Short Research Article

Enhancing growth and yield of *Brassica rapa* subsp. *chinensis* (Pechay) by using Turan Biostimulant

.

ABSTRACT

The growth and yield of pechay as affected by Turan Biostimulant, under field conditions, were studied in Oogong, Sta. Cruz, Laguna Philippines to evaluate its effects and determine its best level for the optimum growth and yield of pechay. Turan is a patented high-analysis formulation with plant nutrients complexed by bioactive polyphenols that enhances nutrient availability to plants and provides a biostimulant effect to improve plant vitality and activate natural bio-defenses to protect the plant from stresses. There is a need for a plant food supplement that can promote quick nutrient absorption in the organic pechay production process, thus a randomized complete block design with four replications experiment was conducted. Parameters such as total fresh yield, marketable yield, non-marketable yield, plant height, number of leaves, leaf width, and root length/biomass were gathered from a sample of 40 plants per treatment (10/rep) and analyzed using statistical methods. The study showed that the test product was able to slightly enhance pechay production in terms of total fresh yield, plant height, leaf length, leaf width, root length, and root biomass with an estimated increase of more than 1.18%, 1.06%, 1.04%, 1.03%, 1.13%, and 1.12%, respectively, compared to inorganic fertilizer application alone. In general, pechay is very responsive to granular fertilization and the application of Turan biostimulant. The findings also showed that while the addition of a biostimulant would further enhance the amount and quality of harvested pechay. One and a half doses of Turan biostimulant, or even more, is strongly recommended in terms of its viability in pechay cultivation to maximize profits.

Keywords: Pechay; Turan Biostimulant; foliar amendment: yield

1. INTRODUCTION

One of the most popular leaf vegetables in the Philippines is pechay (Brassica rapa L. var. chinensis (L.) Hanelt), an erect, biennial herb that is grown as an annual and grows to a vegetative height of roughly 15 to 30 cm (Fernandez, 2021). The ovate leaves are spirally organized and extend out. As they grow upright and enlarge, the petioles create a subcylindrical bundle (Jimenez et al., 2021). A raceme of light-yellow flowers makes up the inflorescence. The seeds are reddish to blackish brown in hue and have a diameter of 1 mm (Gawryś, 2008). The leaves are less crisp than those of other cabbages and are green with a mild flavor. Because it is a crop with a limited lifespan, it needs a supply of nutrients right away, and a plant food supplement that can help with quick nutrient absorption is required for the formation of pechay.

A way to improve crop production is to use plant supplements such as biostimulants, a diverse class of compounds including substances or microorganisms which have positive impacts on plant growth, yield, and chemical composition as well as boosting effects to biotic and abiotic stress tolerance (Shahrajabian et. al., 2021). Hydrolysates of plant or animal protein and other compounds that contain nitrogen, humic substances, extracts of seaweeds, biopolymers, compounds of microbial origin, phosphite, and silicon, among others are the major plant biostimulants.

Turan is a patented high-analysis formulation with plant nutrients complexed by bioactive polyphenols that enhances nutrient availability to plants and provides a biostimulant effect to improve plant vitality and activate natural bio-defenses to protect the plant from stresses. It also contains copper, manganese, and zinc, trace elements that are essential for various stages of crop development. It is needed in substantial amounts by all plants for the formation of cell walls and cell membranes. A continuous supply of calcium in the plant tissues and soil must be available to the plant, due to calcium's immobility. Copper is an essential micronutrient that is an integral part of certain enzyme systems, the process of photosynthesis, and plant respiration, and assists in plant metabolism of carbohydrates and proteins. Manganese sustains metabolic roles within the plant cell compartments and is essential as a co-factor for the oxygen-evolving complex of the photosynthetic process, the water-splitting reaction in photosystem II. On the other hand, zinc helps the plant produce chlorophyll and carbohydrates, conversion of starches to sugars and its presence in plant tissue helps the plant withstand cold temperatures. It is also needed to form auxins that are integral for growth regulation and stem elongation (SCL Italia 2020).

