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Quality of tomato under greenhouse condition as influenced by the application of urea modified hydroxyapatite Nano fertilizer

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Abstract
A greenhouse experiment was conducted at College of Agriculture V.C. Farm, Mandya using CRD design with ten treatments and three replications with an objective to study the "Effect of urea modified hydroxyapatite nano fertilizer (UHA) on quality of tomato under greenhouse condition". Whereas, highest TSS content (5.80 ^{0} Brix) was recorded in the treatment T_9 which received 100% Nitrogen-Urea + 1.00% UHA spray and significantly highest lycopene content was recorded in treatment T_9 (16.85 mg $100g^{-1}$). Highest ascorbic acid content of tomato plant was observed in the treatment T_8 (68.04 mg $100g^{-1}$) with the application of 100% Nitrogen-Urea + 0.50 per cent UHA spray, which showed significant difference with all the treatments. Increased quality parameters in tomato was attributed to increased growth and yield parameters which is due to slow and sustained release of nitrogen, phosphorus and calcium from urea modified hydroxyapatite nano fertilizer.

Keywords: UHA, urea modified hydroxyapatite Nano fertilizer, tomato, vitamin c, lycopene and total soluble sugar

Introduction

Mineral fertilizers played a pivotal role in the past and continue to play the same role at present so also in the near future in the global food and nutritional security. The scientists as well as planners and policy makers and farmers all of them have recognised and understood the importance of mineral fertilizers in enhancing the crop productivity. The extent of world food production depends on fertilizer use invariably increase in future due to increase in population, without fertilizers the world would produce only about half as much staple food and forest lands would have to be put into production (Roberts, 2009) [24]. Mineral fertilizers are the main source of nutrients applied to soils to overcome the deficiency in native nutrient supply. On the other hand the mineral fertilizer use has created some environmental hazards. It has been documented by several researchers that nitrate loss from the soil have toxicological implications for animals and humans (Oves *et al.*, 2013) [19] and the loss of N in the form NO_x may increase global warming potential (Park *et al.*, 2012) [21]. Nitrate along with P also have detrimental impact on the environment leading to the eutrophication of freshwater (Mishra *et al.*, 2014) [17] and marine ecosystems. In this context manage fertilizers and soils in sustainable way so that, not only food demands are met, but soil remains healthy to meet food and nutritional security of future generation with minimum environmental impact. Chemical fertilizers all that applied is not used by the crops, rather most part of these fertilizers are lost through leaching, run-off, volatilization or erosion. It is estimated that about 40–70 per cent of nitrogen, 80–90 per cent of phosphorus, and 50–70 per cent of potassium of the applied fertilizers is lost to the environment and can't be absorbed by plant, causing exchequer loss to the nation and environmental pollution as well (Trenkel, 1997 and Ombodi *et al.*, 2000) [29, 18]. Therefore, there is a clear possibility of optimizing the nutrient use efficiency or partial factor productivity of nutrients. With increase in N use efficiency, the N usage can be reduced by 30 to 60 per cent without a yield loss in rice, wheat and maize in intensive production systems (Prakash *et al.*, 2013; Mishra *et al.*, 2014) [22, 17].

Scientists have come out with number of technologies to enhance nutrient use efficiency in general and N use efficiency in particular.

These technologies include use of coated urea, prilled urea, nitrification inihibitors, PSB, VAM *etc*. In recent years nano technology added another option to enhance the nutrient use efficiency and reduced loss of nutrients to the environment. Thus slow nutrient releasing fertilizers a viable alternative and could be implemented with nanotechnology. Therefore, synthesis of nano fertilizers is gaining momentum. Employing nanotechnology in synthesis and formulations of nano fertilizers and their subsequent use is regarded as a breakthrough in achieving higher nutrient use efficiency with minimum environmental risk. Nanotechnology refers to controlling, building and restructuring materials and devices on scale of atoms and molecules (1-100 nm). The development of nanotechnology in conjunction with biotechnology has significantly expanded the application domain of nanomaterials in various fields including agriculture (Khot *et al.* 2012) [15].

