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Original Research Article

EVALUATION OF MAIZE AND SORGHUM GENOTYPES UNDER DROUGHT, DRAINAGE AND BIOGAS WASTE WATER APPLICATIONS

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Abstract: *Maize and Sorghum crops have been cultivated for thousands of years for overcoming the increasing demand for food, especially in Asia and Africa. Sorghum and maize are stress-sensitive crops because they can't tolerate drought or salinity stress. The aim of the study was to investigate the impact of different stress conditions on maize and sorghum varieties. The research study was carried out with the possible involvement of biogas wastewater and drainage wastewater for investigation of their impacts on plant growth and development. Seeds of maize and sorghum varieties were subjected to different osmotic levels in order to compare the effects of drought, wastewater, and biogas wastewater effects. The results showed that maize was more susceptible to drought stress than sorghum. The applications of biogas wastewater induce stress tolerance in maize and sorghum seedlings to improve seedling growth and development. It was concluded that the use of biogas wastewater in field crop conditions of maize and sorghum may be helpful to improve crop production.*

Keywords: sorghum, maize genotypes, salt, drought, stress conditions

Introduction

80% demand for human food is fulfilled by crops, governed by 50% of cereal grains mostly. Maize and sorghum have emerged as important crops for world food supply (Ullah *et al*., 2021). They supports the ever increasing demand for growing population by directly meeting dietary needs as a consumptive food or indirectly as animal feed (Nawaz *et al*., 2021). Additionally maize that is also called as corn in US acts as a sustainable substitute of fossil fuel which can be used for production of bio ethanol. Maize and sorghum are staple foods, their yield is highly dependent on climatic factors and due to the change in climate conditions they give low yield (Maqbool *et al*., 2021). Among the several abiotic stresses, temperature extremes, drought, nutrient deficiencies, and salt concentration are recognized as the primary environmental variables reducing total maize and sorghum productivity (Ali *et al*., 2016; Ali *et al*., 2011). According to recent research, the two most significant climatic factors are temperature and precipitation, with radiation being another essential element influencing crop production. Indeed, the current climate of droughts, temperature extremes, and water logging has severely hampered maize growth and hence productivity (Ali *et al*., 2013b; Ali *et al*., 2014a; Maswada *et al*., 2021). According to a survey on maize yield losses in India and China, 25–35% and 35–45% of the crop is lost each year because of drought and water logging (Ali *et al*., 2013a; Iqbal *et al*., 2017). Anticipated reductions in total arable land and a growing global population are predicted to force us to feed an additional 2000 million people by 2050, so there is a need to grow those plants that can resist stressed environment for meeting higher demand for food supply (Adugna and Tirfessa, 2014). Thus, developing climate-smart germplasm is critical, and it is possible through a combination of traditional breeding methods and molecular approaches, including transgenic procedures (Achakzai, 2009; Mazhar *et al*., 2020; Mustafa *et al*., 2018).

Salt concentrations levels can cause both sooner (within a few hours to days) osmotic stress and later managed to accumulate ionic sodium ions stress, that also alter vegetation morphological characteristics and enzymatic pathways to varying degrees depending on the plant species, genetic markers, stage of growth, stress duration and intensity, and osmotic stress of the root tissues (Munns and Tester, 2008; Sahi *et al*., 2006; Sarwar *et al*., 2022; Sarwar *et al*., 2021; Zubair *et al*., 2016). Water deficiency is caused by osmotic imbalance, which reduces new leaf formation, stomata closure, reducing photosynthesis and shoot growth. Ionic stress causes early withering of mature leaves due to an overabundance of sodium ion buildup (Boomsma *et*

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al., 2009; Carlson *et al*., 2020). Roots are essential for anchoring plants in their development medium and absorbing water and nutrients from the soil. Due to a decrease in cell division and elongation, high salinity inhibits root growth, particularly the creation and development of lateral roots (West *et al*., 2004). Rooting depth, for example, may be adjusted to the environment to improve moisture and nutrients scavenging and reduce stress exposure (Fang *et al*., 2021; Farooq *et al*., 2011; Mendoza-Grimón *et al*., 2021). However, the modification of the root system design in response to salt stress is still incompletely understood. In several crops, including wheat, salt-tolerant cultivars have been identified by screening procedures under controlled settings (Ali *et al*., 2014b; Ali *et al*., 2014c; Cakir, 2004; Hoque *et al*., 2015). The goals of this study were to assess the growth responses of maize and sorghum crops to various levels of dryness, biogas, and wastewater stress, as well as to discover particular structural behavior(s) leading to their resistance. We anticipated that certain morphological characteristics of maize and sorghum, like root depth, were much more sensitive to salt stress and may be utilized as a criteria for choosing tolerant maize and sorghum genotypes at an early stage of growth.

