Increase of Coriander Yield by Using Bio-Extract from Sensitive Plant

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Abstract

Bio-extract from sensitive plant has been shown to be beneficial for the growth of several vegetables. In this study, the effects of bio-extract from sensitive plant on fresh weight of coriander were determined under field conditions. The experiments were carried out by diluting the bio-extract from sensitive plant with water at the concentrations of 1:50, 1:100, 1:500 and 1:1,000 and then applied to the coriander in a completely randomized design with four replications, ten plants per replication. Five hundred milliliters of bio-extract were applied to coriander plants every six days for five times. The experiments were conducted from August 2019 to May 2020 at the agricultural field station of the Department of Agricultural Technology, Mahasarakham University. After planting, the analyzed data of bio-extract results showed that diluted bio-extract at the concentration of 1:50 could increase the contents of nitrogen and potassium in soil when compared to the control (no added of bio-extract). In addition, the levels of pH and EC in soil treated with diluted bio-extract were significantly lower ($p < 0.01$) than the control. Also, the coriander plants that were treated with diluted bio-extract at the concentration of 1:500 were found to have the maximal fresh weight of 20.55 g per plant at 45 days after planting. This study therefore suggested that the bio-extract from sensitive plant could be beneficial effect for increasing the yield of coriander.

Keywords: Coriander, Bio-extract, Sensitive plant, coriander, organic matter

Introduction

Coriander (*Coriandrum sativum* L.) is an annual vegetable in the Apiaceae family. The entire parts of this plant, including leaf, root and seed, have been used to enhance the flavour of a various Thai foods (Ahmad, Jilani, Arshad, Zahir, & Khalid, 2007). For cooking, coriander is consumed both as fresh vegetables and as a part of ingredients in processed products. Because of its popularity and versatility, it is considered an economical vegetable that can be planted throughout every region of Thailand. Thailand is known as a significant country production of coriander, both domestic consumption and coriander seeds for export (Sharma et al., 2014). The production of coriander in Thailand in the year 2019 was 1.97 metric tons. In comparison, export volume was 21.11K metric tons in 2020 to generate Thailand's income of around USD 49.70K (Tridge, 2021). However, the rapid increase of population and hence the demand for food have driven the escalation of the usage of chemical fertilizers intended to multiply agricultural production, and this has been found to result in a negative effect on coriander production, such as, soil quality. The heavy application of chemical fertilizers leads to poor soil fertility and limits agricultural production in extended areas of coriander planting. In addition, the continued use of these chemical fertilizers predictably leads to serious environmental issues, for example, soil pollution (Shilev, Naydenov, Vancheva, & Aladjadjiyan, 2007), a decrease of soil fertility (in terms of physicochemical properties) and reduction of the levels of essential micronutrients (White & Brown, 2010; Altomare & Tringovska, 2011; Wang, Liu, & Li, 2017). Currently, an alternative, environmentally friendly agricultural production that focuses on improving the physical, chemical, and microbiological characteristics of soil is urgently needed to restore soil fertility and enhance plant growth (Biau, Santiveri, Mijangos, & Lioveras, 2012; Ghosh, Wilson, Ghoshal, Senapati, & Mandal, 2012). There were several methods for improving the soil quality by using natural fertilizers, including manure, compost and bio-extract. All of them were shown to increase soil fertility, both of their physical and chemical properties (Wang et al., 2017; Sánchez, Ospina, & Montoya, 2017). Furthermore, all of these management methods are considered environmentally friendly practices for promoting crop growth and disposing of organic waste (Mandal, Patra, Singh, Swarup, & Masto, 2007). Pathma and Sakthivel (2012) found that natural fertilizers, especially in bio-extract form, could increase the activity of soil microorganisms, promote plant growth, and improve soil characteristics in terms of chemical and physical qualities (Zhang, Shamsi, Xu, Wang, & Lin, 2012). At present, the application of bio-extract derived from fermented plants for increasing soil fertility and crop yield and reducing the cost of production is environmentally friendly and thus popular in many areas of Thailand (Ahmad et al., 2007). Several reports have defined that bio-extract is the organic fertilizer obtained from the fermentation of either plant or animal waste, involving the processes of organic matter degradation through the interaction between natural raw materials and advantage microorganisms (Mungkunkamchao, Kesmala, Pimratch, Toomsan, & Jothityangkoon, 2013; Tancho, 2008; Hu, Sun, Wang, & Sun, 2004). It has been demonstrated that bio-extract application led to a significant increase in the growth of several vegetable crops such as onion, pea, sweet corn (Daly & Stewart, 1999), radish (El-Tarabily, Nassar, Hardy, & Sivasithamparam, 2003), cowpea (Kamla, Limpinuntana, Ruaysoongnern, & Bell, 2008) and tomato (Aung & Flick, 1980; Sangakkara & Higa, 1994; Xu, Zhou, Van Cleemput, & Wang, 2000). Sensitive plant is a crucial legume weed in the family of Mimosoideae and is considered as a broadcast weed with high growth rates throughout many parts of the world, including Thailand, and it has been shown to cause severe damage to the production of several cultivated plants (Sprent, 1995; Sánchez et al., 2017]. For these reasons, utilization of sensitive plant, which is a worthless weed, as a bio-extract to improve soil fertility and plant growth could be one of the alternative methods for achieving sustainable agricultural production. At present, there has been no research related to the utilization of the bio-extract derived from sensitive plant to promote coriander growth. Therefore, this research aimed to investigate the effects of bio-extract from the sensitive plants at different concentrations on specific soil chemical properties and coriander's fresh weight under field conditions.

