



EFFECT OF CHEMICAL AND GRANULAR ORGANIC FERTILIZER WITH HORMONE MIXED FORMULA (HO) FOR QUALITY AND PRODUCTIVITY ON HOARY BASIL (*Ocimum Americanum* L.)

Konchom Ronnarong¹
Rucksarikorn Chawarit²
Intanon Ruankuan³
Intanon Pumisak⁴

ABSTRACT

Purpose: This research study aimed to develop chemical and granular organic fertilizers with hormone mixed formula (HO) and examine its effect on growth, productivity and active principles of hoary basil (*Ocimum americanum* L.) and the effect of HO fertilizer on soil properties.

Method: Experiments were conducted in an RCBD with 6 treatments 4 replications on 1.2x4 m plots with 32 seedlings on each. The soil properties before and after experiments, growth rate, yield and active principles were analyzed by ANOVA, and compared by a DMRT method at the reliability of 95%. The experiments were conducted between September 2020 and September 2021.

Results and Conclusion: The results showed that the HO fertilizers (T4, T5 and T6) improved organic matter, the soil pH, bulk density, soil porosity and water holding capacity. The HO fertilizers also significantly increased secondary and micronutrients. The plants with the HO fertilizers, especially with T6 and T5, showed the highest growth in terms of height, stem size, number of branches and canopy size, with statistically significant differences compared to the other treatments. In terms of yield productivity, T6 had the highest yield (3,192.7), followed by T2 (2,920.5), T5 (2,728.8), T4 (2,667.7), T3(1,952.1) and T1(1,735.8 kg/rai.). According to the active principle analysis, eugenol and methyl eugenol were found highest under T6 (HO-3). As for the net profit in hoary basil production, T6 showed the highest profit of 94,965 baht/rai.

Implications of the Research: It was concluded that the HO fertilizers, as environmentally friendly fertilizing options, could sustainably improve soil quality and HO-3, in particular, has proved to be suitable for hoary basil production to provide high quality, safe products for both domestic and international markets.

Originality/Value: This study highlights the effectiveness of HO fertilizers on increasing yields, yield component and active principles of hoary basil.

Keywords: Chemical and Granular Organic Fertilizer with Hormone Mixed Formula (HO), Hoary Basil, Eugenol and Methyl Eugenol.

¹ Naresuan University, Phitsanulok 65000, Thailand. E-mail: ronnarongk60@nu.ac.th
Orcid: <https://orcid.org/0000-0001-6664-8828>

² Naresuan University, Phitsanulok 65000, Thailand. E-mail: chawalitra59@nu.ac.th
Orcid: <https://orcid.org/0000-0001-6980-7388>

³ Naresuan University, Phitsanulok 65000, Thailand. E-mail: ruankwanintanon@hotmail.com
Orcid: <https://orcid.org/0000-0001-7258-6897>

⁴ Naresuan University, Phitsanulok 65000, Thailand. E-mail: pumisak15@nu.ac.th
Orcid: <https://orcid.org/0000-0002-8131-6212>



EFEITO DO FERTILIZANTE ORGÂNICO QUÍMICO E GRANULAR COM FÓRMULA MISTA DE HORMÔNIO (HO) PARA QUALIDADE E PRODUTIVIDADE NO MANJERICÃO (*Ocimum Americanum* L.)

RESUMO

Objetivo: Este estudo teve como objetivo desenvolver fertilizantes orgânicos químicos e granulares com fórmula misturada hormonal (HO) e examinar seu efeito sobre o crescimento, produtividade e princípios ativos do manjericão do cavalo (*Ocimum americanum* L.) e o efeito do fertilizante HO nas propriedades do solo.

Método: Foram realizados experimentos em um RCBD com 6 tratamentos 4 replicações em parcelas de 1,2x4 m com 32 mudas em cada. As propriedades do solo antes e depois de experimentos, taxa de crescimento, rendimento e princípios ativos foram analisados pela ANOVA e comparados por um método de DMRT com a confiabilidade de 95%. As experiências foram realizadas entre setembro de 2020 e setembro de 2021.

Resultados e Conclusão: Os resultados mostraram que os fertilizantes HO (T4, T5 e T6) melhoraram a matéria orgânica, o pH do solo, a densidade de massa, a porosidade do solo e a capacidade de retenção de água. Os fertilizantes HO também aumentaram significativamente os secundários e micronutrientes. As plantas com fertilizantes HO, especialmente com T6 e T5, apresentaram maior crescimento em termos de altura, tamanho do caule, número de ramos e tamanho da cobertura, com diferenças estatisticamente significativas em relação aos demais tratamentos. Em termos de produtividade de rendimento, T6 teve o maior rendimento (3.192,7), seguido por T2 (2.920,5), T5 (2.728,8), T4 (2.667,7), T3 (1.952,1) e T1 (1.735,8 kg/rai.). De acordo com a análise do princípio ativo, o eugenol e o metil-eugenol foram encontrados em níveis mais altos sob T6 (HO-3). Quanto ao lucro líquido na produção de manjericão do cavalo, o T6 apresentou o maior lucro de 94.965 baht/rai.

