

Effect of Saline Water and Different Management Practices on Yield and Yield Attributes of Sorghum

Korla Aditya Chowdary, Makam Umadevi,
 Kodary Avil Kumar, Veeramalla Ramulu

Received 27 April 2016 ; Accepted 31 May 2016 ; Published online 25 June 2016

Abstract The gradual decrease of fresh water resources leading towards inevitable use of saline water in agriculture. This leads to degradation of crop yields. So management of saline water under field conditions was an immediate action to be taken up. A field experiment was carried out to investigate the effect of saline water irrigation and management practices on yield and yield attributes of sorghum. The highest length of ear head, weight of ear head and number of grains ear head⁻¹ was also recorded by C₂-FYM followed by C₃-FYM. The highest grain and straw yield was recorded in C₂-FYM followed by C₃-FYM. The results of present study indicated that C₂ quality irrigation water along with application of FYM @ 10 t ha⁻¹ was the best among all treatments tested. In situations where C₃ water is available for irrigation, application of FYM @ 10 t ha⁻¹ may be recommended to get higher yields.

Keywords Saline water, Management practices, Yield attributes, Yield.

Introduction

One of the major problems confronting irrigated agriculture nowadays throughout the world is the de-

creasing availability of fresh water. The scarcity of fresh water restricts sustainable agricultural development. At the same time, the quality of irrigation water has also deteriorated. As a result, deficit irrigation and saline water irrigation have been used more prevalently in agriculture to overcome drought and sustain crop yields. With the use of saline waters for irrigation, there is need to undertake appropriate management practices to prevent the development of excessive soil salination for crop production. Francois et al. [1] studied that each unit increase in salinity above this reduced yield by 16% in sorghum. Feizi et al. [2] studied the effects of irrigation water salinity and irrigation management on safflower yield and results showed that with higher levels of water salinity the yield components such as seed yield (26%), 1000-seed weight (52.3%), plant height (62.4%), number of capitula per plant (60.4%) and capitula weight per plant (60.4%) were significantly decreased. Management practices for the control of salinity include selection of crops or tolerant varieties that will produce satisfactory yields under the resulting conditions of salinity, irrigation procedures that maintain a relatively high soil-moisture regime and that periodically leach accumulated salts from the soil and use of organic manures, green manures and amendments. Application of organic manures like farm yard manure or green manuring is one of the easiest methods to mitigate the adverse effects of use of poor quality water. Kahlown and Azam [3] evaluated the effect of saline drainage effluent on soil health and crop yield with wheat-cotton rotation with green manure and farm yard manure application in loamy soils of Paki-

K. A. Chowdary*, M. Umadevi, K. A. Kumar, V. Ramulu
 Water Technology Center, College of Agriculture,
 Rajendranagar, Hyderabad 500030, India
 e-mail: adi.001agri@gmail.com

*Correspondence

stan and found that with highest wheat (2.1 t ha⁻¹) and cotton (1.4 t ha⁻¹) yield with farmyard manure application. From a long term stand point, application of organic manures to soil help in maintaining and improving of soil structure and soil fertility. Under the condition of mechanized farming, where availability of FYM is getting limited, green manuring is gaining importance.

Materials and Methods

The experiment was carried out at the Water Technology Center College Farm, College of Agriculture, Rajendranagar, Hyderabad, India during winter (*rabi*) season, 2012–2013. During the crop growth period (26-10-2012 to 26-02-2013) the mean weekly maximum temperature ranged from 24 to 34 °C with an average of 29.7 °C and the mean weekly minimum temperature ranged from 11 to 19 °C with an average of 15.7 °C. The soil of experimental site was sandy clay loam in texture, medium alkaline in reaction (pH: 8.24) and non-saline (EC: 0.22 dS m⁻¹) with SAR value of 0.82. The experiment was laid out in strip plot design with four main treatments, four sub treatments and three replications. The following main treatments comprised based on different levels of water qualities according to their electrical conductivity (dSm⁻¹), M₁: irrigation with C₂ (good) quality (0.4 dS m⁻¹) water, M₂: irrigation with C₃ (marginal) quality (1.7 dSm⁻¹) water, M₃: irrigation with C₄ (poor) quality (3.5 dSm⁻¹) water and M₄: alternate irrigations with C₃ followed by C₄. The sub treatments comprised of —S₁: control (no organic manure and magnetic treatment), S₂: Farmyard manure @ 10 t ha⁻¹, S₃: green manuring (Sunnhemp) *in situ* and S₄: magnetic treatment to irrigation water. Magnetic treatment to irrigation water means the irrigation water was passed through a device called magnetic pipe. Magnetic field, when applied to normal water restructures the water molecules into very small water molecule clusters, each made up of six symmetrically organized molecules. This miniscule cluster is recognized by the cell as “bio-friendly” due to its hexagonal structure and because the toxins cannot travel within the cluster, and easily enters the passage ways in plant. The result provides maximum, healthy hydration with less water [4]. The FYM was applied fifteen before date of sowing of crop and green manure was grown upto flower-

