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Research Application Summary

Comparative study on organic fertilizer (Elkhaseeb) and inorganic fertilizers effects on tomato (*Solanum lycopersicum* Mill.) and cucumber *(Cucumis sativus* L.) growth, yield and nutrient content under greenhouse conditions

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Abstract

Organic fertilizers are derived mainly from animal matter, human excreta or crop residues, while chemical fertilizers are defined as any inorganic material of wholly or partially synthetic origin, that is added to the soil to sustain plant growth. This study was designed to compare between a commercial organic fertilizer and chemical fertilizers for their effects on tomato (*Solanum lycopersicum* Mill.) and cucumber (*Cucumis sativus* L.) growth, yield and nutrient content under greenhouse conditions. The experiment was conducted in the cropping season of 2016/2017 at the University of Gezira. The experiment consisted of four treatments viz. control, inorganic fertilizers, organic fertilizers (commercial organic fertilizer, Elkhaseeb, of only cow manure) and a combination between organic and inorganic fertilizers. The soil of the experimental site is a riverain silt loam soil. The experiment for the two vegetable crops was arranged in a split plot design with three replications, and two factors, commercial organic fertilizer (OM) and chemical fertilizers (MN) which include nitrogen in the form of urea and phosphorus in the form of triple superphosphate. Foliar fertilization of micronutrients with Ca and B, was used for all treatments. Commercial organic fertilizer: OM was added at the rate of 15 tons /ha and nitrogen was added as urea at 86 kg/ha(2N). Phosphorus was applied as triple superphosphate at 43 kg P2O5/ha (1P). Tomatoes seedlings of cultivar Termis were transplanted on the ninth of February,2017 whereas cucumber seeds, variety Leader were planted on the first of February, 2017.The results showed that the effect of combination of inorganic fertilizers and organic fertilizers is significantly higher than application of either fertilizer alone. The combination resulted in 417.65 kg /ha of tomatoes and 823.53 kg / ha of cucumber. Application of the commercial organic fertilizer alone gave 261.4kg / ha in tomatoes, while in cucumber it gave732.03 kg /ha. Inorganic fertilizers alone gave 256.84 kg/ha in tomatoes and 447.7kg/ha in cucumber. This lead to a recommendation that application of combined fertilizers (organic+ inorganic) is the best practice for tomatoes and cucumber under greenhouse conditions than any of the two fertilizers alone.

Key words: Cucumber, Elkhaseeb, organic fertilizers, green house, Sudan, tomatoes

Résumé

Les engrais organiques proviennent principalement de matières animales, d'excréments humains ou de résidus de cultures, tandis que les engrais chimiques sont définis comme toute matière inorganique

d'origine entièrement ou partiellement synthétique, qui est ajoutée au sol pour soutenir la croissance des plantes. Cette étude a été conçue pour comparer entre un engrais organique commercial et des engrais chimiques pour leurs effets sur la croissance, le rendement et la teneur en éléments nutritifs de la tomate (*Solanum lycopersicum* Mill.) Et du concombre (*Cucumis sativus* L.) en serre. L'expérience a été menée pendant la saison de culture 2016/2017 à l'Université de Gezira. L'expérience consistait en quatre traitements à savoir. lutte, engrais inorganiques, engrais organiques (engrais organique commercial, Elkhaseeb, de fumier de vache uniquement) et une combinaison d'engrais organiques et inorganiques. Le sol du site expérimental est un sol limoneux riverain. L'expérience pour les deux cultures maraîchères a été organisée dans une conception de parcelle divisée avec trois répétitions et deux facteurs, engrais organique commercial (MO) et engrais chimiques (MN) qui comprennent l'azote sous forme d'urée et de phosphore sous forme de triple superphosphate. La fertilisation foliaire de micronutriments avec Ca et B a été utilisée pour tous les traitements. Engrais organique commercial : de la MO a été ajoutée à raison de 15 tonnes / ha et de l'azote sous forme d'urée à 86 kg / ha (2N). Le phosphore a été appliqué sous forme de triple superphosphate à 43 kg de P2O5 / ha (1P). Les plants de tomates du cultivar Termis ont été transplantés le 9 février 2017 tandis que les graines de concombre, variété Leader ont été plantées le premier février 2017.Les résultats ont montré que l'effet de la combinaison d'engrais inorganiques et d'engrais organiques est significativement plus élevé que l'application de soit l'engrais seul. La combinaison a donné 417,65 kg / ha de tomates et 823,53 kg / ha de concombre. L'application de l'engrais organique commercial seul a donné 261,4 kg / ha dans les tomates, tandis que dans le concombre il a donné 732,03 kg / ha. Les engrais inorganiques seuls ont donné 256,84 kg / ha pour les tomates et 447,7 kg / ha pour le concombre. Cela a conduit à une recommandation selon laquelle l'application d'engrais combinés (organiques + inorganiques) est la meilleure pratique pour les tomates et le concombre dans des conditions de serre que n'importe lequel des deux engrais seuls.

