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Comparing the Efficacy of Organic and Inorganic Fertilizers on the Growth of Maize (*Zea mays* L.) Plant

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Abstract

Maize (*Zea mays* L.) is the most important cereal worldwide. This experiment was aimed to determine the effect of organic and inorganic fertilizers on the growth of maize plant (*Zea mays).* The maize seeds that were used during this experiment were obtained from Dutsin-ma market. Each bag containing one seed which make them fifteen, the bags were then divided into three, five of which organic fertilizer was used, while the other five contained inorganic fertilizer, while the last five were kept as control. The experiment was arranged in complete randomized design (CRD). Maize plants treated with inorganic fertilizer was found to have a significant growth on maize plant height with 6.26cm, 22.02cm, 46.2cm, and 77.7cm at week one, two, three, and four after planting, respectively. Maize plants treated with organic fertilizer were having 6.02cm, 22.66cm, 32.64cm, and 62.32cm at week one, two, three, and four after planting respectively. The least growth was observed on control which was having 3.98cm, 16.8cm, 24.58cm, and 37.36cm at week one, two, three and four after planting respectively. On the number of leaves, organic fertilizer was found to have 2, 8, 18, and 10 number of leaves at week one, two, three and four after planting, respectively. Also, maize seedlings treated with inorganic fertilizer were having 2, 8, 10, and 14 leaves at week one, two, three, and four after planting, respectively. The least were control seedlings having 2, 6, 6, and 8 number of leaves at week one, two, three and four after planting, respectively. The inorganic fertilizer was found to be more effective on the growth of maize plant. A full-scale testing should be carried out on the effect of organic and inorganic fertilizer on the growth of maize seedlings under field condition.

Keywords: efficacy; fertilizers; inorganic; organic; maize

Introduction:

Maize (*Zea mays* L.) is the most important cereal worldwide (Adebayo *et al*., 2017; Bashir *et al*., 2018). USA, China and Brazil contribute 63% of the global maize production while Mexico, Argentina, India, Ukraine, Indonesia, France, Canada and South Africa are also major maize producing countries (Bashir *et al*., 2017a&b; FAO, 2010). Many factors like soil fertility, imbalanced nutrition, disturbed soil properties, cultivars being grown weed infestation etc. limit its yield worldwide. Different management practices are adopted to increase and optimize the maize yields. For example, use of organic manures and inorganic fertilizers often lead to increased soil organic matter (SOM), soil structure, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity (CEC) and soil's biological activity (Sathya *et al*., 2009). Although chemical fertilizers are important input to get higher crop productivity, but over reliance on chemical fertilizers is associated with decline in some soil properties and crop yields over time (Groove and Summer, 2005). Therefore, the use of inorganic and organic fertilizers is a sustainable approach for efficient nutrient usage which enhances the growth and yield of many plant varieties efficiently while reducing nutrient losses (Bashir *et al*., 2014; Bashir *et al*., 2016; Shahzad *et al*., 2015). but sole application of farmyard manure (FYM) resulted in increased yield of maize (Adebayo *et al*., 2012), higher SOM content (44%), improved soil porosity (25%) and 16 times more water holding capacity (Musa *et al*., 2017). A long-term residual effect on soil organic C and soil P (about 7 to 8

years). Organic manures also affect the soil biological activity (Agele, 2003), while enhanced phosphorous (P) availability is also well reported with the application of organic manures in the soil (Adebayo *et al*., 2017; Musa *et al*., 2017a&b). Ancient farmers used to rely on organic manures for crop production that proved good for soil health but was slow in response on crop yields. Now, swift economic development has led the farmers to use mineral fertilizers as they are more economical, affordable, easy to use and quick in response. However, their intensive application is leading to land degradation, deteriorated soil health and leaching of nutrients into the underground water thereby posing environmental risks to human and animal health. So, there is a need to draw a mid-way between organic and inorganic extremities that may sustain crop yields without deteriorating soil fertility and/or productivity. Keeping all these aspects in consideration, the present study was therefore conducted to compare the efficacy of organic and inorganic fertilizers on growth and yield of maize.

Inorganic and Organic fertilizers are both beneficial on plants growth, but the use of organic fertilizers is more suitable and eco-friendlier. It has been observed that organic and inorganic fertilizers have demonstrated good efficacy against the growth of maize plants (*Zea mays)*.

