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Compost economize use of irrigation water for sorghum production (Sorghum bicolor) in a sandy soil

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Abstract

Purpose As a result of adverse climatic conditions and inadequate soil management practices an experiment was carried out to study the effect of compost on reducing irrigation water use to product maximum yield of sorghum bicolor in a sandy soil.

Methodology A pot experiment was conducted under natural conditions, the pots were arranged in a complete randomized block design.

The main plots were assigned to water treatment, the sub plots to the compost management and Least Significant Differences (LSD) test was used to determine differences among means (LSD at P<0.05).

Findings The study proved that reducing irrigation water to %50 while increasing quantity of compost to 10 t ha1- produced higher plant height.

Originality/value: The addition of compost to the soil is valuable to economize irrigation water use in a harsh land like a sandy soil.

Keywords: Compost, plant production, irrigation water, Sudan

Introduction

Water problems in arid lands:

Water is the basic element of life. No other environment in the world is suffering more than dessert environment from lack of water. This is a major reason behind unsustainable farming in many arid countries of the world (Mcintoch et al., 2004) .The idea of water is always considered as the backbone of any agricultural scheme., However, and the circumstances in the developing countries, water is touchy a sensitive issue that is usually faced due to a number of constrains. In many of the arid and semi-arid regions of the world, water is likely to become the most critical resources and the most limiting factor in the production of food (Elquosy, 1998). However, moisture management from the addition of compost might provide greater drought resistance and more efficient water utilization, therefore, the frequency and intensity of irrigation may be reduced. Recent research suggested the addition of compost in sandy soils to increase the water holding capacity (Henry, 2005). The development of existing resources and the addition of new sources are becoming more interesting on the other side application of compost to degraded lands stand as the most appropriate solution for some of the chronic and acute problems of water deficit in the arid and semi- arid regions (Elquosy, 1998). Arid and semi-arid environment cover more than 40% of the global land surface (Deichmann and Eklund, 1991) and provides habitat to human. Degraded soils are generally nutrient poor soils because of low content of organic matter which is essential in improving soil physical, chemical and biological properties (Sidhu and Sur, 1993).There is more interest in utilizing soils of low or marginal productivity for crop production to match the demand for agricultural products (Cecil, 1990). The adverse climatic conditions and inadequate soil management practices, has led to the search for new resources of organic matter to increase its level in the soil and water managing (Dinel et al., 2004; Marche et al., 2003; Englande and Reimers, 2001). The increased importance of compost, necessitate that management strategies should focus on maximizing the benefits of its incorporation. Therefore, the objective of this study research is to study the effect of compost reducing irrigation water use to product maximum yield of sorghum bicolor L by using small amount of irrigation water.

Material and method:

The experiment was conducted at the farm of the Faculty of Agriculture, University of Khartoum (Shambat) Latitude 15° 14 N, Longitude 32° 32 E. The soil material used in this study was sand soil, initiated properties (initial moisture content 0.46%, organic matter 2.68gkg-1, holding capacity 15.26gkg-1, Electric conductivity of the saturation extract 0.6 dSm-1, Cation exchange capacity 1.09 C mol (+) kg-1 soil, saturation percentage 21.26, hydraulic conductivity 6.4 Cm/hr , K+1 0.13 meq/l, Na+1 0.3 meq/l, aggregate stability 24.6% and pH 7.7) collected from West Omdurman. The compost used in this study was produced aerobically from sugar cane residues (Baggasse), initial properties (ECe 0.436dSm-1, water holding capacity 81.5%,pH7.16, organic carbon 36.94%,total nitrogen 3.18%, total phosphors2.3%, bulk density0.176 g/cm3 ,and exchangeable potassium

2.2%). Annual sorghum (Sorghum bicolor) was selected.