Nanotechnology has the potential to revolutionize the agriculture and food industry thus making a tremendous impact on agricultural and environmental challenges, such as sustainable use of resources and run-off and accumulation of pesticides as well as fertilizers (Chen and Yada, 2011; Ditta, 2016 and Parisi *et al.*, 2015) [2, 5, 20]. Nanotechnology, plays a pivotal role in sustainable agriculture and precision farming development which ultimately aims to maximize agriculture output (yield), while minimizing input (fertilizers, pesticides and herbicides) and reducing environmental risk due to targeted action of nano materials (Liu and Lal, 2015; Servin *et al.*, 2015 and Fraceto *et al.*, 2016) [16, 26, 8]. Nano fertilizer materials are those which contain conventional fertilizers encapsulated by nano materials, coated with a thin protective nano scale polymeric film, or delivered as nanoemulsions or nano particles (NPs) (De Rosa *et al.*, 2010) [3]. These can supply one or more nutrients to the plants and enhance their growth or can improve the performance of conventional fertilizers (Liu and Lal, 2015) [16]. For instance, nano coatings on fertilizer particles can hold the material more strongly on the plant due to the higher surface tension (Ghormade *et al.*, 2011; Yang *et al.*, 2012) [9, 31]. Nanomaterial may increase plant-uptake efficiency of nutrients and/or reduce the adverse impacts of conventional fertilizer application (Liu and Lal, 2015) [16]. Element essential for plants in the form of NF allows better dissolution and faster absorption and assimilation by the plant compared to traditional fertilizers. This has been demonstrated for N, P, K, Ca, Mg, Fe, Mn, Zn, Cu and Mo by Ditta and Arshad (2016) [5].

Tomato **(***Lycopersicon esculentum* L) is the world's largest vegetable crop after potato and tops the list of canned vegetables. The acid sweet taste and unique flavour accounts for its popularity and diverse usage. Tomatoes are nutritionally valuable for their vitamin C content. However, incidences of pests and diseases, moisture stress, improper rates of fertilizer application and too high and/or too low temperatures are the significant constraints for the production and productivity of this important vegetable crop. Various reports such as Edossa *et al.* (2013) [7] indicated that tomato is grown during cool-dry, hot-dry and rainy seasons, indicating the crop is being grown throughout the year to ensure continuous supply in the country. Whatever may be the season in which tomato is grown, nutrient management plays a crucial role in production, productivity and quality. It is well documented that application of N promotes vegetative growth and fruit yield of tomato and later application in the growing stages favours fruit development and yield thus nitrogen has dramatic effect on tomato growth and development in soils with limited N supplies such as sandy soils (Hokam *et al.*, 2011) [14]. Similarly, the supply of P is very important for root and fruit development. However, the growers are using very high doses of NPK fertilizers while growing hybrids with an intension of rich harvesting. When such high conventional N and P dose when crop demand is low may be subjected to leaching loss of applied nutrients, especially N. High N loss and low nitrogen use efficiency (NUE), caused by high N fertilizer inputs and inappropriate fertilization patterns have become important issues contributing for low yields and environmental risk. Therefore there is a need to use fertilizers especially the N fertilizers with controlled release pattern. With controlled release of applied N fertilizers enhances the N use efficiency besides reduces the environmental risks. So, use of urea modified hydroxyapatite nano fertilizers in place of conventional urea nitrogen fertilizers lessen the nitrogen losses to environment as it releases nitrogen slowly thus coinciding with plant uptake as a result the quantity of fertilizers application can be reduced and reduces the environmental risk associated with conventional N fertilizers. Thus realizing the importance of nano fertilizers in crop nutrition, an experiment was conducted with an objective to study the effect of urea modified hydroxyapatite nano fertilizer on quality of tomato.

Material and methods

Greenhouse experiment

Greenhouse experiment to study the effect of UHA (Urea modified hydroxyapatite nano fertilizer) on quality of tomato crop was conducted in greenhouse facility of Department of Horticulture, CoA, V. C. Farm, Mandya. Details of the experiment are presented in Table 2. Surface soil sample was collected from College of Agriculture Farm was used to fill the pots. Large lumps were crushed and roots and undecomposed litter was removed and used for filling the pots. Before filling the pots with imposition of treatments one composite sample was drawn by randomly taking subsample in different direction of soil heap. The collected sample was analysed for physical and chemical properties by following standard protocol as explained under section 3.6, the properties of the soil used for greenhouse experiment are given in Table 1.

Details of greenhouse experiment

The details of the pot culture study are presented in the Table 2. Eight kilogram of soil used to fill the pots (thirty pots = ten treatments with three replication). Fertlizers were applied as per the treatments details. Tomato seeds were sown in each pot separately. Growth observations *viz,* plant height, number of branches, number of leaves per plant and yield observations such as number of fruits per plant, fruit weight, fruit volume and fruit diameter were recorded in a single plant. The experiment was conducted up to 116 days.

Filling up of pots, FYM and fertilizer application and sowing

Eight kilogram of soil sample was taken on a clean plastic sheet to which calculated quantity of FYM was added and mixed well with the soil. Soil mixed with FYM was filled to each pot and kept the pots for a week. After a week the soil was spread on plastic paper and calculated quantity of basal fertilizer was applied (50% recommended N and 100% of recommended P_2O_5 and K_2O). Phosphorus and potash were supplied through conventional SSP and MOP, respectively. Whereas, the N was supplied through urea (U-N) and urea modified hydroxylapatite Nano material (N-UHA) as per the treatment details given below. After fertilizers addition pots were refilled.

