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Original Research Paper

Effect of bio-stimulant on production and quality of the kiwifruit (*Actinidia deliciosa*) cv. Allison

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ABSTRACT

Although growing in popularity in developed countries, organic kiwifruit production still has several operational challenges, including limited availability of organic growth regulators, organic nutritional inputs, and organic insecticides. In this research, eleven treatments *viz.*, T_1: water spray (control), T_2: 5% KA sap (*Kappaphycus alvarezii*), T_3: 10% KA sap, T_4: 5% GE sap (*Gracilaria edulis*), T_5: 10% GE sap, T_6: 5% AN sap (*Ascophyllum nodosum*), T_7: 10% AN sap, T_8: 5% vermiwash, T_9: 10% vermiwash, T_{10}: 5% humic acid and T_{11}: 10% humic acid were used as foliar spray to study their effects on production and quality of kiwifruit cv. Alison, during 2020 to 2023. Results revealed that treatment T_8, T_2 and T_6 were found to be best for improving growth attributes, while, treatment T_2, T_{11}, T_8 and T_5 for fruit quality attributes of kiwifruit cv. Allison. For antioxidant content, T_8 was best for DPPH assay and T_{10} for ABTS assay. Therefore, it can be concluded that application of biostimulants like seaweed extracts and humic acids can be one of the options for increasing the quality and yield of organic kiwifruit production.

Keywords: *Actinidia deliciosa,* bio-stimulants, foliar spray, organic

INTRODUCTION

Actinidia chinensis Planch. and *A. deliciosa* (A. Chev.) C.F. Liang et A.R. Ferguson are two main closely related species of kiwifruit that are grown worldwide. The literature has extensively established the health advantages of kiwifruit fruits, which are not only rich in nutrients but also improve digestion, immunity, and metabolism (Boeing et al., 2012; Dutta et al., 2023). Vitamins C, E, dietary fibre, potassium, antioxidants, folate, and many enzymes can all be found in significant quantities in kiwifruit.

While organic kiwifruit farming is becoming more popular in industrialised nations, there are still numerous operational obstacles to overcome, such as the scarcity of organic growth regulators, organic nutrient inputs, and pesticides. One of the main problems among these is the lack of a growth regulator that is allowed by organic means. Seaweeds are marine microalgae that come in brown, red, and green forms. They are frequently used in horticulture crops for a number of reasons, including their capacity to enhance crop tolerance to abiotic stresses including drought, extreme heat, and nutrient deficits. Furthermore, organic molecules called humic acids are produced when plants and animals decompose. However, it has been determined in several investigations that seaweed sap and humic acid may be possible sources of phytohormones (auxin, cytokinin, gibberalic acid, abscissic acid, and polyamines) (Dutta et al., 2023; Layek et al., 2023). In view of this, a study was carried out to assess the impact of seaweed extract and humic acid on the quality and production of kiwifruit cv. Allison cultivated organically.

MATERIAL AND METHODS

The experiment was carried out at the experimental farm of ICAR-Research Complex North Eastern Hill Region, Sikkim center, Gangtok, Sikkim, India (27 19 11.339 N, 88 36 9.793 E and 1348 m amsl) during 2020 to 2023. The soil type, with a pH of 5.3-5.9, was identified as sandy loam soil. Other soil characteristics are provided in Table 1. Fifteen years old plants of cv. 'Allison' were selected for the treatments. Kiwifruit plants were planted at a spacing of 4 x 4 m in north-south direction and were trained in telephone system. Eleven treatments were used *viz*., T_1: water spray (control), T_2: 5% KA sap (*Kappaphycus alvarezii*), T_3: 10% KA sap, T_4: 5% GE sap (*Gracilaria edulis*), T_5: 10% GE sap, T_6: 5% AN sap (*Ascophyllum nodosum*), T_7: 10% AN sap, T_8: 5% vermiwash, T_9: 10% vermiwash, T_{10}: 5% humic acid and T_{11}: 10% humic acid. The seaweed extracts were purchased from the market with the tradenames: Sagarika (*Kappaphycus alvarezii*), Biovita liquid (*Ascophyllum nodosum*) and *Gracilaria edulis* was obtained from ICAR Research Complex for NEH Region, Umiam, Meghalaya, India. The recommended dose of organic nutrient (RDON) was adopted as per Avasthe et al. (2014). Two equal splits of farmyard manure (50 kg/tree) and vermicompost (10 kg/tree) were applied during June–July and December–January, following harvest. Each treatment was allocated to ten plants using a randomised block design. The experimental setup was established with the foliar treatment of biostimulants as the treatment, applied four times namely before flower bud opening, after one month of fruit set, after three months of fruit set and after five months of fruit set.