ing and incorporated twenty days before date of sowing of crop. Sorghum variety CSV- 216 R was sown on 26th October adopting a spacing of 40 × 15 cm. A total amount of 431.5 mm of water was used by the crop. Ten plants from each plot were selected for recording weight of ear heads, length of ear head, no for grains per ear head and yield. The data of parameters studied during the course of study were statistically analyzed, applying the technique of analysis of variance described by Gomez and Gomez [5].

Results and Discussion

Yield and yield attributes

The data on yield attributes are given in Table 1. The length of ear head was significantly influenced by water quality, management practices and their interactions. Among water quality levels, the highest length of ear head was recorded by irrigation with C₂ quality (21.67 cm) was significantly higher over other water quality followed by C₃ quality (20.92 cm). The C₃ / C₄ quality (20.33 cm) was on par with C₄ (19.92 cm). It was noticed that the irrigation with C₂, C₃ and C₃ / C₄ resulted in 9, 5 and 2% increase in length of ear head when compared to irrigation with C₄ quality. Among management practices, the highest length of ear head was recorded by application of FYM @ 10 t ha⁻¹ (22.92 cm) which was significantly higher over GM, MT and control. The other treatments GM and MT were also significantly higher over control (18 cm). Among the interactions, the highest length of ear head was recorded by C₂–FYM (24.33 cm) which was significantly higher over other treatments. It was followed by C₃–FYM and C₃ / C₄–FYM (22.67 cm). The lowest length of ear head was recorded by C₄–control (16.67 cm). Salinity affects the crop during both vegetative and reproductive stages. Under no management practices the shortest length of ear head was noticed. With the increase in level of salinity in irrigation water, the length of ear head had decreased accordingly. The same trend was observed by Rad et al. [6] in rice. The number of grains ear head⁻¹ was significantly influenced by water quality, management practices. The interactions were found to be non significant. Among water quality levels, the highest number of grains ear head⁻¹ was recorded by irrigation with C₂ quality (1547 grains ear head⁻¹) which was

Table 1. Effect of saline water irrigation and management practices on length of ear head, no. of grains ear head⁻¹ and weight of ear head of *rabi* Sorghum. * Figures in parentheses indicate the percentage of increase over control. **Figures in parentheses indicate the percentage of increase over C₄ quality.

Treatments	Length of ear head (cm)				No. of grains ear head ⁻¹					
	Con- trol	FYM	GM	MT	Con- trol	FYM	Con- trol	FYM	Con- trol	Mean
C ₂	19.33	24.33 (26)*	22 (14)	21.00 (9)	24.67	1185	1950 (65)	1673 (41)	1381 (17)	1547 [13]
C ₃	18.67	22.67 (21)	22 (18)	20.33 (9)	22.67	1135	1922 (69)	1454 (28)	1336 (18)	1462 [7]
C ₄	16.67	22.00 (32)	21.33 (28)	19.67 (18)	19.67	1022	1746 (71)	1472 (44)	1218 (19)	1365
C ₃ /C ₄	17.33	22.67 (31)	21.33 (23)	20 (15)	21.00	1072	1828 (71)	1549 (44)	1262 (18)	1428 [5]
Mean	18.00	22.92 (27)	21.67 (20)	20.25 (13)	22.00	1103	1862 (69)	1537 (39)	1299 (18)	
	SEm(±)	CD (p = 0.05)			SEm(±)	SEm(±)				
W	0.15	0.52			21	74				
M	0.16	0.55			14	49				
W at same M	0.25	0.74			47	NS				
M at same W	0.26	0.82			46	NS				

W : Water quality (main treatments) :

M : Management practices (sub treatments) :

C₂ : Irrigation with C₂ quality (good) water

M₁ : Control (No. organic manure and magnetic treatment)

C₃ : Irrigation with C₃ quality (marginal) water

M₂ : FYM @ 10 t ha⁻¹

C₄ : Irrigation with C₄ quality (poor) water

M₃ : GM: Green manuring *in situ* (Sunnhemp)

C₃/C₄ : Alternate irrigations with C₃ followed by C₄

M₄ : MT Magnetic treatment to irrigation water

Table 1. Continued.

