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ROLE OF NANO-FERTILIZERS IN IMPROVING PRODUCTIVITY OF PEANUT CROP: A REVIEW

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ABSTRACT

The quantity and quality of the macro- and micronutrients, such as phosphorus, potassium, calcium, Sulphur, iron, zinc, boron, and molybdenum, are crucial for agricultural production. The effectiveness of employing these fertilizers does not surpass 5% of the additive, despite the fact that these nutrients can be obtained from a variety of sources using chelating fertilizers and minerals, as well as addition techniques. By using alternative fertilizers to conventional fertilizers that are both environmentally responsible and highly effective, such as nano-fertilizers, it is better and important to diminish supplement misfortune during preparation and work to increment crop efficiency. As it manages materials and designs whose aspects range from 1-100 nm, nanotechnology is one of the contemporary technologies that has demonstrated good benefits in many domains, including agriculture, medicine, engineering, and energy. It was found that adding nano-fertilizers to the peanut crop (P, K, Ca, S, Fe, Zn, B, Mo) stimulated and accelerated growth as well as boosted production of this crop of pods and seeds.

INTRODUCTION

The growth of agricultural development is required to attain economic and agricultural stability because the agricultural sector faces numerous obstacles, such as climate change, rising consumption of agricultural products, and shrinking cultivated land. Thus, it is crucial to use technology and nanotechnology, which allow for the creation of contemporary approaches to the possibility of finding and resolving numerous agricultural issues This is in addition to some of the major issues facing the agricultural industry, such as the little amount of land that is cultivated, the degree of the crude land, the deficiency of assets like water, manure, and pesticides, as well as the loss of products. Through the numerous applications of nanotechnology, it is possible to address issues such as the rising population's need for food security. Nanotechnology has the biggest impact on community service and environmental development when it comes to solving agricultural problems and promoting the agricultural sector (Usman *et al.*, 2020). One of the most important uses of nanotechnology in agriculture is the production of nanofertilizers, which can be applied sprayed or added to the soil (Abobatta, 2023).

The purpose of this essay is to highlight the role that some nano fertilizers have in raising peanut productivity.

Importance of nano-fertilizers

Nano-fertilizers are important because mineral fertilizers are essential for growing food. Nanotechnology can increase crop output and lower nutrient loss despite the low efficiency of nutrient uptake and significant losses. Due to this, interest in nano-fertilizers and nano-supported fertilizers has increased, giving rise to the concept of fertilizer (Dimkpa and Bindraban, 2017). Due to its capacity to increase soil fertility and supply nutrients, nano-fertilizers may be the best thing to happen to modern agriculture (Prasad *et al.*, 2017-b).

Nano fertilizers are defined as substances with special properties made from very small particles, whose size ranges from 1 to 100 nm, and in which they have a function that defies the laws of physics and chemistry (Guru *et al.*, 2015). The ability to release nutrients and chemical fertilizers as needed to control plant growth and improve target activity is another useful property of nano-fertilizers or nano-encapsulated nutrients (DeRosa *et al.*, 2010).

In order to improve their qualities and composition, nano-fertilizers are modified fertilizers made by physical, chemical, or biological means. These fertilizers have the potential to increase crop yields. It raises the implant's quality criteria (Meena *et al.*, 2017 and Elemike *et al.*, 2019).

Nanotechnology in Agriculture

Nanotechnology is crucial for the agricultural sector because it increases outputs while reducing inputs (fertilizers, herbicides, and pesticides). It also results in lower economic costs because different crops are less likely to contract epidemic diseases and because manufactured fertilizers work more effectively. Cost, the agricultural product's resistance to environmental factors, and other factors (Mehrotra *et al.*, 2010).

It was discovered that nanotechnology offers nanomaterials and devices that are crucial to agriculture, including nanobiological sensors to measure soil moisture content, nutrient status, and water management (Reddy and Chhabra, 2022).

