method gave significantly highest in tiller number per plant (18 tillers) and followed by organic and chemical methods at 60 days which were 13.00 and 14.75 tillers per plant, respectively. Those treatments were significantly differed when compared to the non-treated control (5.50 tillers per plant. With this regards, Tann *et al.* (2011) also reported in similar results tested with different rice varieties but used the same agricultural inputs in each method of organic, GAP and chemicals. Especially, organic method was applied organic biofertilizer during soil preparation prior transplant, filled in water to the plot until water level was about 10 cm above soil. For disease and insect control- sprayed a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (Chaetoimum-biofungicide plus Mycephyt-plant growth stimulant) 10 g/20L, every 15-20 days until harvest as the same as this experiment (Table 3). Withthis, Sibounnavong *et al.* (2011) also reported successfully used these bioproduct including CM product for organic kale.

The organic method gave the highest panicles weight per pot (2.12 kg) which significantly different from non-treated control, GAP and chemical methods (1.22, 1.88 and 1.58 kg, respectively). Moreover, for grain dry weight which sunlight dry for 115 days after harvest to maintain the moisture content of 15 %, gave the highest yield (grain weight) of 0.71 kg per pot, and followed by organic and chemical methods (0.52 and 0.65 kg per pot) when significantly different when compared to the non-treated control (0.29 kg per pot). Result was similar work with Tann *et al* (2011) in rice var. Neang Kong and Neang Kang. As a result, it was shown that organic method gave better rice straw weight per pot (1.60 kg) than non-treated control (1.17 kg), GAP (1.16 kg) and chemicals (0.93 kg) at 115 days of harvesting. However, it is interested that the harvest index (HI) of GAP and chemical methods were not significantly differed from each other as 38.00 % and 41.00 %, respectively. The harvest index of organic method (24.74 %) was not significantly different from the non-treated control (20.25 %). Soytong *et al.* (2001) reported that the biological products used in this research finding have been successfully used for organic crop production in many crops.

It is shown that organic method increased rice straw of 26.87 % but the other methods of GAP and chemicals had not increased at 115 days of harvesting. As a result, Tann, *et al* (2011) reported that the organic, GAP and chemical methods in rice varieties of Neang Kong and Neang Kang gave similar results. Result showed that disease index of rice blast in pot experiment of organic, GAP and chemical methods were 2.00, 2.50 and 3.25 respectively. The organic method was significantly decreased rice blast disease of 80 %, followed by GAP and chemical methods which were 50 and 40 %, respectively

(Table 3). The result was similar to the work of Soytong and Quimio (1989) who reported that *Chaetomium* spp could gave a good control of rice blast pathogen caused by *P. oryzae* which in this study *Chaetomium* spp was mixed to Mycephyt as CM product expressed to maintain efficacy to control blast disease. With regard on the work of Soytong (1992 a,b) stated that *C. globosum, C. cupreum* could gave a good control of rice blast pathogen in the Philippines. The organic method increased in yield of 55.38 % compared to the non-treated control which was applied organic biofertilizer during soil preparation prior transplant, filled in water to the plot until water level was about 10 cm above soil. For disease and insect control- sprayed a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (*Chaetoimum*-biofungicide plus Mycephyt-plant growth stimulant) 10 g/20L, every 15-20 days until harvest, which proved that the use of selected agricultural inputs, especially bioproducts certified by BioAgriCert, IFOAM (International Federation of Organic Agriculture Movements). This result is also confirmed by the works of Soytong *et al* (2001) and Kaewchai *et al* (2009). It is revealed that the organic method increased in plant height of 42.45 %, followed by GAP and chemical methods which were 35.10 and 22.78 %, respectively. The naturally disease incidence of rice blast in pot experiment was scored and found that organic method was significantly lowest blast incidence the non-treated control (Table 4). As stated by Soytong (1992 a,b) *Chaetomium* could gave a good control of rice blast pathogen since in this study *Chaetomium* was mixed with Mycephyt as CM product that could maintain the effectiveness of this bioproduct.