Mots clés : Concombre, Elkhaseeb, engrais organiques, serre, Soudan, tomates

Introduction

Organic fertilizers are derived mainly from animal matter, human excreta or crop residues. Examples include green manure, animal manure, compost and others. Cow manure, a product of bovine animal species, which is usually dark brown in color, is often used as manure. Conventional Farmyard manure (FYM) contains about 0.73% N, 0.18% P and 0.71% K (Tolessa and Friesen, 2001). Organic fertilizers improve soil physical properties, such as water holding capacity, erosion stability and gas exchange (Nyangani, 2010) as well as chemical and biological properties and nutritional status of the soil. Disadvantages of organic fertilizers is their bulkiness with high cost of transportation and labour, high risk of infection with diseases, insects and the risk of weed infestation. Although used for thousands of years in agricultural soils, organic manure has only recently been on the spot due to its positive effects on physical, chemical, and biological soil properties (Santos *et al*., 2001). Organic sources have a role in the management of plant diseases and improving soil fertility in the field and greenhouse (Muhammad, 2011). Chemical fertilizers are rich in all essential nutrients that are needed by crops and always ready for immediate supply of nutrients to plants. They make plants grow more rapidly and appear greener in comparison with organic fertilizers. Chemical fertilizers can expedite plant growth and provide economic benefits to farmers. Some of the disadvantages of chemical fertilizers are that they are harmful to soil life, acidify the soil, pollute groundwater and may cause other hazards such as nitrate pollution in vegetables. It should be noted that the chemical fertilizers used for crop production are still used at inadequate rates (Girma, 2016). Nitrogen is an essential part of proteins and nucleic acids, as well as of the chlorophyll molecule (Taiz and Zeiger, 2004). Phosphorus and potassium are critical for tomato growth and development (Jones, 2008). Phosphorus is essential for seed

and root development, it is associated with early root development and architecture, especially when P levels are low (Heuvelink, 2005).

Tomato (*Solanum lycopersicum* MiLL.) is one of the most widely grown vegetable in the world, belonging to the family Solanaceae. It is an excellent source of minerals, fibers, vitamins and antioxidants, which help in controlling cancer as well as improving the general health of people. Tomato is considered the main vegetable crop that is being cultivated in several locations in the Sudan.

Cucumber (*Cucumis sativus* L.) is one of the most important members of Cucurbitaceous family. It contains fair amount of K, Ca and folate and small amount of other nutrients, including vitamin C and is very low in calories. The mature fruits are eaten raw, in salad or used as pickles. Cucumber is considered as one of the important vegetables in the Sudan, which can be produced in greenhouses because of its limited cultivation period in open farm and its increasing demand for local consumption and export (Abdelrahman,2007).

Greenhouses are very important growth environment in the Sudan, because most vegetables grown are tomato, pepper, cucumber, melon, water melon, marrow, green bean and eggplant which have medium thermal requirements. Sudan has a harsh climatic condition with high temperature and low relative humidity. Organic production of greenhouse crops has developed in the Sudan during the last decades. Greenhouse crops in general have higher nutrient demands than field grown crops and therefore, in order to optimize production, it is essential to focus on growth media and fertilization. In Sudan the number of organic farms has increased from 400 in 1989 to 3500 in 2003 (Danish Plant Directorate, 2003).