Methods and Materials

Experimental location

The experiments were conducted under laboratory and field conditions at the Division of Agricultural Technology, Mahasarakham University from August 2019 to May 2020 in a Completely Randomized Design with four replications and ten plants per replication. The bio-extract treatments at the concentrations of 1:50, 1:100, 1:500 and 1:1000 were compared with the control (no addition of bio-extract).

Bio-extract preparation from sensitive plant

Preparation of the bio-extract was conducted as following: chopping off the grounds (branches and leaves) of the sensitive plant into pieces of 1-2 cm in length, weighing them five kg, and mixing them with molasses at the ratio of 3:1, and then stirring the mixture in 100 litre-fermentation tanks. The fermentation tanks were kept at room temperature (27°C) for 45 days. During fermentation, the tanks were opened and stirred every seven days. Forty-five days after the fermentation process, bio-extract from the sensitive plant was diluted with water at the concentrations of 1:50, 1:100, 1:500 and 1:1,000 ml. They were used for application on coriander plants. The control group was not added with bio-extract.

Coriander planting

Coriander seeds cv. Saisamon were soaked in water for two days before being sown in the black plastic bags (size of 6x12 inch^2) filled with 5 kilograms of a loamy soil under soil series of Kantara Wichai series (Ka) as planting material. Three coriander seeds were sown in each plastic bag. After germination for two weeks, coriander seedlings were removed to be planted only one seedling per bag. After that, the coriander plants were grown under the field conditions (average temperature was 36±2°C, and relative humidity was 60±5%) at the Agricultural Technology, Mahasarakham University, with a spacing of 50×50 cm^2 between the plants. Fourteen Days after planting (DAP), 500 ml of each concentration of the bio-extract from the sensitive plant were poured into the planting material of each coriander seedling. The bio-extract solution was applied to coriander plants repeatedly for five times with an interval of 6 days. A micro-sprinkler system was used for irrigation and watering twice a day in the morning and late afternoon. Weeds were controlled manually during the growing of coriander.

Data collection

To evaluate the effects of diluted bio-extract from the sensitive plants on coriander yields and specific soil chemical properties, soil and bio-extract samples from each treatment were collected to determine the levels of total contents of nitrogen (%N) by Kjeldahl method (Bremner & Mulvaney, 1982), total phosphorus (%P) by Vanadomolybdate method and total potassium (%K) by Flame photometer. The levels of pH and electrical conductivity (EC) of soil and bio-extract sample (diluted 1:10 w/v with deionized water) were determined by pH meter (OHAUS corporation) and EC meter (Mettler Toledo, Five Easy Plus FEP30), respectively. In addition, the percentage of organic matter (OM) in soil and bio-extract was determined by titration with a standard solution of 0.5 N $FeSO_4$. The above chemical properties of bio-extract were analyzed for two periods (before and after planting). In addition, at 45 days after planting, coriander plants were harvested and weighed; the data was expressed as a fresh weight (g per plant).

Data analysis

Analysis of variance (ANOVA) was performed by using SPSS software for Windows (SPSS, Chicago, Version 19.0), and the means were compared by using the least significant difference (LSD) test at $P < 0.01$.

Results

Bio-extract and soil samples were analyzed for chemical properties including N, P, K, pH, EC and OM before planting and after planting as follows.

