

Effect of vermicompost and biostarter on the growth and photosynthetic rate of *Echinacea purpurea*

LUTFIA FAJAR CHOIRUNNISA^{1,*}, SOLICHATUN², AHMAD YUNUS^{3,4,*}

¹Graduate Program of Bioscience, Faculty of Mathematics and Natural Science, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271- 663375, *email: lutfiafchoirunnisa@gmail.com

²Department of Biology, Faculty of Mathematics and Natural Science, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

³Department of Agrotechnology, Faculty of Agriculture, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia. Tel./fax.: +62-271-637457, *email: yunus.uns7@yahoo.com

⁴Center of Biotechnology and Biodiversity, Research and Development, Universitas Sebelas Maret. Jl. Ir. Sutami 36A, Surakarta 57126, Central Java, Indonesia

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Abstract. Choirunnisa LF, Solichatun, Yunus A. 2022. Effect of vermicompost and biostarter on the growth and photosynthetic rate of *Echinacea purpurea*. *Asian J Agric* 6: 35-39. *Echinacea purpurea* (L.) Moench, or purple coneflower, is a medicinal plant that originated in North America and began to cultivate in Indonesia. A proper method is needed to improve its growth and development to adjust and cultivate in tropical areas like Indonesia. This study aimed to determine the effect of vermicompost and biostarter on the growth and photosynthetic rate of *E. purpurea*. Therefore, Split-Plot Randomized Complete Block Design was used. Two factors of this study were organic materials such as vermicompost and biostarter. Both can increase plant growth and the photosynthetic rate of *E. purpurea*. The dosages of vermicompost were 0, 40, 60, and 80 g/plant, and different types of biostarter from Banana peel waste and EM. This study also investigated data that included plant height and width, leaf numbers, leaf area, photosynthetic and transpiration rate, and stomata conductance. The study showed that the treatment of 80 g/plant vermicomposts and EM highest resulted in plant height (73,6 cm), leaf numbers (82), and stomatal conductance (0,4585 mol m⁻²s⁻¹). Moreover, the leaf area (87,21 cm²) and photosynthetic rate (0,6839 μmol m⁻²s⁻¹) showed the highest result with the treatment of 80 g/plant vermicomposts and biostarter from Banana peel waste. On the other hand, the treatment of 60 g/plant vermicompost showed the best result on plant width (50,25 cm) also transpiration rate (0,2390 mmol m⁻²s⁻¹). This study concluded a significant effect between vermicompost and biostarter on the growth and photosynthetic rate of *E. purpurea*.

Keywords: Biostarter, *Echinacea purpurea*, growth, photosynthetic rate, vermicompost

INTRODUCTION

Echinacea purpurea (L.) Moench, or purple coneflower, is a medical plant that originated in North America and began to cultivate in Indonesia. This plant is widely cultivated as medicinal because it increases the human immune system. Many species of *Echinacea* besides *E. purpurea*, like *E. angustifolia* and *E. pallida*, have been identified as important medicinal plants. The morphology characteristics of *E. purpurea* turned out to have various changes after being developed and cultivated in Indonesia. The clear morphological differences are flowers. According to Siddiq et al. (2020), the form of *E. purpurea* flowers cultivated in the lowland area has changed, which correlated with its parent. The shape of the corolla is curved downward, and some are horizontal.

Organic fertilizer is very important in supporting plant growth and development because it provides essential nutrients needed by plants. Vermicompost is an organic fertilizer that uses a worm to convert residues into a secondary organic fertilizer. This fertilizer can improve soil fertility by increasing the nutrients of the soil. In addition, vermicompost can increase water availability and mineral nutrients (Blouin et al. 2019).

Furthermore, it has been reported that using vermicompost significantly increases the level of photosynthetic pigments such as chlorophyll a&b, total chlorophyll, and carotenoids by increasing nitrogen content in plants. It is possible because the fertilizer can improve the soil's structure, increase humidity, and supply nutrients to the plant. The application of vermicompost can increase the level of photosynthetic pigments, sunlight absorption capacity, the material production of photosynthesis, and plant growth and development (Afkari 2018; Jaikishun et al. 2018).

