

Ảnh hưởng của một số phân hữu cơ vi sinh đến sinh trưởng và năng suất của măng tây xanh (*Asparagus officinalis* L.) trồng tại thành phố Quy Nhơn, tỉnh Bình Định

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TÓM TẮT

Cây măng tây (*Asparagus officinalis* L.), có giá trị dinh dưỡng cao và chứa nhiều chất có hoạt tính sinh học, được canh tác cách đây hơn 2000 năm và hiện trồng ở hơn 60 quốc gia. Du nhập vào nước ta từ những năm 1960 và trồng ở nhiều nơi nhưng chủ yếu ở tỉnh Ninh Thuận. Trong xu hướng sản xuất măng tây an toàn và bền vững, việc sử dụng loại phân hữu cơ vi sinh (HCVS) phù hợp giúp cải tạo đất, tăng chuyển hóa các chất giúp cây trồng hấp thụ dinh dưỡng tốt hơn là giải pháp hữu hiệu. Do đó, nghiên cứu được thực hiện nhằm đánh giá ảnh hưởng của một số loại phân HCVS trên thị trường đến sinh trưởng, năng suất chồi và chất lượng măng tây. Thí nghiệm được thiết kế theo khối hoàn toàn ngẫu nhiên của 5 công thức: 4 loại phân HCVS (Tribat T-MB, Đầu trâu HCMK7 Bokashi-Trichoderma+TE, Quế Lâm 01, Sông Gianh) và đối chứng - không bón phân HCVS. Mỗi công thức 3 lần lặp lại. Các chỉ tiêu sinh trưởng được đo bằng thước dây và thước Panme, hàm lượng diệp lục được xác định bằng máy so màu quang phổ, hàm lượng vitamin C xác định bằng sắc ký lỏng hiệu năng cao. Kết quả nghiên cứu cho thấy bón bổ sung phân HCVS đặc biệt phân HCVS Sông Gianh bước đầu giúp tăng chiều cao thân cây, hàm lượng diệp lục, đường kính thân, số thân (7,62 thân/cây), số chồi thu hoạch (7,9 chồi/cây), đường kính chồi (8,8 mm), trọng lượng chồi (12,55 g/chồi), hàm lượng vitamin C (341 mg/100g), năng suất thu hoạch trong 1 tháng đạt 1,6 tấn/ha. Vì vậy, bón bổ sung phân HCVS Sông Gianh bước đầu phù hợp với trồng măng tây xanh Hà Lan F1 Radius trong điều kiện canh tác ở thành phố Quy Nhơn, tỉnh Bình Định.

Từ khóa: *Cây măng tây (*Asparagus officinalis*), năng suất, phân hữu cơ vi sinh, sinh trưởng.*

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Effect of some micro-organic fertilizers on growth and spear yield of *Asparagus officinalis* L. planted in Quy Nhon city, Binh Dinh province

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ABSTRACT

Asparagus officinalis L. which is high in nutrient content and bioactive compounds was cultured more than 2000 years ago and planted in more than 60 countries. This plant was imported into Vietnam in the 1960s and grown in many provinces, mainly in Ninh Thuan province. Toward the safe and sustainable production of asparagus, the use of micro-organic fertilizer (MOF) is an effective solution. The experiment was designed to evaluate the effect of some MOFs on growth, spear yield and some quality indicators of asparagus spear. The experiment was laid out as a randomized complete block design with three replications of 5 treatments (4 different MOFs: Tribat T-MB, Bokashi-Trichoderma + TE, Que Lam 01, Song Gianh and control). The results showed that adding MOFs, especially Song Gianh MOF initially, increased stem height, chlorophyll content, stem diameter, number of stems (7.62 stems.crown⁻¹), number of harvested spears (7.9 spears.crown⁻¹), spear diameter (8.8mm), spear weight (12.55 g. spear⁻¹), vitamin C content (341 mg.100g⁻¹), and spear yield in 1 harvest month was 1.6 tons/hectares. Therefore, the Song Gianh micro-organic fertilizer is concluded as initially suitable to asparagus cultivation in the local conditions.

Keywords: *Asparagus officinalis*, micro-organic fertilizer, spear yield, growth.