Application of organic materials as fertilizers provides growth regulating substances and improves the physical, chemical and microbial properties of soil for plant growth (Adebayo *et al*., 2017). Plants need nitrogen, phosphorus, and potassium, as well as micronutrients and symbiotic relationships with fungi and other organisms to flourish, but getting enough nitrogen, and particularly synchronization so that plants get enough nitrogen when they need it most, is likely the greatest challenge for organic farmers (Kihanda *et al*., 2006). Organic farmers also use animal manure, certain processed fertilizers such as seed meal and various mineral powders such as indigenous rock phosphate (Sheng-wei *et al*., 2009) and greensand, a naturally occurring form of potash which provides potassium, to maintain soil fertility.

Fertilizers are classified in several ways. They are classified according to whether they provide a single nutrient (e.g., K, P, or N), in which case they are classified as "straight fertilizers." "Multi nutrient fertilizers" (or "complex fertilizers") provide two or more nutrients, for example N and P. Fertilizers are also sometimes classified as inorganic and organic. Inorganic fertilizers exclude carbon-containing materials except urea. Organic fertilizers are usually (recycled) plant- or animal-derived matter. Inorganic are sometimes called synthetic fertilizers since various chemical treatments are required for their manufacture. (Bilbao *et al*., 2005). Organic fertilizers are made of decomposed material originating from living organisms which creates compost and can be combined with different manures. The decomposition process occurs through the action microorganisms in the soil which make nutrients in this material available for absorption by plants. Organic fertilizer is applied to the soil in its natural form, in pellets form or granules. Organic fertilizers release their nutrients slowly into the soil and it is applied to plant area well before they are required by the plant. This will prevent nutrient deficiency for the growth of maize plant or other plants (Mahmoud *et al*., 2007).

Inorganic fertilizers or chemical fertilizers are a man-made combination of elements and fossil fuels, which are formulated and manufactured to the prescribed ratios required by various crops. Chemical fertilizer is more immediate in its action than organic fertilizer and is available to the plant soon after it's applied in granule or in liquid form. Excessive use of chemical fertilizer alone can lead to a build-up of salts and a reduction of microbes in the soil, which causes leaching of the soil. This remedied by putting organic material like compost or manure back into the soil and by planting nurseries and ploughing them back into the soil (Redfern *et al*., 2014).

Nitrogen is a key component in many of the processes needed to carry outgrowth. In particular, nitrogen is vital to chlorophyll, which allows plants to carry out photosynthesis (the process by which they take in sunlight to produce sugars from carbon dioxide and water). Nitrogen is also a significant component in amino acids, the basis of proteins. Nitrogen also aids in the compounds that allow for storage and use of energy (Oshundiya *et al*., 2014). One study looked at US cereal yields and how they were affected by omitting nitrogen fertilizer. The study estimated that without nitrogen, average yields for corn declined by a staggering 41%, rice by 37%, barley by 19%, and wheat by 16%. While nitrogen can be taken in and converted into a usable nutrient from the atmosphere, and may be naturally present in soils, it is almost always desirable to supplement nitrogen to ensure plants have the optimum amount available to them. The following materials can be included in NPK blends as a source of nitrogen: (Wintermans and Mots 1965). Urea, urea ammonium nitrate, anhydrous ammonia, common organic sources of N in NPK blends, manure, compost, blood meal and feather meal.

Phosphorus also plays a role in an array of functions necessary for healthy plant growth, contributing to structural strength, crop quality, seed production, and more. Phosphorus also encourages the growth of roots, promotes blooming, and is essential in DNA. The transformation of solar energy into usable compounds is also largely possible because of phosphorus. (Agele and Taiwo, 2013). Like nitrogen, phosphorus in NPK fertilizer can come from both organic and inorganic sources: Common Inorganic Sources of Phosphorus in NPK Blends

The primary source of inorganic phosphorus is phosphate rock. Crushed phosphate rock can be applied to soils directly, but it is much more effective if processed to be more readily available for plant uptake. Common Organic Sources of P in NPK Blends, Manure, Compost, Bio-solids, Blood Meal, Bone Meal (Oshundiya *et al*., 2014).