Biostarter is a liquid that contains various microorganism decomposers and can be useful in decomposing organic waste. Biostarter can be made by utilizing organic waste after fermentation for approximately 7-14 days (Sukmawati et al. 2019). Waste fruit peels are alternative raw materials for biostarter because they contain various nutrients such as carbohydrates, glucose, sodium, potassium, and phosphorus that are suitable for them (Widyabudiningsih et al. 2021). Another type of biostarter used in this study is "Effective Microorganism" (EM), a mixture of various beneficial microorganisms for plant growth. EM can be used to improve the decomposition of organic waste,

increase the plant's nutrients, and suppress the activity of pathogenic microorganisms (Joshi et al. 2019).

Organic materials such as vermicompost and biostarter can increase plant growth and the photosynthetic rate of *E. purpurea*. However, since *E. purpurea* is an introduced species from a subtropical country, a proper method is needed for improving its growth and development to adjust and cultivate in a tropical area like Indonesia.

The study aimed to determine the effect of vermicompost and biostarter (Banana peel waste and EM) on the growth, and photosynthetic rate of *E. purpurea* cultivated in lowland area (± 300 meters above mean sea level), Experimental Garden Faculty of Agriculture, Universitas Sebelas Maret, Sukosari, Jumanthono, Karanganyar, Central Java, Indonesia.

MATERIALS AND METHODS

Experimental area and soil properties

This open-field study was conducted from July to November 2021 and is located in a lowland area (± 300 meters above mean sea level), Experimental Garden Faculty of Agriculture, Universitas Sebelas Maret, Jumanthono, Karanganyar, Central Java, Indonesia ($7^{\circ}37'829''$ S, $110^{\circ}56'901''$ W). The temperature was captured between 27 to 33°C , and the humidity was around 50-60%. The type of soil used in this experimental garden identified as alfisols, with the characteristics is shown in (Table 1).

Procedures

Collection of seeds and preparation of seedlings

Echinacea purpurea seeds were chosen from the Research Center of Medical Plants and Traditional Medicines (B2P2TOOT) collection, Tawangmangu, Karanganyar, Central Java, Indonesia. First, the dried flowers of *E. purpurea* were sorted to select the best seeds from the flower with an embryo. Then, the dry seeds were planted to grow a seedling in the pot tray until the age of six weeks and transplanted into the experimental garden.

Planting and maintenance

The seedlings were planted in the experimental garden with a Split-Plot Randomized Complete Block Design with two factors and three replications. Vermicompost dosages (0, 40, 60, 80 g/plant) and different types of biostarter from Banana peel waste and effective microorganisms with the trademark "EM4". In control plots, neither vermicompost nor biostarter was applied. So, there were 12 combinations of treatments repeated three times with a total of 270 plants of *E. purpurea*. The plant's watering was done every day (morning or afternoon) with the sprinkler irrigation system. Weed control was done manually every week. This current study was conducted in the 2021 rainy season.

Observation

Plant height and width, leaf numbers and area were observed when the plants were six weeks after transplanting in the experimental garden until the flowers bloomed. Measurements were made on 15 plants for each parcel, or 60% (180 plants) were used to determine agronomic performance. In addition, photosynthetic, transpiration rate, and stomatal conductance were observed with the natural light, from 8.30 AM to 11.30 AM, with a Plant photosynthesis meter NY-1020 (Zhengzhou Nanbei Instrument Equipment Co., Ltd.).

The leaf area measurement was done with non-destructive models by a combination of leaf length and maximum width. Based on Aminifard et al. (2016), leaf area estimation on *E. purpurea* can be done by measuring leaf dimension and resulting in the most accuracy with the formulation $[LA = 0,575 (\text{Length} \times \text{width}) - 0,934]$. A ruler measured the length and width of the leaves.

Data analysis

The results were analyzed with Two Way Analysis of Variance (ANOVA) and continued with Duncan Multiple Range Test (DMRT) at the 5% level to know the significant effect of the treatment. The data were analyzed with SPSS 20.0 version.

