The Effect of Tilapia Excreta on the Growth of Jumbo Sweet Pepper Plants

Abstract: This research was carried out using fish excreta as a fertilizer treatment for sweet pepper plants. The fish excreta solution was obtained from a tank containing a species of tilapia Oreochromis mossambicus. Sweet pepper plants (Capsicum annuum var. annuum (Grossum Group) 'Jumbo Sweet F1') were grown in three (3) different beds, while each bed was treated with a different fertilizer treatment; fish excreta, cow manure and N.P.K 6.25.25. The difference in vegetative growth, reproductive yield and effect of the fertilizers on the soils pH was observed and recorded. The differences in vegetative growth recorded for the plants treated with fish excreta compared to cow manure and N.P.K treatments were not statistically significant. The total weight of fruit harvested on plants treated with fish excreta was significantly higher than the weight of fruit yielded from the plants treated with N.P.K and cow manure. The soil pH of the cow manure and the fish excreta treatment stabilized at a range which was suitable for the sweet pepper plants between pH 5.5 and pH 7.5, whilst soil pH of the N.P.K treatment expressed a drastic decrease to a more acidic pH range below the tolerance level of the plants.

Keywords: Tilapia Excreta, Sweet Pepper, cow manure, fish excreta, N.P.K 6.25.25, vegetative growth.

INTRODUCTION

Aquaponics refers to a system whereby conventional aquaculture is combined with hydroponics in a symbiotic environment (Rogosa, 2006). Aquaculture which is commonly referred to as aquafarming is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions (Klinger, 2012). Hydroponics on the other hand is a subset of hydro-culture and is a method of growing plants using mineral nutrient solutions, in water, without the presence soil (Douglas, 1975). The fish waste from aquaculture tanks provides an organic food source for the growing plants and the plants provide a natural filter for the water the fish live in. The third participants are the microbes (nitrifying bacteria) and composting red worms that thrive in the growing media. They do the job of converting the ammonia from the fish waste first into nitrates, then into nitrates and the solids into vermi-composted food for the plants.

This present studies were designed to investigate the effect of fish excreta on the growth of Sweet pepper plants (Capsicum annuum var. annuum (Grossum Group) 'Jumbo Sweet F1') grown in soil. The waste excrement from a fish tank containing indigenous species of tilapia Oreochromis mossambicus (Mozambique tilapia) was used as fertilizer treatment for the sweet pepper plants. Observations were made on plants in terms of vegetative as well as reproductive growth. The effect of the fish excreta on the plants was compared with using NPK inorganic fertilizer (6.25.25) and cow manure.

Jumbo Sweet F1 is a variety of Sweet pepper which is a member of the Capsicum family. Its botanical name is Capsicum annuum var. annuum (Grossum Group) 'Jumbo Sweet F1'. Jumbo Sweet F1 grows as a Vegetable. It tends to grow best over the course of a single year. Jumbo Sweet F1 is known for growing to a height of approximately 1.79 feet (that’s 55.0 cm in metric). Jumbo Sweet F1 Pepper is normally fairly low maintenance and quite easy to grow, as long as a level of basic care is provided throughout the year. Jumbo Sweet F1 needs a potting mix, loamy and silty soil with a pH of 5.5 to 7.5 (weakly acidic soil to weakly alkaline soil) (Old Farmer’s Almanac, 2016).

During late 2005 early 2006, the Government of Guyana called for a Fast Track Sector Development Plan to address commercial aquaculture. Based on research and Guyana’s natural competitive advantages, it was decided that aquaculture should take a front-seat position as a key element of the diversification of Guyana’s rich natural resources, and a movement away from its potentially debilitating dependence on traditional crops such as rice and sugar.
Far earlier than that, though, the 1950’s brought the introduction of two species of Tilapia, the *Oreochromis mossambicus*, and later the introduction of the Red Tilapia (*Oreochromis niloticus*). Presently, Tilapia is considered part of the natural order in Guyana, and it is common to see scenes of fishermen casting nets into canals and lakes to reap Tilapia, which is then sold in local markets (Aquaculture Prospectus for Guyana, 2008).