1. INTRODUCTION

Asparagus (*Asparagus officinalis* L.) which belongs to Lily family (Liliaceae) is originated from the eastern Mediterranean and Asia Minor. This perennial herb has been cultivated for more than 2000 years ago. Recently, more than 60 countries around the world have grown asparagus including the United States, Italy, Netherlands, Canada, Germany and other western developed countries. The cultivation, processing and scientific research of asparagus have extended to developing countries. China and Peru have become the world's largest exporters of asparagus, taking over two-thirds

world export market.¹ Asparagus is rich in protein, fat, vitamins and mineral, and its contents are five times higher than these of other normal vegetables.² Asparagus has also been used as medicine since ancient times. 94 different bioactive compounds of asparagus spears have been identified,³ including steroidal saponins (asparagositides), polyphenols, anthocyanins, fructans (asparagose and asparagositine), ferulic acid, minerals, vitamins and flavonoids, etc. with many pharmacological effects such as antitumor, antibacterial, antioxidant, hypolipidemic, diabetes, decompression, immunomodulatory, antiepileptic and other effects.⁴⁻⁶ Asparagus

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was imported to Vietnam in the 1960s and the cultivation regions are increasingly expanding.⁷ Ninh Thuan province is considered as a main region for asparagus cultivation with approximately 411 hectares. Meanwhile, Binh Dinh province has suitable natural conditions for asparagus growth, but its cultivation has currently only been researched and piloted. The field production is not yet conducted.

The use of chemical fertilizers for farming is currently increasing in Asia. Asian countries have used over 250 kg of NPK per hectare in 2020, as twice the world average level.⁸⁻⁹ Long-term use of chemical fertilizers has contributed to negative consequences, including reducing the soil organic matter content, declining agricultural soil quality, increasing in soil acidification and environmental pollution.^{10,11} Recent trends of agriculture in the world as well as in Vietnam are towards safe and sustainable agriculture. Chemical fertilizers could be replaced by micro-organic fertilizers (MOFs) to yield positive impacts. MOFs are rich in organic matter and nutrient elements that improve many soil aspects, such as soil physical properties, porosity, soil microbial community structure and biochemical properties. In addition, MOFs also contain microbes that prevent diseases and increase plant resistance, enhance agricultural product quality, provide 30-60 kg of N per year, improve fertility, and increase the amount of humus in the soil.^{8,9} The microorganisms in MOFs have the ability to mobilize, facilitate unavailable soil nutrient availability to become available form for better absorption and increase the effectiveness of inorganic fertilizers.¹²⁻¹⁴ Moreover, MOF trade marks on market are very diverse and finding suitable MOF for crop and cultivation soil is important. The objective of this study is to evaluate the effects of some MOFs on the growth and spear yield of asparagus, for contributing to eliminate the chemical fertilizers use, to improve the soil properties and the sustainability of asparagus cultivation in local area.

2. MATERIALS AND METHODS

2.1. Materials

Radius F1 green asparagus variety is originated from Netherlands. Three months asparagus crowns that were provided by Linh Dan Ninh Thuan Co., Ltd., have appropriately grown in local conditions with high spear yield, high quality and economic efficiency.

Fertilizers used include: NPK 16:16:8+TE fertilizer (Garsoni Vietnam Co. Ltd.), Tribat T-MB MOF (Green Saigon Biotechnology Co., Ltd.), Bokashi-Trichoderma + TE MOF (Binh Dien Fertilizer JSC.), Que Lam 01 MOF (Que Lam Group JSC.), Song Gianh MOF (Song Gianh Corporation). These are popular micro-organic fertilizers on Vietnam market with high quality and trusted by farmers.

2.2. Methods

2.2.1. Experimental design

The experiment was carried out from February to June 2020 at the Experimental and research garden for Biology and Agriculture at Quy Nhon University (13.758511N, 109.216792E). The experiment used sandy soil with 86% sand and 0.5% humus. The weather condition includes average temperature of 28.9 - 30.1 °C, average humidity of 72-78%, total rainfall of 88 mm per month, and total sunshine hours of 224 hours per month.