Potassium is also vital in a variety of other processes that contribute to growth and development. Potassium is often referred to as the "quality element," because of its contribution to many of the characteristics we associate with quality, such as size, shape, color, and even taste, among others.

Plants lows in potassium are stunted in growth and provide lower yields. Potassium can be obtained from a wide range of sources, both organic and inorganic: The primary inorganic source of potassium for use in NPK fertilizers is potash. Like phosphate rock, potash is mined all over the world and processed into a more refined product. Potassium can also come from potassium sulfate, langbeinite, and granite dust. The common organic sources of K in NPK blends, manure, compost, wood ash.

Different fertilizers both organic and inorganic have been used and are still in use to improve the growth of varieties of plants all over the world. In Dutsin-ma local government where the experiment was carried out, the practice of using poultry feces, chemical fertilizers, and animals' dung were found to be used by farmers, and some researchers because the inhabitant of the area are mostly farmers. Despite the use of these fertilizers little or no work has been done to compare the efficacy of those fertilizers. Hence there is a need to compare the effectiveness of both organic and inorganic fertilizers on maize plant so as to know which is more effective on the plant growth. The aim of this study was to determine the effect of organic and inorganic fertilizers on the growth of maize plant (*Zea mays*).

Materials and Methods:

Study area:

Dutsin-ma is a local government area in Katsina state; it is located in the Sudan savanna zone of the central part of the state, relatively bounded by Safana and Danmusa Local Government, to the west Kurfi and Charanchi to the east Matazu and Danmusa Local Government in the South. In absolute terms, Dutsin-ma town is found within the climate area of semi-arid and classified as tropical wetland and dry climate (AW) as classified by W.K Oppen maximum and minimum temperature is about 20° C in December and January periods.

Dutsin-ma local government has a total area of 527km² (203sqm) and elevation of about 605m (1,985ft), coordinate of 12° 27¹ 18"N 7°29'29"E. The main occupation of the of the people of the area is farming of cereals and cash crops which include maize, millet, beans, soybeans, groundnut etc.

Maize seeds used:

The maize seeds that were used during this experiment were obtained from Dutsin-ma market. 30 seeds of maize were used for the experiment which were planted inside 15 polythene bags containing up to a half of the bag with soil sample, which was collected from the Department of Biological Sciences, Federal University Dutsin-ma garden. Each bag containing one seed which make them fifteen, the bags were then divided into three, five of which organic fertilizer was used, while the other five were for inorganic fertilizer, while the last five were kept as control.

Maintenance of the plants:

The samples were kept for four weeks and they were watered every day during the period of the experiment, while the fertilizers were applied every week and the growths of the plant was measured weekly interval, with a measuring ruler to determine the growth parameters Bashir *et al*., 2017b. The quantity of fertilizer use was half teaspoon which was equivalent to 3grams per each bag for inorganic fertilizer while for organic one tablespoon which was equivalent to 15 grams was used.

Inorganic fertilizer:

Five polythene bags were used each containing up to a half of loamy soil collected from the Departmental garden, and each containing one seed of maize, the bags were watered for a day to become moist before planting, after a day the seeds were then planted. Fertilizer was applied one week after planting and the measurement of the growth parameters was taken at weekly interval.

NPK 15:15:15 fertilizer was used, and the amount of fertilizer used was half of teaspoon which is equivalent to 3 grams.

Organic fertilizer:

Chicken feces or chicken manure was used as organic fertilizer, which was measured as one tablespoon for each bag, which was equivalent to 10 grams. It was applied after the seed began germinating, the growth of the plant was measured at the interval of one week.

Control seeds:

Five bags were kept as control they neither contain any of the fertilizers organic or inorganic. They were watered regularly, and the growth was measured at the interval of one week.

Results:

Effect of fertilizer type on plant height in maize seedlings:

Maize plants treated with inorganic fertilizer was found to have a significant growth on maize plant height with 6.26cm, 22.02cm, 46.2cm, and 77.7cm respectively at week one, two, three, and four after planting, respectively. Maize plants treated with organic fertilizer were having 6.02cm, 22.66cm, 32.64cm, and 62.32cm at week one, two, three, and four after planting respectively. The least growth was observed on maize seedlings without any treatment (control) which was having 3.98cm, 16.8cm, 24.58cm, and 37.36cm at week one, two, three and four after planting respectively, as presented in Table 1.