*Oreochromis mossambicus* are freshwater and brackish water inhabitants. These tilapias live in warm, weedy pools or sluggish streams, canals, and ponds. They are mainly diurnal. They occur at temperatures ranging from 8º to 42º C. The female tilapias usually incubate the spawn; in aquaculture apparatus the males are removed immediately after spawning. These fishes are omnivorous, they feed on almost anything from algae to insects, crustaceans and other fishes. They can spawn all year around in warm water (above 20º C) (Froese, 2003).

Today aquaponics had been developed as an economical and ecologically friendly method of farming. it utilizes the nutrient rich water from aquaculture that otherwise would have been a waste product or would need to be filtered in a costly manner. Aquaponics eliminates the cost and time involved with mixing traditional hydroponic nutrients. Aquaponics provides a truly organic, natural form of nutrients for the plants. By eliminating the soil in vegetable production it eliminates all soil borne disease. Aquaponics uses a fraction of the water that traditional field production does because no water is wasted or consumed by weeds. In aquaponics, plant spacing can be very intensive, allowing growth of more plants in a given space (Nelson, 2010).

The fishes add nutrient to the water which boosted the rice field’s fertility and reduced fertilizer requirements. Integrating aquaculture with agriculture results in an efficient nutrient use through product recycling since many of the agricultural by-products can serve as fertilizer and feed inputs to aquaculture. This in turn leads to more fish for the household and can put more cash in farmer’s pockets. An important side effect is a cleaner and healthier rural environment. (Halwart, 2004). The majority of organic fertilizers can be prepared locally or on the farm itself. Hence, the cost of these fertilizers is much lower than the cost of chemical fertilizers. In addition to the on-farm production possibilities of organic fertilizers, organic fertilizers help in maintaining the soil structure and increasing its nutrient-holding capacity. Therefore, a farmer who has practiced organic farming for many years will require far less fertilizer, because his soil is already rich in essential nutrients. Organic fertilizers ensure that the farms remain fertile for hundreds of years. Land located at the site of ancient civilizations, such as India and China, are still fertile, even though agriculture has been practiced there for thousands of years (Maeder, 2002).

**MATERIAL AND METHODS:**

**Growing plants**

A plastic seed tray was filled with sieved organic potting soil. The potting soil was moistened and compacted into the compartments of the plastic tray. A single seed was placed into a hole made by a thumb in each seed compartment. After the seeds were distributed to the compartments, the seeds were covered with a thin layer of organic potting soil and were gently tapped to set. Seed tray was kept moist until germination.

After germination young seedlings were watered twice daily and exposed to mild direct sunlight. Watering was done by submerging the bottom of the seed tray in a vessel of water so that water could enter the wholes on the bottom of each compartment moistening the soil. This was done to prevent watering from above where the force of the water could break off leaves and break the young stems causing damage to the seedlings. The seedlings were kept in seed trays for three (3) weeks then they were transplanted to garden apparatus.

**Selecting and preparing soil**

The soil was selected based on the plants pH requirement which ranges from pH 5.5 to pH 7.5. Soil was collected and transported to gardening site, where it was placed to dry so that all moisture would be removed in order for accuracy in weighing the amount of soil used for each crate.
Constructing and preparing garden crates

Three (3) wooden garden crates were constructed using the following dimensions: length 106cm (42”), width 56cm (22”) and depth 40cm (16”). 180kg of soil was placed into crate number 1 and 2. Crate number 3 was filled with 160kg of soil and 20kg composted cow manure. The other 2 crates were left with soil only.

Transplanting seedlings

A total of six (6) seedlings that were three (3) weeks old were transplanted from seed tray to each crate. Seedlings were planted 10” to 12” inches apart from each other in each crate.

Fertilizer treatments

A week (7 days) after seedlings was transplanted to the crates, crate number one was treated with N-P-K 6.25.25 at a dosage of 5grams per plant and crate number 2 was treated with fish excreta solution diluted to a nitrate level between 10 to 15ppm at a dosage of 5ml per plant. Treatments were done on a weekly interval until the end of the project.

Preparing Fish excreta solution

Indigenous species of tilapia Oreochromis mossambicus was collected from a nearby aquaculture firm, the fishes ranged in size between 6cm to 8cm in length. Seventy-five (75) fishes were placed into a 50-gallon tank that was modified into a rearing tank. The fishes were fed daily with a mixture of local rice bran and chicken feed. The tank was aerated using an electric aquarium oxygen pump to ensure an adequate supply of oxygen for the fishes. One (1) week after fishes were introduced to the tank, nitrate level was tested and monitored. If the water tests exhibit a nitrate level ranging between 10 and 15 ppm it was applied as it is to the plants. If the nitrates rise above 35ppm it was diluted before it is applied to plants further before it is applied to the plants. Water in the tank was changed once the nitrates test exceeds 20ppm because a buildup of nitrates in tank could be harmful to towards the fishes.

