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Effect of Minerals (Ca, Fe and Zn) Fortified Humic Acid on Quality Parameters of Mangalore Cucumber (*Cucumis maderaspatensis* L.)

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Abstract

Two field experiments were conducted at College of Agriculture, V. C. Farm Mandya during September (2022) to March (2023) to evaluate the effect of application of Ca, Fe and Zn fortified humic acid on quality parameters such as moisture content, shelf life, TSS, ascorbic acid content, nitrogen and crude protein content of Mangalore cucumber. The experiments were laid out in RCBD design with fifteen treatments replicated thrice. The treatments include absolute control (T_1), Package of Practice (PoP) (T_2), PoP + Humic Acid (HA) foliar spray @ 0.25 per cent (T_3), T_4 to T_7 : PoP + foliar spray of Ca fortified, Fe fortified, Zn fortified and Ca, Fe, Zn (each @ 50 ppm) fortified HA @ 0.25 per cent, respectively, T_8 to T_{11} : foliar spray of Ca, Fe, Zn and Ca, Fe, Zn inorganic salts (each @ 0.5%), respectively and T_{12} to T_{15} : PoP + soil application of Ca fortified, Fe fortified, Zn fortified and Ca, Fe, Zn (each @ 50 ppm) fortified HA @ 5 L ha^{-1}. The pooled analysis results revealed that foliar spray of Ca, Fe and Zn (each @ 50 ppm) fortified humic acid @ 0.25 per cent (T_7) at 30 and 45 DAS recorded higher TSS, ascorbic acid content which was significant only with respect to absolute control. Moisture content and shelf life of Mangalore cucumber fruits did not vary significantly due to different treatments. However numerically higher values of moisture content (93.56%) and shelf life (80.50 days), TSS (4.23 ^{o}brix) and ascorbic acid (24.33 mg $100g^{-1}$) content has been recorded in treatment T_7. Pooled data indicated that significantly higher nitrogen (2.02%) and crude protein content (12.63%) of Mangalore cucumber was recorded with foliar application of Ca, Fe and Zn (each @ 50 ppm) fortified HA @ 0.25 per cent (T_7) at 30 and 45 DAS compared to PoP (1.31% and 8.17%, respectively) and control (0.99% and 6.16%, respectively).

Keywords : Calcium, Iron, Zinc, Fortified humic acid, TSS, Ascorbic acid, Crude protein

Vegetables play a major role in providing the essential vitamins, minerals and plant proteins in human diet. Mangalore cucumber (*Cucumis maderaspatensis* L.) is an important vegetable crop with various nutritional and medicinal properties. It has high water content and low-calorie content. It is rich in essential nutrients, including vitamins and minerals. It contains thiamine, niacin and vitamins A, C, E and K, which contributes to overall health. However, the nutritional quality of the vegetable crop depends on wide range of factors like, soil and soil fertility management, climate, agronomic practices and socio-economic condition of the growers. Among above all, soil and its fertility management play major role. In recent past there is main problem of depletion of soil nutrients due to intensive cultivation, erosion of topsoil, leaching, lack of application of organic matter and excessive use of chemical fertilizers in order to achieve the higher yield. Cultivation of vegetables in these kinds of soil results in poor quality of vegetables.

Humic acid is not only nutrient reservoir and regulator but also it exhibits hormone like activity. It plays a

pivotal role in promoting plant growth, enhances the nutrient absorption and improves the stress tolerance as well as quality of crops (Serenella *et al.,* 2002). Humic acid acts as biostimulant thus enhances the physiological process of crops, thereby increasing the growth, yield and quality of crops (Yildirim, 2007). Similarly, application of humates such as calcium humate, iron humate, zinc humate and potassium humate results in improvement in growth, yield and quality of crops due to increased availability of mineral elements has been reported by Ekinci *et al.* (2014); Gulser *et al*. (2010). In this backdrop, two field experiments entitled 'Effect of minerals (Ca, Fe and Zn) fortified humic acid on quality parameters of Mangalore cucumber (*Cucumis maderaspatensis* L.)' were conducted to study the impact of fortified humic acid.

Material and Methods

Fortification of Humic Acid

Humigrow, a commercially available liquid formulation containing 12 per cent humic acid, has been fortified with calcium, iron and zinc individually and all three in combination. This fortification involves the addition of calculated quantity of calcium nitrate, ferrous sulfate and zinc sulfate to achieve concentrations of 50 parts per million (ppm) for each element.

