Effect of Bee Product, Organic and Chemical Fertilizers on Khao Dawk Mali 105 (KDML 105) Rice Planted in Different Paddy Soils, Ubon Ratchathani Province

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ABSTRACT: Three field experiments were conducted in Phen, Roi Et and Korat soil series in Ubon Ratchathani province with the aim at investigating the effect of bee product, cow manure, granulated organic fertilizer and chemical fertilizer on Khao Dawk Mali 105 (KDML 105) rice. Experimental design was arranged in randomized complete block with four replications similarly for all experiments. Treatments consisted of: T1 = control with no application of all inputs, T2 = 500 kg/rai of cow manure (CM), T3 = 100 kg/rai of granulated organic fertilizer (GOF), T4 = CM + foliar applications of bee product (BP), T5 = GOF + BP, T6 = BP, T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ (CF), and T8 = CF + BP. Cow manure, GOF and CF with and without BP had a positive impact on growth, grain quality and unmilled grain yield of KDML 105 rice in all soils studied. The application of CF with BP foliar application (T8) significantly promoted the highest rice unmilled grained yield of 3.86 t/ha in Phen soil series, 3.65 t/ha in Roi Et soil series and 4.25 t/ha in Korat soil series, and with no statistical difference, sole application of CF (T7) and the combination between GOF and BP foliar application (T5) also led to respective amounts of 3.65 and 3.58 t/ha in Phen soil series and 3.94 and 4.23 t/ha in Korat soil series. The CF + BP foliar application (T8) also statistically contributed to the greatest plant height at all stages of growth, greenness of the topmost, youngest, fully expanded leaf, fresh and dry weights of whole plant biomass, filled-grain percentage, 1,000-grain weight.

Keywords: loamy sand paddy soil, granulated organic fertilizer, cow manure, chemical fertilizer, bee product

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Introduction

Khao Dawk Mali 105 rice (KDML 105), so called jasmine rice, is a premium rice grown mainly in the northeast, Thailand. In 2017, rice planting area in this region was 5,861,843 ha, mainly dominated by jasmine rice, where Ubon Ratchathani province had the largest growing area in the region of 623,749 ha (Office of Agricultural Economics, 2019). This rice variety is a light sensitive plant. Average yield of this rice is still low, apparently lower that its potential yield which was reportedly 2.27 t/ha (Sri-Aun, 2005). This is due mainly to the region having poor soil resources. Soil constraints limiting rice yield such as rather coarse texture, low fertility status owing to soil parent material that derived from siltstone and sandstone, low organic matter, available phosphorus and potassium contents (Saenya et al., 2012; Kaewduang et al., 2013; Saenya et al., 2015; Inboonchuay et al., 2016), including other soil nutrients and water availability, play an adverse part in this term (Jearakongman et al., 1995; Wonprasaid et al., 1996; Fukai et al., 1998; Khunthasuvon et al., 1998). In addition, most rice growing areas are characterized by unulating surface with erratic rainfall pattern (Homma et al., 2003).

There have been numerous studies on how to improve yield of Khao Dawk Mali 105 rice in the region, particularly through fertilizer management and soil amendment usage. Haefele et al. (2006) analyzed an existing database on fertilizer trials conducted between 1995 and 1997 at eight different sites in northeast Thailand and found that nitrogen was clearly the most limiting element, whereas PK treatments increased yields significantly in only 6 out of 78 observations. Average agronomic efficiency of applied nitrogen was good (16 kg grain/kg N), but highly variable among sites. Boling et al. (2011) studied yield gap analysis and the effect of nitrogen and water on photoperiod-sensitive jasmine rice in northeast Thailand and reported that yield gaps could be substantially reduced by 1.48 Mg/ha (34%) through improved N-management practices. Buakhao et al. (2012) compared the effect of acacia leaf used as soil amendment to other soil amendments on improving a sodic soil (Typic Natraqualf) in northeast, Thailand and showed that the use of burnt rice husk gave the highest KDML 105 rice yield of 2.51 t/ha followed by the plot treated with acacia leaf at different rates. Jedrum et al. (2014) found that rice husk used as soil amendment induced the greatest 2-Acetyl-1-pyrroline (2AP) content of 3.50 and 3.97 mg/kg when planted in sodic and saline sodic soils, respectively. Comparing between KDML 105 and RD 42 rice varieties in a Typic Natrustalf, both rice varieties significantly responded to the application of granulated pig manure together with chemical fertilizer 16-8-8 grade at the rate of 125 kg/ha as basal application and 62.5 kg/ha of urea as topdressing application with KDML 105 rice giving the highest grain yeld of 1.88 t/ha while sole application of either organic fertilizer or chemical fertilizer providing inferior outcome (Rann et al, 2016).

