Biological Forum – An International Journal **15(9): 297-302(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Impact of Biostimulant on Growth, Yield and Quality of Potato (*Solanum tuberosum* L.)

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(Received: 16 June 2023; Revised: 26 July 2023; Accepted: 22 August 2023; Published: 15 September 2023)
(Published by Research Trend)

ABSTRACT: The present investigation on "Impact of biostimulant on growth, yield, and quality of potato (*Solanum tuberosum* L.)" was carried out during the period of 2022–23 at "C" Block Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal. The farm is located very close to the Tropic of Cancer, having approximately 22.89°N latitude and 88.45°E longitude. The altitude of the place is about 9.75 m above sea level. The main objectives of this study were to find out the important impact of biostimulants and the ideal stage of application. In present days it shows that application of biostimultant has better opportunities for sustainable farming. The statistical analysis was done using Randomized Block Design (RBD) with three replications and seven treatments. It was noticed in the experiment that the application of biostimulants enhanced crop growth and promoted reproductive growth in later stages of the crop compared to control plants. Amongst the treatments, biostimulant application as foliar spray showed significant influences on growth, yield, and quality parameters. Seaweed extracts (*Ascophyllum nodusum*) applied topically had a substantial impact on the number of tubers produced per plant. Application of seaweed extracts (*Ascophyllum nodusum*) at 500 ml/acre during 25–30 DAPS and 40–45 DAP (T3) significantly registered the highest number of tubers per plant of 10.37. Significant responses were also observed on quality parameters with seaweed extracts, protein hydrolysates, and N-fixing growth promoters when applied as foliar sprays during different stages of plant growth. The highest value of 17.33 g/100 g of CHO was observed in the plants where seaweed extracts (*Ascophyllum nodusum*) were sprayed twice. Based on the results obtained from the present investigation, it may be concluded that application of seaweed extracts (*Ascophyllum nodusum*) twice days after planting, and again, 40–45 days after planting, may be suitable for potato cultivation for increasing production and improving the quality of potato tubers as compared to the control. T6 (protein hydrolysates and N-fixing growth promoter) also showed a good response in some parameters.

Keywords: Physio-activator, biostimulant, protein hydrolysate, amino acid and potato.

INTRODUCTION

Vegetables are very essential to human health as they are rich in dietary fiber and a source of essential vitamins, minerals, trace elements, vitamins, and antioxidants. The two major vegetable crops, *viz*., potato and tomato, contribute above 50% of production (Vanitha *et al.*, 2013). Vegetables are herbaceous annuals that require ample amounts of nutrients within a short period of time to get an optimum yield. Potato (*Solanum tuberosum* L.), an annual herbaceous tuber crop belonging to the Solanaceae family, supplies all the necessary nutrients for good health. Tetraploid with 2n = 48, the extensively cultivated potato has its origins in Peru, South America.

The potato, sometimes known as "the king of vegetables", is now the fourth-most important food crop, surpassing even corn, wheat, and rice. In terms of nutrition, a balanced diet, and global food security, potatoes are crucial. Gupta and Gupta (2019) Potatoes are a good source of high-quality protein, minerals, vitamins B and C (particularly L-ascorbic acid), and other nutrients that are good for health. About 7–8% of the daily required intake of protein, 6–11% of carbs, 50% of vitamin C, 30–40% of potassium, and roughly 17% of fiber can be obtained from 250–300 g of boiling potatoes. Potato tubers include anti-nutritional chemicals such as glycoalkaloids and nitrates, along with nutrients (Thakur *et al.*, 2019). Edible potatoes are evaluated according to how nutritious they are and how few anti-nutrients they contain. A crucial attribute of quality is the sensory quality, such as the darkening that occurs after cooking.

In high-value crop production that is sustainable, biostimulants have been becoming more and more important. These organic compounds improve crop quality attributes, abiotic stress tolerance, and/or nutrient efficiency. Plant biostimulants based on humic acids and seaweed extracts currently hold the largest market share (Magdalena *et al.*, 2019).

Extracts from seaweed are intricate combinations with several modes of action. Seaweed extracts contain bioactive chemicals that boost plant growth, increase nutrient usage efficiency, strengthen plant defenses against diseases, and enhance crop quality (Mukherjee and Patel 2020).

