Benefit From Agricultural Waste to Improve the Properties of Desert Land and Resist Environmental Pollution

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Abstract: The environmental pollution from agricultural waste and waste from the barns are considered of the main sources of environmental pollution facing Egypt and Kingdom of Saudi Arabia as well as poor physical properties and soil fertility that coupled with the desert lands (sandy soils), which cover most of the area of the two specified countries. In addition to, the phenomenon of desertification, which reflects the loss of the soil beside the deserts to its fertility and changed from productive to nonproductive. Getting ride off agricultural waste and reclaiming desert lands, with very poor physical properties, are the challenges. The agricultural waste are rich in organic matter which reduce the pollution load and improve hydro-physical properties of such kind of soil (e.g. Egyptian and Saudi deserts), this research was conducted to study the effect of using two types of compost, prepared from different agricultural waste (i.e. stable wastes and plant residuals), at different application positions. The application positions were surface application (SA), sub-surface application (SbA), and whole application (WA). The studied parameters were soil evaporation (E), evapotranspiration (ET), and water use efficiency (WUE). A pot experiment under green house was carried out to reach those objectives. The obtained results could be summarized as follows. Significantly, E and ET were decreased and WUE was increased. About 13% of applied water could be saved by applying compost to sandy soil, regardless compost type or application position. No significant difference was found between the two applied composts. WA was associated with the highest E and ET and the lowest WUE comparing with the other two application positions. No significant difference was found between SA and SbA. Based on the previously mentioned results the study recommended using compost as an amendment of desert (i.e. sandy soil) for the purpose of water conservation and recycling agricultural wastes as well.
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1. Introduction

The environmental pollution from agricultural waste and waste from the barns are the main sources of environmental pollution facing Egypt and Kingdom of Saudi Arabia as well as poor physical properties, that accompanies the desert lands (sandy soils) Which often lead to the phenomenon of desertification. Such phenomenon reflects the loss of the soil to its fertility and biological capabilities and changed from cultivated and productive soil to bare and nonproductive soil.

Non scientific waste pile lead to the spread of pathogenic bacteria, fungi and weed seeds as well as the loss of nutrients with time. Furthermore, some farmers used to get rid of the waste by burning which increase environmental pollution. Scientific preparation of the pile of compost and by adjusting the proportions of moisture and additions of nitrogen increase the microbial activity and thus increase the temperature inside the pile of compost, which kills pathogenic bacteria, fungi and weed seeds and reduces the ratio of carbon to nitrogen and produces mature compost with a high economic value. This is cope with Shepherd *et al.* (2010), who reported that farmers need to be educated in effective composting procedures. Furthermore, strategies should also be developed and applied to expedite the inactivation of potentially pathogenic bacteria on the compost surface.

The prepared compost could be used as organic amendment to improve soil fertility, physical properties, reduce the need of chemical fertilizers, which should be reflected positively on obtained yield quantity and quality and water saving. Moreover, compost application could help in increasing soil water holding capacity, reducing evaporation and deep seepage and recycling wastes to environmentally safe economic product (compost). In this respect, Yu *et al.* (2012) reported that compared to mineral fertilizer, long-term compost application significantly increased the stability of organic C in the microaggregate but not in the macroaggregate fraction.

Increasing water conservation of sandy soil has become a critical issue with regard to water shortage. When water is applied to soil surface, with no surface runoff or deep seepage, one portion of water is utilized by plant or what known as transpiration and the other is lost via soil evaporation. The summation of the two portions (evaporation and transpiration) is called evapotranspiration (ET). The rates of both evaporation and transpiration are very high in deserts regarding to the surrounding dry air associated with desert climate (e.g. Egyptian and Saudi deserts), causing a massive loss of water, which is already very limited and fragile resource. Which limit and reduce the chance of reclaiming and cultivating deserts. When the aim is water saving, most attention is usually focused on irrigation systems, mulches, or other visible improvements. One less visible, but equally important way to reduce water consumption is adding organic matter to soil. Klocke (2004) declared that: crop residues have the capacity to modify the radiant energy reaching the soil surface and reduce the soil water evaporation.

DPR of Korea (2002) reported that: 31% of continental area on our earth is sandy soil or desert, with a total area amounting to 48,000,000 km^2. Therefore, the improvement of sandy soil and deserts is one of the most important tasks facing mankind at present. FAO (1975) reported that: desert makes up more than 95% of the total area of Egypt, as well as Saudi Arabia.