Plant growth regulator has been used to increase plant growth and yield. Royal jelly, a product originating in the beehive, that is used in the nutrition of larvae, as well as adult queens (Viuda-Martos et al., 2008). It can be used as plant growth regulator due to it being composed of protein, carbohydrate, several vitamins, including plant nutrients such as potassium, magnesium, calcium, iron, phosphorus, sulfur and manganese as well as silicon (Nation and Robinson, 1971; Lakin, 1993; El-Shaikh, 2010). It was examined to have a positive effect on seed germination, seedling growth, mitotic activity and chromosomal aberrations of *Allium cepa* L. germinated under both normal conditions and salt stress (Çavuşoğlu et al., 2016). Bee pollen, a similar resinous substance collected from various plant sources by honeybees, also contains phytochemicals, plant nutrients, carotenoids, flavonoids and phytosterols in a considerable amount (Broadhurts, 1999). Besides, it is highly nutritious, is a good source of protein, amino acids, vitamins, dietary fiber and minerals (mainly potassium, calcium, and magnesium, with significant quantities of phosphorus, iron, sodium, and silica) and is particularly rich in linoleic and linolenic acid, which are essential fatty acids. It also contains enzymes, antibiotics, and bioflavonoids (Alferez and Campos, 2000). In addition, some growth regulators such as indole-3-acetic acid (IAA) and tryptophan (Trp) can be found in bee pollen from apple, tobacco, haselnut, orchids, shrub, pine and corn (Fukui et al., 1958). Hassan et al. (2008) used palm pollen extracts as plant growth substances for banana tissue culture and showed that most of treated plants showed highly growth characteristics such as shoot number, shoot length, root number, root length, fresh weight and dry weight compared to either the cytokinin (benzyl adenine) and/or the auxin (indole butyric acid and naphthalene acetic acid). However, there has no study on the use of bee product, a mixture between royal jelly and bee pollen in water as a growth regulator together with organic and chemical fertilizers for increasing yield of KDML 105 rice in Thailand. Therefore, This study was carried out to investigate the response of KDML 105 rice to bee product in combination with either organic or chemical fertilizers under field condition in farmer fields, Ubon Ratchathani.

Mateterials and Methods

Three field experiments were undertaken in Phen soil series, Don Jig subdistrict, Phibun Mangsahan district (15.119778 N 105.258472 E), Roi Et soil series, Kut Khaopun subdistrict, Kut Khaopun district (15.775363 N 104.993126 E) and Korat soil series, Don Sai subdistrict, Trakan Phuet Phon district (15.695781 N 105.083255 E), all in Ubon Ratchathani province. Respective annual rainfall and raining day of each location during the year of conducting experiment was 1,437.2 mm and 62 days, 1,466 mm and 84 days, and 1,821 mm and 108 days. Property of soils prior to conducting the experiments and soil fertility level are presented in Tables 1 and 2. Experimental design of all three experiments was similarly arranged in randomized complete block (RCB) with 4 replications. Treatments comprised: T1 = control with no application of all inputs, T2 = 3.125 t/ha of cow manure (CM), T3 = 0.625 t/ha of granulated organic fertilizer (GOF), T4 = CM + foliar applications of bee product (BP), T5 = GOF + BP, T6 = BP, T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ (CF), and T8 = CF + BP. Cow manure and granulated organic fertilizer were incorporated into soil before transplanting. Chemical fertilizer was equally split into basal application before transplanting and topdressing application at panicle initiation stage. Foliar application of bee product was applied at the rate of 125 ml/50 L of water/ha for 5 times every 15 days after transplanting. In treatments with no bee product applied the same amount of pure water was applied instead.

Cow manure use in all experiments had pH of 7.41, electrical conductivity (Ece) of 3.26 dS/m, organic carbon content of 214.1 g/kg, total nitrogen content of 11.9 g/kg, total phosphorus content of 10.6 g/kg and total potassium content of

17.4 g/kg. Granulated organic fertilizer had pH of 6.87, electrical conductivity (Ece) of 5.50 dS/m, organic carbon content of 41.76 g/kg, total nitrogen content of 7.90 g/kg, total phosphorus content of 58.2 g/kg and total potassium content of 24.0 g/kg. Bee product in the form of liquid had pH of 4.87, electrical conductivity (Ece) of 2.48 dS/m, organic carbon content of 53.19 g/kg, total nitrogen content of 4.00g/kg, total phosphorus content of 0.10 g/kg and total potassium content of 1.00 g/kg.

Thirty days old seedling of KDML 105 rice was used for transplanting, using 20 x 20 cm spacing. Plot size was 4 x 6 m 2. Composite soil sample of each site was collected from 0-15 cm depth for the analysis of soil property prior to conducting the experiments. Rice was harvested at 135 dya after planting. Plant parameters and yield were recorded, including 1) plant heights measured from soil surface to the tip of rice at 30, 60 and 90 days after transplanting, 2) dry weigt of whole plant (root and aboveground plant part) at 60 days after transplanting, 3) greenness of the topmost, youngest, fully expanded leaf measured using Leaf Colour Chart provided by IRRI that had 4 green strips with color ranging from yellow green to dark green, at 30 days after transplanting or 15 days after the first spray of bee product, 4) number of tiller/hill and number of panicle/hill, 5) unmilled grain quality such as filled grain percentage and 1,000-grain weight and 6) grain yield at 14% moisture content. All data collected were compared among treatments using the analysis of variance for statistical significance, and mean separation was done using SPSS program and Duncan's multiple range test (DMRT) with differences being tested at 0.05 level of significance.