Implicações da pesquisa: Concluiu-se que os fertilizantes HO, como opções de fertilização ambientalmente amigáveis, poderiam melhorar a qualidade do solo de forma sustentável e o HO-3, em particular, tem se mostrado adequado para a produção de manjericão arborizado para fornecer produtos de alta qualidade e seguros para os mercados interno e internacional.

Originalidade/valor: Este estudo destaca a eficácia dos fertilizantes HO no aumento do rendimento, componente de rendimento e princípios ativos do manjericão.

Palavras-chave: Fertilizante Orgânico Químico e Granular com Fórmula Mista de Hormona (HO), Manjericão Hoary, Eugenol e Metil Eugenol.

EFFECTO DEL FERTILIZANTE ORGÁNICO QUÍMICO Y GRANULAR CON FÓRMULA MIXTA HORMONAL (HO) PARA LA CALIDAD Y PRODUCTIVIDAD EN LA ALBAHACA CANOSA (*Ocimum Americanum* L.)

RESUMEN

Propósito: Este estudio de investigación tuvo como objetivo desarrollar fertilizantes orgánicos químicos y granulares con fórmula mixta hormonal (HO) y examinar su efecto sobre el crecimiento, la productividad y los principios activos de la albahaca canosa (*Ocimum americanum* L.) y el efecto del fertilizante HO en las propiedades del suelo.

Método: Se realizaron experimentos en un RCBD con 6 tratamientos 4 repeticiones en parcelas de 1,2x4 m con 32 plántulas en cada una. Las propiedades del suelo antes y después de los experimentos, la tasa de crecimiento, el rendimiento y los principios activos fueron analizados por ANOVA, y comparados por un método DMRT con una fiabilidad del 95%. Los experimentos se llevaron a cabo entre septiembre de 2020 y septiembre de 2021.

Resultados y Conclusión: Los resultados mostraron que los fertilizantes HO (T4, T5 y T6) mejoraron la materia orgánica, el pH del suelo, la densidad aparente, la porosidad del suelo y la capacidad de retención de agua. Los fertilizantes de la OMS también aumentaron significativamente los nutrientes secundarios y los micronutrientes. Las plantas con los fertilizantes HO, especialmente con T6 y T5, mostraron el mayor crecimiento en términos de altura, tamaño del tallo, número de ramas y tamaño del dosel, con diferencias estadísticamente significativas en comparación con los otros tratamientos. En términos de productividad de rendimiento, T6 tuvo el rendimiento más alto (3,192.7), seguido por T2 (2,920.5), T5 (2,728.8), T4 (2,667.7), T3 (1,952.1) y T1 (1,735.8 kg/rai.). Según el



análisis de principios activos, el eugenol y el metil eugenol fueron los más altos en T6 (HO-3). En cuanto al beneficio neto de la producción de albahaca canosa, T6 mostró el beneficio más alto de 94.965 baht/rai.

Implicaciones de la investigación: Se concluyó que los fertilizantes HO, como opciones de fertilizantes respetuosas con el medio ambiente, podrían mejorar de manera sostenible la calidad del suelo y HO-3, en particular, ha demostrado ser adecuado para la producción de albahaca canosa para proporcionar productos seguros y de alta calidad para los mercados nacionales e internacionales.

Originalidad/Valor: Este estudio destaca la efectividad de los fertilizantes de la OMS en el aumento de los rendimientos, el componente de rendimiento y los principios activos de la albahaca canosa.

Palabras clave: Fertilizante Orgánico Químico y Granular con Fórmula Hormona Mixta (HO), Albahaca Canosa, Eugenol y Metil Eugenol.

RGSA adota a Licença de Atribuição CC BY do Creative Commons (<https://creativecommons.org/licenses/by/4.0/>).



1 INTRODUCTION

Hoary basil (*Ocimum americanum* L.) is an important economic vegetable with edible greens and seeds. The plant has several medicinal properties. The leaf with a strong, sweet aroma can be used for improving appetite and deodorizing fishy smell, while the seeds with 80% fiber content are good for those going on a diet, and patients with diabetes who need to lower blood sugar (Abhaibhubejhr, 2022). It was previously cultivated for only domestic consumption. But now it has been expanded into international markets. However, excessive chemical residues found in produce can be an important problem in the production of vegetables and herbs in the future. Standard and safety for consumers are important goals in the production of herbs and vegetables. This practice goes in line with the National Strategy (2018-2037) on promoting safe agricultural production, which implements development planning starting from the farm level. In the production of the basil, large amounts of chemical fertilizers and pesticides are used, causing the soil quality to deteriorate and having a direct impact on the yield of basil. Consequently, the amount of chemical residues detected exceeds the export standard. According to the 2015 Annual Conference on Pesticides, it was found that produce in the Basil family had the highest excessive chemical residues by 62.5% (Thaipan, 2015). To become kitchen of the world, the quality and standards of agricultural products must therefore be taken into account from the farm level upwards, which can be met by using HO fertilizers, a novel innovation developed specifically for plants and soil (Jubkaew and Inthanon, 2012). HO is a controlled-release fertilizer that is made up of materials that provide all 16 essential nutrients mixed with organic matters, soil conditioners, effective microorganisms (EM), liquid organic hormones and



herbal extracts. It was found that HO fertilizers can increase plant growth and yield rates more effectively than chemical fertilizers. (Raksarikorn et al., 2012; Jubkaew and Inthanon, 2012; Phasee et al., 2013; Inthanon, 2013a; Inthanon, 2013b). However, to the best of my knowledge, HO fertilizers specially developed for hoary basil have yet to be studied. Thus, this paper was intended to develop suitable HO fertilizers for hoary basil production, to compare the developed fertilizer with commercial organic fertilizers and chemical fertilizers, and to study the effect of the HO fertilizers on soil properties in comparison to chemical fertilizers and organic fertilizers in terms of growth rate, produce quality, and costs and profits.

