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ASSESSING THE IMPACTS OF INORGANIC AND ORGANIC FERTILIZER ON CROP PERFORMANCE UNDER A MICROIRRIGATION-PLASTIC MULCH REGIME

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Abstract

This study was conducted at S & B Farm located in Eufaula, AL in 2014. The treatments were Inorganic fertilizer/"Farmer's Mix" (NPK 13:13:13 + ammonium nitrate mixed in 3:1 ratio); Inorganic fertilizer/"Farmer's Mix" (NPK 13:13:13 + ammonium nitrate mixed in 3:1 ratio + Bio-grow) plus microbe mix; and Organic Fertilizer – Mighty Grow (4-3-4) with a microbe mix. All fertilizers were applied prior to mulch application after which the following crops squash (*Cucurbita pepo L.*), cucumber (*Cucumis sativus* L.), and okra (*Abelmoschus esculentus* L. Moench*)* were directly seeded in a complete randomized design. The results showed that the inorganic fertilizer had higher yields (lbs/acre) than organic fertilizer. The addition of microbes to the inorganic fertilizer significantly increased the numbers of cucumbers and okra per acre. Overall, the "Farmer mix" with or without the addition of microbes significantly increased yields for all crops compared to the organic-based fertilizer.
Keywords: Inorganic Fertilizer, Organic Fertilizer, Crop Performance, Yield

Introduction

Small and limited resource farmers, concerned with environmental sustainability with respect to nutrient runoff and leaching, have turned to organic fertilizers in order to sustain crop health in their operations. Organic fertilizers that are commonly used are composted animal manure, compost, and household wastes. Organic fertilizers provide nutrients and contribute to the quality of soil by improving the structure, chemistry, and biological activity level of the soil. They are known for the gradual release of nutrients, and they increase soil organic matter content (Sarkar et al., 2003). The improvements to soil organic matter are favored when decomposition is slow. However, decomposition of organic material is strongly affected by temperature and soil moisture. This implies that nutrients may be released when the plant does not need them. Because the nutrient content is low in organic fertilizers, and only a limited amount of organic material is available in many regions, it is generally difficult to meet crop nutrient demands through organic fertilizers alone (Morris et al., 2007).

Inorganic fertilizers are also referred to as mineral or chemical fertilizers. The nutrients in mineral fertilizers are relatively high, and the release of these nutrients is quick because there is no need for decomposition. In other words, the level and timing of nutrient uptake by crop can be predicted reasonably well. However, inorganic fertilizers are known for their high cost and their negative environmental effect if managed poorly (Morris et al., 2007). The use of inorganic fertilizer has been observed to cause the destruction of soil texture and structure, which often leads to soil erosion and acidity as a result of the leaching effect of nutrients. All these give rise to reduced crop yields as a result of soil degradation and nutrients imbalance (Ojeniyi, 2000). Because of the issue of nutrient content in organic fertilizers, along with the reality of higher pricing in the purchase of inorganic fertilizers, some small and limited resource farmers create a "mix" of both organic and inorganic fertilizers. The main objective of the study was to assess the impact of inorganic- and organic-based fertilizers on three crops under a conventional microirrigation-plastic mulch system. Specific objectives were to

(1) determine the effect on total yield, and (2) determine the effect on the number of fruits produced.

Literature Review

The use of fertilizers is indispensable in alleviating nutrient constraints and is important in soil fertility management for improved crop production. Today, a wide range of fertilizers are required to maintain soil fertility and sustainable agricultural systems.

Jahan et al. (2013) carried out a study to assess the effect of different cattle manure levels on organic production of squash in 2005 and 2006. The treatments consisted of four manure levels (10, 15, 20 and 25 t ha^{-1}) and were only applied at the beginning of the first year. In the second year of the experiment, only the effect of manure was investigated. Results indicated that increasing the manure level had a significant effect on fruits and seed yields of squash. However, the response of both fruits and seed yields to residual effect of cattle manure levels were higher in the second year compared to the first year. It was explained that this result could probably be due to the releasing of more nutrients in the second year from the manures used in the first year. Their research indicated that application of 20 t ha^{-1} cattle manure with no chemical fertilizer was an appropriate method for organic production of squash which had the greatest yield.

