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(Original Article)

The Growth and Chemical Composition of *Ficus sycomorus* Plants: Influence of Compost and Endophytic Fungi Application in Sandy Soil

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Abstract

The present work was carried out during 2021 and 2022 seasons at the Agricultural Research Station of Al-Marashda, Qena Governorate, Egypt to study the influence of composted sugarcane straw and endophytic fungi(EF) treatments on the growth parameters and chemical composition of *Ficus sycomorus* transplants in sandy soil. The field experiment was conducted in completely randomized design (CRD) in six treatments. The different 6 treatments were, sandy soil with 25% decomposed sugarcane straw(v/v), sandy soil with 50% decomposed sugarcane straw(v/v), sandy soil and EF, sandy soil with 25% decomposed sugarcane straw (v/v) and EF, sandy soil with 50% decomposed sugarcane straw (v/v) and EFas well as sandy soil alone. The obtained results evident that planting of *F. sycomorus* transplants in sandy soil mixed with 50% compost by volume with the addition of *Chaetomium globosumas* entophytic fungi resulted in the highest values of shoot length, stem diameter and the number of leaves compared to the other treatments in the 1st and 2nd seasons. Concerning the effects of the tested treatments on nitrogen, phosphorus, potassium, phenolic and flavonoids contents in leaves, growing transplants with the mixture of 50% compost with the sandy soil(v/v) and EF addition followed by the mixture of 25% compost with sandy soil plus EF addition resulted in the highest values of these components.

Keywords: *Ficus sycomorus, Endophytes, Compost, Chaetomium globosum.*

Introduction

Ficus sycomorus L. belongs to the Moraceae family, which is indigenous to African countries like Egypt and mostly grows well in the tropical countries. It is a large tree up to 30 m, branches begin from the lower part of the body and form shapes like umbrellas and leaves are dark green, yellow-veined and heart-shaped (Hossain, 2018). The most suitable area for *F. sycomorus* trees is near drainage lines, streams, rivers, springs or dams. It grows well in a deep and well-drained, clay soils and in soils with ground water (Kassa *et al*., 2015). Fruits are eaten when they ripen or stored in stewed or dried and it can also be used to prepare an alcoholic beverage (Dluya *et al*., 2015). The tree is also used to obtain fuel, to provide shade and shelter as well as to prevent erosion. Moreover, it is a medicinal

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plant, as extracts of fruits, leaves, root, and stem barks to treat various ailments such as cough, diarrhea, skin infections, stomach disorders, liver disease, infertility and sterility (Maregesi *et al*., 2007).

The most considerable characteristics of the growing medium are: moisture capacity, drainage properties, permeability, nutrient balance, buffer capacity and the physical stability (Conover and Poole, 1988). Among the characteristics of sandy soil is that contains a high proportion of sand, low specific surface area, low water retention, low fertility and high infiltration rate, low organic content and the nutrients are easily washed through the soil. Therefore, when using sandy soil as a growing media, it must be mixed with other material to increase aeration of the soil (Verdonck *et al*. 1991). Addition of organic matter as compost to sandy soil is the only way to initiate microbial activity, help preserve soil fertility, promote soil aggregation stability, improve hydraulic conductivity and nutrient's ability (Major *et al*., 2010). Moreover, compost usually increase the amount of soil organisms (Cheng and Grewal, 2009). It is a commonly used as soil amendment in forestry and agriculture practices (Duong *et al*., 2012).Certain composted elements constitute a sustainable supply of commonly available nutrients that could promote plant growth and improving the physical, chemical and microbiological properties of the soil (Scotti *et al*., 2015). Saqib *et al*. (2019) pointed out that increase in plant growth of *Acacia nilotica*was observed with the increases in the amount of compost mixture. Also, they recorded that maximum plant height, shoot length and biomass production was observed when 75% compost level was applied, while minimum was observed with the control treatment .