Treatments	Week 1 after planting (cm)	Week 2 after planting (cm)	Week 3 after planting (cm)	Week 4 after planting (cm)
Inorganic fertilizer	6.26±0.02^{a}	22.02±0.01^{a}	46.20±0.20^{a}	77.70±0.00^{a}
Organic fertilizer	6.00±0.03^{a}	21.60±0.02^{a}	32.64±0.02^{b}	62.32±0.01^{b}
Control	5.78±0.00^{b}	16.80±0.04^{a}	24.58±0.00^{c}	37.36±0.02^{c}

Table 1: Efficacy of inorganic and organic fertilizers on the growth of maize for plant height

Effect of fertilizer type on root length in maize seedlings:

The effect of two types of fertilizers on the root length of maize at fourth week, the seedlings with organic fertilizer were having root length of 34 cm, while seedlings with inorganic fertilizer were having 48 cm and the control seedlings were having 26 cm, respectively (Figure 1).

Control (a) **Organic (b)** **Inorganic (c)**

Figure 1: The efficacy of organic and inorganic fertilizers on maize root length

Effect of fertilizer type on the number of leaves in maize seedlings:

Maize seedlings tested with two fertilizers have an effect on the number of leaves with organic fertilizer having 2, 8, 18, and 10 number of leaves at week one, two, three and four after planting, respectively. Also, maize seedlings treated with inorganic fertilizer were having 2, 8, 10, and 14 leaves at week one, two, three, and four after planting, respectively. The least were those with no fertilizer (control) and were having 2, 6, 6, and 8 number of leaves at week one, two, three and four after planting, respectively as presented in Table 2.

Treatments	week 1 after planting	week 2 after planting	Week 3 after planting	Week 4 after planting
Organic	2.00±0.20^{a}	8.23±0.02^{a}	8.00±0.00^{b}	10.12±0.02^{b}
Inorganic	2.11±0.05^{a}	8.33±0.00^{a}	10.00±0.00^{b}	14.40±0.00^{a}
Control	2.00±0.02^{a}	6.50±0.02^{b}	6.41±0.03^{c}	8.10±0.06 c

Table 2: Effect of inorganic and organic fertilizers on the growth of maize for number of leaves

Discussion:

Based on the results obtained inorganic fertilizer was found to be more effective on the growth of maize plant, it was followed by organic and control respectively. Earlier studies on inorganic fertilizer have shown that it contains a total amount of nitrogen, phosphorus and potassium which are both at same concentrations which make the fertilizer more effective for plant growth (Mehasen *et al*., 2012; Musa *et al*., 2017). The results of this experiment compared to other similar research works on the use of inorganic fertilizers shows that, various NPK fertilizers can also be used with different ratios of nitrogen, phosphorus and potassium and they were also effective for the growth of plant. It rapidly increases the rate of germination of plant which makes it more effective for the growth of plant (Musa *et al*., 2017).

The organic fertilizer used was poultry manure or fertilizer (chicken feces) which was also applied in powdered form on top of the soil and then watered which allows it to penetrate through the soil and was also effective for the germination of plants. And the growth rate of the plants containing organic fertilizer was appreciable. Organic fertilizer was found to be safer to use because of it natural origin and environment friendly.

Based on the results obtained the inorganic was found to be more effective due to a significant growth of the plants followed by organic fertilizer and then the control seedlings, which also germinate but the rate of germination was very slow and out of the five samples of the control seeds each containing one seed, three out of the five seeds germinated faster, while the rate of germination for the other two was very slow. So, without the application of any fertilizer the plant growth will be slow which will take much time for the seeds to germinate and delayed harvesting of crops which might lead to loss of agricultural produce, stunted growth and lesser yield.

Conclusion:

The inorganic fertilizer at a concentration of 3grams was found to be more effective than the organic fertilizer, after been tested to

determine the growth of local maize seedlings. Similarly, it was also observed to enhance germination. A full-scale testing should be carried out on the effect of organic and inorganic fertilizer on the growth of maize seedlings under field condition. More researches should be carried out in order to come up with varieties of fertilizers to improve the performance of different crops for human consumption.

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