Results and Discussion

Characteristic and property of soils in the experimental area

Phen soil series (Loamy-skeletal mixed, subactive, isohyperthermic: Aeric Plinthic Paleaquults) is a paddy soil derived from old alluvium of fine-grained sedimentary rock. The soil is formed on the lower part of denudated terrain, having slightly undulating relief with 2% slope. This soil has poorly drained feature with slow runoff and moderate permeability. Soil property prior to conducting the experiment **(Table 1)** showed that topsoil (0-15 cm) was very strongly acid, having low organic matter, very low total nitrogen, moderately low available phosphorus and very low available potassium contents with very low cation exchange capacity. This soil had low fertility level **(Table 2)**.

Roi Et soil series (Fine-loamy, mixed, subactive, isohyperthermic; Aeric Kandiaquults) is a paddy soil derived from old alluvium of siltstone and sandstone. The soil is formed on low terrace, having nearly flat relief with 1% slope. This soil has somewhat poorly drained feature with slow runoff and moderate permeability. Soil property prior to conducting the experiment **(Table 1)** revealed that topsoil (0-15 cm) was very strongly acid, having very low organic matter, very low total nitrogen, moderately low available phosphorus and low available potassium contents with very low cation exchange capacity. This soil was a low fertility status soil **(Table 2)**

Korat soil series (Fine-loamy, siliceous, isohyperthermic; Oxyaquic Kandiustults) is by nature an upland soil which in some areas the landscape has been modified for paddy rice, especially those located next to low terrace area. The soil derived from old alluvium of sandstone. The soil is formed on the lower part of middle terrace, having undulating relief with 3% slope. This soil has moderately well drained feature with moderate runoff and moderate permeability. Soil property prior to conducting the experiment **(Table 1)** showed that topsoil (0-15 cm) was very strongly acid, having low organic matter, very low total nitrogen, high

Table 1 Property of soils (0-15 cm) prior to conducting the experiments.

Property	Phen soil series	Roi Et soil series	Korat soil series
pH (1:1 H2O)[1/]	4.5 (very strongly acid)	4.3 (very strongly acid)	4.6 (very strongly acid)
Electrical conductivity (ECe,dS/m)[2/]	0.19 (low)	0.23 (low)	0.17 (low)
Organic matter (g/kg)[3/]	7.2 (low)	4.7 (low)	6.3 (low)
Total N (g/kg)[4/]	0.36 (very low)	0.24 (very low)	0.32 (very low)
Available P (mg/kg)[5/]	9 (moderately low)	10 (moderately low)	27 (high)
Available K (mg/kg)[6/]	25 (very low)	36 (low)	35 (low)
Cation exchange capacity ($cmol_c$/kg)[7/]	2.56 (very low)	1.02 (very low)	2.44 (very low)
Soil texture[8/]	Sandy loam	Sandy loam	Sandy loam

[1/] aqueous suspensions (1:1 soil/solution ratio) (National Soil Survey Center, 1996); [2/] saturation extract at 25◦C (Richards, 1954); [3/] wet digestion method withWalkley and Black titration (Walkley and Black, 1934; Nelson and Sommers, 1996); [4/] Kjeldahl method (Bremner, 1996); [5/] Bray II (Bray and Kurtz, 1945); [6/] 1 M NH4OAc at pH 7.0 extraction (Pratt, 1965); [7/] 1 M NH4OAc at pH 7 (Chapman,1965); [8/] pipette method (Kilmer and Alexander, 1949; Day, 1965).

Table 2 Fertility level of soils prior to conducting the experiments.

Soil series (0-15 cm)	OM (g/kg)	Avail. P (mg/kg)	Avail. K (mg/kg)	CEC ($cmol_c$/kg)	BS (%)	Total score	Fertility level
Phen	7.2 (1)	9 (1)	25 (1)	2.56 (1)	36.7 (2)	6	low
Roi Et	4.7 (1)	10 (2)	36 (1)	1.02 (1)	18.9 (1)	6	low
Korat	6.3 (1)	27 (3)	35 (1)	2.44 (1)	17.9 (1)	7	low

Scoring is used for the assessment of fertility level (the score is presented in blanket) where: total score of 7 or less, fertility level is low; total score between 8-12, fertility level is medium; total score of 13 or more, fertility level is high.

available phosphorus and low available potassium contents with very low cation exchange capacity. This soil had low fertility level (**Table 2**).