Treatments

Ten Kg of soil was placed in cylindrical plastic pots. The top 10cm of pots were left for irrigation water. A total of 36 pots were used for the whole study, treatments; namely, three Levels of water regimes (L1, L2 and L3) 100% 75% and 50%, respectively depending on the quantity of irrigation for one feddan (4200M2) X three management of compost (M0, 5 t ha-1, 10 t ha-1) X 4 replications. The pots were arranged in a Complete Randomized Block design (CRD).The main plots were assigned to water treatment and the sub plots to the compost management. The irrigation interval chosen was 7 days.

Irrigation

Amount of irrigation water was M3/ plot.

Statistical analysis:

All data were analyzed by using the Analysis of Variance System (ANOVA) using the Statistical System (SAS Institute, Inc., 1997). Least Significant Differences (LSD) test was used to determine differences among means (LSD at $P<0.05$).

Table 1. *Amount of Water added (M3) per pot:*

Treatments	Number of the irrigations	Intervals (days)	Total amount of water per pot
L1	10	7	0.05722
L2	10	7	0.04291
L3	10	7	0.02861

Results & discussion

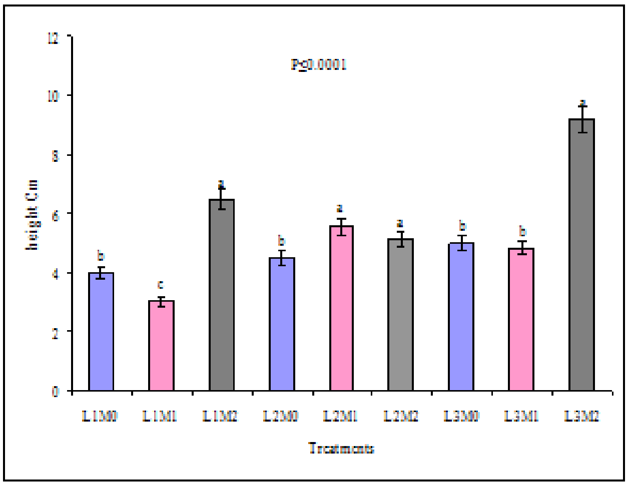
Table 2. *Effet of compost management and water regimes on plant height during the season*

Days after growth													
Treatment		18		25		32		39		46		60	
		H	M	H	M	H	M	H	M	H	M	H	M
L1	M0	4.00		9.26		6.94		10.02		10.09		15.93	
	M1	3.03		8.91		9.40		11.56		14.30		33.12	
	M2	6.45		9.87		14.85		15.85		25.88		15.90	
L2	M0	4.49		7.55		8.00		9.54		10.29		11.87	
	M1	5.57		9.87		13.08		15.95		16.10		27.93	
	M2	5.11		8.95		16.14		15.35		20.57		34.66	
L3	M0	4.96		9.30		11.71		15.75		13.33		21.25	
	M1	4.86		8.11		12.64		15.90		16.11		28.81	
	M2	9.19		12.60		14.75		23.33		27.62		42.08	
Prob.		0.0001	5.29	0.173	9.37	.0001	12.43	.0001	14.80	.0001	17.13	.0001	27.57
LSD		0.9733		1.923		2.043		2.565		3.700		6.230	

L1 = 100 % of irrigation water regimes,
M0 = control 0 t ha-1 compost,
L2 = 75 % of irrigation water regimes
M1 = 5 t ha-1 compost,
L3 = 50 % of irrigation water regimes,
M2 =10 t ha-1 compos,
H= Plant height
M= Mean

