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STUDIES ON NANOPARTICLE INDUCED NUTRIENT USE EFICIENCY OF FERTILIZER AND CROP PRODUCTIVITY

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Abstract

A field experiment was conducted at M/s.Rashtriya Chemicals and Fertilizers, Ltd., Mumbai, India, (RCF) experimental farm to evaluate the effect of ZnO Nanoparticles (ZnO NP) in combination with N: P: K (15: 15:15) complex fertilizer "Suphala" of RCF Ltd. on growth attributes of brinjal (Solanum melongena L) as well as nutrient use efficiency. The experiment was carried out in randomised block design with three replications. The first treatment (T-1), comprised of recommended dose of fertilizer (RDF), N: P: K (50:50:50), applied at the time of transplantation. The second treatment (T-2) was conducted with RDF in combination @ 2kg ZnSO4 (bulk)/ha. The third treatment (T-3) was added, N: P: K (12.5; 12.5; 12.5) in combination to ZnO NP @ 4500mg/ha. The forth treatment (T-C) was without any fertilizer. All treatments were given appropriate quantity of nitrogen per hectare as urea at the 30th day of transplantation.

The combination N: P: K (12.5; 12.5; 12.5) and ZnO NP @ 4500mg/ha yielded 91% and 45.3% higher brinjal yield and biomass respectively than the treatment with only RDF. It was also observed that 38% and 21% higher yield and biomass respectively were recorded in the treatment where combination of RDF with ZnSO4 (bulk) over RDF was used alone.

The results of field trials reveal that, there was synergistic effect of ZnO NP @ 4500mg per hectare with N: P: K complex fertilizer on growth attributes of brinjal as well as nutrient use efficiency.

Key words - Nanoparticles, synergistic effect, growth attributes, Nutrient use efficiency, recommended dose of fertilizer, Biomass, Suphala.

INTRODUCTION

Recent studies suggests that the world will need to produce 60 to 100% more food when the global population will reach 9 billion by 2050 (Dijkand Meijerink, 2014)[1]. This requires a radically changing the way food is produced, stored, distributed and accessed (Godfray et. al 2010)[2].

Intensive farming often leads to a vicious cycle of exhaustion of soil fertility and decline of agricultural yields (policy.org, 2011)3. Because of such activities approximately 40% of the world's agricultural land is seriously degraded (The Guardian, 2011).[4]

Nanotechnology is a science, which deals at the nanoscale. A particle with higher surface area has a greater number of reaction sites than a particle with low surface area thus, results in enhanced chemical reactivity. Nanotechnology use in nanoscale fertilizer particles has offered new techniques in improving existing crop management (Ghafari and Razmjoo, 2013).[5]

Nano-carbon is a new material with special physico-chemical property which stimulates crop growth, improves soil environment and promotes crop growth metabolism (Lu et al., 2002).[6] Reynolds (2002)[7] revealed that micronutrients in the form of NP's can be used in crop production to increase the yield. It was also reported that the use of nano scale zinc oxide particles increased the stem, root growth and pod yield of peanut as compared to ZnSO4 application (Prasad et al., 2012).[8] Laware and Raskar, (2014)[9] have demonstrated that onion crop treated with ZnO-NP at the concentration of 20 and 30µgm/ml showed better growth and flowered 12-14 days earlier than the control.

Zinc is an essential micronutrient element for plant and animals and plays an important role in plant metabolic systems (Broadly et.al. 2007).[10] It is required for the activity of more than 300 enzymes, covering all six classes of enzymes (Keith et al. 2000).[11]

Majority of the Indian soils are deficient in Zinc. It is now considered that Zinc becomes fourth most important yield-limiting nutrient after nitrogen, phosphorus and potassium in India. It is also observed that 48.5% of the soils and 44% of the plant samples were potentially zinc-deficient and this was the most common micronutrient problem affecting crop yields (Singh, 2006).[12] Such deficiency symptoms differ among plant species but can be corrected by Zn fertilization (McKenzie, 2001).[13]

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Suphala (15: 15:15) complex fertilizer is a brand of RCF and well accepted by Indian farmers at large. The cost of the product is continuously increasing because of increase in cost of raw material and utilities. Moreover after the abolishment of the subsidy by Government of India, the cost may increase further. Hence the cost effectiveness for the farmer will be questionable.

If the efficiency of the product is increased considerably, it will be possible to farmers to use the product profitably. It is also needed to be considered that the use of voluminous fertilizer with less efficiency may lead to environment problems (Naderi and Abedi, 2012) [14]such as eutrophication, soil degradation and high energy consumption along with logistics which also requires fossil fuel. In addition to that the natural resources such as Rock, Potassium chloride, Sulphur, Associated gases etc. are also diminishing. To overcome these problems, it is imperative to increase the nutrient use efficiency of all the agricultural inputs.