Field Experiment on Mangalore Cucumber

Two field studies were carried out during 2022 and 2023 *i.e.,* experiment 1 (E_1) from September to December (2022) and experiment 2 (E_2) from December (2022) to March (2023) in 'A' Block at the

Table 1
Initial soil properties of experimental sites

Particulars	Site 1	Site 2	Methods
	Physical properties		
Sand (%)	67.40	69.60	International pipette method
Silt (%)	24.10	21.80	(Piper,1966)
Clay (%)	8.40	8.60	
Textural class	Sandy loam	Sandy loam	
	Chemical properties		
pH (1:2.5)	6.82	7.08	Potentiometric method (Jackson,1973)
EC (1:2.5) (dS m^{-1})	0.17	0.20	Conductometric method (Jackson,1973)
Organic carbon (%)	0.46	0. 47	Wet oxidation method (Walkley and Black,1934)
CEC (cmol (p^+) kg^{-1})	7.82	9.23	Jackson,1973
Available N (kg ha^{-1})	225.34	242.28	Alkaline potassium permanganate method (Subbaiah and Asija,1956)
Available P_2O_5 (kg ha^{-1})	37.71	35.89	Olsen extract (Jackson,1973)
Available K_2O (kg ha^{-1})	204.13	224.87	Flame photometry (Jackson,1973)
Exchangeable Calcium (c mol (p+) kg^{-1})	4.78	5.22	Versanate titration method
Exchangeable Magnesium (c mol (p+) kg^{-1})	2.89	3.21	(Jackson,1973)
Available S (mg kg^{-1})	12.86	14.35	Page *et al.* (1982)
DTPA Fe (mg kg^{-1})	10.12	9.43	
DTPA Zn (mg kg^{-1})	8.10	6.12	Page *et al.* (1982)
DTPA Mn (mg kg^{-1})	0.58	0.41	
DTPA Cu (mg kg^{-1})	0.49	0.38	

College of Agriculture, V.C. Farm (University of Agricultural Sciences, Bangalore), Mandya, Karnataka, India (76°49' 08" E and 12°34' 03" N), which is located in Agro Climatic Zone-6 (Southern Dry Zone of Karnataka) with recommended dose of fertilizer (60-50-80 N-P_2O_5-K_2O kg ha^{-1}) with the recommended spacing of 1.5m×0.7m. The experiments were laid out in RCBD design with fifteen treatments replicated thrice. The initial physical and chemical properties of experimental soil are represented in Table 1.

Treatment Details

The experiment composed of fifteen treatments. The treatment details are : T_1 - Absolute control; T_2 - Package of practice (PoP); T_3 - PoP + unfortified HA foliar spray @ 0.25%; T_4 - PoP + Ca fortified HA foliar spray @ 0.25%; T_5 - PoP + Fe fortified HA foliar spray @ 0.25%; T_6 - PoP + Zn fortified HA foliar spray @ 0.25%; T_7 - PoP + Ca, Fe & Zn fortified HA foliar spray @ 0.25%; T_8 - PoP + Ca foliar spray @0.5 %; T_9 - PoP + Fe foliar spray @ 0.5% ; T_{10} - PoP + Zn foliar spray @ 0.5%; T_{11} - PoP + Ca, Fe & Zn foliar spray each @ 0.5%; T_{12} - PoP + Soil application of Ca fortified HA @ 5 L ha^{-1}; T_{13} - PoP + Soil application of Fe fortified HA @ 5 L ha^{-1}; T_{14} - PoP + Soil application of Zn fortified HA @ 5 L ha^{-1}; T_{15} - PoP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}.

Analytical Methods for Quality Parameters of Fruit

Moisture Content (%)

The moisture content of the fruits was determined by taking known weight of fresh fruit dried in oven at 60°C till constant weight was obtained. The moisture content of fruit was calculated by using following formula.

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight (g) - Dry weight (g)}}{\text{Fresh weight (g)}} \times 100$$

Total Soluble Solids (TSS) of Fruits

Total soluble solids of the fruit was measured with the help of Hand refractometer by putting drop of fruit juice on the prism of Hand refractometer and observed it against the light and the average was worked out as degree brix.

Ascorbic Acid (mg 100 g^{-1}) Content

The ascorbic acid content was estimated titrimetrically using 2, 6 Dichlorophenol indo phenol dye as per modified procedure A.O.A.C., 1960.

Five gram of fresh juice was taken and diluted to a known volume with four per cent oxalic acid. This was filtered through muslin cloth to get a clear juice. 5ml of aliquot was titrated against 2, 6 Dichlorophenol indophenol dye. The result was expressed as mg of ascorbic acid per 100g of fruit juice.

$$\text{Ascorbic acid (mg 100 g}^{-1}\text{)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Volume of filtrate taken} \times \text{Wt. or volume of sample taken.}} \times 100$$

Estimation of Crude Protein

Sample was digested with concentrated sulphuric acid in the presence of catalyst. The digested sample was distilled in the presence of NaOH and the liberated NH_3 was absorbed in boric acid. The content of NH_3 absorbed was determined by titrating against standard acid. Protein per cent was calculated by multiplying the nitrogen content with the factor 6.25.

$$\text{Protein (\%)} = \frac{\text{Titre value x N of Sulphuric acid x 0.014 x 6.25}}{\text{Weight of sample (g)}} \times 100$$

Shelf Life

Five freshly harvested fruits at edible maturity from each treatment were kept at ambient temperature to study the shelf life of fruits.

