



Research Article

Efficacy of Exogenously Applied Bio-Stimulants on Quality Production of *Matthiola incana* L.

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Abstract | To improve yield and shelf life of stock can enhance economic value to flowers growers globally. A study was conducted to evaluate the efficacy of various bio-stimulants on yield and quality of stock. Three cultivars of stock, viz. 'Cheerful White', 'Iron Rose' and 'Iron White' foliarly sprayed by bio-stimulants (Isabion and Tecamin Max) with three different concentrations (1 ppm, 3 ppm, and 5 ppm) with the different number of sprays (1, 2, or 3 sprays). The first spray was applied after one month of transplanting, while the other two were applied at fortnight intervals after the first spray. Fisher's Analysis of variance revealed that Isabion at 1 ppm as 1 spray, 3 ppm as 3 sprays, and 5 ppm as 3 sprays produced the highest plant height for three cultivars of stock. 'Cheerful White' had the highest stem length when plants were sprayed once at 1 ppm Isabion. Among cultivars, 'Iron Rose', produced highest leaf area (42.8 cm²) with 3 ppm Isabion application, when sprayed only one time. Among the number of sprays, plants sprayed three times with Isabion produced the thickest stem diameter followed by 2 and 1 sprays. 'Cheerful White' had maximum leaf total chlorophyll contents, followed by 'Iron White' and 'Iron Rose' (69.1 SPAD and 68.8 SPAD, respectively). Among the number of sprays, plants sprayed three times had the longest vase life. Cheerful White proved early cultivar of stock while Iron White were late cultivars when grown in agro-climatic conditions of Faisalabad. Tecamin Mix is recommended biostimulant for quality production of *Matthiola incana* L. rather than isabion.

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Introduction

Stock (*Matthiola incana* L.) is an annual, biennial, and perennial belongs to the family Brassicaceae

and is native to the Mediterranean region. Due to its longer stems, quality, and best raceme, it is well recognized as a highly valuable specialty cut flower (Regan and Dole, 2010). It is famous for its wide range of

colors, good quality stems, and good vase life. Most cut flower cultivars are double petal flowers, and the bloom has a strong spicy clove-like fragrance (Celikel and Reid, 2002). In mineral fertilizers, biostimulants have been used as a supplement and improve the quality and yield of flowers under certain protected conditions (Harshavardhan *et al.*, 2016). A plant bio-stimulant is referred to as any substance or micro-organism, in the form in which it is, applied to plants, seeds, or the root environment with the intention to stimulate natural processes of plants benefiting nutrient use efficiency, tolerance to abiotic stress, regardless of its nutrients content, or any combination of such substances and/or microorganisms intended for this use (Traon *et al.*, 2014).

Natural plant extracts and biochemicals enhance crop growth (Godlewska *et al.*, 2016). Biostimulants or agricultural bio-stimulants are replacing synthetic fertilizers for crop production (Rouphael and Colla, 2020a). are plant extracts and contain a wide range of bioactive compounds. The nature of most of the bio-active compounds is still under study (Bulgari *et al.*, 2015). Plant bio-stimulants (PBs) are a diverse group of biochemicals that motivate beneficial microorganisms for plant growth regulation (Rouphael and Colla, 2020b). The role of bio-stimulants is to control and accelerate the life processes of plants, increase the resistance to stress, and stimulate their development (roots and leaves) (Calvo *et al.*, 2014; Du Jardin, 2015).

Evaluation of bio-stimulants showed significant improvement in vegetative growth, flowering, and post-harvest attributes through increased availability of nutrients in the soil (Karim *et al.*, 2017). Bio-stimulants applied in plant production have been widely considered as an environment-friendly agricultural practice. Bio-stimulants mostly enhanced seed and transplant vigor stimulated vegetative growth, improved nutrient acquisition, and distribution within the plant, increased antioxidative capacity of plant tissues, contributed to higher stress tolerance, and improved plant yield and flower quality (Paradikovic *et al.*, 2018).

Plant bio-stimulants include microorganisms and substances that enhance plant growth. The role of bio-stimulants is to accelerate the life processes of plants, increase resistance to stress and stimulate their development (roots and leaves). Bio-stimulants con-

tribute to better seed germination and induce the biological activity of plants. These products are also safe for the environment and contribute to sustainable, low input, and high output crop production (Radkowski and Radkowska, 2013). However, there is an insufficient study of bio-stimulants on flowers/ornamental plant production, so there was a gap to find the mechanism of its effect on reproductive growth within the suitable season. The specific objectives of the study were to evaluate the efficacy of various bio-stimulants in the production and quality of different cultivars of stock (*Matthiola incana* L.).

Materials and Methods

The present study was conducted at Floriculture Research Area, Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan, during 2019-2020. In this study, the efficacy of various bio-stimulants on the quality production of stock (*Matthiola incana* L.) was evaluated. Seeds of stock cultivars, viz. 'Cheerful White', 'Iron Rose' and 'Iron White' were purchased from a well reputed local importing agency. The nursery was raised in 128 cell plastic plug trays containing silt, coco coir, and sugarcane press-mud (1:1:1; v/v/v) as the substrate on 16th October 2019. Seedlings of stock cultivars were transplanted on 20th November 2019, at a 2-4 true leaf stage, after thorough soil preparation and addition of basal fertilizer (Di-ammonium phosphate @ 250 kg ha⁻¹). Plant to plant and row to row distance was maintained at 22.5 cm. All other cultural practices, like fertilization, irrigation, weeding, IPM, etc. were similar for all treatments during the entire period of study.

To evaluate the efficacy of various bio-stimulants viz. Isabion and Tecamin Max with three different concentrations (1 ppm, 3 ppm, and 5 ppm in water) and the different number of sprays (1, 2, or 3 sprays), on quality production of stock cultivars viz. 'Cheerful White', 'Iron Rose' and 'Iron White'. Seedlings of stock cultivars were transplanted on flatbeds. Eighteen plants of each cultivar were planted in each replication and all treatments were replicated thrice through Randomized Complete Block Design (RCBD) with factorial arrangements. The first spray of bio-stimulant (Isabion) was applied after one month of transplanting and the next two sprays were applied at fortnight intervals after the first spray.

