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Research Application Summary

Optimization of biosolids as a substrate for quality tomato transplant production

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Abstract

Tomato (*Solanum lycopersicum* L.) is an important fruit vegetable crop for human health and nutrition as well as for income generation. The quality of the transplant affects the overall quality and yield of the crop. However, poor soil conditions greatly affect growth of the seedlings. The objective of the study was to determine effect of biosolids from sewage treatment on quality of tomato transplant. This study was conducted at Egerton University, Njoro, Kenya using tomato variety 'Maxim F1'. The experimental design was randomized complete block design (RCBD) replicated four times. Treatments were biosolids mixed with forest soil at 0% (forest soil), 10%, 20%, 30%, 40%, 50% and 60% (v/v), tea compost and coco peat. Growing media was evaluated for physic-chemical properties while seedlings were evaluated for leaf number, plant height, collar diameter, root volume, and chlorophyll content, root and shoot dry matter content. Biosolid applied in moderate levels (30%) helped to improve the physic-chemical properties (bulk density, moisture content, organic matter, pH, N, P, K, and Mg contents) of the growing media. Seedlings grown using biosolid at 30% had more leaves than forest soil, biosolid at 60% and coco peat. Using biosolid at 30% resulted in taller seedlings than forest soil, biosolid at 40% and coco peat. Application of biosolid at 30% resulted in seedlings with thicker stems compared with all the other growing media. Biosolid at 30% and tea compost had the highest root volume while soil, biosolid at 10% and coco peat had the lowest root volume. Using biosolid at 30% resulted in higher leaf chlorophyll content than all the other growing media. The study demonstrates that using biosolid at 30% proved to be the best for tomato transplant production. Root dry weight was highest in tea compost and biosolid applied at 20, 30, 40 and 50%, while control and coco peat had the lowest root dry weight. Shoot dry weight was the highest in tea compost and biosolid applied at 30% while control and coco peat had the lowest shoot dry weight. This was attributed to more available nutrients in the biosolid hence better seedling physiological development as observed by higher leaf chlorophyll content. Results of this study suggest that 30% of biosolids in forest soil can be customized for their effective improvement on growth and quality of tomato transplants.

Key words: Biosolids, pottinng medium, seedling quality. substrate, tomatoes

Résumé

La tomate (*Solanum lycopersicum* L.) est un légume-fruit important pour la santé et la nutrition humaines ainsi que pour la génération de revenus. La qualité des transplants affecte la qualité globale et le rendement de la culture. Cependant, les mauvaises conditions du sol affectent considérablement la croissance plantules. L'objectif de l'étude était de déterminer l'effet des biosolides provenant du traitement des eaux usées sur la qualité des transplants de la tomate. Cette étude a été menée à l'Université Egerton de Njoro, au Kenya, en utilisant la variété de tomate «Maxim F1». Le dispositif expérimental était un dispositif de blocs complets randomisés (RCBD) répliqué quatre fois. Les traitements étaient des biosolides mélangés avec du sol forestier à 0% (sol forestier), 10%, 20%, 30%, 40%, 50% et 60% (v / v), du compost de thé et de la tourbe de coco. Les milieux de culture ont été évalués pour les propriétés physico-chimiques tandis que les plantules ont été évalués pour le nombre de feuilles, la hauteur de la plante, le diamètre au collet, le volume racinaire et la teneur en chlorophylle, la teneur en matière sèche des racines et des pousses. Le biosolide appliqué à des niveaux modérés (30%) a aidé à améliorer les propriétés physico-chimiques (densité apparente, teneur en humidité, matière organique, pH, N, P, K et Mg) des milieux de culture. Les plantules cultivées en utilisant du biosolide à 30% avaient plus de feuilles que le sol forestier, le biosolide à 60% et la tourbe de coco. L'utilisation de biosolide à 30% a donné des plantules plus grands que le sol forestier, du biosolide à 40% et de la tourbe de coco. L'application de biosolide à 30% a donné des plantules avec des tiges plus épaisses que tous les autres milieux de culture. Le biosolide à 30% et le compost de thé avaient le volume racinaire le plus élevé tandis que le sol forestier, le biosolide à 10% et la tourbe de coco avaient le volume racinaire le plus faible. L'utilisation de biosolide à 30% a entraîné une teneur en chlorophylle foliaire plus élevée que tous les autres milieux de culture. L'étude démontre que l'utilisation de biosolide à 30% s'est révélée être la meilleure pour la production des transplants de tomates. L'étude démontre que l'utilisation de biosolide à 30% s'est révélée être la meilleure pour la production des transplants de tomates. Le poids sec des racines était le plus élevé dans le compost de thé et le biosolide appliqué à 20, 30, 40 et 50%, tandis que le témoin et la tourbe de coco avaient le poids sec des racines le plus bas. Le poids sec des pousses était le plus élevé dans le compost de thé et le biosolide appliqué à 30% tandis que le contrôle et la tourbe de coco avaient le poids sec des pousses le plus bas. Ceci a été attribué à plus de nutriments disponibles dans le biosolide, d'où un meilleur développement physiologique des plantules, comme observée par une teneur plus élevée en chlorophylle foliaire. Les résultats de cette étude suggèrent que 30% des biosolides dans les sols forestiers peuvent être personnalisés pour leur amélioration efficace sur la croissance et la qualité des plantules de tomates.