Treatments	Weight of ear head (g ear head ⁻¹)				Mean
	Control	FYM	GM	MT	
C ₂	49.33 (100)	24.67	49.33 (100)	24.67	37.17 [18]
C ₃	47.67 (110)	22.67	47.67 (110)	22.67	35.33 [12]
C ₄	43.67 (122)	19.67	43.67 (122)	19.67	31.50
C ₃ /C ₄	45.33 (116)	21.00	45.33 (116)	21.10	33.50 [6]
Mean	45.50 (111)	22.00	46.50 (111)	22.00	
	SEm(±)	CD (p = 0.05)			
W	0.18	0.61			
M	0.36	1.24			
W at same M	0.40	NS			
M at same W	0.38	NS			

followed by C₃ quality (1462 grains ear head⁻¹). The lowest number of grains ear head⁻¹ was observed in C₄ (1365 grains ear head⁻¹). It was noticed that the irrigation with C₂, C₃ and C₃/C₄ resulted in 13, 7 and 5% increase in number of grains ear head⁻¹ when compared to irrigation with C₄ quality. Among manage-

ment practices, the highest number of grains ear head⁻¹ was recorded by FYM @ 10 t ha⁻¹ (1862 grains ear head⁻¹) which was significantly higher over GM, MT and control. The other treatments GM and MT were also significantly higher over control (1103 grains ear head⁻¹). The interaction effect was found

Table 2. Effect of saline water irrigation and management practices on stover, grain yield (t ha⁻¹) of *rabi* Sorghum. *Figures in parentheses indicate the percentage of increase over control. **Figures in parentheses indicate the percentage of increase over C₄ quality.

Treatments	Con- trol	Stover			Yield (t ha ⁻¹)					
		FYM	GM	MT	Mean	Con- trol	FYM	GM	MT	Mean
C ₂	4.56	5.85 (28)*	5.67 (24)	5.21 (14)	5.32 [6]**	1.04	2.35 (126)	1.86 (79)	1.44 (39)	1.67 [24]
C ₃	4.51	5.75 (27)	5.57 (23)	5.20 (15)	5.26 [5]	0.97	2.19 (126)	1.77 (83)	1.33 (38)	1.56 [16]
C ₄	4.33	5.73 (32)	5.36 (24)	4.66 (8)	5.02 [2]	0.82	1.92 (135)	1.54 (88)	1.13 (38)	1.35 [8]
C ₃ /C ₄	4.41	5.74 (30)	5.48 (24)	4.82 (9)	5.11 [2]	0.90	2.06 (130)	1.63 (82)	1.24 (38)	1.46 [8]
Mean	4.45	5.77 (30)	5.52 (24)	4.97 (12)		0.93	2.13 (129)	1.70 (83)	1.28 (38)	
		SEm(±)		CD (p = 0.05)			SEm(±)		CD (p = 0.05)	
W		0.04		0.13			0.01		0.04	
M		0.02		0.06			0.01		0.05	
W at same M		0.03		0.10			0.02		0.06	
M at same W		0.05		0.15			0.02		0.06	

W : Water quality (main treatments) :
 C₂ : Irrigation with C₂ quality (good) water
 C₃ : Irrigation with C₃ quality (marginal) water
 C₄ : Irrigation with C₄ quality (poor) water
 C₃ / C₄ : Alternate irrigations with C₃ followed by C₄