Copper, manganese, and zinc are also components of superoxide dismutase (SOD) enzyme that catalyze the dismutation of superoxide radicals to oxygen and hydrogen peroxide. This is a significant role in the defense against toxic-induced oxygen species which are generated as byproducts of plant reactions. SOD has been also seen as important for plant stress tolerance (SCL Italia 2020).

Polyphenols or Polyphenolic compounds as a component of Turan are secondary plant metabolites and are generally involved in abiotic stress response. Such stress is extreme temperatures, drought, flood, light, salt, and heavy metals that largely influence plant development and crop productivity. Complexing Polyphenols and Calcium results in a more potent biostimulant to further improve plant productivity regardless of the crop's nutrition status (SCL Italia 2020).

The trial was conducted to evaluate the bio-efficacy of Turan Biostimulant on the growth and yield of pechay in farmer's fields.

2. METHODOLOGY

The trial was conducted for one season at Oogong, Sta. Cruz, Laguna Philippines from November 2021 – January 2022. An open-pollinated pechay cultivar, Pavito (East-West Seeds, Sampaloc, San Rafael, Bulacan, Philippines) was used as the test crop/cultivar.

2.1 Soil Analysis

Prior to making beds, surface (0-15 cm) soil samples were randomly collected from five different points on the experimental site for physical and chemical analyses. Samples were collected per plot at harvest for post-harvest soil analysis. An accredited Soils Laboratory of the Department of Agriculture Region IV-A Philippines performed a complete soil chemical analysis. The levels of organic matter, nitrogen, phosphorus, and potassium were determined, while moisture and pH were also measured.

2.2 Land Preparation

The trial field was plowed and harrowed twice in different directions. Bed preparation was done manually. Plots measuring 2x5 m2 were made, and a total of 20 plots were established.

2.3 Experimental Design and Treatment Application

The experiment followed a randomized complete block design with four treatments, including control, with four replications (Table 1). The inorganic fertilizer was applied basally at seed sowing, while Turan was applied at 10 and 20 days after sowing (DAS).

Table 1. Treatment combinations evaluated in the trial.

Treatments	Granular Fertilization	Turan
1	Inorganic Fertilizer alone (1RR) @ 8.5 bags 14-14-14 & 4 bags urea/ha	
2	Inorganic Fertilizer (1RR) @ 8.5 bags 14-14-14 & 4 bags urea/ha	1rr Turan @ 20ml 500 ml/ha
3	Inorganic Fertilizer (1RR) @ 8.5 bags 14-14-14 & 4 bags urea/ha	½rr Turan @ 10ml 250 ml/ha
4	Inorganic Fertilizer (1RR) @ 8.5 bags 14-14-14 & 4 bags urea/ha	1½rr Turan @ 30ml 750 ml/ha
5	Control (no fertilizer or biostimulant applied)	

2.4 Seed Sowing

Five rows per meter were line drilled covering the 5 meters stretch of the plot. The distance between rows is 20 cm. Pechay seeds were directly sown to the soil using drill method at 1 gram per $2m^2$. The sown seeds were covered with soil. The plots were dusted with carbaryl (Bayer Philippines, McKinley Hill Cyberpark, Pinagsama, Taguig City, Metro Manila, Philippines) to prevent ant foraging.

2.5 Cultural Management

The following cultural practices were implemented as needed:

2.5.1 Irrigation. Watering was done every day depending on soil moisture content and weather condition.

2.5.2 Weeding. Weeds were removed at weekly intervals to avoid competition with the crop.

2.5.3 Cultivation. Tilling the soil was done to aerate the soil and to control some weed pests.

2.5.4 Insect Pest Control. Insect infestation was managed by applying insecticides appropriate to the insect pests of pechay.