Mots clés: Biosolides, milieu de culture, qualité des plantules, substrat, tomates

Introduction

Tomato (*Solanum lycopersicum* L.) is an important vegetable crop globally, used as salad as well as for cooking purposes. It is known for its nutritional importance. It is a rich source of nutrients such as Na, K, Fe, vitamin A and C and antioxidants especially lycopene and salicylate (Afzal *et al.,* 2013). Production of tomato in Kenya is rated far below the developed countries and this may be due to challenges related to costly planting materials, lack of awareness in the use of integrated nutrients and pest management practices (Gogo *et al.,* 2012). However, tomato remains the leading greenhouse vegetable crop both in Kenya and all over the world. High yields combined with high fruit quality are common requirement of tomato growers, and this can only be achieved if critical production factors are put into consideration. These factors include proper transplant production and availability, irrigation and nutritional management, disease management, cultural techniques, and favourable climatic conditions (Bombiti, 2006). Hence, to increase tomato productivity, there is need for adoption of improved and sustainable production technologies that are farmers friendly in terms of production costs (Qin *et al.,* 2010).

Tomatoes are established by direct seeding or from transplants. In comparison with direct sowing, transplants are a more reliable method of ensuring higher plant survival, faster establishment, improved plant uniformity, earlier maturity, and reduced cost of production than direct seeded plants (Gogo *et al.,* 2012). The production of tomato seedlings, especial in sub-Saharan Africa with great open field and greenhouse crops expansion, is a highly competitive business; uniform and rapid seed emergence and quality is essential prerequisites to increase yield, quality, and profits (Wachira *et al.,* 2014). In addition, tomato seeds especially F_1 hybrids are expensive and farmers in developing countries cannot afford poor germination as a result of poor soil conditions (HCD, 2017). Use of ideal crop substrates with appropriate physicochemical properties, is therefore critical (Sterrett, 2001).

Under nursery conditions, soilless media such as coco peat is widely used as the main substrate component for production of containerized seedlings. However, coco peat has become more expensive and its properties more variable as well as raw material shortage (Chrysargyris *et al.,* 2013). Thus, it is important to look for good quality and locally available low-cost substrate substitutes. The need to recycle wastes and increasing environmental pressures associated with the waste leads to an increasing interest in the feasibility of using organic wastes and by-products. A number of potential alternatives have been identified, including use of biosolids from sewage treatment, which have been proven to be promising (Vyas, 2011; Giannakis *et al.,* 2014). The effects of organic part of Municipal Solids wastes (MSW) on seedling emergence and growth have been investigated (Chrysargyris and Tzortzakis, 2015). Studies indicate that on application of boisolids as a peat in marigold (*Tagetes erecta* L.) and basil (*Ocimum basilicum* L.) seedlings production can produce very good results as growing media (Tzortzakis *et al.,* 2012). Similarly, use of organic urban waste compost for tomato (*Solanum lycopersicum* L.) transplant production has also been reported by Herrera *et al*. (2008), resulting into quality transplant in the seed bed. Chrysargyris and Tzortzakis (2015) specified biosolids as an ideal component of mixed-peat substrates for eggplant (*Solanum melongena* L.) seedlings, at rate less than 30% substrate mixture in combination with fertigation. In another study on cucumber transplants production, Mami and Peyvast (2010) recommended the use of MSW compost level at 5% and below on peat mixture. However, the use of such biosolid as substrates depending on the ratios may cause some problems as a consequence of its high salt content, unsuitable physical properties (texture, structure, moisture content, porosity etc.), heavy metal toxicity, and variable quality and composition (Papamichalaki *et al.,* 2014). The appropriate amount of biosolids composts added in growth medium needs to be determined to improve plant growth. In some cases, mixtures of compost with soil may be used as substrates without the need for additional mineral fertilizer, as the necessary nutrient amount is provided by the compost itself (Mardi *et al.*, 2002). Therefore this paper investigated biosolids as a potential substrate for tomato transplants production.