Five healthy and recently matured leaves were taken, and their total chlorophyll contents were measured from three different points of leaves (tip, middle, and bottom) with a digital leaf chlorophyll meter (PN: 0131). Raceme length was recorded at harvest with meter rod. The number of florets per raceme was counted from 5 stems of each cultivar. Stem diameter was measured from the center of the stem with a digital Vernier caliper (LF 07) from 5 stems of each cultivar. Diameter of the lowest open floret was measured with a digital Vernier caliper (LF 07). Five stems of each cultivar from each replication were weighed on an electric weighing balance model (HK-DC-320AS). Brown paper bags were labeled accordingly and oven-dried in a laboratory dry oven model (DHG-9053A) at a constant temperature of 65°C for 48 hours. For measuring flower quality, different characters were undertaken for rating the quality of flowers which included bud development, flower size, and color development. The rating was done by three judges at a scale of 1-5 (1 for poor, 3 for average, and 5 for best) following the method given by Dest and Guillard (1987), and the average was recorded. Stems were recut to a length of 50 cm and placed in distilled water until termination in the postharvest evaluation room at a temperature of 22 ± 2°C along with a light period of 12 hours. Vase life was ended when stems showed wilting, drooping, and senescence of florets on ≥ 50% of the raceme.

Production time (days) was recorded from the date of transplanting to the lower two florets opening on the raceme, which is the time to harvest the first marketable stem. Days were counted and the average was calculated. The height of the plant was measured at harvest with a meter rod from the base to the top of the plant in centimeters. Stem length was measured after harvest from bottom to top of the raceme in cm with a meter rod. Two fully mature leaves were taken from the center of the stem from each replication, their length and maximum width were measured with a measuring scale and leaf area was calculated according to the following formula described by Carleton and Foote (1965).

$$\text{Leaf area (cm}^2\text{)} = \text{Length} \times \text{Maximum width} \times 0.68 \text{ (constant factor)}$$

Statistical analysis

Data were analyzed using the analysis of variance (ANOVA) technique according to Fisher’s technique

of analysis (Statistix 8.1) and treatment means were compared according to the Least Significance Difference test at 5% level of probability (Steel *et al.*, 1997).

Results and Discussion

Production time (days)

Various concentrations and the number of sprays had a significant influence on the production time of all tested cultivars. ‘Cheerful White’ took the least days (92.9) to produce flowers when plants sprayed once with 1 ppm Isabion, ‘Cheerful White’ took the least days to produce flowers (90.4) when plants were sprayed three times at 3 ppm Tecamin Max. Among cultivars, ‘Iron Rose’ took the least days to produce flowers (93.3) with 1 ppm Tecamin Max application when plants were sprayed three times. In contrast, when the number of sprays was decreased to one or two, the delayed production time was observed with 1 ppm and 5 ppm Tecamin Max application (106.7 and 113.1, respectively). For ‘Iron white’ earlier flower production (92.3) was obtained with 1 ppm when sprays were applied three times. However, when the number of sprays was one or two, more production time was recorded with 5 ppm or 1 ppm (104.3 and 111.5, respectively). (Table 1).

Table 1: *Effect of various number of sprays and concentrations of Isabion and Tecamin Max on production time (days) of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron’.*

Treatments	Isabion	Tecamin Max
Production time (days)		
Cultivars		
‘Cheerful White’	92.9 b	95.9
‘Iron Rose’	97.2 a	99.2
‘Iron White’	97.6 a	94.2
Significance	< 0.0001	NS
No. of sprays		
1	94.8 c	99.7 a
2	96.8 a	95.4 ab
3	96.2 b	94.2 b
Significance	< 0.0001	< 0.0001
Conc. (ppm)		
1	95.2 c	100.0 a
3	96.1 b	100.0 a
5	96.5 a	89.3 b
Significance	< 0.0001	0.03

Table 2: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on plant height of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments	Plant height (cm)			
	Cultivars	No. of Sprays	Conc. (ppm)	Isabion Tecamin Max
‘Cheerful White’	1	1	57.1 a	55.7 b-f
‘Cheerful White’	1	3	47.5 ghi	62.5 a
‘Cheerful White’	1	5	50.6 b-g	53.3 b-h
‘Cheerful White’	2	1	52.2 a-g	56.9 b
‘Cheerful White’	2	3	54.8 abc	55.4 b-f
‘Cheerful White’	2	5	53.2 a-e	56.1 bcd
‘Cheerful White’	3	1	47.5 ghi	56.5 bc
‘Cheerful White’	3	3	53.0 a-f	54.4 b-g
‘Cheerful White’	3	5	56.6 ab	54.9 b-g
‘Iron Rose’	1	1	48.2 e-i	47.2 kl
‘Iron Rose’	1	3	52.7 a-f	49.1 i-l
‘Iron Rose’	1	5	44.2 hi	50.0 h-l
‘Iron Rose’	2	1	49.4 d-g	52.3 d-j
‘Iron Rose’	2	3	49.3 d-h	51.9 e-j
‘Iron Rose’	2	5	49.2 d-i	56.0 b-e
‘Iron Rose’	3	1	53.5 a-d	52.4 c-i
‘Iron Rose’	3	3	49.2 d-i	51.9 e-j
‘Iron Rose’	3	5	51.6 b-g	51.7 f-j
‘Iron White’	1	1	52.7 a-f	48.9 i-l
‘Iron White’	1	3	49.2 d-i	48.9 i-l
‘Iron White’	1	5	47.4 ghi	51.2 g-k
‘Iron White’	2	1	52.0 b-g	45.9 l
‘Iron White’	2	3	48.0 f-i	51.2 g-k
‘Iron White’	2	5	44.1 i	54.4 b-g
‘Iron White’	3	1	47.6 ghi	49.5 h-l
‘Iron White’	3	3	49.6 d-i	50.2 h-k
‘Iron White’	3	5	52.8 a-f	48.2 jkl