In order to achieve adequate yields and high-quality products, growers use a wide range of fertilizers and pesticides, which account for up to 38 and 43 percent, respectively, of the plants' total production costs. Heavy use of these synthetic chemicals can have adverse effects on non-targeted species and chemical contamination of soil, water supplies, and harvested produce (Krithiga *et al.*, 2022). In order to avoid using excessive amounts of external inputs without compromising crop performance, it is essential for a sustainable potato production system to maximize soil nutrient availability and nutrient usage efficiency. Plant biostimulants could be quite beneficial to farmers in this situation.

Seaweed liquid extract has recently gained importance as a foliar spray for lots of crops, including various varieties of grasses, flowers, cereals, vegetables, and spices (Pramanick *et al.*, 2013 & 2014). Further, Zodape (2001) tried various modes of seaweed extract application, such as foliar spray, application to soil, and soaking of seeds before sowing, and reported that extract not only enhances the germination of seeds but also increases uptake of plant nutrients and gives resistance to frost and fungal diseases. In this context, a liquid formulation of protein hydrolysate and amino acids is a complex mixture of peptides and amino acids that can be produced from various biomass sources. The formulations can be used as foliar sprays and are available as liquid extracts. Due to their abundance of bioactive chemicals and their outstanding effectiveness in improving crop outputs, the goods are becoming more and more popular. The addition of 180 kg ha^{-1} nitrogen to onion crop raised through onion-set and produced best outcomes in almost all the studied parameters (Khan *et al*., 2021).

It has been shown that foliar application perform important roles as biostimulants by modulating the physiological and molecular processes of plants, which promote growth, boost production, and lessen the effects of abiotic stress on crops. In addition to their direct impacts on plants, PHs have also been shown to have indirect effects on plant nutrition and growth. Foliar treatments have been demonstrated to increase the efficiency with which macro- and micronutrients are absorbed and utilized.

To achieve reasonable yields and high-quality produce, growers use a wide range of fertilizers and pesticides, which account for up to 38 and 43% of total crop production costs, respectively. Abundant use of these synthetic chemicals can result in detrimental effects on non-target species and chemical contamination of soil, water supplies, and harvested products. Growers continue to search for sustainable strategies that will improve crop yields without adversely impacting the environment. Keeping this view in perspective, the present investigation describes the dosage and stage of application of bio-stimulants, protein hydrolysates, and N-fixing growth promoters to find out the impact on growth and yield in Potato (*Solanum tuberosum*).

MATERIALS AND METHODS

The field experiment was conducted at C-block farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, and West Bengal. The experiment was done during the Rabi season of 2021–22. The laboratory work was carried out at the "Department of Vegetable Science" and the "Quality Control Laboratory", Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia. The experimental site is located at 22.89º N latitudes and 88.45º E longitudes at 9.75m AMSL. The "C" block farm is situated in a warm sub-tropical humid climate within the torrid regions but in proximity to the Bay of Bengal with a network of rivers, which protects the place from extreme conditions. The average temperature ranges from 25º-36.5ºC during the summer months and between 12ºC and 25ºC during the winter months. The experimental field is located in the New Alluvial Plains of West Bengal. The soil was sandy loam with a slightly acidic nature. The experimental site had assured irrigation facilities. The trial was laid out in a randomized block design with seven treatments, each replicated three times. The treatment factors included the following treatments:

Treatments	Products	Dose/acre	No. of application	Time of application
T1	Seaweed extracts (*Ascophyllum nodusum*)	500 ml	1	25-30 DAP
T2	Seaweed extracts (*Ascophyllum nodusum*)	500ml	1	40-45 DAP
T3	Seaweed extracts (*Ascophyllum nodusum*)	500ml	2	I^st^ application: 25-30DAP II^nd^ application: 40-45 DAP
T4	Protein hydrolysates and N-fixing growth promoter	500ml	1	25-30DAP
T5	Protein hydrolysates and N-fixing growth promoter	500ml	1	40-45 DAP
T6	Protein hydrolysates and N-fixing growth promoter	500ml	2	I^st^ application: 25-30DAP II^nd^ application: 40-45 DAP
T7	Control (water only)			