2.6 Harvesting

The pechay plants were harvested ~28 days after planting. The harvested plants were then sorted into either marketable or non-marketable. The non-marketable yield was classified based on plants whose leaves had holes ≥ 1 cm in diameter.

2.7 Data Gathering

The fresh weight yield of the above-ground biomass plants was expressed in kg/ha and recorded. In addition, the non-marketable yield was also expressed in percent (%) of the total (marketable + non-marketable) yield. Growth parameters such as plant height, number of leaves, leaf length, leaf width, root length, and biomass were also gathered from a sample of 40 plants per treatment (10/rep). Data were gathered as follows:

2.7.1 Fresh weight yield. Total yields were derived from matured plants harvested per treatment per replication. The plants for each plot were weighed using a standard weighing scale.

2.7.2 Percent marketable and non-marketable yield. These were computed after separating the marketable from non-marketable plants. Non-marketable plants are plants that are deformed, small, and damaged by insects or other organisms (≥ 1 cm holes).

2.7.3 Plant height. The distance between the base of the plant and the longest/highest leaf was measured after harvesting. Ten plant samples per replication were measured.

2.7.4 Number of leaves. The number of mature leaves not smaller than one-inch diameter was counted. A sample of 10 plants per replication was measured.

2.7.5 Leaf width. This was done by getting 10 sample plants per replication and measuring the biggest leaf for each plant.

2.7.6 Root length and biomass. From 10 sample plants, the roots were measured in centimeters (cm) from the tip of the root to the tallest leaf, and biomass in grams (g).

2.8 Data Analysis and Interpretation

The generated data were analyzed statistically using Genstat 64-bit Release 21.1. Analysis of variance and treatment mean comparison using Tukey's Test was done at 5% probability level. Two-way tables were prepared to show the means and their corresponding alphabet notations. Interpretations were done by comparing each treatment, especially with the control. Conclusions and recommendations were formulated based on the results generated.

3. RESULTS AND DISCUSSION

3.1 Effect on total fresh yield of pechay

The total yield was derived from the 10 m^2 plot area and converted to fresh yield per hectare. The highest fresh yield was obtained from the plants treated with the 1.5 rr Turan biostimulant, however, this is not significantly different with the plants treated with inorganic fertilizer and Turan biostimulant at any rate. On the other hand, the lowest fresh yield was obtained from the control plants and is significantly different from the plants treated with Turan biostimulant and inorganic fertilizer (Table 2).

The results revealed that pechay plants were responsive to Turan biostimulant application, which gave a yield increase of 7.67 and 34.43 tons per hectare over the granular inorganic fertilization alone and the control, respectively. On the other hand, at the recommended rate of Turan biostimulant, a yield of 29.46 tons over the control plants was obtained. This supported the fact that Turan biostimulant is already effective at 250 ml/ha, but higher rates could possibly provide better yields and additional trials should be conducted to confirm this.

Table 2. Total fresh yield of pechay treated with Turan biostimulant.

	TREATMENT	MEAN YIELD (tons/ha)				MEAN
		1	2	3	4	
1	Inorganic Fertilizer alone (IF)	45.88	37.88	55.33	29.50	42.14 b
2	IF + 1rr Turan @ 20 ml	54.13	41.25	44.00	40.00	44.84 b
3	IF + ½rr Turan @ 10 ml	35.38	47.625	36.50	51.38	42.72 b
4	IF + 1½rr Turan @ 30 ml	58.25	31.63	53.63	55.75	49.81 b
5	Control	10.75	15.63	17.25	17.88	15.38 a

cv 7.6, $p<0.001$ *Means with the same letter are not significantly different at $\alpha = 0.05$

3.2 Effect on number and percent marketable yield of pechay

The marketable yield is equivalent to the total yield since the pechay plants were all in good condition with no visible damage, and the quality has passed the requirements of the consumers. The leaves are free from any insect damage, deformities or disease signs and symptoms. Preventive control measures against insect pests were successful in preventing any economic damage to the pechay plants, thus all plants were considered acceptable to the consumers.