RESULTS AND DISCUSSION

Of the total of 270 *E. purpurea*, 60% were used as a sample (180 plants). The growth rate parameters are height, width, leaf numbers and area. The photosynthetic rate parameters are photosynthetic rate, transpiration rate, also stomata conductance.

Plant height

Plant height is one of the plant growth parameters and indicates the plant's physiological function. Therefore, this measurement is frequently used to know the effect of the treatments given in the study. The plant height measured is the distance of the upper boundary of the plant or the upper part above the ground.

Quantitative analysis shows that the height of *E. purpurea* among the treatments given is significantly different in DMRT at a 5% level. The results showed that the treatment of 80 g/plant vermicomposts and EM had the highest result in plant height (73,6 cm) compared to the control with only 23,60 cm (Table 2). The addition of vermicompost has a positive effect on plant growth and development. Its also been reported that nitrogen, phosphorus, potassium, several micronutrients, and microbial and enzymatic activities were correlated to it. The use of vermicompost enhanced the quality of the plant by increasing its nutritional status (Awadhpersad et al. 2021).

Table 1. Soil properties in the experiment

Characteristic	N (%)	P ₂ O ₅ (%)	K ₂ O (%)	Mg (%)	pH	C organic (%)
Vermicompost	1.70	1.10	1.49	0.26	7.6	15.47

Table 2. Effect of vermicompost and biostarter on plant height (cm) of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	23.60c	30.80c	35.45c	58.00c
Banana peel waste	43.20b	46.20ab	47.00b	65.90b
EM	44.60a	56.60a	65.20a	73.60a

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

Plant width

The important thing to measure besides plant height is plant width. Plant width is an essential geometric trait among various phenotypes that can indicate plant growth rate. The plant width we measured is the canopy width or distance between one edge of the leaf on a plant to the other. Based on Table 3, the treatment of 60 g/plant vermicomposts EM showed the best result on plant width (50,25 cm) compared to the control (42,20 cm). El-Mageed et al. (2020) reported that EM could help plants increase nutrient uptake and enhance plant growth. On the other hand, EM can activate the beneficial microorganisms in the soil and improve the soil's physical and chemical characteristics.

EM is a solution containing various beneficial aerobic and anaerobic, nonpathogenic microorganisms considered a soil starter or activator improving soil structure, fertility, and nutrient cycling (Talaat et al. 2015).

Leaf numbers

The treatment of 80 g/plant vermicomposts and EM gave the highest result on leaf numbers (82,60) compared to the control (45,40). The results are given in Table 4. Using vermicompost can increase plant growth properties like leaf number. That can be attributed to plant growth regulators such as auxin. Ahmadpour and Armand (2020) stated that Zinc (Zn) is an important element from vermicompost and plays an important role in the structure of Tryptophan Amino Acid (the main precursor to the auxin synthesis). Auxin can increase cell walls, leading to an increase in the longitudinal growth of the plant.

Organic fertilizers like vermicompost play an important role in the plant growth regulator (as auxin and cytokinin) by increasing the microorganism community and soil activity. Also, humic acid found in the vermicompost has many elements that increase the plants' availability and improve their growth and development properties (Amiri et al. 2017).

Leaf area

Leaf area is a very important growth parameter and effective monitoring for the growth and development of the plant. Leaf area showed the highest result with the treatment of 80 g/plant vermicomposts and biostarter from Banana peel waste (87,21 cm²) compared to the control is 59,34 cm² (Table 5).

According to Ahmadpour and Armand (2020), increasing the leaf area shows more photosynthetic capacity. There is a direct relationship between the photosynthetic system to dry matter yield. The addition of vermicompost has a role in maintaining water-soluble nutrients from the root to the leaf by passive transmission in the xylem. The macro and microelements of the vermicompost also nourish the leaf and leaf morphology.