Testing soil pH

All pH testing was done using an Etekcity 0.05pH High Accuracy Pocket Size Digital Laboratory PH Meter. A small measured amount of soil sample was collected from the sites; collected samples were well labeled to prevent any misplacement. An equal amount of distilled water was mixed into each soil sample and left to settle. The pH meter was uncapped, turned on and vertically placed into the samples so that the sensors came into contact with the solution, the meter was held still until the reading stabilized. The sensors were washed with distilled water and dried after and before every testing.

Harvesting

The sweet peppers were harvested as soon as they reached a full grown size and started to turn from a dark emerald to a lime-green color. A sharp knife was used to cut peppers clean off from the plants, leaving a short stub of stem attached to the fruit. Pulling peppers by hand can cause entire branches to break off. Harvested peppers were rinsed with tap water and patted dry with a dry piece of cloth. The peppers harvested from the plants grown with different treatments were kept in separate bags that were well labeled to avoid any mixing that would affect the accuracy of the result.

RESULTS AND DISCUSSION:

Figure 1. Average number of leaves

*Figure 1* represents the average number of leaves counted on the plants grown using the different fertilizer treatments.
According to the graph, plants treated with cow manure unveiled an average count of 23.32034483 leaves per plant while plants treated with N.P.K exhibited a smaller average amount of 19.95862069 leaves; however, plants treated with fish excreta displayed an average amount of 25.08724138 leaves which is a larger average than plants grown with cow manure and treatments of N.P.K. Based on a single factor ANOVA data analysis, \( p\)-value = 0.599550473 thus these averages displayed on figure 1 above representing the differences in average amount of leaves per plant are considered statistically not significant since the \( p\)-value is >0.05.

Figure 2. Average size of leaves

Figure 2 represents the average size in centimeter (cm) of leaves produced by the plants grown with different fertilizer treatments. As the graph depicts, leaves of plants treated with cow manure revealed an average size of 9.47586cm, while plants treated with fish excreta exhibited a larger average leaf size of 9.76896cm. Plants treated with N.P.K however shows a leaf size average of 8.82758cm, which is a smaller average leaf size than both the plants treated with cow manure and plants treated with fish excreta. Using a single factor ANOVA data analysis a \( p\)-value = 0.765230461 was given, thus the averages illustrating the differences in size of leaf of the plants grown with different fertilizer treatments on figure 2 above are considered statistically not significant since the \( p\)-value is >0.05.
Figure 3 represents the average height of plants in centimeter (cm) recorded for the plants grown with the three different fertilizers treatments. The plants grown with cow manure shows an average height of 29.25862cm, while plants treated with N.P.K exhibited an average height of 28.60344cm. However plants treated with fish excreta show an average height of 37.78137cm which is taller than both the plants grown with cow manure and N.P.K treatments. A $p$-value=0.269586071 was calculated from single factor ANOVA data analysis, thus the differences in average heights of the plants grown with different fertilizer treatments displayed on figure 3 above are considered statistically not significant since the $p$-value is >0.05.

Figure 4 illustrates the stem circumference or the stem thickness in centimeter (cm) of the plants grown with different fertilizer treatments. The plants grown with cow manure show an average stem circumference of 2.25344cm, while plants grown with N.P.K show a thinner stem circumference of 2.03448cm. However, plants treated with the fish excreta unveil a thicker stem circumference average of 2.38965cm. Based on a single factor ANOVA data analysis, $p$-value=0.706588562, thus differences in average stem circumference displayed on figure 4 above are considered statistically not significant since the $p$-value is >0.05.
Figure 5 represents weight of fruit in kilogram (kg) harvested from plants grown with the three (3) different fertilizer treatments. The graph displays weight taken at each of the 4 harvesting intervals along with a total of the entire harvest. The total weight of fruit harvested for the treatments shows that plants treated with cow manure measured to a weight of 5.469kg, while fruits harvested from plants treated with N.P.K measured to a lesser weight of 3.318kg. Plants treated with fish excreta exhibited a greater yield than both the plants treated with cow manure and N.P.K with a total weight of 5.912kg. Based on a single factor ANOVA data analysis a p-value of 0.005778504 was given, thus the differences in weight of plants displayed on figure 5 above are considered statistically significant since the p-value is <0.05.