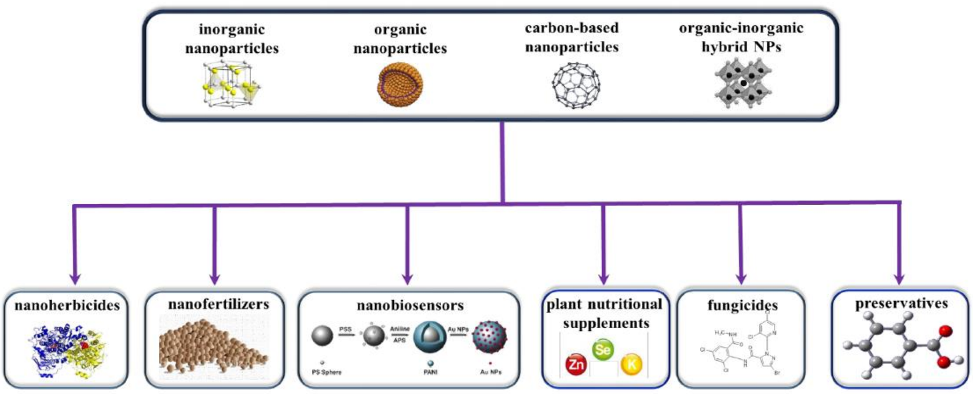

Figure (1): Classification of engineered nanoparticles and a few of their uses in agriculture (Hong *et al.*, 2021)

Nano Fertilizer's Role in Plant Development and Growth

There are many different types of nanoparticles, and this influences how they interact with plants and how they react when they absorb nutrients from the soil.

Research on particular nutrient supplies has led to the development of nano-fertilizers, which include micronutrient, macronutrient, and nanomaterial-enhanced fertilizers. With soil and foliar application, these fertilizers seek to establish sustainable agricultural management while boosting food productivity. (Duhan *et al.*, 2017). Figure (2).

Figure (2): Types of nanofertilizers and their smart nutrient delivery system in plants (Al-Mamun et al., 2021)

Benefits of nanoparticle fertilizers:

The utilization of nanomaterials in preparation programs is a fruitful trade for regular manures since it accomplishes many benefits because of its utilization in more modest amounts and its high steadiness under different circumstances, which expands the capacity to store it for longer periods. These advantages are achieved in the following ways for the plant and the environment:

1. Because nano-fertilizers are so tiny, they don't require a lot of space.
2. It is applied as a spray to the plant's vegetative system, allowing it to take effect more quickly.
3. Quick absorption enables it to be employed as needed according on the real needs of the plant.
4. Nano-fertilizers contribute to the preservation of the environment and public health.
5. The cost of fertilization and spraying is reduced, which boosts the profitability of farms.
6. The use of nano-fertilizers contributes to a significant decrease in our resource and energy consumption, which results in environmentally friendly economic growth.
7. The usage of nano-fertilizers aids in addressing the issues of soil and water pollution as well as lowering traditional fertilizer plants' carbon emissions, which have a negative impact on the climate.
8. Soaking the seeds in nano-fertilizers enhances their germination and makes the seedlings more resilient to environmental changes.

9. Nano-fertilizers give the plant more prominent space to different metabolic cycles, which speeds up photosynthesis and builds how much dry matter and harvest yield.
10. In addition, nano-fertilizers boost plants' ability to mobilize nutrients, increasing crop output by 17–54% and releasing more helpful enzymes to enhance soil health and parent nutrient mobilization (Rezk *et al.*, 2021).

The advantages of nano-fertilizers (NFs) versus natural fertilizers

Figure (3) illustrates how nutrient release is controlled by the encapsulation of nanoparticles with nanomaterials based on plant requirements. Plants' NUE values rise as a result (Qureshi *et al.*, 2018). More specifically, natural fertilizers (NFs) release their nutrients in 40-50 day, whereas synthetic fertilizer can only do so in 4-10 day. Accordingly, leaching and volatilization cause synthetic urea fertilizer to lose more than 70% of its nitrogen content after field application (Kahrl *et al.*, 2010).