2 REVIEWS

Hoary basil (*Ocimum americanum* L.) is an important economic vegetable with edible greens and seeds. The plant has several medicinal properties. The leaf with a strong, sweet aroma can be used for improving appetite and deodorizing fishy smell, while the seeds with 80% fiber content are good for those going on a diet, and patients with diabetes who need to lower blood sugar (Abhaibhubejhr, 2022).

Therefore, the production of quality suitable for consumption and extraction of important substances for medical purposes is an important goal, starting from plot-level management, and fertilizer management is another important factor in increasing the yield of basil arachnids. Development of fertilizers with holistic properties to increase yields in both quantity and quality. With a focus on sustainable production and environmentally friendly, we have developed Chemical and Granular Organic Fertilizer with Hormone Mixed Formula or HO, which is an innovative fertilizer that combines all 16 essential nutrients according to the needs of each plant with effective microorganisms (EM), mixed with organic hormones, water, combined with herbal extracts, soil conditioners are placed in the same granule and coated with nutrient release regulators to have slow-dissolved fertilizer properties. Can be used on all plants Inthanon)2013b(

Rakrikkorn et al. (2012) studied the use of hormone fertilizer to mold pellets with compound formula instead of chemical fertilizer in rubber plantation appropriately. The RCBD experiment consists of 5 treatments, 4 replications, as follows: T0 without fertilizer (control), T1 HO-1, T2 HO-2, T3 HO-3 and T4)46-0-0(1-year-old rubber tree at the rate of 300 grams/tree and 4-year-old rubber tree at the rate of 1,000 grams/tree. The results of the experiment on 1-year-old rubber tree showed that T3,T1,T2,T4 and T0 the highest results,



respectively, and in 4-year-old rubber trees, T3, T4, T2, T1 and T0 showed the highest results, respectively. When considered, it was found that T3 HO-3. It is most appropriate to promote the replacement of chemical fertilizers for rubber. Age range 1-4 years.

Phasee et al. (2013) studied the influence of Chemical and Granular Organic Fertilizer with Hormone Mixed Formula)HO(on Growth, Yield and Starch Percentage. The RCBD experiment plan consisted of 8 treatments, 4 replications. By developing Chemical and Granular Organic Fertilizer with Hormone Mixed Formula)HO(for cassava according to the formula of Inthanon (2009), it was found that cassava growth in T4(HO-4) had the highest growth. The yield component includes the number of tubers per plant. Tuber length, tuber size, tuber fresh weight. The process with the highest starch percentage was T3 27.9%, not statistically significant difference with T4 26.9%, which is 23.9% higher than chemical fertilizer, while T0)Control) had the lowest yield of 1,380 kg/rai and the lowest starch percentage of 20.9%, respectively.

Chumman and Intanon (2016) studied the influence of Chemical and Granular Organic Fertilizer with Hormone Mixed Formula on rice growth and yield. Affect the Infestation load of BPH. The RCBD experiment plan consisted of 6 treatments, 3 replications, as follows: T1 without fertilizer (Control), T2 (46-0-0), T3 (46-0-0 50%+ 16-20-0 50%), T4 (HO-1), T5(HO-2) and T6(HO-3) with fertilizer at the rate of 50 kg/rai in all treatments. Divided into 2 times when the rice is 30 and 60 days. Tested in Chai Nat 1. It was found that the growth of T4 (HO-1) was the highest yield and Chemical and Granular Organic Fertilizer with Hormone Mixed Formula)HO(group T4-T6 compound yielded higher yields than the chemical fertilizer group T2-T3. By T4 (HO-1) 926.6 kg/rai, statistically significant difference from other. As for the influence of fertilizers on BPH resistance and pathogenesis, it was found that the number of BPH was the lowest in T4 and T6, so it was concluded that T4 improves yield and has an influence on reducing the destruction of BPH over chemical fertilizers and also helps to improve soil nourishment. In line with Monteiro (2023) has used bio-fertilizers to test the germination efficacy of seed gourds. It was found that the use of bio-fertilizers with concentrations of 50 and 75% proved to be efficient in the seed germination process and germination speed index. The 25% concentration of goat bio-fertilizer provided better performance in the morphological characteristics of jack bean seeds as well as Lima et al (2021) studied the effect of goat manure bio-fertilizer concentration between 46% (460 ml L⁻¹) to 48% (480 ml L⁻¹) to obtain pepper seedlings (*Capsicum frutescens* L.) with good phytotechnical quality, because in this



range the best results were found for most of the analyzed variables. The same applies to HO fertilizers, which contain bio- fertilizers, making them useful for plant growth development.