3.3 Effect on plant height of pechay

The plant height was measured during harvesting by measuring the length between the base of the plant and the tallest leaf. The data showed that the tallest plants were obtained from the plants treated with 1.5rr Turan biostimulant but were not significantly different from the Turan-treated plants at any rate. On the other hand, the shortest plants were obtained from the control which were significantly different from the plants treated with inorganic fertilizer and Turan biostimulant at any rate. The inorganic fertilizer-treated plants were significantly different from the control and 1.5rr Turan-treated plants but were comparable with the ½rr and 1rr treated pechay plants. The data revealed that Turan biostimulant has an enhancing effect on the growth of pechay such that higher rates can initiate taller plants (Table 3).

Table 3. Plant height of pechay treated with Turan biostimulant.

	TREATMENT	PLANT HEIGHT (cm)				MEAN
		1	2	3	4	
1	Inorganic Fertilizer alone (IF)	30.68	31.45	30.25	31.40	42.14 b
2	IF + 1rr Turan @ 20 ml	32.90	30.95	30.90	32.55	44.84 b
3	IF + ½rr Turan @ 10 ml	33.20	30.10	33.20	28.10	42.72 b
4	IF + 1½rr Turan @ 30 ml	33.90	31.40	33.85	32.20	49.81 b
5	Control	24.80	26.75	25.80	25.30	15.38 a

cv 1.8, $p<0.001$ *Means with the same letter are not significantly different at $\alpha = 0.05$

3.4 Effect on leaf length of pechay

The leaf length was measured from the biggest leaf of each plant sample (Table 4). The data were like the plant height data in terms of the relationship of treatments among each other. The data revealed that the longest leaves were from plants treated with 1.5rr Turan biostimulant but were not significantly different from the rest of the treatments except for the control plants. On the other hand, the shortest leaves were obtained from the control plants and were significantly different from the rest of the treatments.

Table 4. Leaf length of pechay with Turan biostimulant at harvest

	TREATMENT	LEAF LENGTH (cm)				MEAN
		1	2	3	4	
1	Inorganic Fertilizer alone (IF)	22.10	20.10	22.75	18.05	20.75 b
2	IF + 1rr Turan @ 20 ml	19.75	23.05	19.20	22.80	21.20 b
3	IF + ½rr Turan @ 10 ml	22.50	21.10	20.55	20.35	21.13 b
4	IF + 1½rr Turan @ 30 ml	23.70	19.70	21.65	21.75	21.70 b
5	Control	14.55	16.25	15.05	14.40	15.06 a

cv 13.6, $p<0.001$ *Means with the same letter are not significantly different at $\alpha = 0.05$

3.5 Effect on leaf width of pechay

The leaf width was measured from the biggest leaf of each plant sample (Table 5). The data were like the plant height data in terms of the relationship of treatments among each other. The data revealed that the widest leaves were obtained from the plants treated with 1.5rr Turan biostimulant but were not significantly different from the rest of the treatments, except for the control plants. On the other hand, the narrowest leaves were obtained from the control plants and were significantly different from the rest of the treatments.

Table 5. Leaf width of pechay with Turan biostimulant at harvest

	TREATMENT	LEAF WIDTH (cm)				MEAN
		1	2	3	4	
1	Inorganic Fertilizer alone (IF)	18.85	17.85	18.05	15.25	17.50 b
2	IF + 1rr Turan @ 20 ml	18.65	14.95	18.15	19.20	17.74 b
3	IF + ½rr Turan @ 10 ml	16.25	19.30	15.80	19.20	17.64 b
4	IF + 1½rr Turan @ 30 ml	19.05	17.61	18.80	16.70	18.04 b
5	Control	10.05	12.55	10.80	10.50	10.98 a

cv 12.9, $p<0.001$ *Means with the same letter are not significantly different at $\alpha = 0.05$

3.6 Effect on the number of leaves of pechay

The number of leaves data was gathered by counting all matured leaves bigger than one inch in size. The highest number of leaves was obtained in the plants treated with inorganic fertilizer alone while the least number was obtained from the control (Table 6). All plants treated with either inorganic fertilizer alone or with Turan biostimulant, at any rate, are comparable with each other except the control plants.