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Plant height (cm)

‘Cheerful White’ had the highest plant height (57.1) when plants were sprayed once at 1 ppm Isabion. Moreover, with increasing Isabion concentration and the number of sprays, the plant height of ‘Cheerful White’ also increased. Among cultivars, ‘Iron Rose’, produced the tallest plants (53.3) with 3 ppm Isabion application when sprayed only once. For ‘Iron White’, the highest plant height (52.8) was obtained with 5 ppm Isabion when sprayed three times. Among cultivars ‘Iron Rose’, produced the tallest plants (56.0) with 5 ppm Tecamin Max application when plants

were sprayed two times. For ‘Iron white’ the highest plant height (54.4) was obtained with 5 ppm Tecamin Max when sprayed two times. However, when the number of sprays was one or three greatest plant height was recorded with 5 ppm and 3 ppm as (51.2 and 50.2, respectively) (Table 2).

Table 3: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on stem length of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments	Stem length (cm)			
	Cultivars	No. of Sprays	Conc. (ppm)	Isabion Tecamin Max
‘Cheerful White’	1	1	54.9 a	53.6 a-e
‘Cheerful White’	1	3	45.4 fgh	60.5 a
‘Cheerful White’	1	5	48.6 c-f	51.3 b-f
‘Cheerful White’	2	1	50.2 a-f	54.9 ab
‘Cheerful White’	2	3	52.7 abc	53.4 a-e
‘Cheerful White’	2	5	51.1 a-d	53.7 a-e
‘Cheerful White’	3	1	53.4 abc	54.4 abc
‘Cheerful White’	3	3	50.8 a-e	54.4 a-d
‘Cheerful White’	3	5	54.4 ab	52.8 b-e
‘Iron Rose’	1	1	46.1 e-h	44.9 f
‘Iron Rose’	1	3	50.8 a-e	47.1 def
‘Iron Rose’	1	5	42.3 gh	47.9 b-f
‘Iron Rose’	2	1	47.3 def	50.2 b-f
‘Iron Rose’	2	3	47.4 def	49.9 b-f
‘Iron Rose’	2	5	47.2 d-g	50.0 b-f
‘Iron Rose’	3	1	51.5 a-d	50.4 b-f
‘Iron Rose’	3	3	47.3 d-g	49.9 b-f
‘Iron Rose’	3	5	49.6 b-f	49.6 b-f
‘Iron White’	1	1	50.7 a-e	46.6 ef
‘Iron White’	1	3	46.9 d-h	46.8 ef
‘Iron White’	1	5	45.3 fgh	49.1 b-f
‘Iron White’	2	1	50.1 a-f	44.0 f
‘Iron White’	2	3	46.0 e-h	49.2 b-f
‘Iron White’	2	5	42.1 h	46.9 ef
‘Iron White’	3	1	47.2 d-g	47.3 c-f
‘Iron White’	3	3	46.7 d-h	48.0 b-f
‘Iron White’	3	5	50.7 a-e	29.4 g

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Stem length (cm)

‘Cheerful White’ had the highest stem length (54.9) when plants were sprayed once at 1 ppm Isabion. Among cultivars ‘Iron Rose’, produced the tallest stem length (51.5) with 1 ppm Isabion application

Table 4: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on leaf area of stock cultivars viz. 'Cheerful White', 'Iron Rose' and 'Iron White'.

Treatments Cultivars	No. of Sprays	Conc. (ppm)	Leaf area (cm ²)	
			Isabion	Tecamin Max
'Cheerful White'	1	1	39.2 a-e	37.2 a-g
'Cheerful White'	1	3	28.2 e-h	45.3 a
'Cheerful White'	1	5	19.9 h	33.9 b-h
'Cheerful White'	2	1	28.1 e-h	33.5 c-h
'Cheerful White'	2	3	32.5 b-h	38.6 a-f
'Cheerful White'	2	5	40.1 a-e	40.5 a-e
'Cheerful White'	3	1	33.1 b-g	33.8 b-h
'Cheerful White'	3	3	36.6 a-e	36.5 a-h
'Cheerful White'	3	5	36.9 a-e	43.5 ab
'Iron Rose'	1	1	31.8 b-h	26.7 hi
'Iron Rose'	1	3	42.8 abc	31.4 d-i
'Iron Rose'	1	5	20.9 fgh	32.1 d-i
'Iron Rose'	2	1	33.1 b-h	33.1 c-h
'Iron Rose'	2	3	29.3 d-h	38.6 a-f
'Iron Rose'	2	5	33.9 b-e	31.4 d-i
'Iron Rose'	3	1	40.9 a-d	30.1 f-i
'Iron Rose'	3	3	35.0 b-e	30.7 e-i
'Iron Rose'	3	5	33.4 b-f	33.6 b-h
'Iron White'	1	1	48.5 a	32.2 d-i
'Iron White'	1	3	42.8 abc	35.5 a-h
'Iron White'	1	5	34.5 b-e	27.5 ghi
'Iron White'	2	1	41.4 a-d	22.3 i
'Iron White'	2	3	34.5 b-e	35.2 b-h
'Iron White'	2	5	20.5 gh	38.6 a-f
'Iron White'	3	1	30.8 c-h	30.7 e-i
'Iron White'	3	3	35.4 b-e	42.3 abc
'Iron White'	3	5	43.5 ab	40.8 a-d

when spray was applied three times. In contrast, when the number of sprays was one or two, the highest stem length was observed with 3 ppm and 5 ppm Isabion application (50.8 and 49.6, respectively). For 'Iron white' highest stem length (50.7) was obtained with 1 ppm and with 5 ppm concentrations of Isabion, when sprays were applied one time or three times respectively. 'Cheerful White' had the highest stem length (60.5) when plants were sprayed once at 3 ppm Tecamin Max. Moreover, with increasing Tecamin Max concentration and the number of sprays, the stem length of 'Cheerful White' become decreased. Among cultivars 'Iron Rose', produced the tallest stem length (50.4 cm) with 1 ppm Tecamin Max application when spray was applied three times.