Tomato and cucumber are very important vegetable crops for human consumption with high economic value, short duration of growth and with other uses. For instance, oils extracted from cucumber seeds are used for medicinal purposes; reduced cholesterol and help in fighting cancers. Also, tomato is one of main ingredients in hundreds of dishes and its products (paste, juice, catchup etc) are sold in supermarkets throughout the world. This means that there is an increase demand for tomatoes and cucumber. For these reasons expansion of tomato and cucumber production specially under greenhouse conditions is necessary. Therefore, the main objective of this study was to carry out a comparison between a commercial organic fertilizer (Elkhaseeb) and chemical fertilizers for their effects on tomato (*Solanum lycopersicum Mill*.) and cucumber (C*ucumis sativus* L.) growth, yield and nutrient content, under greenhouse conditions.

Materials and methods

The experiment was conducted in the cropping season of 2016/2017 at the Central laboratory Greenhouse, University of Gezira, Wad Medani, Sudan, latitude14° 24’ N, longitude 33° E, and altitude 411 m.a.s.l. The experiment consists of four treatments viz. control, inorganic fertilizers, organic fertilizers (commercial organic fertilizer, only of cow manure) and a combination of organic and inorganic fertilizers.

Soil analyses. The soil of the experimental site was a riverain loamy soil (Day ,1965). Bulk density was determined in an air –dry soil, using core method (Jamison ,1950), field capacity was determined by small soil core method (Mclntyre,1974) in which the soil samples were subject to 0.3 bar soil moisture tension. The soil pH was measured using a pH meter with a glass electrode (Jackson ,1973),

electrical conductivity (ECe) was measured using EC-meter (Richads,1954). The soil was non-saline, non-sodic. Available P was determined by Olsen method (1954); total N was determined by micro-Kjeldahl procedure (Jackson,1962) and organic carbon was determined by oxidation -reduction titration with ferrous ammonium sulphate (Walkley and Black ,1954). The cation exchange capacity (CEC) was measured using ammonium saturation (Richads,1954).

Organic manure analyses. Organic manure analyses for pH was by using a pH meter glass electrode in manure water suspension and the measurements included: pH, O.C, total N, and K (FCO,1985). The experiment was arranged in a split plot design with three replications, with main plot assigned to chemical fertilizers and subplot to commercial organic fertilizer. The land was prepared manually making level beds with plots measuring 30 m x 0.8 m. Each sub plot measured 3.0m^2 (0.8 m x 3.75m). Cucumber seeds, variety Leader was planted manually on the first of February, 2017 at 40 cm inter row spacing. Transplanting of tomato seedlings of cultivar Termis was done manually on the ninth of February, 2017 at 40 cm inter row spacing. Half of the greenhouse (southern) was allotted to cucumber and the other half (northern) was allotted to tomato. Commercial organic fertilizer (OM) was added at the rate of 15 tons /ha and nitrogen was added as urea at 86 kg/ha (2N). Phosphorus was applied as triple superphosphate at 43 kg P_2O_5/ha (1P). Foliar fertilizer (Calboro2) which contains Ca and micronutrients was used for all treatments. Drip irrigation was used in the experiment.

Growth analyses. Growth data were taken for plant height and number of leaves per plant every two weeks for the first and second reading, then every week. The number of fruits per plant were taken from the first pick on the 16th March, 2017 for cucumber, while the first pick for tomato was done on the 13th April, 2017 and thereafter every week until the end of the experiment for both crops.

Nutrient analysis. Leaves and fruits of tomato and cucumber were dried in an air- forced oven (70 C for 48 hours) grinded, sieved and analysed for N and P. Nitrogen content in plant tissues was determined by Kjeldahl method according to Ryan *et al*. (2001). Phosphorus content in plant leaves and fruits was extracted by hydrochloric acid to determine phosphorus content using spectrophotometer (Ryan *et al*., 2001).

Fruit yield. Total yield was calculated from all harvests for the two crops, starting at first production of fruits, until the final harvest after four months from planting date for cucumber and transplanting of tomato. The yield of fruits was calculated on fresh weight basis and dried, grinded, sieved and saved for further analyses.