Results and Discussion

Moisture Content (%)

The pooled data revealed that moisture content did not vary significantly due to different treatments (Table 2). However, highest moisture content of 93.56 per cent was recorded with the PoP treatment and foliar spray of Ca, Fe and Zn fortified HA @ 0.25 per cent (T_7) which was followed by T_6 (93.42%).

Whereas T_2 recorded a value of 90.92 per cent and absolute control (T_1) recorded lowest moisture of 89.93 per cent.

Shelf Life

The pooled data of two experiments (Table 3) indicated that shelf life of Mangalore cucumber fruit did not vary significantly due to treatments. However, the numerically higher shelf life of 80.50 days has been recorded with foliar spray of Ca, Fe and Zn fortified HA @ 0.25 per cent along with PoP (T_7) followed by T_6 (80.50 days), T_4 (78.50 days). Lowest shelf life of 64.50 days was recorded in absolute control (T_1).

TSS (^{o}Brix)

The data pertaining to the effect of fortified humic acid on TSS has been given in the Table 4 and Fig. 1. The data revealed that TSS content of Mangalore cucumber fruit did not vary significantly in both experiments as well as in pooled data compared to package of practice (T_2). However, the numerically higher TSS of 4.23 ^{o}Brix has been noticed in treatment T_7 (PoP + Foliar spray of Ca, Fe and Zn fortified HA @ 0.25%) and treatment T_2 recorded TSS of 4.06 ^{o}Brix. The lower TSS of 3.79 ^{o}Brix has been recorded in control.

Table 2

Effect of Ca, Fe and Zn fortified humic acid on moisture content of Mangalore cucumber

Treatments	Moisture content (%)		
	E_1	E_2	pooled
T_1 - Absolute control	90.03	89.82	89.93
T_2 - Package of practice (POP)	91.03	90.81	90.92
T_3 - POP + unfortified HA foliar spray @ 0.25%	91.31	91.12	91.22
T_4 - POP + Ca fortified HA foliar spray @ 0.25%	93.07	92.87	92.97
T_5 - POP + Fe fortified HA foliar spray @ 0.25%	92.77	92.56	92.67
T_6 - POP + Zn fortified HA foliar spray @ 0.25%	93.52	93.32	93.42
T_7 - POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25%	93.65	93.47	93.56
T_8 - POP + Ca foliar spray @ 0.5%	92.34	92.14	92.24
T_9 - POP + Fe foliar spray @ 0.5%	92.05	91.88	91.97
T_{10} - POP + Zn foliar spray @ 0.5%	92.63	92.43	92.53
T_{11} - POP + Ca, Fe & Zn foliar spray each @ 0.5%	92.76	92.57	92.67
T_{12} - POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	91.63	91.42	91.53
T_{13} - POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	91.31	91.11	91.21
T_{14} - POP + Soil application of Zn fortified HA @5 L ha^{-1}	91.76	91.58	91.67
T_{15} - POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	92.14	91.94	92.04
S.Em±	3.32	3.32	3.32
CD @ 5%	NS	NS	NS

Note : POP (Recommended dose of fertilizer& FYM), HA- Humic acid

TABLE 3

Effect of Ca, Fe and Zn fortified humic acid on shelf life of Mangalore cucumber

Treatments	Shelf life (Days)		
	E_1	E_2	pooled
T_1 - Absolute control	64.00	65.00	64.50
T_2 - Package of practice (POP)	68.00	67.00	67.50
T_3 - POP + unfortified HA foliar spray @ 0.25 %	75.00	74.00	74.50
T_4 - POP + Ca fortified HA foliar spray @ 0.25 %	80.00	81.00	80.50
T_5 - POP + Fe fortified HA foliar spray @ 0.25 %	78.00	79.00	78.50
T_6 - POP + Zn fortified HA foliar spray @ 0.25 %	79.00	78.00	78.50
T_7 - POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	81.00	80.00	80.50
T_8 - POP + Ca foliar spray @ 0.5 %	78.00	79.00	78.50
T_9 - POP + Fe foliar spray @ 0.5 %	77.00	78.00	77.50
T_{10} - POP + Zn foliar spray @ 0.5 %	77.00	76.00	76.50
T_{11} - POP + Ca, Fe & Zn foliar spray each @ 0.5 %	78.00	78.00	78.00
T_{12} - POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	76.00	76.00	76.00
T_{13} - POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	75.00	76.00	75.50
T_{14} - POP+ Soil application of Zn fortified HA @5 L ha^{-1}	75.00	74.00	74.50
T_{15} - POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	76.00	75.00	75.50
S.Em±	2.73	2.73	2.72
CD @ 5%	NS	NS	NS