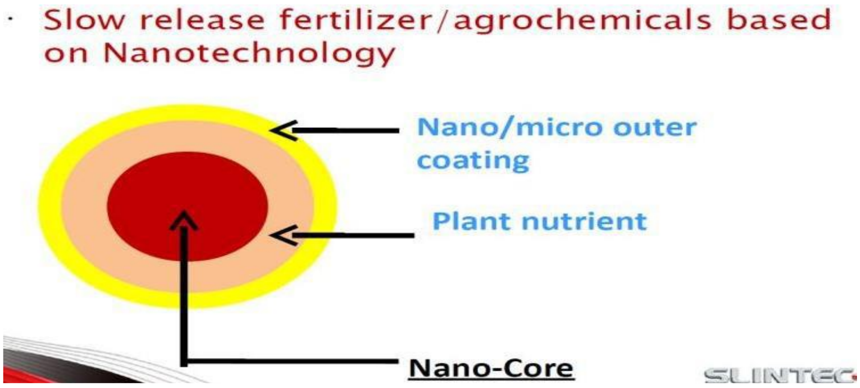

Figure (3): Nano-micro coating for nutrient encapsulation: A thin layer of nanomaterial is coated

Foliar nanofertilizers: Absorption, Transfer, and Influences

Foliar nanofertilizers can penetrate plants by the stomata or epidermis, and then move through the apoplast or symplast pathways (Raliya *et al.*, 2016; Lv *et al.*, 2019; Usman *et al.*,2020). Although vacuole and cell wall are the main sites of NP accumulation, xylem and phloem are also crucial for NP transport (Shahid *et al.*, 2017; Li et al., 2020). Plant physiological characteristics, NP feature (size, shape), and abiotic factors (temperature and humidity) all affect the absorption, transport, and accumulation of NP. Nanofertilizers work better and are better for the environment when applied foliarly rather than being exposed to the soil or roots (Borišev *et al.*, 2016; Achari and Kowshik, 2018; Clarke *et al.*, 2020). Plant characteristics, environmental conditions, and NP quality are the various factors that affect how well foliar-applied nanofertilizers are absorbed and transported. These factors are shown in Figure (4).

Mechanisms of foliar nanoparticle absorption and transmission. Because of the tiny pore size of the epidermis, stomata penetration might be the primary absorption pathway on surface of leaf. It has been shown that particles larger than 20 nm have trouble fitting through cell membrane pores (Alshaal, and El-Ramady, 2017). Since some species of leaves have stomata on their upper surface, nanofertilizers have a higher chance of being absorbed by surface of leaf. In addition, juvenile leaves are more capable of absorbing nutrients than mature leaves due to their immaturity and thinner wax covering, which inhibits the absorption of metals (Shahid *et al.*, 2017). Growing seeds have been observed to obtain nutrients from early leaves because of a lack of fully formed wax of leaf (Rawat *et al.*, 2017).

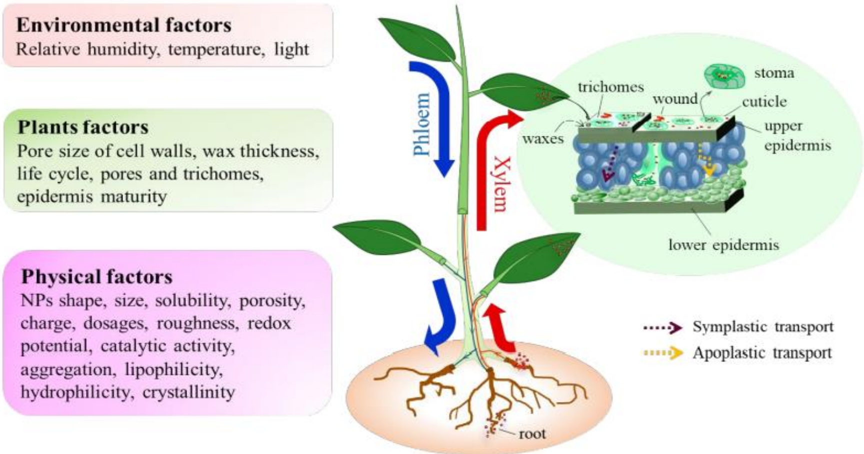

Figure (4): Factors influencing how well plants absorb and transport nanoparticles after foliar application (Hong et al., 2021)

The increased solubility, dispersion, and bioavailability of modern nano-sized nanofertilizer formulations minimize nutrient losses. (Prasad *et al.*, 2017-a). Numerous purines, vitamins, coenzymes, activators of photosynthesis, proteins, and pigments involved in photosynthetic processes are all present in plants, are impacted by nanoscale materials (Jakiene *et al.*, 2015).