Table 1 : Soil properties of the experimental site

Physicochemical properties	Value
Texture	Sandy loam
pH	5.3-5.9
Bulk density (g/cm^3)	1.53
Available N (kg/ha)	304.7-308.8
Available P (kg/ha)	14.2-14.9
Available K (kg/ha)	407.8-412.3
Organic carbon (%) at 0-15 cm	1.65-1.88
Water Holding Capacity (%)	37.89-43.34

A modified version of the standard methodology was utilised to perform the 2,2-diphenyl-2-picrylhydrazyl (DPPH) test (Dutta et al., 2018). The DPPH activity was measured in trolox equivalent (μM TE 100 g^{-1} fresh weight. The ABTS solution for the 2,22-azinobis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) test was made by combining an equivalent volume of 7.4 mM ABTS solution with 2.6 mM potassium persulfate, and it was then stored in the dark for 12 hours. The findings were represented in μM trolox equivalent per 100 g fresh weight (μM TE 100 g\L), with absorbance measured at 734 nm (150 mL sample plus 2850 mL of the ABTS solution, held 2 h in dark) (Arnao, 2000).

Sprouting percentage, fruitful buds percentage, fruit/shoot and grade A fruit percentage (fruits weighing 70 g. and above are graded as 'A' grade) were all counted manually during the respective phases. Yield/tree and fruit fresh weight (g) were measured with a digital weighing balance (Aczel Pvt. Ltd.), firmness was measured using a standard penetrometer (SLBT, Model SL-1144) and expressed in kg, total soluble solids were determined with an Erma Inc. portable refractor, total sugar and reducing sugar were estimated with a standardized method (Somogyi, 1952) and standard method was used to test the titrable acidity of fruit (Macrae et al., 1989).

The significance of the experimental data, was determined using the "F" test. Analysis of variance (ANOVA) used to analyse the data (Gomez et al., 1984). The critical differences (CD) with 5% probability (P=0.05) were calculated for each parameter under investigation in order to evaluate variations in treatment means. If there was more than a CD value difference between the means of two treatments, the treatment was categorised as significant difference. SPSS-16 was used to analyse the data (Frey, 2017).

RESULTS AND DISCUSSION

Growth attributes of kiwifruit cv. Allison are influenced by foliar application of different biostimulants (Table 2). All the growth attributes were highly significantly ($P<0.001$) affected by the treatments of various biostimulants except Grade A (%) fruits which were significantly ($P<0.05$) affected (Table 2). Plant extracts known as biostimulants include a variety of bioactive substances, the majority of which are currently unknown. These compounds often increase a plant's tolerance to both biotic and abiotic stressors and increase the plant's efficiency in using nutrients. Applying biostimulants to vegetables allowed for a decrease in fertiliser usage without compromising quality or production. Biostimulants have been shown to enhance the quality of leafy crops like rocket that are prone to nitrate buildup while ensuring that the nitrate levels remain within the national restrictions (Bulgari et al., 2015). All biostimulants have effects that have been scientifically proven to contribute to one or more of the following agricultural functions: they improve crop quality attributes, abiotic stress tolerance, and/or nutrition efficiency. Quality attributes might include things like shelf life, protein content in grains, and nutritional value (du Jardin, 2015).

