

A Review on the Impact of Organic, Conventional and Nano Fertilizer Application in Crop Production

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Abstract

Both organic, conventional, and nano fertilizers have advantages and disadvantages. This paper aimed to find out the three kinds of fertilizers and their efficiency in crop production and management. However, it will also depend on some factors to consider. An example is the area of farm for crop production and the capacity of a farmer to acquire such fertilizers. Organic fertilizers are bulky to carry on the farm. These require high transportation costs when compared with synthetic fertilizers. These also lower costs and can be made locally. The slow-release of nutrients into the plants is the vital action of these fertilizers. This will increase the nutrient use efficiency of a plant. The nutrients are slowly distributed into the plants making them sustainable and continually. Conventional fertilizers are not bulky to carry as compared to organic fertilizers. Since these fertilizers contain a high amount of macronutrients and have fast release. Meaning the nutrients are rapidly distributed into the plants. This will lead to elemental loss through leaching, evaporation, or volatilization, and other losses which decrease the availability of these fertilizers into the plants. Similarly, this also pollutes the environment such as water, air, and soil. On the other hand, nano fertilizers are cost-effective. Only 25% is used from the recommended rate as compared with conventional fertilizers. This is also slow-release like with the organic fertilizers. This slow-release action of nano fertilizers results in higher nutrient use efficiency. When large crop plantation, nano fertilizers is suitable while smaller farms are suitable by using organic and conventional fertilizers. This strategy resulted to crop production efficiency.

Keywords: Fertilizers application, yield impact, conventional and nanotechnology

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INTRODUCTION

Many factors can affect crop production, one of these is fertilizer. Fertilizers are the driving force to have a better crop yield, quality, and efficiency of production and most importantly the enhancement of food for human consumption. Recent advances in high-yielding varieties need a plentiful amount of fertilization. And most of these varieties need intensive use of chemicals. On the other hand, natural farming is introduced for healthier human food consumption from the farm. But it needs time for its effectivity, on which the mouth to feed is increasing. However, the soil's fertility is decreasing as it was intensively cultivated previously. It needs an increasing amount of fertility from what the plant needs. But the challenge is the price of fertilizers as of today also increases.

The increasing human population is the big challenge on how the production system works efficiently to supply human needs. As to the current observation, food production systems are all instant. In contrast, the production made shorten the inputs to have an extreme output. The question is, is it safe to consume?

This paper would be the answer to how these conventional, organic, and nano fertilizers could contribute significantly and effectively the crop production. Additionally, this also helps farmers find and choose the best inputs to use on the farm.

According to Hassani et al., (2015), the use of chemical fertilizers is essential to bridge the gap between supply and demand in food and also in soil fertility. It was also the need to have the highest yield per area of a crop planted. These chemical fertilizers may be conventional or nano fertilizers.

In connection, Ullah et al., (2008) reported that the application of both organic and inorganic fertilizers alone or combined had a significant effect on the vegetative growth of the crop. So, therefore, both these kinds of fertilizer can enhance the production of a crop. Kakar et al., (2020) also presented that the combined application of manure (organic) and inorganic fertilizer significantly improved the physiological and morphological status of crops. This paper aimed to find out the advantages and disadvantages of synthetic and organic fertilizers. Specifically, to determine the advantages of using conventional fertilizers, organic fertilizers, and nano fertilizers in crop production; evaluate the bad effects of these three types of fertilizers, and discuss its comparison related to crop production efficiency.

RESULTS AND DISCUSSION

Advantages in Conventional Fertilizers

Conventional fertilizers are synthetic fertilizers that are locally available in the market. These kinds of fertilizers are mainly composed of nitrogen, phosphorus, potassium, and other trace elements. Some of the fertilizers are compounds, which means that a bag of fertilizers contains more than one element. On the other hand, some are single elements like urea. According to Ullah et al., (2008) that conventional fertilizer's application significantly affects the fast flowering and fruiting of an eggplant crop. They also reported that soil pH gradually increased when applied with conventional fertilizers.