Peanut (Groundnut)

The Fabaceae family member peanut (*Arachis hypogaea* L.) is a significant oil crop grown primarily for oil production. Peanut seeds have a high percentage of oil that reaches more than 50%, as well as a high percentage of protein that reaches more than 25% and carbohydrates 12% (Nath and Alam, 2002; Ahmed *et al.*, 2007). Peanuts are also consumed right after roasting and used to make sweets and veal. Because of its high content of unsaturated fatty acids and high quality, peanut oil is favoured in food for lowering blood cholesterol levels (Arab Development Organization, 2009).

Effect of macro nano-fertilizers on peanut yield

Nano-fertilizers can be used to improve crop yield and quality, boost fertilizer application efficiency, and lessen the detrimental effects of false fertilizer on more sustainable agriculture (Seleiman *et al.*, 2020). By decreasing nutrient-altering substances in the soil, nano fertilizers prevent nutrient loss by releasing nutrients directly into the root zone of plants. Different forms of nanofertilizers are generated depending on substance or carrier, such as hydroxyapatite nanoparticles, zeolites, permeable nanoparticles made of silicon dioxide, nitrogen, copper, zinc, silicon dioxide, and carbon, as well as polymeric nanoparticles (Guo *et al.*, 2018).

Nano-Phosphorus Fertilizers

Due to its role in development, growth, and cell division of plant cells as well as the production of seeds, phosphorus is one of the essential nutrients for plants. For most agricultural crops, phosphorus is the third most important nutrient in terms of quantity after nitrogen and potassium. As a result, it must be present in the soil when plants are growing, especially when they are branching and flowering (Havlin *et al.* 1999). Phosphorus is crucial for a number of metabolic processes, including degradation, metabolic pathways, and macromolecules (Hussain *et al.*, 2022).

When Kumari *et al.* (2017) studied various levels of nano-phosphorus (0, Suggested portion of $N:P_2O_5:K_2O$/20:40:50 Kg ha^{-1}, RDF (Refuse-derived fuel) NK + Soil use of nanophos as impregnated granules/65 Kg ha^{-1} at planting, NK + Soil utilization of biophos/65 Kg ha^{-1} at planting, NK + foliar use of 1% P as DAP (Diammonium phosphate), NK + foliar use of nanophos/1 ml l^{-1}, NK + foliar use of nanophos /2 ml l^{-1}, NK + foliar use of biophos/2 ml l^{-1}, NK + foliar use of biophos/4 ml l^{-1}), they found that there were notable changes across the levels, with the fourth level being preferable in terms of pod yield. Hagab *et al.* (2018) found that adding nano-phosphorus to the peanut crop significantly increased production in their investigation of various levels of nano-phosphorus (Nano hydroxyl appetite (nHA) $Ca_5(PO_4)_3OH$), Bohrnano-fertilizer, Nano rock phosphate (RP), Nano hydroxyl appetite ($Ca(H_2PO_4)_2$), Nano zeolite). Bakry *et al.* (2022) discovered that the addition of nano-phosphorous at the level of Two dose 200 ppm led to an increase in seed yield while studying five levels of nano-phosphorus (0, One portion 100 ppm, One portion 200 ppm, Two portion 100 ppm, and Two portion 200 ppm). The study by Kavitha *et al.* (2023) found that there were significant variations in the amounts of nano-phosphorus (0, 100 percent RDP (Refuse-derived bacteria) + Soil use of BBPF (Biochar-based phosphorus fertilizer)/4 Kg ha^{-1}, 75% RDP + Soil utilization of BBPF/4 Kg ha^{-1}, half RDP + Soil use of BBPF/4 Kg ha^{-1}, 100 percent RDP + Soil use of BBPF/6 Kg ha^{-1}, 75% RDP + Soil use of BBPF/6 Kg ha^{-1}, half RDP + Soil use of BBPF/6Kg ha^{-1}, 100 percent RDP + Soil use of BBPF/8 Kg ha^{-1}, 75% RDP + Soil use of BBPF/8 Kg ha^{-1}, half RDP + Soil use of BBPF/8 Kg ha^{-1}, 100 percent RDP + Soil use of BBPF/10 Kg ha^{-1}, 75% RDP + Soil use of BBPF/10 Kg ha^{-1}, half RDP + Soil use of BBPF/10 Kg ha^{-1}), with the level above 100 percent RDP + Soil use of BBNPF/4 Kg ha^{-1} in the yield of cases.