Effetc of bee product, organic and chemical fertilizers on KDML 105 rice

Plant height at 30 days after transplanting

At tillering stage of growth, the application of CF + BP (T8) significantly induced the greatest rice height in all soils studied with the height one in the range of 63.9-66.0 cm **(Table 3)**. There was only CF treatment (T7) in Roi Et soil series that showed no difference to that of the highest. Among different types of fertilizers, chemical fertilizer (T7) accelerated rice height the best while both organic fertilizers (T2 and

T3) showed no difference between them. With no fertilization, KDML 105 rice statistically responded to BP (T6) similarly to the control with no foliar application of BP, giving the lowest plant height in all soils, varying between 43.3-48.2 cm.

Plant height at 60 days after transplanting

At 60 days after transplanting, soils treated with CF with or without GOF (T7 and T8) foliar application statistically stimulated the greatest rice height in the range of 89.7-98.7 cm. A rather similar performance of rice was found in GOF + BP treatment (T5) in all soils. In addition, BP tended to suplementarily have more pronounced effect when sprayed to the plant along with all types of fertilizers added **(Table 3)**. With no fertilization, the control treatment (T1) gave the poorest height of rice at this stage of growth while KDML 105 rice received only BP foliar application (T6) performing slightly better

Plant height at 90 days after transplanting

At early maturing stage of growth, there were slight differences in terms of the response of plant height to fertilization and BP application comparing among three soils. In Phen soil series, the significantly greatest height of rice was from the plot treated with all types of fertilizers used together with BP foliar application (T4, T5 and T8), giving the height in the range of 119.2-126.4 cm whereas with no BP sprayed inferior result was obtained. In Roi Et soil series, all plots fertilized with GOF (T6) and CF (T7) and that with BP foliar application (T4, T5 and T8) significantly gave the greatest plant height in the rane of 118.4-122.8 cm. In the case of rice planted in Korat soil series, KDML 105 rice significantly responded better to CF with and without BP application (T7 and T8) than to organic fertilizers with only the adition of GOF together with BP foliar application (T5) statistically having the same height **(Table 3)**. These three treatments had the height of rice in the range of 123.7-127.3 cm.

Greenness of the topmost, youngest, fully expanded leaf

A measurement of greenness of the topmost, youngest, fully expanded leaf of KDML 105 rice using the Leaf Color Chart (LCC) was undertaken at 30 days after transplanting or 10 days after the first foliar application of BP. The LCC is used to determine the N fertilizer needs of rice crops (IRRI, 2019). Result of the study showed that fertilization and BP foliar application had clear effect on the greenness of rice leaf, indicating that nitrogen was required in different amounts when compared among treatments. Considering dark green colour (>3 scale) as tentative nitrogen sufficiency, the application of CF with and without BP foliar application (T7 and T8), both organic fertilize together with BP addition (T4 and T5), and GOF (T4) significantly induced the highest greenness of rice leaf in Phen soil series with average values ranging between 3.64-3.68 **(Figure 1)**. Rather similar trend of a response of rice to fertilization and BP to a previous soil was also detected in Roi Et soil series but overall greenness of rice in this soil was lighter. A different story was in Korat soil series which all plots gave the value of greater than 3, nevertheless, the application of only CM, GOF and CF (T2, T3 and T7) already showed great effect on greenness of rice leaf as the combination between fertilizing the soil whith these fertilizers and BP foliar application had no statistical difference in this context.

Table 3 Effect of bee product, cow manure, organic fertilizer and chemical fertilizer on plant height measured at 30, 60 and 90 days after transplanting (DAP).

Treatment	Phen soil series			Roi Et soil series			Korat soil series		
	30 days	60 days	90 days	30 days	60 days	90 days	30 days	60 days	90 days
	(------------cm-------------)			(------------cm------------)			(------------cm-----------)		
T1	43.3d	87.1b	103.8c	47.6d	69.5c	101.3c	44.4d	76.8b	111.6c
T2	55.5c	90.3b	117.3b	52.2c	75.6c	114.4b	54.5bc	83.3b	118.4b
T3	54.8c	88.2b	117.6b	53.6c	81.1b	118.7a	54.4bc	86.1a	117.8b
T4	59.0b	92.5b	119.2a	53.4c	86.3b	119.3a	56.5b	88.2a	119.2b
T5	58.8b	97.3a	122.1a	58.2b	89.8a	119.8a	58.6b	88.9a	123.7a
T6	48.2d	98.2a	106.8c	46.6d	80.3b	112.2b	48.1d	79.5b	121.0a
T7	58.6b	98.7a	113.6c	59.4ab	90.5a	118.4a	58.2b	89.7a	124.4a
T8	64.4a	96.9a	126.4a	63.9a	93.8a	122.8a	66.3a	92.7a	127.3a
F-test	*	*	*	*	*	*	*	*	*
%CV	12.1	10.8	12.1	5.0	9.9	6.3	6.5	5.8	4.0

* significantly different at 0.05 probability level; means with different lowerscript letters within a column indicate a significant difference according to Duncan's multiple range test at $P \leq 0.05$.
T1 = control (no fertilization); T2 = CM 3.125 t/ha; T3 = GOF 0.625 t/ha; T4 = CM 3.125 t/ha + BP; T5 = GOF 0.625 t/ha + BP; T6 = BP; T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$; T8 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ + BP.
CM = cow manure; GOF = granulated organic fertilizer; BP = bee product.