Note : POP (Recommended dose of fertilizer & FYM), HA - Humic acid

TABLE 4

Effect of Ca, Fe and Zn fortified humic acid on TSS of Mangalore cucumber

Treatments	TSS (°Brix)		
	E_1	E_2	pooled
T_1 - Absolute control	3.80	3.79	3.79
T_2 - Package of practice (POP)	4.07	4.05	4.06
T_3 - POP + unfortified HA foliar spray @ 0.25 %	4.13	4.09	4.09
T_4 - POP + Ca fortified HA foliar spray @ 0.25 %	4.17	4.15	4.16
T_5 - POP + Fe fortified HA foliar spray @ 0.25 %	4.13	4.13	4.13
T_6 - POP + Zn fortified HA foliar spray @ 0.25 %	4.20	4.19	4.19
T_7 - POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	4.23	4.22	4.23
T_8 - POP + Ca foliar spray @ 0.5 %	4.13	4.12	4.13
T_9 - POP + Fe foliar spray @ 0.5 %	4.10	4.09	4.09
T_{10} - POP + Zn foliar spray @ 0.5 %	4.17	4.15	4.16
T_{11} - POP + Ca, Fe & Zn foliar spray each @ 0.5 %	4.20	4.19	4.19

Continued....

TABLE 4 Continued....

Treatments	TSS (°Brix)		
	E_1	E_2	pooled
T_{12} - POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	4.10	4.09	4.09
T_{13} - POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	4.07	4.05	4.06
T_{14} - POP + Soil application of Zn fortified HA @5 L ha^{-1}	4.13	4.12	4.13
T_{15} - POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	4.17	4.15	4.16
S.Em±	0.07	0.07	0.07
CD @ 5%	NS	NS	NS

Note : POP (Recommended dose of fertilizer& FYM), HA- Humic acid

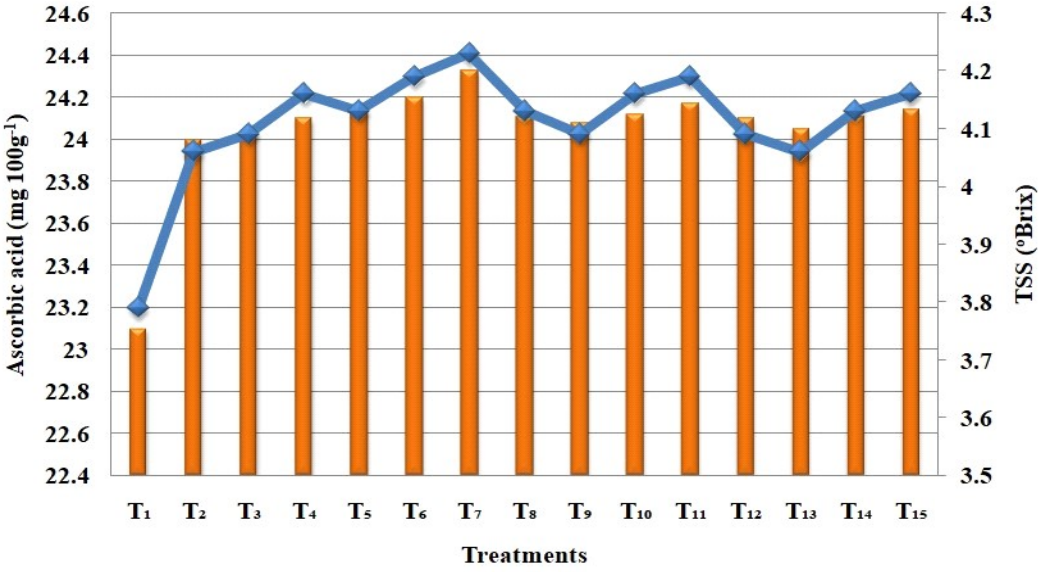

Fig. 1 : TSS and Ascorbic acid content of Mangalore cucumber as influenced by application of Ca. Fe and Zn fortified humic acid

Ascorbic Acid (mg $100g^{-1}$)

As indicated in Table 5 ascorbic acid content did not vary significantly in two experiments as well as in pooled data compared to treatment supplied with package of practice (T_2).

The pooled analysis (Table 5 and Fig. 1) indicated that, higher ascorbic acid content of 24.33 mg $100g^{-1}$ was recorded in T_7 (PoP + foliar spray of Ca, Fe and Zn fortified HA @ 0.25%) which was 1.37 per cent higher than T_2 (PoP) which recorded 24.00 mg $100g^{-1}$ and lowest ascorbic acid content of 23.10 mg $100g^{-1}$ has been recorded in absolute control (T_1).