The above findings are also supported by Nizamuddin et al., (2003) that during the vegetative stage of potatoes, it is gradually increased as the rate of conventional fertilizers increases. Especially, the increased rate of nitrogen fertilizer. Additionally, a higher yield is obtained when the dose of conventional fertilizer is above the recommended rate, particularly in potatoes. And also increases marketable yield.

Table 1 and Table 2 below show the significant results of using conventional fertilizers on the yield and its components of potato (Nizamuddin et al., 2003). The results showed that treatment 6 which is the highest fertilizer dose had yielded the maximum as compared to other treatments. The number of tubers, including the medium and big sizes, their weight, and most importantly the marketable tubers was significantly affected by 120kg N, 150kg P₂O₅, and 75kg K₂O of conventional fertilizers, as they concluded and suggested rate.

Table 1. The Treatments Presented by Nizamuddin et al., (2003) in their study on the potato crop

Treatments	N (kg ha ⁻¹)	P ₂ O ₅ (kg ha ⁻¹)	K ₂ O (kg ha ⁻¹)
T1	0	0	0
T2	100	0	0
T3	100	50	0
T4	100	50	50
T5	150	100	50
T6	200	150	75

Table 2. The effect of conventional fertilizers on the yield of potatoes (Nizamuddin et al., 2003).

Treatments	No. of tubers m ²	% Small Tubers <35mm	% medium tubers 35-55mm	% of big tubers >55mm	Ave. Tuber wt. (g)	Yield (t/ha)	% Marketable Yield
T1	42.00d	33.67a	58.67b	7.66d	67.23e	21.00e	66.33d
T2	41.00d	26.67b	59.00b	14.33c	96.50d	27.40d	73.23c
T3	45.00c	20.00c	66.00a	14.00c	103.51c	33.00c	80.00b
T4	46.33bc	14.00d	67.34a	18.33b	110.92b	35.76c	86.43a
T5	48.00b	13.67d	66.00a	20.00ab	116.28a	38.50b	86.09a
T6	51.67a	12.67d	65.33a	22.00a	118.00a	44.10a	87.23a

The study of Janmohammadi et al., (2016) also supported the results of Nizamuddin et al., (2003). Janmohammadi et al., (2016) reported that conventional fertilizers as one of the treatments applied in fertilizing potatoes increase the height of a crop and its stems. The quickest row closure or increased ground cover of potatoes is also influenced by the application of conventional fertilizers as compared to bio-fertilizers. Application of complete conventional fertilizer increases the number of tubers and 16% increased in potato tuber yield. Moreover, also increased in harvest index and significantly increased the nitrate content. Due to nitrate content in potatoes, this also increased and improved the vegetative and tuber yield as significantly affected by complete conventional fertilizer.

Disadvantages of Conventional Fertilizers

Even though conventional or synthetic fertilizer promotes plant growth, the world's food security is met, and the plants cultivated in this manner do not acquire good plant characteristics. The consumer of this chemically produced food will accumulate in the human body, which is bad for the health.

The negative effects of chemical fertilizers will begin with the manufacturing of these chemicals, whose products and byproducts include hazardous substances or gases such as NH₄, CO₂, CH₄, and others that pollute the air. Additionally, these chemical fertilizers are high costly (Chandini et al., 2019).

Table 3. The average use of chemical fertilizers by selected countries (Savci, 2012).

Country	Amount of Chemical Fertilizer Used (kg/ha) N+P ₂ O ₅ +K ₂ O
Turkey	100.4
Netherlands	665.5
Egypt	624.8
Japan	373.2
China	301.5
Britain	287.5
Germany	205.4
France	180.1
USA	160.8
Italy	126.4
India	121.4
Greece	115.4
Indonesia	106.9

Table 3 shows the average use of chemical fertilizers kilogram per hectare from the selected countries. Netherlands and Egypt used a huge amount of fertilizers kilogram per hectare as compared to Indonesia and Turkey which are the lowest average chemical fertilizer used. Additionally, Savci, (2012) reported that most of the farms cultivated with water like aquaculture or in a greenhouse will utilize a huge amount of chemical fertilizer resulting in severely polluted water.