Photosynthetic rate

Photosynthetic rate is one of the photosynthetic parameters determined by the portable photosynthesis meter NY-1020 (Zhengzhou Nanbei Instrument Equipment Co., Ltd.). Table 6 shows the treatment of 80 g/plant vermicomposts and Banana peel waste resulted in a photosynthetic rate (0,6839 $\mu\text{mol m}^{-2} \text{s}^{-1}$) compared to the control (0,0931 $\mu\text{mol m}^{-2} \text{s}^{-1}$). Conversely, the photosynthetic reduction rate in the treatment of 0, 40 g/plant vermicomposts and Banana peel waste from 0,4237 $\mu\text{mol m}^{-2} \text{s}^{-1}$ to 0,1117 $\mu\text{mol m}^{-2} \text{s}^{-1}$ is still unresolved. Mu and Chen (2021) stated that the decreasing photosynthesis rate might be the physiological response to N deficiency and allocation in leaf structure.

Ahmadpour and Armand (2020) reported that adding biofertilizers like vermicompost increases the microorganism's activity in the soil and has a main role in nitrogen fixation. This terrestrial microorganism's activity leads to releasing the plants' required elements (zinc, iron, manganese, and magnesium) that have the main role in chlorophyll structure. Therefore, increasing the macronutrients (Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium) and micronutrients (Iron, Zinc, Copper, and Manganese) in the leaf is important to the photosynthetic. Moreover, vermicompost also has the primary role in maintaining the photosynthetic system and pigments stability.

Table 3. Effect of vermicompost and biostarter on plant width (cm) of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	42.20b	42.40b	45.20b	47.45b
Banana peel waste	45.00a	46.20a	49.80a	50.20a
EM	45.80a	47.80a	50.25a	48.00a

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

Table 4. Effect of vermicompost and biostarter on leaf numbers of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	45.40b	46.33b	47.75b	54.50b
Banana peel waste	55.20a	70.80a	74.00a	68.40a
EM	63.20a	72.60ab	75.20a	82.60a

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

Table 5. Effect of vermicompost and biostarter on leaf area (cm²) of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	59.34a	69.80ab	70.39b	79.67c
Banana peel waste	65.21a	64.42ab	72.82b	87.21c
EM	67.02a	69.84ab	78.93b	83.83c

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

Table 6. Effect of vermicompost and biostarter on photosynthetic rate ($\mu\text{mol m}^{-2}\text{s}^{-1}$) of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	0.0931b	0.1741b	0.2708ab	0.5332a
Banana peel waste	0.4237b	0.1117b	0.4096ab	0.6839a
EM	0.2234b	0.2864b	0.6486ab	0.4865a

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

Table 7. Effect of vermicompost and biostarter on transpiration rate ($\text{mmol m}^{-2}\text{s}^{-1}$) of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	0.0323	0.0754	0.2390	0.0880
Banana peel waste	0.0795	0.1548	0.0691	0.1185
EM	0.1873	0.0596	0.1873	0.1249

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

Table 8. Effect of vermicompost and biostarter on stomatal conductance ($\text{mol m}^{-2}\text{s}^{-1}$) of *Echinacea purpurea*

Treatments biostarter type	Vermicompost dosages (g/plant)			
	0	40	60	80
Control	0.0405c	0.2848bc	0.2843ab	0.3407a
Banana peel waste	0.2456c	0.2720bc	0.3689ab	0.4356a
EM	0.1196c	0.1843bc	0.4574ab	0.4585a

Note: Numbers followed by different letters in the same column show a significant difference in DMRT at a 5% level

The addition of vermicompost also increases the stability of the photosynthetic system. Maintaining the process of photosynthesis depends on how the plant produces and receives the high-energy molecules, including Adenosine Triphosphate (ATP) and Nicotinamide Adenine Dinucleotide Phosphate (NADPH), by taking the sunlight energy. The addition of vermicompost increases CO₂ production in the soil and increases microorganism activity. The better production of CO₂ in the root environment plays an important role in providing CO₂ photosynthesis (Hosseinzadeh et al. 2018).

Transpiration rate

Transpiration rate is the gas exchange parameter and is directly related to photosynthesis. The treatment of 60 g/plant vermicompost with no biostarter showed the best result on transpiration rate ($0.2390 \text{ mmol m}^{-2} \text{ s}^{-1}$) compared to the control is $0.0323 \text{ mmol m}^{-2} \text{ s}^{-1}$ (Table 7). However, in the transpiration rate, we found no significant effect on adding vermicompost and biostarter. Therefore, the results on leaf transpiration are unclear between the treatments and control. Still, Pereira et al. (2021) stated that it might be related to the presence of phytohormones in its plant. Also, the reduction level of transpiration rate resulted in higher water use efficiency and CO₂ assimilation.

