Oner F and Soysal AOS (2020)
Notulae Scientia Biologicae 12(3):693-701
DOI:10.15835/nsb12310766
Research Article

Determination of germination and seedling growth parameters of rice (*Oryza sativa* L.) varieties under stress conditions

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Abstract

Rice (*Oryza sativa* L.) is an important food for more than half of the world's population. Globally, rice is grown on approximately 160 million hectares with an average annual production of 740.96 million tonnes. Salinity is an important abiotic factor for germination. In this study rice varieties were analysed for salt stress tolerance at germination growth stage. The response of eight rice varieties against six (0, 25, 50, 75, 100, 150 mM NaCl) salinity levels were studied at germination stage. Seeds of eight rice varieties ('Yatkin', 'Miss-2013 Passali', 'Kale', 'Manyas Yildizi', 'Efe', 'Biga Incisi' and 'Osmancik-97') were kept under six salt stress levels. Number of seeds germinated (number), germination rate (%), average germination time, fresh and dry weight of germinated seeds (g), fresh and dry weight of the coleoptile (g), fresh and dry weight of the radicle (g), the length of the coleoptile and radicle (mm) were recorded. The results showed that with increasing salt stress, germination in all the varieties was delayed. The increase in salt stress also reduced every measured trait significantly in all the varieties. Maximum germination percentage (100%) was observed in 'Biga Incisi' under all the salt stress levels. Our research data would be helpful for identification of the tolerant varieties which can be studied further in terms of economically.

Keywords: abiotic stress; germination; NaCl; rice; salinity stress seedling

Introduction

According to the data of the year of 2018, 782 million tonnes of paddy rice were produced in the world. In Turkey production has been made in the area of 120.137 ha (FAO, 2020). So that; rice, one of the most important staple crops, feeds more than one half of the world's population.

Rice is among the most important cereal products consumed by people. Rice (*Oryza*) is a member of the family Poaceae. *Oryza sativa* is most commonly grown in Asia (Linares, 2002; Vaughan *et al.*, 2008).

Salinity is one of the major obstacles in enhancing rice production in growing areas in the world. Salinity soluble salts which are washed in arid and semi-arid climates especially in arid and semi-arid climatic zones, escaping to the surface of the soil through capillary with high base water and accumulating on the surface of the soil by evaporation-ending water (Kwiatowski and King, 1998). Salinity's high levels reduce the ability of plants to absorb water from the soil and have toxic effects on cell metabolism (Munns and Tester, 2008). Rice is very sensitive to salinity stress (Anon, 2018). Salinity is an important abiotic stress factor that threatens the sustainability of world rice production. By adding salt at very low concentrations (50 mM NaCl) the yield

Received: 23 Jun 2020. Received in revised form: 07 Aug 2020. Accepted: 22 Sep 2020. Published online: 29 Sep 2020.

can be reduced considerably, as is the case with many plants resistant to salt stress (Yeo and Flowers, 1986; Grattan *et al.*, 2002; Munns and Tester, 2008). It has been shown by many researchers that salinity inhibits seed germination, pressure root and stem extension, reduces fresh weight and water content (Kabar and Baltepe 1987; Dash and Panda, 2001; El-Mashad and Kamel, 2001; Gulzar and Khan, 2002; Ashraf *et al.*, 2002). Understanding the physiology of rice germination adaptation to under salinity will help to improve rice seedling concern under these adverse conditions (Kurniasih *et al.*, 2013). The aim of this proposed study was to observe the effect of different salt doses on germination and germination properties of different rice varieties.

Materials and Methods

In this study, eight rice (*Oryza sativa* L.) varieties ('Yatkin', 'Miss-2013', 'Passali', 'Kale', 'Manyas Yildizi', 'Efe', 'Biga Incisi' and 'Osmancik-97') and 5 different salt (NaCl) concentrations (0, 25, 50, 100 and 150 ml) were used as materials. The research was carried out at the laboratory of Ordu University Faculty of Agriculture Department of Field Crops with 3 replications according to the factorial regulations in randomized parcels. In each Petri dish 20 seeds were planted for the study. These twenty seed per cultivar were placed on a filter paper in 10 cm petri dishes containing two sheets of filter paper were moistened initially with 5 ml of distilled with different concentrates solutions 0, 25, 50, 100, and 150 ml NaCl (saline conditions). The petri dishes were placed in a growth chamber for 12 days at 25 °C ± 1 for germination. In this research; number of seeds germinated (number), germination rate (%), average germination time, fresh and dry weight of germinated seeds, fresh and dry weight of the coleoptile, fresh and dry weight of the radicle, the length of the coleoptile and radicle were calculated.

Statistical analysis

All obtained data were statistically analysed according to the SPSS 21 for the factorial regulations in randomized parcels. Duncan computer software package was used to test the differences between treatment means at 5% and 1% level of probability.

