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Original Research Article

EFFECTS OF NaCl, DROUGHT, DRAINAGE AND BIOGAS WASTE WATER APPLICATIONS ON MAIZE AND SORGHUM SEEDLING GROWTH

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Abstract: *A research study was conducted to evaluate the impact of different stress conditions on the seedling growth rate of maize cultivars and sorghum cultivars. Drought stress, biogas water, and wastewater stress with salt NaCl were applied as treatments to maize and sorghum. The results were statistically analyzed. There were significant differences between the maize and sorghum seedling growth and development during different stress conditions. Sorghum varieties more effectively withstand stress conditions as compared with maize plants. Data was collected for plant dry weight, leaf area, fresh root weight, and fresh shoot weight. The sorghum genotypes showed batter performance and growth under biogas wastewater application. The excellent performance under biogas wastewater indicated that its applications may be helpful to improve crop plant production under stress conditions.*

Keywords: maize, sorghum, salt stress, drainage, drought, biogas water

Introduction

We are facing global loss in grain production of annual crops because of biotic factors and abiotic factors, such as dehydration and nutritional limits are in top the list of constraints (Munns and Tester, 2008; Quiroga *et al*., 2017). Notably, when assessing the effects of climate change on crops, maize and sorghum are found to be the most negatively affected (Tebaldi and Lobell, 2018; Zampieri *et al*., 2019), with water stress, temperature extremes, salt content, and nutritional deficiencies being known foremost environmental disturbances that have a deleterious effect on global yield. Indeed water shortages, lower or higher heat, and floods have harmed corn and wheat growth and productivity (Ahuja *et al*., 2010; Hasanuzzaman *et al*., 2013). Furthermore, ambient temperatures are expected to fluctuate as a result of climate change, which may modify the severity and frequency of drought in various maize producing locations across the world (Yang *et al*., 2014). Climate variability accounts for around half of the total variations and sorghum yield adversely affected in most locations of the Indo-Gangetic plains and Sub-Saharan Africa (Mendoza-Grimón *et al*., 2021; Mi *et al*., 2021; Ray *et al*., 2015). Though dependent on plant germplasm and stress at a formative stage, abiotic stressors throughout, and dryness in particular, have shown to be particularly detrimental to total production (Alikhani *et al*., 2012). Sorghum (*Sorghum bicolor* L. Moench) is the world's third most significant cereal crop and a nutritional mainstay for much more than 400 million people in more than 30 nations, third highest in the world's grain crops (El Naim *et al*., 2012). Sudan grass, Shallo, Feterita, Durra, Egyptian millet, Daza, Milo, Gonia corn, Sorgo, Kaffir corn, Jowar are some of the local names for grain sorghum (Ahmed *et al*., 2016; Jabereldar *et al*., 2017).

Sorghum is a staple diet for the majority of people in Africa and Asia. Furthermore, it fed millions of animals that produce milk and meat for people; more than 55 percent of grain produced globally is utilized for human consumption, with the remaining 33 percent used to feed livestock. In various regions of the globe, sorghum is farmed across an area of around 42.7 million hectares, with a yield of approximately 58.7 million tonnes (Aaliya *et al*., 2016; Alikhani *et al*., 2012). Sorghum can grow and yield in locations with little rainfall. Because of its resilience to drought and heat stress, the crop is grown in locations where other cereals are deemed too dry and hot (Reddy, 2019; Starr *et al*., 2020). Better plant development in soil salinity is determined by tolerance to salt stress during the germination and seedling emergence stages. In general, increased salinity lowers the percentage and rate of germination, root and shoot length, and fresh and dry weights of plants exposed (Ahsan *et al*., 2013; Ali *et al*., 2017; Ali *et al*., 2015). The goals of this study are to estimate the salt, water stress, sewerage, as well as biogas tension of various sorghum genotypes and maize genotypes, to assess each genotype's ability to fight back effects of

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drought, salt stress, biogas stress, and sewage wastewater stress.

Materials and Methods

A field experiment was conducted for one season at the Institute of Molecular Biology and Biotechnology, University of Lahore, Lahore Pakisatn experimental farm. Average daily temperature was ranged from 35-40°C throughout the experimental season. Three genotypes of maize (EV-1097Q, Raka-Poshi and Pak Afgoi) and three genotypes of sorghum (Safaid, Shakar and Jambo) were selected as an experimental material. Biogas water and waste water was added in the sand as treatment for each pot. The following sets of biogas water and waste water treatments are kept for study that are T_1: Drought (60%), T_2: Waste Water + NaCl, T_3: Biogas Water + NaCl, T_4: Biogas Water + Waste Water, T_5: Biogas wastewater and T_6: Control. For these treatments different pots were designed and then in each pot the seeds were grown according to the treatment criteria. Seeds were grown in pots that were marked properly. Morphological traits examined were included shoot length (SL), root length (RL), root umber (RN), shoot root weight ratio (RSWR) and shoot root length ratio (RSLR). The data was statistically analyzed through analysis of variance techniques by using SPSS23.1 software.