In recent years, the development of research aimed at promoting increasingly sustainable agriculture has become more common. It is possible to see research with the use of compost, soil conditioners, herb extract, plant growth hormone, bio-fertilizer (Inthanon, 2013b), among others, which show the interest of the agricultural sector in seeking alternative technologies that do not harm the environment. The use of HO fertilizer is a viable alternative that promotes the achievement of this objective. However, more research is needed on the effect of these compounds on plant development.

3 MATERIALS AND METHODS

The production of HO fertilizers started with preparing a binder with the mixture of herbal extract, liquid hormone and liquid bio-fertilizer in a ratio of 3:2:1. The prepared binder was then used to develop 3 formulas of HO fertilizers, namely HO-1, HO-2 and HO-3, as detailed in Table 1.

Table 1

Materials and the components of chemical and granular organic fertilizers with hormone mixed formula)HO(

Formula	Components of HO fertilizers (by weight kg.)						Total (kg)
	A	B	C	D	E	F	
HO-1	30	20	30	5	5	10	100
HO-2	35	15	25	5	10	10	100
HO-3	40	10	20	5	10	15	100

Remark: A = chemical fertilizer (25-7-7), B = compost, C = soil conditioner, D = herb extract, E = plant growth hormone, F = bio-fertilizer

Source: (Ragsarikorn, 2012; Chumman, 2016)

The experiments were carried out in an RCBD with 6 treatments 4 replications: T1-No Fertilizer)control(, T2-Chemical Fertilizer (15-15-15), T3-Fertilizer)organic(, T4 (HO-1), T5)HO-2) and T6 (HO-3). Seedlings were planted in seedling trays with loam soil, rice husk ash and coconut coir in an ratio of 1: 1: 1. After 30 days, the seedlings were transplanted in 96 plots of 4.8 m², each with 30 x 50 cm planting spacing and a 1.2 m² harvesting area. The treatments were given at the rate of 50 kg/rai, which was split for each use. The first treatment was given after 30 days of transplantation. The first harvest was done on day 80. After the first harvest,



branch pruning was done, and then the second treatment was given. The second harvest was done on day 120. The soil properties were analysed before and after the treatment. The fertilizer properties, growth rate at a 10-day interval, yield and yield components and active principles (eugenol and methyl eugenol) were analyzed by ANOVA, and compared by a DMRT method at the reliability of 95%. The experiments were conducted at Phrae Agricultural Research and Development Center between September 2020 and September 2021.

4 RESULTS AND DISCUSSION

4.1 RESULTS

During the experimental period between September 2020 – September 2021, the average minimum and maximum temperatures were 22.46 and 33.06 degrees Celsius, the average precipitation was 9.98 mm, and the average relative humidity was 52.02%, which is a favorable condition for the growth of hoary basil, according to Phrae Rice Research Center.

According to the soil analysis before the treatment, Mae Rim soil (Mr) was moderately fertile and slightly acidic with a shallow topsoil, a low amount of NPK macronutrients and organic matter, and low cation exchange capacity. After the experiment, T6)HO-3(resulted in the highest increase of macronutrients (N, P, K), secondary nutrients (Ca, Mg, S) and micronutrients compared to the other treatments, an increase in pH from 5.4 to 6.7, in OM content from 1.07% to 1.54%, and in EC from 0.55 mS/cm to 0.92 mS/cm. The soil bulk density (Db) decreased among all the treatment methods, compared to the soil before the experiment. The highest water holding capacity)WC%(was found in T6)HO-3(from 12.91% to 19.10% as shown in Table 2

Table 2

Analysis of soil properties before and after plantation

Treatment			Soil properties before	Soil properties after					
				T1	T2	T3	T4	T5	T6
Primary macronutrients	N	%	0.07	0.05 ^c	0.08 ^{ab}	0.06 ^{bc}	0.08 ^{ab}	0.07 ^{ab}	0.09 ^a
	P	%	16	20.0 ^e	85.0 ^{bc}	63.0 ^d	84.0 ^c	87.0 ^b	96.0 ^a
	K	%	99	90.0 ^e	143.0 ^b	121.0 ^d	135.0 ^c	145.0 ^b	164.5 ^a
Secondary macronutrients	Ca	mg/kg	497	450.0 ^f	483.3 ^c	621.8 ^d	666.0 ^b	627.0 ^c	674.0 ^a
	Mg	mg/kg	86	70.8 ^f	79.0 ^e	82.0 ^d	92.0 ^c	94.0 ^b	102.0 ^a
	S	mg/kg	3.17	0.15 ^e	0.18 ^e	1.83 ^d	4.65 ^c	5.62 ^b	6.30 ^a
Micronutrients	Fe	mg/kg	109	62.87 ^c	101.0 ^d	115.1 ^c	127.5 ^b	128.7 ^b	134.7 ^a
	Mn	mg/kg	62.88	29.8 ^e	38.4 ^d	23.7 ^f	75.5 ^c	76.8 ^b	82.3 ^a
	Zn	mg/kg	1.10	0.92 ^e	0.95 ^d	2.26 ^c	2.61 ^b	2.59 ^b	2.69 ^a



