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Research Article

Effect of salt NaCl stress on seed germination and vegetative growth of Gaillardia (*Gaillardia puchella* L.)

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Abstract

In order to the influence of Salt NaCl stress on seed germination and vegetative growth of Gillardia, during the successful year 2018, at the Horticultural, Garden Sindh Agriculture University Tandojam Pakistan. The experiment was conducted as factorial Complete randomized design (CRD) with three replication in the Seed of two varieties (Lorenziana double mix and Gaillardia sundance) and salinity levels (0, 1, 3, 5 and 7ds/m). The results showed that cultivar has significant affect on the irrigation water (Control canal irrigated water) growth and development showed that (80.37%) seed germination (6.54) numbers of leaves plant$^{-1,}$ (1064.1) and Seedling vigor index 13.23, and other cultivars. The highest and lowest Salinity levels of shoot length (8.03 g), fresh shoot biomass (15.65 cm), root length cm (10.23), root biomass (0.65 g) and electrolyte leakage of leaf (67.53%) The different between these cultivars were observed. It seems that the Salt stress on seed germination is not properly useful for the assessment of salt and tolerance of Gaillardia.

Keyword: Gaillardia (*Gaillardia pulchella* L.); Growth and Yield; Salt stress

Introduction

Gaillardia (*Gaillardia pulchella* L.) common name blanket flower is a genus of flower plant in sunflower a member of family Asteraceae is native Central and Westran United states [1]. It is popularly known as Blanket flower are Daisy_like flowers in shades of yellow, bronze and scarlet with a purplish base, it is often used as cut flowers. Flower head are solitary or few on long peduncles. Flowers are wide purple or brownish purple and loosely hairy rays usually 13, 1, 3, and 5 cm flower are long and which are grow in the garden under the varied soil and climate conditions [2]. The gaillardia flourished well in any garden, the drought and heat tolerance withstand high light intensities the better than most of the flowering plants [3]. It is also use for interior decorations and useful design. The salt stress is a major environmental stress which the affects seed germination growth and development metabolic process and productivity the high level of salt concentration can be adversely affected the plant growth and productivity. Salinization is one the major factor limiting the crop production particularly in tropical and sub tropical of the world [4, 5]. In pakistan almost 6.3 m ha of land is affected by the salinity which is estimated to be 14% of irrigation land this causes a yield losses of 64% soil salinity may be the affected seed germination as it reduces as moisture absorption of seeds and by facilitating the entry of ions in the higher amount of that seed health [6]. The salinity levels at which the seed germination is reduced different with species environmental conditions and potentials. In Sindh, Pakistan, the effect of sodium chloride (NaCl) [Kindly follow same way and follow the journal guideline] on seed germination and vegetative growth of gaillardia is not well documented. In this perspective, it is mandatory to evaluate the effect of salt (NaCl) stress. However, the objective of this study was to effects of salt stress on germination and vegetative growth of Gaillardia to different levels of salinity.

Materials and methods

The pot experiment was conducted during 2018, at Horticultural garden, department of Horticulture, Sindh Agriculture University Tandojam. For this study complete randomized design CRD with factorial was laid out three replication and each replication contain three pots, in each pot seeds were contain in six seed was sown. The growing mixture medium was filled in the each pot approximately one inch space at the top. The present research work, the seeds of two Gaillardia varieties (lorenziana double mix and Gaillardia sundance), was sown in pots. After that each observation was recorded of each plant of both varieties.

Observations recording methodology

Seed germination percentage

Germination was checked on every alternative day for up to 7th day of plantation and the germination percentage was calculated by using the following equation as described by [7].

$$GP = \Sigma n / N \times 100$$

Where n is number of germinated seeds at each counting and N is total seeds in each treatment.

Germination index (GI) was calculated by the formula given by the Association of Official Seed Analysts 1983.

$$GI = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} + \text{----------} + \text{----------} + \frac{\text{Number of germinated seeds}}{\text{Days of last count}}$$

Seedling vigor index (SVI): was calculated by using the following formula [8].

Vigor index (VI) = [seedling length (cm) × germination percentage]

One and half months old seedlings were kept under observation for number of leaves vine^{-1}, fresh shoot biomass and electrolyte leakage of leaf percentage.

Electrolyte leakage of leaf

The electrolyte leakage of leaf was measured by using the formula givrn by [9]. The leaf was measured by taking leaf discs of size 1 cm^2 and weight 0.5 g from random samples of leaf. The leaf discs were rinsed well with deionized water prior to incubation in 25 ml of deionized water for 3 h at room temperature. After incubation, the conductivity (value A) of the bathing solution was measured by the conductivity meter. The petal discs were boiled with bathing solution for 15 minutes to lyses all cells. After cooling at room temperature, the conductivity (value B) of the bathing solution was again measured. The electrolyte leakage was expressed as percent (%) value according to the formula given below.

