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Effect of Fortified Humic Acid on Total Uptake of Primary Nutrients (NPK) by Mangalore Cucumber and NPK Status in Postharvest Soil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field experiment was conducted from December (2022) to March (2023) at College of Agriculture, V. C. Farm. Mandya to study the effect of minerals (Ca, Fe and Zn) fortified humic acid on totalmajor nutrient (N P K) uptake by Mangalore cucumber and NPK status of soil after harvest of Mangalore cucumber. The experiment was laid out in Randomized Complete Block Design (RCBD)

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with fifteen treatments, which involves foliar spray of humic acid (T_3), fortified humic acid (T_4 to T_7) and inorganic salts (T_8 to T_{11}) at 30 and 45 DAS and soil application of fortified humic acid (T_8 to T_{11}) at the time of sowing. The data unveiled that foliar application of Ca, Fe and Zn (each @ 50 ppm) fortified humic acid @ 0.25 % (T_7) at 30 and 45 DAS recorded significantly higher total uptake of nitrogen (53.89 kg ha^{-1}), phosphorus (17.59 kg ha^{-1}) and potassium (58.40 kg ha^{-1}).Lowest available N, P_2O_5 and K_2O status in soil after harvest of Mangalore cucumber has been noticed in absolute control 204.42 kg ha^{-1}), 27.27 kg ha^{-1} and 204.65 kg ha^{-1}, respectively and it was followed by treatment T_7 which recorded available N, P_2O_5 and K_2O status of 207.48, 49.87 and231.17 kg ha^{-1}, respectively. The results suggested that two foliar spray of Ca + Fe + Zn fortified HA at 30 and 45 DAS along with PoP resulted in higher NPK uptake by Mangalore cucumber.

Keywords: Fortified humic acid; nutrient uptake; soil nutrient status; foliar spray; inorganic salts.

1. INTRODUCTION

Humic substances (HS) are remains of decomposed plant and animal materials such as lignin, tannins, cellulose and cutins. Humic substances are classified as humic acids (HA), fulvic acids (FA) and humins based on their solubility in water, acid or alkali. The humic acids are those components of humic substances which are soluble in strong bases but insoluble in strong acids. Humic acid (black gold of agriculture) are complex, brown to black in colour, polymeric organic acids which have more phenolic and carboxylic functional groups. The humic substances are known to play direct and indirect role to improve plant growth and soil properties [1]. Humic acid act as biostimulant [2] and help in improving the vital physiological processes of the crop such as photosynthesis [3] and it also increases the root growth and cell permeability [4] there by increasing the nutrient uptake results in higher yields and quality [5].

Mangalore cucumber (*Cucumis maderaspatensis* L.) is indeed an important vegetable crop with several nutritional and medicinal properties. Mangalore cucumber is known for its high water content and low calorie count [6]. However growth and development, consequently the nutrient uptake by the cropis influenced by various factors, including soil and its fertility management, climate, agronomic practices and socio-economic conditions. Each of these factors can impact the nutrient content and overall health of the crops. Among these factors, soil and soil fertility management are highly crucial. Because nutrient-rich soil provides essential elements like nitrogen, phosphorus, potassium, calcium, iron, zinc to plants. These elements are then absorbed by the vegetables and contribute to higher uptake and quality of the crop. In the recent past, there has been decline in soil fertility due to intensive cultivation, erosion of top soil, leaching of nutrients and lack of organic matter application. As a result, there will be decrease in concentration of vital elements in plants and its economic part, rendering them less nutritious. The decline in soil fertility can have severe implications on human nutrition. Nutrient deficiencies in the soil can result in inadequate levels of essential minerals such as potassium, calcium, iron, zinc in the crops.In this backdrop the study was conducted to the know the effect of fortified humic acid on primary nutrients (N P K) uptake by Mangalore cucumber and N P K status in postharvest soil.

2. MATERIALS AND METHODS

Field study was carried out at the College of Agriculture, V. C. Farm, Mandya, Karnataka, India, from December (2022) to March (2023) with Mangalore cucumber as test crop, Urea (46% N), DAP (46% P_2O_5 18% N) and MOP (60% K_2O) fertilizers are used as a source of N, P and K during the experiment. The soils of the experimental sites had Sandy loam texture with a pH of 7.