The potato cultivar Super-6 was under investigation. Nitrogen, phosphorus, and potassium were applied in the form of urea, di-ammonium phosphate, and muriate of potash, respectively. All recommended agronomic practices as well as plant protection measures were adopted for potato crop production. All growth-attributing characters and yield parameters were observed in five randomly selected and tagged plants from each plot. These five plants from each treatment were continued up to harvesting without dehauling. Disease-free medium-size tubers are planted at a distance of 60 cm row to row and 20 cm plant to plant, as per bed size of 3 × 4.5 = 14.5 sq m. The F-test was computed to find out the significance of treatments impacts on the potato crop. Standard errors of variance and critical differences of various treatments were computed at the 5% level of significance to assess the authenticity of each respective treatment.

RESULTS AND DISCUSSIONS

Growth parameters

Plant height (cm): The effect of seaweed extract and Protein hydrolysates on Plant height of the potato was observed to be highly significant. It revealed from the Table -1 that the height of the plant varied from 59.33 cm to 65.05 cm with different treatments. The plant height was measured among all treated and untreated plants and was recorded highest plant height of 65.05 cm in plants with the application of seaweed extract (*Ascophyllum nodusum*) with two application, first application was given 25-30DAP and the second application was given during 40-45DAP. The second highest plant of 64.62cm was observed from T_6 treatments plants (Protein hydrolysates) was given 25-30DAP and the second application was given during 40-45DAP. The lowest plant height of 59.33 cm was obtained in plants with spray of water as control and the second lowest plant height of 62,02cm was recorded from the T_4 (Protein hydrolysates applied once during 25-30DAP). The present investigation on plant height showed good response of biostimulator at when sprayed as foliar @ 500ml/acre during the two stages of plant growth i.e., 25-30DAP and 40-45DAP. The similar finding was also reported by Farouk, S. (2015).

Number of branches per plant (cm): A significant influence on the number of branches per plant was observed due to seed weed extract foliar application at the various stages of plant growth. The number of branches or plants showed a good amount of difference in seed weed extract foliar application. The number of branches or plants varied from 3.49 to 3.89. The maximum number of branches per plant of 3.89 was obtained from the plants where seaweed extract (*Ascophyllum nodusum*) was applied during 25–30 DAP and 40–45 DAP (T3). The second-highest number of branches or plants (3.86) was found in T6. It was revealed from the table that the minimum number of branches per plant was found to be the lowest of 3.49 in the control plants, followed by T4, which produced 3.77 branches per plant. Kargapolova *et al.* (2020) have worked with *Azospirillum umbrasilense* Sp245, SR80, and *Azospirillum halopraeferensis* and reported significant growth promotion of potatoes in terms of the number of leaves.

Yield attributing characters

Number of tubers per plant: The data recorded on the number of tubers per plant is furnished in Table 1. Among the treatments, foliar application of biostimulant exhibited a significant influence on the number of tubers per plant. Application of seaweed extract (*Ascophyllum nodusum*) at 500 ml/acre during 25–30 DAP and 40–45 DAP (T3) significantly registered the highest number of tubers per plant of 10.37. The treatments, *viz.*, application of protein hydrolysates during 25–30 DAP and 40–45 DAP, stood next in order of ranking for producing a higher number of tubers (8.90). Biostimulant and protein hydrolysates when sprayed as foliar during 40–45 DAP also showed an increasing tendency to produce more tubers than when these two foliar were sprayed in the early stage of growth, i.e., 25–30 DAP. It indicates from the observation that these biostimulant foliars have a pronounced effect on producing more tubers per plant, and the vital stages for application are twice as many. (25-30 DAP and 40-45 DAP). The lowest number of tubers (5.00) per plant was observed in the control treatment. These results are inconsistent with the findings of Głosek *et al.* (2018). This might be due to the better physio-chemical properties of the biostimulant, which helped in achieving a higher number of tubers per plant.