Table 6. Number of leaves of pechay with Turan biostimulant at harvest

	TREATMENT	NUMBER OF LEAVES				MEAN
		1	2	3	4	
1	Inorganic Fertilizer alone (IF)	8.9	8.2	8.5	8.5	8.53 b
2	IF + 1rr Turan @ 20 ml	8.1	8.2	8.0	7.6	7.98 b
3	IF + ½rr Turan @ 10 ml	8.0	8.0	8.8	7.9	8.18 b
4	IF + 1½rr Turan @ 30 ml	9.1	7.7	8.4	7.7	8.23 b
5	Control	6.6	7.9	6.8	7.7	7.25 a

cv 1.4, $p<0.001$ *Means with the same letter are not significantly different at $\alpha = 0.05$

3.7 Effect on root length of pechay

The root length data were gathered by measuring the roots of ten plant samples for each plot. The data showed that the longest roots were produced in the pechay plants treated with 1.5rr Turan biostimulant which was comparable to inorganic fertilization and Turan-treated plants, at any rate. On the other hand, the shortest roots were observed in the control plots but were not significantly different from the rest of the treatments, except for the 1.5rr Turan-treated plants (Table 7).

Table 7. Root length of pechay with Turan biostimulant at harvest

	TREATMENT	ROOT LENGTH (cm)				MEAN
		1	**2**	**3**	**4**	
1	Inorganic Fertilizer alone (IF)	11.70	14.20	12.05	12.70	12.66 ab
2	IF + 1rr Turan @ 20 ml	16.00	13.90	11.80	12.40	13.52 ab
3	IF + ½rr Turan @ 10 ml	14.40	13.00	14.40	11.75	13.39 ab
4	IF + 1½rr Turan @ 30 ml	14.32	13.55	14.50	14.75	14.28 b
5	Control	11.70	11.15	11.85	14.45	12.29 a

cv 2.2, p=0.03 *Means with the same letter are not significantly different at α = 0.05

3.8 Effect on root biomass of pechay

The root biomass was gathered by weighing the roots of ten plant samples for each plot. The data revealed that the heaviest roots were produced in the pechay plants treated with 1.5rr Turan biostimulant which was comparable to inorganic fertilization and Turan-treated plants, at any rate. On the other hand, the shortest roots were observed in the control plots and were significantly different from the rest of the treatments (Table 8).

Table 8. Root biomass of pechay with Turan biostimulant at harvest

	TREATMENT	ROOT BIOMASS (g)				MEAN
		1	**2**	**3**	**4**	
1	Inorganic Fertilizer alone (IF)	9.1	7.5	5.8	5.5	12.66 ab
2	IF + 1rr Turan @ 20 ml	7.0	9.6	6.1	7.5	13.52 ab
3	IF + ½rr Turan @ 10 ml	9.5	5.7	6.0	7.0	13.39 ab
4	IF + 1½rr Turan @ 30 ml	7.5	7.5	8.0	8.4	14.28 b
5	Control	4.0	3.6	3.9	6.1	12.29 a

cv 8.9, p<0.001 *Means with the same letter are not significantly different at α = 0.05