I) Before Planting

After finishing fermentation, the highly significant differences ($P < 0.01$) of N, P, K, pH, EC and organic matter were observed in bio-extract compared with soil (Table 1). The results showed that soil showed the maximal P level and pH (0.2309% and 5.5850, respectively). While 100% bio-extract from sensitive plant significantly ($P < 0.01$) increased N, K, EC and organic matter to be the highest values of 0.0766%, 1.3369%, 8.4300 dS/m and 4.2014%, respectively compared with the other diluted bio-extract. However, the lowest level of pH and intense EC value of 100% bio-extract indicated the high salinity, which may have detrimental effects on plant growth. In addition, all diluted bio-extract (1:50, 1:100, 1:500 and 1:1,000) showed statistically significant increases in the contents of N, P and organic matter. These results indicated that the advantage effects of diluted bio-extract from sensitive plants can increase soil fertility and coriander production.

Table 1 Contents of nitrogen, phosphorus, potassium, pH, EC and organic matter in soil and bio-extract before planting

Diluted bio-extract	N (%)	P (%)	K (%)	pH	EC (dS/m)	OM (%)
soil	0.0696a	0.2309a	0.2726b	5.5850a	1.1345b	0.8734b
100%	0.0766a	0.0098b	1.3369a	3.6150e	8.4300a	4.2014a
1:50	0.0067b	0.0035b	0.1996bc	3.8000d	0.3535c	0.1012b
1:100	0.0046b	0.0031b	0.1894bc	3.9475c	0.2110d	0.0869b
1:500	0.0022b	0.0026b	0.1389cd	3.9475c	0.0739e	0.0726b
1:1,000	0.0015b	0.0003b	0.0860d	4.2450b	0.0554e	0.0822b
F-test	**	**	**	**	**	**
LSD	0.0118	0.0365	0.1001	0.0468	0.0850	0.8590
C.V.(%)	29.70	58.87	18.19	0.75	3.35	64.04

Means within the same column followed by the same lower case letters are not significantly different ($p<0.01$) as compared by LSD test.

II) After Planting

Total N

For nitrogen analysis, the results showed a significant increase of total N in the loamy soil of all the treatments with different concentrations of bio-extract when compared to the control (no adding of bio-extract) ($p <$ 0.01). However, there were no significant differences in the levels of total N in loamy soil treated with different concentrations of bio-extract as they were relatively similar and ranged between 0.1407-0.1458% (Table 2).

Total P

The results showed no significant differences in phosphorus contents between the loamy soil that received diluted bio-extract and the control (0.2312-0.02344%) (Table 2).

Total K

The results showed that the K contents were significantly different among the treatments with varying concentrations of bio-extract. Table 2 showed that soil treated with 1:50 bio-extract had the maximal K contents at 0.4722%, while that receiving 1:1000 bio-extract had the minimal K contents at 0.3586%. The results revealed that the higher concentration of bio-extract, the more K contents found in soil.

Table 2 Contents of nitrogen, phosphorus and potassium in soil after receiving various diluted levels of bio-extract derived from sensitive plant

Diluted bio-extract	N (%)	P (%)	K (%)
1:50	0.1458[a]	0.2344	0.4722[a]
1:100	0.1437[a]	0.2340	0.4620[b]
1:500	0.1414[a]	0.2335	0.4115[c]
1:1,000	0.1407[a]	0.2312	0.3586[d]
Control	0.0696[b]	0.2309	0.2726[e]
F-test	**	ns	**
LSD	0.0092	-	0.0003
C.V.(%)	13.57	4.95	0.15

Means within the same column followed by the same lower case letters are not significantly different ($p<0.01$) as compared by LSD test. ns = no significance.

pH

The pH levels were found to be significantly different between the control and the treatments with diluted bio-extract. The results indicated that soil receiving 1:50 bio-extract had the lowest pH level of 3.80, while Control had the maximum pH at 6.07 (Table 3).

Electric conductivity (EC)

The results illustrated that EC values were inversely associated with the concentration of bio-extract. The highest EC value was found in Control (0.5175 dS/m), significantly different from that of the treatments with bio-extract from the sensitive plants. The bio-extract at the concentrations of 1:500 and 1:1,000 had lower EC values at 0.0739 and 0.0554 dS/m, respectively (Table 3).

Organic matter content (OM)

There were no significant differences in OM contents among the treatments with different concentrations of bio-extract when compared to the control. The results showed that treatments with varying concentrations of bio-extract had similar levels of OM contents of 0.9459-0.9745% (Table 3).