Results and Discussion

Radicula and plumula length (mm)

In this research, germination rate of eight rice varieties significantly decreased in increasing NaCl levels. All rice varieties showed more than 90% germination at all NaCl concentrations Figure 1. Statistically non-significant were found in number of seeds germinated (number), the germination rate (%). The percentage of germination significantly decreased in all varieties due to increasing salinity level indicated by Hakim *et al.* (2010). There was no difference between the varieties in terms of number of germination seeds (Table1). The average number of germinated seeds for the 8 varieties used was found to be 19.53 number. All the seeds in the 'Biga Incisi' variety were germinated (%100) (Table1). A decrease in germination rate was observed after 50 ml NaCl dosing. However, the germination rate was high even at 150 ml of NaCl. The highest GR's were 99.79, 98.54, 97.29 and 96.67% for 50, 0, 25 and 100 ml NaCl salinity levels, respectively; the lowest GR (95.83%) was determined at the highest salinity level (150 ml NaCl) (Figure 3). Hakim *et al.* (2010) reported in their research that salinity level reduced the osmotic effect so GR is reduced by this effect. There were statistically differences in mean germination time. The germination rates were calculated after 2 day in 0 and 25 NaCl doses were the first in terms of day. At 0 and 25 NaCl were the germination rate was calculated after 2 day). Ahmad and Wani (2014) reported the number of days were calculated of germination in the study after 4th day. Figures 1 and 2 show the values of germinated seeds (number), germination rate (%), radicula and plumula length (mm).

There was found a difference in length of coleoptile between cultivars, but no difference in radicle length. As a result of the statistical analysis, there was a statistically significant difference between salt concentrations in terms of coleoptile and radicula lengths. The length of coleoptile increased up to 100 ml NaCl. Whereas the length of the radicle decreased by salt levels. Cavusoğlu *et al.* (2007) also noted that increasing levels of saltiness have an inhibitory effect on seedling growth parameters (percent coleoptile, radicle and coleoptile extension, fresh weight) as well as the final germination percentage of barley seeds. Figures 1 and 2 shows also the values of coleoptile length and radicula length, average number of germinations, respectively. The longest coleoptile length was found 51.17 cm (‘Osmancik-97’) and the shortest length was found 33.33 cm (‘Miss-2013’). The longest and shortest radicula value was found 59.45 - 49.41 mm, ‘Passali’ and ‘Biga Incisi’ cultivars, respectively.

Table 1. Correlation table on average o number of seed germinated (number), germination rate (%), average germination time (day), fresh and dry weight of coleoptile (g), fresh and dry weight of the radicle (g) between each other and salinity concentrations (NaCl)

	GP	GR (%)	AGT (number)	FWGS (g)	DWGS(g)	FWC (g)	DWC (g)	FWR (g)	DWR (g)	CL (mm)	RL (mm)
GR	1.00**										
AGT	-0.07	-0.07									
FWGS	0.11	0.11	-0.40**								
DWGS	0.02	0.02	0.72**	-0.41**							
FWC	0.12	0.12	-0.55**	0.73**	-0.43**						
DWC	0.04	0.04	-0.38**	0.35**	-0.22*	0.49					
FWR	0.007	0.00	-0.38**	0.65**	-0.50**	0.51	0.21**				
DWR	0.09	0.095	-0.32**	0.44**	-0.33**	0.38	0.33**	0.39**			
CL	0.14	0.149	-0.26**	0.08	-0.007	0.09	0.06**	-0.03	-0.01		
RL	0.15	0.156	-0.49**	0.53**	-0.52**	0.59	0.43**	0.51**	0.57**	0.07	
NaCl doses	-0.16	-0.16	0.63**	-0.47**	0.66**	-0.54	-0.36**	-0.56**	-.67**	-0.01	-0.76

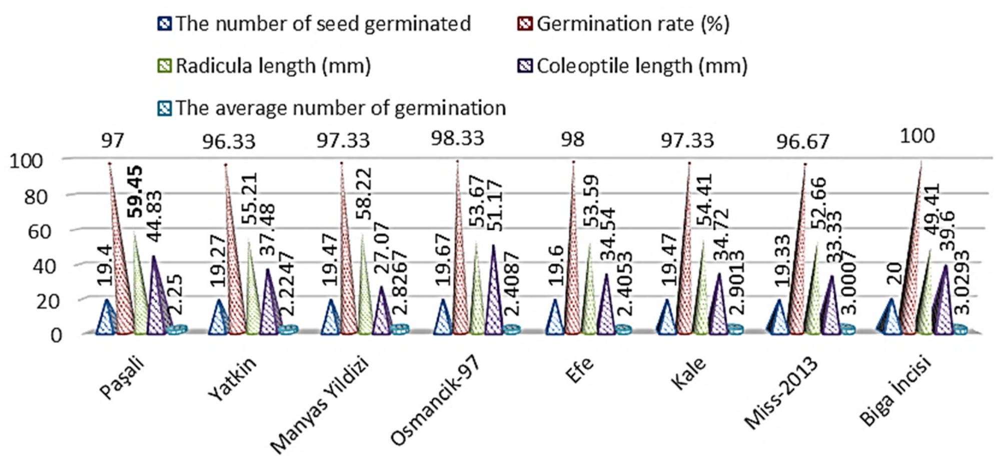

Figure 1. Different NaCl levels effect on the number of seed germinate (number), germinated rate (%), coleoptile length and radicula length (mm) and the average number of germination (number)