Fertilizers and pesticides play a crucial role in agriculture, providing growers a powerful tool to increase yield and guarantee continuous productivity throughout the seasons under both optimal and suboptimal conditions. Several technological innovations have been proposed to enhance the sustainability of agricultural production systems, by significantly reducing the use of synthetic agrochemicals like pesticides and fertilizers. Fertilizer supplements have been evaluated to maximize the growth and yield of various crops (Adorada et.al., 2023; Fernandez and Agan, 2021; Magbalot-Fernandez et al., 2020; Montifalcon and Fernandez, 2017; Fernandez and Sabay, 2016; Fernandez and Miñoza, 2015). The use of plant biostimulants, which are any substance or microorganism applied to plants can enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrient content (Rouphael and Colla, 2020; Colla and Rouphael, 2015). Biostimulants could be seaweed extracts (Battachatyya et al, 2015; Rouphael et al, 2017a), humic and fulvic acids (Canellas et al., 2015; Nardi et al., 2016), silicon (Savvas, 2015), protein hydrolysates (Colla et al, 2015; Nardi et al., 2016; Rouphael et al., 2017b), phosphates (Gomez-Merino and Trejo-Tellez, 2015), soybean peptide (Matsumiya and Kubo, 2011), chitosan (Pichyangkura and Chadchawan, 2015), plant growth -promoting rhizobacteria (Ruzzi and Aroca, 2015), and fungi such as Trichoderma (Lopez-Bucio et al., 2015) and arbuscular mycorrhizal fungi (Rouphael et al., 2015).

According to Calvo et. al (2014), the stimulation of germination, seedlings, and plant growth, as well as crop productivity in response to plant biostimulant application, has been usually associated with the action of signaling bioactive molecules in the primary and secondary metabolisms, fostering plant growth and development throughout the crop life cycle from seed germination to plant maturity in a number of demonstrated ways, including but not limited to improving the efficiency of the plant's metabolism to induce yield increases and enhanced crop quality; facilitating nutrient assimilation, translocation and use; enhancing quality attributes of produce, including color, fruit seeding, sugar content, etc.; rendering more efficient water use; enhancing certain physicochemical properties of the soil and fostering the development of complementary soil micro-organisms; increasing plant tolerance to and recovery from abiotic stresses;. However, biostimulants have no direct action against pests and therefore do not fall within the regulatory framework of pesticides (European Biostimulants Industry 2012). Biofertilizers, as a biostimulants sub-category, can increase nutrient use efficiency and can open new routes of nutrient acquisition by plants, while microbial biostimulants including mycorrhizal and non-mycorrhizal fungi, bacterial endosymbionts, e.g. Rhizobium, and Plant Growth-Promoting Rhizobacteria (PGPR) that can have dual function of biocontrol agent and biostimulant (du Jardin, 2015).

The global market for biostimulants was worth around US$3.34 billion in 2022, projected to be from US$3.69 billion in 2023 to US$7.97 billion by 2023 (Biostimulants Market Size, Share & COVID-19 Impact Analysis, 2023). But despite the growing use of biostimulants in agriculture, many in the scientific community consider biostimulants to be lacking enough scientific evaluation (Calvo et. al., 2013).

4. CONCLUSION

The new product, Turan biostimulant performed well in the trial by giving yield advantages over the control and slightly to the conventional inorganic fertilization. The study revealed that the test product was able to slightly enhance pechay production in terms of total fresh yield, plant height, leaf length, leaf width, root length, and root biomass with an estimated increase of more than 1.18%, 1.06%, 1.04%, 1.03%, 1.13%, and 1.12%, respectively relative to inorganic fertilizer application alone. Plants treated with 1.5rr Turan biostimulant can significantly improve the yield and quality of pechay. In addition, the bioefficacy data on total fresh yield, plant height, leaf height, leaf width, root length, and root biomass showed significant differences with the control. The control plants are relatively inferior in quality in terms of size and color, thus, Turan biostimulant can be applied as a foliar amendment to enhance pechay production.