The experiment was laid out as a randomized complete block design with 5 treatments (Treat.) and three replications. The basal fertilizer consists of 20 tons of manure + 1.200 kg NPK 16:16:8+TE fertilizer per hectare (400 kg for soil preparation and 800 kg for experiment period, according to the cultivation process proposed by the Linh Dan Ninh Thuan Co., Ltd.).¹⁵ The MOFs tested include 4 supplemental MOFs and NPK fertilizer used as the control. The amount applied that is average dose of manufacturer's instructions, were calculated for 5 experiment months (Table 1).

Table 1. Definition of treatments

No.	Treat.	MOF kind, descriptions and dose of experimented fertilizer
1	Treat.1 (Control)	3.6 kg of NPK fertilizer 16:16:8+TE, including N (16%), P_2O_5 (16%), K_2O (8%), MgO (2%), B (100 ppm), Zn (100ppm), Fe (100 ppm), Mn (100 ppm).
2	Treat.2	NPK fertilizer (Control) + 30kg of Tribat T-MB MOF, including organic matter (15%), N (1%), P_2O_5 (1%), K_2O (1%), <i>Trichoderma sp.</i> (1×10^6 CFU/g), pH_{H_2O} (≥ 5), humidity (30%).
3	Treat.3	NPK fertilizer (Control) + 15kg of HCMK7 Bokashi-Trichoderma+TE MOF, including organic matter (18%), N (2%), P_2O_5 (2%), pH_{H_2O} (5), B (300 ppm), Cu (300 ppm), Zn (500 ppm), <i>Trichoderma sp.</i> (1×10^6 CFU/g), humidity (30%).
4	Treat.4	NPK fertilizer (Control) + 48kg of Que Lam 01 MOF, including organic matter (15%), nitrogen fixing microorganisms (1×10^6 CFU/g), Phosphate solubilizing microbes (1×10^6 CFU/g), cellulose degrading microbes (1×10^6 CFU/g); Ca, Mg, S, B, Cu, Fe, Mn, Zn, humic acid, and growth regulator, humidity ($\leq 30\%$).
5	Treat.5	NPK fertilizer (Control) + 45 kg of Song Gianh MOF, including organic matter (15%), P_2O_5 (1.5%), humic acid (2.5%), Ca (1%), Mg (0.5%), S (0.3%), <i>Bacillus</i> (1×10^6 CFU/g), <i>Azotobacter</i> (1×10^6 CFU/g), <i>Aspergillus sp.</i> (1×10^6 CFU/g), pH_{H_2O} (5), humidity (30%).

The experiment area of 200 m² included protection path around with 3 blocks of 50 m² (5.5 m in width and 9.0 m in length). Each block consisted of five plots/beds (5 m in length and 1.2 m in width) where we transplanted one row of 10 asparagus crowns with 50 cm between crowns, equivalent of 17.000 crowns per hectare.

2.2.2. Cultivation process

Soil preparation: the soil is plowed 30 cm in deep, chopped, removed weeds and stones, diged a trench of 40 cm in wide and 30 cm in deep, interspace of 1.2 m. We put basal fertilizer to trench, added 1,200 kg of lime powder per hectare and trichoderma inoculant. After fertilizing, the soil was digged 2-3 times and dried for 30 days before transplanting.^{7,15}

Transplanting, fertilizing and caring (according to instructions of Linh Dan Ninh Thuan Co., Ltd.):¹⁵ The bed was digged the holes of 40x40cm with 50 cm apart. The corresponding fertilizer of each treatment was laid into holes and mixed with soil. Then, asparagus crowns were vertically transplanted so that the stem

base is 10cm above the natural ground. The root was covered by soil layer of 5-10 cm in thick to protect the root neck and hold the stems upright. After transplanting, we plugged two stakes and used nylon line tentioned to prevent falling trees. During growing, it is necessary to gradually raise the line for keeping the stems always upright. Plants were daily watered by the drip irrigation system in the morning to maintain the humidity of 60-70%. For each 15 days, plants were periodically fertilized and pruned the branches below 50 cm and the weak and old stems. 4-6 healthy stems per asparagus crown were kept for spear production. We cut the stem apex over 1.5 m in high for promoting spear emergence. It is necessary to regularly visit field for catching asparagus pests and treating diseases, such as soil worms, asparagus beetle, beet armyworm, green worms, and anthracnose.^{7,16}

Harvesting: The asparagus spears were daily harvested since the 5th month after transplanting. After 15 days harvesting, the fertilizer with equal dose in the first month was applied. After a harvest month, it is necessary

to stop harvesting spears for replacing the old, weak and diseased asparagus stems.