Materials and Methods

A pot experiment was conducted for one season at the Institute of Molecular Biology and Biotechnology, University of Lahore, Lahore Pakistan. The soil was sandy; the average daily temperature was range from 30-50°C throughout the experimental season. Three genotypes of maize (EV-1097Q, Raka-Poshi and Pak Afgio) 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 along with control plat. The following sets of biogas water and waste water treatments were kept for study that are drought, Waste Water, Biogas wastewater, Biogas Water + Waste Water and 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 the pots that were marked properly. The data was recorded for shoot length (SL), leaf length (LL), Root Number (RN), Leaf Area (LA) and root length (RL). The data was statistically analyzed through analysis of variance techniques by using SPSS23.1 software.

Results and Discussion

The results given in table 1 suggested that significant differences were found among genotypes and applications of treatment while non-significant for interactions between treatments × genotypes. The CV (coefficient of variation) was found lower for all traits under different treatment indicated that there was consistency among the results which also cleared that the results were reliable for traits of maize and sorghum under different treatment applications of wastewater, biogas water and drought. Results showed that this maize could be used as a stress tolerant crop in future for better growth, yield and productivity by providing some kind of better conditions (Ali *et al*., 2017; Ali *et al*., 2013a; Song and Jin, 2020; Wang *et al*., 2018).

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

Source of variations	SL	LL	LA	RN	RL
Replications	0.00356	0.0029	0.7542	0.6889	0.5556
Genotypes	0.0029*	0.0202*	0.7219*	0.4222*	0.1556*
Treatments	0.0036*	0.0558*	0.3247*	2.700*	1.1667*
Genotypes ×Treatments	0.0212*	0.0083*	0.3339*	3.7833*	2.1001*
Error	0.0164	0.0148	0.3062	1.1175	1.1746
Grand Mean	3.2089	7.2578	3.7827	6.3778	8.1341
CV	3.99	1.68	14.63	16.57	6.03

* = Significant at 5% probability level, SL = Shoot length, RL = Root length, RN = Root numbers, LL = Leaf length, LA = Leaf area

Table 2 Mean differences among maize genotypes under different treatment

Genotypes	Treatments	**SL**	**RL**	**RN**	**LL**	**LA**
EV-1097Q	50% Drought	3.21	11.11	8	7.11	3.68
EV-1097Q	Biogas wastewater	3.22	11.45	4	7.48	4.38
EV-1097Q	Waste Water	3	11.33	8	7.43	4.93
EV-1097Q	Biogas wastewater +Waste Water	3.31	11.21	5	7.12	4.20
EV-1097Q	Control	3.42	11.32	4	7.12	4.20
Raka-Poshi	50% Drought	3.43	11.22	5	7.13	3.68
Raka-Poshi	Biogas wastewater	3.42	11.32	7	7.22	4.56
Raka-Poshi	Waste Water	3.48	11.36	9	7.42	3.29

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Raka-Poshi	Biogas wastewater +Waste Water	3.64	11.23	6	7.21	3.73
Raka-Poshi	Control	3.51	11.33	6	7.34	3.78
Pak-Afgoi	50% Drought	3	11.42	7	7.14	3.68
Pak-Afgoi	Biogas wastewater	3.21	11.32	6	7.35	3.78
Pak-Afgoi	Waste Water	3.22	11.12	6	7.54	3.89
Pak-Afgoi	Biogas wastewater +Waste Water	3.12	11.43	8	7.45	4.38
Pak-Afgoi	Control	3.31	11.13	5	7.26	3.73

SL = Shoot length, RL = Root length, RN = Root numbers, LL = Leaf length, LA = Leaf area