Another study conducted by Oyewole et al. (2011) investigated the effects of different nutrient sources (inorganic fertilizer, poultry manure, inorganic fertilizer + poultry manure) as well as rates on the growth and yield of tomato and okra on a predominantly sandy soil. Three rates of nitrogen were applied (0, 150 and 300 Kg N ha^{-1}) using inorganic, organic, and their combination. The results showed that integrated nutrient applications performed better than individual applications for all the nutrient sources, with the best performance obtained with the inorganic fertilizer + poultry manure combinations. The integrated application of N at the rate of 150 Kg poultry manure ha^{-1} + 150 Kg of inorganic fertilizer ha^{-1} was recommended for higher tomato and okra yield.

However, Anjanappa et al. (2012) reported that the combinations of inorganic, organic and biofertilizers were best for earliness and higher productivity of cucumber. They carried out an experiment on how organic, inorganic, and biofertilizers influence the yield and economics of cucumber in 2005 and 2006. This resulted in increased number of fruits per plant and fruit weight per plant, which ultimately resulted in more fruit yield per hectare. The increased fruit length, fruit cavity, fruit volume, and fruit diameter were attributed to balanced nutrition, better nutrient uptake, and synthesis of more carbohydrates.

Sarhan et al. (2011) analyzed the effect of bio and organic fertilizers on growth, yield and fruit quality of summer squash. They used a bio-fertilizer i.e. *Azotobacter* with a control treatment, and three levels (0, 1.5 and 3.0 t $dunam^{-1}$; 1 dunam equals 0.1 hectares) of organic fertilizer. The results revealed that Azotobacter alone or in combination with organic fertilizer improved the quantitative and qualitative traits of fruit yield of squash. The interaction effect of the combination of bio and organic fertilizers resulted in the best performance of squash in terms of yield and quality. This result could be due to the release of growth promoting compounds like cytokinins, Indole Acetic Acid (IAA) and/or the release of siderophores compounds increasing the availability of iron for different biophysical and biochemical processes. They explained that the *Azotobacte*r had an indirect impact mainly through the improvement of soil structure, and through the release of compounds like polysaccharides that help keep the soil particles intact. The above studies indicate that the potential of fertilizers increases when used together with bio-fertilizers resulting in an improved soil status and hence increased crop yields.

Methodology

Study Site

The experiment was conducted at S & B Farm located in Eufaula, AL (31°46'3"N, 85°11'16.80"W). The farm is 80 acres with 32 acres devoted to animal production (beef cattle, chicken, pigs, and goats) and fruit and vegetable production, and the other 48 acres devoted to agroforestry. For the fruit and vegetable production, the farm utilizes tunnel houses and plastic on drip irrigation. A map display of the study area is shown in Figure 1.

Figure 1. An aerial display of the layout of the 15 acres in active production of fruit, vegetable, and livestock. The study area is outlined in yellow. Not pictured are the 65 acres in forage grasses and forest land.

Experimental Design and Statistical Analysis

The study consisted of three treatments: inorganic fertilizer/"Farmer Mix" (NPK 13:13:13 + ammonium nitrate mixed in a 3:1 ratio); inorganic fertilizer/"Farmer Mix" (NPK 13:13:13 + ammonium nitrate mixed in a 3:1 ratio + Bio- grow) plus microbe mix; and organic fertilizer – Mighty Grow (4-3-4) with a microbe mix. The microbe mix which was added included: *Bacillus subilis* 7.2 10^9 CFU/lb., and *Saccharomyces cerevisae* 5.4 x$10^{\mathbf{8}}$ CFU/lb. The microbes present in the organic Mighty Grow fertilizer was not disclosed by the manufacturer.

Each treatment was replicated three times in a complete randomized design. Fertilizer was applied as a band in the center of a formed bed, after which white on black plastic mulch was applied with drip irrigation lines. After the application of the plastic mulch the following crops were randomly seeded on May 17, 2014: squash (*Cucurbita pepo*), cucumber (*Cucumis sativus*), and okra (*Abelmoschus esculentus*) – heirloom variety. The plots were irrigated for 1hour and 30 minutes, 3 times a week. The squash and cucumber plots were ready for the first harvest by June 30, 2014 and okra was harvested on July 18, 2014. Data such as total yield, total number of squash, total number of cucumbers, and total number of okra were collected. All data were statistically analyzed using the analysis of variance and means separation using Duncan Multiple Range test as described by Snedecor (1966).

