Journal of Horticultural Science and Technology 7(4): 101-106 (2024)
ISSN: 2617-3220 (Print), 2664-9489 (Online)
https://doi.org/10.46653/jhst24074106

Original Research

Comparative Effects of Biostimulants on Germination, Growth, and Yield of Bitter Gourd (*Momordica charantia* L.)

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ABSTRACT

With increasing environmental challenges, sustainable approaches are required to maintain crop productivity. These issues can be resolved by advanced techniques, such as the usage of biostimulants as a sustainable approach to enhance physiological efficiency, nutrient assimilation, and stress tolerance in crops. Therefore, the field trial was executed in summer 2023 to investigate the comparative impact of different biostimulants on the growing and yielding parameters of bitter gourd. The research was performed in the SAU Nursery, Department of Horticulture, Sindh Agriculture University, Tandojam, in a Randomized Complete Block Design (RCBD) under three blocks. Treatments included two different biostimulants, viz: Quantis and Rely, used at 1, 1.5 and 2% and untreated seeds were considered as control. The results demonstrated that the seeds of bitter gourd treated with 1% Rely showed maximum results for the majority of parameters, including germination index, leaves vine-1, flowers vine-1, fruits vine-1, fresh biomass of fruit, fruit length, fruit diameter, single fruit weight, and fruit weight plant^{-1}. At the same time, seed germination was higher with 2% Rely biostimulant. At the same time, the vine length was better in bitter gourd treated with 1 % Quantis biostimulant. The findings of the study lead to the conclusion that the bitter gourd treated with 1% Rely showed higher results for vegetative as well as reproductive attributes, followed by the application of 1% Quantis and 2% Rely biostimulants.

Keywords: *Biostimulants, crop production, Quantis, Rely, sustainability.*

Article History: *Received 01 September 2024; Revised 18 November 2024; Accepted 22 December 2024; Published 31 December 2024.*

INTRODUCTION

Bitter gourd, classified as (*Momordica charantia* L.), commonly called Karela, possesses exceptional nutritional value when it comes to rich minerals, macro-nutrient contents and vitamins (Ahmad et al., 2016). This plant has a longstanding presence in traditional culinary and healing systems across regions like India, China, and Southeast Asia, where it is esteemed for its nutritional richness and therapeutic potential. Packed with biologically active substances found throughout its various parts, like roots, leaves, stems, and fruits, it serves as a significant source of natural medicinal agents (El-Khayat et al., 2023). This impressive array of benefits has sparked a growing interest in its agricultural production, aiming to enhance yield, quality, and overall cultivation practices. However, several factors such as climatic conditions, fertility of the soil, agronomic practices, and occurrence of pests and diseases inhibit the growth and productivity of the plant; the recent agricultural advances with genetical betterment and modern methods of crop handling allow the enhancement of growth and productivity of crops (Silva et al., 2017).

The desire to increase bitter gourd's growth, yield, and quality has led to the consideration of various steps; among them, the usage of biostimulants is gaining grounds for which various advanced studies are conducted to examine its effect on bitter gourd, as biostimulants are those essential substances or microbes that are applied to plants to enhance their growth, development, and stress tolerance, they are a blend of organic carbons, potassium, calcium, and energy source carbohydrates, amino acids and nutrients (Tegeder and Masclaux, 2018). Amino acids are essential organic compounds that play vital roles in diverse biological functions, including hormone synthesis, enzymatic reactions, and nutrient transport. They are crucial precursors of hormone synthesis, act as signalling molecules in physiological pathways, and regulate processes such as nitrogen fixation, root biomass increasing, translocation of different nutrients, enzymatic activity, and encourage nutrient uptake (El-Khayat et al., 2023). In order to optimise the yield, biostimulants decrease the inorganic fertiliser usage; hence, reduced pollution by water is observed. At present, the inorganic fertiliser, which is given to crops, half of rapidly goes into water. Incorporation of biostimulants increases production by up to 25% and could be

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Table 1: Comparative effect of Quantis and Rely biostimulants on the seed germination and growth-related characteristics of bitter gourd.

