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INFLUENCE OF GROWING SUBSTRATES AND BIOSTIMULANTS SPRAY ON THE GROWTH, YIELD AND QUALITY PARAMETERS OF HYDROPONICALLY GROWN BITTER GOURD

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ABSTRACT

Recently, hydroponic system for vegetable production is very popular across the globe. In a hydroponic system selection of suitable growing substrate is an important factor as it directly involved in development of plant roots and shoots. As well as nutrition solution has a great effect on high crop production along with crop quality. Thus, an experiment was carried out within the controlled environment of a glasshouse consisting with the four different compositions of growing substrates i.e., GM1 = 60% rice husk + 30% coconut coir + 10% vermicompost, GM2 = 60% coconut coir + 30% perlite + 10% vermicompost, GM3 = 60% sawdust + 30% perlite + 10% vermicompost, and GM4 = 60% ash + 30% perlite + 10% vermicompost along with three levels of bio-stimulant (*Ascophyllum nodusum*) solutions (Bs1 =1ml/l, Bs 2 = 2ml/l, and Bs 3 =3ml/l). In the experiment amongst the different growing substrate, the substrates with 60% coconut coir, 30% perlite and 10% vermicompost (GM2) exhibits best performance on the growth (Number branches per plant), yield (Fruits number, length, girth, weight, Number of seeds per fruit). In case of quality parameters (Ascorbic acid, total carotenoids, protein, TSS and reducing sugars were also found in higher site with the substrates of 60% coconut coir + 30% perlite + 10% vermicompost. The application of bio-stimulants was also found to be ideal for increasing the fruit number and fruit weight, respectively. The highest fruit weight of 176.49gm was obtained from the treatment with the combination of GM2 and BS1.

Key words : Growing Substrates, Biostimulants, Hydroponic, Bitter gourd.

Introduction

Growing vegetable crops through hydroponic now a day's becoming popular in the smart farming systems for producing high value crops, which have a great demand in between consumers as well as have a good market value. For development of hydroponic system selection of suitable growing substrate is an important factor as it directly involved in development of plant root and shoot. According to Abad *et al*. (2002) a suitable growing substrate support the plant by serving as reservoir for water and nutrients, it allows oxygen diffusion to the plant roots, and permits gaseous exchange between the roots and atmosphere. There are so many options available for growing substrate, which are organic in nature, *e.g.*, coco peat, rice hull, saw dust, carbonized rice husk. Generally, coco peat is widely used for growing different horticultural crops. As coco peat has good pH, electrical conductivity with other chemical attributes, it is considered as good growing substrate (Abad *et al*., 2002). But the pros of coco peat are having high water holding capacity it causes low aeration with in the medium (Rahman *et al*., 2018). According to Yahya *et al*. (1997) coco peat can be used to produce several crops with acceptable quality. For cell division and root differentiation rice husk is good (Moe, 1988). Rice hull contains some extent of nutrition and it can be also used as coarse material to provide a good drainage and aeration to the plants. Some others material can be also used as coarser material, such as perlite, brick broken, gravel, etc. Furthermore, a good growing substrate with suitable components is important for better crop production.

Apart from growing medium, nutrition solution has a great effect on high crop production along with crop quality. According to Rahman and Inden (2012), the nutrient solution is directly involved in producing higher yield and quality of horticultural crops. Plant bio-stimulants are formulations that contain either a single or a combination of microbes, vitamins, amino acids, algal, seaweed extracts, and hydrolysed proteins, which are applied either as foliar or to the rhizosphere of the plant and amplify the processes to increase crop quality and production, by augmenting nutrient uptake and nutrient usage efficiency, as well as improving the crop resistance to environmental stress (Rouphael and Colla, 2018; Koleska *et al*., 2017; Du Jardin, 2015; Calvo *et al*., 2014; Halpern *et al*., 2015). All nutrition combinations are the mostly effected on hydroponically grown plant (Nowak, 1980). Availability of nitrate in the nutrient solution helps in nitrate accumulation in placenta stated by Monforte-Gonzalez *et al*. (2010).