Cu	mg/kg	1.10	0.96 ^c	0.95 ^c	1.26 ^d	2.06 ^b	1.98 ^b	2.19 ^a
B	mg/kg	0.14	0.08 ^d	0.13 ^d	0.34 ^c	0.53 ^b	0.59 ^b	0.68 ^a
Organic Matter)OM(%		1.07	1.08 ^f	1.12 ^e	1.27 ^d	1.47 ^b	1.44 ^c	1.54 ^a
pH(soil : water = 1:1		5.4	5.5 ^d	5.3 ^e	6.2 ^c	6.4 ^b	6.7 ^a	6.7 ^a
EC. At 25°C		0.55	0.53 ^e	0.40 ^f	0.76 ^d	0.82 ^c	0.88 ^b	0.92 ^a
Water content)WC(%		12.91	18.07 ^{ab}	17.70 ^b	18.06 ^{ab}	18.18 ^{ab}	18.72 ^{ab}	19.10 ^a
Bulk Density)Db(g/cm ³		2.03	1.65 ^b	1.68 ^{ab}	1.69 ^a	1.68 ^{ab}	1.67 ^{ab}	1.69 ^a
Porosity)E(%		37.52	64.70	64.19	64.91	65.71	65.18	65.85

Source: Author 2024

According to the chemical properties analysis of HO-1, HO-2 and HO-3 fertilizers, T2 showed the highest macronutrients, followed by T6 (13.5-0.2-0.4%), T5 (7.9-0.2- 0.3%), T4 (7.4-0.2-0.3%) and T3 (1.3-3.8-0.3%) respectively, whereas T6 showed the highest secondary and micronutrient contents in all items (Table 3).

Table 3

Analysis of chemical properties of Ho fertilizer

Fertilizer/Treatment		Chemical Fertilizer	Organic Fertilizer	HO-1	HO-2	HO-3
Primary macronutrients	Total N (%)	15.5	1.3	7.4	7.9	13.5
	Total P (%)	15.4	3.8	0.2	0.2	0.2
	Total K (%)	15.4	0.3	0.3	0.3	0.4
Secondary macronutrients	Ca (%)	-	14.7	8.0	8.5	10.3
	Mg (%)	-	1.1	2.1	2.4	2.9
	S (%)	-	0.4	8.7	10.1	10.4
Micronutrients	Fe)mg/kg)	-	-	2.14	2.35	2.48
	Mn)mg/kg)	-	-	197.00	211.00	211.00
	Zn)mg/kg)	-	-	91.00	157.00	171.00
	Cu)mg/kg)	-	-	19.00	21.00	25.00
	Cl)mg/kg)	-	-	1.95	2.11	2.54
OM (%)		-	0.34	0.87	1.13	1.27
pH (1:1)		6.2	8.1	6.82	6.74	6.65
EC (1:10 dS/cm)		-	1.2	30.25	32.12	36.17
C/N ratio		-	0.40	0.07	0.06	0.04

Source: Author 2024

For the growth of hoary basil in terms of height, stem diameter, number of branches and canopy diameter, T6 and T5 showed the highest rate in all terms, with a statistically significant difference from the others (Table 4).



Table 4

Effect of chemical and granular organic fertilizers with hormone mixed formula (HO), chemical and organic fertilizers on vegetative growth of hoary basil

Treatment	Height (cm.)	Stem diameter (mm.)	No. of branches (branch)	Canopies diameter (cm.)
T1	44.14 ^c	5.23 ^c	10.81 ^{ab}	45.25 ^c
T2	45.54 ^{bc}	6.36 ^{ab}	10.00 ^b	47.30 ^{bc}
T3	44.81 ^{bc}	5.31 ^c	11.03 ^{ab}	46.13 ^c
T4	46.83 ^{bc}	6.12 ^b	10.94 ^{ab}	45.63 ^c
T5	51.92 ^a	6.46 ^{ab}	11.35 ^a	49.50 ^{ab}
T6	48.64 ^{ab}	6.91 ^a	11.73 ^a	50.97 ^a
F-test	4.12*	0.57*	1.06*	2.58*
C.V.)%(	5.81	6.27	6.43	3.60

Source: Author 2024

*Significant at 95% confident interval in each column of the same period, the different in small indicated significance at 95% ($p < 0.05$) by DMRT

The analysis of yield and yield components of the first harvest on day 80 showed that T6 had the highest leaf fresh weight (492.07 g) and dry weight (96.06 g) per harvest area, which was statistically significantly different from the other treatments (Table 5). In the first harvest, T6 showed the highest yield (1,118.1 kg/rai), with a statistically significant difference from the others)Table 6(. In the second harvest, T6 also showed the highest leaf fresh weight (829.86 g) and dry weight (144.31 g) per harvest area, which was statistically significantly different from the other treatments (Table 5). In terms of yield of the second harvest, T6 showed the highest (3,192.7 kg/rai), with a statistically significant difference from the others)Table 6(.

The analysis of the active principles in hoary basil including the amount of eugenol and methyl eugenol found that T6 had the highest values among the other treatments. The eugenol amounts were T6 (136.51). T5 (91.53), T2 (3.67), T4 (2.65), T3 (1.76) and T1 (1.04) $\mu\text{g/ml}$. Similarly, T6 had the highest amount of methyl eugenol (166.93), followed by T5 (163.11), T2 (111.35), T4 (67.30), T3 (30.44) and T1 (16.43) $\mu\text{g/ml}$. respectively (Table 7).