Using compost (which is a product derived from agricultural waste) as an amendment of such kind of soil, for the purpose of water conservation, become mandatory consistent with environmental and economic consideration of Egypt and Saudi Arabia.

The compost absorbs and holds the moisture. Howell (2001) stated that: in irrigated agriculture, Water use efficiency (WUE) is broader in scope than most agronomic applications and must be considered on a watershed, basin, irrigation district, or catchment scale. The main pathways for enhancing WUE in irrigated agriculture are to increase the output per unit water by reducing water losses. Maximization of WUE has become a high priority for numerous studies in the desert sandy soils. Applying compost is simple, and inexpensive and also it is a good way to dispose and recycle agricultural wastes. Wanas and Omran (2006) found that Egyptian sandy soil hydro-physical properties were improved by applying two types of compost, prepared from cotton and banana. Because of such beneficial effect of compost application, and also since the effect of compost on E, ET and WUE are currently not available for the desert lands of Egypt and Saudi Arabia. The main objective of this study is evaluating and quantifying the effect of compost application (i.e. type and position) on E, ET, and WUE of Egypt and Saudi Arabia desert lands for the purpose of water saving and agricultural wastes recycling.

2. Material and Methods

Two types of compost (named compost 1 and compost 2) were prepared to be used in testing the effect of compost on some soil properties. The composts used in the experiment were prepared according to the method described by Rynk (1992). Compost 1 was prepared from agricultural waste (by grinding and mixing plant residuals after harvest with poultry waste). Compost 2 was prepared from agricultural waste (by grinding and mixing plant residuals after harvest with farm animal shelters waste).

A greenhouse experiment was conducted at Taif university, Saudi Arabia. The experiment was carried out in completely randomized design with three replicates in plastic pots. Each pot received 10 Kg of air dried un-reclaimed sandy soil, collected from Taif governorate.

The two prepared composts were added to the soil at a rate of 25g/Kg soil (about 60 tons/hectare).

Two types of compost were applied to the experimental soils as follows:

a) Control treatment (CT): No compost was added.
b) Surface addition treatment (SA): composts were incorporated with the surface layer (0-15cm).
c) Subsurface addition treatment (SbA): composts were incorporated with the subsurface layer (15-30cm).
d) Whole addition treatment (WA): composts were incorporated with the whole soil in the pot (0-30cm).

Mineral nutrients were added to the pots at a rate of 2:1:1of NPK respectively. The applied fertilizers for NPK were ammonium nitrate , super phosphate and potassium sulphate , respectively.

Spinach (Spinacia Oleracea L.) was chosen as a test plant. Because it is classified as a short-season shallow root system plant. Lorenz and Maynard (1980) find that the time required for Spinach to reach market maturity from seedling are 37 and 45 days for early and late variety respectively and between 60:70 days for spinach cultivated in Mediterranean area according to FAO (1998). The average root length is ranging between 46-61 cm according to Lorenz and Maynard (1980) and ranging between 30-50 cm according to FAO (1998). So, 30 cm consider a suitable depth under pot experiment and full water requirement compensation condition with short irrigation intervals. Ten seeds per pot were planted, then thinned to five plants selected to grow until the end of the season (Spinach plants were harvested at age of 70 days).

The moisture content was maintained at field capacity (i.e. daily irrigation) until the plants were well established. After that, soil moisture depletion was compensated, by irrigation, twice a week. The irrigation requirement was calculated based on the weight difference between pot (i.e. soil) at field capacity and at the actual moisture content. For calculating soil evaporation, E, (soil losses from bar soil) and evapotranspiration, ET, (water depletion from cultivated soil), the pots weight were monitored and 10 day average values were estimated overall the entire season. Both rate and cumulative E and ET were calculated and also transpiration, T, over ET ratio for all experimental treatments were calculated.

After harvest, the plant shoots were washed and dried at 70^{o}C, then the dry weight was recorded. WUE was calculated using the data of shoot dry weight and total water consumed by spinach plants.

Data are subjected to three factors (i.e. compost type, application position and plant age) analysis of variance to determine if E and ET significantly changed with the three studied factors using the commercial program STATISTICA. All tests were performed at the 0.05 significant level. The treated soil is correlated to control soil throughout linear regression analysis using the commercial program EXCEL.