Leaf area (cm²)

'Cheerful White' had maximum leaf area (40.1) when plants were sprayed two times at 5 ppm Isabion. Among cultivars, 'Iron Rose', produced the highest leaf area (42.8) with 3 ppm Isabion application, when sprayed only one time. For 'Iron white' highest leaf area (48.5) was obtained with 1 ppm when spray was applied only a single time. However, when the number of sprays was increased to two or three highest leaf area was recorded with 1 ppm and 5 ppm Isabion application (41.4 and (43.5, respectively). 'Cheerful White' produced the highest leaf area (38.1). Among the number of sprays, plants sprayed three times produced the highest leaf area (35.8). Among different concentrations of Tecamin Max, 3 ppm produced the highest leaf area (37.1) (Table 4).

Table 5: Effect of various number of sprays and concentrations of Isabion and Tecamin Max on leaf total chlorophyll contents (SPAD) of stock cultivars viz. 'Cheerful White', 'Iron Rose' and 'Iron White'.

Treatments	Isabion	Tecamin Max
Leaf total chlorophyll contents (SPAD)		
Cultivars		
'Cheerful White'	74.7 a	73.4 a
'Iron Rose'	69.8 c	69.4 b
'Iron White'	71.3 b	69.8 b
Significance ^y	< 0.0001	< 0.0001
No. of sprays		
1	71.6	70.6 ab
2	71.9	72.2 a
3	72.3	69.9 b
Significance ^y	NS	0.02
Conc. (ppm)		
1	71.8	71.1
3	71.7	71.1
5	72.3	70.6
Significance ^y	NS	NS

Mean sharing different letters in the column are statistically different at P ≤ 0.05.

Leaf total chlorophyll contents (SPAD)

Leaf total chlorophyll contents for the stock were dependent on cultivars, while independent of different concentrations and number of sprays, 'Cheerful White' had maximum leaf total chlorophyll contents (74.7). Among the number of sprays, plants sprayed three times with Isabion had maximum leaf total chlorophyll contents (72.3). Among different concentrations of Isabion, 5 ppm produced maxi-

imum leaf total chlorophyll contents (72.3). ‘Cheerful White’ had the highest leaf total chlorophyll contents (76.1) when plants were sprayed two times at 1 ppm Tecamin Max. Among cultivars ‘Iron Rose’, produced the highest leaf total chlorophyll contents (71.1) with 1 ppm Tecamin Max application when sprays were applied two times. For ‘Iron white’ highest leaf total chlorophyll contents (73.1) was obtained with 5 ppm concentrations of Tecamin Max, when plants sprayed only once. However, when the number of sprays was two or three, greater leaf total chlorophyll contents were recorded with 5 ppm and 3 ppm (72.8 and 71.1, respectively). (Table 5).

Table 6: Effect of various number of sprays and concentrations of Isabion and Tecamin Max on raceme length (cm) of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments	Isabion	Tecamin Max
Raceme length (cm)		
Cultivars		
‘Cheerful White’	13.96 a	15.9 a
‘Iron Rose’	10.84 b	11.4 b
‘Iron White’	13.63 a	15.2 a
Significance ^y	< 0.0001	< 0.0001
No. of sprays		
1	12.25	12.9 b
2	12.60	14.1 ab
3	13.25	15.5 b
Significance ^y	NS	0.04
Conc. (ppm)		
1	13.04	13.1 b
3	12.66	14.4 ab
5	12.72	15.1 a
Significance ^y	NS	0.13

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Raceme length (cm)

Raceme length for the stock was dependent on cultivars, while independent of different concentrations and number of sprays, which demonstrated that different concentrations and number of sprays had no influence on raceme length of all tested cultivars. ‘Cheerful White’ had the longest raceme length (13.9). Among the number of sprays, plants sprayed three times with Isabion had maximum raceme length (13.3). Among different concentrations of Isabion, 1 ppm produced the largest raceme length (13.0). Results revealed that ‘Cheerful White’ had the highest

raceme length (18.0) when plants were sprayed two times at 1 ppm Tecamin Max. Among cultivars ‘Iron Rose’, produced the tallest raceme length (13.9) with 1 ppm Tecamin Max application when spray was applied three times. For ‘Iron white’ the highest raceme length (28.1) was obtained with 5 ppm concentrations of Tecamin Max when sprays were applied three times. Moreover, with decreasing concentration and number of sprays, raceme length of ‘Iron white’ also decreased. (Table 6).

Number of florets per raceme

The number of florets per raceme for the stock was dependent on cultivars, while independent of different concentrations and number of sprays, which demonstrated that different concentrations and number of sprays had no influence on the number of florets per raceme of all tested cultivars. ‘Iron White’ had the maximum number of florets per raceme (21.9). Among the number of sprays, plants sprayed three times with Isabion had the maximum number of florets per raceme (20.2). Among different concentrations of Isabion, 1 ppm produced the maximum number of florets per raceme (19.9). ‘Cheerful White’ had the highest number of florets per raceme (21.7) when plants were sprayed three times at 3 ppm Tecamin Max. Among cultivars ‘Iron Rose’, produced the highest number of florets per raceme (21.8) with 1 ppm Tecamin Max application when sprays were applied two times. In contrast, when the number of sprays was one or three, the highest number of florets per raceme was observed with 5 ppm Tecamin Max application (19.5 and 21.3, respectively). For ‘Iron white’ highest number of florets per raceme (23.8) was obtained with 5 ppm concentrations of Tecamin Max, when sprays were applied three times respectively (Table 7).