Table 1: Initial properties of the soil used for laboratory incubation and greenhouse experiment

Parameters		Content
Physical properties		
Particle size distribution	Sand (%)	73.26
	Silt (%)	07.84
	Clay (%)	18.90
	Textural class	Sandy loam
Maximum water holding capacity (%)		55.36
Field capacity (%)		27.68
Chemical properties		
pH (1:2.5)		8.10
EC (dS m^{-1})		0.22
OC (g kg^{-1})		5.16
Available Nitrogen (mg kg^{-1})		138
Available Phosphorus (mg kg^{-1})		9.46
Available Potassium (mg kg^{-1})		139
Exchangeable Calcium (C mol (p^+) kg^{-1})		8.33
Exchangeable Magnesium (C mol (p^+) kg^{-1})		4.53
Available Sulphur (mg kg^{-1})		12.40
DTPA-Iron (mg kg^{-1})		2.76
DTPA-Copper (mg kg^{-1})		1.12
DTPA-Manganese (mg kg^{-1})		2.69
DTPA-Zinc (mg kg^{-1})		1.45

Table 2: Details of the greenhouse experiment

Location	CoA, V. C. Farm, Mandya.
Crop	Tomato
Hybrid	Arka Samrat (F_1)
Duration	115-120 days
Design	Completely Randomised Design
Replications	Three
Treatments	Ten
Season	*Kharif* 2018
RDF	250:250:250 (N, P_2O_5, K_2O kg ha^{-1}) and FYM (39.75 t ha^{-1})

Table 3: Treatment details

T_1	RDF (NPK)+ FYM
T_2	RD (PK) + 75% N-U + 25%N-UHA + FYM
T_3	RD (PK) + 50% N-U + 50% N-UHA + FYM
T_4	RD (PK) + 25% N-U + 75% N-UHA + FYM
T_5	RD (PK) + 50% N- UHA + FYM
T_6	RD (PK) + 75% N- UHA +FYM
T_7	RD (PK) + 100% N- UHA +FYM
T_8	T_1+ 0.50 per cent UHA spray
T_9	T_1+ 1.00 per cent UHA spray
T_{10}	Absolute control

Note

- RDF: Recommended dose of conventional fertilizers.
- Recommended fertilizer (250:250:250 NPK kg ha^{-1}) and FYM (39.75 t ha^{-1}) dose for tomato crop was used
- Hundred per cent of N was supplied through urea (N-U) and urea modified hydroxylapatite Nano fertilizer (N-UHA) or in combination of both as per the treatment details. However, the recommended P and K which were common to all the treatments were supplied through SSP and MOP, respectively.

Three hybrid tomato seeds were sown per pot. Two seedlings were removed from each pot after 15 days. The remaining 50 per cent of nitrogen was applied after dissolving the required quantity of urea or UHA or both in water and it was uniformly applied to each pots after 4^{th} and 8^{th} weeks after sowing in equal proportion. The spray solution of UHA (0.5 & 1%) was prepared by dissolving UHA in distilled water and spraying was done using hand sprayer at flowering stage as per the treatment details.

After care

Care was taken to remove the weeds in the pots. One spraying was done using Lamda cyhalothrin 5 EC to control sucking pests and water was added once in two days based on weight loss to bring the moisture to field capacity.

Fruit quality parameters analysis

Total soluble solids content (^{0}Brix)

A drop of randomly selected (treatment wise) tomato fruit juice was used to determine the total soluble solids with the help of hand refractometer and the value was recorded as ^{0}Brix at room temperature (Savitha *et al.*, 2015) [25].

Ascorbic acid content (mg per 100 g)

The ascorbic acid content was estimated titrimetrically using 2, 6 Dichlorophenol indo phenol dye as per modified procedure of Srivastava and Singh (1993) [28].

Five gram of fresh fruit 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. Five ml of aliquot was titrated against 2, 6- Dichlorophenol indo phenol dye. The ascorbic acid content was expressed as mg of ascorbic acid per 100 g of fruit juice.

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

Lycopene content (mg per 100 g)

The lycopene content of tomato fruit was analyzed by using the procedure outlined by Ranganna (1977) [23].

One gram of fruit sample was taken in to a mortar and pulp was extracted repeatedly with acetone until the residue turned colourless. The acetone extract was transferred to a separating funnel containing 10 to 15 ml of petroleum ether and mixed gently. Carotenoid pigments in the acetone extract were taken in to petroleum ether layer by diluting the acetone with water. Petroleum ether containing pigment was transferred to 25 ml volumetric flask and diluted up to mark with petroleum ether. Then one ml of aliquot was further diluted to 10 ml with petroleum ether and absorbance or OD was read in a spectrophotometer at 530 nm. Lycopene content (mg 100^{-1} g) in fruit was calculated by using the formula:

$$\text{Lycopene} = \frac{\text{3.1206 X OD of sample X Volume made up X Dilution X 100}}{\text{Weight of sample X 1000}}$$

Statistical analysis

The data collected from the greenhouse experiment were analysed statistically following the procedure as described by Gomez and Gomez (1984) [10]. The level of significance used in 'F' test was P=0.01. The critical differences were calculated wherever 'F' test was significant.