Many commercial bio-stimulants contain the extracts of *A. nodosum*, which has been shown to considerably increase crop production, biometric traits, quality and it also imparts tolerance against various abiotic stresses (Ali *et al*., 2016; Shukla *et al*., 2019; Goni *et al*., 2018). Many researchers have reported that SW extracts (bio-stimulants) promoted growth, increased yield and quality of vegetables crops such as cucumber (Sarhan *et al*., 2011), tomato (Kumari *et al*., 2009), broccoli (Mattner *et al*., 2013), spinach (Xu and Leskovar, 2015) and bean (Beckett *et al*., 1994). Also, a plethora of studies explained that *A. nodosum* has bio-stimulation effects on various agricultural and horticultural crops, such as watermelon (Bantis and Koukounaras, 2022, 2023), tomato (Ahmed *et al*., 2022; Ali *et al*., 2022; Ikuyinminu *et al*., 2022), wheat (Langowski *et al*., 2022), soybean (Repke *et al*., 2022), sweet pepper (Rajendran *et al*., 2022), pea (Rashad *et al*., 2022), maize (Shukla and Prithiviraj, 2021) and okra (Ali *et al*., 2022). Therefore, we formulated the hypothesis that *A. nodosum* bio-stimulant might improve the plant growth, yield and fruit quality of bitter gourd to get high yield with better quality in hydroponic crop cultivation also. Consequently, this programme was carried out to find out influence of growing substrates and bio-stimulants spray on the photosynthetic response and antioxidant content of hydroponically grown bitter gourd.

Materials and Methods

The experiment was carried out within the controlled environment of a glasshouse located in the Department of Vegetable Science, which lies under the Experiential Learning Unit of the Faculty of Horticulture at Bidhan Chandra Krishi Viswavidyalaya in Mohanpur, Nadia, West Bengal. The experiment took place during the summer season of 2022–2023. The experimental site is situated at a latitude of 23.5°N and a longitude of 80°E, with an average altitude of 9.75 m above the mean sea level (MSL). The experiment recorded average lowest and maximum temperatures of 30 ± 2°C and 37 ± 2°C, respectively. The relative humidity during the experiment ranged from 70% ± 10% to 85% ± 10% is recorded by instruments under the polyhouse. The experiment was conducted using a fully completely randomised design, consisting of twelve treatments that were each replicated three times. The experiment was carried out within a 20×20 cm growing bag, with the placement of a single seed in each bag. Each individual growing bag is filled with a specific growing medium mixture, which serves as a treatment in the experiment. Each treatment was tested using three replications. A two-factor experiment was conducted with four different types of growing media mixtures (GM1 = 60% rice husk + 30% coconut coir + 10% vermicompost, GM2 = 60% coconut coir + 30% perlite + 10% vermicompost, GM3 = 60% sawdust + 30% perlite + 10% vermicompost, and GM4 = 60% ash + 30% perlite + 10% vermicompost) and three different compositions of Bio stimulants (*Ascophyllum nodusum*) solutions (Bs1 =1ml/l, Bs 2 = 2ml/l, and Bs 3 =3ml/l). The study involved the collection of data pertaining to various growth parameters and yield-contributing characteristics, including vine length, number of branches per plant, leaf area, number of fruits, fruit length, fruit girth, fruit weight, seed number, and seed weight. Additionally, data were also collected on fruit-related characteristics such as fruit colour, flesh thickness, flesh colour, and placenta colour. The biochemical parameters that were assessed in this study included, ascorbic acid levels, protein concentration, total soluble solids (TSS) and reducing sugar content. For protein estimation, Lowry's method was used. The total carotenoids and β-carotene contents were estimated by photometric and high-performance liquid chromatography (HPLC) methods. Ascorbic acid content was estimated by diluting the known volume of bitter gourd juice with 3% metaphosphoric acid and titrated with 2, 6-Dichlorophenol-indophenol solutions (AOAC, 1980). The data obtained from the trials were merged and subjected to a two-way analysis of variance using SPSS software developed by SPSS Inc. in Chicago, IL. Subsequently, the treatment means were compared using Tukey's test (Tukey, 1977), with a significance level set at $P < 0.05$.