In general, pechay is very responsive to granular fertilization and the application of Turan biostimulant**.** At a very conservative amount of 750 ml/hectare, it gave a yield advantage of 7,670.00 and 34,437.50 kgs/ha over the full dose of inorganic fertilizer and the control, respectively. This could be translated to additional income of PhP 191,718.75 (US$ 3,834.38) to PhP 860,937.50 (US$ 17,218.75) at Php 25/kg (US$ 0.5/kg) (as of December 2021 farm gate price) over the full dose of inorganic fertilizer alone and the control, respectively.

The data also revealed that granular inorganic fertilization generally dictates the growth and performance of pechay, but the addition of a biostimulant would further improve the quantity and quality of pechay yield. In terms of its feasibility in pechay production, one and a half doses of Turan biostimulant or higher is highly recommended to obtain the highest possible income.

The present study was a successful attempt to validate the benefits of applying biostimulants as an enhancer of crop growth and yield.

REFERENCES

Adorada JL, Adorada AL, Recuenco-Adorada J. Field efficacy of Alka Foliar 5-5-8 fertilizer on the growth and yield of *Brassica rapa* subsp. *chinensis* (Pechay). International Journal of Multidisciplinary Research and Publications, 2023; 5(12): 132-137.

Battacharyya D, Babgohari MZ, Rathor P, Prithiviraj B. Seaweed extracts as biostimulants in horticulture. Sci. Hortic. 2015; 196:39–48. doi: 10.1016/j.scienta.2015.09.012

Biostimulants Market Size, Share & COVID-19 Impact Analysis. Fortune Business Insights. Retrieved 20 July 2023 from https://www.fortunebusinessinsights.com/industry-reports/biostimulants-market-100414.

Bullion A. Biostimulants market growing strongly at 10% per annum. 2022. https://www.spglobal.com/commodityinsights/en/ci/research-analysis/biostimulants-market-growing-strongly-at-10-per-annum.html

Canellas LP, Olivares FL, Aguiar NO, Jones DL, Nebbioso A, Mazzei P, Alessandro, P. Humic and fulvic acids as biostimulants in horticulture. Sci. Hortic. 2015; 196:15–27. doi: 10.1016/j.scienta.2015.09.013

Colla G, Rouphael Y. Biostimulants in horticulture. Sci. Hortic. 2015; 196:1–2. doi: 10.1016/j.scienta.2015.10.044

Colla G, Nardi S, Cardarelli M, Ertani A, Lucini L, Canaguier R, Rouphael Y. Protein hydrolysates as biostimulants in horticulture. Sci. Hortic. 2015; 196:28–38. doi: 10.1016/j.scienta.2015.08.037

Du Jardin P. Plant biostimulants: Definition, concept, main categories, and regulation. Scientia Horticulturae, 2015; 196:3-14.

European Biostimulants Industry Council. EBIC and biostimulants in brief. 2012. http://www.biostimulants.eu/

Fernandez AM, Agan MS. Bio-Forge promotes growth and yield performance of pechay (*Brassica rapa* L. var. *chinensis* (L.) Hanelt). Annales Universitatis Paedagogicae Cracoviensis, Studia Naturae, 6: 2021; ISSN2543-8832

Fernandez AM, Miñoza E. Growth and yield of pechay (*Brassica pekinensis*) as affected by Green Herds organic based foliar fertilizer. Special Issue: First International Conference on Quality Management of Organic Horticultural Produce 2015. Book of Proceedings, Horticulturae. Basel, Switzerland. 2015; p.346.

Fernandez AM, Sabay JL. Growth of tissue-cultured abaca hybrid (*Musa textiles* var. ´seven´) plantlets using bioforge supplement. *Imperial Journal of In*terdisciplinary Research, 2016; 2(8):249–252.

