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Review Article

NANO FERTILIZERS IS A NEW WAY TO INCREASE NUTRIENTS USE EFFICIENCY IN CROP PRODUCTION

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Abstract- Nano fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters with increase nutrient use efficiency, reduce wastage of fertilizers and cost of cultivation. Nano-fertilizers are very effective for precise nutrient management in precision agriculture with matching the crop growth stage for nutrient and may provide nutrient throughout the crop growth period. Nano-fertilizers increase crop growth up to optimum concentrations further increase in concentration may inhibit the crop growth due to the toxicity of nutrient. Nano-fertilizers provide more surface area for different metabolic reactions in the plant which increase rate of photosynthesis and produce more dry matter and yield of the crop. It is also prevent plant from different biotic and abiotic stress.

Keywords- Nano ZnO, Nano hydroxyl apatite, Nano iron, crop plants.

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Introduction

World agricultural cropping systems intensively using large amount of fertilizers, pesticides, herbicides to achieve more production per unit area but using more doses than optimum of these chemicals and fertilizers leads to several problems like environment pollution (soil, water, air pollution), low input use efficiency, decrease quality of food material, develop resistance in different weeds, diseases, insects, less income from the production, soil degradation, deficiency of micro nutrient in soil, toxicity to different beneficial living organism present above and below the soil surface etc. Despite these problems there is also challenge to feed the growing population of the world [1, 2]. Therefore in the future, there is need to produce nutritive agricultural produce rich in protein and other essential nutrient required to the human and animal consumption that is why emphasis should be laid on production of high quality food with the required level of nutrients and proteins [1, 3]. For solving these problems in crop production nano-fertilizers, pesticides and herbicides may effective tools in agriculture for better pest and nutrient management because these nano-materials having more penetration capacity, surface area and use efficiency which avoid residues in environment. Size below 100 nm nano-particles can use as fertilizer for efficient nutrient management which are more ecofriendly and reduce environment pollution. Hence, these agricultural useable nano-particle develop with the help of nanotechnology can be exploited in the value chain of entire agriculture production system [4].

Challenges & Solutions of present agricultural practices

Present agriculture is generally chemically intensive where using more doses of chemicals for insect, disease, weeds and nutrient management to get maximum production per unit area without caring about natural resources and ecosystems. In present agriculture fertilizer contributes to the tune of 50% of the agricultural production but increasing use higher doses of fertilizers does not guarantee to improved crop yield but it leads several problems like degradation of soil and pollution of surface and underground water resources. Solution: Increase the fertilizer nutrient use efficiency and reduce doses. According to [5], reported that fertilizer alone contributed 50% in crop production. High transportation cost of fertilizers due to require in large quantity. Solution: Decrease the application rate of fertilizers. More wastes of fertilizers material by using over doses in crop production. Solution: Value-addition to traditional fertilizers and reduce doses per unit area. Multi nutrient deficiency in the soils. Solution: combine application of macro and micronutrient sources.

Nanotechnology applications in agriculture

Now a days nanotechnology providing different nano devices and nano material which having a unique role in agriculture such as nano biosensors to detect moisture content and nutrient status in the soil and also applicable for site specific water and nutrient management, Nano-fertilizers for efficient nutrient management, Nano-herbicides for selective weed control in crop field, Nano-nutrient particles to increase seed vigor, Nano-pesticides for efficient pest management. alginate/ chitosan nano-particles can be use as herbicide carrier material specially for herbicide such as paraquat [6]. Nano herbicides are effective in weed management [7]. Hence, nanotechnology have greater role in crop production with environmental safety, ecological sustainability and economic stability. The nano-particles produced with the help of nanotechnology can be exploited in the value chain of entire agriculture production system [8].

What is nano fertilizer?

Nano-fertilizers "Nano fertilizers are synthesized or modified form of traditional fertilizers, fertilizers bulk materials or extracted from different vegetative or reproductive parts of the plant by different chemical, physical, mechanical or biological methods with the help of nanotechnology used to improve soil fertility, productivity and quality of agricultural produces. Nanoparticles can made from fully bulk materials [9].