Diameter of tuber (cm): The different treatments had a significant difference in tuber diameter. The results have been presented in Table 1. Tuber diameter (cm) variations across types were statistically significant. It measures 5.70cm by 6.75cm. The plants that were given twice foliar sprays of biostimulant at 25–30 DAP and 40–45 DAP had the largest tuber diameter at 6.75 cm, followed by the plants that received twice applications of protein hydrolysates and N-fixing growth promoter at 25–30 DAP and 40–45 DAP. Differences in tuber diameter between the treatments may be due to the impact of biostimulant foliar, which may aid in enhancing tuber diameter. The lowest diameter of the tuber from the control plant was only 5.70 cm. From the present investigation, it clearly indicates that seaweed extract has more boosting capacity to enhance the development and size of potatoes compared to protein hydrolysates and N-fixing growth promoters.

Average tuber weight (g): A significant difference in average tuber weight (g) due to different treatments of foliar application of biostimulant at different stages was observed during the investigation. The details of the experiment were presented in Table 5. Among the various treatments, it was observed that when seaweed extract was applied twice in the growing period, it exhibited the highest average weight of tubers (66.39g). The second-highest average weight of tubers (61.20g) was found in the plants in T6 treatments. Seaweed extract, protein hydrolysates, and N-fixing growth promoter application showed a good response for increasing the weight of tubers when applied twice during 25–30 DAP and 40–45 DAP. The application of these stimulants once at a growing period is not effective compared to twice the application. The minimum average weight of tubers (45.73g) was obtained from control plants, followed by plants that exhibit a value of 49.80 g, where single protein hydrolysate applications were given during 25–30 DAP.

Tuber dry matter (%): Tuber dry matter showed highly significant variations. The highest tuber dry matter was observed at 21.718% when the plants were foliar sprayed with biostimulant during 25–30 DAP and 40–45 DAP. The second-highest tuber dry matter percentage of 21.505% was found from twice the application of protein hydrolysates. Regarding the application of these stimulants, it was noticed that a good response was found when applied twice in the growing period. Similarly, it was noticed that if a single application was done, it was better to apply 40–45 DAP. The lowest tuber dry matter (%) of 16.89 was found in the control treatment.

Total yield (t/ha): The different treatments had a significant difference in tuber yield. The results have been presented in Table 1 and Fig. 1. Graded and total tuber yield (t/ha) also exhibited significant differences due to the different applications of these biostimulants. The maximum small graded bulb was found in T2, and the minimum was obtained from T3 and T5. The maximum medium-graded bulb of 20.8 t/ha was obtained from T3. Overall total yield of 32.2 t ha was obtained from the plants that were applied foliar spray seaweed extract twice in a growing period. Protein hydrolysates and N-fixing growth promoter application twice in a growing season also proved to be getting the second highest total yield of 29.3 t/ha. The minimum total yield of 22.3 t/ha was obtained from the plant, which was not given any stimulants. (T7).

Quality attributing characters

Total sugar (%): The effect of different treatments on total sugar (%) was found to be significant. The results have been presented in Table 2. Total sugar (%) for different foliar biostimulants showed highly significant variations. The highest total sugar (%) of 7.33 was observed when plants were given foliar sprays of seaweed extract at 500 ml/acre at 25–30 DAP and 40–45 DAP. The lowest total sugar was observed at 4.18% from the control. The results are inconsistent with the findings of Haider *et al.* (2012).

Reducing sugar (%): A significant response was observed to reducing sugar percentages with seaweed extract and protein hydrolysates when applied as foliar sprays during different stages of plant growth. It revealed from the present findings that the reducing sugar percentage was found to be highest at 0.54% in the plants that were treated with seaweed extract (*Ascophyllum nodusum*) at 500 ml/acre, followed by the plants that received protein hydrolysates twice in the same stages (0.52%). In all treatments, the values of reducing sugar did not differ highly. The lowest of 0.38% was obtained from the control.

Total Soluble Solids (ºBrix): Total Soluble Solids (º Brix) content was influenced significantly. Total Soluble Solids (ºBrix) content varied from 0.36 (ºBrix) to 0.81 (ºBrix). The highest value of 0.81 (ºBrix) was obtained from the treatments when seaweed extract was applied at 25–30 DAP. The lowest value of total soluble solids was obtained from control plants, followed by T6. It was clear that the application of protein hydrolysates and N-fixing growth promoters was not effective in increasing the values of total soluble solids.