Gawryś W. *Latin-Polish dictionary of herbaceous plants* (*Słownik roślin zielnych łacińsko-polski*). Kraków: Officina Botanica. 2008. [In Polish]

Gómez-Merino FC, Trejo-Téllez LI. Biostimulant activity of phosphate in horticulture. Science Hortic. 2015; 196:82–90. doi: 10.1016/j.scienta.2015.09.035

López-Bucio J, Pelagio-Flores R, Herrera-Estrella A. Trichoderma as biostimulant: exploiting the multi-level properties of a plant beneficial fungus. Sci. Hortic. 2015; 196:109–123. doi: 10.1016/j.scienta.2015.08.043

Magbalot-Fernandez A, Matuguinas JP, Basu SK. Growth performance of tissue-cultured ´Lakatan´ Banana (*Musa acuminata*) plantlets using stimulant. International Journal of Agricultural Sciences, 2020; 12(2):56–58.

Magbalot-Fernandez A, Montifalcon L. Effects of organic-based fortified foliar fertilizer on the growth and yield of 'Lakatan' Banana (*Musa acuminata*). Asian Journal of Research in Crop Science, 2019; 3(4):1–9. https://doi.org/10.9734/ajrcs/2019/v3i430053

Matsumiya Y, Kubo M. "Soybean peptide: novel plant growth promoting peptide from soybean," in Soybean and Nutrition. Ed. El-Shemy, H. (Rijeka: In Tech Europe Publisher), 2011; 215–230. doi: 10.5772/19132

Montifalcon JR, Fernandez AM Enhanced growth and yield of lowland rice (*Oryza sativa* L.) with greenshield organic-based fortified foliar fertilizer. Asian Journal of Soil Science and Plant Nutrition, 2017; 1(1):1–10.

Nardi S, Pizzeghello D, Schiavon M, Ertani A. Plant biostimulants: physiological responses induced by protein hydrolyzed-based products and humic substances in plant metabolism. Sci. Agric. 2016; 73:18–23. doi: 10.1590/0103-9016-2015-0006

Pichyangkura R, Chadchawan S. Biostimulant activity of chitosan in horticulture. Sci. Hortic. 2015:196:49–65. doi: 10.1016/j.scienta.2015.09.031

Rouphael Y, Colla G. Editorial: Biostimulants in Agriculture. Front. Plant Sci. 2020; 11:40. doi: 10.3389/fpls.

Rouphael Y, Franken P, Schneider C, Schwarz D, Giovannetti M, Agnolucci, M., De Pascale S, Bonini P, Colla G. Arbuscular mycorrhizal fungi function as biostimulants in horticultural crops. Sci. Hortic. 2015; 196:91–108. doi: 10.1016/j.scienta.2015.09.002

Rouphael Y, De Micco V, Arena C, Raimondi G, Colla G, De Pascale S. Effect of Ecklonia maxima seaweed extract on yield, mineral composition, gas exchange and leaf anatomy of zucchini squash grown under saline conditions. J. Appl. Phycol. 2017a; 29:459–470. doi: 10.1007/s10811-016-0937-x

Rouphael Y, Cardarelli M, Bonini P, Colla G. Synergistic action of a microbial-based biostimulant and a plant derived-protein hydrolysate enhances lettuce tolerance to alkalinity and salinity. Front. Plant Sci. 2017b; 8:131. doi: 10.3389/fpls.2017.00131

Ruzzi M, Aroca R. Plant growth-promoting rhizobacteria act as biostimulants in horticulture. Sci. Hortic. 2015; 196:124–134. doi: 10.1016/j.scienta.2015.08.042

Savvas D, Ntatsi G. Biostimulant activity of silicon in horticulture. Sci. Hortic. 2015; 196:66–81. doi: 10.1016/j.scienta.2015.09.010

SCL Italia. New crop management approach for sustainable agriculture. 2020. Retrieved from https://www.fertiglobal.com.

Shahrajabian MH, Chaski C, Polyzos N, Petropoulos SA. Biostimulants Application: A Low Input Cropping Management Tool for Sustainable Farming of Vegetables. Biomolecules. 2021 May 7;11(5):698. doi: 10.3390/biom11050698.