Physical analysis (particle size analysis) of the experimental soil was determined by pipette method (Majumdar and Singh, 2000). Chemical analysis of the experimental soil was determined according to Black et al. (1965). Some physical and chemical analyses of the experimental soil and applied composts were presented in Tables 1, 2 and 3 respectively.

Table 1: Physical analysis of the experimental soil

Particle size distribution, %				Texture	Density, g/cm^3		Soil moisture constants as a percent (by weight)	
Course Sand	Fine sand	Silt	Clay		Real	Bulk	Field capacity	Wilting point
76.7	14.32	5.95	3.03	Sandy	2.65	1.58	7.3	1.8

Table 2: Chemical analysis for the experimental soil

Organic Mutter, %	EC ds/m	pH	Soluble ions, meq/100 g soil							
			Cations				Anions			
1.89	0.38	7.85	0.74	0.65	1.15	0.34	0	0.95	1.42	0.5

Table 3: Some chemical characteristics of the two proposed composts

Compost type	PH	EC dS/m	C/N ratio	N (%)	P (%)	K (%)	Waxes (%)	Legnin (%)	Hemi-cellulose (%)
Compost 1	7.25	2.28	19.3	1.94	0.71	3.66	1.05	3	6.12
Compost 2	7.31	1.92	22.6	2.07	0.49	2.8	1.67	3.86	9.4

3. Results and Discussion

Table 4 shows the effect compost 1 and compost 2 application on evaporation (E) and transpiration (ET). An average values were recorded every 10 days was recorded for all the experimental treatments through the growing season.

Data in table 4 indicated reduction of average daily E. About 13% of applied water was saved by applying compost to sandy soil regardless compost type or application position.

Table 5 representing calculated LSD values of E and ET between compost type and positions and 10 days average values of the entire growing season.

The statistical analysis (LSD), presented in table 5, showed significant decrease of both soil E, and ET, with applying compost 1 and compost 2 comparing with control, for both bar and cultivated soil. No significant differences were found between compost 1 and compost 2. This may be due to that the organic matter working as a cement material between soil particles, increasing its water holding capacity and increasing soil available water to plant roots. This may be explained by Chollak and Rosenfeld, 1998 reported that: organic matter in the soil reduces the need for fertilization and can reduce the need for supplementary watering by 60% when compared to sites with un-amended topsoil. ET was significantly increased with time increase along the growing season or plant age, inversely with E was not significantly affected. This could be explained as follows: in bar soil losing water through evaporation (no plant uptake) is controlled only by weather parameters which were almost constant in winter during the experiment period and under controlled conditions (e.g. green house). On the other hand, in cultivated soil, the crop water requirement was increased with time or plant age until it reaches the maximum growth. Significant differences were found between SA and WA and between SbA and WA, where no significant differences were observed between SA and SbA. The highest E and ET values were associated with control followed by WA then both SA and SbA. This may be due to that the application of compost affect soil water holding capacity. In this respect, Sullivan (2002) found that organic matter increases water storage by 16,000 gallons per acre foot for each 1% organic matter. Organic matter also increases the soil's ability to take in water during rainfall events, assuring that more water will be stored. Also, Klocke (2004) reported that: evaporation from the soil surface after irrigation or rainfall is controlled by the atmospheric conditions and by the shading of a crop canopy. Water near the surface readily evaporates and does so at a rate that is only limited by the energy available. Crop residues have the capacity to modify the radiation energy reaching the soil surface and reduce the soil water evaporation.

Table 4: E and ET of the experimental treatments.