Electrolyte leakage of leaf % = (Value A/Value B) x100

Statistical analysis

Analyzed the research data by used computer Statistix 8.1 the computer soft ware [10], the least significant difference LSD test was applied compare treatment superiority in case results are significant at $P \leq 0.05$ probability levels.

Results and discussion

Seed germination (%)

The results in regards to germination of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salt (NaCl) stress on varieties are presents [11]. While the interactive effect of different salt (NaCl) stress × varieties on plant germination also significant (P<0.05) statistically [12]. Reported that the maximum average seed germination percentage of *gaillardia* flower was (80.37%) when grown under S_1- Canal irrigation water control, followed by (76.91, 70.04, and 56.83%) when the *gaillardia* flower grown as S_2=1, S_3=3, S_4=5.0 dS m^{-1} in table 1. The minimum germination (47.88%) was observed when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum germination (67.72%) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to 65.10% germination for Lorenziana Double Mix. The interactive effects showed that maximum germination (81.33%) was achieved when the *gaillardia* plant grown under S_1 = Canal Irrigation water control x *gaillardia* sundance, while the minimum germination (46.67%) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix.

Table 1. Seed germination (%) as influenced by salt (NaCl) stress and varieties

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S1 = Canal Irrigation water (Control)	79.41	81.33	80.37
S2 = 1.0 dS m-1	76.07	77.77	76.91
S3 = 3.0 dS m-1	68.03	71.75	70.04
S4 = 5.0 dS m-1	55.00	58.67	56.83
S5 = 7.0 dS m-1	46.67	49.10	47.88
Mean	65.10	67.72	

S.E. 722.591
LSD 0.05, 2.101

Number of leaves plant^{-1}

The number of leaves plant^{-1} of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salt (NaCl) stress on varieties are presented in *gaillardia* germination in table 2, While these interactive effect of different salt (NaCl) stress × varieties on plant germination are also significant [13], repoeted the data indicates that average maximum leaves plant^{-1} of *gaillardia* flower was (6.54) when grown under S_1- Canal irrigation water control, followed by (6.27, 5.28, 4.28,) when the *gaillardia* flower grown as S_2=1, S_3=3, and S_4= 5 dS m^{-1} in respectively. However the minimum leaves plant^{-1} (3.27), when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum leaves plant^{-1} (5.29) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to 4.97 leaves plant^{-1} for Lorenziana Double Mix [14]. Repoeted that the maximum leaves plant^{-1} (6.78) to achieved the gaillardia grown as under the S_1= Canal Irrigation water control x *gaillardia* sundance, while the minimum leaves plant^{-1} (3.10) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix. The LSD test demonstrated that the differences in leaves plant^{-1} length as influenced by salt (NaCl) stress and varieties were significant (P<0.05) and also significant (P<0.05) between rest of the treatments and varieties.

Seedlings vigor index (SIV)

The results in regards to plant height of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salt (NaCl) stress of variance analysis showed that there was significant (P< 0.05) on *gaillardia* seedlings vigor index, while the plant seedlings vigor index also significant ($P<0.05$) statistically [15]. The data in table 3 indicates that average maximum seedlings vigor index of *gaillardia* flower was (1064.1) when grown under S_1- Canal irrigation water control, followed by (979.1, 789.0, 536.4) when the *gaillardia* flower grown under S_2= 1, S_3=3 and S_4= 5.0 dS m^{-1} in respectively. The minimum seedling vigor index (407.2) was observed when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum seedling vigor index (790.96) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to (719.32) seedlings vigor index for Lorenziana Double Mix. The interactive effects shows that maximum seedlings vigor index (1130.06) was achieved when the *gaillardia* plant grown under S_1 = Canal Irrigation water control x *gaillardia* sundance, while the minimum seedlings vigor index (387.65) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix [16]. The LSD test demonstrated that the differences in seedling vigor index as influenced as influenced by salt (NaCl) stress and varieties.

Table 2. Number of leaves plant^{-1} as influenced by the salt NaCl stress and varieties.