Stomatal conductance

The treatment of 80 g/plant vermicomposts and EM highest resulted in stomatal conductance ($0.4585 \text{ mol m}^{-2} \text{ s}^{-1}$) compared to the control, which is $0.0405 \text{ mol m}^{-2} \text{ s}^{-1}$ (Table 8). It has been reported that the higher result of stomatal conductance between the treatments and the control could be attributed to their higher water-holding capacity, which reduced the water stress level (Mahmud et al. 2020). Stomatal conductance regulates the uptake of CO₂ photosynthesis and water loss through transpiration. The result of stomatal conductance observed in the field was rarely at the absolute maximum or achievable when the specific growth conditions were at the optimum condition. The measurement was on interveinal areolae at the mid-surface of the healthy, fully expanded, and sun-exposed leaves (Murray et al. 2019). Environmental factors affect stomatal conductance, including water and nutrient status, light, CO₂ levels, and temperature. As the main nitrogen source for plants, nitrate could regulate stomatal movement (Mu and Chen 2021).

This study concluded that there is a significant effect between vermicompost and biostarter on the growth and photosynthetic rate of *E. purpurea*. The treatment of 80 g/plant of vermicompost and EM showed the best result on plant height, leaf numbers, and stomatal conductance. Furthermore, the treatment of 80 g/plant of vermicompost and biostarter from Banana peel waste showed the highest leaf area and photosynthetic rate. The treatment of 60 g/plant vermicompost showed the best result on plant width also transpiration rate. Further studies are necessary to promote the integration of vermicompost and biostarter in *E. purpurea* to improve its growth and development to adjust and cultivate in a tropical area like Indonesia. A good adaptation for an introduced species like *E. purpurea*, especially in Indonesia, is very important because this plant is quite a promising opportunity to develop medicinal uses and products.