CHO(g/100g): The significant effect was observed on CHO(g/100g) contents. It varied from 12.40–17.33 g/100 g (Fig. 3). The highest value of 17.33 g/100 g of CHO was observed in the plants where seaweed extract was sprayed twice. The second highest CHO was obtained from the plants that were sprayed with protein hydrolysates and N-fixing growth promoters. It was clear that foliar sprays of biostimulant have a pronounced effect on getting the highest CHO.

Starch content (%): The different treatments had a significant difference in starch content (%). The results have been presented in Table 2 and Fig. 1. Starch content (%) with respect to foliar application of biostimulant at different stages influenced significantly, and the highest starch content of 12.39% was observed from the application of seaweed extract (*Ascophyllum nodusum*) at 500 ml/acre twice.

Table 1: Effect of biostimulant on yield parameters of Potato.

Treatments	Plant height (cm)	No. of branches per plant	% dry matter production	No. of tubers per plant	Diameter of tuber (cm)	Average Tuber weight (gm)	Total yield(t/ha) (Grade wise)				
							Small	Medium	Large	Deformed	Total
T_1	**61.67**	**3.78**	18.948	5.80	5.81	52.14	3.5	16.8	6.6	0.2	26.6
T_2	**63.31**	**3.81**	20.722	8.60	6,45	57.13	4.0	17.6	7.1	0.1	28.3
T_3	**65.05**	**3.89**	21.718	10.37	6.75	66.39	2.70	20.8	8.3	0.1	32.2
T_4	**62.02**	**3.77**	17.502	5.60	5.77	49.80	2.90	15.2	7.1	0.2	25.4
T_5	**62.32**	**3.81**	19.772	7.20	6.37	56.52	2.70	17.2	7.2	0.3	27.4
T_6	**64.62**	**3.86**	21.505	8.90	6.68	61.20	3.30	18.6	7.3	0.1	29.3
T_7	**59.33**	**3.49**	**16.89**	5.00	5.70	45.73	3.00	14.2	5.2	0.2	22.3
SE(m)±	**0.72**	**0.037**	**0.094**	0.70	0.04	0.153	0. 54	0.77	0.04	0.03	1.09
CD (5%)	**2.16**	0.113	0.284	2.103	0.125	0.461	1.62	2.34	0.138	0.10	3.27

Table 2: Effect of biostimulant on quality parameters of Potato.

Treatment	Total Soluble Solids (°Brix):	Reducing sugar (%)	Total sugar content (%)	CHO(g/100g)	Starch Content (%)
T_1	0.81	0.42	5.17	14.16	9.64
T_2	0.71	0.50	4.28	15.66	9.83
T_3	0.72	0.54	7.33	17.33	12.39
T_4	0.46	0.49	7.13	14.02	9.10
T_5	0.51	0.47	4.22	14.16	9.21
T_6	0.45	0.52	7.21	16.32	11.81
T_7	0.36	0.38	4.18	12.40	8.58
SE(m) ±	0.03	0.03	0.15	5.25	0. 68
CD (5%)	0.11	0.11	0.46	15.76	2.05

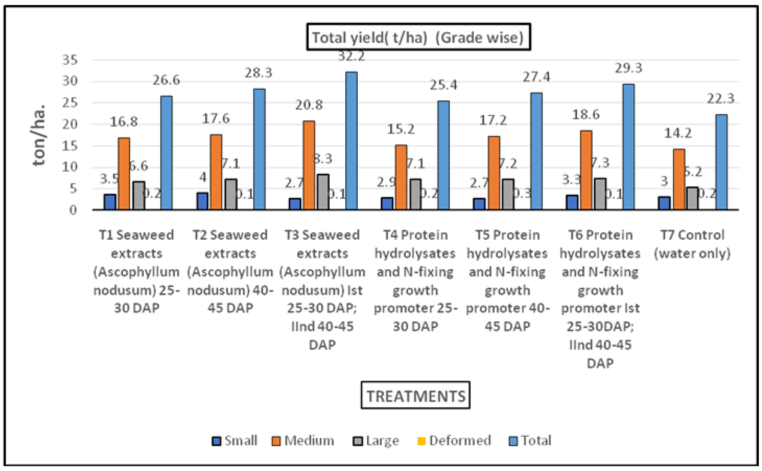

Fig. 1. Effect of bio stimulants on total yields of potato.