Fresh and dry weight of coleoptile and radicula (g)

Statistical analysis result was found significantly important for fresh and dry weight of the coleoptile. The longest fresh weight of coleoptile was found in ‘Yatkin’ cultivar. ‘Manyas’ ‘Yildizi’ and ‘Kale’ cultivars responded negatively to the increasing salt doses and the fresh weight of the coleoptile decreased. Except for these two varieties, the fresh weight of coleoptile increased till 50 ml NaCl. After 50 ml of NaCl, the values decreased (Figure 6). Similarly, Jamil and Rha (2007) observed that shoot length, root lengths and dry weight were decreased with increasing salt stress. When the dry weight of coleoptiles was compared with the control, they were increased with salinity except 150 ml NaCl. Figure 6 shows that 150 ml NaCl was the limiting value. But the optimum dry weight was achieved at 50 mL NaCl dose. Fresh and dry weight of the radicle were found statistically important. FWR and DWR decreased in different saline levels in all cultivars (Figure 7). Figure 7 shows that the highest FWR (0.469g) and DWR (0.0502 g) and the lowest FWR and DWR, 0.1373 g, 0.022 g, respectively. In terms of this parameter, 25 ml NaCl values were in the same statistical group with the control group. The results conducted by Anbumalarmathi *et al.* (2013) research are similar to those we have found for radicula weight.

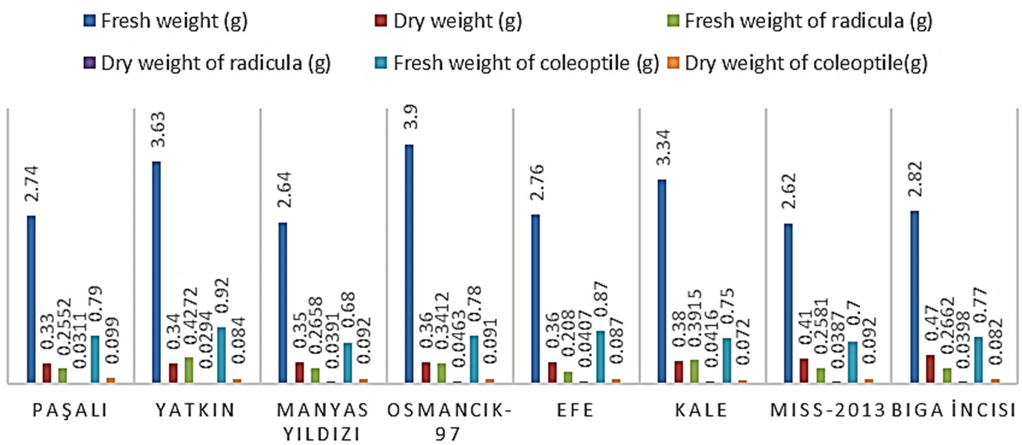

Figure 2. Different NaCl levels effect on fresh weight (g), dry weight(g), dry weight of coleoptile (g), fresh weight of radicula (g)

Fresh and dry weight (g)

In our research, fresh and dry weight of germinated seeds effected by salinity. The seedling fresh weight was found directly proportional to the salinity levels (Figure 2). The fresh weight of germination diminished at all salt concentrations that were increased, the except of 25% NaCl for 'Osmancik-97', 'Biga Incisi' and 'Pasteur'. There was a statistical difference in terms of dry weight of the seeds. Mean fresh weight of germination varied between 2.04 and 3.85. Afzal *et al.* (2012) reported that higher salinity affected negatively the FWGS (Fresh weight of germinated seed) reduced. Bohnert *et al.* (1995) and Al-Karaki (2001) said that; reduced fresh weight and water content of the fidelity in the salt environment can be explained by the lack of sufficient water intake of the roots due to the high osmotic pressure of the environment. Islam and Karim (2010) reported that in all genotype the seedling dry weight and percent relative dry weight were decreased due to increasing the salinity level.