Potassium Nano- Fertilizers

Potassium losses in the soil can be reduced by applying potassium nanofertilizer in a slow-release formulation, while at the same time ensuring that plants have access to potassium for a longer length of time. Due to its function in the creation of bacterial nodules, the activation of more than 80 enzymes, and its beneficial effect in the transfer of photosynthetic products, potassium is one of the critical nutrients in terms of yield and quality (Shabala and Cuin, 2008; Helmy and Ramdan, 2014). Potassium is abundant in our soil, but because of the alkalinity issue, which increases its stability, the plant cannot absorb it. It is therefore advisable to add a spray to the shoots to promote growth and enhance output (Veerhadrappa and Yeledhali, 2005).

The eighth treatment was much better in terms of seed yield, an increase of 91.5%, in a study by Afify *et al.* (2019) to determine the impact of increasing amounts of potassium nanoparticles (Control, 100, 200, 300, 400, 50 + 50, 100 + 100, 150 + 150, 200 + 200 ppm).

Nano- Calcium Fertilizers

Since calcium is one of the essential secondary fertilizer elements and is crucial for both soil health and plant nutrition, it plays a significant role in plant growth. the calcium reserves in aging leaves. The plant obtains the calcium it requires from various soil minerals and rocks, as well as from calcium-containing fertilizers that are applied to the soil, such as calcium nitrate (Petrocal), which contains 26.5% calcium oxide (Mesurani and Ram, 2020).

Three levels of nanocalcium (No application, Foliar application, Integrated method) were significantly more effective than the third level in terms of seed yield, according to Nobahar *et al.* (2019). When examining various treatments of nanoscale calcium (0, Gypsum + $Ca(NO_3)_2$, $Ca(NO_3)_2$, 100% nano $Ca(NO_3)_2$, 75% nano $Ca(NO_3)_2$, 50% nano $Ca(NO_3)_2$, 25% nano $Ca(NO_3)_2$, 12.5% nano $Ca(NO_3)_2$, Chelated Ca), Hamza *et al.* (2021) found that the third treatment had a noticeably higher seed output. When comparing the seed yield of the four levels of nanoparticles (Control, Ca, B, and Ca + B), Abdelghany *et al.* (2022) found that the fourth level was best. The level of 50% calcium nitrate + 50% nano-calcium, as determined by El-temsah *et al.* (2023) in their study of five levels of nano-calcium (gypsum calcium sulfate, calcium nitrate, nano-calcium, half calcium nitrate + half nano-calcium, half calcium sulfate + half nano-calcium), worked on the yield of peanut.

Nano- Sulphur Fertilizers

Sulphur is a part of proteins and is crucial for the production of oil. Peanuts have a high Sulphur demand due to their high protein and oil content. Additionally, the usage of Sulphur increased the rate of photosynthesis significantly, which increased the production of pods and the harvester's yield (Chaubey *et al.*, 2000). Sulphur deficit and the resulting crop response are quite evident, especially in oilseed crops like peanut.

Thirunavukkarasu et al. (2012) found that there were significant variations between the levels of nanoSulphur (0, 10, 20, 30, 40 kg.S ha^{-1}), as level exceeded 30 kg S/ha in the yield of pods.

Effect of micro nano-fertilizers on peanut yield

A significant and determining factor in agricultural productivity In addition to lowering the absorption and fixing of the elements by the colloidal portion or lime in the soil, micronutrients in the form of nanoparticles increase their solubility with a good distribution of the elements in the soil. All of these improved and increased crop output and quality by enhancing the validity of nutrients (Seleima *et al.*, 2020-a).