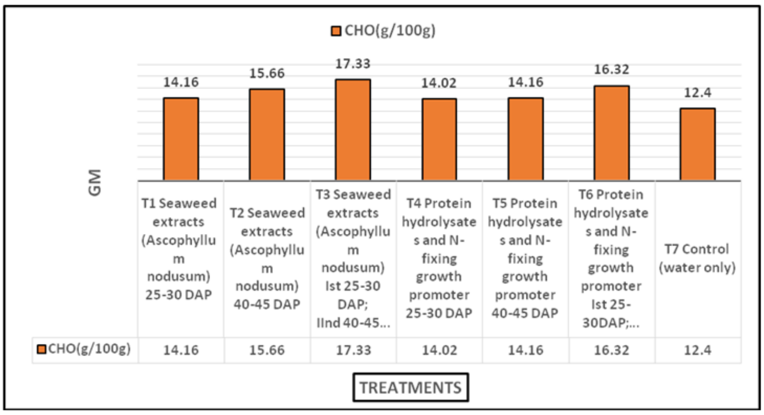

Fig. 2. Effect of bio stimulants on CHO content of potato.

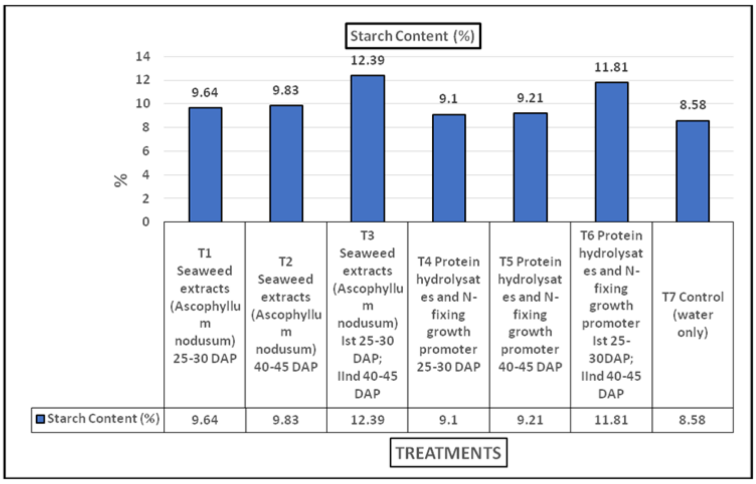

Fig. 3. Effect of bio stimulants on starch content of potato.

CONCLUSIONS

It can be inferred from the present findings that biostimulant application is essential to improving potato tuber yield. Although the application of stages is also one of the important factors for vegetative parameters of crop growth, based on the results obtained from the present investigation, it may be concluded that application of seed weed extract (*Ascophyllum nodusum*) at 500 ml/acre twice during 25–30 days after planting and again during 40–45 days after planting may be suitable for potato cultivation for increasing production and getting quality tubers of potato.

FUTURE SCOPE

Research on the "Impact of biostimulants on the growth, yield, and quality of potato (*Solanum tuberosum* L.)" is expected to continue, and there are several intriguing directions that it might go. Researchers should focus more on perfecting biostimulant formulations and application methods for particular potato varieties and environmental conditions as sustainable agriculture becomes more and more important. Future research should also look into how using biostimulants over the long term affects soil health and biodiversity. In order to improve potato output while reducing resource inputs, it may also be possible to investigate how biostimulants can be combined with other cutting-edge farming techniques, such as precision agriculture and controlled-environment agriculture. To effectively execute biostimulant adoption in agriculture on a larger scale, it will also be essential to comprehend its economic viability and scalability.

Acknowledgement. I extend my sincere thanks to Prof. (Dr.) Umesh Thapa (major advisor), Department of Vegetable Science, Bidhan Chandra Krishi Viswavidyalaya for giving me proper guidance throughout the course of study.
Conflict of Interest. None.

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How to cite this article: S. Karak, U. Thapa and N.N. Hansda (2023). Impact of Biostimulant on Growth, Yield and Quality of Potato (*Solanum tuberosum* L.). *Biological Forum – An International Journal, 15*(9): 297-302.