Brinjal is one of the most common tropical vegetables grown in India. It is a versatile crop adapted to different agro-climatic conditions and can be grown throughout the year. It is a perennial but grown commercially as an annual crop. Brinjal is also valued for its medicinal properties and has got decholestrolizing property primarily due to presence of poly-unsaturated fatty acids (linoleic and lenolenic) present in flesh and seeds of fruit in higher amount (65.1%). Brinjal is originated in Indo- Burma region. The crop is distributed in south and south East Asia, southern Europe, China and Japan. Brinjal plant from Solanaceae group of vegetables (tomato, chilli and brinjal) is a worldwide important long duration fruit vegetable crop with high yield and removes high amount of nutrients from the soil for its growth. India is the second largest producer of brinjal in the world next to China (TNAU, 2011).[15]

In view of this an attempt was made to study the synergistic effect of ZnO NP's and N: P: K-15:15:15 on increase in the nutrient use efficiency and on growth attributes of brinjal crop.

EXPERIMENTAL

The zinc oxide nanoparticles (ZnO NP) used in the experiments, were procured from Central Institute for Research on cotton technology (CIRCOT), Matunga, Mumbai along with the detailed analysis report. These particles were blended with NPK "Suphala" brand complex fertilizer of RCF for formulation and further used for field trials.

The recommended dose of fertilizer for brinjal crop is 100:50:50, (Kanawade, *et.al.* 1996).[16] The saplings of brinjal, one and half month old were selected and used for the experimentation.

Four treatments with three replications were carried out for the experiment. The treatment one i.e. T-1 comprised of recommended dose of fertilizer (RDF), N: P: K (50:50:50) was applied at the time of transplantation and appropriate quantity of N as urea was given at the 30th day of transplantation. Second treatment, T- 2 was conducted with RDF in combination @ 2kg $ZnSO_4$ (bulk) /ha. In the third treatment i.e. T - 3, N: P: K (12.5; 12.5; 12.5) in combination to ZnO NP @ 4500mg/ha was applied. The fourth treatment T-C was without any fertilizer. Proper irrigation and pest control was done time to time. The fruits were plucked on same day from all the treatments at each harvest. Entire harvesting was done on 125th day. The results were tabulated and presented as in the Table.

RESULTS

After the harvesting of the crop the measurement of growth parameters viz. total weight of fruits harvested from each treatment are noted as an yield and the weight of the complete plant after harvest was noted as Biomass.

Table 1: Yield of brinjal (in gm)

Sr. No.	Treatment No.	Treatment Details	Average Yield in gm	Biomass in gm
1	T - 1	RDF (100:50:50)	1823	4570
2	T - 2	RDF(100:50:50) + $ZnSO_4$ (Bulk)	2248	5530
3	T - 3	1/4th RDF (25:12.5:12.5) + ZnO (NP)	3106	6660
4	T - C	No fertilizer	1335	4025

The yield and biomass of the treatment (T - 3) where 1/4th dose of Suphala i.e. 25:12.5:12.5 along with 4500mg of ZnO (NP)/ha used is 91% and 45.73% respectively, higher than the yield and biomass obtained from the treatment T - 1 where only RDF is used. The yield and biomass in the treatment T - 2 where the RDF along with ZnO (Bulk) @2kg/ha used is 31% and 21% respectively, higher

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than the treatment T - 1 where RDF is applied alone. It also to be noted that the yield and biomass in the treatment T - 3, where ZnO Np used is 38.16% and 20.43% higher than yield and biomass respectively, in the treatment T - 2 where $ZnSO_4$ is used. The treatment T - C, where no fertilizer is used, both the yield and biomass were minimum.