Moisture content, shelf life, TSS and ascorbic acid content of Mangalore cucumber did not vary significantly due to treatments as these traits are varietal characteristics mainly governed by environmental condition such as temperature and stress. Similar results were reported in cucumber by Umamaheshwarappa and Krishnappa (2004). Abdellatif *et al*. (2017) concluded that HA application had the least impact on vitamin C and total soluble solids (TSS) concentration of tomato fruits as compared to control. The application of humic acid fortified with Ca, Fe and Zn resulted in numerically higher values of quality parameters such as TSS, ascorbic acid content and shelf life. This could be

TABLE 5

Effect of Ca, Fe and Zn fortified humic acid on ascorbic acid content of Mangalore cucumber

Treatments	Ascorbic acid (mg $100g^{-1}$)		
	E_1	E_2	pooled
T_1 - Absolute control	23.13	23.01	23.10
T_2 - Package of practice (POP)	24.03	23.99	24.00
T_3 - POP + unfortified HA foliar spray @ 0.25 %	24.07	24.01	24.04
T_4 - POP + Ca fortified HA foliar spray @ 0.25 %	24.13	24.07	24.10
T_5 - POP + Fe fortified HA foliar spray @ 0.25 %	24.16	24.09	24.13
T_6 - POP + Zn fortified HA foliar spray @ 0.25 %	24.23	24.16	24.20
T_7 - POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	24.36	24.31	24.33
T_8 - POP + Ca foliar spray @ 0.5 %	24.14	24.05	24.11
T_9 - POP + Fe foliar spray @ 0.5 %	24.11	24.05	24.08
T_{10} - POP + Zn foliar spray @ 0.5 %	24.15	24.09	24.12
T_{11} - POP + Ca, Fe & Zn foliar spray each @ 0.5 %	24.20	24.14	24.17
T_{12} - POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	24.13	24.06	24.10
T_{13} - POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	24.08	24.02	24.05
T_{14} - POP + Soil application of Zn fortified HA @5 L ha^{-1}	24.14	24.08	24.11
T_{15} - POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	24.17	24.11	24.14
S.Em±	0.17	0.17	0.17
CD @ 5%	NS	NS	NS

Note : POP (Recommended dose of fertilizer& FYM), HA - Humic acid

attributed to the roles of Ca, Fe and Zn as components of various enzymes, enhancing enzymatic activity and the photosynthesis process. These elements positively influenced fruit quality by regulating enzymes involved in the conversion of carbon compounds to glucose. Additionally, humic acid, acting as a plant growth hormone, stimulated crop growth, improving both vigour and crop quality. Similar findings due to application of HA by Yildirim *et al.,* 2007 in tomato; Halime *et al*. (2011) and Sure *et al*. (2012) in cucumber; Aminifard *et al.* (2012) in hot pepper with application of potassium humate by Rady (2011) in tomato, with application of iron humate and fulvate by AL-Hamadani *et al*. (2013) in cucumber.

Nitrogen Content (%)

The data on nitrogen content of Mangalore cucumber as influenced by application of fortified humic acid are presented in Table 6 and Fig. 2.

The nitrogen content varied significantly due to treatments in both experiments as well as in pooled analysis. Highest nitrogen content (2.02%) has been noticed in the treatment T_7 which received foliar application of Ca, Fe & Zn fortified HA @ 0.25 per cent along with POP which was significant with $T_1, T_2, T_3, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14}$ and T_{15} treatments except T_6 (1.96%), T_4 (1.90%) and T_5(1.85%) treatments. Significantly lower nitrogen content of 0.99 per cent has been noticed in absolute control (T_1).

Nitrogen content of the fruit has been increased significantly due to treatments. This might be due to application of fortified humic acid, which acts as a source of essential nutrients and improvement in root, vine and leaf growth of the plant which in turn resulted in increased absorption and uptake of nitrogen. Application of fortified humic acid enhanced the utilization and accumulation of

TABLE 6

Effect of Ca, Fe and Zn fortified humic acid on nitrogen content of Mangalore cucumber

