Journal Of Research Technology & Engineering
www.jrte.org

Development of an organic fertilizer instant-cube with pest repellent efficacy (FERTIPEST)

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Received: 20 August 2021; Revised: 25 September 2021; Accepted: 30 September 2021; Available online: 10 Oct 2021

Abstract: Besides the conventional organic fertilizer production for agricultural purposes, an instant organic fertilizer cube with pest repellent efficacy is designed. Optimization of the organic fertilizer absorbing time for the farming crop is achieved as a mixture of several ingredients. In this new method, organic fertilizer develops by using several food wastes and readily available plant leaves to enhance the nutrient content. Most of the raw materials, such as cow bone, tea dust, banana peel, and eggshell, are the waste product of food industries. At the same time, neem, Gliricidia and pine needles are readily available in the environment. The raw materials are blended to reduce particle size and mixed to produce instant fertilizer cubes with all required ingredients for agriculture. The neem leaves and seeds, and pine needles act as a pest repellent agent for developed fertilizer. Therefore, the additional pesticide is not required for the agricultural lands when applying FERTIPEST for plantations. The product has no foul odour as it is well mixed and developed in an optimized ratio to fulfil all required nutrient levels. The FERTIPEST is produced and finished as a handy cubical, around 1 inch of dimensions for easy handling and storing. Therefore, it can easily use for any indoor plantation as well.

Keywords: Agriculture, Crop, Fertilizer, Nutrients, Organic Farming, Pest Repellent.

1 INTRODUCTION

Fertilizers are added to crops to produce enough food for the human population worldwide. Fertilizers provide essential nutrients, such as potassium (K), phosphorus (P), and nitrogen (N), which allow crops to grow faster, bigger and to produce a higher amount of crops. Nutrients act as the building blocks of the crop material, which is vital for its growth and survival. Fig. 1 represent the structure of the growth of crops with required nutrients categories.

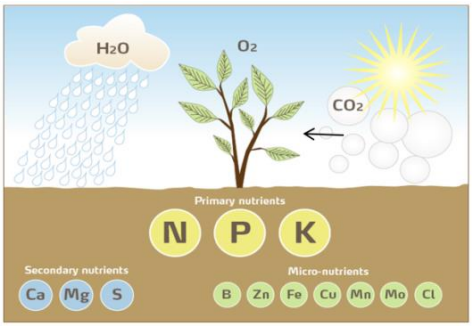

Fig. 1. Essential nutrients for crops to grow [1]

As crops consume the nutrients from the soil and take up a considerable amount with the harvest, replacing a substantial proportion of these nutrients in the field is essential. Some nutrients can return to the field through crop residue and organic matter, which is left behind after the harvesting process. However, this alone cannot provide optimum fertilizer requirement for crop yield over time. Therefore, the required amount of essential nutrients should be added back to the field as a chemical or organic fertilizer. In both cases, the crop will utilize the same inorganic molecules for its growth.

According to the literature, in 2015, the world used more than 180 million tons of fertilizer, almost six times higher than the consumption in 55 years prior [2]. The majority of the fertilizer consumption is due to the developing nation as their population and population growth are higher than developed countries [2]. Several researchers have already documented the long-term impact of chemical fertilizers on soil [3, 4, 5, 6, 7, 8].

Though fertilizers improve soil fertility, intensive inorganic fertilizer usage in agriculture leads to uncountable health problems and unrecoverable environmental damages. Thus, organic fertilizer has been developed worldwide, such as organic agriculture, sustainable agriculture, or ecological farming, reducing or eliminating the adverse effects of synthetic fertilizers on human health and the environment. Studies have identified that using organic fertilizers resulted in improvements in soil fungal to bacterial ratio and soil enzyme efficiency, which are highly important for crops [9]. The soil acidification gradually alleviated with the organic fertilizer, which has been increased due to the long term application of chemical fertilizers [10].