According to Savci, (2012) that nitrogen fertilizers reach water in three ways, these are drainage, leaching, and surface flow. Figure 1 shows the distribution of chemical fertilizers in the soil. Plants only use 50% of nitrogenous fertilizers applied to soil, 20% lost through evaporation, 20% react organic compounds in the clay soil and the remaining 10% interfere with surface and groundwater.

According to Chandini et al., (2019) that one of the serious pollutants in water from applied nitrogen fertilizers is nitrates. This could mix in groundwater which contributes to bad effects to human health as drinking water when it exceeds the intolerable amount. Bad effects such as baby blue syndrome in infants and gastric cancer in ruminants.

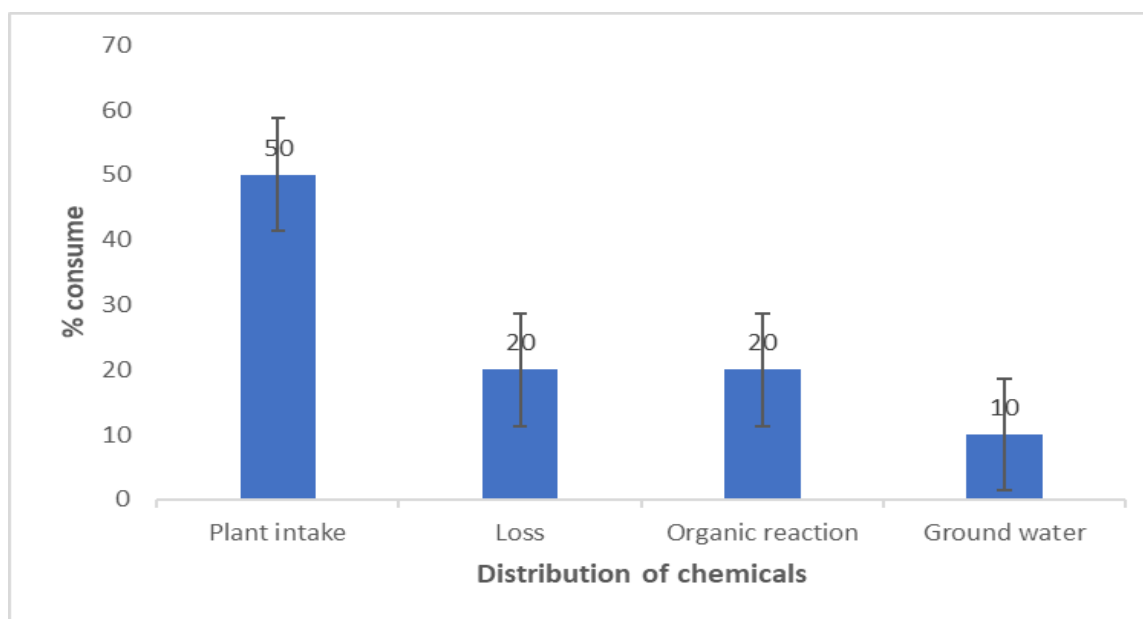


Figure 1. The Distribution of chemical fertilizers applied in the farm (Savci, 2012).

Additionally, Chandini et al., (2019) also reported that chemical fertilizer could pollute not only in water but also in soil and air. The high amount of nitrogen chemical fertilizers may contribute to harmful greenhouse gases that could decrease the protective ozone layer which results in harmful direct effects on humans. For soil pollution, a huge amount of application of chemical fertilizer may result in soil acidity and degrade soil physical and chemical properties caused by imbalance used of the essential nutrients needed by plants. This results in inefficient crop production. This is also supported by Assefa & Tadesse, (2019) that the use of conventional caused the destruction of soil texture and structure that lead to soil erosion and acidity resulting from the leaching of soils.