Number of tiller and panicle per hill

The application of CM, GOF and CF with and without BP foliar application showed no clear effects on number of tiller and panicle per hill as shown by results in **Table 4.** Comparing among three soils, the number of tiller per hill was rather identical whereas KDML 105 rice seemed to produce more numbers of panicle per hill in Korat soil series than in the other two soils.

Fresh and dry weight of whole plant (root and aboveground plant part)

Whole plant, root and aboveground plant part, was collected at 60 days after transplanting for a record of fresh and dry weigth as affected by treatments. Fertilization with and without BP application clearly had the influence of fresh and dry rice biomasses. The highest fresh biomass in Phen soil series was obtained when treated with both organic fertilizers together with BP foliar application (T4 and T5), CF with and without BP application (T7 and T8), significantly giving values in the range of 49.4-55.6 g/hill **(Figure 2a)**. Only the CF + BP foliar application significantly produced the highest fresh biomass of 58.1 g/hill in Roi Et soil series. Cow manure (T2) and GOF (T3) statistically induced inferior fresh biomass to the same fertilizer with the addition of BP (T4 and T4), 43.3 and 47.1 g/hill compared to 52.2 and 51.8 g/hill, respectively. In Korat soil series, all plot treated with fertilizers with BP involved (T4, T5 and T8) significantly promoted the highest

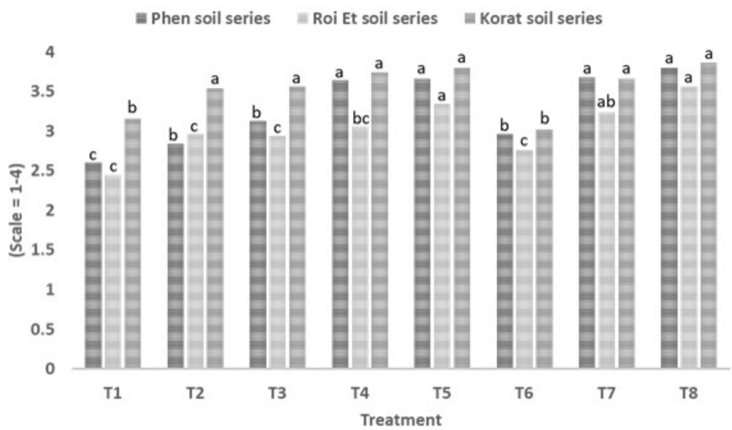


Figure 1 Effect of bee product, cow manure, organic fertilizer and chemical fertilizer on greenness of the topmost, youngest, fully expanded leaf measured at 15 days after the 1st spray of bee product. Different lowercase letters on bars grouped under the same soil series are significantly different ($P \leq 0.05$).

T1 = control (no fertilization); T2 = CM 3.125 t/ha; T3 = GOF 0.625 t/ha; T4 = CM 3.125 t/ha + BP; T5 = GOF 0.625 t/ha + BP; T6 = BP; T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$; T8 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ + BP.

CM = cow manure; GOF = granulated organic fertilizer; BP = bee product.

fresh biomass of 53.8, 57.2 and 57.3 g/hill, respectively **(Figure 2a)**. The control plot with no fertilization (T1) gave the lowest fresh biomass in all soils and the amounts were statistically lower than that obtained from the plot only having BP sprayed (T6).

In the case of dry biomass, almost similar trend to fresh biomass was gathered. The application of CM, GOF and CF together with BP foliar application (T4, T5 and T8) had identical effect of dry biomass in Phen and Korat soil series, significantly contributing to the highest amount given in the range of 28.8-29.8 g/hill in the former soil and 27.5-30.9 g/hill in the latter soil (Figure 2b). In Roi Et soil seris, the plot treated with CF + BP (T8) significantly gave the greatest dry biomass of 34.6 g/hill and BP foliar application seemed to have less influence in terms of the enhancement with both organic fertilizers.