There are some pros with organic fertilizer, such as the level of nutrients present in organic fertilizer is often low. Because of that, to get the required amount of nutrients for crops to grow, it consumes a higher quantity of organic fertilizer. In addition, the nutrients are usually in complex chemical structures, which means using organic fertilizer may not produce the same yield as used to be taken by chemical fertilizer. Therefore, the development of organic fertilizer with fast nutrient absorption is considered in the present study. However, microorganism activities with organic fertilizer should also be carefully considered as organic fertilizer creates a pest-friendly nature in the agricultural land. Therefore, the development of instant fertilizer with pest repellent activity is vital to promote organic farming with higher yields to achieve sustainable goals. Here, considered the development of instant organic fertilizer cube suitable for indoor farming and hydroponic culture with pest repellent efficacy, which is called FERTIPEST.

2 METHODOLOGY

In comparison with chemical fertilizers, manures supply relatively less amount of nutrients. However, the total amount of manure added to the farmland is relatively high compared to the chemical composition. It will be important to develop the organic fertilizer with more nutrients to supply an adequate level of nutrients with less quantity. Conventional organic fertilizer takes around six weeks, depending on the soil temperature and the moisture content. A longer reaction time is not suitable for a large scale agricultural industry.

Moreover, the traditional production of organic fertilizer not providing all the required nutrients for proper plantation. At the same time, the conventional organic fertilizer process requires large space as that comes with large scale quantities to the market. Conventional organic fertilizer will not act as a pest repellent, eventually attracting more pests and insects to the crops. As this is organic farming, it should not use chemical pesticides for the crops to kill pests. Therefore, the final crop at the harvesting stage will be

significantly reduced with conventional organic fertilizer.

The biggest disadvantage of using an organic fertilizer is that it may not contain primary nutrients like nitrogen, phosphorous or potassium, also known as NPK. It takes a considerably longer time to absorb the required major nutrients [11]. Therefore, carefully analyzed the raw materials to design the organic fertilizer cube with essential nutrient supply for better growth. As the most important ingredients, cow bone, tea dust, eggshell, and banana peel are selected, waste of the food industry. Therefore, this will help to reduce the waste generation and handling cost as well. The proposed FERTIPEST will support a solid waste management option as well. Other ingredients of neem leaves and seeds, dendro leaves, pine needles are readily available everywhere. Therefore, raw material availability for mass production is not a problem for industrial-scale fertilizer production. The neem leaves and seeds, and pine needles act as a pest repellent agent for developed fertilizer. Therefore, the additional pesticide is not required for the agricultural lands when applying FERTIPEST for plantations.

Banana peels

Banana peels are considered one of the main components as they are rich in potassium (K). K helps promote metabolism by acting as an enzyme activator and helps regulate the leaf stomates where water is released to cool the plant [12]. Banana Peels are rich in potassium (K) which is around 42% [13]. Fresh banana peel is present in Fig. 2.

Fig. 2. Banana peel powder.

Waste tea powder

Dried tea leaves contain 4.4% Nitrogen, 0.24% Phosphorus and 0.25% Potassium, making it an organic source of NPK fertilizer. Tea leaves (Fig. 3) are high in tannic acid and valuable nutrients that make them more fertile. It can be considered boiled tea waste (formed after making tea) or as tea dust generated as a waste in the tea processing industry. In both cases, it is used to correct the pH of the soil with the help of tannic acid [14].

Fig. 3. Waste tea powder

Egg shell

Eggshells will add Calcium, Potassium, and a small amount of Sodium. Calcium helps to maintain cell integrity and membrane permeability, and it will be important for the normal cell division. In addition to that, Ca involve in the formation of the cell wall membrane. Ca act as an activator of some enzyme systems in protein synthesis and carbohydrate transfer. Ca plays a major role to enhance crop yield by reducing soil acidity [14].

Fig 4. Egg shell

Cow bone

The cow bone is discarded as a waste in the meat production industry, which accounts for more than 15% of the whole carcass [11]. According to the literature, cow bone meal contains nearly 19.3% of Ca and 9.39% of P are essential for plant growth [11]. Ground cow bones are given in Fig. 5. Cow bone powder and banana peel act as a binding agents for the fertilizer cubes.

Fig 5. Ground cow bones

Dendro (Gliricidia)

Gliricidia is considered as one of the nitrogen rich source for organic fertilizer production. According to the previous studies, N supply of Gliricidia (Fig. 6) has been perfectly reported [15].