The analysis of costs and profits showed that T2 had the highest cost (17,000.0 baht/rai(, followed by T6 (16,780.0), T5 (16,700.0), T4 (16,650), T3 (16,350.0) and T1 (14,200.0), while T6 gained the highest profit)94,965 baht/rai(, followed by T2)85,218(, T5)78,808(, T4)76,720(, T3)51,974(and T1)46,553(respectively)Figure 2).



Table 5

Effect of chemical and granular organic fertilizers with hormone mixed formula (HO), chemical and organic fertilizer on yields component of lemon basil. First cut)80 day(and Second cut (120 day(

Treatment	Weigh)g/(1.2 m ²		Cut 2 nd	
	Cut 1 th			
	Fresh leaves)g(	Dry leaves)g(	Fresh leaves)g(	Dry leaves)g(
T1	314.00 ^c	63.84 ^b	380.37 ^c	74.10 ^c
T2	456.45 ^{ab}	83.02 ^{ab}	727.99 ^{ab}	139.26 ^{ab}
T3	347.76 ^{bc}	73.40 ^{ab}	433.18 ^c	78.36 ^c
T4	420.50 ^{abc}	80.44 ^{ab}	646.64 ^b	113.59 ^b
T5	440.20 ^{abc}	92.93 ^a	685.33 ^b	119.96 ^{ab}
T6	492.07 ^a	96.06 ^a	829.86 ^a	144.31 ^a
F-test	0.22*	0.18*	139.94*	29.12*
C.V.)%(	22.08	22.76	15.04	17.31

*Significant at 95% confident interval in each column of the same period, the difference in small indicated significance at 95% (p<0.05) by DMRT

Source: Author 2024

Table 6

Effect of chemical and granular organic fertilizers with hormone mixed formula (HO), chemical and organic fertilizer on yields of hoary basil

treatment	Yield No.1)kg./rai.(	Yield No.2)kg./rai.(	Total Yield)kg./rai.(
T1	784.9	950.9 ^c	1,735.8 ^c
T2	1,100.5	1,820.0 ^{ab}	2,920.5 ^{ab}
T3	869.2	1,082.9 ^c	1,952.1 ^c
T4	1,015.5	1,616.6 ^b	2,667.7 ^b
T5	1,051.1	1,713.3 ^b	2,728.8 ^{ab}
T6	1,118.1	2,074.6 ^a	3,192.7 ^a
F-test	438.2 ^{ns}	349.85*	499.6*
C.V.)%(	29.37	15.04	13.09

*Significant at 95% confident interval in each column of the same period, the difference in small indicated significance at 95% (p<0.05) by DMRT

Source: Author 2024

Table 7

Effect of chemical and granular organic fertilizers with hormone mixed formula (HO), chemical and organic fertilizers on active principles of hoary basil

Treatment	Eugenol (µg/ml)	Methyl Eugenol (µg/ml)
T1	1.04 ^f	16.43 ^f
T2	3.67 ^c	111.35 ^c
T3	1.76 ^e	30.44 ^e
T4	2.65 ^d	67.30 ^d
T5	91.53 ^b	163.11 ^b



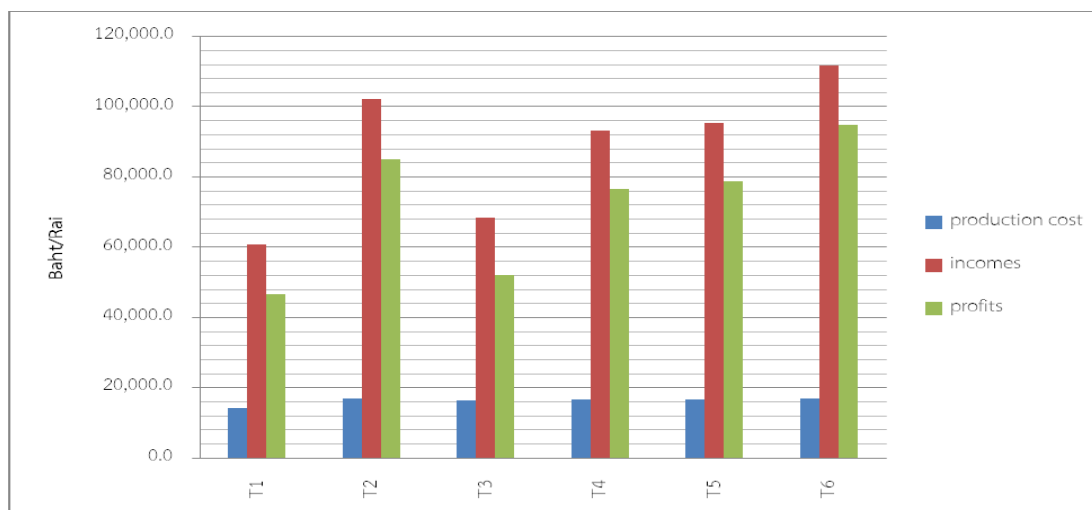
T6	136.51 ^a	166.93 ^a
F-test	0.51*	0.11*
C.V.%(	0.86	0.08

*Significant at 95% confident interval in each column of the same period, the difference in small indicated significance at 95% ($p < 0.05$) by DMRT