2.2.3. Indicators and measurement

Growth and development characteristics: we marked 5 crowns in each plots (equivalent of 15 crowns for a treatment). The stem growth of marked crowns were measured every 4 days, including stem height (cm): distance from the ground level to stem apex, using a tape measure; Stem diameter (mm) measured at 2 cm above ground level with a micrometer; Number of pruned stems (pruned stems.crown⁻¹); Stem number per crown (stems.crown⁻¹); The leaf chlorophyll content determined by using spectrophotometry.

Spear yield parameters: Spear diameter (cm) measured at spear butt (about 2 cm above ground level) with a micrometer; Number of harvested spears per crown (harvested spears.crown⁻¹): number of harvested spears with 25-30 cm in length until the end of 5th month after transplanting (June 30, 2020); Ratio of market spears (%) = (Number of each spear grade divides to total number of harvested spears) x 100. There are 3 spear grades, including grade I spears (9-12 mm in diameter or more and 19-23 cm in length), grade II spears (6-9 mm in diameter and 19-23 cm in length), grade III spears (3-6mm in diameter and 17-23 cm in length); average spear weight (g.spear⁻¹): average weight of harvested spear; Net spear yield (tons.ha⁻¹): total weight of harvested spears of treatment was converted to unit of ton.ha⁻¹; Economic profit = Total revenue – total cost.

Quality properties: Dry matter content (%): asparagus spears were dried at 103 °C to constant weight for 72 hours; Fiber content (%): according to FAO test method 14/7 p.230-231 (1986);

Protein content (mg.100g⁻¹) was determined according to the FAO test method 14/7 p.221-223 (1986); Vitamin C content (mg.100g⁻¹ fresh spear) was determined by using high performance liquid chromatography (TCVN 8977:2011).

2.2.4. Statistical analysis

The data of results were analyzed by using MS. Excel 2007 and Statistix (ver. 8.0). The experimental results were statistically analyzed by one-way ANOVA analysis with LSD (least significant difference) test for multiple comparisons at a 5% significance level.

3. RESULTS AND DISCUSSIONS

3.1. Asparagus stem growth

Three months asparagus plants which grown in the nursery were dug and cut off whole stems. After transplanting in the experimental field, asparagus crowns sprouted first spear and second spear at 7-10 days and 30-35 days after transplanting, respectively. The spears became stems during growth times. The heights of first stems and second stems at different growth times are shown in Table 2.

The data in Table 2 show that asparagus stem height increased sharply at 8-12 days after sprouting (DAS) and slowed down after that. The second stems are higher than first stems measured at same DAS. The growths of first stems and second stems of treatments were not statistical different. The height is 110.27 - 124.6 cm for first stems and 134.57- 147.13 cm for second stems. Except for Treat.5, first stems had superior height of 124.6 cm after 16 DAS. So, the asparagus crowns used the nutrients from rhizomes and soil fertilizer. The microorganisms in MOFs did not affect on plant growth in the early period after transplanting.

Table 2. Height of first stems and second asparagus stems at different growth times (cm)

Treat.	First stems				Second stems			
	4 DAS	8 DAS	12 DAS	16 DAS	4 DAS	8 DAS	12 DAS	16 DAS
Treat.1	4.57 ^b	61.9 ^c	102.57 ^b	110.27 ^b	42.0 ^a	101.3 ^a	125.67 ^b	134.57 ^b
Treat.2	5.14 ^b	68.87 ^{bc}	102.9 ^b	111.17 ^b	41.47 ^a	101.9 ^a	128.1 ^{ab}	139.2 ^{ab}
Treat.3	5.21 ^b	73.6 ^b	104.33 ^b	112.43 ^b	40.77 ^a	102.23 ^a	129.8 ^{ab}	142.13 ^{ab}
Treat.4	7.52 ^{ab}	75.59 ^b	105.1 ^b	111.07 ^b	47.37 ^a	109.23 ^a	135.4 ^a	147.13 ^a
Treat.5	8.97 ^a	90.4 ^a	115.87 ^a	124.6 ^a	41.37 ^a	103.93 ^a	133.5 ^{ab}	142.67 ^{ab}
CV(%)	9.05	18.46	12.19	11.6	8.82	11.19	10.16	11.08
LSD_{0.05}	3.15	9.96	9.43	9.62	8.94	8.45	9.65	11.38

Note: Mean followed by the same letter is not significantly different within the columns according to LSD test at a 5% significance level; CV (coefficient variance); DAS is the day after sprouting.