Treatments	Nitrogen content (%)		
	E_1	E_2	pooled
T_1 - Absolute control	0.99	0.98	0.99
T_2 - Package of practice (POP)	1.31	1.30	1.31
T_3 - POP + unfortified HA foliar spray @ 0.25 %	1.53	1.51	1.52
T_4 - POP + Ca fortified HA foliar spray @ 0.25 %	1.91	1.89	1.90
T_5 - POP + Fe fortified HA foliar spray @ 0.25 %	1.85	1.84	1.85
T_6 - POP + Zn fortified HA foliar spray @ 0.25 %	1.96	1.95	1.96
T_7 - POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	2.03	2.01	2.02
T_8 - POP + Ca foliar spray @ 0.5 %	1.72	1.70	1.71
T_9 - POP + Fe foliar spray @ 0.5 %	1.65	1.64	1.65
T_{10} - POP + Zn foliar spray @ 0.5 %	1.76	1.76	1.76
T_{11} - POP + Ca, Fe & Zn foliar spray each @ 0.5 %	1.84	1.82	1.83
T_{12} - POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	1.57	1.56	1.57
T_{13} - POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	1.52	1.51	1.52
T_{14} - POP + Soil application of Zn fortified HA @5 L ha^{-1}	1.64	1.62	1.63
T_{15} - POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	1.66	1.66	1.66
S.Em±	0.06	0.06	0.06
CD @ 5%	0.17	0.17	0.17

Note : POP (Recommended dose of fertilizer & FYM), HA - Humic acid

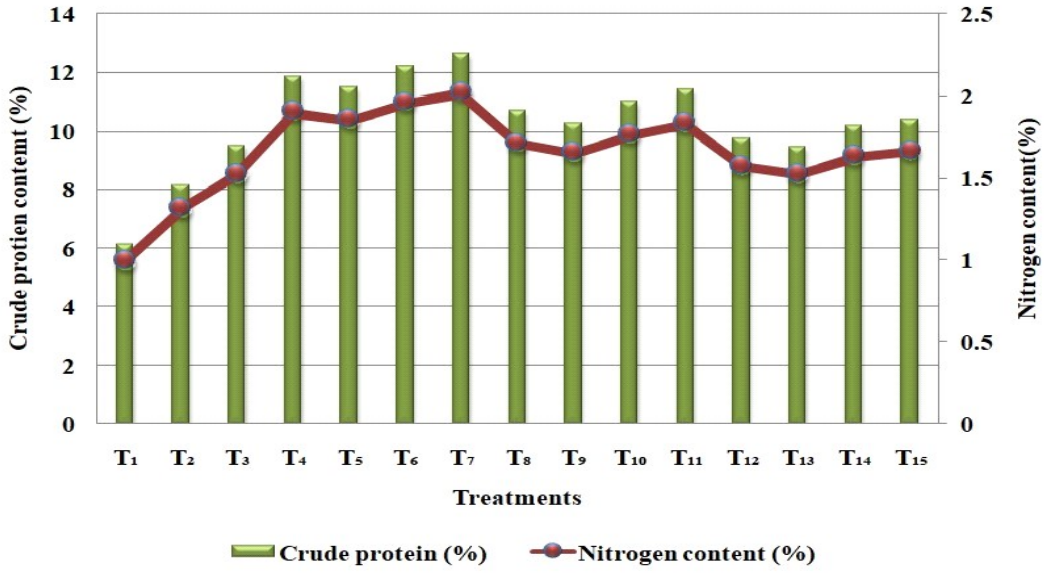

Fig. 2 : Nitrogen and crude protein content of Mangalore cucumber as influenced by application of Ca. Fe and Zn fortified humic acid

nitrogen in the fruits of Mangalore cucumber. This ultimately resulted in increased concentration of nitrogen in fruits of Mangalore cucumber. Similar results due to foliar application of fortified humic acid has been reported by Olfati*et al*. (2009); El-Nemr *et al*. (2012); Shehata *et al*. (2012); Sure *et al*. (2012); Shafeek *et al.* (2016); Abd El-Baky *et al.* (2018); Harshitha & Shyamalamma (2021) and Reddy *et al*. (2022) in cucumber; Avinash (2016) in capsicum; Gayathri & Srinivasamurthy (2015) and Kiran (2020) in maize.

Crude Protein Content (%)

Pooled analysis data (Table 7 and Fig. 2) revealed that crude protein content was significantly influenced by treatments. In both the experiments as well as in pooled analysis foliar application of Ca, Fe and Zn fortified HA @ 0.25 per cent with PoP recorded the higher crude protein content of 12.63 per cent which was on par with T_4 (11.88%),T_5 (11.53%) and T_6 (12.22%) treatments and significant with rest treatments. Treatment T_2 recorded a crude protein content of 8.17 per cent. Absolute control (T_1) recorded lowest crude protein content of 6.16 per cent.

Crude protein content has been significantly increased due to foliar application of fortified humic acid this may be attributed to increased uptake of nutrients due to root proliferation, particularly those (Nitrogen, phosphorus and sulphur) which are crucial for the synthesis of amino acids and proteins. This in turn increases the concentration of protein and amino acids in the fruit similar results were concluded by Hak *et al*. (2012) and Singh and Chandel, 2005.