Stem diameter (mm)

Stem diameter for the stock was dependent on cultivars, while independent of different concentrations and number of sprays, which shows that different concentrations and number of sprays had no influence on stem diameter of all tested cultivars. ‘Iron White’ had maximum stem diameter (9.9). Among the number of sprays, plants sprayed three times with Isabion produced the thickest stem diameter (72.3). Among different concentrations of Isabion, 1 ppm produced the highest stem diameter (9.2). Results revealed that ‘Cheerful White’ had the highest stem diameter (8.9) when plants were sprayed once at 3

ppm Tecamin Max. Among cultivars ‘Iron Rose’, produced the thickest stem diameter (10.8) with 3 ppm Tecamin Max application when spray was applied two times. In contrast, when the number of sprays was one or three, the highest stem diameter was observed with 5 ppm Tecamin Max application (10.3 and 10.1, respectively). For ‘Iron white’ highest stem diameter (10.3) was obtained with 3 ppm concentrations of Tecamin Max, when sprays were applied thrice (Table 8).

Table 7: Effect of various number of sprays and concentrations of Isabion and Tecamin Max on number of florets per raceme of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments	Isabion	Tecamin Max
No. of florets per raceme (no.)		
Cultivars		
‘Cheerful White’	17.89 b	19.9 b
‘Iron Rose’	18.89 b	20.0 b
‘Iron White’	21.91 a	24.8 a
Significance ^y	< 0.0001	0.003
No. of sprays		
1	19.09	19.9 b
2	19.43	20.6 b
3	20.18	24.3 a
Significance ^y	NS	0.01
Conc. (ppm)		
1	19.92	19.6 b
3	19.52	21.1 ab
5	19.26	23.9 a
Significance ^y	NS	0.05

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Floret diameter (mm)

‘Cheerful White’ had the highest floret diameter (56.8) when plants were sprayed once at 1 ppm Isabion. Moreover, with increasing Isabion concentration and the number of sprays, the floret diameter of ‘Cheerful White’ become decreased. Among cultivars ‘Iron Rose’, produced the highest floret diameter (51.1) with 5 ppm Isabion application, when sprayed three times. In contrast when the number of sprays was one or two highest floret diameter was observed with 3 ppm and 1 ppm (45.4 and 45.7, respectively). For ‘Iron white’, the highest floret diameter (50.3) was obtained with 5 ppm when sprays were applied three times. Moreover, with increasing Isabion concentrations and the number of sprays, the floret diameter

of ‘Iron white’ has increased. ‘Cheerful White’ had the highest floret diameter (59.2) when plants were sprayed once at 3 ppm Tecamin Max. Among cultivars ‘Iron Rose’, produced the highest floret diameter (48.8) with 1 ppm Tecamin Max application, when sprayed two times. For ‘Iron white’ highest floret diameter (50.5) was obtained with 3 ppm when sprays were applied three times. (Table 9).

Table 8: Effect of various number of sprays and concentrations of Isabion and Tecamin Max on stem diameter (mm) of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments	Isabion	Tecamin Max
Stem diameter (mm)		
Cultivars		
‘Cheerful White’	7.2 b	8.0 b
‘Iron Rose’	9.8 a	9.7 ab
‘Iron White’	9.9 a	11.5 a
Significance ^y	< 0.0001	0.005
No. of sprays		
1	9.1	9.1
2	8.9	9.1
3	8.8	11.1
Significance ^y	NS	NS
Conc. (ppm)		
1	9.2 a	8.6 b
3	8.9 ab	9.3 ab
5	8.6	11.3 a
Significance ^y	0.1	0.03

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Stem fresh weight (g)

‘Cheerful White’ produced the highest stem fresh weight (110.4) when plants were sprayed once at 1 ppm Isabion. Among cultivars ‘Iron Rose’, produced the highest stem fresh weight (136.3) with 5 ppm Isabion application when sprayed two times. In contrast, when the number of sprays was one or three highest stem fresh weight was observed with 3 ppm and 1 ppm (113.7 and 132.2, respectively). For ‘Iron white’, the highest stem fresh weight (113.2) was obtained with 1 ppm when sprays were applied two times. Results depicted that ‘Cheerful White’ produced the highest stem fresh weight (127.6) when plants were sprayed once at 3 ppm Tecamin Max. Moreover, with increasing Tecamin Max concentration and number of sprays, stem fresh weight of ‘Cheerful White’ become decreased. Among cultivars ‘Iron Rose’, produced

Table 9: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on floret diameter of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments Cultivars	No. of Sprays	Conc. (ppm)	Floret diameter (mm)	
			Isabion	Tecamin Max
‘Cheerful White’	1	1	56.8 a	53.1 a-g
‘Cheerful White’	1	3	49.2 b-g	59.2 a
‘Cheerful White’	1	5	49.1 b-g	47.8 d-i
‘Cheerful White’	2	1	49.4 b-g	54.5 abc
‘Cheerful White’	2	3	49.4 b-g	55.7 ab
‘Cheerful White’	2	5	51.7 abc	53.3 a-f
‘Cheerful White’	3	1	49.6 b-f	54.2 a-d
‘Cheerful White’	3	3	49.7 b-f	53.6 a-e
‘Cheerful White’	3	5	52.1 ab	53.5 a-f
‘Iron Rose’	1	1	42.7 ij	40.3 jk
‘Iron Rose’	1	3	45.4 d-i	44.9 hij
‘Iron Rose’	1	5	39.3 j	47.9 d-i
‘Iron Rose’	2	1	45.7 d-i	48.8 c-i
‘Iron Rose’	2	3	44.3 f-j	42.8 ij
‘Iron Rose’	2	5	42.8 hij	42.6 ij
‘Iron Rose’	3	1	44.5 e-j	43.7 ij
‘Iron Rose’	3	3	45.3 d-i	46.6 hij
‘Iron Rose’	3	5	51.1 a-d	46.7 g-j
‘Iron White’	1	1	44.8 e-j	46.7 g-j
‘Iron White’	1	3	45.3 d-i	47.7 e-i
‘Iron White’	1	5	49.7 b-f	47.2 f-i
‘Iron White’	2	1	48.6 b-h	46.4 hij
‘Iron White’	2	3	47.0 b-i	47.7 e-i
‘Iron White’	2	5	43.5 g-j	46.1 hij
‘Iron White’	3	1	45.8 c-i	45.1 hij
‘Iron White’	3	3	46.8 b-i	50.5 b-h
‘Iron White’	3	5	50.3 b-e	34.2 k

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

the highest stem fresh weight (142.5) with 1 ppm Tecamin Max application when sprayed two times. In contrast when the number of sprays was one or three highest stem fresh weight was observed with 5 ppm and 1 ppm (121.9 and 130.3, respectively).