3.2. Asparagus stem diameter

The stem diameter is an important growth indicator. At 40 days after transplanting, asparagus crowns had 3 stems. The results of the stem diameters are shown in Table 3.

Table 3. Effect of MOFs on asparagus stem diameter (mm)

Treat.	First stems	Second stems	Third stems
Treat.1	5.03 ^a	6.63 ^b	7.37 ^b
Treat.2	5.13 ^a	6.77 ^{ab}	8.77 ^a
Treat.3	5.13 ^a	7.2 ^{ab}	8.77 ^a
Treat.4	5.17 ^a	7.1 ^{ab}	8.57 ^a
Treat.5	5.33 ^a	7.37 ^a	8.97 ^a
CV(%)	16.03	13.94	15.86
LSD_{0.05}	0.60	0.71	0.98

Note: Mean followed by the same letter is not significantly different within the columns according to LSD test at a 5% significance level; CV (coefficient variance).

The data in Table 3 show that the stem diameter increased gradually through stem sets. In the first stems, there was no significant difference in stem diameter between the treatments. In the second stems and third stems, the asparagus stem diameter was different between the treatments. The treatments supplemented with MOFs had

larger stem diameter compared with control and the Treat.5 had superior stem diameter (7.37 mm for the second stems and 8.97 mm for third stems). Thus, the additional MOFs affected on the asparagus growth as increasing the stem diameter, and the Song Gianh MOF is initially more suitable for green asparagus than other MOFs. Because of MOF compositions, especially Song Gianh MOF provided a large amount of organic matter and mineral elements N, Mg, S, P, the additional microorganisms which promoted the ability converting and using carbon sources, soil nutrition,¹⁴ fixed nitrogen for better absorption.¹⁷ Furthermore, the humic acid enhanced the micro and macronutrients absorption,¹⁸ thereby promoting plant growth.^{19,20}

3.3. Leaf chlorophyll content and number of asparagus stems

Leaf chlorophyll content at 50 days after transplanting was shown in Table 4. The analysis results showed that the leaf chlorophyll content of treatments were statistically significant difference. The chlorophyll content of treatments supplemented with MOFs was higher than those of control. In which, Treat.5 had the highest chlorophyll a and chlorophyll b content (0.89 and 2.43 mg.g⁻¹ fresh leaf weight, respectively) and the lowest in control (1.52 mg.g⁻¹ fresh leaf weight). The MOF addition, especially additional

Song Gianh MOF provided supplemental Mg, S, K and microorganisms that improve nutrients and mineral absorption.^{14,20} The mineral elements

(Potassium and Sulfur) activated the enzymes that catalyze chlorophyll synthesis and Nitrogen is also an essential component of chlorophyll.²¹

Table 4. Effect of MOFs on leaf chlorophyll content, stem number and number of pruned stems

Treat.	Number of pruned stems (pruned stems.crown ⁻¹)	Stem number (stems.crown ⁻¹)	Chlorophyll a (mg.g ⁻¹)	Chlorophyll b (mg.g ⁻¹)	Chlorophyll a+ b (mg.g ⁻¹)
Treat.1	4.36 ^a	6.27 ^{ab}	1.04 ^e	0.48 ^e	1.52 ^d
Treat.2	4.00 ^a	5.67 ^b	1.07 ^d	0.50 ^d	1.57 ^c
Treat.3	4.67 ^a	6.67 ^{ab}	1.42 ^c	0.76 ^c	2.18 ^b
Treat.4	4.31 ^a	7.23 ^{ab}	1.62 ^a	0.80 ^b	2.42 ^a
Treat.5	4.15 ^a	7.61 ^a	1.54 ^b	0.89 ^a	2.43 ^a
CV(%)	13.63	11.62	0.52	1.53	0.76
LSD _{0.05}	2.00	2.03	0.01	0.02	0.3

Note: Mean followed by the same letter is not significantly different within the columns according to LSD test at a 5% significance level; CV (coefficient variance).