Nano- Iron Fertilizers

As a structural component of the cytochromes, which are responsible for the transfer of electrons, and as a component of the oxidation and reduction processes involved in photosynthesis and respiration, iron plays a significant and significant role in the vital processes of the plant. It also activates the enzymatic processes within the plant in addition to its structural role in the parts of the plant, accounting for 80% of the total iron (Rout and Sahoo, 2015).

El-Metwally *et al.* (2019) discovered in their study that varying concentrations of iron, manganese, and zinc nano-fertilizers (Control, 10, 20, 30, and 40 ppm) had an impact on seed yield and that there were significant variations between the concentrations.

Nano- Zinc Fertilizers

Zinc is a crucial mineral for plants since it helps to develop and produce chlorophyll, activates numerous enzymes required for plants, and plays a significant part in the production of plant protein. The plant hormone Indole acetic acid (IAA) is required for the division and elongation of cells, and it aids in the formation of the amino acid tryptophane. It also influences the fertilization process because a lack of zinc reduces the formation of seeds, so it is preferable to give the plant zinc at the time of flowering (Hafeez *et al.*, 2013). It also functions as a cofactor in the synthesis, activation, and transport of electrons (Hashim *et al.*, 2023).

Figure (5) revealed an idea model for ZnO nanoparticles to be released synchronously based on crop requirements. ZnO fertilizer nanoparticles (dark grey) are coated in a thin polymer film (blue) that is home to a nanobiosensor (red) that binds to specific root chemical signals (yellow). Zinc Oxide Nanoparticles, or ZnO NPs, are released, dissolve, and aggregate in the soil solution of crop rhizospheres as a result of the selective signalbiosensor binding process (Bindraban *et al.*, 2015).

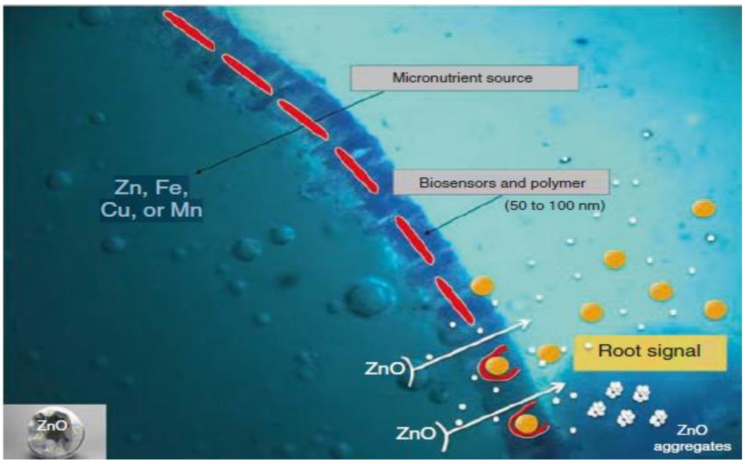

Figure (5): Mechanism of Zno nanoparticles as fertilizer

As the fourth treatment had a higher pod yield, Prasad *et al.* (2012) demonstrated that there were substantial changes between the concentrations of zinc oxide nanoparticles they tested (Control, 400, 1000, and 2000 ppm). The expansion of nanoparticle zinc oxide at a grouping of 300ppm prompted a significant expansion in seed yield in a concentrate by Rajiv and Vanathi, (2018) to look at effect of various convergences of nanoparticle zinc on nut yield. Hanumonthappa *et al.* (2019) reported that spraying peanut plants with a concentration of 300 ppm led to a considerable increase in the output of pods. They employed several concentrations of zinc nanoparticles in their investigation (Blank (water), 300, 600, 900, 1200, and 1500 ppm). According to Abdel-Hamid *et al.*'s study (2020), introducing zinc nanoparticles at a concentration of 600 ppm resulted in a considerable increase in peanut production. The study examined four concentrations of zinc nanoparticles (Control, 200, 400, and 600 ppm). According to Al-Juheishy's (2020) research, cultivating oil crops such as peanut with nano-zinc boosted their seed and oil productivity as well as their growth and acceleration. Al-Yasari and Al-Yasari (2022) found throughout their investigation of three zinc nanoparticle concentrations (0, 50, and 100 mg. L^{-1}) with a concentration greater than 100 mg. L^{-1} increased the pod yield substantially. According to Prasad *et al.* (2023), foliar feeding of (N-CaO + N-ZnO + N-SiO_2) at a concentration of 350 ppm increased peanut output.