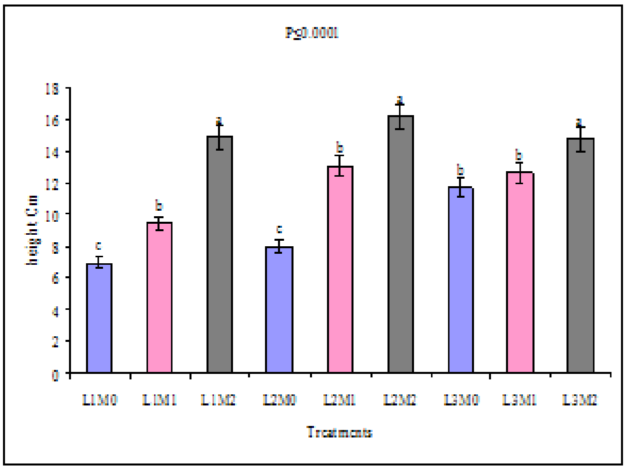
Plant height (cm) recorded after 18, 32, 46, and 53 days from sowing, statistical analysis showed there were highly significant differences among all treatments and in all weeks. After 18 days from application of compost, the plant height increased significantly ($P \leq 0.0001$). At this stage of growth, decreasing water to 50 or 75% coupled with increased quantity of compost to generally10 t ha-1 produced higher plants. This indicated that after 2-3 weeks, reduction of irrigation water could produce similar results if there is an increase in compost quantity. However, the highest height recorded from L3M2 was 9.19cm. The lowest values were obtained from L1M0, L1M1, respectively (Table 2 and Fig. 1). These results clearly show that reducing irrigation while increasing quantity of compost produced higher plant height .These results were in agreement with Barzegar et al., (1997) who pointed out that composted baggasse and wheat straw compost increase plant height to 213 cm after sixty days after sowing of maize compared with un-amended soil of180 cm.

Figure 1. *Effect of compost and water regimes on average plant height (cm)1 8 days after germination*



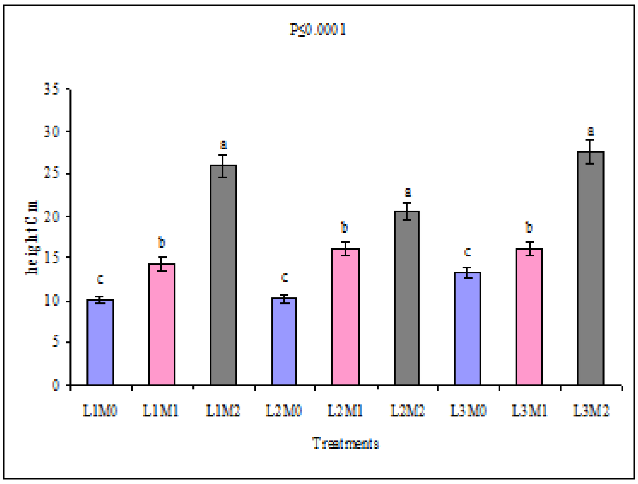
Similarly, in the third week, (Table 2 and Fig. 2) application of compost had significantly ($P \leq 0.001$) increased plant height. However, the highest height was 16.14cm and was recorded from L2M2. The lowest values were obtained from L1M0, L2M0 and their values were 6.94cm, 8cm and 9.4cm, respectively. Also, these results clearly showed that reducing irrigation while increasing quantity of compost produced higher plant height.

Figure 2. *Effect of compost and water regimes on average plant height (cm) 32 days after germination*



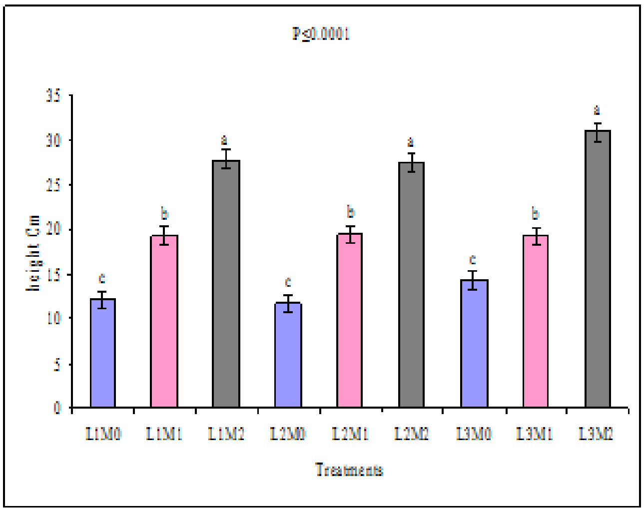
After the six week, the study showed that treatments had significant ($P \leq 0.0001$) effect on plant height (Table 2 and Fig. 3). It was found that application of 10 t ha-1 of compost in all levels of irrigation water quantity produced similar plant height. This indicates that it could possibly be meaningful to reduce irrigation water by 50% saving. The lowest values were obtained from L1M0, L2M0 and L3M0 and they were 10.09cm, 10.29cm and 13.33cm, respectively. These results reflect also reducing irrigation water while increasing compost produced higher height.