Statistical analysis. Data were analyzed using the statistical package Statistix 8.0for both (ANOVA and Mean separation).

Results and discussion

Soil analyses. Analysis of the Physical properties of the soil showed that it was riverain silt loam soil with 2% sand, 73% silt, and 25% clay and bulk density of 16.7 $gcm^{-3,}$ and 40.6% moisture field capacity. On the other hand in terms of the chemical properties, the soils had pH 7.6, CEC cmol/kg soil (46), ECe ds/m (0.5), Av.P mg/kg soil (10.4), TN% (0.043) and O.C% (0.081). The organic manure analyses (of Elkhaseeb commercial organic manure) revealed pH (7.1), O.C% (31.5), TN% (1.4), TP% (1.60) and K% (1.45)

Growth analysis of tomato and cucumber. Plant height of tomato was recorded at 15, 30, 37 and

44 days after transplanting (DAT) and at the final harvest. Figure 1 shows that plant height increased continuously from 15 DAT to 44 DAT in all the treatments. At 44 DAT the tallest plants were observed with the combination (organic+ inorganic) fertilizers (T4) , followed by inorganic fertilizers alone (T2), then organic manure alone (T3) and finally the control treatment (T1), which gave the lowest plant height.These results agree with those of Yousef *et al*. (2001) who reported that treatments with organic manure in combination with ammonium nitrate resulted in taller plants than other treatments.

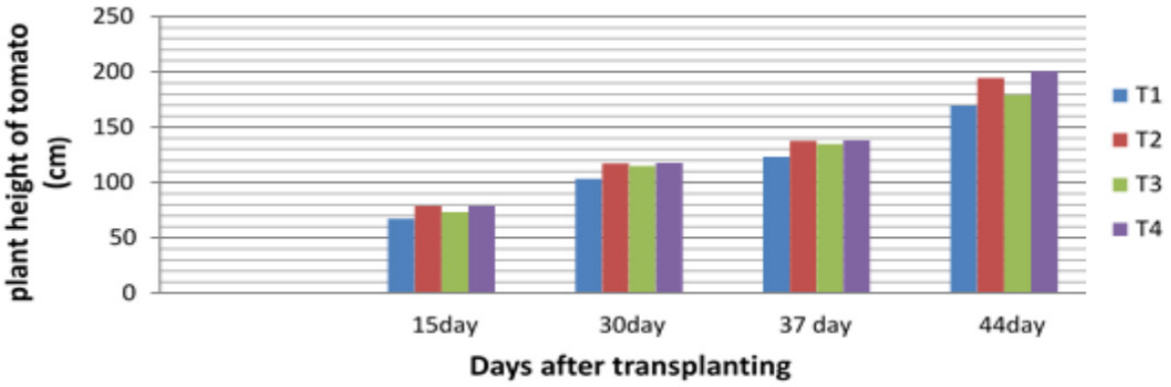

Figure 1. The effect of organic manure and inorganic fertilizers on plant height (cm) of tomato at different days after transplanting

Vine length of cucumber. Vine length of cucumber was taken at 15, 30, 37 and 44 DAT. Figure 2 show that the combination of organic manure and inorganic fertilizers (T4) recorded highest vine length of cucumber in comparison with other treatments. This was followed by organic manure alone, then chemical fertilizers alone, with control giving the shortest vine length. These results agree with those of Krupnik *et al*. (2004) who reported that combined use of organic and inorganic fertilizers reduced cost and amount of fertilizer required by crops. It also produced the maximum plant growth (Alam, 2006).