M : Management practices (sub treatments) :
 M₁ : Control (No organic manure and magnetic treatment)
 M₂ : FYM @ 10 t ha⁻¹
 M₃ : GM : Green manuring *in situ* (Sunnhemp)
 M₄ : MT : Magnetic treatment to irrigation water

to be non significant and it ranges from 1022 to 1922 grains ear head⁻¹. The number of grains ear head⁻¹ and the grain weight increased in fresh or good quality water, possibly because of less competition but this could not fully compensate the yield loss caused by ear head reduction in treatments irrigated poor quality water. Yield of sorghum dropped sharply when salt stress was strongest even though growth was less affected [7]. The highest number of grains ear head⁻¹ was found in FYM treatment due to low salt concentration in the root zone of the crop especially less saline environment near root. These findings were similar to that of Khan et al. [8]. The weight of ear head was significantly influenced by water quality, management practices. Whereas the interactions effect was found to be non significant. Among water quality levels significantly the highest weight of ear head was recorded by irrigation with C₂ quality (37.17 g ear head⁻¹) which was followed by C₃ quality (35.33 g ear head⁻¹). The lowest weight of ear head was ob-

served in C₄ (31.50 gear head⁻¹). It was noticed that the irrigation with C₂, C₃ and C₃/C₄ resulted in 18, 12 and 6% increase in weight of ear head when compared to irrigation with C₄ quality. Among management practices, the highest weight of ear head was recorded by FYM @ 10 t ha⁻¹ (46.50 g ear head⁻¹) which was significantly higher over GM, MT and control. The other treatments GM and MT were also significantly higher over control (22 g ear head⁻¹). The interaction effect was found to be non significant and it ranges from 19.67 to 49.33 g ear head⁻¹. The highest weight of ear head C₂-FYM was might be due to more number of grains ear head⁻¹ and higher test weight of the grains which in turn leads to the higher weight of ear head.

Grain yield (t ha⁻¹)

The data on grain yield are given in Table 2. The grain yield was significantly influenced by water quality,

management practices and their interactions. Among water quality levels, significantly the highest grain yield was recorded by irrigation with C_2 quality (1.67 t ha^{-1}) which was followed by irrigation with C_3 quality water (1.56 t ha^{-1}). The lowest grain yield was observed in irrigation with C_4 quality (1.35 t ha^{-1}). It was noticed that the irrigation with C_2 , C_3 and C_3 / C_4 resulted in 24, 16 and 8% increase in grain yield when compared to irrigation with C_4 quality. Among management practices, the highest grain yield was recorded by FYM @ 10 t ha^{-1} (2.13 t ha^{-1}) which was significantly higher over GM, MT and control. The other treatments GM and MT were also significantly higher over control (0.93 t ha^{-1}). Among the interactions, the highest grain yield was recorded by C_2 -FYM (2.35 t ha^{-1}) which was significantly higher over other treatments and followed by C_3 -FYM (2.19 t ha^{-1}). The lowest grain yield recorded by C_4 -control (0.82 t ha^{-1}). Decrease in number of grains ear head⁻¹ due to salinity might have resulted in the production of lesser grain yield. Number of grains ear head⁻¹ was most important attributing character, which improves the grain yield by providing maximum number of ear heads m^{-2} . The cumulative effect of all these growth and yield components was reflected on grain yield. The decrease in grain yield due to salinity was also reported by Katerji et al. [9] in maize and sunflower, Chawla et al. [10] in sunflower, Ragab et al. [11] in wheat, Ghane et al. [12] in wheat and Lacerda et al. [13] in cowpea and maize crops. Grain yield can be increased by using different amendments which control the root zone salinity. Higher grain yield can be obtained by using FYM as a management practice. Similar increase in grain yield with application of FYM as a management practice to reduce salinity on wheat was reported by Khan et al. [8]. The yield of cyclic irrigation was better than C_4 quality might be due to the stress exerted by saline water was relieved for some time. The same results were obtained by Phogat et al. [14] in wheat and pearl millet.

Stover yield (t ha^{-1})

The data on stover yield are given in Table 2. Among water quality levels, the highest stover yield was recorded by irrigation with C_2 quality (5.32 t ha^{-1}) closely followed by irrigation with C_3 quality water

