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Comparative Analysis on the Effects of Banana Peels Nano-fertilizer and Urea Fertilizer on Germination Rate of *Spinacia oleracea* and *Solanum lycopersicum*

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ABSTRACT

Banana contains important nutrients, which could be recycled into useful materials to be reused for different purposes. The primary goal of this investigation is to extract mixed nanobiostimulant fertilizer from banana peels. The synthesized nanofertilizer contained chelated potassium, chelated iron, tryptophan, urea, amino acids, proteins, and citric acid. Nanofertilizer extracted from banana peels was applied to two agricultural crops, tomato and spinach. The data revealed that germination percentage increased with increasing doses of the synthesized nanofertilizer for both crops. For the tomato crop, the germination percentage was increased from 14% (control without nanofertilizer) to 99.5% after 7 days of plantation. Also, the same trend was noticed for the spinach crop; the germination percentage was enhanced from 25% (control without nano) to 97%. The germination percentage also increased in the case of urea fertilizer from 13% to 0.32.6%. The combination of nanofertilizer and urea also increased the germination percentage and height of the cultivars as the dose increased. As a result, the nanofertilizer had an amazing effect on both crops' germination percentage and height compared to conventional urea fertilizer. The variance analysis revealed an insignificant difference between using nanofertilizer alone and in combination with urea chemical fertilizer.

Keywords: *Nano-fertilizer, Urea, Germination, Sinacia oleracea , Solanum lycopersicum*

INTRODUCTION

The quest to apply nanotechnology in agriculture arises from the fact that the human population is constantly growing, necessitating more food. A population survey has estimated about 9.6 billion people by the end of 2050 (Rachel, 2015). Farm lands are losing their fertility due to human activities on them and societal change in lifestyle. This invariably affects crop production and could lead to famine and hunger; therefore, concerted efforts are necessary to improve plants for increased production. Nanotechnology serves as the latest technology for precision agriculture, whereby strategies are formulated and channeled towards meeting the food demands of the increasing human population. The word "nano" means one-billionth, so nanotechnology refers to materials that are measured in a billionth of a meter (nm). A nanometer is so small that a human hair's width is 80,000 nanometers. The field of nanotechnology has resulted from advances in chemistry, physics, pharmaceuticals, engineering, and biology. The size of a nanomaterial is typically about 1 to 100 nanometers. They can be naturally occurring or engineered. Due to their extremely minute size, they have many unique properties that are now being explored for new opportunities in agriculture. There is a diversion from the traditional ways of crop production to technologies that could increase agricultural productivities with required nutrients, cost effective and efficient resource use that guarantees nutrient security, uplifts the value of production, boosts farmers' economy, delivers agri-value chain to rural partakers and supports pollution free environment (Subramanian et al., 2011). This technology uses improved materials to add value to agriculture, by exploiting the nanoscale properties. Nanotechnology, as applied to agriculture, is bridging the gap in nutrient loss and fortification of crops. Farmers are using this science in the nano-regime to boost the quality and quantity of agricultural produce. The application of nanotechnology in agriculture includes nanobiotechnology, livestock, nanotoxicology, agrochemicals, hydroponics, biotechnology, etc. Urban agriculture that makes use of recent nanotechnologies has the potential to contribute immensely to food security and healthy nutrition. Although there are associated risks from chemicals which may have emanated from soils, water or air (Xion et al.,2017), the ultimate goals for application of nanomaterials in agriculture spans reducing hazard chemicals, nutrient losses, pest control and crop yield improvement (Thakur et al, 2018). The nutrients needed by the plants are fortified in the fertilizers, with the belief that they could be absorbed by the plants.

The lack of the micronutrients is manifested by abnormal growth of the plant parts; however, sometimes the soil may not be deficient of the micronutrient, but rather the roots are unable to absorb and translocate the nutrients due to small root pore size. Therefore, it is imperative to investigate strategies for improving crop quality and their essential nutrients in order to meet the growing population's food demands. The use of chemical fertilizers is an age long practice and has tremendously increased crop yields. However, they lead to soil mineral imbalance, destroy the soil structure, soil fertility and general ecosystem, which are serious impediments in the long term. To deal with the situation, it is pertinent to develop smart materials that can release nutrients to targeted areas and contribute to clean environment. Nanotechnology seems to be the alternative that could revolutionize this field of agriculture as the entire nanotechnology industry had grown to $1 trillion in 2015 (Harper, 2015).