Table 2 : Growth attributes of kiwifruit cv. Allison as influenced by foliar application of different biostimulants

Treatment	Sprouting (%)	Fruitful buds (%)	Fruit/shoot	Yield/tree (kg)	Fruit fresh weight (g)	Grade A (%)
T_1: Control (water spray)	54.0 ± 1.7 (3.9)	51.3 ± 1.5 (3.9)	5.3 ± 0.3	14.1 ± 0.1	91.7 ± 1.8	14.7 ± 0.7 (2.7)
T_2: KA sap 5%	74.0 ± 1.5 (4.3)	64.0 ± 1.5 (4.2)	7.3 ± 0.3	17.1 ± 0.5	100.7 ± 1.5	19.7 ± 0.3 (3.0)
T_3: KA sap 10 %	70.6 ± 2.3 (4.2)	61.0 ± 1.7 (4.1)	6.3 ± 0.3	16.2 ± 0.3	99.7 ± 1.2	17.7 ± 0.9 (2.9)
T_4: GE sap 5%	70.3 ± 1.2 (4.2)	66.3 ± 0.9 (4.2)	7.0 ± 0.6	16.4 ± 0.2	98.0 ± 2.1	18.0 ± 0.6 (2.9)
T_5: GE sap 10%	67.3 ± 2.0 (4.2)	58.0 ± 0.6 (4.1)	6.7 ± 0.3	15.7 ± 0.2	98.0 ± 2.1	17.0 ± 0.6 (2.8)
T_6: AN sap 5%	65.6 ± 0.9 (4.2)	60.0 ± 1.5 (4.1)	6.3 ± 0.3	15.8 ± 0.3	108.7 ± 2.8	17.3 ± 0.9 (2.9)
T_7: AN sap 10%	62.6 ± 1.2 (4.1)	76.3 ± 1.8 (4.3)	5.3 ± 0.3	15.7 ± 0.2	99.7 ± 1.2	17.3 ± 1.2 (2.9)
T_8: Vermiwash 5%	66.0 ± 1.5 (4.1)	78.0 ± 1.2 (4.4)	7.7 ± 0.3	16.5 ± 0.5	107.0 ± 4.2	20.7 ± 0.9 (3.0)
T_9: Vermiwash 10%	66.3 ± 0.9 (4.2)	56.7 ± 0.9 (4.0)	7.3 ± 0.3	16.9 ± 0.3	96.0 ± 1.5	19.0 ± 1.2 (2.9)
T_{10}: Humic acid 5%	63.3 ± 1.2 (4.1)	58.7 ± 1.2 (4.1)	6.0 ± 0.6	15.0 ± 0.2	99.0 ± 2.1	17.0 ± 0.6 (2.8)
T_{11}: Humic acid 10%	68.6 ± 2.6 4.2)	64.3 ± 2.3 (4.2)	7.3 ± 0.3	16.4 ± 1.3	102.7 ± 4.2	17.3 ± 0.9 (2.9)
LSD (p <0.01)	4.9	4.3	1.1	1.3	7.1	2.7
F-value	9.38**	29.01**	4.40**	3.64**	3.66**	2.82*

Data are presented as the mean ±SeM (n =3); LSD, least significant difference; NS, non-significant; *significant at p <0.05, **significant at p <0.01

Sprouting percentage has been found to be highest with T_2: KA sap 5% (74.0%) and lowest with T_1: control (water spray) (54.0%) (1.37 fold difference). Unlike vegetative bud sprouting, sprouting of seeds had been found in many crop species with the application of seaweed saps (Dutta et al., 2019; Mattner et al., 2013). Fruitful bud percentage has been found to be highest with the application of T_8: vermiwash 5% (78.0%) and lowest with T_1: control (water spray) (51.3%) (1.52 fold difference). Fruit per shoot was also found to be highest in T_8: vermiwash 5% (7.7) and lowest with T_1: control (water spray) (5.3) (1.45 fold difference). Yield per tree was recorded highest for the treatment T_2: KA sap 5% (17.1 kg/tree) lowest with T_1: control (water spray) (14.1 kg/tree) (1.21 fold difference). Fruit fresh weight has been found to be highest with treatment T_6: AN sap 5% (108.7 g) and lowest with T_1: control (water spray)