Results and Discussion

It has been revealed from the results given in table 1 that there were significant differences among the genotypes, treatments and interaction between genotypes and treatments. The average mean shoot length of maize and sorghum under all of the treatments was found as 3.8029cm, root length 7.224cm, root number 8.807, shoot to root length ratio 0.378 and shoot root weight ratio 1.302. The coefficient of variation of shoot length was 5.22%, root length 6.124%, root number 8.182%, shoot root length ratio 6.02% and shoot root weight ratio 7.102% were found very low which indicated that the there was consistency among results which persuaded that the more data analysis may be carried out and predictions may be made for selection of crop plant genotypes (Ali *et al*., 2015; Ali and Ahsan, 2015; Munns and Tester, 2008; Reddy, 2019; Sahi *et al*., 2006).

Table 1 Analysis of variance for maize and sorghum under different treatments

Source of variations	SL	RL	RN	RSLR	RSWR
Replications	0.0146	0.0026	0.0024	0.0289	0.0051
Genotypes	0.0489*	0.0521*	0.8521*	0.6482*	0.5851*
Treatments	0.0024*	0.0673*	0.3724*	4.280*	2.6037*
Genotypes ×Treatments	0.0632*	0.0972*	0.242*	5.2133*	3.1901*
Error	0.0164	0.0235	0.4012	2.0215	2.7046
Grand Mean	3.8029	7.224	8.807	0.378	1.302
CV	5.22	6.124	8.182	6.02	7.102

* = Significant at 5% probability level, SL = Shoot length, RL = Root length, RN = Root numbers, RSLR = Root shoot length ratio, RSWR = Root shoot weight ratio

Table 2 Mean differences among maize genotypes under different treatment

Genotypes	Treatments	SL	RL	RN	RSLR	RSWR
EV-1097Q	60% Drought	3.83	9.61	8.12	0.36	1.00
EV-1097Q	Biogas wastewater	3.94	8.35	9.43	0.38	1.33
EV-1097Q	Waste Water + NaCl	3.71	9.62	7.33	0.35	1.22
EV-1097Q	Biogas wastewater + NaCl	3.65	9.35	5.54	0.35	1.67
EV1097Q	Biogas wastewater + waste water	3.54	7.22	4.53	0.36	1.11
EV-1097Q	Control	3.87	9.52	6.22	0.36	1.00
Raka-Poshi	60% Drought	3.97	8.84	7.35	0.38	1.80
Raka-Poshi	Biogas wastewater	3.65	7.22	6.75	0.35	1.57
Raka-Poshi	Waste Water + NaCl	3.57	8.62	8.54	0.33	1.25
Raka-Poshi	Biogas wastewater + NaCl	3.65	9.31	9.44	0.35	1.80
RakaPoshi	Biogas wastewater + waste water	3.74	7.23	8.35	0.43	1.02
Raka-Poshi	Control	3.84	9.52	8.44	0.36	1.00
Pak-Afgoi	60% Drought	3.72	9.25	6.32	0.36	1.57
Pak-Afgoi	Biogas wastewater	3.84	7.62	7.22	0.36	1.13
Pak-Afgoi	Waste Water + NaCl	3.55	9.55	9.12	0.33	1.83
Pak-Afgoi	Biogas wastewater + NaCl	3.86	8.37	8.15	0.37	1.50
Pak-Afgoi	Biogas wastewater + waste water	3.56	9.24	7.35	0.38	1.13
Pak-Afgoi	Control	3.63	8.51	9.45	0.34	1.29

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SL = Shoot length, RL = Root length, RN = Root numbers, RSLR = Root shoot length ratio, RSWR = Root shoot weight ratio