Filled-grain percentage and 1,000-grain weight

Apart from influencing growth and biomass of KDML 105 rice, BP foliar application also had the effect of rice grain quality. The application of CM, GOF and CF together with BP foliar application (T4, T5 and T8) significantly induced the highest filled grained percentage in all soils, giving the ranges of 78.6-19.5% in Phen soil series, 76.8-80.4% in Roi Et soil series, and 79.4-81.3% in Korat soil series **(Figure 3a)**. However, sole application of CF (T7) in Phen and Korat soil series, and only BP foliar application (T6) in Roi Et soil series also gave this plant parameter with no statistical difference to that of the highest ones. With no fertilization, the control plot (T1) gave inferior filled-grain percentage than that applying BP (T6) in all soils

Plots involving the application of all types of fertilizer together with

BP foliar application (T4, T5 and T8) significantly stimulated the greatest 1,000-grain weight measured at 14% moisture content in all soils with values varying from 25.5-26.0 g in Phen soil series, 24.9-25.7 g, and 25.0-260 g in Korat soil series **(Figure 3b)**. It was rather surprising that sole application of organic fertilizer and CF with no BP addition (T2 and T3) statistically gave no difference to the control with no inputs (T1) and only spraying BP (T6) in his context.

Unmilled grain yield of KDML 105 rice

Fertilizers applied and BP foliar application evidently had a positive impact on unmilled grain yield of KDML 105 rice planted in all soils. Comparing among the effect of only fertilizer added, CF (T7) statistically promoted far greater amount of unmilled rice grain yield weighed at 14% moisture content than organic fertilizers (T2 and T3), producing 3.65 t/ha compared to 2.84 (T2) and 3.03 (T3) t/ha in Phen soil series, 2.93 t/ha compared to 2.48 (T2) and 2.59 (T3) /ha in Roi Et soil series, and 3.94 t/ha compared to 3.28 (T2) and 3.48 (T3) t/ha (Figure 4). With foliar application of BP enhanced, the prospect of unmilled rice grain yield given was changed. The highest rice grained yield was from CF + BP foliar application (T8) in all soils with the quantiies ranging between 3.65-4.25 t/ha, however, the combination between GOF and BP foliar application (T5) also statistically gave similar yield in Phen soil series (3.58 t/ha) and Korat soil series (4.23 t/ha) as of sole addition of CF (T7) in both soils (3.65 and 3.94 t/ha, respectively). In all soils, only foliar application of BP (T6) still significantly induced better unmilled rice grain yield than did the control (T1) with no inputs at all **(Figure 4)**.

At the early stage of growth (30 days after transplanting, KDML 105 rice responded well to chemical

Table 4 Effect of bee product, cow manure, organic fertilizer and chemical fertilizer on number of tiller per hill and number of panicle per hill.

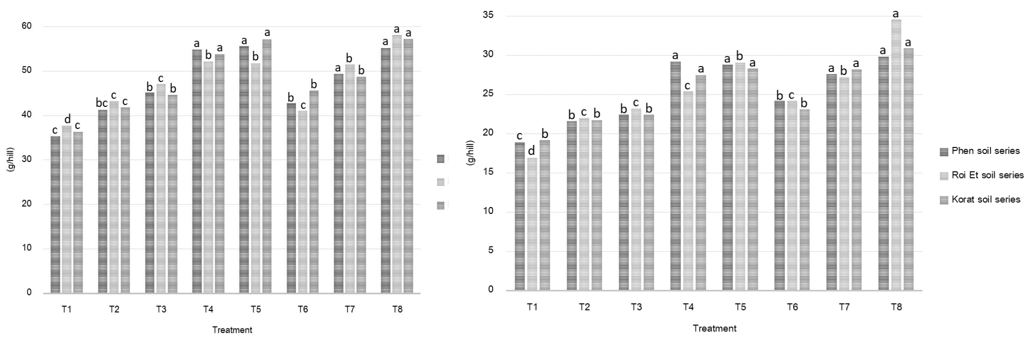
Treatment	Number of tiller (No./hill)			Number of panicle (No./hill)		
	Phen soil series	Roi Et soil series	Korat soil series	Phen soil series	Roi Et soil series	Korat soil series
T1	8.6	8.8	9.4	10.1	9.0	10.1
T2	9.0	9.0	9.0	10.1	10.0	12.2
T3	9.0	9.2	9.0	10.8	10.4	12.0
T4	9.2	9.4	9.3	11.2	10.4	11.8
T5	9.6	9.0	9.4	10.4	10.6	12.6
T6	9.6	9.0	9.5	9.8	9.4	11.6
T7	9.8	10.0	9.3	11.0	10.4	11.8
T8	9.8	9.8	9.3	12.2	10.3	12.2
F-test	ns	ns	ns	ns	ns	ns
%CV	4.7	4.6	2.0	7.3	5.6	6.4

ns = not significant.

T1 = control (no fertilization); T2 = CM 3.125 t/ha; T3 = GOF 0.625 t/ha; T4 = CM 3.125 t/ha + BP; T5 = GOF 0.625 t/ha + BP; T6 = BP; T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$; T8 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ + BP.