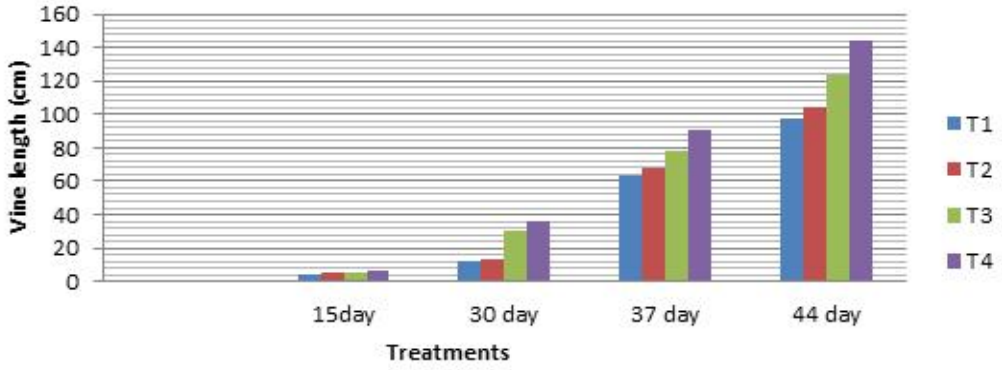

Figure 2. Effect of organic and inorganic fertilizers on vine length (cm) of cucumber.

Number of leaves per plant of tomato. A higher number of leaves indicate better growth and development of the crop. When there is greater number of leaves, the greater will be the photosynthetic area which may result in higher fruit yield. Figure 3 shows that the highest number of leaves per plant was produced by the combination of organic and inorganic fertilizers (T4) at 37 DAT. This is possibly due to the greater plant height and available nutrients. The results agree with those of Naidu *et al*. (2002) at Jabalpur, Madhya Pradesh, India, who found that application of 100 kg N + 50 kg P_2O_5 + 50 kg K_2O + 20 tonnes FYM ha^{-1} gave significantly maximum plant height (50.68 cm) and number of leaves $plant^{-1}$ (49.50) and number of branches $plant^{-1}$ (16.83). Number of leaves per plant of tomato was measured but did not show significant differences between treatments because of the lavish growth of the leaves in all treatments.

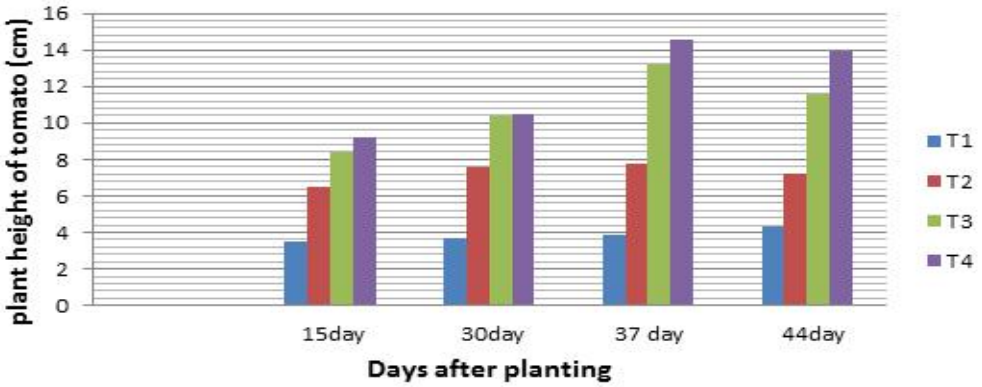

Figure 3. Number of leaves of cucumber as affected by application of organic manure and inorganic fertilizers at different days after planting.

Number of leaves per plant of cucumber. Data presented in Figure 3 show that the combination of organic and inorganic fertilizers (T4) recorded the highest number of leaves per plant for cucumber followed by organic manure alone (T3), then inorganic fertilizers (T2) and the control (T1) which produced the fewest number of leaves per plant. This may be due to the nutrient availability from organic and inorganic fertilizers. These results are similar to those of Indriyani *et al*. (2007) who observed that the soil + manure (1:1) medium gave better growth in terms of plant height, length of leaf, leaf width, number of leaves, and fresh weight of pineapple seedlings than for other treatments in their study.

Yield of tomato. There was a gradual increase in tomato production with time of harvesting until it reached a maximum then declined as time passed until the final harvest (Fig. 4). The combination of organic and inorganic fertilizer recorded maximum productivity of tomato, followed by organic manure (T3) which recorded similar yield to use of inorganic fertilizers (T2) alone. The lowest yield was from control treatment (T1). These results support the finding of Yahaya *et al*. (2010) who reported many fruits per plant under the combined application of 10 t ha^{-1} organic manure with inorganic fertilizers. The increase in fruit number per plant might be due to the increased growth attributes which in turn lead to the increased photosynthetic rate and dry matter production.