Endophytic fungi are microorganisms that colonize and found asymptomatic infections in healthy plants (Suryanarayanan and Kumaresan, 2000). Fungal endophytes are considered mycorrhizal associations among temperate-zone plants (Carroll, 1988), it has been found in the different conifers (Legault *et al*., 1989), and both monocotyledonous and dicotyledonous angiosperms (Rajagopal and Suryanarayanan, 2000). Endophytic fungi have a great attention in the past few decades due to its ability to produce novel secondary metabolites for medical, agricultural, and industrial use as well as they are also considered as an outstanding source of bioactive compounds due to its ability to occupy any plants at any environments (Strobel and Daisy, 2003).Due to the capability of endophytic fungi on colonizing internal tissues of plants and their ability to promote plant growth, endophytic microorganisms can be used in agriculture as a tool to improve crop performance (Yuan *et al*., 2009).Results of Ebeid and Shebany (2017) pointed out that all the used endophytic fungi had significant effects on the seedling parameters of *Chrysophyllum oliviforme* compared to the control. Application of *Alternariaalternata* resulted in the most effective, while *Nigrospora oryzae* resulted in the best result for chlorophyll and nitrogen content. Therefore, the main objective of this research was to study the effect of *Chaetomium globosumas* endophytic fungi and composted sugarcane straw on the growth and some chemical constitutes of *Ficussycomorus* transplants in sandy soil.

Materials and Methods

The experiment was conducted at the Agricultural Research Stationof Al-Marashda, Qena Governorate, Egypt during the two seasons of 2021 and 2022 to study the effect of endophytic fungi and composted sugar cane straw on the growth and chemical composition of *Ficus sycomorus* L.in sandy soil. Cuttings were collected from healthy tree in a private farm of Qena Governorate on the 1st of February of the two seasons. Cuttings were planted in a polyethylene potfilled with loamy sand soil, even success of rooting.

Fungal isolation, identification, and cultivation

Ficus sycomorus leaves were collected from a private farm at Qena, Egypt. Leaf samples were washed carefully by tap water, then by sterilized distilled water. Samples were surface sterilized by sequential immersion in 75% ethanol for 1 min, 4 % sodium hypochlorite for 3 min finally, 75% ethanol for 30 s. The samples were then rinsed by using sterilized distilled water, and shade dried (Filip *et al*., 2003). Leaves were cut for small pieces and placed on prior poured glucose-Czapek's agar, then incubated at 28± 2 °C for 2 - 3 weeks in a microbiological incubator until the desired *Chaetomium globosum* fungi growth (Smith and Dawson, 1944).

Table 1a. Physical and chemical properties of the used sandy soil

Character	E.C. dS/m^{-1}	pH	Coarse sand (%)	Fine sand (%)	Silt + Clay (%)	Anion (meq/ L)			Cation (meq/L.)			
						HCO_3^-	Cl^-	SO_4^-	Ca^{++}	Mg^{++}	Na^+	K^+
Value	0.20	7.76	75.5	15.0	9.5	0.6	0.70	0.81	0.56	0.44	0.67	0.22

Table 1b. Some properties of the composted sugarcane straw used in the experiment

Organic matter (%)	pH 1:10	E.C. dS/m^{-1} 1:10	Total nitrogen (%)	Total carbon (%)	C/N ratio	Total phosphorus (%)	Total potassium (%)
43.30	7.60	2.25	1.65	26.22	15.89	0.63	0.80

Transplanting in the growth media and treatments

After success of rooting, plants were transplanted (40 days after planting). One vigorous transplant of *F. sycomorus* was transplanted into each plastic pot of 3 L volume on 10th March of the 2021 and 2022 seasons. The plants were transplanted into sandy soil already amended with 25% or 50% composted sugarcane straw, while the sandy soil which was not amended used as control. Some properties of the composted sugarcane straw and sandy soil are shown in Table (1 a & b). Treatments with endophytic fungi (EF) i.e., *Chaetomium globosum* was commenced on 20th March and continued until 20th July of seasons; treatments with these endophytic fungi that containing 10^6 spores ml^{-1}. Four doses in this period at the rate of 100 ml/ pot every 30 days, added as drench to the soil. Each pot was watered and weeded when needed. Experiment was conducted in completely randomized design (CRD). Six treatments were used as follows: control (sandy soil alone), sandy soil with 25 % decomposed sugarcane straw(v/v), sandy soil with 50% decomposed sugarcane straw(v/v), sandy soil and EF, sandy soil with 25% decomposed sugarcane straw and EF as well as sandy soil with 50% decomposed sugarcane straw(v/v) and EF. The experiment was replicated seven times, so the total number of *F. sycomorus* transplants in this experiment is forty-two (42) of 15 cm in length.