Treatments		Seed Germination	Germination index	Vine length	Number of leaves vine^{-1}	Flowers vine^{-1}
Quantis	Control	75.26 C	0.91 A	112.13 E	126.73 E	7.86 C
	Distilled water	77.60 AB	0.96 A	135.27 D	130.60 D	8.13 BC
	1%	79.20 A	0.80 B	202.33 A	134.93 C	9.33 AB
	1.5%	76.20 BC	0.89 A	173.53 B	139.07 B	9.60 A
	2%	76.13 BC	0.91 A	152.00 C	142.73 A	9.53 A
	±SE	2.232	0.0834	1.7932	3.6227	1.2453
	LSD 0.05	1.112	0.0454	0.8945	1.8323	0.6230
	p value	0.0075	0.0075	0.0075	0.0075	0.0108
Rely	Control	63.33 D	0.72 D	146.87 E	87.07 E	5.80 D
	Distilled water	72.20 C	0.80 BC	151.20 D	106.73 D	5.73 D
	1%	81.53 B	1.31 A	155.73 C	181.53 A	15.06 A
	1.5%	83.33 AB	0.88 B	159.33 B	156.80 B	10.06 B
	2%	84.00 A	0.77 CD	162.13 A	141.93 C	7.80 C
	±SE	2.2100	0.0843	1.7925	3.6377	1.2273
	LSD 0.05	1.1003	0.0420	0.8924	1.8111	0.6110
	p value	0.0000	0.0000	0.0000	0.0000	0.0000

seen as it is an organic application (Gouveia et al., 2020).

Moreover, biostimulants have been seen to erase the harmful effect of abiotic stressors, such as the presence of water and salt, on bitter gourd plants, thereby improving yield stability under challenging environmental conditions (Rouphael and Colla, 2020). These findings highlight the potential of biostimulants as sustainable tools for increasing bitter gourd yield and productivity while ensuring environmental sustainability. The application of biostimulants offers a promising approach to enhancing the yield and quality of bitter gourd by improving nutrient uptake, hormonal balance, and stress tolerance. Further research is needed to explore the optimal formulations and application methods of biostimulants for maximising their efficacy in bitter gourd cultivation (Franzoni et al., 2023).

Climatic stresses affect the growth and productivity of crops. In this regard, Biostimulants may play a vital role in reducing the effects of different biotic and abiotic stresses. The present experiment was, therefore, designed to investigate the effects of biostimulants on the seed germination, growth and yield of bitter gourd.

MATERIALS AND METHODS

Research design and location

This study was executed in the summer of 2023 at the SAU Nursery, Sindh Agriculture University Tandojam, to examine the interactive impact of varying biostimulants on the growing and yielding parameters of bitter gourd. The chosen layout design was a Randomized Complete Block Design (RCBD) under three blocks.

Current research had various concentrations of biostimulants [Quantis (Syngenta Company) and Rely (Kanzo Company)]. The concentrations of Quantis and Rely (1%, 1.5%, and 2%) were used as treatments, and the seeds that did not undergo any treatment were taken as controls. Seeds of *Momordica charantia* L. were procured from a local market. Prior to sowing, seeds were carefully inspected for physical integrity and viability, serving as the foundational material for all experimental treatments.

Data collection and methodology

The growing and reproductive parameters' data were analysed for further statistical analysis. The recorded parameters were seed germination (%), germination index, vine length (cm), number of leaves, flowers, and fruits vine-1, fresh biomass of fruit (g), fruit length (cm), fruit diameter (mm), single fruit weight (g), and fruit weight plant^{-1} (g).

Vegetative parameters

Examination of seed germination was done weekly for a month. Counting was done for germinated seeds, leading to percentage calculation with the formula mentioned below, with the application of the following formula (Larsen and Andreasen, 2004).

Seed germination (%) = $(\sum n)/N \times 100$

Where n is taken as germinated seeds counted, and N is the overall number of seeds in each treatment. GI was calculated with the help of a formula that the Association of Official Seed Analysts (1983) gave.

GI = Number of germinated seeds/days of first count+ ------- + ------ + Number of germinated seeds/days of last count

In a random pattern, five plants were selected to examine the length by scale over 15-day intervals across the developmental period. Several leaves of vine-1 of random 50% plants from each treatment were counted visually, and thereby, the average was calculated.