Application of agricultural inputs for GAP and Organic for Rice production var Sen Pidao in the field

Result showed that plant height was not significantly difference in all treatments. GAP method (10.25 tillers/plant) gave significantly better number of tillers than non-treated control, organic and chemical methods which were 7.75, 10.25 and 8.75 tillers/plant at 60 days, respectively. It was shown that GAP method gave significantly highest in panicle weight of 0.44 kg/m^2 which significantly better than organic (0.39 kg/m^2) and chemical method (0.41 kg/ m^2) when compared to the non-treated control (0.29 kg/ m^2). However, grain yield of organic, GAP and chemical methods were not significantly difference which were 0.14, 0.17 and 0.15 kg/m^2, respectively when compared to the non-treated control (0.10 kg/m^2). It revealed that rice straw weight per pot in organic, GAP and chemical methods were not significantly difference which were 0.24, 0.26 and 0.25 kg/ m^2 when compared to the non-treated control (0.19 kg/ m^2). The harvest index (HI) indicated that GAP method was the highest harvest index of 39.44 %, while organic and chemical methods were 37.93 and 37.73 %, respectively and non-treated control was 33.47 %. This research finding in the field experiment showed that plant height was increased in organic, GAP and chemical methods of 2.67, 2.15 and 5.20 %, respectively. The number of tillers was also increased in organic, GAP and chemical methods of 11.42, 24.39 and 11.42 %, respectively. It was also revealed that the panicle weight was increased in organic, GAP and chemical methods of 25.64, 34.09 and 29.26 %. GAP method gave the highest grain yield in field experiment of 41.17 % and followed by chemical and organic methods of 33.33 and 28.57 %, respectively. These results were also similar to previous work of Tann *et al.* (2011) in rice var. Neang Kong and Neang Kang. Harvest Index (HI) of organic, GAP and chemical methods was 11.75, 15.13 and 11.29 % (Table 5).

Good Agriculture Practice (GAP) in the field experiment gave mostly higher parameters than organic and chemical methods. With this, GAP method was applied chemical-biofertilizer (9-3-4) at 0.7 kg/plot (10x7m) before transplanting of 10 days old of rice seedlings, filled in water to the plot until water level was about 10 cm above soil. The experimental plot was then applied chemical biofertilizer (8-3-8) at 0.7 kg/plot after flowering. Alternative spraying with bioproducts and chemicals at every 15-20 days as a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (Metarhizium and Beauveria) 40 cc/20L., and CM product (Chaetoimum-biofungicide plus Mycephyt-plant growth stimulant) 10 g/20L and chemical insecticide (abamectin 20 cc/20L) and chemical fungicide (benomyl 5 g/20L) every 15-20 days until harvest. This result in using bioproducts could confirm successfully that can be used in alternative application with chemicals (Sibounnavong *et al.,* 2011 and Tann *et al.,* 2011). It is concluded that GAP method (10.25 tillers/plant) gave significantly better number of tillers than non-treated control, organic and chemicals.GAP method gave significantly highest in panicle weight of 0.44 kg/m^2which significantly better than organic (0.39 kg/m^2) and chemical method. The harvest index (HI) indicated that GAP method was the highest harvest index of 39.44 %, while organic and chemical methods were 37.93 and 37.73 %, respectively. Plant height was increased in organic, GAP and chemical methods of 2.67, 2.15 and 5.20 %, respectively The number of tillers were also increased in organic, GAP and chemical methods of 11.42, 24.39 and 11.42 %, respectively. It was also revealed that the panicle weight was increased in organic, GAP and chemical methods of 25.64, 34.09 and 29.26 %.

However, grain yield of organic, GAP and chemical methods were not significantly difference which were 0.14, 0.17 and 0.15 kg/m^2, respectively when compared to the non-treated control (0.10 kg/m^2). However, Pormsing (2005) clearly demonstrated the use of these methods of organic, GAP and chemicals can be made successfully in kale, especially these bioproducts can be used solely for organic crop and in alternative with chemicals as in GAP method. The organic methods was also confirmed to be successfully applied the organic biofertilizer 0.7 kg/plot during soil preparation prior transplant of 10 days old of rice seedlings, filled in water to the plot until water level was about 10 cm above soil. Experimental plots were sprayed a mixture of liquid biofertilizer 40 cc/20 L, Bioinsecticide (*Metarhizium* and *Beauveria*) 40 cc/20L., and CM product (Chaetoimum-biofungicide plus Mycephyt-plant growth stimulant) 10 g/20L, every 15-20 days until harvest. As a result organic method increased in yield of 28.57 %. This work was also similar to Tann *et al* (2011) investigated these bioproducts to compare with organic, GAP and chemical methods in rice var. Neang Kong and Neang Kang.