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S1 = Canal Irrigation water (Control)	6.30	6.78	6.54 A
S2 = 1.0 dS m-1	6.17	6.38	6.27 A
S3 = 3.0 dS m-1	5.20	5.37	5.28 B
S4 = 5.0 dS m-1	4.07	4.50	4.28 C
S5 = 7.0 dS m-1	3.10	3.44	3.27 D
Mean	4.97 B	5.29 A	

S.E. 4712.63
LSD 0.05, 2.101

Table 3. Seedlings vigor index (S I V) as influenced by salt (NaCl) stress and varieties

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S_1 = Canal Irrigation water (Control)	998.1	1130.06	1064.1 A
S_2 = 1.0 dS m^{-1}	944.59	1013.53	979.1 A
S_3 = 3.0 dS m^{-1}	758.76	819.13	789.0 B
S_4 = 5.0 dS m^{-1}	507.41	565.37	536.4 C
S_5 = 7.0 dS m^{-1}	387.65	426.71	407.2 D
Mean	719.32 B	790.96 A	

S.E. 88960.51
LSD 0.05, 2.101

Shoot length

The results in regards to shoot length of *gaillardia* varieties “Lorenziana Double Mix and *Gaillardia* Sundance” as affected by different salinity level on varieties are presented [17]. Reported that of vaiance significant and different effect of salinity levels on *gaillardia* shoot length also significant ($P<0.05$) statistically. The data in table 4 indicates that average maximum shoot length of *gaillardia* flower was (13.23) when grown under S_1- Canal irrigation water control, followed by (12.72, 11.27 and 9.43) when the *gaillardia* flower grown under the S_2= 1, S_3= 3 and S_4= 5.0 dS m^{-1} respectively. The minimum shoot length (8.49) was observed when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum shoot length (11.99) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to (11.35) shoot length for Lorenziana Double Mix [18]. The interactive effects shows that maximum shoot length (13.90) was achieved when the *gaillardia* plant grown under S_1 = Canal Irrigation water control x *gaillardia* sundance, while the minimum shoot length (8.31) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix. The LSD test demonstrated that the differences shoot length as influenced by salt (NaCl) stress.

Table 4. Shoot length as influenced by salt (NaCl) stress and varieties

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S_1 = Canal Irrigation water (Control)	12.57	13.90	13.23 A
S_2 = 1.0 dS m^{-1}	12.42	13.03	12.72 A
S_3 = 3.0 dS m^{-1}	11.13	11.42	11.27 B
S_4 = 5.0 dS m^{-1}	9.27	9.61	9.43 C
S_5 = 7.0 dS m^{-1}	8.31	8.67	8.49 C
Mean	11.35 B	11.99 A	

S.E. 873.211
LSD 0.05, 2.101

Fresh shoot biomass (g)

The results in regards to fresh shoot biomass of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salinity level on varieties in table 5. The *gaillardia* fresh shoot biomass, while the salt (NaCl) stress on fresh shoot biomass also significant ($P<0.05$) statistically. The data indicates that average maximum fresh shoot biomass of *gaillardia* flower was (8.03) when grown under S_1-Canal irrigation water control, followed by (7.64, 6.39 and 5.36) when the *gaillardia* flower. The minimum fresh shoot biomass (4.56) was observed when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum shoot biomass (6.59) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to (6.21) fresh shoot biomass for Lorenziana Double Mix [19]. The interactive effects shows that maximum fresh shoot biomass (8.42) was achieved when the *gaillardia* plant grown under S_1 = Canal Irrigation water control x *gaillardia* sundance, while the minimum fresh shoot biomass (4.50) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix. The LSD test demonstrated that the fresh shoot biomass as influenced by salt (NaCl) stress.

Table 5. Fresh shoot biomass as influenced by salt (NaCl) stress and varieties

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S_1 = Canal Irrigation water (Control)	7.65	8.42	8.03 A
S_2 = 1.0 dS m^{-1}	7.34	7.96	7.64 A
S_3 = 3.0 dS m^{-1}	6.30	6.48	6.39 C
S_4 = 5.0 dS m^{-1}	5.24	5.48	5.36 D
S_5 = 7.0 dS m^{-1}	4.50	4.62	4.56 D
Mean	6.21 B	6.59 A	

S.E. 4612.26
LSD 0.05, 2.101

Root length (cm)

The results in regards to root length of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salt (NaCl) stress on varieties are presented [20], reported that there was different levels and interaction different salt stress on root length also significant ($P<0.05$) statistically. The data in table 6 indicates that average maximum root length of *gaillardia* flower was (15.65) when grown under S_1- Canal irrigation water control, followed by (15.37, 13.63 and 11.39) when the *gaillardia* flower grown under the variance minimum root length (10.23) was observed when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum root length (13.41) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to (13.11) root length for Lorenziana Double Mix. The interactive effects shows that maximum root length (15.86) was achieved when the *gaillardia* flower grown under S_1 = Canal Irrigation water control x *gaillardia* sundance [21]. While the minimum root length (10.13) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix. The LSD test demonstrated that the differences root length as influenced by salt stress.

Table 6. On root length cm as influenced by salt NaCl stress and varieties.