Fig. 6. Dried Gliricidia Powder

Neem leaves

The neem *(Azadirachta indica)* leaves and seeds act as a pest repellent agent for developed fertilizer. Therefore, the additional pesticide is not required for the agricultural lands when applying FERTIPEST for

plantations. The neem tree was the richest inactive compound and the most potent source of effective natural pesticides worldwide [16, 17]. The dried neem leaves and seeds are grounded and used as a raw material for FERTIPEST (Fig. 7).

Fig. 7. Neem Leaves and seeds

Pine Needles

Pine straw is the uppermost layer of forest floor consisting of recently fallen pine needles that have not yet decayed for a more extended period. Not only is it aesthetically pleasing, but pine straw acting as a mulch in landscaping also has the same positive effect on plant growth. The layer of pine needles, fresh and at various stages of decomposition, has many essential functions in the forest, affecting its productivity. Pine straw reduces evaporative water loss from the soil surface, and it has excellent water-holding capacity. Moreover, pine needles act as a pest repellant for insects to distract from agriculture damage [18]. The powdered pine needles are shown in Fig. 8.

Fig. 8 . Pine Needles Powder

Those mentioned raw materials are mixed into the correct ratio to balance the fertilizer's N:P: K supply. The approximate amount of raw material mixing is given in Table 1 to achieve the required nutrient supply.

Table 1. Percentage of raw material mixing for instant fertilizer-cube

BANANA PEEL	TEA POWDER	EGG SHELL	COW BONE	DENDRO LEAVES	NEEM LEAVES AND SEEDS	PINE NEEDLES
10%	5%	20%	15%	40%	5%	5%

The percentage of the raw material is considered to achieve the nutrients level. Some amount of water is added and molded into a cubical shape after proper mixing of the raw materials. The drawings of the Mixing unit and the piston press machine are given in Fig. 9 and Fig. 10, respectively.