Stem dry weight (g)

‘Cheerful White’ produced the highest stem dry weight (11.4) when plants were sprayed once at 1 ppm Isabion. Among cultivars, ‘Iron Rose’, produced the highest stem dry weight (14.6) with 5 ppm Isabion application when sprayed two times. In contrast when

Table 10: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on stem fresh weight of stock cultivars viz. ‘Cheerful White’, ‘Iron Rose’ and ‘Iron White’.

Treatments Cultivars	No. of Sprays	Conc. (ppm)	Stem fresh weight (g)	
			Isabion	Tecamin Max
‘Cheerful White’	1	1	110.4 a-h	83.6 fgh
‘Cheerful White’	1	3	58.8 jk	127.6 a-e
‘Cheerful White’	1	5	56.4 k	77.7 gh
‘Cheerful White’	2	1	67.4 h-k	89.3 e-h
‘Cheerful White’	2	3	77.6 f-k	89.5 e-h
‘Cheerful White’	2	5	86.1 d-k	101.25 d-h
‘Cheerful White’	3	1	85.3 b-k	86.6 fgh
‘Cheerful White’	3	3	75.3 g-k	91.8 d-h
‘Cheerful White’	3	5	84.8 b-k	94.3 c-h
‘Iron Rose’	1	1	109.4 a-i	76.5 gh
‘Iron Rose’	1	3	113.7 a-h	90.6 d-h
‘Iron Rose’	1	5	60.5 ijk	121.9 a-f
‘Iron Rose’	2	1	104.6 a-j	142.5 a
‘Iron Rose’	2	3	107.8 a-h	132.7 abc
‘Iron Rose’	2	5	136.3 a	103.3 c-h
‘Iron Rose’	3	1	132.2 abc	130.3 a-d
‘Iron Rose’	3	3	126.8 a-f	120.3 a-f
‘Iron Rose’	3	5	100.6 a-k	128.4 a-e
‘Iron White’	1	1	132.0 ab	103.9 c-h
‘Iron White’	1	3	122.9 a-g	111.3 c-g
‘Iron White’	1	5	114.9 a-g	97.4 c-h
‘Iron White’	2	1	139.2 a	67.3 h
‘Iron White’	2	3	113.2 a-h	122.9 a-f
‘Iron White’	2	5	79.9 c-k	104.3 c-h
‘Iron White’	3	1	85.7 e-k	93.7 c-h
‘Iron White’	3	3	121.2 a-e	138.0 ab
‘Iron White’	3	5	131.6 a-e	66.6 h

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

the number of sprays was one or three highest stem dry weight was observed with 3 ppm and 1 ppm (11.8 and 13.6, respectively). However, when the number of sprays was one or three highest stem dry weight was recorded with 1 ppm and 5 ppm (13.8 and 13.5, respectively). ‘Cheerful White’ produced the highest stem dry weight (13.3) when plants were sprayed once at 3 ppm Tecamin Max. Among cultivars ‘Iron Rose’, produced the highest stem dry weight (14.3) with 1 ppm Tecamin Max application when plants were sprayed two times. In contrast, when the number of sprays was one or three, the highest stem dry weight

was observed with 5 ppm and 1 ppm (12.5 and 14.2, respectively). For 'Iron white' highest stem dry weight (14.1) was obtained with 3 ppm when sprays were applied three times. (Table 11).

Table 11: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on stem dry weight of stock cultivars viz. 'Cheerful White', 'Iron Rose' and 'Iron White'.

Cultivars	No. of Sprays	Conc. (ppm)	Stem dry weight (g)	
			Isabion	Tecamin Max
'Cheerful White'	1	1	11.54 a-h	8.9 efg
'Cheerful White'	1	3	6.6 jk	13.3 a-d
'Cheerful White'	1	5	6.5 k	8.0 fg
'Cheerful White'	2	1	7.7 h-k	9.5 d-g
'Cheerful White'	2	3	8.8 f-k	9.8 c-g
'Cheerful White'	2	5	9.3 d-k	10.2 b-g
'Cheerful White'	3	1	9.6 b-k	9.0 efg
'Cheerful White'	3	3	8.2 g-k	9.7 c-g
'Cheerful White'	3	5	9.8 b-k	9.7 c-g
'Iron Rose'	1	1	11.1 a-i	8.5 fg
'Iron Rose'	1	3	11.8 a-h	9.3 efg
'Iron Rose'	1	5	6.8 ijk	12.5 a-e
'Iron Rose'	2	1	10.9 a-j	14.3 a
'Iron Rose'	2	3	11.6 a-h	13.9 ab
'Iron Rose'	2	5	14.6 a	11.0 a-g
'Iron Rose'	3	1	13.6 abc	14.3 a
'Iron Rose'	3	3	12.9 a-f	12.8 a-e
'Iron Rose'	3	5	10.5 a-k	13.3 abc
'Iron White'	1	1	13.8 ab	11.0 a-g
'Iron White'	1	3	12.5 a-g	11.7 a-f
'Iron White'	1	5	12.3 a-g	10.2 b-g
'Iron White'	2	1	14.7 a	7.4 g
'Iron White'	2	3	12.0 a-h	12.5 a-e
'Iron White'	2	5	9.5 c-k	10.7 a-g
'Iron White'	3	1	9.1 e-k	9.8 c-g
'Iron White'	3	3	13.4 a-e	14.1 a
'Iron White'	3	5	13.5 a-e	7.6g

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Flower quality (Ranking 1-5)

Flower quality for the stock was dependent on cultivars, while independent of different concentrations and number of sprays, which demonstrated that different concentrations and number of sprays had no influence on flower quality of all tested cultivars. 'Cheerful White' produced very good flower quality

(3.7). Among the number of sprays, plants sprayed three times produced very good flower quality (3.6). Among different concentrations of Isabion, 1 ppm and 3 ppm produced the highest flower quality (3.5). 'Cheerful White' had excellent flower quality (4.5) when plants were sprayed once at 3 ppm Tecamin Max. Moreover, with increasing Tecamin Max concentration and number of sprays, flower quality of 'Cheerful White' also increased (Table 12).