The results from table 2 indicated that the maize genotypes showed variations for studied traits under different treatments. The shoot length of maize showed variation under the applications of all treatments. It was found that the shoot length of EV-1097Q under biogas wastewater was 3.94cm followed by 60% drought (3.83cm) while lower under biogas wastewater + waste water (3.54cm). The shoot length of Raka-Poshi was found higher for 60% drought (3.97cm) while lower for waste water + NaCl (3.57cm). The shoot length of Pak-Afgoi under biogas wastewater (3.84cm) followed by biogas wastewater + NaCl (3.86cm) while lower under biogas wastewater + wastewater (3.56cm). The higher shoot length under biogas wastewater + NaCl indicated that biogas wastewater provided tolerance against salt stress (Ali *et al*., 2013a; Ali *et al*., 2013b). It was found that the root length of EV-1097Q under wastewater + NaCl was 9.62cm followed by 60% drought (9.61cm) while lower under biogas wastewater + waste water (7.22cm). The root length of Raka-Poshi was found lower for biogas wastewater + waste water (7.23cm) while higher for biogas wastewater + NaCl (9.31cm). The root length of Pak-Afgoi under waste water + NaCl (9.55cm) followed by biogas wastewater + NaCl (9.24cm) while lower under biogas wastewater (7.62cm). The higher root length indicates that the tolerance of maize genotypes under the applications of biogas wastewater, NaCl applications showed the potential of maize genotypes for improvement of growth and development of maize seedlings (Ali *et al*., 2016; Ali *et al*., 2014a; Mendoza-Grimón *et al*., 2021; Song *et al*., 2019). It was found that the root shoot weight ratio in EV-1097Q under biogas wastewater + NaCl was 1.67. The root shoot weight ratio in Pak-Afgoi was found higher for wastewater + NaCl (1.83). The root shoot length ratio in Raka-Poshi under biogas wastewater + NaCl (1.80) and 60% drought (1.80). The higher root shoot weight ratio indicates that the tolerance of maize genotypes under the applications of biogas wastewater, NaCl applications showed the potential of maize genotypes for improvement of growth and development of maize seedlings. Due to stress conditions the root shoot length ratio increased which induce tolerance in maize seedlings (Ali *et al*., 2014b; Ali *et al*., 2014c; Fang *et al*., 2021; Hasanuzzaman *et al*., 2013).

It was found that the root shoot length ratio in EV-1097Q under biogas wastewater was 0.38. The root shoot length ratio in Raka-Poshi was found higher for biogas wastewater + wastewater (0.43). The root shoot length ratio in Pak-Afgoi under biogas wastewater + wastewater (0.38). The higher root shoot length ratio indicates that the tolerance of maize genotypes under the applications of biogas wastewater, NaCl applications showed the potential of maize genotypes for improvement of growth and development of maize seedlings. Due to stress conditions the root shoot length ratio increased which induce tolerance in maize seedlings (Ali *et al*., 2011; Farooq *et al*., 2011). It was found that the number of roots in EV-1097Q under biogas wastewater was 9.43 followed by 60% drought (8.12) while lower under biogas wastewater + waste water (4.53m). The number of root in Raka-Poshi was found higher for biogas wastewater + NaCl (9.44) while lower for biogas wastewater (6.75). The number of root in Pak-Afgoi under waste water + NaCl (9.12) followed by biogas wastewater + wastewater (8.15) while lower under biogas wastewater (7.22). The higher number of root indicates that the tolerance of maize genotypes under the applications of biogas wastewater, NaCl applications showed the potential of maize genotypes for improvement of growth and development of maize seedlings. Due to stress conditions the number of roots increased which induce tolerance in maize seedlings (Ali *et al*., 2014b; Boomsma *et al*., 2009; Carlson *et al*., 2020; Iqbal *et al*., 2017; Maqbool *et al*., 2021).

Table 2 Mean differences among sorghum genotypes under different treatment

Genotypes	Treatments	SL	RL	RN	RSLR	RSWR
Safaid	60% Drought	2.72	7.61	6.12	0.36	2.19
Safaid	Biogas wastewater	2.34	7.53	7.34	0.31	1.60
Safaid	Waste Water + NaCl	2.42	7.82	5.33	0.31	1.92
Safaid	Biogas wastewater + NaCl	2.31	7.74	4.54	0.30	2.75
Safaid	Biogas wastewater + waste water	2.55	7.47	3.25	0.34	1.56
Safaid	Control	2.74	7.86	4.23	0.35	1.71
Shakar	60% Drought	2.42	7.64	5.54	0.32	1.80
Shakar	Biogas wastewater	2.57	7.57	3.36	0.33	1.91
Shakar	Waste Water + NaCl	2.38	7.78	5.53	0.30	1.43
Shakar	Biogas wastewater + NaCl	2.66	7.65	6.46	0.34	1.80

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Shakar	Biogas wastewater + waste water	2.77	7.77	4.64	0.35	2.59
Shakar	Control	2.46	7.64	4.36	0.32	1.27
Jambo	60% Drought	2.54	7.83	7.36	0.32	2.00
Jambo	Biogas wastewater	2.63	7.43	5.28	0.35	1.13
Jambo	Waste Water + NaCl	2.72	7.53	6.29	0.36	1.60
Jambo	Biogas wastewater + NaCl	2.52	7.42	5.26	0.34	1.71
Jambo	Biogas wastewater + waste water	2.36	7.83	4.64	0.29	1.67
Jambo	Control	2.44	7.54	6.83	0.32	1.80