Results and Discussion

The total yield (lbs/acre) of squash in Table 1 showed significant differences among the three treatments. The highest yield was achieved when the inorganic fertilizer was mixed with microbes generating a yield of 31,931.33 lbs/acre. The number of fruits (nos/acre) of squash (Table 2) produced did not show significant differences between inorganic fertilizer and inorganic fertilizer mixed with microbes treatments although there was a significant difference when the two treatments were compared with organic fertilizer treatment with microbes. The inorganic fertilizer and inorganic fertilizer mixed with microbes treatments presented higher numbers (19,370.67 and 20,581.33 nos/acre, respectively, versus 12,712.00 nos/acre).

Table 1. Total Yield (lbs/acre) of Squash, Cucumber, and Okra Harvested from Plots Fertilized with Three Different Fertilizers

Treatments	**Squash *(Cucurbita pepo)***	**Cucumber *(Cucumis sativus)***	**Okra *(Abelmoschus esculentus)***
Inorganic Fertilizer	27,694.00^{b}	59,625.33^{b}	25,437.62^{a}
Inorganic Fertilizer + microbes	31,931.33^{a}	72,791.33^{a}	24,697.60^{a}
Organic Fertilizer with Microbes	11,047.33^{c}	21,943.33^{c}	14,043.73^{b}

*Means with the same superscript are not significantly different at the 5% level of probability

However, the total yield (lbs/acre) of cucumber (Table 1) showed highly significant differences among all the treatments. The inorganic fertilizer mixed with microbes' treatment generated the highest yield (72,791.33 lbs /acre). In terms of numbers of cucumber fruits (nos/acre) that were produced (Table 2), the result also showed significant differences among the treatments. The highest number of cucumbers (nos/acre) 132,870.67 was achieved when inorganic fertilizer was mixed with microbes.

Meanwhile, no significant difference occurred in the total yield (lbs/acre) of okra between inorganic fertilizer and inorganic fertilizer mixed with microbes treatments (Table 1). When the two treatments were compared with the organic fertilizer treatment, there was a significant difference; this showed the higher yield of okra for inorganic fertilizer and inorganic fertilizer mixed with microbes treatments (25,437.62 and 24,697.60 lbs/acre, respectively, versus 14,043.73 lbs/acre). Significant differences were found in the number (nos/acre) of okra produced among the three treatments (Table 2). The highest number achieved was with inorganic fertilizer treatment mixed with microbes at 483,358.67 nos/acre.

Table 2. Numbers (nos/acre) of Squash, Cucumbers, and Okra Harvested from Plots Fertilized with Three Different Fertilizers

Treatments	**Squash** ***(Cucurbita pepo)***	**Cucumber** ***(Cucumis sativus)***	**Okra** ***(Abelmoschus esculentus)***
Inorganic Fertilizer	19,370.67[a]	112,894.67[b]	469,738.67[b]
Inorganic Fertilizer + microbes	20,581.33[a]	132,870.67[a]	483,358.67[a]
Organic Fertilizer with Microbes	12,712.00[b]	48,124.00[c]	300,548.00[c]

*Means with the same superscript are not significantly different at the 5% level of probability

Generally, the significant increase in total yield (lbs/acre) for squash and cucumber, and the significant increase in the numbers (nos/acre) of cucumber and okra were due to the addition of microbes to the "farmer mix" fertilizer; this is in conformity with the findings of Sarhan et al. (2011). However, several authors (e.g., Abd-Allah et al., 2001; Aly 2002; Bayoumi 2005; Ehaliotis et al., 2005) indicated that application of organic fertilizer increased crop yields compared to using chemical fertilizers. Moral et al. (2005) reported that organic fertilizers were good as inorganic fertilizer for cucumber production. Aiyelaagbe (2007) also reported that application of 10t/ha of organic fertilizer is a good substitute for 4.2t of inorganic fertilizer/ha in terms of fruit yield of cucumber. Also, Rotenberg et al. (2005) reported that addition of organic fertilizers to agricultural soils can lead to improved soil quality and reduced severity of crop diseases as well as increased cucumber yield. Premsekhar and Rajashree (2009) and Tiamiyu et al. (2012) reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of the soil resulting in better supply of nutrients to the plants. In addition, it was reported that fruit and seed yield of squash increased by applying a higher rate of organic manure (Jahan et al., 2013). This study provided no such evidence because the organic fertilizer was applied at the time of planting. This made the nutrients insufficiently available for early growth of squash and cucumber since the organic fertilizer had not yet mineralized.