At nano scale physical and chemical properties are differ than bulk material. Similarly reported [10]. Rock phosphate if use as nano form it may increase availability of phosphorus to the plant because direct application of rock phosphate nano particles on the crop may prevent fixation in the soil similarly there is no silicic acid, iron and calcium for fixation of the phosphorus hence it increase phosphorus availability to the crop plants[11].

Important properties of nano fertilizers which facilitate higher nutrient use efficiency

The nano-fertilizers have higher surface area it is mainly due to very less size of particles which provide more site to facilitate different metabolic process in the plant system result production of more photosynthets. Due to higher surface area and very less size they have high reactivity with other compound. They have high solubility in different solvent such as water. Particles size of nano-fertilizers is less than 100 nm which facilitates more penetration of nano particles in to the plant from applied surface such as soil or leaves.

Nano fertilizer have large surface area and particle size less than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve uptake and nutrient use efficiency of the nano-fertilizer. Reduction of particle size results in increased specific surface area and number of particles per unit area of a fertilizer that provide more opportunity to contact of nano-fertilizers which leads to more penetration and uptake of the nutrient [12].

Fertilizers encapsulated in nano-particles will increase availability and uptake of nutrient to the crop plants[13]. Zeolite based nano-fertilizers are capable to release nutrient slowly to the crop plant which increase availability of nutrient to the crop though out the growth period which prevent loss of nutrient from denitrification, volatilization, leaching and fixation in the soil especially NO_3-N and NH_4-N. Particle size below 100 nm nano-particles can use as fertilizer for efficient nutrient management which are more eco-friendly and reduce environment pollution [4].Main reason for high interest in fertilizers is mainly their penetration capacity, size and very higher surface area which is usually differ from the same material found in bulk form. This is partially due to the fact that nano particles show a very high surface: volume ratio. Thus, the reactive surface area is proportionally over-represented in nano particles compared to larger particles. Particle surface area increases with decreasing particle size and the surface free energy of the particle is a function of its size. Similar result obtained[12].

Achievements of nano-fertilizers

Nano fertilizers providing greater role in crop production and several research study revealed that nano fertilizers enhanced growth, yield and quality parameters of the crop which result better yield and quality food product for human and animal consumption. This translates into an improvement to three major areas of production.

Yields: Several research studies revealed that application of nano-fertilizers significantly increase crop yield over control or without application of nano-fertilzer it is mainly because of increasing growth of plant parts and metabolic process such as photosynthesis leads to higher photosynthets accumulation and translocation to the economic parts of the plant. Foliar application of nano particles as fertilizer significantly increase in yield of the crop[14]. Nutritional Value: Nano fertilizers provide more surface area and more availability of nutrient to the crop plant which help to increase these quality parameters of the plant (such as protein, oil content, sugar content) by enhancing the rate of reaction or synthesis process in the plant system. Application of zinc and iron on the plant increase total carbohydrate, starch, IAA, chlorophyll and protein content in the grain [15]. Nano-Fe_2O_3 increase photosynthesis and growth of the peanut plant [16].

Health: Some nutrient also responsible disease resistance to the plant and due to the more availability of nano nutrient to the plant it prevent from disease, nutrient deficiency and other biotic and abiotic stress which indicate that nano fertilizers enhance overall health of the plant. ZnO nano-particles also helpful to plant under stress conditions [17]. Aqueous solutions of Ag+ and Au+ drastically reduced the body weight of *P. ricini* larvae [18].

Advantages of nano fertilizers over traditional fertilizers

Nano fertilizers are advantageous over conventional fertilizers as they increase soil fertility yield and quality parameters of the crop, they are nontoxic and less harmful to environment and humans, they minimize cost and maximize profit. Nano particles increase nutrients use efficiency and minimizing the costs of environment protection [19]. Improvement in the nutritional content of crops and the quality of the taste. Optimum use of iron and increase protein content in the grain of the wheat [20]. Enhance plants growth by resisting diseases and improving stability of the plants by anti-bending and deeper rooting of crops.[8] also suggested that balanced fertilization to the crop plant may be achieved through nanotechnology.