Source: Author 2024

Figure 1

The total production costs, incomes and profit of hoary basil production



Source: Author 2024

4.2 DISCUSSION

Before the treatment, Mae Rim soil (Mr) had a shallow topsoil with slight acidity, low amount of organic matters, moderate fertility and low macronutrients, but after the experiment, HO fertilizers showed a higher increase of macronutrients, secondary nutrients and micronutrients than the chemical treatment. In addition, a substantial rise in the amount of organic matter was found in the soil with HO fertilizers, being HO-2, HO-3 and HO-1, respectively. In terms of chemical properties (pH), it was found that HO fertilizers contained soil conditioners enriched with Ca (Inthanon, 2013a), thus helping to improve the soil acidity. As for the OM content in the soil, it was found to increase in the soil with HO fertilizer treatments because HO fertilizers contain organic matter constituents. This results in higher OM and nutrient content. This finding is in line with that of the EC. The physical properties were improved; for example, soil bulk density (Db) of HO fertilizer group decreased by 1.67-1.69 g/cm³, and soil porosity (E) increased by 65.18-65.85 percent, which is consistent with Raksarikorn et al. (2012) who found that the use of organic fertilizers can enhance soil structure conditions and physical properties, and boost plant nutrient uptake.



The developed HO fertilizers had a positive effect on the plant growth. The experiments showed that T6 and T5 had the highest growth rate in terms of height, stem size, number of branches and canopy size, but with no statistically significant differences. HO fertilizers was found to contain a variety of fertile materials, resulting in a high level of primary macronutrients, secondary macronutrients and micronutrients, such as Fe, Cu and Zn, providing balanced nutrients plants require in a synthesis process. An HO as a slow release fertilizer is thus suitable and effective for short-lived plants like hoary basil (Sharma, A. et al., 2017). Nitrogen is involved in cell elongation and cell division of plants, helping plants to grow in height. This is in accordance with a previous study (Sanjeeva Rao, P. et al., 1998) finding that nitrogen has a direct connection with plant cell division and a positive effect on plant growth rate. In this study, T6 in particular proved to be more effective than the other treatments in all aspects, and therefore positively affected the vegetation cover, number of branches and number of leaves)Hussein, M. M.et al., 2011(.

In terms of yield productivity and components, the HO fertilizers, especially T6, showed higher yield than purely chemical or organic fertilizers. This is due to various components of the HO fertilizers sufficiently available that enhance nutrient assimilation and plant yield, and seems to be consistent with a study by Ahmad, I. I. et al. (2011), showing that the use of organic extract fertilizers significantly stimulated PGRs which escalate nutrient transport and weight accumulation across the plant. The amount of EC and C/N ratios in the fertilizers are essential impacts on the plant metabolism that supplements nutrient assimilation and photosynthesis (Shadanpour, F. et al., 2011; Chuinon, C., and Inthanon, P., 2011). A finding in this study showing that T5 (HO-2) had the highest dry weight is concordant with that of Canellas, L. P. et al. (2002) which used humic acids extract from OM to stimulate H⁺-ATPase in the plasma membrane and oxygen in corn roots that help in root elongation. The study showed an statistically significant increase in total productivity.

Eugenol and methyl eugenol content was found the highest especially in T6, giving higher active principle than the purely chemical or organic fertilizer groups. This seemingly results from the fact that HO fertilizers are complete fertilizers that provide all vital nutrients, including primary macronutrients, secondary macronutrients and micronutrients. This also helps in photosynthetic efficiency and total organic matter accumulation in the plant that influence the plant quality and yield. With well-balanced nutrients, sufficient synthesis of carbon dioxide, water, sunlight and chlorophyll is reinforced (Jubkaew, S., and Inthanon, 2012), thereby resulting in a high level of organic matter in plants. A finding of this current study



showing that HO fertilizers had a positive effect on active principles goes along with a study conducted by Konchom et al. (2023) which found that eugenol and methyl eugenol were found highest under T6 (HO-3) with a statistically significant difference. This finding indicates that HO fertilizers positively affect accumulation of the plant organic matter.

As for the production cost, T2 had the highest cost (17,000.0 baht/rai), followed by T6 (16,780.0), T5 (16,700.0), T4 (16,650), T3 (16,350.0) and T1 (14,200.0), while T6 showed the highest profit of 94,965 baht/rai. HO fertilizers, as environmentally friendly fertilizing options, could sustainably enhance soil quality and HO-3, in particular, has proved to be suitable for hoary basil production to provide high quality, safe products for both domestic and international markets.

5 CONCLUSION AND RECOMMENDATIONS

1. The soil properties after the treatments (HO-1, HO-2 and HO-3) showed significant rise in primary macronutrients, secondary macronutrients and micronutrients.
2. The chemical and granular organic fertilizers (HO-1, HO-2 and HO-3) improved soil properties such as organic matters, electrical conductivity and pH value, which indirectly improved the soil physical properties and boosted the water holding capacity, resulting in better fertility.
3. T6 (HO-3) at the rate of 50 kg per rai had a high effect on yield and yield component. Also had the highest positive effect on proportions of crude extract, eugenol and methyl eugenol, showing a significant difference from all other treatments.
4. The T6 fertilizer (HO-3) at the rate of 50 kg per rai gave the highest profit at 92,620 baht per rai.