Materials and methods

This study was conducted at the Horticulture Research and Teaching Field, Egerton University, Njoro, Kenya in January to February, 2018 and from February to March, 2018. A portion was selected in a high greenhouse tunnel measuring 8 m by 60 by and 3 m height was covered with UV stabilized polythene sheet gauge 150 µm from Amiran, Co Ltd Nairobi Kenya. Tomato (*Solanum lycopersicun* L. cv. Maxim F1) was sourced from Meya Co. Ltd Nakuru, Kenya. Maxim F1 is ideal for both greenhouse and field production with indeterminate growth characteristic.

Data collection

Determination of physico-chemical properties of the growing media. Electrical Conductivity (EC) for substrate salinity was measured by conductivity meter using a conductivity bridge for each growing media. The pH was measured using pH meter (digital ion analyzer). In brief, 50 g of air-dried growing media was taken into a 100 ml glass beaker and 50 ml distilled water added using a graduated cylinder and mixed well and allowed standing for 30 minutes. The suspension was stirred after every 10 minutes and pH determined according to Okalebo *et al.* (2002). For Organic Matter Content, 1 g of air-dried growing media was placed into a 500 ml beaker. Then, 10 ml of potassium dichromate solution and 20 ml concentrated sulfuric acid added and swirled beaker to mix the suspension. After 30 minutes, 20 ml of distilled water was added along with 10 ml concentrated orthophosphoric acid and allowed the mixture to cool. Ten drops of diphenylamine indicator was added. The solution was titrated with 0.5 M ferrous ammonium sulfate solution and upon color changed from violet blue to green the reading was recorded and organic matter content determined according to Okalebo *et al.* (2002).

Bulk Density was determined using a 5 cm diameter thin-sheet metal tube of known weight (w) and volume (v) was inserted in to the soil surface. Soil from around the tube was excavated and cut beneath the tube bottom. Excess soil from the tube end was removed using a knife then tube and the soil dried at 105 ^{0}C. Bulk density was determined according to Okalebo *et al.* (2002). Determination of moisture content was estimated after saturated soil has been drained without allowing its moisture stores be depleted by evaporation. The potted substrate was filled with water and free water allowed to drain off then covered with plastic containers for 2 days. Moisture content was then determined based on the initial and final weight according to Okalebo *et al.* (2002).

Total nitrogen and phosphorus was measured in a digest obtained by treating soil and other substrates with digestion mixture, hydrogen peroxide, sulphuric acid, selenium and salicylic acid. Samples of the substrate were air dried and 1 g transferred into clean digestion tube. Four millilitres of the digestion mixture was added to each tube and reagent blank for each batch of samples. Digestion temperature was set at 360 ^{0}C for 2 hours, cooled and transferred to 50 ml volumetric flask then filled to volume with distilled water. Two 5.0 ml aliquot was used from for total N and P determination by colorimetric method according to the procedure of Okalebo *et al.* (2002). The determination of K, Ca Mg and Na in the substrate was done using double acid (Mehlich) method of extraction. Atomic absorption spectrophotometer (AAS) was used for estimation of these available elements in the tested substrate according to Okalebo *et al.* (2002).

Transplant growth parameters. The number of seedling emergence determined by counting. Based on the number of planted seeds, seedling emergence percentages were computed progressively after 7, 9 and 11 days after planting (DAP). One transplant growth, ten tomato seedlings were randomly selected and tagged for data collection on growth. Data collection on seedling height, collar diameter, leaf number and leaf chlorophyll content was determined 14, 21 and 28 DAP. Seedling height was determined using a measuring tape from the ground level to the tip of the seedling. Collar diameter, otherwise known as stem thickness was determined by use of digital veneer calipers, 5 cm from the ground level. Number of leaves were determined by counting of the true leaves. Leaf chlorophyll content was measured using chlorophyll content meter (CCM-200) plus; Opti-Sciences, Tyngsboro, MA). Estimate of chlorophyll content was in chlorophyll concentration index units (CCls). During seedling harvesting on the fourth week (28 days after planting), four seedlings were randomly selected and carefully uprooted. The roots were washed clean in running tap water on a sieve of pore diameter of 1 millimeter. Clean intact root of transplants were used to determine root volume using WINRHIZO Equipment.