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S_1 = Canal Irrigation water (Control)	15.45	15.86	15.65 A
S_2 = 1.0 dS m^{-1}	15.20	15.55	15.37 A
S_3 = 3.0 dS m^{-1}	13.49	13.78	13.63 B
S_4 = 5.0 dS m^{-1}	11.28	11.50	11.39 C
S_5 = 7.0 dS m^{-1}	10.13	10.34	10.23 D
Mean	13.11 B	13.41 A	

S.E. 38.9525
LSD 0.05, 2.101

Root biomass (cm)

The results in regards to root biomass of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salt (NaCl) stress on varieties are presented in table 7. While the root biomass also significant (P<0.05) statistically. The data indicate that average maximum root biomass of *gaillardia* flower was (0.82) when grown under S_1- Canal irrigation water control, followed by (0.75, 0.62 and 0.51) when the *gaillardia* flower and the minimum root biomass (0.44) was observed when the *gaillardia* flower grown with S_5 = 7.0 dS m^{-1}. In case of varieties, maximum root biomass (0.65) was produced by the *gaillardia* flower when grown under with *Gaillardia* Sundance as compared to (0.62) root biomass for Lorenziana Double Mix [22]. The interactive effects shows that maximum root biomass (0.84) was achieved when the *gaillardia* plant grown under S_1 = Canal Irrigation water control x *gaillardia* sundance, while the minimum root biomass (0.43) were recorded for the interaction of S_5 = 7.0 dS m^{-1} x lorenziana double mix. The LSD test demonstrated that the differences root biomass.

Table 7. Root biomass (g) as influenced by salt (NaCl) stress and varieties

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S_1 = Canal Irrigation water (Control)	0.82	0.84	0.82 A
S_2 = 1.0 dS m^{-1}	0.73	0.77	0.75 A
S_3 = 3.0 dS m^{-1}	0.60	0.64	0.62 B
S_4 = 5.0 dS m^{-1}	0.50	0.53	0.51 BC
S_5 = 7.0 dS m^{-1}	0.43	0.47	0.44 C
Mean	0.62 B	0.65 A	

S.E. 668.320
LSD 0.05, 2.101

Electrolyte leakage of leaf (%)

The results in regards to electrolyte leakage of leaf of *gaillardia* varieties "Lorenziana Double Mix and *Gaillardia* Sundance" as affected by different salt (NaCl) stress on varieties are presented in table 8, and *gaillardia* Electrolyte leakage of leaf % ; while the interactive effect of different salt (NaCl) stress × varieties on electrolyte leakage of leaf % of *gaillardia* flower was (85.29%) when grown under S_5-7.0 dS m^{-1}, followed by (78.47, 64.84 and 53.62 %) when the *gaillardia* flower under the different levels [23], reported that the minimum electrolyte leakage of leaf (51.60 %) was observed when the *gaillardia* flower grown with S_1 = Control. In case of varieties, maximum electrolyte leakage of leaf (67.53%) was produced by the *gaillardia* flower when grown under with lorenzinnia double mix as compared to (66.00%) electrolyte leakage of leaf for *Gaillardia* sundance. The interactive effects shows that maximum electrolyte leakage of leaf (85.65%) was achieved when the *gaillardia* plant grown under S_5 =7.0dS m^{-1} x *gaillardia* sundance, while the minimum electrolyte leakage of leaf (50.87%) were recorded for the interaction of S_1- Canal irrigation water control x *gaillardia* sundance. The LSD test demonstrated that the differences electrolyte leakage of leaf as influenced by salt (NaCl) stress.

Table 8. Electrolyte leakage of leaf (%) as influenced by salt (NaCl) stress and varieties

Salinity level	Varieties		Mean
	Lorenziana Double Mix	Gaillardia sundance	
S_1 = Canal Irrigation water (Control)	52.33	50.87	51.60 D
S_2 = 1.0 dS m^{-1}	55.09	52.16	53.62 D
S_3 = 3.0 dS m^{-1}	65.64	64.04	64.84 C
S_4 = 5.0 dS m^{-1}	79.66	77.28	78.47 B
S_5 = 7.0 dS m^{-1}	84.94	85.65	85.29 A
Mean	67.53 A	66.00 B	

S.E. 2278.80
LSD 0.05, 2.101

Conclusion

It is concluded that canal irrigation water (Control) improved growth of *gaillardia*. The salinity at 5, 3 and 7 dSm^{-1} caused simultaneous adverse effects son all the studied parameters that increased parallel to the increasing salinity levels. Among *gaillardia* varieties, surpassed variety *Gaillardia* sundance and Lorenziana Double Mix in germination percentage. However, for other investigated traits, *gaillardia Gaillardia* sundance showed better performance than Lorenziana Double Mix.

Authors' contributions

Designed & idea the experiments: AQ Gola & MH Unar, performed the experiments: NA Wahocho, implements the experiments: AQ Gola, T Aziz, MI Jakhro, JA Abro & GH Bugti, Contributed reagents/ materials/ analysis tools: AQ Gola, Z Khan & NA Wahocho, Wrote the paper AQ Gola.

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