Table 3 : Fruit quality attributes of kiwifruit cv. Allison as influenced by foliar application of different bio-stimulants

Treatment	Firmness (kg)	Soluble solids (°Brix)	Total sugar (%)	Reducing sugar (%)	Titratable acidity (as % citric acid)
T_1: Control (water spray)	8.0 ± 0.6	10.7 ± 0.9	6.3 ± 0.3 (1.8)	4.3 ± 0.2 (1.5)	1.4 ± 0.1
T_2: KA sap 5%	10.0 ± 0.6	13.0 ± 0.6	7.7 ±0.3 (2.0)	5.0 ± 0.1 (1.6)	0.9 ± 0.1
T_3: KA sap 10 %	9.3 ± 0.3	14.0 ± 0.9	6.6 ± 0.1 (1.9)	4.9 ± 0.2 (1.6)	1.1 ± 0.1
T_4: GE sap 5%	10.0 ± 0.6	12.7 ± 0.9	7.0 ± 0.2 (1.9)	4.3 ± 0.1 (1.5)	1.3 ± 0.1
T_5: GE sap 10%	9.3 ± 0.9	14.0 ± 0.9	6.4 ± 0.2 (1.9)	4.9 ± 0.1 (1.6)	1.2 ± 0.1
T_6: AN sap 5%	9.0 ± 1.2	13.7 ± 0.3	7.0 ± 0.1 (1.9)	4.9 ± 0.1 (1.6)	0.9 ± 0.1
T_7: AN sap 10%	10.0 ± 0.6	13.0 ± 0.6	7.3 ± 0.2 (2.0)	4.7 ± 0.1 (1.5)	1.0 ± 0.1
T_8: Vermiwash 5%	9.0 ± 0.6	14.3 ±0.9	6.9 ± 0.1 (1.9)	4.9 ± 0.1 (1.6)	1.1 ± 0.1
T_9: Vermiwash 10%	10.0 ± 0.6	13.3 ± 0.7	7.0 ± 0.5 (1.9)	4.9 ± 0.1 (1.6)	1.1 ± 0.2
T_{10}: Humic acid 5%	10.0 ± 0.6	13.3 ± 0.9	6.7 ± 0.2 (1.9)	4.9 ± 0.1 (1.6)	0.9 ± 0.1
T_{11}: Humic acid 10%	10.7 ± 0.9	14.0 ± 0.9	7.2 ± 0.1 (2.0)	5.0 ± 0.1 (1.6)	1.0 ± 0.1
LSD (p <0.01)	1.4	1.8	0.6	0.3	0.2
F-value	1.22*	2.42*	2.94*	4.59**	2.61*

Data are presented as the mean ±SeM (n =3); LSD, least significant difference; NS, non-significant; *significant at p <0.05, **significant at p <0.01

(91.7 g) (1.18 fold difference). Grade A fruit percentage was recorded highest for the treatment T_8: vermiwash 5% (20.7%) and lowest with T_1: control (water spray) (14.7%) (1.40 fold difference). Exogenous foliar application of seaweed extracts and humic acids has been found to be beneficial for getting high quality fruits and increased production in many fruit crops like citrus, kiwifruit, peaches, grapes and apricots (Khan et al., 2022; Rana et al., 2023). Fruit qualities have likely improved significantly as a result of the presence of betaines, auxins, and cytokinins in seaweed extracts which affected cell expansion and division in the early phases of development, leading to greater fruit sizes (Dutta et al., 2023; Khan et al., 2022).