The results from table 2 indicated that the maize genotypes showed variations for studied traits under different treatments. The genotype Raka-Poshi showed better behavior for shoot length under all of the applied treatments 50% drought (3.43cm), biogas water (3.42cm), waste water (3.48cm), biogas water + wastewater (3.64cm) and control (3.51cm). The genotype EV-1097Q showed similar type of behavior like Pak-Afgoi 50% drought (3.21cm, 3cm), biogas water (3.22cm, 3.21), waste water (3cm, 3.22cm), biogas water + wastewater (3.31cm, 3.12cm) and control (3.42cm, 3.31cm) respectively. The root length was found higher for treatments biogas wastewater + waste water (11.43cm), 50% drought (11.42cm) for Pak-Afgoi, waste water (11.36cm) for Raka-Poshi while biogas wastewater (11.45cm) for EV-1097Q. The root number was found higher under 50% drought (8), wastewater (8) for EV-1097Q, waste water (9) for Raka-Poshi and biogas wastewater (8) for Pak-Afgoi. The leaf length of maize was found higher under biogas wastewater (7.48cm), waste water (7.43cm) for EV-1097Q, waste water (7.42cm) for Raka-Poshi and waste water (7.54cm), biogas waste water + waste water (7.45cm) for Pak-Afgoi. The leaf area was found higher under biogas wastewater (4.38cm2), waste water (4.93cm2) for EV-1097Q, biogas wastewater (4.56cm2) for Raka-Poshi and biogas wastewater (4.38cm2) for Pak-Afgoi. The application of biogas wastewater showed to increase the seeding growth which indicated that the application of biogas wastewater provides nutrients to improve growth and development of maize seedlings under various stress conditions. The higher shoot length revealed that the genotypes may be used to develop drought stress varieties and hybrids (Ali *et al*., 2015; Ali *et al*., 2016; Daryanto *et al*., 2016; Farooq *et al*., 2011; Mi *et al*., 2021).

Table 2 Mean differences among sorghum genotypes under different treatment

Genotypes	Treatments	SL	RL	RN	LL	LA
Safaid	50% Drought	2.22	6.33	7	5.43	2.40
Safaid	Biogas wastewater	2.63	6.55	5	5.66	1.66
Safaid	Waste Water	2.24	6.43	4	5.34	1.96
Safaid	Biogas wastewater +Waste Water	2.55	6.66	6	5.77	2.76
Safaid	Control	2.43	6.75	5	5.64	1.24
Shakar	50% Drought	2.74	6.84	7	5.57	2.04
Shakar	Biogas wastewater	2.66	6.45	5	5.35	2.35
Shakar	Waste Water	2.43	6.54	4	5.47	1.60
Shakar	Biogas wastewater +Waste Water	2.64	6.36	3	5.56	1.22
Shakar	Control	2.75	6.48	5	5.76	2.95
Jambo	50% Drought	2.73	6.55	4	5.38	1.57
Jambo	Biogas wastewater	2.68	6.63	8	5.66	2.07
Jambo	Waste Water	2.66	6.46	6	5.34	2.35
Jambo	Biogas wastewater +Waste Water	2.45	6.74	5	5.55	2.85
Jambo	Control	2.77	6.35	3	5.46	1.20

SL = Shoot length, RL = Root length, RN = Root numbers, LL = Leaf length, LA = Leaf area

The results from table 3 indicated that the sorghum genotypes showed variations for studied traits under different treatments. The genotype safaid showed better behavior for shoot length under the applied treatments biogas wastewater (2.63cm), biogas water + wastewater (2.55cm). The genotype Shakar showed similar type of behavior like Jambo 50% drought (2.74cm, 2.73cm), biogas wastewater (2.66cm, 2.68), control (2.75cm, 2.77cm) respectively. The root length was found higher for treatments biogas wastewater + waste water (6.66cm), control (6.75cm) for Safaid, waste water (6.63cm) for Jambo while

50% drought (6.84cm) for Shakar. The root number was found higher under 50% drought (7), biogas wastewater (6) for Safaid, 50% drought (7) for Shakar and biogas wastewater (8) for Jambo. The leaf length of sorghum was found higher under biogas wastewater (5.66cm), biogas wastewater + waste water (5.77cm) for Safaid, 50% drought (5.57cm) for Shakar and biogas waste water (5.66cm), biogas waste water + waste water (5.55cm) for Jambo. The leaf area was found higher under biogas wastewater + wastewater (2.76cm^2), 50% drought (2.40cm^2) for Safaid, biogas wastewater (2.35cm^2) for Shakar and biogas wastewater + waste water (2.85cm^2) for Jambo. The application of biogas wastewater showed to increase the seeding growth which indicated that the application of biogas wastewater provides nutrients to improve growth and development of sorghum seedlings under various stress conditions (Aaliya *et al*., 2016; Mazhar *et al*., 2020; Munns and Tester, 2008; Mustafa *et al*., 2018; Quiroga *et al*., 2017; Reddy, 2019).

Conflict of interest

The authors declared absence of conflict of interest for manuscript.

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