Growth parameters

The effects of the different treatments were evaluated 130 days later (on the 1st of August) based on shoot length (cm), stem diameter (cm) and number of leaves / plant.

Chemical Analysis

NPK in dry leaves

Foliar samples from *F. sycomorus* seedlings from each treatment were collected and oven dried at 80°C till constant weight was achieved. Sampled were grinded and analyzed for N, P and K (mg/ g DW) following methods described by Anderson and Ingram (1993).

Total phenolic content(mg GAE/g)

The soluble phenolic content of leaf-water extract was determined using Folin-Ciocalteu reagent. 0.5 mL of extract were incubated in a water bath at 45°C for 45 minutes with the addition of 2.5 mL of 10% Folin-Ciocalteu reagent and 2.5 mL of $NaHCO_3$ (7.5%). The absorbance of the mixture was measured spectrophotometric ally at 765 nm. Total phenolic content is expressed as mg gallic acid equivalents (mg GAE/g) as reported by Stanković (2011).

Total flavonoid content (mg RE/g)

1 ml of leaf-water extract was diluted with 5 mL of distilled water. 0.3 mL of 5% $NaNO_2$ was added to the samples and incubated for 5 min at room temperature. Then 0.6 mL of 10% $AlCl_3.6H_2O$ was added to the mixture, 2 mL of 1M NaOH was added, and the final volume of the reaction mixture was completed with distilled water to 10 ml. The absorbance of the prepared mixtures was determined spectrophotometric ally at 510 nm. Total flavonoid content was expressed as mg routine equivalents (mg RE/g) according to Sharma and Vig (2013).

Data of the tested treatments were tabulated, and the means were compared by using L.S.D. test at 5% probability, according to Snedecor and Cochran (1980).

Results and Discussion

Shoot length

Table 2 showed that shoot length of *Ficus sycomorus* were significantly varied according to the addition of endophytic fungi and composted sugarcane straw. Obtained results indicated that significant differences among different treatments. Shoot length ranged from 24.70 to 64.37 and 24.37 to 64.97cm in the 1st and 2nd seasons, respectively. Significant differences were detected with the highest values being obtained due to planting in the sandy soil with 50 % decomposed sugar straw + EF addition for the shoot length, while the lowest values were noticed in the control treatment. The treatment with composted sugarcane straw with endophytic fungi gave higher shoot length than without compost, this due to macro and micronutrients and high pH of the compost (Bernas *et al*., 2020). These results like Aisueni *et al*. (2009), who showed that 100 g compost/ seedling was enough for six months old plant. Also, Dialami and Mohebi (2010) revealed that date plant grew well on high pH. Similar results reported by Bernas *et al*. (2020).In addition, the shoot length was increased by adding endophytic fungi with composted sugarcane straw. Endophytic fungi are asymptomatic and may be mutualistic, plant protect and feed endophytes, which produce plant- growth-regulators, antimicrobial, antiviral, or insecticidal substances to enhance the growth and competitiveness of the host (Carroll, 1988).The finding of this study revealed that the increased of nutrient in the growth media may be useful in the growth performance of *F. sycomorus* transplants. *Chrysophyllum oliviforme* transplants treated by *Alternaria alternata*as endophytic fungi were significantly increased values of the plant height compared to the other treatments (Ebeid and Shebany, 2017).