Table 2: Comparative effect of Quantis and Rely biostimulants on fruit-related attributes of bitter gourd.

Treatments		Number of fruits vine^{-1}	Fresh biomass of fruit (g)	Fruit length (cm)	Fruit diameter (mm)	Single fruit weight	Fruits weight plant^{-1} (g)
Quantis	Control	6.33	21.26	11.92 C	3.23 B	54.00	474.88 E
	Distilled water	6.60	21.13	12.33 C	3.36 B	53.96	493.24 D
	1%	7.66	21.66	13.17 B	3.61 AB	55.39	535.49 C
	1.5%	8.20	22.46	13.70 AB	3.93 A	56.18	571.44 B
	2%	7.33	22.06	13.99 A	3.98 A	57.24	598.27 A
	±SE	1.6134	3.1470	0.8224	0.4332	3.0345	14.951
	LSD 0.05	0.8213	1.5631	0.4321	0.2132	1.5031	7.4235
	p value	0.1415	0.9071	0.0000	0.0023	0.1522	0.0000
Rely	Control	4.06 D	10.73 D	10.81 D	2.26 D	43.32 E	204.95 E
	Distilled water	4.13 D	10.93 D	11.63 C	3.07 C	46.95 D	287.26 D
	1%	13.26 A	36.80 A	16.76 A	5.30 A	71.44 A	994.25 A
	1.5%	8.20 B	28.26 B	13.81 B	4.00 B	61.15 B	727.85 B
	2%	6.46 C	21.86 C	12.10 C	3.47 C	53.91 C	459.01 C
	±SE	1.6157	3.1380	0.8113	0.4348	3.0313	14.908
	LSD 0.05	0.8044	1.5623	0.4039	0.2165	1.5092	7.4224
	p value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Reproductive parameters

Flowers vine^{-1} of 50% of plants from each treatment were counted visually, and thereby, the average was calculated. The tagged plants were harvested and counted to determine the number of fruits. The average of these five random plants was taken as several fruit vine^{-1}. The fresh biomass of fruit was taken, and the weight was measured using an electronic balance. The values were expressed as averages in grams. The length of the fruit was measured from the top to the end of the fruit in (cm) via a measuring scale. Fruit diameter was measured with a vernier calliper. All the labelled plants' fruits were taken and weighed on an electronic balance.

Statistical analysis

The Statistics 8.1 computer software (Statistics, 2006) was used to analyse the data. The LSD test was applied to check the superiority among treatments when necessary.

RESULTS

The results were observed for the germination, vegetative, and reproductive parameters; it was seen that the interactive results in all the parameters were non-significant. However, the factors individually had a statistically significant impact on all the parameters recorded. The results regarding seed germination (%) and germination index of bitter gourd seeds as impacted by varying levels of biostimulants viz: Quantis and Rely (Table 1). While observing the Quantis treatment for seed germination, it was seen that treatment comprising 1% Quantis maximised the bitter gourd seed germination (79.20%), followed by the results of distilled water. However, opposite results were seen for the germination index, where the maximum result was observed from distilled water (0.96). The minimum seed germination (75.26%) was observed under the control of Quantis, while the least germination index was observed (0.80) when bitter gourd was treated with 1% Quantis. The results obtained by applying Rely showed that the maximum seed germination of bitter gourd was recorded with 2% Rely (84.00%). In comparison, the highest germination index of bitter gourd was recorded at 1% Rely (1.31). The minimum seed germination (63.33%) and germination index (0.72) were observed under the control of Rely. Among both biostimulant treatments, Rely outperformed Quantis. Table 1 also illustrates that varying concentrations of the biostimulants Quantis and Rely significantly influenced the vine length of bitter gourd. Application of 1% Quantis resulted in the greatest vine elongation, reaching 202.33 cm, indicating a strong promotive effect on vegetative growth. In contrast, the shortest vine length (112.13 cm) was observed in the control of Quantis. Similarly, among the Rely treatments, the maximum vine length was achieved with 2% Rely (162.13 cm), while the lowest value (146.87 cm) occurred under the control of Rely. These results highlight the efficacy of biostimulant application in enhancing vine growth, with specific concentrations demonstrating superior performance, particularly 1% Quantis and 2% Rely. Another vegetative parameter in Table 1 is the number of leaves vine^{-1}, which indicates a deviation from the expected response. The results showed that treatment comprising 2% Quantis resulted in a maximum number of leaves vine^{-1} (142.73) in the bitter gourd, and the minimum number of leaves vine^{-1} (126.73) was observed in the control of Quantis. While assessing the results acquired by the incorporation of Rely, it was observed that the highest number of leaves of vine^{-1} of bitter gourd was recorded with 1% Rely (181.53). However, the least-leaf vine^{-1} (87.07) was obtained under the control of Rely. The obtained results of Quantis showed that the treatment comprised 1.5% quantiles (9.60) and 2% Quantis (9.53) provided with the maximum number of flower vine^{-1}. Also, when no treatment was applied, the lowest number of flowers was vine^{-1} (7.86). The results obtained by incorporation of Rely further showed that the highest number of flowers, vine-1 of bitter gourd, was recorded with 1% Rely (15.06). Meanwhile, the least quantity of flowers vine^{-1} (5.80) was observed under control.