Table 12: Effect of various number of sprays and concentrations of Isabion and Tecamin Max on flower quality (1-5) of stock cultivars viz. 'Cheerful White', 'Iron Rose' and 'Iron White'.

Treatments	Isabion	Tecamin Max
Flower quality (Ranking 1-5)		
Cultivars		
'Cheerful White'	3.7 a ^z	3.9
'Iron Rose'	3.2 b	3.4
'Iron White'	3.5 ab	3.7
Significance	0.02	NS
No. of sprays		
1	3.4	3.5
2	3.4	3.9
3	3.6	3.7
Significance	NS	NS
Conc. (mL L⁻¹)		
1	3.5	3.7
3	3.5	3.9
5	3.4	3.5
Significance	NS	NS

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Vase life (days)

'Cheerful White' produced the longest vase life (9.8) when plants were sprayed once at 1 ppm Isabion. With increasing Isabion concentration and the number of sprays, the vase life of 'Cheerful White' become decreased. Among cultivars, 'Iron Rose', produced the longest vase life (14.5) with 1 ppm Isabion application when sprayed only once. For 'Iron white', the longest vase life (15.3) was obtained with 1 ppm when spray was applied a single time. However, when the number of sprays was two or three longest vase life was recorded with 1 ppm and 5 ppm as (14.1 and 10.5, respectively). 'Cheerful White' produced the longest vase life (11.5) when plants were sprayed two times at 1 ppm Tecamin Max. Moreover, with increasing Tecamin Mix concentration and the number of sprays,

the vase life of 'Cheerful White' also increased. Among cultivars 'Iron Rose', produced the longest vase life (15.6) with 5 ppm Tecamin Max application when sprayed three times. In contrast, when the number of sprays was one or two, the longest vase life was observed with 5 ppm and 1 ppm (6.8 and 11.7, respectively). For 'Iron white' longest vase life (16.4) was obtained with 5 ppm when sprays were applied three times. However, when the number of sprays was one or two, the longest vase life was recorded with 5 ppm and 1 ppm (8.0 and 11.1, respectively). (Table 13).

Table 13: Effect of various concentrations and number of sprays of Isabion and Tecamin Max on vase life of stock cultivars viz. 'Cheerful White', 'Iron Rose' and 'Iron White'.

Treatments	Vase life (days)			
	Cultivars	No. of Sprays	Conc. (ppm)	Isabion
'Cheerful White'	1	1	9.8 efg	7.1 jk
'Cheerful White'	1	3	7.0 hi	7.6 ijk
'Cheerful White'	1	5	7.4 h	7.0 jk
'Cheerful White'	2	1	7.0 hi	11.5 c
'Cheerful White'	2	3	6.7 hi	8.3 ghi
'Cheerful White'	2	5	7.0 hi	9.3 fg
'Cheerful White'	3	1	6.5 hij	10.2 def
'Cheerful White'	3	3	8.1 gih	9.4 efg
'Cheerful White'	3	5	8.3 fgh	10.5 cde
'Iron Rose'	1	1	14.5 ab	5.7 m
'Iron Rose'	1	3	12.8 bcd	5.8 lm
'Iron Rose'	1	5	6.3 hij	6.8 klm
'Iron Rose'	2	1	12.9 bc	11.7 c
'Iron Rose'	2	3	13.8 ab	7.8 ijk
'Iron Rose'	2	5	6.6 hi	8.4 ghi
'Iron Rose'	3	1	5.0 ij	11.3 cd
'Iron Rose'	3	3	7.3 hi	13.9 b
'Iron Rose'	3	5	9.9 efg	15.6 a
'Iron White'	1	1	15.3 a	6.9 jkl
'Iron White'	1	3	12.6 bcd	6.9 j-m
'Iron White'	1	5	10.8 cde	8.0 hij
'Iron White'	2	1	14.1 ab	11.1 cd
'Iron White'	2	3	13.9 ab	9.1 fgh
'Iron White'	2	5	6.6 hi	8.7 ghi
'Iron White'	3	1	4.3 j	11.4 c
'Iron White'	3	3	7.5 h	13.7 b
'Iron White'	3	5	10.5 def	16.4 a

Mean sharing different letters in the column are statistically different at $P \leq 0.05$.

Bio-stimulants become the cause of vegetative growth enhancement by stimulating the activity of carbon metabolism. Recently plant biostimulants have been proven to enhance flowering quantity and quality, plant biomass of flowering plants (EU, 2019). This phenomenon was observed in present results when plants sprayed by Isabion took the least days to produce flowers. Various cultivars, the number of sprays, and concentrations of Tecamin Max show significant interaction and produced early flowers when spray was applied Tecamin Max. This might be due to the stimulation of flowering phyto-hormones. These results are supported by Zeljkovic *et al.* (2010) who described the influence of bio-stimulants and substrate volume on scarlet sage transplants growth and stated that bio-stimulants application improved growth and development of above groundmass, which is important for faster plant adaptation to stress during transplanting.

Bio-stimulants may either directly interact with plant signaling cascades or act through the stimulation of endophytic and non-endophytic bacteria, yeast, and fungi to produce molecules of benefit to the plant. In present outcomes, the highest plant height was produced when Isabion was applied. And highest plant height was produced when sprayed Tecamin Max, as the number of sprays and concentration become increased, plant height decreased. These results are supported by Chen *et al.* (2019) who stated that there is increasing evidence that polyamines, whether applied exogenously or produced endogenously, can positively affect plant growth, productivity, and stress tolerance. Yassen *et al.* (2020) conducted a field experiment and resulted that foliar spray of vermiwash increased all growth parameters and yield in comparison with the application control. In addition, they also stated that verminwash foliar spray could be safely recommended for improving most vegetative growth, yield, and nutrition status of lettuce plants.