SL = Shoot length, RL = Root length, RN = Root numbers, RSLR = Root shoot length ratio, RSWR = Root shoot weight ratio

The results from table 3 indicated that the sorghum genotypes showed variations for studied traits under different treatments. The shoot length of sorghum showed variation under the applications of all treatments. It was found that the shoot length of Safaid under biogas wastewater + wastewater was 2.55cm followed by 60% drought (2.72cm) while lower under biogas wastewater + NaCl (2.31cm). The shoot length of Shakar was found higher for biogas wastewater (2.66cm) followed by biogas wastewater + wastewater (2.77cm) while lower for waste water + NaCl (2.38cm). The shoot length of Jambo under biogas wastewater (2.63cm) followed by biogas wastewater + NaCl (2.72cm) while lower under biogas wastewater + wastewater (2.36cm). The higher shoot length under biogas wastewater + NaCl indicated that biogas wastewater provided tolerance against salt stress (Farooq *et al*., 2011; Hasanuzzaman *et al*., 2013; Mazhar *et al*., 2020; Mustafa *et al*., 2018; Sarwar *et al*., 2022). It was found that the root length of Safaid under wastewater + NaCl was 7.82cm followed by biogas wastewater + NaCl (7.74cm) while lower under biogas wastewater (7.53cm). The root length of Shakar was found lower for wastewater + NaCl (7.78cm) while higher for biogas wastewater + wastewater (7.77cm). The root length of Jambo under 60% drought (7.83cm) followed by biogas wastewater + wastewater (7.83cm) while lower under biogas wastewater + NaCl (7.42cm). The higher root length indicates that the tolerance of sorghum genotypes under the applications of biogas wastewater, NaCl applications showed the potential of sorghum genotypes for improvement of growth and development of sorghum seedlings. It was found that the number of roots in Safaid under biogas wastewater was 7.34 followed by 60% drought (6.12) while lower under biogas wastewater + wastewater (3.25). The number of root in Shakar was found higher for biogas wastewater + NaCl (6.46) while lower for biogas wastewater (3.36). The number of root in Jambo under 60% drought (7.36) followed by wastewater + NaCl (6.29) while lower under biogas wastewater + wastewater (4.64). The higher number of root indicates that the tolerance of sorghum genotypes under the applications of biogas wastewater, NaCl applications showed the potential of maize genotypes for improvement of growth and development of sorghum seedlings. Due to stress conditions the number of roots increased which induce tolerance in sorghum seedlings (Cakir, 2004; Nawaz *et al*., 2021; Sarwar *et al*., 2021; Satyavathi *et al*., 2019; Zubair *et al*., 2016). It was found that the root shoot length ratio in Safaid under 60% drought was 0.36. The root shoot length ratio in Shakar was found higher for biogas wastewater + wastewater (0.35). The root shoot length ratio in Jambo under wastewater + NaCl (0.36). The higher root shoot length ratio indicates that the tolerance of sorghum genotypes under the applications of biogas wastewater, NaCl applications showed the potential of maize genotypes for improvement of growth and development of sorghum seedlings. Due to stress conditions the root shoot length ratio increased which induce tolerance in sorghum seedlings. It was found that the root shoot weight ratio in Safaid under biogas wastewater + NaCl was 2.75 and 60% drought (2.19). The root shoot weight ratio in Jambo was found higher for wastewater + NaCl (1.71) and 60% drought (2.0). The root shoot length ratio in Shakar under biogas wastewater + wastewater (2.59) and bioga wastewater (1.91). The higher root shoot weight ratio indicates that the tolerance of sorghum genotypes under the applications of biogas wastewater, NaCl applications showed the potential of sorghum genotypes for improvement of growth and development of sorghum seedlings. Due to stress conditions the root shoot length ratio increased which induce tolerance in sorghum seedlings (Ali *et al*., 2013b; Ali *et al*., 2016; Ali *et al*., 2011; Carlson *et al*., 2020; Maqbool *et al*., 2021; Mazhar *et al*., 2020).

Conclusion

From research study it is concluded that in relation to many levels of induced salt stress, water stress, biogas water stress and wastewater stress of all selected genotypes of maize and sorghum. Results have shown that increase in stress conditions results in increased inhibition, seedling growth as compared with controls. Moreover, it was found that sorghum genotypes showed reduction in all the studies factors as compared to maize genotypes under similar conditions. So in future an exploratory research is required about their mechanism of action to stress conditions.

Conflict of interest

The authors declared absence of any conflict of interest.

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