Results and Discussion

Vine length (cm) : The vine length of bitter gourd plant was varied from 255.77 cm to 333.71 cm. From the Table 1, the result indicate that the maximum vine length was recorded during the growing period from the treatments of GM1 with Bs2 bio-stimulants application is 333.71 followed by 318.27 (GM2 Bs 1), 311.86 (GM3 Bs 1), 302.72 (GM2 Bs3). The lowest vine length was observed from the treatments combination of GM4 Bs 2 (255.77) followed by GM4 Bs1 (256.62), GM2 Bs2 (259.36). Similar result was also reported by the Chrysargyris *et al*. (2018) in case of *A. nodosum* bio-stimulant application in lettuce.

Number branches per plant : The number of branches per plant varied with the growing media modifications and bio stimulants levels. The GM2 with Bs1 had the highest average number of branches per plant (11.41) followed by GM3Bs2 (10.29) and GM2 Bs2 (9.38). Whereas the GM4, the number of branches showed least 5.13(GM4 Bs2) followed by GM4 Bs1 (5.42) and GM4 Bs3(5.64). The present investigation results are in accordance with Sureshkumar *et al*. (2019). The presence of variation indicates the potential influence of the treatment combinations on branching patterns. Further statistical analysis would be required to determine the significance of these findings. The similar result was also reported by Kundu *et al*. (2023), they also suggest that biostimulant has a significant effect on number of branches per plant.

Fruit number : The study assessed the effect of different treatments on the number of fruits per plant. The number of fruits per plant displayed (Table 1) variation across the growing media modifications and bio stimulants levels. Notably, the treatment of GM2, especially with nitrogen level Bs2 (60.62), showed the highest average number of fruits per plant. Conversely, the GM3with the Bs3bio-stimulant level recorded the least (40.36) followed by GM1Bs1 (41.65) and GM4Bs1(43.06). The similar result was also found by Sureshkumar *et al*. (2019) in a field trial on bitter gourd with application of vermicompost along with sea weed extract bio-stimulant. The observed variations suggest the potential impact of the treatment combinations on fruit yield. A more detailed statistical evaluation would be essential to validate the significance of these observations.

Fruit length (cm) : The study aimed to evaluate the effects of different treatments on the mean fruit length, measured in centimetres (cm). Fruit length displayed variations across the different growing media mixture and bio stimulants levels. Notably, the GM2 growing media

Table 1 : Influence of growing media mixture and nutrient solution on quantitative character of bitter gourd.

Treatment	Vine length (cm)	No. branches per plant	No. fruits/ plant	Fruit length (cm)	Fruit girth (cm)	Fruit wt. (g)	Seed no. per fruit
GM1 Bs1	295.08	7.41	41.65	8.21	15.78	147.85	22.79
GM1 Bs2	333.71	9.25	45.51	7.42	15.75	166.08	23.15
GM1 Bs3	292.60	7.09	48.28	9.46	16.52	148.95	22.67
GM2 Bs1	318.27	11.41	58.34	12.55	17.15	176.49	22.49
GM2 Bs2	259.36	9.38	60.67	11.99	16.37	150.63	23.29
GM2 Bs3	302.45	7.66	55.59	12.27	15.19	140.49	24.15
GM3 Bs1	311.86	8.48	49.28	11.21	16.82	151.49	19.44
GM3 Bs2	302.72	10.29	55.43	7.53	15.35	155.04	19.34
GM3 Bs3	283.00	7.83	40.36	9.73	15.24	139.60	18.24
GM4 Bs1	256.62	5.42	43.06	9.27	13.55	132.56	21.54
GM4 Bs2	255.77	5.13	48.17	8.50	12.98	122.16	18.99
GM4 Bs3	274.39	5.64	55.27	9.55	14.26	119.93	20.93
C.D.	24.12	1.62	5.10	2.93	1.72	27.07	2.11
SE(m)	8.22	0.55	1.74	1.00	0.59	9.22	0.72
SE(d)	11.62	0.78	2.45	1.41	0.83	13.04	1.02
C.V.	4.90	12.10	6.00	17.61	6.57	10.94	5.82

GM1 = 60% rice husk + 30% coconut coir + 10% vermicompost, **GM2** = 60% coconut coir + 30% perlite + 10% vermicompost, **GM3** = 60% sawdust + 30% perlite + 10% vermicompost and **GM4** = 60% ash + 30% perlite + 10% vermicompost) and three different compositions of nutrient solutions (**Bs1** = 1ml/l, **Bs2** = 2ml/l and **Bs3** = 3ml/l).