Table 3 The levels of pH, EC and organic matter contents in soil after receiving various diluted levels of bio-extract derived from sensitive plant

Diluted bio-extract	pH	EC (dS/m)	OM (%)
1:50	3.80[d]	0.3535[b]	0.9745
1:100	3.95[c]	0.2110[c]	0.9602
1:500	3.95[c]	0.0739[d]	0.9459
1:1,000	4.25[b]	0.0554[e]	0.9555
Control	6.07[a]	0.5175[a]	0.8734
F-test	**	**	ns
LSD	0.0163	0.0034	0.0230
C.V.(%)	0.76	1.91	4.88

Means within the same column followed by the same lower case letters are not significantly different ($p<0.01$) as compared by LSD test. ns = no significance.

Fresh weight

For evaluation of fresh weight, coriander plants were harvested at 45 DAP, and the results showed that different concentrations of bio-extract could affect the fresh weight of coriander. For example, coriander plants treated with bio-extract at the concentration of 1:500 were found to have the maximal fresh weight (20.55 g per plant), which was significantly different from that treated with bio-extract at the concentration of 1:50, which giving the minimal fresh weight of 8.97 g per plant (Table 4).

Table 4 Fresh weight of coriander after receiving different ratios of diluted bio-extract from sensitive plant

Diluted bioextract	Fresh weight (g per plant)
Control	13.92[c]
1 : 50	8.97[d]
1 : 100	17.82[b]
1 : 500	20.55[a]
1 : 1,000	16.42[b]
F-test	**
LSD	1.4446
C.V. (%)	6.17

Letters within columns indicate least significant differences (LSD) at P**< 0.01.

Discussion

For total nitrogen level, the results demonstrated that application with diluted bio-extract could provide a good source of N. These results are consistent with Virginia (1986) that reported the addition of soil nutrients, especially soil nitrate (NO_3), by some tree legumes including *Prosopis glandulosa* and *Dalea spinosa*. Orozco, Cegarra, Trujillo, and Roig (1996) and Benitez, Nogales, Elvira, Masciandaro, and Ceccanti (1999) also reported that bio-extract from vermicomposts contained several nutrients which could be easily absorbed by plants. The results also revealed that the bio-extract at all concentrations did not affect the P contents. These results are contrary to Virginia (1986), who reported that both Prosopis glandulosa and Dalea spinose, which were tree legumes, could release phosphorus to soil in the form of phosphate (PO_4). These suggested that the application of bio-extract from the sensitive plants at the concentration of 1:50 may play an essential role in enhancing K contents in soil. For potassium content, the result was similar to Virginia (1986), who reported the improvement of legume plants' soil characteristics, both physical and chemical properties. Thus, bio-extract from the sensitive plants could be used for restoring soil fertility to be suitable for coriander production since it contained some plant nutrients, including nitrogen (N) and potassium (K). Chaoui, Zibilske, and Ohno (2003) also showed that bio-extract could act as a slow-release source of plant nutrients in natural conditions. However, no research has examined the response of coriander plants on the addition of bio-extract derived from the sensitive plants.

For pH level, the results indicated that soil pH was lowered by adding bio-extract. The higher concentration of diluted bio-extract, the lower level of pH observed. These pH differences may probably relate to bio-extract from the fermentation process having a slightly lower pH (Atiyeh, Arancon, Edwards, & Metzger, 2000). These results agree with the reports of Suthar and Singh (2008) and Garg, Gupta, and Satya (2006), which showed that fermentation of bio-extract could increase the levels of organic acids and hence reduce the levels of pH.

While the values of electrical conductivity (EC) of the soil sample, the results indicated that high levels of EC indicated high concentration of salt, leads to the unsuitable condition for plant growth. These results showed that the lower levels of EC were found in soil with lower concentrations of bio-extract. These agrees with the results of Atiyeh, Edwards, Subler, and Metzger (2001), who reported that the decreases in EC values by lowering the concentrations of bio-extract of the sensitive plants could be related to low concentrations of soluble salts in the soil. Thus, soil with lower EC should be at less risk of soil salinity and, hence, suitable for plant growth. The high EC value of the control implied that it contained a high level of salt (De Koning, Veldkamp, & LÓpez-Ulloa, 2003; Courtney & Mullen, 2008). These results also agreed with that of Marinari, Masciandaro, Ceccanti, and Grego (2000). They reported the high EC values of the soil that causing severe salinity stress and inappropriate conditions for plant growth.