During asparagus growth, the weak, old and diseased stems are pruned and the healthy stems were kept for spear production. The number of stems pruned and the number of stems kept for four months after transplanting are presented in Table 4. The data in Table 4 show that the number of pruned stems in the treatments were stable (4-4.46 pruned stems.crown⁻¹) and the means are not statistical significant difference. However, the number of healthy stems kept was

different between the treatments, and Treat.5 had the highest number of stems (7.61 stems.crown⁻¹) and Treat.2 had the lowest number of stems (5.67 stems.crown⁻¹).

3.4. Asparagus spear yield and yield parameters

Since 5th month after transplanting, asparagus crowns produced harvest spears. The number, diameter and weight of harvested spears are statistically analyzed and presented in Table 5.

Table 5. Effect of MOFs on asparagus spear yield components in one harvest month

Treat.	Number of harvested spears (harvested spears.crown ⁻¹)	Spear diameter (mm)	Spear weight (g.spear ⁻¹)	Spear yield (tons.ha ⁻¹)	Total market spears (spears)	Rate of market spear grades (%)		
						Grade I	Grade II	Grade III
Treat.1	5.3 ^c	6.89 ^b	9.31 ^b	0.78	75	15.39	53.84	30.77
Treat.2	5.63 ^b	7.29 ^a	11.04 ^{ab}	1.04	85	30.77	38.46	30.77
Treat.3	6.1 ^b	7.39 ^a	11.77 ^{ab}	1.18	90	15.39	69.22	15.39
Treat.4	6.8 ^a	8.58 ^a	12.5 ^{ab}	1.39	100	31.58	57.89	10.53
Treat.5	7.9 ^a	8.8 ^a	12.55 ^a	1.6	115	44.44	38.89	16.37
CV(%)	17.48	10.94	15.30	-	-	-	-	-
LSD _{0.05}	1.28	1.99	1.	-	-	-	-	-

Note: Mean followed by the same letter is not significantly different within the columns according to LSD test at a 5% significance level; CV (coefficient variance).

The number of harvested spears of each crown in treatments had a significant difference. The treatments complemented with MOFs had higher number of harvested spears compared with the control (5.3 harvested spears.crown⁻¹) and the Treat.5 had a highest harvest spears (7.9 harvested spears.crown⁻¹), followed by Treat.4 (6.8 harvested spears.crown⁻¹), Treat.3 (6.1 harvested spears.crown⁻¹), Treat.2 (5.63 harvested spears.crown⁻¹). The diameter and weight of harvested spears in treatments supplemented with MOFs were also higher than those in the control, but the difference was not statistical significant. However, the harvested spears of Treat.5 possessed the best diameter and weight (8.8 mm and 12.55 g.spear⁻¹, respectively), followed by Treat.4 (8.58mm and 12.5 g.spear⁻¹), Treat.3 (7.39 mm and 11.77 g.spear⁻¹), Treat.2 (7.29 mm and 11.04 g.spear⁻¹) and the smallest harvested spears in control (6.89 mm and 9.31 g.spear⁻¹, respectively).

The data collected from 15 asparagus crowns of each treatment showed that the total number of harvested spears and the rate of spear market grades at treatments supplemented with MOFs were higher than those in the control. Treat.5 had the best results (115 harvested spears, 44.44% grade I spears and 38.89% grade II spears), followed by Treat.4 (100 harvested spears, 31.58% grade I spears and 57.89% grade II spears). Asparagus spear yield for one harvest month was highest in Treat.5 (1.6 tons.ha⁻¹.month⁻¹), followed by Treat.4 (1.39 tons.ha⁻¹.month⁻¹), Treat.3 (1.18 tons.ha⁻¹.month⁻¹), treat.2 (1.04 tons.ha⁻¹.month⁻¹) and the lowest spear yield in control (0.78 tons.ha⁻¹.month⁻¹).