Figure 3. *Effect of compost and water regimes on average plant height (cm) 46 days after germination*



After six week, the study showed that treatments had significant (P≤0.001) effect on plant height (Table 2 and Fig. 4). It was found that application of 10 t ha-1 compost in level three (L3) of irrigation water quantity produced higher plant height was (42.08cm). Followed by L2M2 was (34.66cm). The lowest value were obtained from L2M0 , L1M2 and L1M0 and they were 11.87cm ,15.9cm and 15.95cm respectively., These results clearly showed that reducing irrigation while increasing quantity of compost produced higher heights.

Figure 4. *Effect of compost and water regimes on average plant height (cm) 53 days after germination*



These results indicate that combined application of compost and irrigation water quantity produce significant effect on plant growth. It concluded that in a sandy soil with weak water retention capacity can be improved by incorporation of compost at 10 t h-1 level. Water scarcity in arid soil necessitates economization and improvement of use efficiency. Many studies support this finding e.g David and F. Mary (2001) and Mtabanegwe, and Mapfuno (2007).

Improve soil physical properties:

Water holding capacity:

Results showed that application of compost had highly significantly (P≤0.0001) increased soil water holding capacity (Table 3 and Table 4).The highest value of water holding capacity (17.50 g kg-1) was recorded from L1M1 followed by L1M2 (15.88 g kg-1) .These results showed that increasing irrigation water while increasing quantity of compost resulted in higher soil water holding capacity. These could be attributed to the addition of organic material which improves soil physical properties. These results agreed with the finding of Sur (1992) who mentioned that organic matter from green manure increased water holding capacity. Moreover, it is also supported by the finding of Henry (2005). In addition, results showed that L1 had significant (P≤0.03) effect on water holding capacity (W.H.C) at M0, M1 and M2 (Table 4). However, the highest value (17.57 g kg-1) was recorded from M2 followed by M1 (16.96 g kg-1), the lowest value was recorded from M0 (15.76 g kg-1).This results indicated that increasing irrigation to 100% while increasing quantity of compost to10 t ha-1 had similar (W.H.C) as 5 t ha-1. Decreasing level of irrigation water to 75 %(L2) had resulted in no significant

(P≤0.3) effect on (W.H.C) at either M0, M1 or M2 (Table 4). This result indicated that decreasing irrigation to 75% while increasing quantity of compost 10 t ha-1 had similar (W.H.C) as 5 t ha-1. Similarly, results showed that L3 had no significant (P≤0.09) effect on (W.H.C) at M0, M1 and M2 (Table 4). However, the highest values were recorded from M1 (15.4925 g kg-1) and M2 (15.0875 g kg-1). The lowest value was recorded from M0 (13.99 g kg-1). This result indicated that decreasing irrigation to 50% while increasing quantity of compost to 10 t ha-1 had similar (W.H.C) as 5 t ha-1. It could be stated that at this level it's recommended to use 5 t ha-1 when irrigation water is reduced to 50% in sandy soils. This also reflects the importance of adding organic matter in such soils with limited capacity to store water.