Treatments			Period in days (10 day average)						
			10	20	30	40	50	60	70
Bar soil (E, cm/day)	Control		0.19	0.20	0.18	0.22	0.16	0.20	0.20
	Compost 1	SA	0.11	0.13	0.09	0.11	0.10	0.11	0.12
		SbA	0.13	0.12	0.12	0.13	0.14	0.11	0.12
		WA	0.15	0.17	0.13	0.18	0.15	0.12	0.17
	Compost 2	SA	0.10	0.12	0.11	0.12	0.09	0.13	0.08
		SbA	0.12	0.12	0.11	0.12	0.14	0.10	0.11
		WA	0.15	0.15	0.17	0.14	0.14	0.16	0.17
Cultivated soil (ET, cm/day)	Control		0.17	0.21	0.22	0.36	0.44	0.52	0.51
	Compost 1	SA	0.13	0.16	0.19	0.27	0.36	0.45	0.47
		SbA	0.12	0.18	0.19	0.30	0.38	0.47	0.47
		WA	0.15	0.17	0.21	0.31	0.39	0.46	0.49
	Compost 2	SA	0.12	0.15	0.20	0.26	0.34	0.44	0.47
		SbA	0.13	0.16	0.21	0.29	0.39	0.46	0.45
		WA	0.16	0.18	0.22	0.32	0.43	0.48	0.49

Table 5: LSD of E and ET of compost type and position and plant age

LSD	Type	Position	Plant age
E	0.026	0.012	N.S.
ET	0.028	0.015	0.011

Linear regression analysis was done to develop equations describe the relationship between control treatment and both compost 1 and compost 2 treatments for the purpose of predicting ET or water consumptive use associated with compost application to different soil layers or positions.

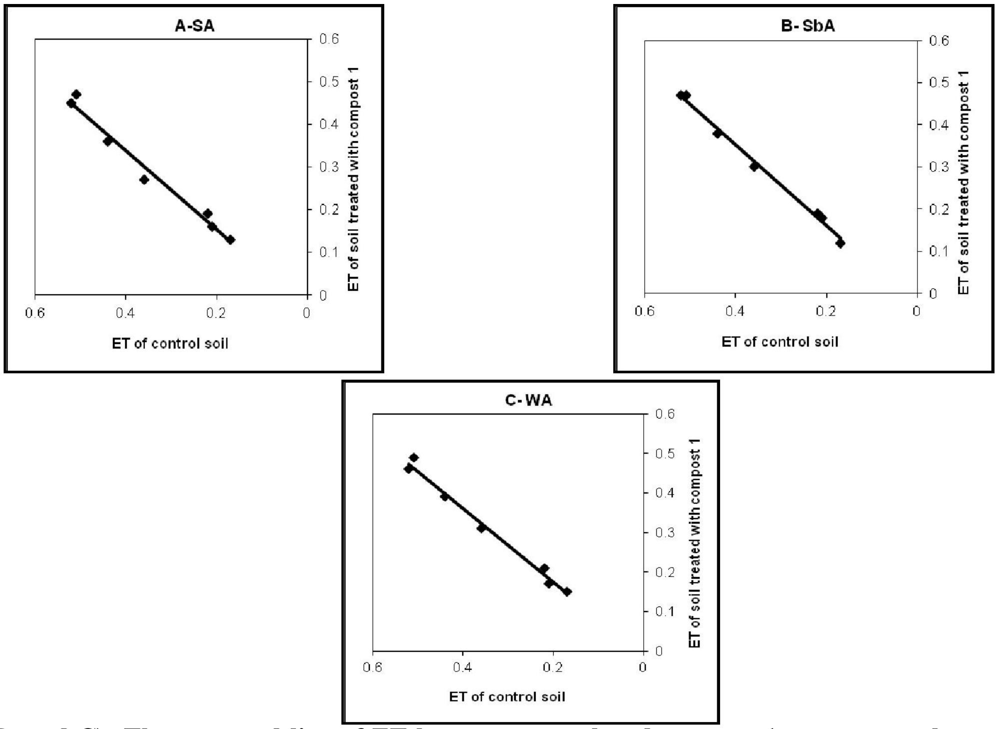

Fig 1 (A, B, and C): The regretted line of ET between control and compost 1 treatments along the growing season for SA, SbA, and WA application positions respectively