CM = cow manure; GOF = granulated organic fertilizer; BP = bee product.

fetilizer in all soils when compared to organic fertilizer (CM and GOF) due to nitrogen from chemical fertilizer was more sufficiently readily available to the plant while mineralization of nitrogen from cow manure and granulated taking longer time to be available to the plant. In the latter stage of growth (60 and 90 days after transplanting), a different prospect of growth as affected by different fertilizers applied was found as nitrogen released from organic fertilizer started to have a pronounced effect of vegetatve growth of KDML 105 rice. However, with no bee product foliar application KDML 105 rice fertilized with both organic fertilizers still showd inferior growth but more satisfactory result was obtained whe bee product was added. It demonstrated that bee product



(A) (B)

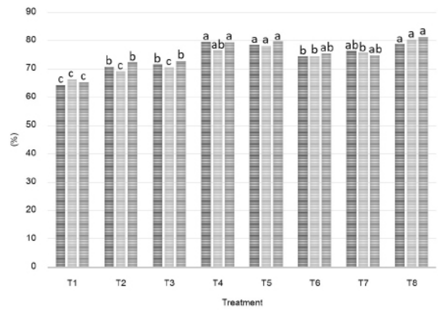
Figure 2 Effect of bee product, cow manure, organic fertilizer and chemical fertilizer on fresh weigth (a) and dry weight (b) of whole plant measured at 60 days after transplanting. Different lowercase letters on bars grouped under the same soil series are significantly different ($P \leq 0.05$).

T1 = control (no fertilization); T2 = CM 3.125 t/ha; T3 = GOF 0.625 t/ha; T4 = CM 3.125 t/ha + BP; T5 = GOF 0.625 t/ha + BP; T6 = BP; T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$; T8 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ + BP.

CM = cow manure; GOF = granulated organic fertilizer; BP = bee product.

can supplement or enhance the effciency use of nitrogen or other plant nutrients as expressed by increased growth to the level that chemical fertilizer could provide. This was because bee product, a mixture between royal jelly and bee pollen, contained plant nutrients to some degree, including some plant regulators (Fukui et al., 1958; Nation and Robinson, 1971; Lakin, 1993; Broadhurts, 1999; Alferez and Campos, 2000; El-Shaikh, 2010; Çavuşoğlu et al., 2016). The composition of bee product used in this study analyzed prior to conducting the experiments showed that beside major plant nutrients as previously mentioned, it was also composed of 0.3 g/kg of calcium, 0.1 g/kg of magnesium, 25.8 mg/kg of boron in addition with 19 amino acids with a total of 6,370.43 mg/mL of which tryptophan and methionine were dominant in the amounts of 74.18 and 126.22 mg/100 mL. This is supported by the study of El-Awadi et al. (2011) that the use of liquid fertilizer containing both amino acids foliarly applied at the rate of 100 mg/L on *Phaseolus vulgaris* L. promoted greater both growth and yield than did no amino acids or other types of fertilizers. Addiionally, the result also revealed that it can reduce the use of nitrogen fertilizer up to 65%. This coincided with the greenness of rice leaf detected in this study that the use of bee product in the plots treated with organic fertilizers gave the highest greenness.

Apart from the use of bee product together with chemical fertilizer



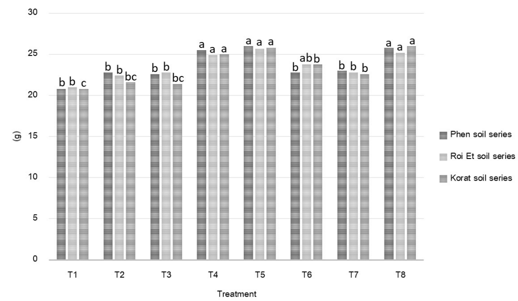


Figure 3 Effect of bee product, cow manure, organic fertilizer and chemical fertilizer on % filled grain (a) and 1000-grain weight (14% moisture content) (b). Different lowercase letters on bars grouped under the same soil series are significantly different ($p \leq 0.05$).

T1 = control (no fertilization); T2 = CM 3.125 t/ha; T3 = GOF 0.625 t/ha; T4 = CM 3.125 t/ha + BP; T5 = GOF 0.625 t/ha + BP; T6 = BP; T7 = 50:50:25 kg/ha of N:P_2O_5:K_2O; T8 = 50:50:25 kg/ha of N:P_2O_5:K_2O + BP.

CM = cow manure; GOF = granulated organic fertilizer; BP = bee product.

and organic fertilizers that improved plant height, the enhancement between them also promoted total biomass of KDML 105 rice, both fresh and dry weight, including rice grain quality such as filled-grain percentage and 1,000-grain weigth in all three soils. This designated that bee product also played a part in this context as previous studies showed that amino acids in royal jelly positively contributed to seed emergence, growth of seedling, mitotic activity and chromosomal aberrations of *Allium cepa* L. under both normal conditions and salt stress (Çavuşoğlu et al., 2016), and Hassan et al. (2008) also investigated that most of treated plant with pollen extracts of date palm that contained auxin (IBA) and tryptophan (auxin precursor) showed high growth characteristics such as shoot number, shoot length, root number, root length, fresh weight and dry weight compared to either the cytokinin (benzyl adenine) and/or the auxin (indole butyric acid and naphthalene acetic acid).