Advantages of Organic Fertilizers

Organic manure such as from poultry and cow have multiple benefits due to the balanced supply of nutrients, including complete micronutrients, increased soil nutrient availability due to increased soil microbial activity, the decomposition of harmful elements, soil structure improvements, root development, and increased soil water availability (Han et al., 2016).

Moreover, Ullah et al., (2008) also reported that the availability of major plant nutrients mostly macro elements is also affected by organic farming. This results in an increase of nitrogen, phosphorus, and sulfur from the applied poultry manure. And increase the availability of potassium when cow dung is applied. These was shown below in table 4. From the finding, chemical fertilizers had the lowest value of microelements than poultry manure and cow dung. In addition, Lin et al., (2019) also reported that the use of organic fertilizers can enhance crop yield and soil properties and will prevent pest and disease infestations.

Table 4. The effect of organic manure on the soil's chemical properties (Ullah et al., 2008).

Treatments	Soil pH	%OM	Total N (%)	Available P (ppm)	Exchangeable K (me/100g)	Available S (ppm)
T1	6.01c	2.05cd	0.16bc	13.12b	0.17a	12.75ab
T2	6.27ab	2.67bc	0.16bc	13.59b	0.16b	12.09ab
T3	6.13bc	3.06ab	0.17ab	14.91a	0.17a	13.50a
T4	6.38a	1.82d	0.16bc	13.10b	0.15c	12.19b
T5	6.19abc	3.57a	0.16bc	13.55b	0.16bc	12.80ab
CV (%)	2.04	4.06	3.09	5.08	3.47	5.28
Initial Value	6.36	1.98	0.12	12.59	0.14	12.02

Legend: T1-Cowdung; T2-Mustard oil cake; T3-Poultry manure; T4-Chemical fertilizer; T5-Organic 50% + inorganic chemical 50%

Moreover, Lin et al., (2019) reported that the soil pH level was significantly higher in the organic fertilizer application than chemical fertilizers. They also found out that these organic fertilizers are decreasing the number of heavy metals in the soils of tea farms. According to Assefa & Tadesse, (2019) organic fertilizers are the by-products of plant, animals, and mineral decomposition. The nutrients from it will be released slowly. This will allow the plant to process it the natural way that results in undamaged the plant. Additionally, soil drainage and air circulation improved. It also reduces soil acidity and does not cause leaching.

Disadvantages of Organic Fertilizers

Organic manure has several disadvantages, including little nutrient content of each manure, slow decomposition, and unlike nutrient compositions depending on its organic materials (Han et al., 2016).

According to Assefa & Tadesse, (2019), the increased demand for organically grown crops or food for consumption leads to expensive produce. In connection, Ullah et al., (2008) reported from the result of their study that organic manures did not increase the vegetative growth of plants, this is due to the slow release function of this kind of fertilizers.

Moreover, Ukoje & Yusuf, (2013) reported that with the growing population, the demand for food sustainability is critical. Adapting organic farming alone without the application of fast-release fertilizers will not sufficiently support the demand for food in the people of Africa.

Combination of Organic and Inorganic fertilizers

The productive results of cultivating solanaceous crops are due to the combined application of organic and inorganic fertilizers. This result is due to organic fertilizers functioning as slow-release while inorganic fertilizers are fast-release. So, the nutrients needed by plants are supplied continuously and rapidly. In addition, these results in more productive, continuous soil fertility and productivity of crops (Ullah et al., 2008).

Fertilizer Cost Efficiency

Fertilization costs accounted for 20% to 30% of the total production costs in biomass production. However, the effects of the mixed-use of chemical fertilizer and organic manure on the growth of trees and soil fertility vary significantly according to the fertilizer amounts and the organic manure characteristics. The amount of organic manure required is mainly determined by the nitrogen content. However, special attention needs to be paid because the ratios of nutrients other than nitrogen can differ from the trees' requirements (Adegbidi et al., 2003). Nano fertilizers only require 25% of the recommended rate, then the production is optimum. So, therefore, nano fertilizer is cost-effective.