Furthermore, the application of bio-extract had no significant effect on OM contents in soil. However, De Koning et al. (2003) reported that OM in soil significantly associated with soil characteristics, plant species, climate, and soil nutrition. Erfanzadeh, Bahrami, Motamedi, and Pétillon (2014) suggested that the quality and quantity of OM may depend on the nature and components of the plant species. Nevertheless, at the moment, the chemical characteristics of bio-extract from the sensitive plants have not been well examined. Therefore, bio-extract from the sensitive plants can improve the plant nutrition and chemical properties of planting soil. These indicated that sensitive plant has potential use for producing coriander.

For a fresh weight of harvested coriander, the results agreed with the results of Atiyeh et al. (2001), who reported that plant growth is positively associated with organic fertilizer application. These may be because of the positive changes in soil characteristics, particularly its physicochemical and microbial properties. In addition, the organic fertilizer could increase the crop yield because it enriched the soil physical structure and increased the levels of soil enzymes and microbial populations (Tomati, Grappelli, & Galli, 1987; Hidalgo, 1999; Saciragic & Dzelilovic, 1986). Furthermore, boosting of the essential elements for plant growth could be achieved by adding the organic fertilizer, especially the compost, which providing the sources of nitrogen, phosphorus, and potassium, in the forms that were readily available for plant uptake, and thus contributing to the high crop yield (de Bertoldi, Vallini & Pera, 1983). In addition, Krishnamoorthy and Vajrabhiah (1986) also indicated that organic fertilizer could stimulate plants' growth promoter hormones, such as auxins, gibberellin and cytokinins (Hopkins, 1995; Stirk, Arthur, & Lourens, 2004). In this study, bio-extract could act as organic fertilizer (Vessey, 2003). Furthermore, Noisopa, Prapagdee, Navanugraha, and Hutacharoen (2010) found that microorganisms in bio-extract could increase the level of available plant nutrients to promote plant growth. It may improve the soil structure (Shetty, Hetrick, Figge, & Schwab, 1994), activate biological activities (Marinari et al., 2000), and lead to increased growth and yield of the plant. There were reports which indicated that adding of the bio-extract, mainly those derived from legumes, could increase the populations of several species of advantageous soil microorganisms, both bacteria and fungi, as well as their activities which had positive effects on promoting plant growth (Vessey, 2003; Zink & Allen, 1998). Furthermore, Ram Rao, Kodandaramaiah, Reddy, Katiyar, and Rahmathulla (2007) reported that the bio-extract application at an appropriate concentration could promote carbohydrate production in leaf and result in more remarkable plant growth. However, the various dilutions of bio-extract application affected coriander growth differences.

According to the literature, Bhakuni, Dhar, Dhar, Dhawan, and Mehrotra (1969) reported that stems and leaves of the sensitive plants contain both adrenaline alkaloids and tannin, which may be adverse effects for plant growth, especially at high concentration (1:50), which lead to being harmful effects of salinity on plant growth. In addition, these results also implied that EC value of bio-extract at 1:50 may cause high salinity toxicity to coriander's plant (Fernández-García, Martínez, Cerdá, & Carvajal, 2002). While the applications of bio-extract significantly increased coriander's fresh weight ($P < 0.01$) when fertilizer was applied at a low rate (1:500). From this study, it could be suggested that diluted bio-extract from the sensitive plants at the concentration of 1:500 is the appropriate dilution for coriander production. The study suggests that the appropriate dilution and the pH level of bio-extract should be considered in coriander's growth enhancement. Because it has been reported that soil pH greatly influences the availability of optimal plant nutrients (Jensen, 2010) and soil biogeochemical processes (Neina, 2019), leading to promote plant growth and yield. The results from this experiment indicated that sensitive plant causes several agricultural problems and has the potential to be used as an application for producing another organic vegetable. However, further investigation is required to analyze the activities of enzymes, microorganisms, and plant hormones found in beneficial bio-extract derived from sensitive plants to increase coriander yield.

Conclusion and Suggestions

Diluted bio-extract from the sensitive plants at different concentrations, including 1:50, 1:100, 1:500, 1:1000 and control (no bio-extract), was applied to coriander plants by pouring at the aerial stem. The results revealed that the bio-extract increased the levels of nitrogen and potassium contents in soil and decreased the EC value. In addition, the application of diluted bio-extract from the sensitive plants at the concentration of 1:500 significantly increased the coriander's fresh weight.

Therefore, bio-extract from the sensitive plants at the concentration of 1:500 may be recommended for improving the coriander yield.

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