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REFERENCES

- Ahmadpour R, Armand N. 2020. Effect of ecophysiological characteristics of tomato (*Lycopersicon esculentum* L.) in response to organic fertilizers (compost and vermicompost). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca* 48 (3): 1248-1259. DOI: 10.15835/nbha48311834.
- Afkari A. 2018. An investigation to the vermicompost efficacy on the activity level of antioxidant enzymes and photosynthetic pigments of borage (*Borago officinalis* L.) under salinity stress conditions. *Russ Agric Sci* 44 (4): 310-317. DOI: 10.3103/S106836741804002X.
- Aminifard MH, Khayyat M, Bayat H. 2016. Estimation of leaf area in coneflower (*Echinacea purpurea* L.) using independent variables keywords: Leaf length, leaf width, linear model, non-destructive methods. *J Ornament Hort* 6 (4): 245-251.
- Amiri H, Ismaili A, Hosseinzadeh SR. 2017. Influence of vermicompost fertilizer and water deficit stress on morpho physiological features of chickpea (*Cicer arietinum* L. cv. Karaj). *Compost Sci Util* 25 (3): 152-165. DOI: 10.1080/1065657X.2016.1249313.
- Awadhpersad VRR, Lydia O, Abdullah AA. 2021. Production and effect of vermiwash and vermicompost on plant growth parameters of tomato (*Lycopersicon esculentum* Mill.) in Suriname. *Intl J Recycl Org Waste Agric* 10: 397-413.
- Blouin M, Barrere J, Meyer N, Lartigue S, Barot S, Mathieu J. 2019. Vermicompost significantly affects plant growth. A meta-analysis. *Agron Sustain Dev* 39: 34-49. DOI: 10.1007/s13593-019-0579-x.
- El-Mageed TAA, Rady MM, Taha RS, Azeam SAE, Simpson CR, Semi WM. 2020. Effects of integrated use of residual sulfur-enhanced biochar with effective microorganisms on soil properties, plant growth and short-term productivity of *Capsicum annum* under salt stress. *Scientia Horticulturae* 261: 1-10. DOI: 10.1016/j.scienta.2019.108930.
- Hosseinzadeh SR, Amiri H, Ismaili A. 2018. Evaluation of photosynthesis, physiological, and biochemical responses of chickpea (*Cicer arietinum* L. Cv. Pirouz) under water deficit stress and use of vermicompost fertilizer. *J Integr Agric* 17 (11): 2426-2437. DOI: 10.1016/S2095-3119(17)61874-4.
- Jaikishun S, Hoosein A, Ansari AA. 2018. The effects of vermicompost and vermiwash from the medicinal plants, neem (*Azadirachta indica*) and lime (*Citrus aurantifolia*), on the growth parameters of lettuce in a hydroponic system. *Nusantara Biosci* 10: 91-95. DOI: 10.13057/nusbiosci/n100205.
- Joshi H, Somduttand, Choudhary P, Mundra SL. 2019. Role of effective microorganisms (EM) in sustainable agriculture. *Intl J Curr Microbiol Appl Sci* 8 (3): 172-181. DOI: 10.20546/ijcmas.2019.803.024.
- Mahmud M, Abdullah R, Yaacob JS. 2020. Effect of vermicompost on growth, plant nutrient uptake and bioactivity of ex vitro pineapple (*Ananas comosus* var. MD2). *Agronomy* 10: 1-22. DOI: 10.3390/agronomy10091333.
- Mu X, Chen Y. 2021. The physiological response of photosynthesis to nitrogen deficiency. *Plant Physiol Biochem* 158: 76-82. DOI: 10.1016/j.plaphy.2020.11.019.
- Murray M, Soh WK, Yiotis C, Batke S, Parnell AC, Spicer RA, Lawson T, Caballero R, Wright IJ, Purcell C, McElwain JC. 2019. convergence in maximum stomatal conductance of C3 woody angiosperms in natural ecosystems across bioclimatic zones. *Front Plant Sci* 10: 1-20. DOI: 10.3389/fpls.2019.00558.
- Pereira TDS, Paula AMD, Ferrari LH, Silva JD, Pinheiro JB, Cajamarca SMN, Jindo K, Santos MP, Zandonadi DB, Busato JG. 2021. *Trichoderma*-enriched vermicompost extracts reduces nematode biotic stress in tomato and bell pepper crops. *Agronomy* 11 (8): 1655. DOI: 10.3390/agronomy11081655.
- Sidhiq DF, Widiyastuti Y, Subositi D, Pujiasmanto B, Yunus A. 2020. Morphological diversity, total phenolic and flavonoid content of *Echinacea purpurea* cultivated in Karangpandan, Central Java, Indonesia. *Biodiversitas* 21 (3): 1265-1271. DOI: 10.13057/biodiv/d210355.
- Sukmawati NMS, Suniti NW, Sujana IN. 2019. Teknologi fermentasi dalam pembuatan biostarter berbasis daun dan buah di Desa Antapan Baturiti Tabanan. *Buletin Udayana Mengabdi* 18 (1): 138-142. DOI: 10.24843/BUM.2019.v18.i01.p14. [Indonesian]
- Talaat NB, Ghoniem AE, Abdelhamid MT, Shawky BT. 2015. Effective microorganisms improve growth performance, alter nutrients acquisition and induce compatible solutes accumulation in common bean (*Phaseolus vulgaris* L.) plants subjected to salinity stress. *Plant Growth Regul* 75: 281-295. DOI: 10.1007/s10725-014-9952-6.
- Widyabudiningsih D, Troskialina L, Fauziah S, Shalihattunnisa, Riniati, Djenar NS, Hulupi M, Indrawati L, Fauzan A, Abdilah F. 2021. Pembuatan dan pengujian pupuk organik cair dari limbah kulit buah-buahan dengan penambahan bioaktivator EM4 dan variasi waktu fermentasi. *Indones J Chem Anal* 4 (1): 30-39. DOI: 10.20885/ijca.vol4.iss1.art4. [Indonesian]