Advantages of Nano fertilizer

Nano fertilizer application promoted the growth, development, and antioxidant activity in rice which have the potential to improve crop production and plant nutrition (Benzon et al., 2015). According to Astaneh et al., (2021) nano fertilizer can increase crop yield, improve soil fertility, reduce pollution and make a favorable environment for microorganisms in the soil. It also prevents nutrient loss in the soil such as leaching, evaporation or volatilization, and other ways that the nutrients needed are essential to plants.

In connection, Burhan & AL-Hassan, (2019) revealed that productivity of wheat grain yield applied with nano fertilizers increases, about 48.99%, the protein percentage has 27.24%, gluten ratio in flour has 58.45% and flag leaf area 38.69%, nitrogen has 19.37%, phosphorus has 44.11% and potassium has 12.03% as shown below in table 5.

Table 5. The effect of Nano fertilizer on the physiological traits of wheat (Astaneh et al., 2021).

Application of N fertilizer (kg/ha)	% Protein		Phosphorus (mg)		Potassium (mg)	
	Conventional N fertilizer	Nano N fertilizer	Conventional N fertilizer	Nano N fertilizer	Conventional N fertilizer	Nano N fertilizer
80	4	33	17	26	11	11
160	10	54	35	58	18	25
240	17	69	54	80	27	38

Moreover, Astaneh et al., (2021) concluded that the problem of a growing population that increases the demand for food and the problem of environmental pollution, nano fertilizers can help provide a solution on this issue. Accordingly, they also recommended that conventional fertilizers are good to be replaced by nano fertilizers especially in some soil types that are prone to leaching.

The study of Abdel-Aziz et al., (2021) revealed that the 25% concentration NPK nano fertilizers promote the growth of crops and showed better results with fruit yield and quality. So, it is more effective with low concentration application of NPK nano fertilizers into the crops than synthetic or conventional chemical fertilizers.

Khalid et al., (2021) also presented the result of their study that nano fertilizers help increase morphological parameters of the crop by 50–93% while 28–50% only when applied with conventional fertilizers and the increase in chlorophyll content of about 30-80% is observed when nano fertilizers are applied.

Disadvantages of Nano fertilizers

According to Abdel-Aziz et al., (2021) that their results from the study suggested that it needs future research about toxicological studies about nano fertilizers. In which they believe and observed that this nano fertilizer may have a toxic substance that might affect the health of humans and animals.

Conclusion and Recommendation

This paper finally found out that these three kinds of fertilizers have also provide an efficient nutrients needed by the crop. However, it will also depend on some other factors to consider in crop production and management. An example is the type of the soil in the farm for crop production and the capacity of a farmer to acquire such fertilizers. Organic fertilizers are bulky to carry on the farm. These require high transportation costs when compared with synthetic fertilizers. These also lower costs and can be made locally. The slow-release of nutrients into the plants is the vital action of these fertilizers. This will increase the nutrient use efficiency of a plant. The nutrients are slowly distributed into the plants making them sustainable and continually. Conventional fertilizers are not bulky to carry as compared to organic fertilizers. Since these fertilizers contain a high amount of macro-nutrients. On which function as fast release. Meaning that the nutrients are rapidly distributed into the plants. This will lead to elemental loss through leaching, evaporation, or volatilization, and other losses which decrease the availability of these fertilizers into the plants. Similarly, this also pollutes the environment such as water, air, and soil. Nano fertilizers are cost-effective. Only 25% is used from the recommended rate as compared with conventional fertilizers. This is also slow-release like with the organic fertilizers. This slow-release action of nano fertilizers results in higher nutrient use efficiency or NUE. When large crop plantation, nano fertilizers is suitable while smaller farms are suitable by using organic and conventional fertilizers. This results to crop production efficiency. Nutrient use efficiency (NUE) is a critically important concept in the evaluation of crop production systems. The objective of nutrient use is to increase the overall performance of cropping systems by providing economically optimum nourishment to the crop while minimizing nutrient losses from the field.

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