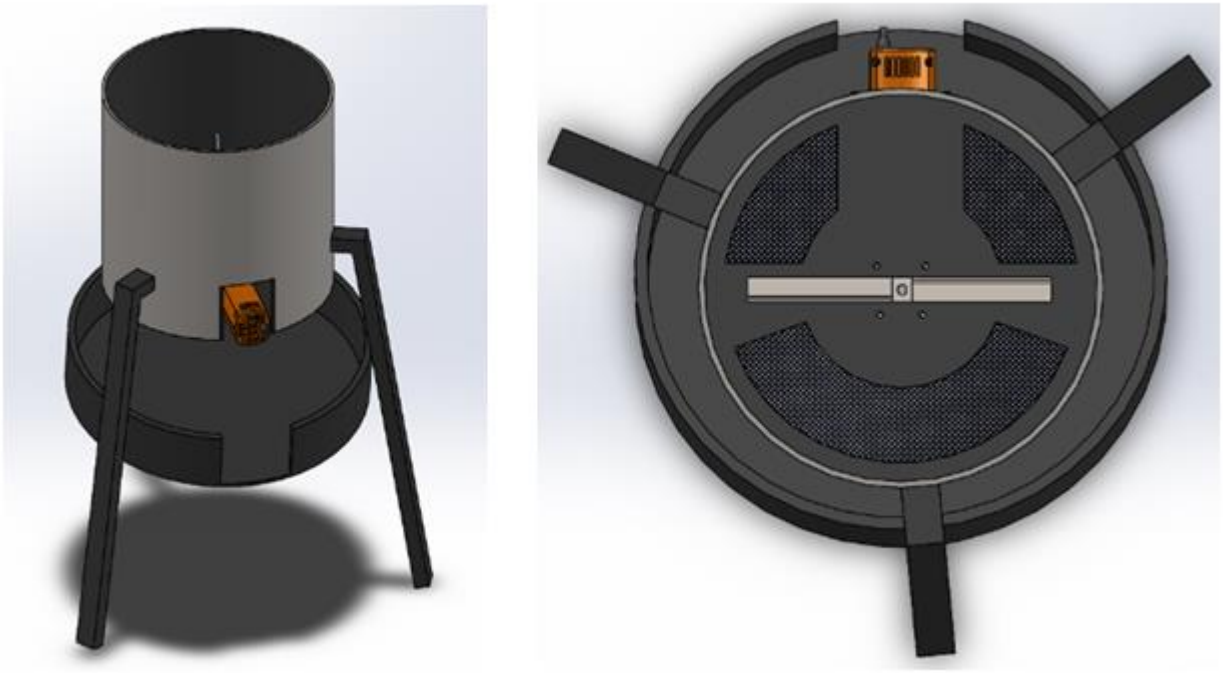

Fig. 9. Mixer

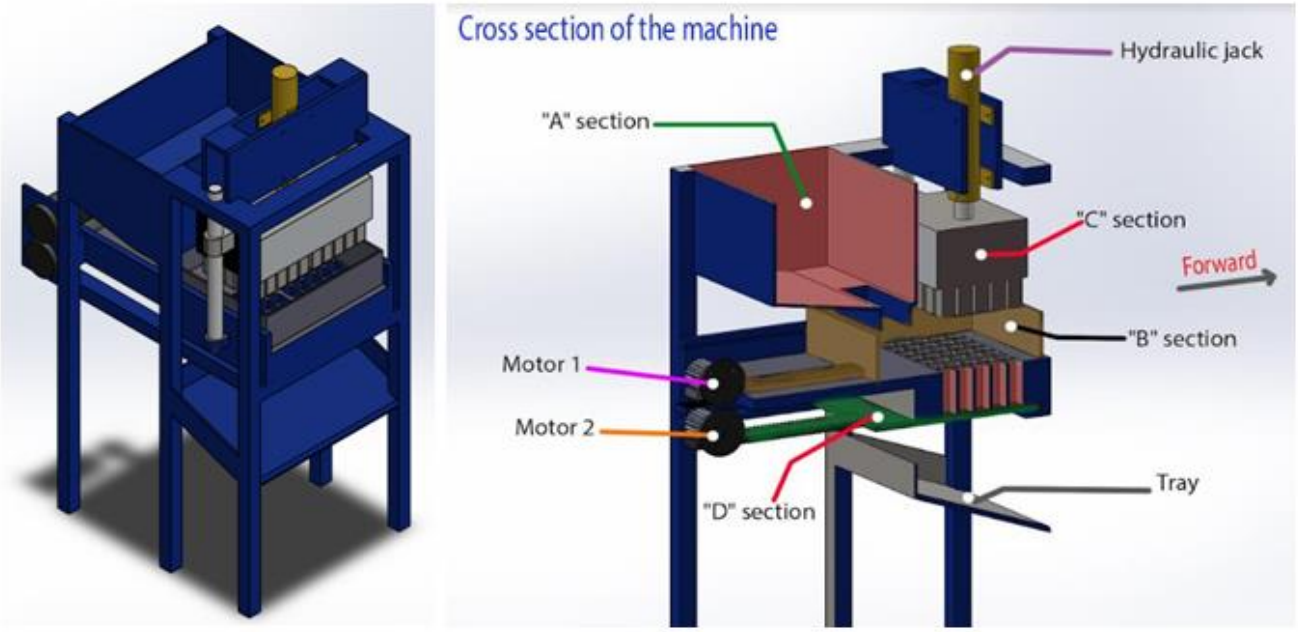

Fig. 10. Hydraulic press machine

A mixing unit for particle size reduction is implemented for proper mixing of the raw materials. A mixer with eight blades in a shaft is connected for mixing purposes. Mixing supports particle size reduction, which is important for pressing as an instant cube. The cubical shape final product is developed with the piston press machine. At once, 36 cubes can be produced, and the production time of one batch is around 1 minute. Cow bone powder and banana peel act as a binding agents for the fertilizer cubes. The developed cubes are applied to the hydroponic agricultural system to check the solubility of the fertilizer cube.

The developed fertilizer cube (FERTIPEST) was applied to the hydroponic system. The solubility is a measure for four days period to check the efficiency of the fertilizer. The fertilizer cube was applied for green chilli plants to check the impact of the instant-cube with a parallel control system without fertilizer and with compost fertilizer. At the same time, the soil sample was collected and heated to 110°C to kill all the microorganisms and arranged in three sample bags. FERTIPEST is added to one of the packets, named A, compost added to the second one as B, and the third one maintained without adding any external as C. Three parallel samples are also prepared to confirm the accuracy. Then Greenhill seeds are added to all six bags and water too. Those six packets were left under a shaded environment for two weeks while adding the required amount of water daily. After two weeks, results were observed and recorded for further evaluation.