The reproductive performance of bitter gourd, as measured by the number of flowers vine^{-1} (Table 1), was markedly influenced

by the application of different concentrations of the biostimulants Quantis and Rely. Among the Quantis treatments, 1.5% and 2% concentrations resulted in the highest flower production, with 9.60 and 9.53 flowers per vine, respectively, indicating a positive response to higher doses. In contrast, the control treatment, which received no Quantis application, recorded the lowest flower count (7.86), reflecting limited reproductive activity under untreated conditions. Notably, the application of Rely demonstrated a more substantial enhancement in floral output, with the maximum number of flowers per vine (15.06) observed at 1% concentration. The lowest reproductive performance in the Rely group was recorded under the control treatment (5.80 flowers per vine).

The reproductive parameters of bitter gourd, including number of fruits per vine, fruit biomass, and fruit length, were significantly influenced by the application of different concentrations of the biostimulants Quantis and Rely, as presented in Table 2. The Quantis treatments showed no significant difference in the number of fruits vine^{-1}. In contrast, Rely treatments exhibited a more pronounced effect, with 1% Rely yielding the highest fruit count per vine (13.26), whereas the minimum (4.06) was again noted under the control. Quantis treatments did not show statistically significant differences in fresh fruit biomass, with values ranging narrowly from 21.13 g to 22.46 g, indicating limited variation across concentrations. However, a distinct response was observed with Rely applications, where 1% Rely produced the highest fruit biomass (36.80 g), and the control treatment yielded the lowest (10.73 g). Fruit length followed a similar trend; the maximum fruit length under Quantis treatments was recorded with 2% Quantis (13.99 cm), while the shortest fruits (11.92 cm) were observed in the control. Under Rely application, 1% Rely led to the most excellent fruit length (16.76 cm), whereas the minimum (10.81 cm) was again noted in the untreated control. These results demonstrate that both biostimulants, particularly Rely at 1% concentration, significantly enhanced the reproductive performance of bitter gourd across multiple fruit-related traits.

Reproductive traits of bitter gourds, such as fruit diameter, individual fruit weight, and total fruit weight per plant, were significantly influenced by the application of different concentrations of Quantis and Rely biostimulants, as presented in Table 2. Among the Quantis treatments, the largest fruit diameters were observed at 2% (3.98 mm) and 1.5% (3.93 mm), while the minor diameter (3.23 mm) was recorded under the control treatment. Rely treatments exhibited a more substantial effect, with 1% Rely resulting in the highest fruit diameter (5.30 cm), in contrast to the control with the smallest value (2.26 cm). In terms of individual fruit weight, Quantis application showed no significant difference; however, under Rely treatments, 1% Rely yielded the most significant individual fruit weight (71.44 g), and the control treatment recorded the minimum (43.32 g). Regarding total fruit weight per plant, 2% Quantis produced the maximum value (598.27 g), with the lowest (474.88 g) observed in the untreated control. Rely showed a more dramatic impact, as 1% Rely resulted in the highest total fruit weight per plant (994.25 g), whereas the control treatment yielded only 204.95 g. These results indicate that biostimulants, particularly Rely at 1% concentration, significantly enhance key reproductive attributes and overall fruit productivity in bitter gourd.