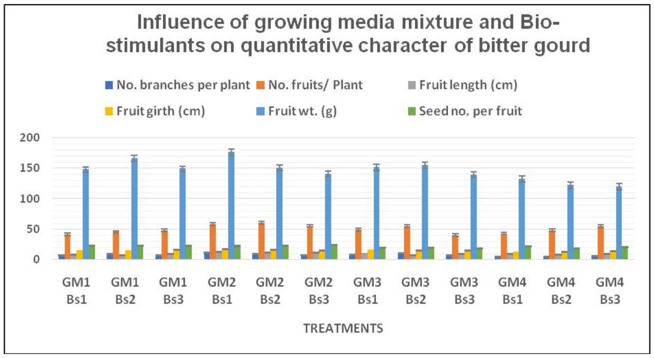

Fig. 1 : Influence of growing media mixture and nutrient solution on quantitative character of bitter gourd.

displayed in table1. Fruit weight showed distinct variations across different growing media mixture and bio stimulants levels. Particularly, the GM2 growing media mixture at the Bs1 bio stimulants levels demonstrated the highest average weight (176.49) followed by GM1Bs2 (166.08) and GM3 Bs2 (155.04), while the GM4 growing media at the Bs3 bio stimulants levels showed the least (119.93). The differences in results emphasize the potential impact of the combination of growing media mixture and bio stimulants levels on fruit weight. In-depth statistical scrutiny is pivotal to provide a comprehensive understanding and validation of these observations. Taller plants with a greater number of branches and leaves increased photosynthetic area and favourable physiological activity under higher nutrient levels could have resulted in more production and translocation of photosynthates in plants, which accelerated the formation of a greater number of large sized fruits resulting in higher yields. As suggested by Aisha *et al.* (2014).

Plate 1 : Bitter gourd plants and fruits of promising treatments.

mixture show cased the longest average fruit lengths across all its bio-stimulant levels, with GM2 Bs1 being the highest (12.55). In contrast, the GM1 growing media mixture at the Bs2 bio-stimulant level displayed the shortest fruit length (7.42) followed by GM3Bs2 (7.53) and GM1 Bs1 (8.21). These differences underscore the potential influence of the treatment combinations on fruit length. Comprehensive statistical analysis would be vital to further understand and validate the significance of these differences. The result is in agreement with the findings with Alam *et al.* (2013) in strawberry production.

Fruit girth (cm) : Fruit girth of bitter gourd exhibited variations based on different growing media mixture and bio stimulants levels. Specifically, the GM2 growing media mixture at the Bs1 bio stimulants levels recorded the largest average girth (17.15), whereas the GM4 growing media mixture at the Bs2 bio stimulants levels recorded the smallest (12.98) followed by GM4 Bs1(13.55) and GM4 Bs3 (14.26). The observed differences hint at the potential impact of the treatment combinations on fruit girth. Further statistical analysis is essential to confirm and elaborate on the significance of these differences.

Fruit weight (g) : The effect of different treatments on the mean fruit weight measured in grams (g) and

Number of seed per fruit : The number of seeds per fruit show cased variations across the different growing media mixture and bio-stimulants levels. The GM2 growing media mixture at the Bs3 bio-stimulants levels recorded the highest average seed count per fruit (24.15), whereas the GM3 growing media mixture at the Bs3 bio-stimulants levels exhibited the lowest (18.24). The observed differences highlight the potential effects of the treatment combinations on seed yield per fruit. A more detailed statistical analysis would be pivotal to validate and interpret the significance of these results.

Ascorbic acids (mg/100 g) : The effects of different treatments on the mean ascorbic acid content, measured in milligrams per 100 grams (mg/100 g) of fruit. The ascorbic acid content exhibited variations based on the distinct growing media mixtures and bio-stimulants levels. The GM2 growing media mixtures at the Bs1 bio-

Table 2 : Influence of growing media mixture and nutrient solution qualitative character of bitter gourd.