Fruit quality attributes of kiwifruit cv. Allison as influenced by foliar application of different biostimulants (Table 3). All the fruit quality attributes were significantly (*P<0.05*) affected by the treatments of various biostimulants. Fruit firmness has been found to be highest with T_{11}: Humic acid 10% (10.7 kg) and lowest with T_1: control (water spray) (8.0 kg) (1.33 fold difference). Treatment T_8: vermiwash 5% recorded the highest soluble solids (14.3°B), while, minimum was recorded with T_1: control (water spray) (10.7°B) (1.33 fold difference). Total sugar was recorded highest with treatment T_2: KA sap 5% (7.7%) while lowest was recorded with T_1: control (water spray) (6.3%) (1.22 fold difference). Reducing sugar percentage was recorded highest for the treatment T_2: KA sap 5% and T_{11}: humic acid 10% (5.0%) and lowest with T_1: control (water spray) (4.3%) (1.16 fold difference). Titratable acidity (as % citric acid) was recorded lowest for the treatment T_2: KA sap 5%, T_6: AN sap 5% and T_{10}: humic acid 5% (0.9%) and highest with T_1: control (water spray) (1.4%) (1.55 fold difference). Antioxidant assay (DPPH and ABTS) of kiwifruit as influenced by different concentration of biostimulants is presented in Fig. 1.

DPPH antioxidant content was found to be highest in T_8: vermiwash 5% (715.89 µM TE/100 g fresh weight) and lowest with T_1: control (water spray) (486.0 µM TE/100 g fresh weight) (1.47 fold difference). Moreover, ABTS antioxidant content was found to be highest in T_{10}: humic acid 5% (275.22 µM TE/100 g fresh weight) and lowest with T_1: control (water spray) (172.44 µM TE/100 g fresh weight) (1.59 fold difference). The results showed that treatments with seaweed extract significantly affected

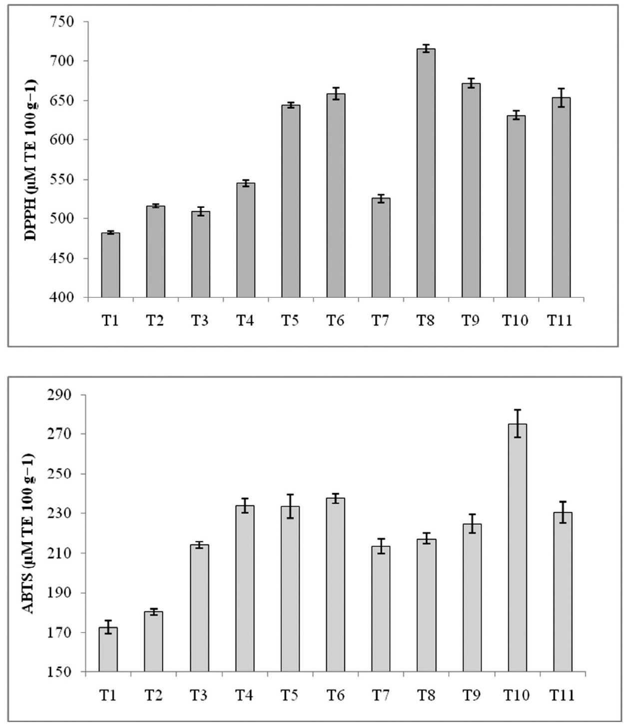

Fig. 1 : Antioxidant assay (DPPH and ABTS) of kiwifruit as influenced by different concentration of seaweed saps

the characteristics of kiwifruit fruit. El-Miniawy et al. (2014) reported that seaweed extract (2 mL/L) increased the amount of total soluble solids in strawberries, while, Khan et al. (2012) found that spraying seaweed extract at different phases of growth in grapes increased the total soluble solids content. Numerous micronutrients included in seaweed extract are involved in the synthesis of proteins, amino acids, carbohydrates, and other molecules. Similar effects on photosynthetic pigments, starch, TSS, proteins, phenols, ascorbic acid, DPPH assay, ABTS assay, decreasing sugars, and acidity compared to control plants have been seen in tomato plants treated with seaweed extract (Layek et al., 2018).

CONCLUSION

Humic acid and seaweed sap have a beneficial effect on the quality and productivity of organic kiwifruit production. The best treatments for enhancing the development characteristics were determined to be T_8, T_2, and T_6 and for fruit quality T_2, T_{11}, T_8, and T_5 in kiwifruit cv. Allison.

The treatment T_8 was the best for the DPPH assay and T_{10} for ABTS assay for antioxidant content. Thus, it can be inferred that using biostimulants such as humic acids and seaweed extracts is one way to improve the quality and quantity of kiwifruit production that is grown organically.

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