Biofertilizers are recommended as an alternative or supplement for mineral nutrients. Active agents in biofertilizers are microorganisms that are involved with their activity in the preparation of herbal assimilative and other biotic substances for plant needs. These results are supported by Tosic *et al.* (2016), who described that the application of this bioproduct affected the earlier formation of the lettuce head and overall higher leaf yield.

Tecamin Max sometimes increases key amino acid stimulation which leads to more growth. So, this chemical showed the highest leaf total chlorophyll contents. However, when the number of sprays was two or three, greater leaf total chlorophyll contents were recorded with 5 ppm and 3 ppm. Maximum leaf chlorophyll contents were recorded in Cheerful White. The results are in line with [Tosic et al. \(2016\)](#), who described that the application of this bioproduct affected the earlier formation of the lettuce head and overall higher leaf yield. Bio-fertilizers are recommended as an alternative or supplement for mineral nutrients. Active agents in biofertilizers are microorganisms that are involved with their activity in the preparation of herbal assimilative and other biotic substances for plant needs.

Results depicted that number of sprays and different concentrations of Isabion had a non-significant effect on the raceme length of different cultivars of stock. And results show significant interaction between cultivars, number of sprays, and concentrations of Tecamin Max for raceme length of the stock. When the number of sprays was three and the concentration of Tecamin Max was maximum, the longest raceme length was produced. These results are contradicted with [Chen et al. \(2019\)](#), who stated that there is increasing evidence that polyamines, whether applied exogenously or produced endogenously, can positively affect plant growth, productivity, and reproductive traits.

The maximum number of florets were recorded in the plants that were sprayed 2 times at 1 ppm Isabion. Results described that number of sprays and concentrations of *Tecamin Max* had significant interaction with cultivars and the maximum number of florets per raceme were recorded when three sprays were applied with a 5 ppm concentration of *Tecamin Max*. These results are in line with the findings of [Harshavardhan et al. \(2016\)](#) reported that bio-stimulants used as supplements improve the quality and yield of flowers.

The results described that the thickest stem diameter was produced when spray was applied two times at a concentration of 3 ppm. These results are also supported by [Yassen et al. \(2020\)](#) who conducted a field experiment and resulted that foliar spray of vermin-wash trended to increase all growth parameters and yield in comparison with the application control. In addition, they also stated that vermin wash foliar

spray could be safely recommended for improving most vegetative growth, yield, and nutrition status of lettuce plants.

The highest floret diameter was obtained in the plants that were treated with a single spray of Isabion at the concentration of 1 ppm. The results described that the thickest floret diameter was produced when spray was applied a single time at a concentration of 3 ppm Tecamin max. Bio-stimulants are involved in enzyme activation which was observed previously in *Vicia faba* ([Abbas, 2013](#)).

Maximum fresh weight was recorded when two sprays were applied at a concentration of 1 ppm Isabion. Results described that the highest stem fresh weight was recorded when the concentration was 1 ppm when sprays were applied two times. The results are in line with the findings of [Paradikovic et al. \(2018\)](#) who stated that various bio-stimulants have beneficial effects on plant growth, development, stress tolerance, crop yield, and quality.

Different cultivars of the same species have different behavior when sprayed with different chemicals. Results describe that cultivar, the number of sprays and concentrations of Tecamin Max had significant interaction, maximum dry weight was produced with two sprays at 1 ppm concentration of Tecamin Max. Results depicted that interaction between cultivars, number of sprays, and concentration is non-significant. This might be due to the fact that bio-stimulants enhance nutrient use efficiency ([Colla et al., 2015](#); [Nardi et al., 2016](#)).

Excellent flower quality was recorded in the plants that were sprayed Isabion. Results depicted that excellent flower quality was recorded in the plants that were sprayed three times at 5 ppm concentrations of Tecamin Max. The results are in line with [Karim et al. \(2017\)](#) who reported that bio-stimulants mostly enhanced seed and transplant vigor, stimulated vegetative growth, improved nutrient acquisition, and increased antioxidative capacity of plant tissues, contributing to higher stress tolerance and improved plant yield and flower quality.

The various sprays and concentrations of Isabion have a significant effect on the vase life of different cultivars of stock. A single spray of Isabion gave maximum vase life of the stock. And the various sprays and con-

centrations of Tecamin Max have a significant effect on the vase life of different cultivars of stock. Maximum vase life was recorded when sprays were applied Tecamin Max. The results are in line with Sankari *et al.* (2015) who reported that foliar application of 0.2% humic acid increased the postharvest quality characters, the longevity of cut spike in tap water, and in 2% sucrose were greatly influenced by the same treatment.

Conclusions and Recommendations

Based on production time, plant height, stem length, stem diameter, leaf area, chlorophyll content, raceme length, number of florets and its diameter, fresh and dry mass of stems, flowering quality, and vase life it was concluded that among three cultivars of stock, 'Cheerful White' proved early cultivar of stock, while 'Iron White' proved late-flowering cultivars when grown in agro-climatic conditions of Faisalabad. On an overall basis, Tecamoin Mix performed better. So, Tecamoin Mix is recommended bio-stimulant for quality production of *Mathiola incana* L. rather than Isabion.

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Novelty Statement

A lot of research is done, however, there is not sufficient study for the quality production of stock. The study would assist in the quality production of stock with the various chemical applied in the best way for its cultivars under consideration.

Author's Contribution

Hafiz Kashif Ali: Conducted the research experiment and collected research data.

Iftikhar Ahmad: Supervised the research experiment.

Mujahid Ali: Guided about layout, statistics, and analysis of data.

Zahoor Hussain: Assisted in the treatment plan.

Muhammad Ather Nadeem: Reviewed the article and assisted in write of the manuscript and reference style.

Malik Abdul Rehman, Barkat Ali, and Muhammad

Iftikhar: Critically reviewed, technically analysed the manuscript. Also helped in reviewing the process.

Conflict of interest

The authors have declared no conflict of interest.

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