The experimental results could be explained by the supplemental MOFs, especially Song Gianh MOF and Que Lam 01 MOF that provide nutrients and other utilities. The additional microbiome promote metabolizing nutrients,¹³ fixing nitrogen.¹⁷ Moreover, the

humic acid enhances micro and macronutrients absorption.¹⁸ These factors consequently increase the chlorophyll content, synthesis of organic compounds,¹⁹ and nutrient accumulation in the spears. So, the diameter, weight and number of harvested spears were enhanced.

3.5. Asparagus spear quality

The analysis data of asparagus spear quality was presented in Table 6. The dry matter content of spears ranged from 8.34 to 9.54% and the treatments supplemented with MOF had higher dry matter content than that in control, but there is not statistically significant difference. The fiber content of spears (2.0 - 2.2%) and total protein (1.8 - 2.2%) decreased slightly in the treatments supplemented with MOFs, but the difference was not statistical significant. The vitamin C content of asparagus spears in treatments supplemented with MOF is higher than that in control (278 mg.100 g⁻¹ fresh spears) and Treat.5 had the highest content (341 mg.100 g⁻¹ fresh spears).

Table 6. Effect of MOFs on quality characteristics of asparagus spears

Treat.	Dry matter content (%)	Fiber content (%)	Total protein content (%)	Vitamin C (mg.100g ⁻¹)
Treat.1	8.34 ^b	2.2	2.2	278
Treat.2	9.16 ^{ab}	2.2	2.1	282
Treat.3	9.26 ^{ab}	2.1	2.0	321
Treat.4	9.59 ^a	2.1	2.1	318
Treat.5	9.54 ^a	2.0	1.8	341
CV(%)	6.68	-	-	-
LSD_{0.05}	1.12	-	-	-

Note: Mean followed by the same letter is not significantly different within the columns according to LSD test at a 5% significance level; CV (coefficient variance).

3.6. Profit of asparagus cultivation

Table 7. Effect of MOFs on cost and profit of asparagus cultivation

Unit: 1,000 VND

Treat. Costs	Treat. 1	Treat. 2	Treat. 3	Treat. 4	Treat. 5
Crowns	360	360	360	360	360
NPK fertilizer	43.2	43.2	43.2	43.2	43.2
Labor	200	200	200	200	200
Manure	84	84	84	84	84
Trichoderma	75	75	75	75	75
Other costs	70	70	70	70	70
MOF	0	390	300	576	540
Total cost	832	1,222	1,132	1,408	1,372
Total income	105	129	138	203	214
Profit compared with control	0	24	33	98	109

Note: Asparagus spear price of current market at Quy Nhon city): Grade I (120,000 VND.kg⁻¹), Grade II (70,000 VND.kg⁻¹), Grade III (40,000 VND.kg⁻¹).

Asparagus culture needs a high initial investment but the harvest time is long, possibly up to 5-7 years.⁷ Total cost and total income (for a harvest month) in treatments are shown in the Table.7. Research data shows that the profit of treatment complemented with MOF is higher than that in control. The highest profit is in Treat.5 (109,000 VND), followed Treat.4 (98,000 VND), Treat.3 (33,000 VND) and Treat.2 (24,000 VND).

4. CONCLUSIONS

MOF complementation, especially Song Gianh MOF during asparagus cultivation stages initially enhanced the stem height, stem diameter, chlorophyll content, number of stems (7.62 stems.crown⁻¹), number of harvested spears (7.9 harvested spears.crown⁻¹), average spear diameter (reaching to 8.8 mm), spear weight (12.55 g.spear⁻¹), vitamin C content (reaching 341 mg.100g⁻¹), asparagus spear yield reaching 1.6

tons.ha⁻¹ for one harvest month. It is proposed to continue further studies on using supplemental Song Gianh MOF in the cultivation process of Netherland F1 Radius green asparagus to assess completely its suitability for asparagus cultivation conditions in Quy Nhon city, Binh Dinh province.