Effects of nano-fertilizers on seeds germination & growth parameters of the plant.

Several researches reported that nano fertilizers significantly influenced the seed germination and seedling growth which revealed the effect of nano fertilizers on seed and seed vigor. Nano fertilizers can easily penetrate into the seed and increase availability of nutrient to the growing seedling which result healthy and more shoot length and root length but if concentration is more than the optimum it may show inhibitory effects on the germination and seedling growth of the plant. The toxicity of ZnO nano-aprticles on the root growth of garlic (*Allium sativum L.*) [21]. Nano particles have both positive and negative effects on the plant [22]. Nano ZnO recorded higher peanut seeds germination percent and root growth compare to bulk zinc sulphate [23]. Similarly positive effective of nano-scale SiO_2 and TiO_2 on germination was reported in soya bean [16]. Reported higher seed germination, shoot length, root length under nano fertilizers treatment over control or without nano fertilizer treated seeds. Nano fertilizers increase availability of nutrient to the growing plant which increase chlorophyll formation, photosynthesis rate, dry matter production and result improve overall growth of the plant [24-27]. Reported similar result that nano-TiO_2 treated seed produced plant recorded more dry weight, higher photosynthetic rate, chlorophyll-a formation compared to the control [28]. Which indicate that nano fertilizers significantly improve seed germination and overall growth of the plant.

Yield & Yield Parameters

Nano fertilizers enhance the seed germination, vigor, growth parameters (plant height, leaf area, leaf area index number of leaves per plant) dry matter production, chlorophyll production, rate of the photosynthesis which result more production and translocation of photosynthets to different parts of the plant.[5] reported similar result that nano-TiO_2 treated seed produced plant recorded more dry weight, higher photosynthetic rate, chlorophyll-a formation compared to the control. This improve translocation of photosynthets from source (leaves) to sink (economic part of the plant it may be grain, tuber, bulb, stem, fibre and leaves.) which result in more yield and quality parameters from nano-fetilizers treated plants compare to without nano fertilizers treated plants or traditional fertilizers treated plants. [29-31] reported similar result and nano hydroxyl appetite (nHA) application produced 5.9 g soybean seeds per plant, compared to 4.9 g per plant under regular P treatment, and merely 1.1 and 0.6 g soybean per plant respectively for the controls without P application [29]. This is the first report on synthesis and application of nHA as nano P fertilizer for increasing soybean yields.The estimated yield increase by nano-K fertilizer at 20 kg K_2O/ha over MOP at the same level is around 8 % and no significant difference between 20 kg K_2O/ha and 30 Kg K_2O/ha in the form of nano-K [31]. Accordingly, improvement of grain yield with the application of nano-K fertilizer is highly correlated with the increase in seeds/panicles. [20, 32] also reported higher value of yield parameters under nano fertilizers treated plants compare to bulk nutrient sources. Iron content was more in the plant under nano iron treated plant than control [22].

Need to Study

Research is underway to develop nano-composite to supply all the required essential nutrients in suitable proportion through smart delivery system which may help in balance supply of nutrient to the crop, there is need to study about nano nutrient delivery in the plant systems, assess the impact of nano fertilizers on soil and soil beneficial microorganism, fate of nano fertilizers in soil and plant have to be studied, need to optimizes concentration and doses of nano fertilizers for different crop and site specific management of nano fertilizers in precision agriculture these are several issues need to standardise to achieve better result from nano-fertiliers in crop production.

Conclusion

Application of different nano-fertilizers have greater role in enhancing crop production this will reduce the cost of fertilizer for crop production and also minimize the pollution hazard. The application of nano-fertilizers in agriculture should have a greater concern to society. Fertilizer nutrient use efficiency in crop production can be enhanced with effective use of nano-fertilizers. Nano fertilizers improve crop growth and yield up to optimum applied doses and concentration but they also have inhibitory effect on crop plant if concentration is more than the optimum which result reduces growth and yield of the crop.

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