Although the production of okra (lbs/acre) did not seem to be affected by the addition of microbes to the fertilizer mix, okra is long-term crop and the effect of the microbes may have been negligible at that particular stage of growth. It can be explained that the microbes added to the inorganic fertilizer increased availability of nutrients, colonized plant root zones, created a favorable condition in the rhizosphere so that plant roots could efficiently uptake the available nutrients, and this increased the synthesis of growth regulators. Ratti et al. (2001) found that a combination of microbes and an insoluble inorganic fertilizer maximized biomass and P content of the aromatic grass palmarosa. Naidu et al. (1999), working on okra and Anjanappa et al. (2012) working on cucumber, reported that increase in yield could be due to the influence of biofertilizer in combination with NPK and farm yard manure.

These factors may have enhanced the synthesis of photosynthates by increasing the synthesis of growth regulators. According to Sarhan et al. (2011), bio- and organic fertilizer had an additive impact on the growth and yield of squash plants. Though no measurements were taken for plant physiology/anatomy during the growth period in this study, there were clear physical differences in the growth of the three plants as demonstrated in Figures 2a, 2b, and 2c.

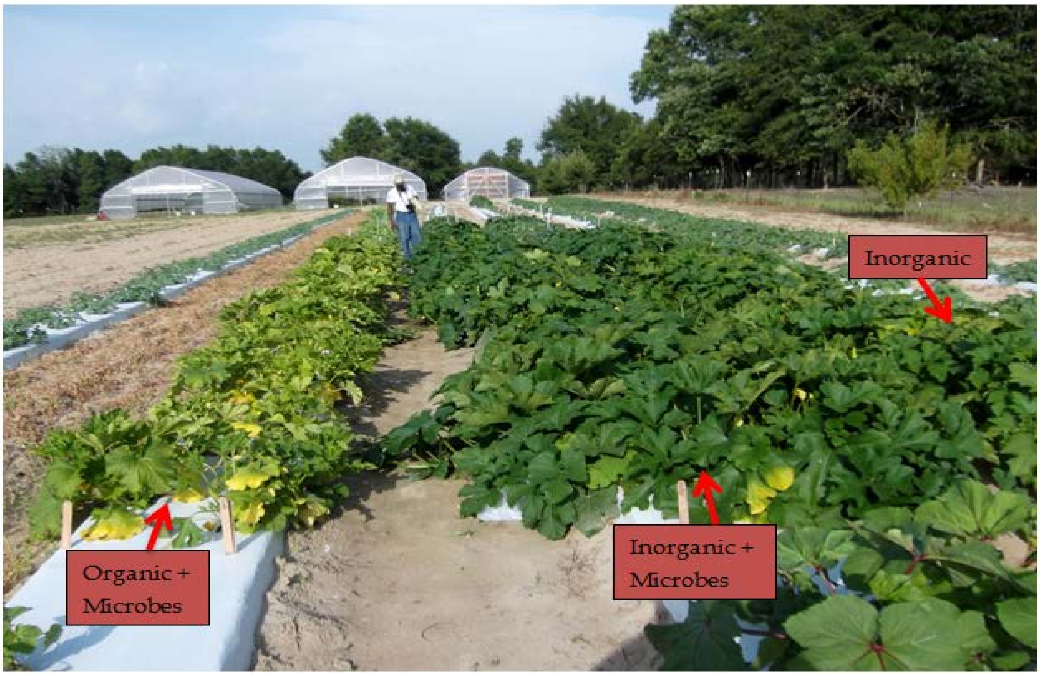

Figure 2a. A picture depicting the physical differences in squash plants at flowering under the different fertilizer treatments.

Conclusion

From the results obtained, it can be concluded that the inorganic fertilizer mixed with microbes had the greatest impact in terms of crop performance for squash, cucumber, and okra. This is associated with a greater yield (lbs/acre) for squash and cucumber compared to okra, and greater the number of fruits (nos/acre) for okra and cucumber compared to squash.

Farmers, especially small and limited resource farmers (SLRFs), should consider the application time of organic fertilizers on their farms as this may likely affect the availability of nutrients for the plants. The application of organic fertilizer at the time of planting is not encouraged because the nutrients will not be readily available for uptake by plants, and this could lower crop production. This in turn, can negatively affect more the income of SLRFs. Based on the reasons alluded to, it is recommended that further studies be conducted on applying organic fertilizer for a longer time period before planting.

Figure 2b. A picture depicting the physical differences in cucumber plants at flowering under the different fertilizer treatments.

Figure 2c. A picture depicting the physical differences in young okra plants under the different fertilizer treatments.

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