Table 2. The effect of endophytic fungi (EF) and composted sugarcane raw on the shoot length (cm) of *Ficus sycomorus* in sandy soil during the 2021 and 2022 seasons

Treatments	Shoot length (cm)	
	1st season	2nd season
Control (sandy soil alone)	24.70	24.37
Sandy soil with 25 % decomposed sugarcane straw(v/v).	28.77	29.27
Sandy soil with 50 % decomposed sugarcane straw (v/v).	33.30	32.73
Sandy soil + EF	35.83	35.60
Sandy soil with 25 % decomposed sugarcane straw(v/v) + EF	53.77	53.47
Sandy soil with 50 % decomposed sugarcane straw (v/v) + EF	64.37	64.97
Mean	40.12	40.07
LSD 5%	2.98	2.58

Stem diameter

Stem diameter of *F. sycomorus* were significantly varied due to endophytic fungi and composted sugarcane straw additions (Table 3). Results indicated that stem diameter ranged from 0.24 to0.58 and 0.26 to 0.60 cm in the 1st and 2nd seasons, respectively. Maximum stem diameter was noticed with sandy soil amended with 50 % decomposed sugarcane straw (v/v) + EF treatment, while minimum diameter in the control treatment. The highest values of stem diameter with composted sugarcane straw + endophytic fungi gave higher stem diameter than without compost, this due to macro and micronutrients and high pH of the compost. There was a significant correlation between seedling development and the different amounts of biological fertilization (Amin *et al*., 1994). The lowest values of stem diameter under sandy soil alone might have been due to its effects on cell elongation as well as cell division. The results of Saqib *et al*. (2019) demonstrated that there were positive effects of compost addition on the growth of *Acacia nilotica*. The seedling developments were improved considerably with different levels having greater percentage of organic fertilizer and it was revealed that compost and endophytic fungi improved plant growth and soil fertility, which act as organic and bio- fertilizers in farming and forestry practices to improve the growth and yield of crops and trees. Similar results were reported by Elamin *et al*. (2017) and Ebeid and Shebany (2017).

Table 3. The effect of endophytic fungi (EF) and composted sugarcane raw on the stem diameter (cm) of *Ficus sycomorus* in sandy soil during the 2021 and 2022 seasons

Treatments	Stem diameter (cm)	
	1st season	2nd season
Control (sandy soil alone)	0.24	0.26
Sandy soil with 25 % decomposed sugarcane straw(v/v).	0.31	0.30
Sandy soil with 50 % decomposed sugarcane straw (v/v).	0.35	0.33
Sandy soil + EF	0.38	0.37
Sandy soil with 25 % decomposed sugarcane straw (v/v) + EF	0.46	0.48
Sandy soil with 50 % decomposed sugarcane straw (v/v) + EF	0.58	0.60
Mean	0.38	0.39
LSD 5%	0.029	0.021

Table 4. The effect of endophytic fungi (EF) and composted sugarcane straw on the number of leaves of *Ficus sycomorus* in sandy soil during the 2021 and 2022 seasons

Treatments	No. leaves	
	1st season	2nd season
Control (sandy soil alone)	6.20	6.30
Sandy soil with 25 % decomposed sugarcane straw(v/v).	8.47	8.57
Sandy soil with 50 % decomposed sugarcane straw (v/v).	9.27	9.37
Sandy soil + EF	10.27	10.07
Sandy soil with 25 % decomposed sugarcane straw (v/v) + EF	16.67	16.60
Sandy soil with 50 % decomposed sugarcane straw (v/v) + EF	19.50	19.30
Mean	11.73	11.70
LSD 5%	1.12	1.27

Number of leaves

Data in Table 4 show the effect of different compost rates and endophytic fungi on leaves number of *F. sycomorus* during the two growing seasons. The leaves number /plant were increased significantly with the addition of different treatment compared to the control. It illustrates that both sandy soils amended with 50 % decomposed sugarcane straw and EF addition significantly augmented number of leaves/plant, in both seasons, over those of the other treatments. On the contrary the lowest values of leaves number were noticed with untreated plants. This result may be due to the organic materials that rich in the essential plant nutrients as vitamins, micronutrients, and hormones; then, increased growth of *F. sycomorus* transplants. Our results are in harmony with those of Mohammed *et al.* (2010) on pear trees, Sondarva *et al.* (2017) on *Khaya senegalensis*. They found that addition of compost as soil application gave better effect on the vegetative characteristics compared to the control. Haggag *et al*. (2014) concluded that, application of compost as soil drench with or without mineral nutrients gave the highest number of leaves/ seedlings of olive cv. Aggizi as compared to the control.