Result in the field experiment at 115 days of harvesting revealed that GAP was significantly highest panicle weight (0.44 kg/m^2), followed by chemical (0.41kg/m^2) and organic (0.39 kg/m^2) which significantly differed from the non-treated control (0.29 kg/m^2). It is very interesting that organic, GAP and chemical were not significantly different in grain yield which were 0.14, 0.17, 0.15 kg/m^2, respectively but significantly differed from non-treated control (0.10 kg/m^2). The weight of rice straw at 115 days in the field experiment of organic, GAP and chemical methods were not significantly different which were 0.24, 0.26 and 0.25 kg/m^2, respectively but significantly differed from the non-treated control (0.19 kg/m^2). HI of GAP gave the highest (39.44%) while organic and chemical methods were 37.93 and 37.74 %, respectively. Plant height at 60 days in the field experiment was highest increased in chemical method and followed by organic and chemical methods which were 2.67 and 2.15 %, respectively. GAP method showed the highest increasing number of tillers (24.39%) while organic and chemical methods increased tiller number of 11.42 %. The increased in panicle weight of GAP (34.09 %) showed in GAP method in the field trial while chemical and organic methods increased panicles weight of 29.26 and 25.64 %, respectively. It is confirmed that GAP method increased in grain yield of 41.17 % while chemical and organic methods increased yields of 33.33 and 28.57 %, respectively. In term of rice straw, the organic, GAP and chemical increased 20.83, 26.92 and 24.00 %, respectively. Harvest index (HI) of organic, GAP and chemical increase 11.75, 15.13 and 11.29 %, respectively (Table 6). The result of organic method was similar to Sibounnavong *et al.* (2006) in term of application of the same biological products for organic crop production of kangkong (*Ipomoea aquatica*) in the field.

Table 1. Colony diameter of *Pyricularia oryzae* in bi-culture test

Methods	Colony dia. (cm)	inhibition (%)
Control plate (*P. oryzae*)	9.00 a	
Biculture (*C. globosum vs P. oryzae*)	4.38 b	49.92
Biculture (*C. cupreum vs P. oryzae*)	3.16 b	64.85
C.V(%)	3.23	

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

Table 2. Plant height, tiller number at 60 days, dry weight of panicles, grain, rice straw and harvest index at 115 days of rice var Sen Pidao in pot experiment

Methods	Plant height (cm)	Tiller number per plant	Panicles weight per pot (kg)	Grain weight per pot(kg) or yield	Straw weight per pot	harvest index (%)
Control	94.80 c[1]	5.50 c	1.22 b	0.29 c	1.17 ab	20.25 b
Organic	97.80 bc	13.00 b	2.12 a	0.52 b	1.60 a	24.75 b
GAP	106.80 a	18.00 a	1.88 ab	0.71 a	1.16 ab	38.00 a
Chemical	101.65 b	14.75 ab	1.58 ab	0.65 ab	0.93 b	41.00 a
C.V (%)	2.18	14.14	20.85	12.07	18.20	9.55

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

Table 3. Percentage of increased in plant height and tiller number at 60 days and dry weight, grain, rice straw and harvest index at 115 days of Rice var Sen Pidao in pot experiment

Methods	plant height	tiller number	Panicle dry weight per pot	Grain yield	Rice straw weight per pot	harvest index
Organic	03.06	57.69	42.45	44.23	26.87	18.18
GAP	11.23	69.44	35.10	59.15	00.00	46.71
Chemical	06.73	62.71	22.78	55.38	00.00	50.60

Table 4. Disease idex and disease reduction of rice blast

Methods	Disease index of rice blast	Disease reduction
Control	5.00 a[1]	-----
Organic	2.00 c	80 a
GAP	2.50 bc	50 ab
Chemical	3.25 b	40 c
C.V (%)	16.74	29.48

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

Table 5. Plant height, tiller number at 60 days and weight of panicles, grain yield, rice straw and harvest index at 115 days in the field experiment

Methods	Plant height (cm)	Tiller number /hill	Panicle weight (kg)	Seed weight (yield), kg	Straw dry weight per pot	Harvest index
Control	45.50 a[1]	7.75 b	0.29 c	0.10 b	0.19 b	33.47 b
Organic	46.75 a	8.75 ab	0.39 b	0.14 a	0.24 a	37.93 ab
GAP	46.50 a	10.25 a	0.44 a	0.17a	0.26 a	39.44 a
Chemical	48.00 a	8.75 ab	0.41 ab	0.15 a	0.25 a	37.73 ab
C.V (%)	9.56	10.45	4.57	8.33	4.65	5.21

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

Table 6. Percentage of increased in plant height at 60 days, increased in panicles and grian yield weight, rice straw and harvest index at 115 days in field experiment

Methods	plant height	tiller number	Panicle weight	seed weight (yield)	Rice straw	harvest index
Control	0.00	0.00	-	-	0.00	0.00
Organic	2.67	11.42	25.64	28.57	20.83	11.75
GAP	2.15	24.39	34.09	41.17	26.92	15.13
Chemical	5.20	11.42	29.26	33.33	24.00	11.29

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