Results and Discussion

Effect of urea modified hydroxyapatite Nano particles on quality of tomato are presented in Table 4.

There was a significant difference in total soluble solid (^{0}Brix) content due to imposition of treatments. TSS content varied from 4.90 ^{0} Brix in treatment T_1 (RDF (NPK) + FYM) and T_3 (RD (PK) + 50% N-U + 50% N-UHA + FYM) to 5.80 ^{0} Brix in treatment T_9 which received RDF (NPK) + FYM + 1.00 per cent UHA spray. Whereas, TSS content of T_7 (5.57 ^{0}Brix) and T_8 (5.53 ^{0}Brix) are on par with T_9.

Table 4: Effect of application of N through urea and UHA on quality parameters of tomato

Treatments	TSS (^{0} Brix)	Lycopene (mg $100g^{-1}$)	Ascorbic acid (mg $100g^{-1}$)
T_1: RDF (NPK)+ FYM	4.90	14.73	46.52
T_2: RD (PK) + 75% N-U + 25%N-UHA + FYM	5.13	14.79	47.21
T3: RD (PK) + 50% N-U + 50% N-UHA + FYM	4.90	15.58	46.52
T_4: RD (PK) + 25% N-U + 75% N-UHA + FYM	5.00	15.82	47.21
T_5: RD (PK) + 50% N- UHA + FYM	5.07	16.51	57.23
T_6: RD (PK) + 75% N- UHA +FYM	5.13	14.76	55.25
T_7: RD (PK) + 100% N- UHA+FYM	5.57	15.54	59.67
T_8: T_1+ 0.50 per cent UHA spray	5.53	16.11	68.04
T_9: T_1+ 1.00 per cent UHA spray	5.80	16.85	47.91
T_{10}: Absolute control	5.20	15.23	46.52
S.Em ±	0.11	0.16	0.93
CD (P= 0.01)	0.46	0.66	3.75

Significantly highest lycopene content was recorded in treatment T_9 (16.85 mg $100g^{-1}$) which received RDF (NPK)+ FYM + 1.00 per cent UHA spray, which is on par with the treatment T_5 (16.51 mg $100g^{-1}$) which received RD (PK) + (50% N- UHA) + FYM, compared to control (T_1: RDF (NPK)+ FYM) with a lycopene 14.73 mg $100g^{-1}$.

Highest ascorbic acid content of tomato plant was observed in the treatment T_8 (68.04 mg $100g^{-1}$) with the application of RDF (NPK) + FYM + 0.50 per cent UHA spray, which showed significant difference with all the treatments, which was followed by T_7 (59.67 mg $100g^{-1}$) with the application of RD (PK) + (100% N- UHA)+FYM.

Lycopene is carotenoid with 11 conjugated double bonds which is responsible for redness in tomato fruits. Highest TSS and lycopene content in tomato plant was noticed with 1.0 per cent foliar application of UHA and highest ascorbic acid content was recorded with 0.50 per cent foliar spray. There are many reports indicating positive response on metabolic reaction, synthesis of antioxidants and quality of the produce with the application of NPs and NMs to crop plants (Ditta and Arshad, 2016 [4]). These findings are in line with those reported by Chaurasia *et al.* (2005) [1], who have reported that application of 5 foliar sprays of water soluble fertilizers increased growth, yield and quality of tomato. Similarly, Guvenc *et al.* (1995) [11] recorded an improvement in vit c and titrable acidity parameters with foliar application of urea to tomato crop. Further, Heeb *et al.* (2005) [13] stated that the form of nitrogen applied influence the yield, quality and taste of tomatoes. Similar results were recorded by Vafa *et al.* (2015) [30] in savory; Soliman *et al.* (2016) [27] in baobab; Harish and Gowda (2017) [12] in groundnut.

Conclusion

Nanomaterial may increase plant-uptake efficiency of nutrients and/or reduce the adverse impacts of conventional fertilizer application (Liu and Lal, 2015). Element essential for plants in the form of NF allows better dissolution and faster absorption and assimilation by the plant compared to traditional fertilizers and thus enhances quality paramters of tomato, whereas the highest TSS and lycopene content (5.80 ^{0} Brix and 16.85 mg $100g^{-1}$) was recorded in the treatment T_9 and highest ascorbic acid content (68.04 mg $100g^{-1}$) was observed with the application of RDF (NPK) + FYM + 0.50 per cent UHA spray.

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