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REFERENCES

1. J. Schwarz, E. Mathijs. Globalization and the sustainable exploitation of scarce groundwater in coastal Peru, *Journal of Cleaner Production*, **2017**, 147, 231-241.
2. S. Hu. Asparagus - the king of vegetables, *China Inspection and Quarantine*, **2000**, 46 [in Chinese].
3. C. Jiménez-Sánchez, J. Lozano-Sánchez, C. Rodríguez-Pérez, A. Segura-Carretero, A. Fernández-Gutiérrez. Comprehensive, untargeted, and qualitative RP-HPLC-ESI-QTOF/MS2 metabolite profiling of green asparagus (*Asparagus officinalis*), *Journal of Food Composition and Analysis*, **2015**, 46, 78-87.
4. A. E. Al-Snafi. The pharmacological importance of *Asparagus officinalis* – A review, *Journal of Pharmaceutical Biology*, **2015**, 5(2), 93-98.
5. Q. Guo, N. Wang, H. Liu, Z. Li, L. Lu and C. Wang. The bioactive compounds and biological functions of *Asparagus officinalis* L. – A review, *Journal of Functional Foods*, **2020**, 65, 103727.
6. J. S. Negi, et al. Chemical constituents of Asparagus, *Pharmacogn Rev*, **2010**, 4(8), 215-220.
7. L. Cam and Le Hong Trieu. *Techniques for planting and growing green asparagus (Asparagus)*, Hai Phong publishing house, 2011 [in Vietnamese].
8. Le Thi Thu Tra. *Micro-organic fertilizers and bio-organic fertilizers in agricultural production*,

- Western highlands Agriculture and forestry science Institute (WASI), 2016 <<http://wasi.org.vn/phan-huu-co-vi-sinh-va-huu-co-sinh-hoc-trong-san-xuat-nong-nghiep/>>, accessed on 2nd December 2020 [in Vietnamese].
9. Nguyen The Dang, Nguyen Tuan Anh, Nguyen Duc Nhuan and Nguyen Thi Mao. *Organic agriculture textbook*, Agricultural publishing house, Hanoi, 2012 [in Vietnamese].
 10. C. Lazcano, M. Gómez-Brandón, P. Revilla, J. Domínguez. Short-term effects of organic and inorganic fertilizer on soil microbial community structure and function, *Biol Fertil Soils*, **2012**, 49, 723–733.
 11. C.-c. Ning, P.-d. Gao, B.-q. Wang., W.-p. Lin, N.-h. Jiang, and K.-z. Cai. Impacts of chemical fertilizer reduction and organic amendments supplementation on soil nutrient, enzyme activity and heavy metal content, *Journal of Integrative Agriculture*, **2017**, 16(8), 1819-1831.
 12. M. Diacono, F. Montemurro. Long-term effects of organic amendments on soil fertility, A review, *Agronomy for Sustainable Development*, **2010**, 30, 401-422.
 13. Pham Tien Hoang. Organic fertilizers in the integrated plant nutrient management system. *Journal of Soil Science*, **2003**, 8, 120 – 126 [in Vietnamese].
 14. H. Ke, H. HuaXing, L. WeiSheng, L. YuanJin, W. LiBin. Effect of microbial organic fertilizer application on soil microbial activity, *Chinese Journal of Eco-Agriculture*, **2010**, 18(2), 303-306.
 15. Nguyen Van Tam. *Techniques for planting and asparagus intensive farming (Internal documentation)*, Linh Dan Ninh Thuan Co. Ltd., 2017 [in Vietnamese].
 16. C. Quansheng. Technical specifications about control of diseases and pests in green asparagus, *Anhui Agricultural Science Bulletin*, **2007**, 18.
 17. K. Blankenau, H.W. Kuhlmann, H. Olf. Effect of microbial nitrogen immobilization during the growth period on the availability of nitrogen fertilizer for winter cereals, *Biology and Fertility of Soils*, **2000**, 32, 157–165.
 18. Z. Varanini and R. Pinton. *Humic acid substances and plant nutrition*, In: Behnke HD., Lüttge U., Esser K., Kadereit J.W., Runge M. (eds) *Progress in Botany*, Springer, Berlin, 1995.
 19. Y. Chen, C. Clapp, H. Magen. Mechanisms of plant growth stimulation by humic substances: the role of organo-iron complexes, *Soil Science and Plant Nutrition*, **2004**, 50, 1089 -1095.
 20. S. Nardi, D. Pizzeghello, A. Muscolo, A. Vianello. Physiological effects of humic substances on higher plants, *Soil Biology and Biochemistry*, **2002**, 34, 1527–1536.
 21. H. Marchner. *Mineral nutrition of higher plant*, Institute of plant University of Hohenheim, Federal Republic of Germany, 1996.