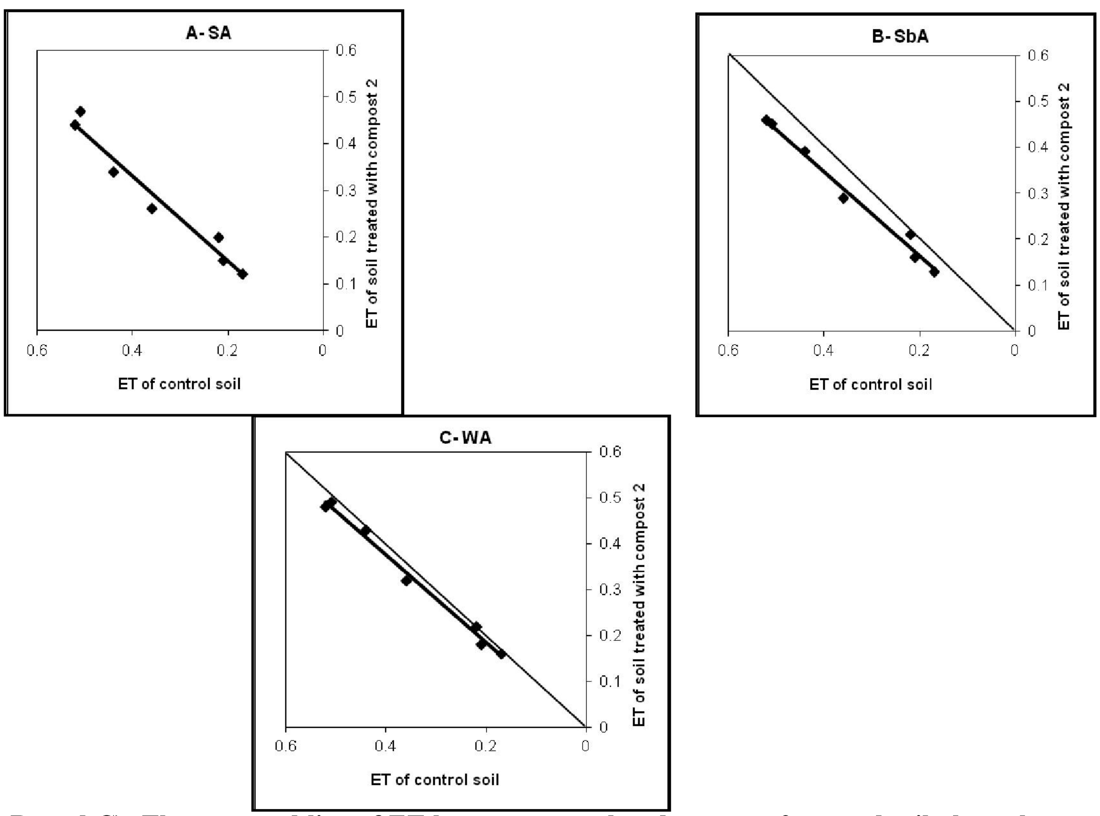

Fig 2 (A, B, and C): The regretted line of ET between control and compost 2 treated soil along the growing season for SA, SbA, and WA application positions respectively

Fig 1 and 2 showed the regretted lines for daily ET measured based on 10 days average under compost 1 and compost 2 treatments respectively. The obtained equations and R^2 values were as follows:

Control versus compost 1:

$ET_{compost\ 1,\ SA} = 0.9282\ ET_{control} - 0.0322$ $R^2 = 0.9787$

$ET_{compost\ 1,\ SbA} = 0.9642\ ET_{control} - 0.0333$ $R^2 = 0.9935$

$ET_{compost\ 1,\ WA} = 0.9345\ ET_{control} - 0.013$ $R^2 = 0.9787$

Control versus compost 2:

$ET_{compost\ 2,\ SA} = 0.9142\ ET_{control} - 0.0345$ $R^2 = 0.9598$

$ET_{compost\ 2,\ SbA} = 0.9204\ ET_{control} - 0.0209$ $R^2 = 0.9871$

$ET_{compost\ 2,\ WA} = 0.9565\ ET_{control} - 0.0063$ $R^2 = 0.9898$

The equations could be used in predicting ET and water saving in case of applying compost 1 and compost 2 to different layers of sandy soils (desert lands).

WUE was described in the literature on various scales. The most common term is characterized as crop yield or dry weight (DW) per unit of water use. or yield/water-supply ratio (Teare *et al.,*1973, Sinclair *et al.,*1984; Bos, 1985, and Hatfield *et al.,*2001).

Spinach WEU, under the different compost treatments was presented in fig 3.