The fifteen treatments were replicated three times in randomized block designThe treatments consists of T_1 - Absolute control (without recommended dose of FYM and chemical fertilizer); T_2 - Package of practice (PoP) (recommended dose of FYM and chemical fertilizer *i.e.,* 25 t ha^{-1} + 60- 50- 80 N-P_2O_5-K_2O kg ha^{-1}); 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}.Commercially available liquid formulationcontaining 12% humic acid, has been fortified with calcium, iron, and zinc individually and all three in combination at 50 ppm by the use of sources such as calcium nitrate, ferrous sulfate and zinc sulfate. Foliar spray of fortified and unfortified humic acid (T_3 to T_7) and inorganic salts (T_8 to T_{11}) was done at 30 and 45 DAS. Soil application was done at the time of sowing. The available N, P_2O_5 and K_2O content of post harvest soil samples were analyzed by standard method.

2.1 Nutrient Uptake by Crop

Nutrient content in fruit, vine and leaf was determined by following standard analytical methods and expressed in percentage. Nutrient uptake (kg ha^{-1}) by Mangalore cucumber was calculated for each treatment using the following formula.

$$\text{Nutrient uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient concentration (\%) x biomass yield (kg ha}^{-1}\text{)}}{100}$$

3. RESULTS AND DISCUSSION

3.1 Total Primary nutrient uptake (kg ha^{-1}) by Mangalore cucumber

3.1.1 Nitrogen uptake

The perusal of the data revealed that significant variation in total nitrogen uptake by Mangalore cucumber (Table 2 and Fig. 1).

Foliar application of Ca, Fe and Zn fortified HA @ 0.25 % along with PoP (T_7) recorded significantly higher total nitrogen uptake of 53.89 kg ha^{-1}and it was superior overT_1, T_2, T_3, T_8, T_9, T_{10}, T_{11}, T_{12}, T_{13}, T_{14} and T_{15}but statistically on par with T_4 (48.59 kg ha^{-1}), T_5 (47.20 kg ha^{-1}) and T_6 (50.28 kg ha^{-1}) treatments and lower total nitrogen uptake of 9.75 kg ha^{-1} has been noticed in absolute control (T_1).

Table 1. Physico-chemical properties of experimental soil

Particulars	values	Methods
	Physical properties	
Sand (%)	69.60	International pipettemethod (Piper,1966)[7]
Silt (%)	21.80	
Clay (%)	8.60	
Textural class	Sandy loam	
	Chemical properties	
pH (1:2.5)	7.08	Potentiometric method (Jackson,1973) [8]
EC (1:2.5) (dS m^{-1})	0.20	Conductometric method (Jackson,1973) [8]
Organic carbon (%)	0. 47	Wet oxidation method (WalkleyandBlack,1934)[9]
CEC (cmol (p$^+$) kg^{-1})	9.23	Jackson,1973 [8]
Available N (kg ha^{-1})	242.28	Alkaline potassium permanganate method(SubbaiahandAsija,1956) [10]
Available P_2O_5 (kg ha^{-1})	35.89	Olsen extract (Jackson,1973)[8]
Available K_2O (kg ha^{-1})	224.87	Flame photometry (Jackson,1973)[8]
Exchangeable Calcium (c mol (p+) kg^{-1})	5.22	Versanate titration method (Jackson, 1973)[8]
Exchangeable Magnesium (c mol (p+) kg^{-1})	3.21	
Available S (mg kg^{-1})	14.35	Page et al. (1982)[18]
DTPA Fe (mg kg^{-1})	9.43	Page et al. (1982)[18]
DTPA Zn (mg kg^{-1})	6.12	
DTPA Mn (mg kg^{-1})	0.41	
DTPA Cu (mg kg^{-1})	0.38	