Table 3. *Effect of water regimes and compost management on soil water holding capacity (g kg1-)*

Compost management	Water regimes			
	L1	L2	L3	Mean
M0	15.76	15.18	13.99	14.976
M1	17.57	14.10	15.49	15.721
M2	16.88	14.60	15.08	15.530
Mean	16.73	14.63	14.85	
LSD				0.749
Probability				0.0001

L S D : Least Significant Different, Prob.: Probability, L 100 : 1 % of irrigation water regimes, L 75 : 2 % of irrigation water regimes, L 50 : 3 % of irrigation water regimes, M0 : control 0 t ha1- compost , M5 : 1 t ha1- compost, M2 : soil management with 10 t ha1- compost

Table 4. *Shows statistical differences of L1, L2, L3 at Mo, M1 and M2 on water holding capacity (g kg1-)*

	Water regimes		
Comp.	L1 Mean	L2 Mean	L3 Mean
(M0) No. comp	15.760 b	15.1775 a	13.99 b
(M1) 5 t ha-1	16.9653 a	14.6250 a	15.493 a
(M10 (2 t ha1-	17.570 a	14.1025 a	15.087 a
Probability	(P≤0.05)	(P≤0.331)	(P≤0.09)

Values in columns followed by similar letters are not significantly different at P ≤ 0.05 using Least Significant Difference (LSD)

Hydraulic conductivity cm/hr:

Results showed that application of compost had significantly (P≤0.03) increased hydraulic conductivity (Table 5). However, the highest hydraulic conductivity (19.42 cm/hr) was recorded from L3M2. These results clearly showed that reducing irrigation water while increasing quantity of compost resulted in higher hydraulic conductivity. This agreed with the findings of Sidhu and Sur (1993) who stated that incorporation of organic materials increased infiltration rate of 1.4 times the control. Ekwue (1992) found higher infiltration rate with organic matter and attributed that to the addition of organic matter to the soil. Similarly, it was confirmed later when Barzegar et al. (2002) revealed that application of organic materials had significantly increased infiltration rate.

Table 5. *Shows statistical differences of L1, L2, L3 at Mo, M1 and M2 on hydraulic conductivity (cm/hr)*

	Water regimes		
Comp.	L1 Mean	L2 Mean	L3 Mean
(M0) No. comp	11.470 a	10.728 b	9.755 b
(M1) 5 t ha-1	12.540 a	12.740 a	12.388 a
(M10 (2 t ha1-	15.310 a	14.648 a	19.605 a
Probability	(P≤0.2)	(P≤0.13)	(P≤0.05)

Values in columns followed by similar letters are not significantly different at P ≤ 0.05 using Least Significant Difference (LSD)

Discussion and Conclusion:

The study showed that on all levels of compost, (M0, M1 and M2) L1 had no significant ($P \leq 0.2$) effect on hydraulic conductivity (H.C) (Table 6). This result indicated that increasing irrigation to 100% while increasing quantity of compost to 10 t ha-1 had similar H.C as 5 t ha-1. On the other hand, this study on all levels of compost, (M0, M1 and M2) L2 had no significant ($P \leq 0.1$) effect on H.C (Table 6). However, the highest values recorded from M2 (14.648 cm/hr) and M1 (12.74 cm/hr), the lowest value recorded from M0 (10.728 cm/hr). This result indicated that decreasing irrigation to 75% while increasing quantity of compost to 10 t ha-1 had similar H.C as 5 t ha-1. Moreover, decreasing water to 50% (L3) had resulted in significant ($P \leq 0.05$) effect on H.C at M0, M1 and M2 (Table 6). The highest value was recorded from M2 (19.605 cm/hr) and M1 (12.388 cm/hr), thought they statistically similar, this result indicated that decreasing irrigation to 50% while increasing quantity of compost to 10 t ha-1 had similar H.C as 5 t ha-1. It could be concluded that application of compost as a source of organic materials to soils proved to have a remedial solution to nutrients and water storage poor soils such as sandy soils.

Finally the study proved that reducing irrigation water to 50% while increasing quantity of compost to 10 t ha-1 produced higher plant height during all weeks of growing.

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