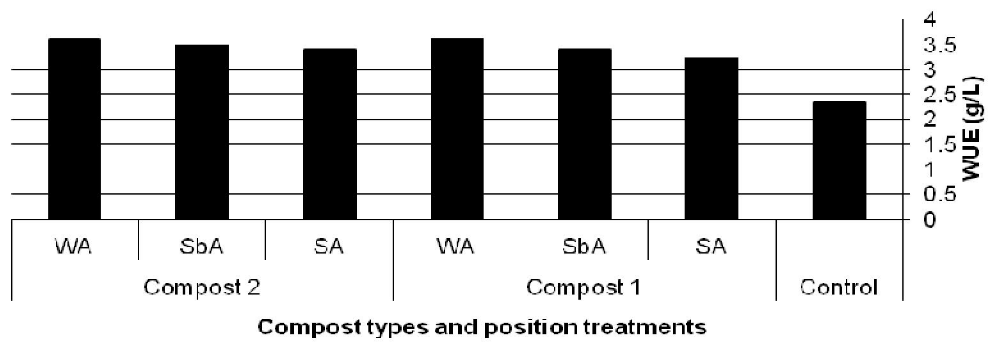

Fig 3: WUE of the experimental treatments

Fig. 3 generally, reveals that all compost treatments showed higher WUE comparing with control treatment. Such result could be explained by Wanas and Omran (2006) who found, in experiment using composts prepared from cotton and banana wastes, that hydro-physical properties of sandy soil were improved by compost application.

It is also important to find out the effect of compost treatments on both T and ET to show if there was an extra benefit of utilizing water by plant in composted and non composted soil and compare that with bare soil. In other words, to study the effect of compost application on $\frac{yield}{T}$ or $\frac{DW}{T}$ ratio. The total amount of water required for transpiration is closely related to crop yield or biomass production, when the weather conditions are constant. The $\frac{DW}{T}$ ratio seems to be a good tool to judge the effect of compost on the efficient use of water by plant. In other words, it could help in finding out weather compost affect the plant physiology in uptaking utilizing water. In this respect, Mylavarapu and Zinati (2009) reported that sequential applications of compost with and without fertilizer increased the fresh weight of parsley, nutrient uptake and soil nutrient concentrations, soil water retention, and reduced soil bulk density.

Fig 4 represented the $\frac{DW}{T}$ ratio of spinach dry weight (gram) versus applied irrigation water (liter).

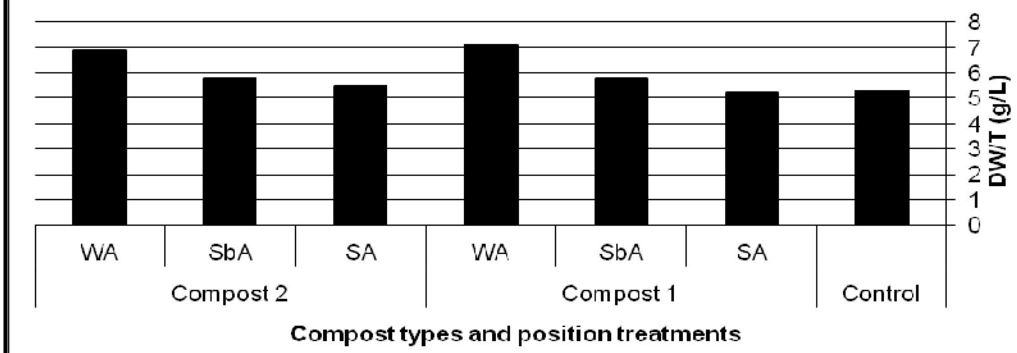

Fig 4: DW / T of the experimental treatments

Ringersma (2003) reported that: for given species and location there is a good relation between the amount of produced biomass and the amount of transpired water. The previous author also suggests a scientific term called Green Water Use Efficiency (GWUE) rather than WUE. GWUE was defined as the fraction of rain water (or irrigation) that infiltrates into the rooted soil zone and that is used, through the process of transpiration, for biomass production or $\frac{transpiration}{irrigation}$ ($\frac{T}{ET}$) which should be more relevant concept. So, the previous ratio is important because it increases plant production involves CO_2 intake through stomatal openings which is come with increasing transpiration rate. On the other hand, low transpiration or stomatal closure interferes with CO_2 intake, which reduces assimilation and dry matter production consequently. Fig 4 indicates that the WA treatment showed the highest DM per unit water transpired. The results showed favorable plant physiological effect of compost application. Such obtained result may be may be occurred due to that compost improve the characteristics of the root zone comparing with SA and SbA which are improving the surface or sub-surface area only. In this respect, Hatfield *et al.* (2001) mentioned that: plant management practices (e.g. the addition of N and P) have an indirect effect on water use through the physiological efficiency of the plant. This could be explain the positive effect of mixing compost (i.e. the treatment of WA), which contains N and P, with crop root zone.