Treatment	Ascorbic acids (mg/100 g)	Total carotenoids (mg/100 g)	Protein (mg/100 g)	TSS (%)	Reducing sugar (%)
GM1 Bs1	98.78	2.77	2.13	5.15	5.92
GM1 Bs2	103.42	2.96	1.98	5.06	5.63
GM1 Bs3	95.85	2.52	2.17	5.15	5.54
GM2 Bs1	109.11	2.99	2.31	5.38	6.46
GM2 Bs2	106.30	2.80	2.30	5.11	6.24
GM2 Bs3	100.79	2.91	2.23	5.12	6.29
GM3 Bs1	105.15	2.98	2.23	5.26	6.21
GM3 Bs2	101.67	2.76	1.96	5.28	6.28
GM3 Bs3	99.66	2.24	2.04	5.11	6.00
GM4 Bs1	101.89	2.42	1.56	4.81	5.38
GM4 Bs2	100.09	2.86	2.10	5.24	5.35
GM4 Bs3	100.86	2.28	2.19	5.23	5.08
C.D.	5.96	0.19	0.26	0.21	0.70
SE(m)	2.03	0.07	0.09	0.07	0.24
SE(d)	2.87	0.09	0.13	0.10	0.34
C.V.	3.45	4.23	7.32	2.41	7.02

GM1 = 60% rice husk + 30% coconut coir + 10% vermicompost, **GM2** = 60% coconut coir + 30% perlite + 10% vermicompost, **GM3** = 60% sawdust + 30% perlite + 10% vermicompost, and **GM4** = 60% ash + 30% perlite + 10% vermicompost) and three different compositions of nutrient solutions (**Bs1** = 1ml/l, **Bs2** = 2ml/l, and **Bs3** = 3ml/l).

stimulants level yielded the highest ascorbic acid content (109.11), whereas the GM1 growing media mixtures at the Bs3 bio-stimulants level registered the lowest (95.85). These observed variances accentuate the potential impacts of the combination of growing media mixtures and nitrogen levels on ascorbic acid concentration. Our result is in accordance with the findings of Subramaniyan *et al*. (2023) and Hussain *et al*. (2021) on tomato in field condition.

Total carotenoids (mg/100 g) : The effect of distinct treatments on the mean total carotenoid content, measured in milligrams per 100 grams (mg/100 g) of fruit. The total carotenoid content show cased variations across different growing media mixtures and bio-stimulants levels. The GM2 growing media mixtures at the Bs1 bio-stimulants level displayed the highest carotenoid content (2.99), whereas the GM3 growing media mixtures at the Bs3 bio-stimulants level showed the lowest (2.24).

Protein (mg/100 g) : Protein content manifests variances across the diverse growing media mixtures and their respective levels. The GM2 growing media mixtures at the Bs1 level produced the highest protein concentration (2.31), whereas the GM4 growing media mixtures at the Bs1 level presented the lowest (1.56). The observed disparities highlight the importance of the interplay between growing media mixtures and their levels on the protein content of the samples.

TSS (%) : The TSS content exhibited fluctuations among the distinct growing media mixtures and their corresponding levels. The GM2 growing media mixtures at the Bs1 level recorded the highest TSS content (5.38), while the GM4 growing media mixtures at the Bs1 level exhibited the lowest (4.81). These findings underline the importance of the interplay between growing media mixtures and their associated levels on the TSS concentration. Similar results were also reported by Hussain *et al*. (2021) in case of tomato.

Reducing sugar (%) : Reducing sugar content displayed variations across the diverse growing media mixtures and their respective levels. Notably, the GM2 growing media mixtures at the Bs1 level produced the highest concentration of reducing sugar (6.46), whereas the GM4 growing media mixtures at the Bs3 level registered the lowest (5.08). Results are in agreement with Karak *et al*. (2023) that biostimulant has a significant effect on reducing sugar.

Conclusion

Seaweed and seaweed products are increasingly used in crop production. However, the mechanism(s) of actions of seaweed extract-elicited physiological responses are largely unknown. The present investigation showed that the growing media made up of 60% coconut coir, 30% perlite along with 10% vermicompost gives the best fruit yield of bitter gourd in hydroponic system. As well as application of sea weed extract *A. nodosum* bio-stimulant application also improves the plants growth and yield parameters and other quality parameters as well. So, from this experiment we can suggest the use of 60% coconut coir, 30% perlite along with 10% vermicompost growing media with application of *A. nodosum* bio-stimulant may achieve best results in better gourd production in a hydroponic system.

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