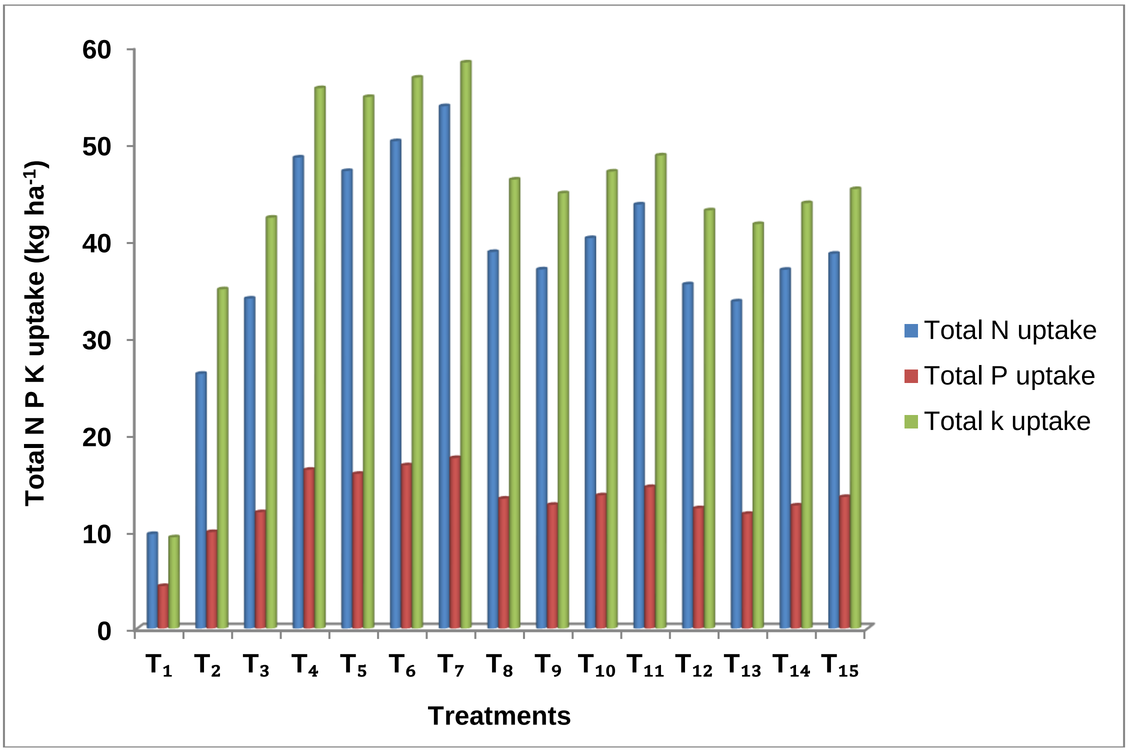

Fig. 1. Total uptake of primary nutrients by Mangalore cucumber as influenced by the application of Ca, Fe and Zn fortified humic acid

Table 2. Effect of Ca, Fe and Zn fortified humic acid on total uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) by Mangalore cucumber

	Treatments	Total N uptake	Total P uptake	Total K uptake
T_1	Absolute control	9.75	4.38	9.41
T_2	Package of practice (POP)	26.28	9.95	35.00
T_3	POP + unfortified HA foliar spray @ 0.25 %	34.04	12.00	42.39
T_4	POP + Ca fortified HA foliar spray @ 0.25 %	48.59	16.38	55.75
T_5	POP + Fe fortified HA foliar spray @ 0.25 %	47.20	15.96	54.84
T_6	POP + Zn fortified HA foliar spray @ 0.25 %	50.28	16.84	56.84
T_7	POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	53.89	17.59	58.40
T_8	POP + Ca foliar spray @ 0.5 %	38.85	13.40	46.32
T_9	POP + Ca foliar spray @ 0.5 %	37.05	12.76	44.91
T_{10}	POP + Zn foliar spray @ 1.0 %	40.28	13.74	47.15
T_{11}	POP + Ca, Fe & Zn foliar spray each @ 0.5 %	43.75	14.60	48.81
T_{12}	POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	35.51	12.41	43.14
T_{13}	POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	33.75	11.83	41.73
T_{14}	POP +Soil application of Zn fortified HA @5 L ha^{-1}	37.01	12.69	43.89
T_{15}	POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	38.67	13.57	45.34
S.Em±		0.06	2.28	0.60
CD @ 5%		0.17	6.61	1.75

3.1.2 Phosphorus uptake

The data indicated that (Table 2 and Fig. 1) higher total phosphorus uptake of 17.59kg ha^{-1} by Mangalore cucumber has been noticed in the treatment T_7 (foliar application of Ca, Fe and Zn fortified HA @ 0.25 % along with PoP), And it was significant with rest of the treatments except T_4 (16.38kg ha^{-1}),T_5 (15.96kg ha^{-1}) and T_6 (16.84kg ha^{-1}) treatments. Control (T_1) recorded significantly lower phosphorus uptake of 4.38 kg ha^{-1}.