Considering unmilled grain yield of KDML 105 rice obtained in this study, a comparison of the effect among cow manure, granulated organic fertilizer and chemical fertilizer showed that KDML 105 rice responded the best to chemical fertilizer application followed by granulated organic fertilizer which was slightly better than cow manure. This was in agreement with the study of Rann et al. (2016) that KDML 105 and RD 42 rice reacted better to chemical fertilizer than granulated pig manure but the combination between chemical fertilizer and granulated pig manure gave the best result. Additionally, recent reviews across the globe reported that the use of organic and inorganic nutrients was responsible for obtaining 0.78%–117% higher yield compared to chemical fertilizers alone. Application of biofertilizer along with 50% reduced nitrogen and phosphorus gave 32% higher rice yield over chemical fertilizers (Naher et al., 2019). Also, neither manure nor fertilizers alone can sustain soil fertility and crop productivity, their combination is considered one of the best management options for sustainable rice production (Sarkar et al., 2016). Integrated plant nutrient system was an appropriate combination of mineral fertilizers, organic manures, crop residues, composts, nitrogen fixing crops, and biofertilizers as shown by previous studies conducted in northeast, Thailand (Buakhao et al., 2012; Jedrum et al, 2014; Phunyalit et al., 2018).

Furthermore, as shown in this study, bee product can be integrated very well with soil application of chemical fertilizer, illustrating that the influence

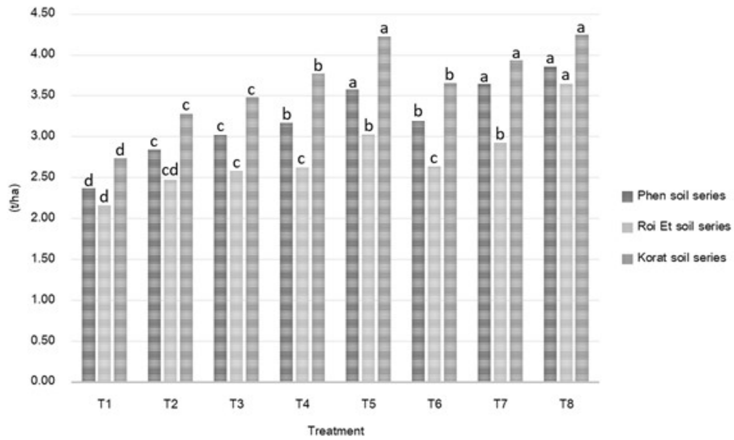


Figure 4 Effect of bee product, cow manure, organic fertilizer and chemical fertilizer on unmilled grain yield of KDML 105 rice measured at 14% moisture content. Different lowercase letters on bars grouped under the same soil series are significantly different ($P \leq 0.05$).

T1 = control (no fertilization); T2 = CM 3.125 t/ha; T3 = GOF 0.625 t/ha; T4 = CM 3.125 t/ha + BP; T5 = GOF 0.625 t/ha + BP; T6 = BP; T7 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$; T8 = 50:50:25 kg/ha of $N:P_2O_5:K_2O$ + BP.

CM = cow manure; GOF = granulated organic fertilizer; BP = bee product.

of bee product was not because of its giving major plant nutrients to the plant. Rather, plant growth regulators composed in this product apparently played a part in increasing the efficiency use of plant major nutrients and subsequently increased KDML 105 rice yield. However, proper combination of plant nutrients applied and other limiting factors that can have the impact on KDML 150 rice yield planted in these sandy loamy paddy soils in Ubon Ratchathani should be further investigated in order to gain better quality and grain yield of this premium rice. Such a case was also showed by Sukkasem and Anusontpornperm (2019) when conducted similar experiment in Ubon and Roi Et soil series. Even though, the additional use of of this supplementary bee product can increase rice yield, cost/benefit ratio of using bee product should be taken into account as in this study the product was applied 5 times throughout the growth period of rice that can increase cost of producting, both the costs of product and labour, before transferring this technology to farmers.

Conclusions

Khao Dawk Mali 105 rice planted in three different soils, Phen, Roi Et and Korat soil series, all having sandy loam texture in topsoil and low fertility status, responded to cow manure, granulated organic fertilizer and chemical fertilizer with and without bee product foliar application. The application of 50:50:25 kg/ha of $N:P_2O_5:K_2O$ together with bee product foliar application for 5 times gave the highest plant height at all stages of growth, greenness of the topmost, youngest, fully expanded leaf, fresh and dry weights of whole plant biomass, filled-grain percentage, 1,000-grain weight, and unmilled rice grain yield measured at 14% of moisture content. The highest unmilled rice grain yield as treated by the same input was obtained from Korat soil series, followed by that from Phen soil series and Roi Et soil series, respectively. Bee procuct tended to enhance similarly well with chemical fertilizer and granulated organic fertilizer, regarding rice growth and yield obtained. Cow manure comparatively gave inferior result to granulated organic fertilizer.

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