Conventional fertilizers are normally sprayed on the crops by either spraying or broadcasting. However, one of the primary elements that decides the manner of application is the final concentration of fertilizers going to the plant. In a practical scenario, very minimal reaches to the desired site due to leaching of chemicals, drift, runoff, evaporation, hydrolysis by soil moisture, and photolytic and microbiological destruction. It has been calculated that roughly 40–70% of nitrogen, 80–90% of phosphorus, and 50–90% of potassium content of applied fertilizers are lost in the environment and could not reach the plant, which produces sustainable and economic losses (Trenkel, 1997; Ombodi and Saigusa, 2000). These problems have triggered repeated usage of fertilizer and pesticides, which adversely affect the inherent nutrient balance of the soil. Hence, it can be desirable that different ways of fertilization be likewise studied and applied to give sufficient nutrients for plant growth and crop production while keeping the soil structure in excellent form (Miransari, 2011). Therefore, this work attempted to assess the effect of organically generated nanofertilizer from banana peels utilizing alkaline digestion and urea conventional fertilizer on the germination rate of Solanum lycopersicum (tomato).

MATERIALS AND METHOD

Materials

Banana peels, commercial grade potassium hydroxide produced by Lobal Chemie Company, citric acid and urea obtained from chemistry laboratory Federal University Dutse and the chemical fertilizer (urea).

Sample Collection and Preparation

A total of 1000g of banana peels were collected from Sabuwar Kasuwa Duste Jigawa State. The banana peels were washed with tap water to remove the dust and any impurities that adhered to the outer surface. The peels were then, dried by hugging in an open air for one week and then grinded into powder.

Formulation of nano-fertilizer from dried banana peels using Potassium hydroxide (Alkaline digestion)

The procedure used for the extraction was carried out using the method described by (Hussein et al., 2019) will little modification.

Dried banana peel powder (125g) was measured into a conical flask using weighing balance.Tap water was added to the powder to top up 1000ml and mixed. The obtained viscous slurry was mixed with 20g of potassium hydroxide (as catalyst) and stirred for 5 minutes to get homogenous slurry. The alkaline banana peel slurry was subjected to boiling with stirring for 30 min. After boiling, the slurry was kept for cooling at room temperature to be ready for further processing. The cold slurry was subjected to vacuum filtration (using Whatman filter paper of size 0.005) to get clear brown filtrate and thick dark brown sludge. Hence, the clear filtrate was heated to about 70 °C, with continuous stirring at 300 rpm using magnetic stirrer. After that, urea and citric acid (5% solution) were added dropwise till pH is 5(slightly acidic). 500ml of the obtained brown clear solution (liquid nanofertilizer) was centrifuge at 4000rpm for 1 hour. The obtained pellets were separated from the supernatant and then dried at 105°C using oven, and finally grinded to fine powder (powdered nanofertilizer).

Application of formulated Nano fertilizer in agriculture

Seeds of two crops (tomato) were cultivated in Jigawa State clay loam texture soil taken from Science Laboratory School Farm in Jigawa State Polytechnic Dutse. The seeds were irrigated using tap water with the addition of different doses (4, 8, 12, and 16 ml) of nanofertilizer extracted from banana peels and a control. After 7 days, data concerning germination rate was recorded as described by Duncan (1959).

Application of the Chemical Fertilizer (Urea)

80 seeds of the same crops were also used, and the seeds were cultivated in Jigawa State clay loam texture soil taken from Jigawa State Polytechnic Dutse. The seeds were irrigated using tap water with the addition of different doses (0.5, 1.0, 1.5 2gm) of urea fertilizer and a control. After 7 days, data concerning with germination was recorded (Duncan, 1959).