Figure 6. Change in soil pH

Figure 6 represents a line graph illustrating the changes in soil pH as it was influenced by the different fertilizer treatments. As the line graph depicts the soil pH of the cow manure treatment and fish excreta treatment were closely together moving slightly up to a more alkaline condition, however the soil pH of the N.P.K treatment drastically decreased to a more acidic pH range.

DISCUSSION:
The effect of the different fertilizer treatments on the growth and production of the sweet pepper plants

Based on the result, even though the differences in the vegetative growth were not statistically significant; fish excreta however exhibited best results in terms of leaf size, number of leave and height of plant compared to the other two treatments.

The fish excreta contained nitrates; nitrates are known to be the most readily assimilated form of nitrogen by plants and are essential for plant growth and survival (cropnutrition, 2013). Nitrates are one of the three forms of nitrogen found in soil that plants use to grow and produce chlorophyll and proteins. It is a component of DNA, which transfers genetic information cell reproduction and plant reproduction (Shapiro, 2005). Nitrate ions (NO$_3^-$) builds proteins and stimulates plant growth; nitrates are used in making of amino acids and amino acids are the building blocks of protein (Gunnars, 2012).

Nitrate stimulates the IAA (indole-3-acetic acid) and Auxins of the plants, initiating great terminal growth. Auxins are plant growth hormones which cause the elongation of cells in shoots and are involved in regulating plant growth. These hormones play important roles in a number of plant activities, which includes: development of the embryo, leaf formation, phototropism, gravitropism, apical dominance, fruit development, abscission and root initiation and development. Auxin does not only elongate cells, but it specifically elongates them in response to the environment (Petrášek, 2011). Thus the plants treated with fish excreta exhibited a leading vegetative growth as compared to N.P.K treatments and cow manure.

The effect of the different fertilizer treatments on the pH of the soil

Sweet peppers are known to best flourish at a pH range of 5.5 to 7.5 (Votava, 2013). However when growing vegetables there is always a goal to keep the soil’s pH within 0.5 of the actual tolerance range of the plants (Quinlan, 2010).
In vegetable crops, high levels of soil acidity would affect the dispersal of other important nutrients in the soil inhibiting the plant's ability to absorb these nutrients. The University of Arizona Cooperative Extension states “In a very acidic soil, macronutrients such as calcium, magnesium and phosphorous are not absorbed while others reach toxic levels” (Troeh, 2005).

During week 3 of treatment, the leaves of plants treated with N.P.K began yellowing and eventually fell off. This was assumed to be a result of the increase in acidity of the soil’s pH caused by an overdose of N.P.K fertilizer. Thus, N.P.K treatments were stopped for a week in order to allow the plants to utilize the excess nutrients that were present in the soil.

Figure 6 illustrates that the soil pH of cow manure treatment and fish excreta treatment were equivalent throughout the 8 weeks period, that is, a pH range suitable for the growth of sweet pepper plants. However, the soil pH of the N.P.K treatment started to express a drastic decrease from week 3 to a more acidic pH, that is, below the tolerance level of the plants. N.P.K is an ammonium based nitrogen fertilizer which accounts for the decline in soil pH level. Though nitrogen is a key element in plant growth excessive amounts can lead towards a slower growth. Excessive nitrogen that is not used by plants are leached out in the soil, increasing the soil’s acidity (Mangan, 2015). Low pH in soil, affects the microbial activity within, limiting the symbiotic relationship they share with the plants. Thus, affecting the plants’ growth. (Bolland, 2004).

While ammonium-based fertilizers have the greatest potential to acidify soil; fish excreta and other nitrate-based products are known to be the least acidifying of all nitrogen fertilizers (cropnutrition, 2013). Thus the pH range tested on soil treated with Fish excreta remains at a stable range which was suitable for the sweet pepper plants.

REFERENCES:
12. (2016). Old Farmer’s Almanac. 1121 Main Street, P.O. Box 520, Dublin, NH: Yankee Publishing, Inc.