ACKNOWLEDGEMENTS

We would like to thank Department of Agricultural Sciences Faculty of Agriculture, Natural Resources and Environment Naresuan University and the Bureau of Agricultural Research and Development Region 1, Chiang Mai Province, for the assistance in providing us with the resources we needed to conduct the research.



REFERENCES

- Ahmad, I. I., ASIF, M., AMJAD, A., & Ahmad, S. (2011). Fertilization enhances growth, yield and xanthophyll contents of marigold. *Turk. J. Agric. For*, 35, 641-648.
- Abhaibhubejhr, (2022). Lemon basil herb in the kitchen : Good for blood and skin. Retrieved, April, 8,)2023(, from https://technologychaoban.com/bullet-new-today/article_107627/
- Canellas, L. P., Olivares, F. L., Okorokova-Façanha, A. L., & Façanha, A. R. (2002). Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane H⁺-ATPase activity in maize roots. *Plant physiology*, 130(4), 1951-1957.
- Chuinon, C., and Inthanon, P. (2011). Development of high quality bio-fertilizer for rice production. *Naresuan University Journal*, 19(2), 8-18.
- Chumman, W and Inthanon, P. (2016). Influence of Compounded Pellet Hormone Fertilizers on Growth and Yield and Affect the Infestation Load of BPH. *Agricultural Theme*. 44(2):65-274.
- Hussein, M. M., Sakr, R. A., Badr, L. A., & Mashat, K. M. A. L. (2011). Effect of some fertilizers on botanical and chemical characteristics of pot marigold plant (*Calendula officinalis* L.). *J. Hortic Sci. Ornament Plants*, 3, 220-231.
- Inthanon , P., (2012). Agricultural Development and Promotion Project. A case study of extension of Palm oil plantation in Sukhothai Province. Final report. Faculty of Agriculture Natural Resources and Environment. Naresuan University. 132 pp.
- Inthanon, P. (2013a). The Influence of Different Types of Fertilizer on Productivity and Quality of Maize in the Area of Kwaew Noi Dam, Phitsanulok Province, Thailand. *International Journal of Environmental and Rural Development*, 4. International Society of Environmental and Rural Development. Tokyo. 192 pp
- Inthanon, P. (2013b). Comparison of Fertilizer Management to Increase Yield and Quality of Rice. *International Journal of Environmental and Rural Development*, 4. International Society of Environmental and Rural Development. Tokyo. 192 pp
- Jubkaew, S. and Inthanon, P., (2012). Effect of granular organic fertilizer mixed with plant hormone on growth and yield of rice. *Khon kaen agriculture Journal*. Special edition Vol. 4 : 265-274
- Lima, D. F., de Jesus, A. C., de Almeida Veras, D., Pereira, R. Y. F., de Sousa Ramos, D., de Araújo Costa, E. W., ... and Serrano, L. J. P., (2021). Growing levels of goat biofertilizer in the initial growth of the pepper. *Revista Ibero-Americana de Ciências Ambientais*, 12(3), 63-71.
- Monteiro, S. S., Marini, F. S., da Silva Santos, D., Monteiro, S. S., de Lima, J. F., and de Lima, L. O., (2023). Effect of the Application of Biofertilizer Goatish as a Biostimulant on



Germination *Canavalia Ensiformis* L. *Revista de Gestão Social e Ambiental*, 17(1), e03153-e03153.

- Phasee, P., Trelo-ges, V., Dejbhimon, K. and Intanon, P.,)2013(. Effect of chemical fertilizer and chemical and granular organic fertilizer with hormone mixed formula on growth, yields and starch content percent of cassava. The 3rd National Soil and Fertilizer Conference proceeding. Faculty of Agriculture, khon kaen University, 25-27 April 2013. p. 35.
- Raksarikorn, C., Phasee, P. and Intanon, P., (2012). Effect of chemical fertilizer and chemical and granular organic fertilizer with hormone mixed formula on growth of rubber tree. *Naresuan University Journal* 20(3) : 18-28
- Konchom, R., Intanon, P. and Raksarikorn, C. Development of Chemical and Granular Organic Fertilizer with Hormone Mixed Formula (HO) for Productivity and Active Principle of *Ocimum basilicum* Linn.)Sweet basil(. In Proceeding Phetchabun Rajabhat University Conference (2023).)p.467-477(. PCRU : Faculty of Science technology
- Sanjeeva Rao, P., Saraswathyamma, C. K., & Sethuraj, M. R. (1998). Studies on the relationship between yield and meteorological parameters of para rubber tree (*Hevea brasiliensis*). *Agric. For. Meteorol*, 90, 235-245.
- Shadanpour, F., Torkashvand, A. M., & Majd, K. H. (2011). The effect of cow manure vermicompost as the planting medium on the growth of Marigold. *Annals of biological research*, 2(6), 109-115.
- Sharma, G., Sahu, N. P., & Shukla, N. (2017). Effect of bio-organic and inorganic nutrient sources on growth and flower production of African marigold. *Horticulturae*, 3(11), 43-51. doi: 10.3390/horticulturae3010011
- Van Scholl L and R Nieuwenhuis.)2004(. *Soil Fertility Management*. 4thed. Agromisa Foundation. Wageningen. 528 pp
- Thaipan, (2015(. Monitoring of pesticide residues in domestic vegetables in Thailand during 2015. Retrieved, April 8, 2023, from <https://www.thaipan.org/data/330>.