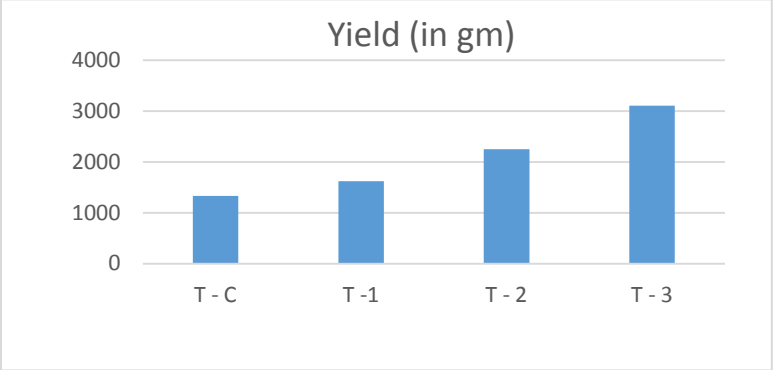

Figure 1: Yield performance against the treatments

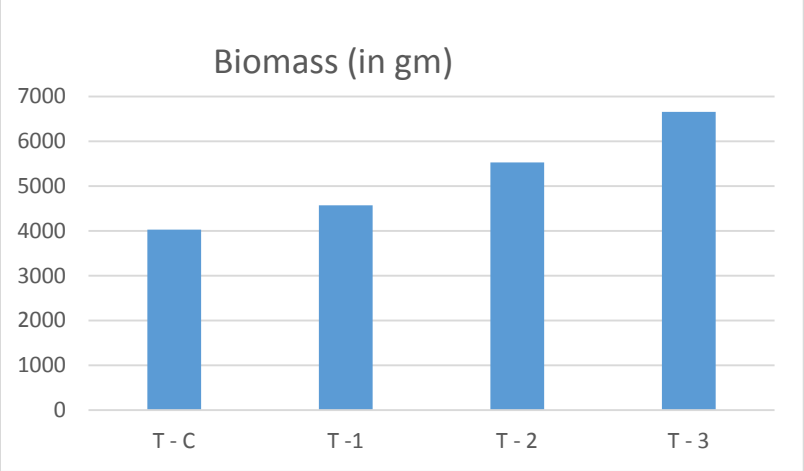

Figure 2: Total biomass against the treatments

DISCUSSION

There was an increase in the growth attributes Viz. yield and biomass of brinjal by 91% and 45.73% respectively in the treatment where1/4th RDF along with ZnO NP @ 4500mg/ha was used. This increase in the yield and biomass with reduction in dose of fertilizer must be due to presence of ZnO Np. Researchers have shown that use of nano particles has enhancement in growth and yield parameters of different crops in agriculture. Roughage Shekhbaglou, *et.al*. (2010) [17] showed that Nano iron oxide effect on leaf plus dry pod weight was significant. Liu.*et.al* (2005)[18] also showed that nano iron oxide compared to other treatment such as organic material and iron citrate facilitates the photosynthate and iron transferring to leaves of peanuts. Use of nano calcium carbonate compared to humic acid and organic fertilizer caused more tillering in peanuts and low concentration of nano calcium carbonate caused increasing the number of leaf and leaf area, dry weight, soluble sugar and peanut protein.

It is also observed from the results that, the quantity of fertilizer reduced to 25% in the treatment T - 3, where ZnO NP along with 1/4th complex fertilizer dose used. This implies that the nutrient use efficiency of the complex fertilizer has increased four times. Similar observations were recorded by Liu, J., *et.al*, (2008) [19] where they demonstrated that the combined application of N and nano-carbon can increase the yield, quality of crop and save fertilizer and labour.

Jinghua (2004)[20] proved that the application of nano – composite consist of N,P,K, Micronutrient, manures and amino acids enhance the uptake and use of nutrients by grain crops. Studies have also shown that the fertilizer incorporation in to co chelate nano tubes (rolled up – lipid bilayer sheets) had improved crop yield (De Rosa *et.al.* 2010).[21] Lili Fan *et.al.* (2012) [22] showed that the increase in

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yield of rice crop with combined application of 70% conventional fertilizer and nano carbon (N150.5 KG /HM ^{2} and nano carbon (0.836 kg/ HM ^{2}). This fact indicates that the combined application of nano - carbon which can save N- fertilizer in production practice. They have also shown that the combined application of nano carbon and conventional N fertilizer encourages plant to absorb and utilize nitrogen. Xiao, Q. *et. al.* (2008),[23] showed that nano carbon (NC) is a material with special physico-chemical properties which stimulates crop growth, improve soil environment and promote crop growth metabolism.

The increase in the yield and biomass in the treatment where ZnO NP was used is 38.16% and 20.43% higher than the yield and biomass respectively in the treatment T - 2 where $ZnSO_4$ bulk is used. This results are in the line with the results obtained by Prasad, *et.al* (2012).[8]

CONCLUSION

The growth attributes of brinjal viz. yield and biomass have shown increase of 91% and 45.73% respectively in the treatment where 1/4th RDF along with ZnO NP is used over the treatment with RDF alone. This indicates that the recommended dose of fertilizer can be reduced by the use of ZnO NP, in combination with complex fertilizer. It also implies that the nutrient use efficiency of complex fertilizer can be increased by ZnO NP. The results have also confirmed that ZnO NP are having more impact on the growth attributes of brinjal crop than the $ZnSO_4$ bulk.

Further efforts for reduction in dose of ZnO NP: complex fertilizer and sustainability studies need to be carried out.

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