3.1.3 Potassium uptake

The potassium uptake by Mangalore showed significant variation due to treatments, as presented in Table 2 and Fig. 1.

The pooled analysis dataindicated that significantly higher potassium uptake of 58.40kg ha^{-1} was recorded in the treatment T_7 with foliar application of Ca, Fe and Zn fortified HA @ 0.25 % with PoP and it was on par with T_4 (55.75 kg ha^{-1}),T_5 (54.84 kg ha^{-1}) and T_6 (56.84 kg ha^{-1}) treatments and significant with rest of the treatments. Significantly lower potassium uptake of 9.41 kg $ha^{-1}$was recorded in absolute control (T_1).

Fortification of essential minerals elements (Ca, Fe and Zn) with HA due to its established role as organic chelator results in increased availability ofCa, Fe and Znelements to plants besides role of HA as biostimulant increased growth and vigour of plants*i.e.,* proliferation of root as well as shoot growth which increased the concentration of primary nutrient content in leaf, vine and fruit of Mangalore cucumber as well as uptake of these essential nutrients. Similar increase in the biomass yield and nutrient content consequently total uptake of nutrients by crops with the application of Zn fortified HA has been reported by Avinash [11] in capsicum, with combined application HA enriched with micro nutrients by Dhanasekaran and Bhuvaneswari [12] and Kazemi [13] in tomato, Ameta et al. [14] in cucumber, with Fe humate by Sharma et al. [15] in soybean, lettuce and chilli, with Zn humate by Manas et al. [16] in pepper, with K- humate in tomato by Rady [17].

3.2 NPK Status of Post Harvest Soil

3.2.1 Available nitrogen

The data (Table 3 and Fig. 2) on soil available N status after harvest indicated that the higher soil nitrogen was recorded in treatment T_2(258.12 kg ha^{-1}) which was significantly higher than T_1 (204.42 kg ha^{-1}),T_4 (212.57 kg ha^{-1}), T_5 (214.02 kg ha^{-1}),T_6 (210.89 kg ha^{-1})andT_7 (207.48 kg ha^{-1}) and it was on par with rest of the treatments.

3.2.2 Available phosphorus

The data revealed that soil phosphorus in the postharvest soil ranged from 27.27 to 64.57 kg ha^{-1}. Significantly higher phosphorus content of 64.57 kg ha^{-1} has been recorded in treatment which is supplied with PoP (T_2) which is significantly higher than T_1 (27.27 kg ha^{-1}),T_4 (50.91 kg ha^{-1}), T_5 (53.45 kg ha^{-1}),T_6 (50.24 kg ha^{-1}), T_7(49.87 kg ha^{-1})and it was on par with all the other treatments (Table 3 and Fig. 2).

Table 3. Effect of Ca, Fe and Zn fortified humic acid on available nitrogen, phosphorus and potassium status(kg ha^{-1}) of soil after harvest of Mangalore cucumber

	Treatments	Avail. N	Avail. P_2O_5	Avail. K_2O
T_1	Absolute control	204.42	27.27	204.65
T_2	Package of practice (POP)	258.12	64.57	284.06
T_3	POP + unfortified HA foliar spray @ 0.25 %	250.43	61.73	274.47
T_4	POP + Ca fortified HA foliar spray @ 0.25 %	212.57	50.91	236.74
T_5	POP + Fe fortified HA foliar spray @ 0.25 %	214.02	53.45	238.85
T_6	POP + Zn fortified HA foliar spray @ 0.25 %	210.89	50.24	233.26
T_7	POP + Ca, Fe & Zn fortified HA foliar spray @ 0.25 %	207.48	49.87	231.17
T_8	POP + Ca foliar spray @ 0.5 %	242.80	58.69	268.47
T_9	POP + Ca foliar spray @ 0.5 %	238.36	59.36	270.12
T_{10}	POP + Zn foliar spray @ 1.0 %	235.89	57.38	265.41
T_{11}	POP + Ca, Fe & Zn foliar spray each @ 0.5 %	230.31	56.96	260.12
T_{12}	POP + Soil application of Ca fortified HA @ 5 L ha^{-1}	245.55	61.12	272.46
T_{13}	POP + Soil application of Fe fortified HA @ 5 L ha^{-1}	251.28	62.97	275.46
T_{14}	POP +Soil application of Zn fortified HA @5 L ha^{-1}	242.14	60.74	271.85
T_{15}	POP + Soil application of Ca, Fe & Zn fortified HA @ 5 L ha^{-1}	237.06	59.09	269.24
S.Em±		0.06	9.47	2.25
CD @ 5%		0.17	27.42	6.53