TABLE 7

Effect of Ca, Fe and Zn fortified humic acid on crude protein content of Mangalore cucumber

Treatments	Crude protein (%)		
	E_1	E_2	pooled
T_1 - Absolute control	6.19	6.13	6.16
T_2 - Package of practice (POP)	8.19	8.15	8.17
T_3 - POP + unfortified HA foliar spray @ 0.25 %	9.56	9.44	9.50
T_4 - POP + Ca fortified HA foliar spray @ 0.25 %	11.94	11.81	11.88
T_5 - POP + Fe fortified HA foliar spray @ 0.25 %	11.56	11.50	11.53
T_6 - POP + Zn fortified HA foliar spray @ 0.25 %	12.25	12.19	12.22
T_7 - POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	12.69	12.56	12.63
T_8 - POP + Ca foliar spray @ 0.5 %	10.75	10.63	10.69
T_9 - POP + Fe foliar spray @ 0.5 %	10.31	10.25	10.28
T_{10} - POP + Zn foliar spray @ 0.5 %	11.00	11.00	11.00
T_{11} - POP + Ca, Fe & Zn foliar spray each @ 0.5 %	11.50	11.38	11.44
T_{12} - POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	9.81	9.75	9.78
T_{13} - POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	9.50	9.44	9.47
T_{14} - POP + Soil application of Zn fortified HA @5 L ha^{-1}	10.25	10.13	10.19
T_{15} - POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	10.38	10.38	10.38
S.Em±	0.38	0.37	0.37
CD @ 5%	1.09	1.08	1.08

Note : POP (Recommended dose of fertilizer & FYM), HA - Humic acid

Minerals fortified humic acid has positive effect on quality of Mangalore cucumber due to beneficial effect of fortified minerals and humic acid on plant growth. Quality parameters such as moisture content, TSS, ascorbic acid and shelf life of Mangalore cucumber didn't vary significantly due to treatments. But numerically higher values of moisture content, TSS, ascorbic acid and shelf life and significantly higher nitrogen and crude protein contents were recorded in the treatment T_7 with foliar application of Ca, Fe and Zn (each @ 50 ppm) fortified HA @ 0.25 per cent at 30 and 45 DAS.

References

A.O.A.C., 1960, Official methods of analysis. 18 Ed. *J. Assoc. off. Agric. Chem.,* Washington.

Abd El-baky, M. M. H., Abd El-rheem, K. M. A., Mona E. El-azab and Kassem, A. S. M., 2018, Response of growth, yield and nutritional status of cucumber plants (*Cucumis sativus* L.) to different foliar application of humic acid and naphthalene acetic acid. *Middle East J. Appl. Sci.,* **8** (2) : 594 - 598.

Abdellatif, Y. M. I., Abdel-ati, Y. Y., Abdel-mageed, T. Y. and Hassan, M. A. M., 2017, Effect of humic acid on growth and productivity of tomato plants under heat stress. *J. Hortic. Res.,* **25** (2) : 59 - 66.

Al-hamadani, F. M., Al-Hadethi, A. A. and Sarheed, B. R., 2013, Effect of some chelated fertilizers sources of iron in the growth and yield of cucumber under protected farming conditions. *Anbar J. Agric. Sci.,* **11** (2) : 181 - 194.

Aminifard, M. H., Aroiee, H., Azizi, M., Nemati, H. and Hawa Jaafar, Z. E., 2012, Effect of humic acid on antioxidant activities and fruit quality of hot Pepper (*Capsicum annuum* L.). *J. Herbs Spices Med. Plants*, **18** : 360 - 369.

Avinash, 2016, Fortification of humic acid with zinc and boron and its effect on soil properties, growth, yield and quality of capsicum. *M.Sc. (Agri.) Thesis*, College of Agriculture, UAS, Bengaluru, Karnataka (India).

Ekinci, M., Esringu, A., Dursun, A., Yildirim, E., Turan, M., Karaman, M. R. and Arjumend, T., 2014, Growth, yield and calcium and boron uptake of tomato (*Lycopersicon esculentum* L.) and cucumber (*Cucumis sativus* L.) as affected by calcium and boron humate application in greenhouse conditions. *Turk J. Agric. For.,* **39** : 613 - 632.

El-nemr, M. A., El-desuki, M., El-bassiony, A. M. and Fawzy, Z. F., 2012, Response of growth and yield of cucumber plants (*Cucumis sativus* L.) to different foliar applications of humic acid and bio-stimulators. *Aust. J. Basic Appl. Sci.,* **6** (3) : 630 - 637.

Gayathri, B. and Srinivasamurthy, C. A., 2015, Effect of different levels and sources of humic acid extracted from organic wastes on soil properties, growth, yield and nutrient uptake by maize. *Mysore J. Agric. Sci.,* **50** (2) : 463 - 468.