These results suggested that organic substances have the potential to provide the plant with the necessary nutrients, improve the physical and chemical properties of soil, then increased the seedling growth as compared to sandy soil alone (Biocycle, 2004).The results of Fini *et al*. (2016) showed that compost increased growth, carbon storage, and improved water use efficiency of Ulmus trees.

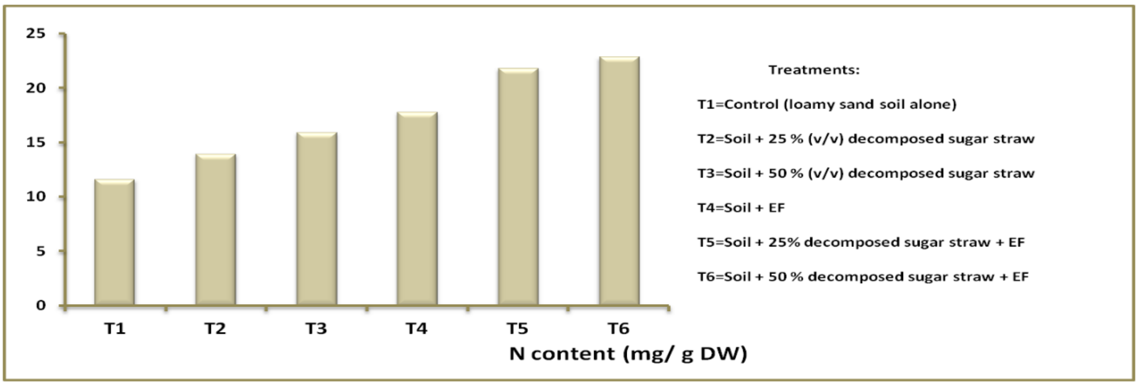

Figure 1. The effect of endophytic fungi (EF) and composted sugarcane straw on the nitrogen content (mg/ g DW) in leaves of *Ficus sycomorus* in sandy soil during the 2022 season

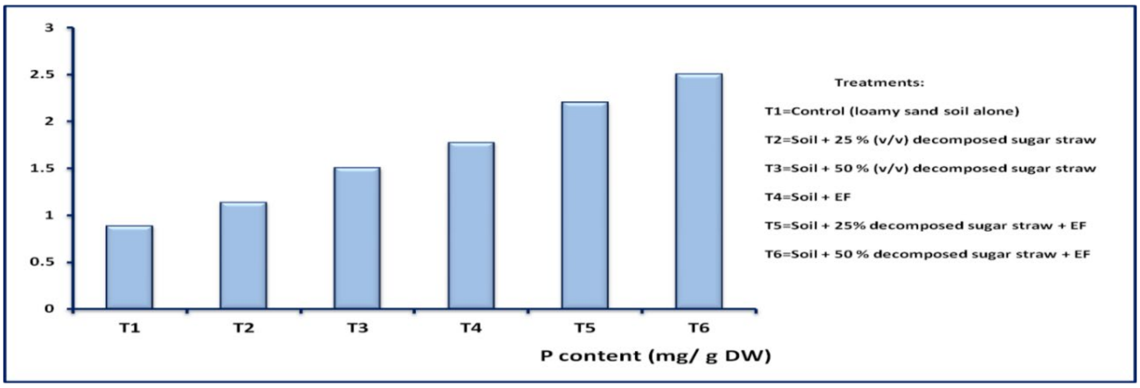

Figure 2. The effect of endophytic fungi (EF) and composted sugarcane straw on the phosphorus content (mg/ g DW) in leaves of *Ficus sycomorus* in sandy soil during the 2022 season