DISCUSSION

Frequent and excessive use of chemical-based treatments in agriculture has been shown to induce stress in crops and adverse effects on biochemical processes, morphology, physiology, and gene expression in plants, ultimately impairing both visible and internal plant traits (Zhang et al., 2023). Consequently, a significant challenge in modern crop production is to develop sustainable strategies that enhance plant resilience without negatively impacting the environment. These problems can be mitigated through modern agricultural advancements, which significantly reduce the usage of chemical fertilisers to increase crop establishment and yield (Padmaja et al., 2023). Such modern advancements include practical methods for crop cultivation, such as the utilisation of eco-friendly organic biostimulants (du Jardin et al., 2015). Biostimulants are organic materials or microbes that increase plant growth in multiple ways. The application of biostimulants enables plants to have tolerance towards abiotic stresses (Franzoni et al., 2023); recent observations reveal that biostimulants may regulate physiological procedures in plants so that plants can grow sufficiently with improved quality (Nephali et al., 2020), showing that organic measures will enhance agricultural development (Ramesh et al., 2005). The current study aims to address the impact of biostimulants by comparing their various levels applied to bitter gourd.

In this study, it was observed that 1% of Rely provided better results about vegetative and reproductive attributes, encompassing the fact that biostimulants regulate proper cultivation. This finding is coherent with the study of (Gajjela et al., 2018), who elaborated that organic solutions obtained from plants or animals are productive for the growth promotion of plants and increase crop biological efficiency. According to this study (Benitez et al., 2013), the vegetative growth of bitter melon significantly increased with the incorporation of organic components, which could be due to the increased photosynthesis, which significantly supports translocation (Abdelgalil et al., 2021). In the study of Pusta and Macusi (2024), the vegetative parameters like vine length and days to flowering and reproductive parameters like fruit length, number of fruit plant-1, fruit weight and fruit yield were seen to be increased upon application of organic biostimulant, their study supports this study where vegetative and reproductive parameters increased when biostimulant was applied.

Rai et al. (2023) backed this study by observing elite results regarding the vegetative growth of bitter gourd under the application of organic components. In addition, higher vegetative and yielding results were observed when organic components were applied by (Jat et al., 2023) in turmeric, okra, and tomato, respectively. Patel et al. (2020) elaborated that the length of the main vine was found to be best (286.67 cm) upon biostimulant application. This could be due to the application of organic materials along with bio-fertilizers, where the organic matter maintains the nutrient balance for plants and flourishes the physical as well as chemical characteristics of the soil. The positive influence on growth parameters obtained in this study was supported by (Singh et al., 2022) in bitter gourd. Along with the examination of vine length, the study of Patel et al. (2020) aligns with this study for yielding aspects. He found superior

fruit yield plant^{-1} (3.09 kg), which might be the consequence of organic nutrient favour, which enhances yield per plant due to favourable soil conditions, which increases the uptake of NPK nutrients because of bio fertiliser impact, which provides favourable conditions around the root rhizosphere, leading to better nutrient absorption. The results obtained are in line with the findings of (Anjanappa et al., 2012) in cucumber.

CONCLUSION

It is concluded from the present study that the use of biostimulants has a significant effect on seed germination, growth and yield of bitter gourd. In comparison to biostimulants, Rely exhibited better results as compared to Quantis.

DECLARATION OF COMPETING INTERESTS

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION STATEMENT

Sanif Hanif: Executed trial and collected data. **Noor-un-Nissa Memon:** Planned the study and reviewed the manuscript. **Afifa Talpur:** Prepared the manuscript. **Muhammad Nawaz Baloch:** Reviewed the manuscript. **Maryam Khaskheli:** Contributed to manuscript writing.

FUNDING

Not applicable.

ETHICAL STATEMENT

Not applicable.

AVAILABILITY OF DATA AND MATERIAL

All data is published in this research article.

INFORMED CONSENT

Not applicable.

CONSENT FOR PUBLICATION

All authors submitted consent to publish this research article in the 'Journal of Horticulture Science and Technology'.

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