Application of the Combination of the Nanofertilizer and Urea fertilizer

The same crops were cultivated using tap water and the combination of the produced nanofertilizer and urea conventional fertilizer (0.5g/4ml, 1.0g/8ml, 1.5g/12ml, 2g/16ml of urea and nanofertilizer respectively. After 7 days, data concerning with germination was recorded according to (Duncan 1959).

RESULTS

Effect of Nanofertilizer on germination percentage of two the vegetable crops (tomato and spinach)

The collected data in Table 1 indicate that irrigated tomato seeds and spinach seeds using banana peel extract as fertilizer increased germination percentage compared with the control sample. Also, data revealed that germination percentage increased with increasing dose of the banana peel extract for both crops. The germination ratio increased as the addition of banana peel extract increased from 4 to 16 ml. This ratio was increased to nearly 58.5% after the addition of 4 ml of banana extract and reached to 94% by adding 8ml of the same extract. Finally, the ratio increased to 99.5% in using 16 ml of banana extract. Also,

in the case of spinach plant, the germination ratio in control was 25% after 1 week and this ratio was increased to nearly 80% after the addition of 8 ml of banana extract and reached to 97% on adding 16 ml.

Table 1 Effect of banana peel extract in nanoform on germination percentage of tomato and spinach

Dose Nanofertilizer	Tomato (%)	Spinach (%)
Control	14.1	25.2
4ml	58.5	46.2
8ml	94.2	80.1
12ml	98.3	90.2
16ml	99.5	97.1

Note: each data was replicated and the average was used to make the generalization using 1 significant figure as shown in the table above

Effect of Urea Fertilizer on Germination Percentage of the Two Vegetable Crops (Tomato and Spinach)

Application of urea at doses of (0.5, 1.0, 1.5, 2.0gm) increased the germination percentage of both tomato and spinach compared with the control sample as shown in table 2. The germination ratio increased as the addition of urea increased from 0.5 to 2.0gm.This ratio was increased to 21.6% after the addition of 0.5of banana extract and reached to 25% by adding 1.5gm of the same Urea. Finally, the ratio increased to 32.6gm% in using 2.0gmof urea. Also, in the case of spinach plant, the germination ratio in control was 6.6% after 1 week, this ratio was increased to 15% after the addition of 1.5gm of urea and reached to 18gm% on adding 2.0gm.

Table 2 Effect of urea on germination percentage of tomato and spinach

Dose of urea	Tomato (%)	Spinach (%)
Control	13.3	6.6
0.5gm	21.6	10.0
1.5gm	28.3	13.0
1.0gm	25.0	15.0
2.0gm	32.6	18.0

Effect of the Combination of Urea and Nanofertilizer on Germination Percentage

Application of the combination of urea and the biologically synthesized nanofertilizer significantly increased the germination percentage of the two vegetable crops compared with the control as shown in table 3 below. The germination ratio increased as the addition of the nanofertilizer and urea increased from 0.5g/4ml to 1.5g/12ml after 1 week. This ratio was increased to nearly 54.4% after the addition of 0.5g/4ml of nanofertilizer and urea and reached to 91% by adding 1.5g/12ml of the same Urea. Finally, the ratio increased to 97.7% in using 2.0g/16ml of urea. Also, in the case of spinach plant, the germination ratio in control was 23% after 1 week and this ratio was increased to nearly 89% after the addition of 2.0g/116ml of the nanofertilizer and urea and reached to 93.1% on adding 2.0g/16ml.

Table 3 Effect of the Combination of Urea and Nanofertilizer on Germination Percentage of Tomato and Spinach

Effect of combined urea Banana peel nanofertilizer	Tomato (%)	Spinach (%)
Control	15	23
0.5gm + 4ml	54.5	42
1.0gm + 8ml	99.5	79.5
1.5gm + 12ml	91	89
2gm + 16ml	97.7	93.1

4.4 Comparative Analysis of the Effect of the Nanofertilizer, Urea and their Combination on the Plant Heights

Increase in height was noticed in all the experiments compared with the controls as the doses creased from 0.5g/4ml to 2g/16ml. However, a greater increase in height was noticed in using nanofertilizer compared with urea (as seen in table 4 below).