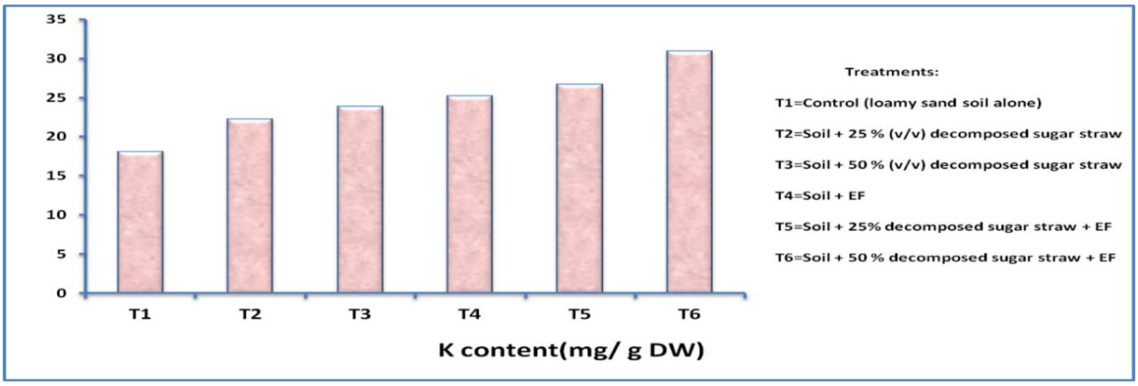

Figure 3. The effect of endophytic fungi (EF) and composted sugarcane straw on the potassium content (mg/ g DW) in leaves of *Ficus sycomorus* in sandy soil during the 2022 season

Mineral contents

Figures 1, 2 and 3 indicated that, composted sugarcane straw and entophytic fungi treatment had significant effect on N, P and K contents in leaves of transplants during the 1st and 2nd seasons. Planting *F. sycomorus* transplants in sandy soil with compost at 50% (v/v) and application of endophytic fungi as soil drench recorded the maximum N, P and K contents in leaves, while the lowest ones were obtained with the control treatment in the two seasons. These results may be attributed to the ability of compost and endophytic fungi to induce the absorption and translocation of N, P and K by leaves tissues compared to sandy soil alone. Combinations between compost and sandy soil as well as EF addition resulted in extra significant increases in N, P and K availability in the media and consequently raised their uptake by the transplants especially with the increment in application rate of compost. These findings are harmony with those reported by Mohammed *et al.* (2010) on pear, Allam *et al.* (2012) on grapevines, Haggag *et al.* (2014) on "Aggizi" olive and El-Shony *et al*. (2019)on peanut and wheat crops. Ahmad *et al*. (2021) pointed out that *Bombaxceiba* exhibited its better growth because of application compost at 75%.

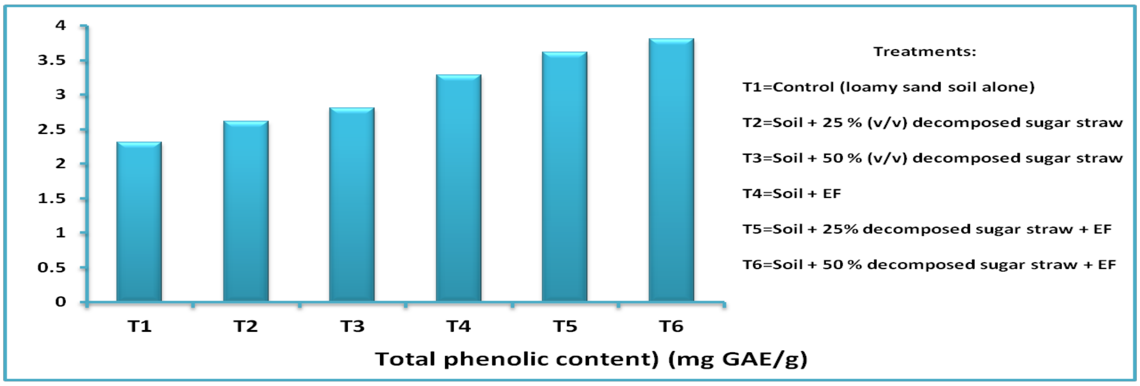

Figure 4. The effect of endophytic fungi (EF) and composted sugarcane on total phenolic content (mg gallic acid equivalents/ g) (mg GAE/g) in leaf- water extract of *Ficus sycomorus* in sandy soil during the 2022 season