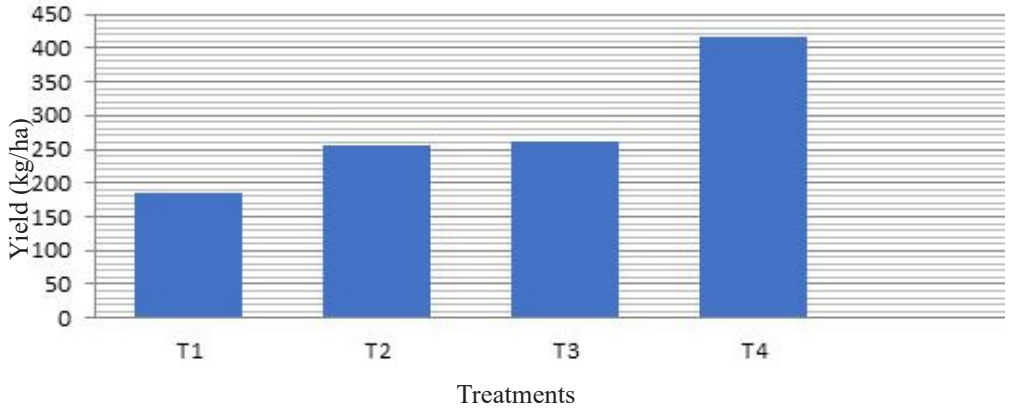

Figure 4. Average yield (kg / ha) of tomato as affected by application of organic manure and chemical fertilizers. **T1= control, T2= inorganic fertilizers, T3= organic manure, and T4= organic and inorganic fertilizers**

Yield of cucumber. Figure 5 shows that the yield of cucumber was highest with the combination of organic and inorganic fertilizes, followed by organic manure, then inorganic fertilizer, and finally the control treatment which gave the lowest yield. These results agree with that of Huang *et al*. (2001) who indicated that application of organic manure combined with chemical fertilizers improved the yield of crops. The difference in yield between treatments was more pronounced with cucumber than with tomato.

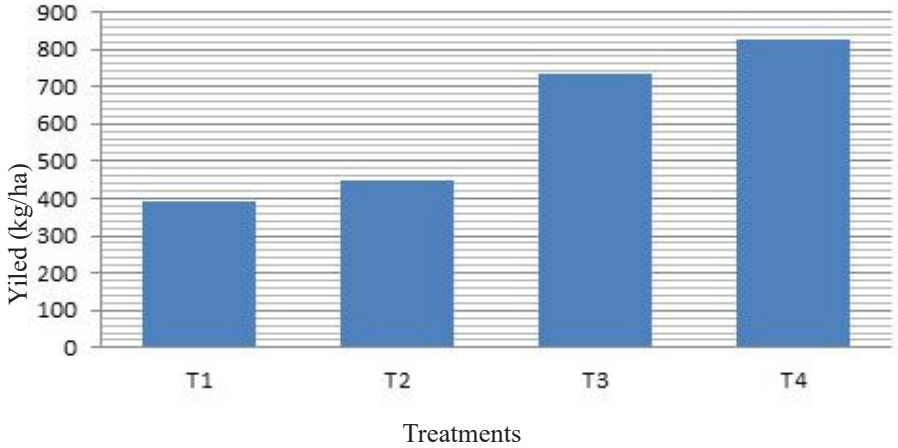

Figure 5. Average yield kg / ha of cucumber as affected by application of organic manure and chemical fertilizers. T1= control, T2= inorganic fertilizers, T3= organic manure, and T4= organic and inorganic fertilizers

Conclusion

Application of organic manure together with inorganic fertilizers improved growth parameters of tomato and cucumber. The combination of inorganic fertilizers and organic manure recorded highest productivity of tomato and cucumber. Therefore It is recommended that application of inorganic fertilizers and organic manure be used for tomato and cucumber production under greenhouse conditions than use of either alone.

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