Nano- Boron Fertilizers

Cell division, the arrangement of cell walls, the advancement of leaf buds, and the help of the development and move of photosynthetic items from passes on to dynamic regions in the plant are a portion of the essential capabilities that boron acts in plants (Hu and Brown, 1997 and Brown *et al.*, 2002). Research indicates that micronutrients, among which boron is one are critical for the pollination, fertilization, and setting of seeds (Al-Juheishy, 2020).

Hanumanthappa (2019) came to the conclusion that the concentration of 300 ppm in the yield of peanut pods was greatly exceeded by other concentrations of nano-boron (Blank (water), 300, 600, 900, 1200, and 1500 ppm).

Nano- Molybdenum Fertilizers

In addition to its roles and indirect and non-specific importance in plant metabolism, molybdenum is a necessary component of many significant enzymes, including nitrate reductase, nitrate reductase, xanthine reductase, and sulfite oxidation. Additionally, it results in an improvement in root node weight, function, growth traits, and yield (Kaiser *et al.*, 2005).

In their investigation on the effects of various molybdenum nanoparticle concentrations (0, 1, 2, 3 g.L^{-1}), Manjili et al. (2014) found that the addition of nano-molybdenum at a concentration of 3 g. L^{-1} increased peanut yield. The findings of Manjili et al.'s (2014) study on the effects of nano-molybdenum at four different concentrations (0, 1, 2, 3 g.L^{-1}) revealed that the productivity of peanuts increased when nano-molybdenum was added at a concentration of 3 g. L^{-1}.

CONCLUSIONS

We can infer from this article's findings that adding nano-fertilizers (P, K, Ca, S, Fe, Zn, B, Mo) to peanuts improved and increased the crop's productivity, it was discovered that peanut responded quite well to nanofertilizers.

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CONFLICT OF INTEREST

Researchers back up the claim that this effort does not clash with other people's interests.

دور الأسمدة النانوية في تحسين إنتاجية محصول الفول السوداني: مقال مراجعة

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الخلاصة

تعتبر كمية ونوعية المغذيات الكبيرة والصغرى، مثل الفوسفور والبوتاسيوم والكالسيوم والكبريت والحديد والزنك والبورون والموليبدينوم، ضرورية للإنتاج الزراعي. فاعلية استخدام هذه الأسمدة لا تتعدى 5٪ من المادة المضافة بالرغم من توافر العديد من مصادر الأسمدة المعدنية والمخلبية لهذه العناصر وكذلك طرق الإضافة المختلفة. من خلال استخدام الأسمدة البديلة للأسمدة التقليدية المسؤولة بيئياً والفعالة للغاية، مثل الأسمدة النانوية، من الأفضل والأهم وتقليل فقد المغذيات أثناء التحضير والعمل على زيادة كفاءة المحاصيل. نظرًا لأنها تتعامل مع المواد والتصاميم التي تتراوح ابعادها من 1−100 نانومتر، تعد تقنية النانو واحدة من اهم التقنيات المعاصرة التي أظهرت فوائد جيدة في العديد من المجالات، بما في ذلك مجال الزراعة والطب والهندسة والطاقة وغيرها من المجالات الاخرى. ولوحظ ان اضافة الاسمدة النانوية (P ، K ، Ca ، S ، Fe ، Zn ، B ، Mo) على محصول الفول السوداني ادى الى تحفيز وتسريع النمو وزيادة انتاجية هذا المحصول من القرنات والبذور.

الكلمات المفتاحية: تقنية النانو، الاسمدة النانوية الكبرى، الاسمدة النانوية الصغرى، فستق الحقل، الحاصل.

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