4 RESULTS AND DISCUSSION

By changing the number of ingredients appropriately, organic fertilizer was developed as an instant cube that will suddenly dissolve in water (FERTIPEST). The plant growth speed was measured with the developed fertilizer. It takes 60% less time for the plantation to reach the same level of plant growth compared to conventional organic fertilizer. Moreover, FERTIPEST will act as a pest repellent as that has an optimized level of neem leaves and seed and the pine needles powder. The final product will come as an instant cube with dimensions of 1 inch on each side (Fig. 11). That is easy for transportation and the store and applies for agricultural purposes such as offices, indoor plants, greenhouses, and so on.

Fig. 11. Final FERTIPEST cube

Fig. 12 represent the fertilizer solubility in hydroponic system for four days period.

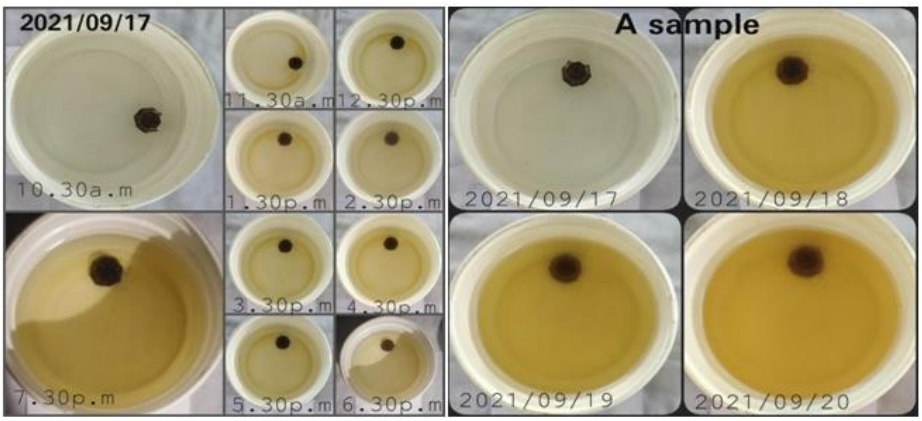

Fig. 12. Solubility of the final FERTIPEST; Left: within 8 hours, Right: within four days period

Reaction time reduces to one week from the general six weeks. That is highly important for large scale to

avoid food crops delay. Moreover, small size cube provides the same or higher amount of all nutrients required for the proper plantation, such as N, P, K, Ca, Mg, and S. The composition of the fertilizer is optimized as 4-5 :3-4: 2-3 of N:P: K ratio together with Ca and S to get the maximum outcome.

The developed fertilizer cube is tested by applying it to the hydroponic system to identify the effectiveness of the nutrient supply. According to Fig 12, it can be seen that the fertilizer cube dissolved within one week period. It will provide the nutrients for the remaining 30 days period to grow plants with adequate nutrients. Fig. 13 represent the germinated green chilli seeds for soil with cow dung (left), soil with FERTIPEST (middle), and soil alone (right) with the same amount of water for 14 days period.

Fig. 13. Chilli seeds germination after 14 days period.

Germination is successful for the sample of soil with FERTIPEST than the other two samples. The number of plants was also higher than the other two samples. Moreover, the quality of those plants is better with Fertipest added pot. It can be concluded that FERTIPEST is acting as a high efficient organic fertilizer for chilli germination.

5 CONCLUSIONS

This cube can be easily applied at all stages of the plant. FERTIPEST provides all the nutrients that the plant need in a short period. Most of the raw materials that are used to create this cube are everyday household waste. This can be recommended for the indoor cultivation of the urban population and landscaping plants in institutions. Also, the FERTIPEST is suitable for greenhouse cultivation. Finally, the suitability of the fertilizer cube for the hydroponic system is evaluated. The developed fertilizer cube has a higher solubility for the hydroponic system. Required N:P: K ratio can be achieved with the FERTIPEST with pest repellant efficacy. It will help rebuild your soil so that it's at its healthiest. It may take longer to get the results you want, but they will be well worth it in the end.

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