Table 4 effect of the nanofertilizer, urea and combination of both on plant heights

Nanofertilizer Doses (ml)	Plant Height (m)	Urea doses (gm)	Plant height(m)	Nanofertilizer + Urea (gm/ml)	Plant Height (m)
0ml	4	0.0g	4	0.0	4
4ml	9	5.0	7	0.2/4	8
8ml	9.5	1.0	7	0.6/8	8.6
12ml	9.9	1.5	7.5	0.6/12	9
16ml	10.2	2.0	7.9	0.8/16	9.9

Discussion

Nano-fertilizer was prepared from banana peels using potassium hydroxide as extracting agent at optimum operating conditions (temperature 100 °C, and cooking time 30 min). The nanoparticles are assumed to be of sizes 1 to 50 nm. This corroborates the sizes of nanoparticles obtained by Hussein (2019) using the same method. Conversion to nanostructure is attributed to the presence of both urea and citric acid, as citric acid reacted with the minerals, forming mineral citrate, while urea is used as a carrier for the mineral citrate in the nanoform. Also, it is known that alkaline medium increases cellulose solubility during a digestion process of banana peels that results in liberating the micronutrients of tryptophan and total protein extraction efficiencies, which reach maximum value when using 20 g potassium hydroxide. On applying banana peel extract as fertilizer in tomato and fenugreek irrigation, it was noticed that the germination percentage increased compared with the control sample. This was similar to the findings of Hussein et al. (2019), who studied the effect of banana peel nanofertilizer on tomato and fenugreek. These results may be referred to as the high

content of amino acids (i.e., L-tryptophan), nutrient elements such as potassium, and growth promoters (Lee et al., 2010; Emaga et al., 2007).

This can be supported by Aboul-Enein et al. (2016), who investigated the effects of tryptophan on the growth of plants (wheat, periwinkle) and showed that tryptophan may improve many physiological processes. For example, it regulated the plant growth, metabolism of plants under water stress, and increasing physiological availability of water and nutrients, besides the effect of tryptophan on increasing levels of endogenous hormones. Consequently, it can stimulate cell division and/or cell enlargement and subsequently growth (El-Bassiouny, 2005; Talaat et al., 2005; Sadak and Orabi, 2015). Regarding the banana peel composition, it contains K+, Ca++, Na+, Fe+++, P, and Mg++. The addition of potassium hydroxide breaks lignin and cellulose. While urea and citric acid utilization liberated minerals, amino acids, tryptophan, and total protein, the presence of these liberated materials has great effects on the plant germination, as shown by Aboul-Enein et al. (2016). As the chemical elements of banana peels combined with organic compound (citric acid), the organic complex was formed (chelates) that tightly trapped the metallic elements, preventing their release to the soil. Trapped metals in chelates lost their cationic properties, making them less susceptible to precipitation, which is useful in agriculture. When natural products decompose, they can generate naturally chelating agents such as organic acids, amino acids, lignin-sulfonates, lignin poly carboxylates, sugar acids and derivatives, phenols, poly flavonoids, siderophores, and phytosiderophores.

Other chelating agents could be developed synthetically, both types of chelating/complexion causing an increment in micronutrient solubility. One of the most important characteristics of the chelating agents used is the relative stability of various metal chelates, especially if one is considering synthetically developed chelates. In other words, it is the degree of affinity that a given agent has for a metal. From the stability constant data, the ability of one metal to compete with another can be estimated. Stability of micronutrient chelate bonded generally determines “plant availability” of the applied micronutrient. An effective chelate relationship is sellable plant parts (Feagley and Fenn, 1998).

Conclusion

Nano bio stimulant fertilizer can be extracted from banana peels under alkaline conditions using KOH as an extracting agent, urea as a carrier of the nanonutrients and citric acid as a chelating agent. The obtained nano bio stimulant shows great germination efficiency in the first planting week for both tomato and spinach, so it is recommended as a biological promoter for seed germination and seedling growth performance. Utilizing nanotechnology to transfer the banana peel extract from normal form to nanoform added a positive value for this extraction and reinforced its positive impacts as growth promoter. And for this, more studies should be conducted on other crop wastes to emphasize the positive role of banana peel in nanoform and study its biological effect on soil microorganism activity.

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