Gulser, F., Ferit, S. and Sibel, B., 2010, Effects of calcium nitrate and humic acid on pepper seedling growth under saline condition. *J. Envir. Bio.,* **31** (5) : 873 - 876.

Hak, S. H. G., Ahmed, A. N. and Moustafa, Y. M. M., 2012, Effect of foliar application with two antioxidants and humic acid on growth, yield and yield components of peas. *J. Horti. Sci.,***4** (3) : 318 - 328.

Halime, O. U., Husnu, U. N. L. U., Kakrakurt, Y. and Padem, Y., 2011, Changes in fruit yield and quality in response to foliar and soil humic acid application in cucumber. *Sci. Res. Essays,* **6** (13) : 2800 - 2803.

Harshitha, C. K. and Shyamalamma, S., 2021, Morphological characterization of local cucumber (*Cucumis sativus* L.) genotypes for fruit quality traits. *Mysore J. Agric. Sci.,* **55** (4) : 130 - 141.

Jackson, M. L., 1973, *Soil chemical analysis*, Prentice Hall of India Private Limited, New Delhi.

Kiran, S. K., 2020, Effect of biostimulants on growth, yield, uptake of nutrients and quality of maize and soil, properties in Alfisol. *Ph.D.(Agri.) Thesis*, College of Agriculture, UAS, Bangalore, Karnataka (India).

Olfati, J. A., Peyvast, G. H., Qamgosar, R., Sheikhtaher, Z. and Salimi, M., 2009, Synthetic humic acid increased nutrient uptake in cucumber soilless culture. *In IV International Symposium on Cucurbits*, 871, pp. : 425 - 428.

PAGE, A. L., MILLER, R. H. AND KEENEY, D. R., 1982, Methods of soil analysis. Part 2 - chemical and microbiological properties. 2nd edition. *Agronomy No. 9, Part 2. ASA.*

PIPER, C. S., 1966, *Soil and Plant Analysis,* Inter-science Publishers, Inc., New York, pp. : 368.

RADY, M. M., 2011, Effects on growth, yield and fruit quality in tomato (*Lycopersicon esculentum* Mill.) using a mixture of potassium humate and farmyard manure as an alternative to mineral-N fertiliser. *J. Hortic. Sci. Biotechnol.*, **86** (3) : 249 - 254.

REDDY, M. V., MURTHY, P. V., SRINIVASAPPA, K. N., HANUMANTHARAYA, B. G., MOHAN RAO, A. AND PRASANNA KUMAR, M. K., 2022, Morphological characterization of local cucumber (*Cucumis sativus* L.) genotypes for fruit quality traits. *Mysore J. Agric. Sci.,* **55** (4) : 130 - 141.

SERENELLA, N., PIZZEGHELLOA, A., MUSCOLOB, N. AND VIANELLO, A., 2002, Physiological effects of humic substances on higher plants. *Soil Biol. Biochem.,* **34** : 1527 - 1536.

SHAFEEK, M. R., HELMY, Y. I. AND NADIA, M. O., 2016, Effect of spraying or ground drench from humic acid on growth, total output and fruits nutritional values of cucumber (*Cucumis sativus* L.) grown under plastic house conditions. *Int. J. Pharmtech. Res.,* **9** (12) : 52 - 57.

SHEHATA, S. A., YASSER, M. A., YOUSSEF, T. E. AND MAHMOUD, A. A., 2012, Influence of some organic and in organic fertilizers on vegetative growth, yield and yield components of cucumber plants. *Research J. agric. biol. Sci.*, **8** : 108 - 114.

SINGH, P. K. AND CHANDEL, A. S., 2005, Effect of biozyme on yield and quality of wheat (*Triticum aestivum*). *Indian J. Agron.,* **50** : 58 - 60.

SUBBIAH, B.V. AND ASIJA, G. L., 1956, A rapid procedure for determination of available nitrogen in soils. *Curr. Sci.,* **25** : 259 - 260.

SURE, S., AROOIE, H., SHARIFZADE, K. AND DALIRIMOGHADAM, R., 2012, Responses of productivity and quality of cucumber to application of the two biofertilizers (humic acid and nitroxin) in fall planting. *Agril. J.,* **7** (6) : 401 - 404.

UMAMAHESWARAPPA, P. AND KRISHNAPPA, K. S., 2004, Effect of nitrogen, phosphorus and potassium on cucumber cv. Poinsette grown in dry region of Southern India. *J. Trop. Sci.,* **44** : 174 - 176.

WALKLEY, A. J. AND BLACK, I. A., 1934, An examination of the degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Sci.,* **37** : 29 - 38.

YILDIRIM, E., 2007, Foliar and soil fertilization of humic acid affect productivity and quality of tomato Acta Agriculturae Scandinavica. *Soil Pl. Sci.,* **57** : 182 - 186.