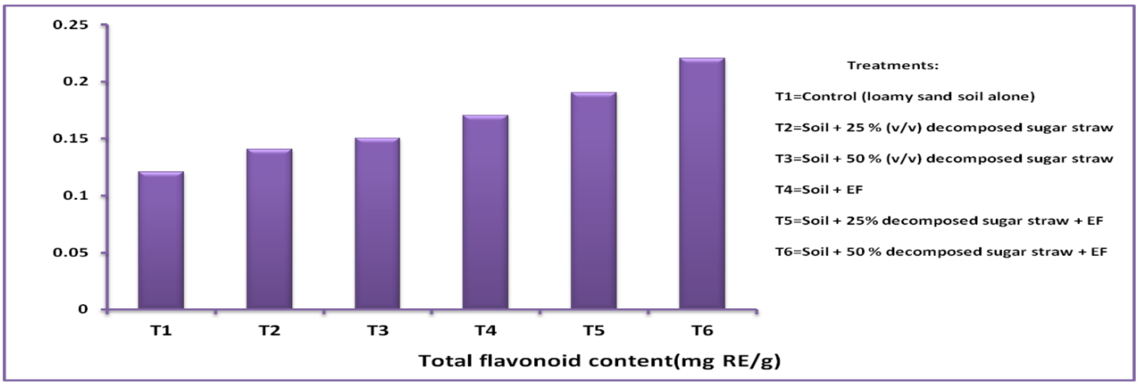

Figure 5. The effect of endophytic fungi (EF) and composted sugarcane on total flavonoid content (mg routine equivalents) (mg RE/g) in leaf- water extract of *Ficus sycomorus* in sandy soil during the 2022 season

Total phenolic and flavonoid contents

Figures 4 and 5 show the effect of composted sugarcane straw and endophytic fungi on the total phenolic and flavonoid contents in leaves of *F. sycomorus*. Cultivated transplants in sandy soil amended with compost at 50% (v/ v) and enophytic fungi had the highest values of these contents, while the least values were recorded in the control treatment. Treated transplants with compost 50% plus endophytic fungi followed the same trend with the highest values being recorded for the growth and mineral contents of transplants. The present obtained results suggested that these organic and bio fertilizers have the potential to provide the plant with the necessary nutrients resulted in improving physical and chemical properties of soil as well as suppress plant diseases, then increases the transplant growth (Biocycle, 2004). Another study of Ghareeb *et al*. (2015), percentage yield extraction of the leaf-methanol extract was found 14.0%.The water, ethanol and acetone extracts had an extraction yield of 32.45, 27.4 and 4.85%, respectively (Tanoğlu, 2019). These findings are harmony with those of Mahmoud and Hussein (2021) on *Inga edulus* seedlings.

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النمو والمكونات الكيميائية لنباتات الجميز: تأثير اضــافة الكمبوســت والفطريات الداخلية بالتربة الرملية

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الملخص

أجريت هذه الدراسة خلال موسمي 2021 و2022 بمحطة البحوث الزراعية بالمراشدة – قنا مركز البحوث الزراعية لدراسة تأثير الكمبوست الناتج عن قش قصب السكر والفطريات الداخلية والمتمثلة في فطر كوتوميمجلوبوزيم على بعض صفات النمو والمكونات الكيميائية لشتلات الجميز النامية بتربة رملية. استخدم في التجربة سبع مكررات. وكان أهم النتائج ما يلي:

نتج أعلي القيم الخاصــة بصــفات النمو متمثلة في طول الشـتلة، قطر الســاق، عدد الأوراق/ شـتلة نتيجة للزراعة في البيئة المكونة من 50% كمبوسـت مع التربة الرملية مع اضــافة الفطريات الداخلية.

أيضــا، تم الحصــول علي أعلي القيم الخاصــة بالمكونات الكيميائية بالأوراق من النيتروجين، الفوســفور، البوتاســيوم، المواد الفعالة بالأوراق من محتوي الفينولات والفلافونيدات نتيجة زراعة شــتلات الجميز بالبيئة المضـــاف اليها 50% كمبوســـت مع التربة الرملية مع اضـــافة الفطريات الداخلية.

من خلال النتائج من هذه الدراسة يمكن أن نخلص الي أنه للحصول على شتلات جميز قوية ذات جودة عالية نامية بالتربة الرملية ذات العناصر الغذائية المنخفضة، توصي الدراسة بأن تزرع الشتلات في بيئة مكونة من 50% كمبوست مع التربة الرملية مع اضـافة الفطريات الداخلية متمثلة في فطر كوتوميمجلوبوزيم.