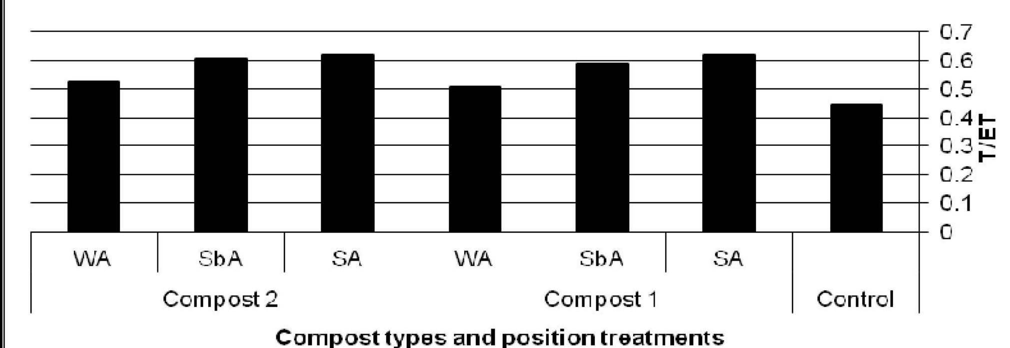

Fig 5: The ratio of T / ET for the studied experimental treatments

Fig 5 reveals that $\frac{T}{ET}$ ratio was greatly increased by applying compost to soil comparing with control, for the two compost types under consideration. This means that WUE was improved with compost application. The obtained results agree with what was found by Russel (2006) who stated that: the ratio of T to ET was 58%, but it was around 70% during the months when the plants were achieved their maximum growth. This result may be that: during the off season and early crop growth stage, E is the main portion of ET. Later when the plant grow and cover the soil surface the percent of T increased. Our concern here is not evaluate the micro-changes of such ratio during short periods, but to evaluate it as one average value for each treatment of the entire season. Hatfield *et al.*(2001) reported that: soil management practices (compost addition) affect the processes of ET by modifying the available energy, the available water in the soil profile, or the exchange rate between the soil and the atmosphere.

Fig 6 shows the effect of compost (type and positions) application on E to ET ratio comparing with control (untreated soil).

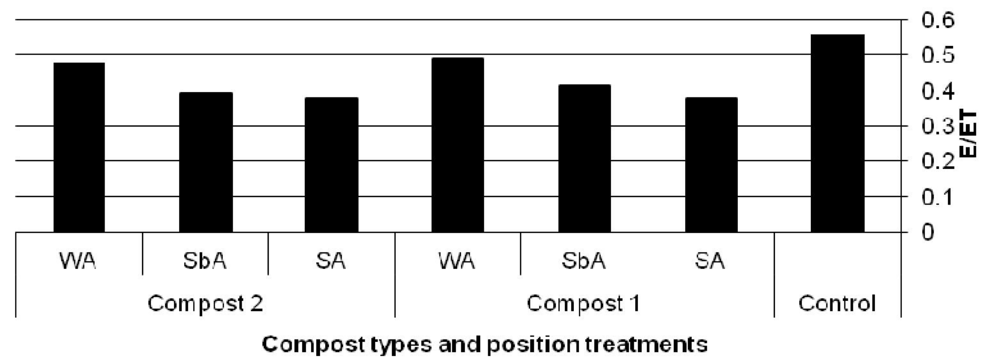

Fig 6: the ratio of E / ET for the studied experimental treatments

Fig 6 indicated that soil E to ET ratio was generally decreased with all compost treatments comparing with control, in addition to the occurred improvement of WUE. In general, the results clearly figure out that compost could be considered an excellent soil conditioner and could be used as an amendments for desert sandy soil.

The research strongly recommended using composts, prepared from agricultural wastes, for reclaiming Egyptian and Saudi Arabia desert lands, water saving and reducing pollution load resulting from plant, poultry and farm animal wastes as well.

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