Results

Physical and chemical characteristics of the growing media. Growing media used in tomato transplant production had different physic-chemical characteristics. Bulk density was highest in forest soil and lowest in tea compost and coco peat. Forest soil had the lowest moisture content, followed by biosolid at 10%. The rest of the treatments had higher moisture content, however biosolid at 10 and 20% were not different. Electrical conductivity was highest in coco peat and biosolid at 40, 50 and 60%. Forest soil had the lowest electrical conductivity. Most of the studied growing media had pH near neutral except biosolid at 50 and 60% which had the lowest pH. Organic matter was high in all the growing media except forest soil and coco peat that had the lowest. N and P content was high in tea compost and biosolid at 30% and lowest in forest soil. K content was high in biosolid applied at 10 to 40% and lowest in forest soil. Ca content was highest in tea compost and coco peat while the rest of the treatments were not different. Mg content was high in tea compost, coco peat, and forest soil, and biosolid at 10, 20 and 30%. Na content was high in biosolid at 50 and 60% and lowest in forest soil.

Transplant growth. Seedling emergence was enhanced by rates of biosolids applied in the substrate. Tea compost and biosolid at 30% had the highest emergence percentage compared with the rest of the growing media throughout the evaluation, while Coco peat had the lowest emergence percentage. On seedling growth, plant height was affected by use of biosolid at 30% and tea compost had the tallest seedlings while forest soil (control) and coco peat had the shortest seedlings. Use of biosolids on tomato transplant production influenced leaf number. Tomato planted using tea compost, biosolid applied at 20, 30 and 40% had the most number of leaves, while control and coco peat had the lowest leaf number. Using biosolid in tomato production affected collar diameter. Tomato seedling grown using biosolid at 30% had the thickest stems compared with the rest of the treatments. Tomato transplant root volume was affected by use of biosolid Biosolid at 30% and tea compost had the highest root volume while soil, biosolid at 10% and coco peat had the lowest root volume. Biosolid affected tomato seedling root and shoot dry weight. Root dry weight was highest in tea compost and biosolid applied at 20, 30, 40 and 50%, while control and coco peat had the lowest root dry weight. Shoot dry weight was the highest in tea compost and biosolid applied at 30%. Tomato seedling grown using biosolid at 30% had the highest leaf chlorophyll content compared with the rest of the treatments while tomato seedling grown using coco peat had the lowest chlorophyll content.

Discussion

The need to recycle wastes and increasing environmental pressures against synthetic fertilizers leads to an increasing interest in the feasibility of using organic wastes and by-products. It is important to look for good quality and locally available low cost substitutes for inorganic fertilizers (Peyvast *et al.,* 2003; Chrysargyris and Tzortzakis, 2015). The present study evaluated the effect of biosolid waste from sewage treatment for its use in tomato transplant production. The studied growing media had varied physical and chemical properties contributing to their effect on transplant growth. Biosolids provide a stabilized form of organic matter that improves the physical properties of soils by increasing nutrient and water holding capacity, total pore space, aggregate stability, erosion resistance, temperature insulation and decreasing apparent soil density (Shiralipour *et al.,* 1992). These factors played a major role during germination and emergence of tomato seedlings. Tomato seeds are small and therefore require fine and light soil for ease of germination and emergence. Soil temperature and moisture content were also noted to play a critical role during germination and emergence of tomato seedlings (Weaver *et al.,* 1988). Recent finding revealed that biosolids enhanced seed germination and emergence in eggplant transplants (Chrysargyris and Tzortzakis, 2015), which is in line with the present study. Mineral elements such as N, P, Mg, Fe and Zn are critical in chlorophyll synthesis and have been reported to be high in biosolids from organic part of municipal solid wastes (Chrysargyris and Tzortzakis, 2015; Giannakis *et al.,* 2014). Application of biosolids helped to enhance growth of tomato seedlings as exhibited by taller and thicker seedlings with more leaves, higher root and shoot dry matter content as well as root volume compared with the control (soil). One of the critical physiological developments responsible for seedling growth is photosynthesis. Quantity of chlorophyll per unit area is an indicator of photosynthetic capacity. Therefore, this could explain the better growth observed in tomato seedlings grown under biosolids. Similar results were observed by Tzortzakis *et al.* (2012).

Biosolid applied in moderate levels (30%) helped to improve the physic-chemical properties (bulk density, moisture content, organic matter, pH, N, P, K, and Mg contents) of the growing media. Biosolid applied at 30% was the best media for tomato transplant production and comparable with tea compost. This was exhibited by higher emergence percentage, higher leaf chlorophyll content, taller and ticker seedlings with more leaves as well as higher root and shoot dry matter content. Biosolid may act as a locally available low-cost alternative substrate for high quality tomato transplant production.

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