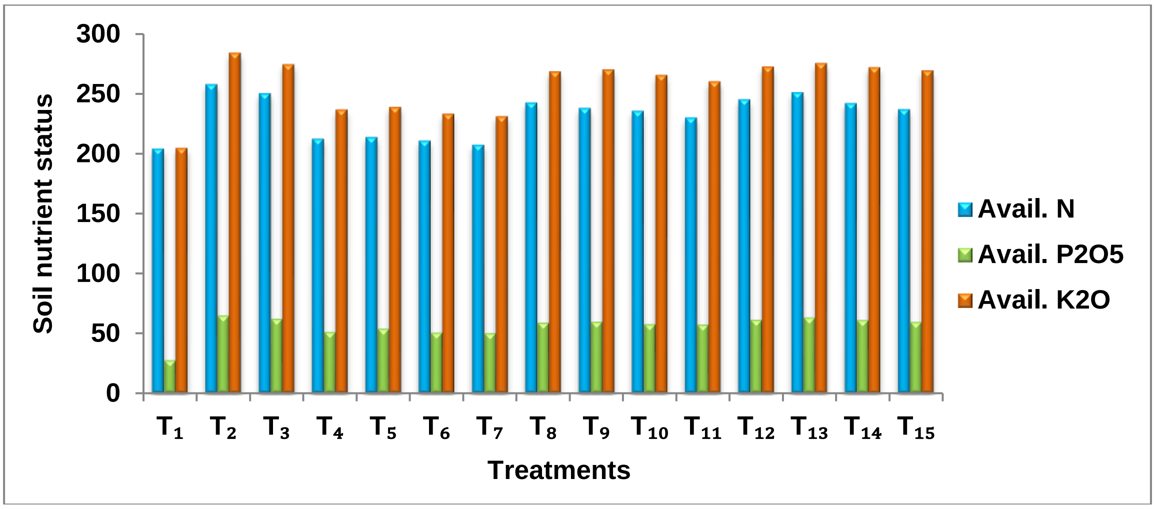

Fig. 2. Available N, P_2O_5 and K_2O status of post harvest soil of Mangalore cucumber as influenced by the application of Ca, Fe and Zn fortified humic acid

3.2.3 Available potassium

The data of soil available potassium (Table 3 and Fig. 2) revealed that significantly higher potassium content in soil was recorded in T_2 treatment (284.06 kg ha^{-1}) which was significantly higher compared to control (T_1) (204.65 kg ha^{-1}),T_4 (236.74 kg ha^{-1}), T_5 (238.85 kg ha^{-1}), T_6 (233.26 kg ha^{-1}), T_7 (231.17 kg ha^{-1})and on par with remaining treatments.

The available nutrient status (NPK) after the harvest of Mangalore cucumber varied significantly, the higher available N P K status was noticed in the treatment (T_2) which received RDF + FYM (25 t ha^{-1}) than all biofortication treatments due to lesser uptake of essential nutrients due to lesser yield and the lower nutrient status was recorded in the treatment T_7 (foliar application of Ca, Fe and Zn (each @ 50 ppm) fortified HA @ 0.25 % + PoP) due higher uptake of essential nutrients due to higher yield.

4. CONCLUSION

Fortification of essential minerals elements with HA results in increased availability of Ca, Fe and Zn for plants besides the role of HA as biostimulsant which increased growth and vigour of plants which increased the concentration of primary nutrient content in leaf, vine and fruit of Mangalore cucumber as well uptake of these essential nutrients. Among different biofortified treatments foliar application of Ca, Fe and Zn fortified HA @ 0.25% (T_7) resulted in significantly higher N P K content and uptake by Mangalore cucumber compared to PoP and absolute control due to which lower available N, P_2O_5 and K_2O status in post harvest soil was noticed in the same treatment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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