(5.26 t ha^{-1}) and both were significantly higher over alternate irrigation C_3 / C_4 (5.11 t ha^{-1}) and C_4 quality (5.02 t ha^{-1}). It was noticed that the irrigation with C_2 , C_3 and C_3 / C_4 resulted in 6, 5 and 2% increase in stover yield when compared to irrigation with C_4 quality. Among management practices, the highest stover yield was recorded by FYM @ 10 t ha^{-1} (5.77 t ha^{-1}) which was significantly higher over GM, MT and control. The other treatments GM and MT were also significantly higher over control (4.45 t ha^{-1}). Among the interactions, the highest stover yield was recorded by C_2 -FYM (5.85 t ha^{-1}) and differs significantly over other treatments and on par with C_3 -FYM (5.75 t ha^{-1}). The lowest stover yield was recorded by C_4 -control (4.33 t ha^{-1}). Application of FYM along with good quality water, might have recorded higher yields, because of better supply of nutrients to crop under congenial environment leading to better root activity and higher nutrient absorption. The stover yield of crop reduced as the salinity of water increased. Application of mulch material or manures increased the straw yield when compared to control. This was mainly might be due to decreased salinity in the root zone which resulted in higher stover yields. The lower stover yields noticed with poor quality water could be due to reduced leaf area and existence of high salt concentration near root zone in poor quality irrigation. The similar results were obtained by De Pascale et al. [15] in vegetables and Amer [16] in corn.

References

1. Francois LE, Donovan T, Mass EV (1984) Salinity effects on seed yield, growth and germination of grain sorghum. *Agron J* 76 : 741—744.
2. Feizi M, Hajabbasi MA, Fard BM (2010) Saline irrigation water management strategies for better yield of safflower (*Carthamus tinctorius* L.) in an arid region. *Aust J Crop Sci* 4 : 408—414.
3. Kahlowan MA, Azam M (2003) Effect of saline drainage effluent on soil health and crop yield. *Agric Water Manag* 62 : 127—138.
4. Magnetic Technologies, LLC Head quarters : P. O : Box 27559, Dubai, U. A. E. e-mail: magtech@emirates.net.ae. Web page : www.magneticcast.com.
5. Gomez KA, Gomez AA (1984) Statistical procedures in agricultural research. 2nd edn. Wiley-Interscience Publ, New York.
6. Rad HE, Aref F, Rezaei M (2012) Evaluation of salinity stress affects rice growth and yield components in northern Iran. *Am J Scien Res* 54 : 40—51.
7. Ma W, Mao Z, Yu Z, Van Mensvoort MEF, Driessen

- PM (2008) Effects of saline water irrigation on soil salinity and yield of winter wheat-maize in north china plain. *Irrig Drainage Systems* 22 : 3—18.
8. Khan MJ, Jan MT, Khan AU, Arif M, Shafi M (2010) Management of saline sodic soils through cultural practices and gypsum. *Pak J Bot* 42 : 4143—4155.
 9. Katerji N, Van Hoorn JW, Hamdy, Akram F, Mastro-rilli A (1996) Effect of salinity on water stress, growth and yield of maize and sunflower. *Agric Water Manag* 30 : 237—249.
 10. Chawla KL, Kumar A, Manoj SKR, Sharma DR, Khosla BK (1998) Response of sunflower to different planting techniques and salinity of irrigation water. *J the Ind Soc Soil Sci* 46 : 338—340.
 11. Ragab AAM, Hellal FA, Abd El-Hady M (2008) Water salinity impacts on some soil properties and nutrients uptake by wheat plants in sandy and calcareous soil. *Aust J Basic and Appl Sci* 2 : 225—233.
 12. Ghane E, Feizi M, Fard BM, Landi E (2009) Water productivity of winter wheat in different irrigation planting methods using saline irrigation water. *Int J Agric and Biol* 11 : 131—137.
 13. Lacerda CF, Silva FB, Rocha neves AL, Silva FL, Gheyi HR, Lange ness, RL, Gomes-Filho E (2011) Influence of plant spacing and irrigation water quality on a cowpea-maize cropping system. *Int Res J Agric Sci and Soil Sci* 1 : 163—171.
 14. Phogat V, Satyavan, Kumar S, Sharma SK (2011) Effects of cyclic and blending uses of saline and good quality water on soil salinisation and crop yields under pearl millet-wheat rotation. *J Ind Soc Soil Sci* 59 : 94—96.
 15. De Pascale S, Maggio A, Ruggiero C, Barbieri G (2003) Growth, water relations, and ion content of field-grown celery [*Apium graveolens* L, var dulce (mill.) Pers.] under saline irrigation. *J Am Soc Hort Sci* 128 : 136—143.
 16. Amer KH (2010) Corn crop response under managing different irrigation and salinity levels. *Agric Water Manag* 97 : 1553—1563.