The response of the dry weight of the seeds to increasing salt concentrations has been positive. This can be explained by the low water intake of the seeds as the salt rate increases. Ahmad and Wani (2014) have reported dry weight of the seeds were decreased by salinity levels. Their results are exactly the opposite of our results. The highest DWGS (Dry weight of germinated seed) (0.44 g) was determined at 150, followed by 100 ml NaCl with 0.41g and 50 ml NaCl with 0.37g in the different statistical group. And the lowest DWGS was determinate at 0 ml NaCl (0.31 g). Anbumalarmathi *et al.* (2013) obtained that plumula dry weight showed inverse relationship with salt concentration. The highest FWGS was found 3.85g at 25 ml NaCl and the lowest FWGS was found 2.04 g at the highest NaCl concentration (150 ml) (Figure 5).

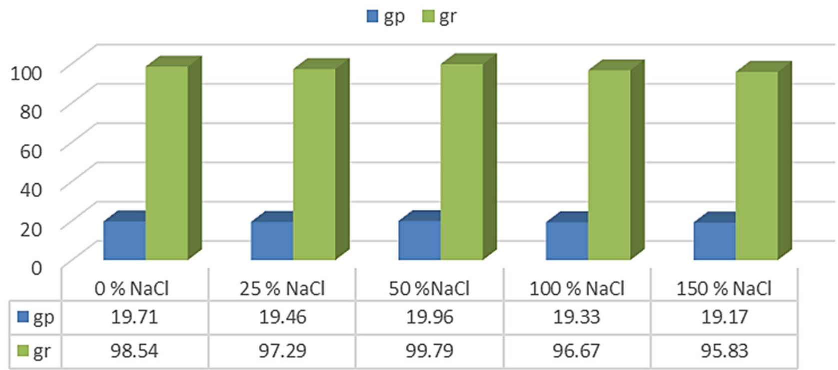

Figure 3. Effect of salt stress on germination percentage (GP) and germination rate (GR)

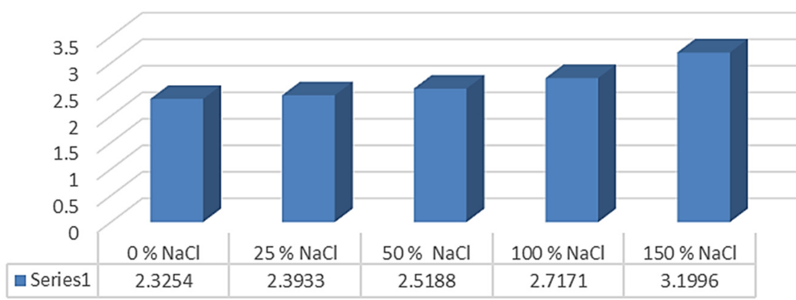

Figure 4. Effect of salt stress on average germination time (AGT)

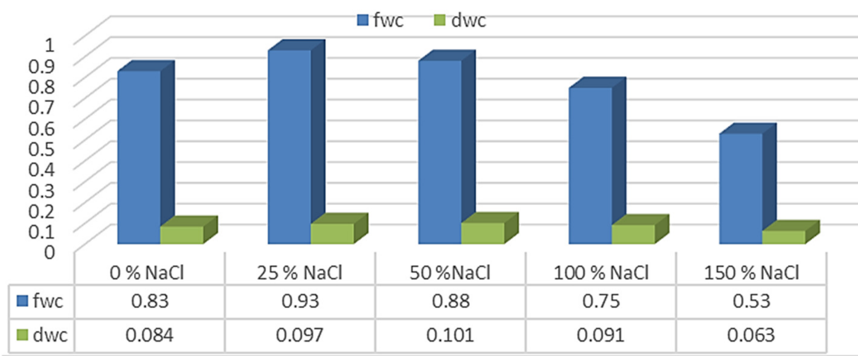

Figure 5. Effect of salt stress on fresh weight germinated seed (FWGS) and dry weight germinated seed (DWGS)

Almost all of the parameters regression results were found close to best value. Figure 8 show us the regression analysis table. Regression analysis table is show that our finding results are represent the truth.

When the correlation table (Table 1) is examined, there was a positive correlation between dry weight and average salt concentration of germinated seeds. There was a negative correlation between salt levels and fresh weight of germinated seeds, dry weight of the coleoptile, fresh and dry weight of the radicle.

The last table, variation table (Table 2), showed us NaCl and variety interaction found very important at 1% level ($P<0.01$) on average germination time, fresh and dry weight of coleoptile, fresh and dry weight of radicle, fresh weight and total seed weight. Interaction found significant ($P<0.05$) on seed weight, dry weight and coleoptile length. All rice varieties' impact was found statistically significant ($P<0.01$) on all of parameters except number of seed, germinated rate and radicle length. NaCl doses effects were found statistically important at 1% level ($P<0.01$) almost all parameters apart from number of seed, germinated rate and seed weight. And NaCl impact on coleoptile length at 5% level (Table 2).

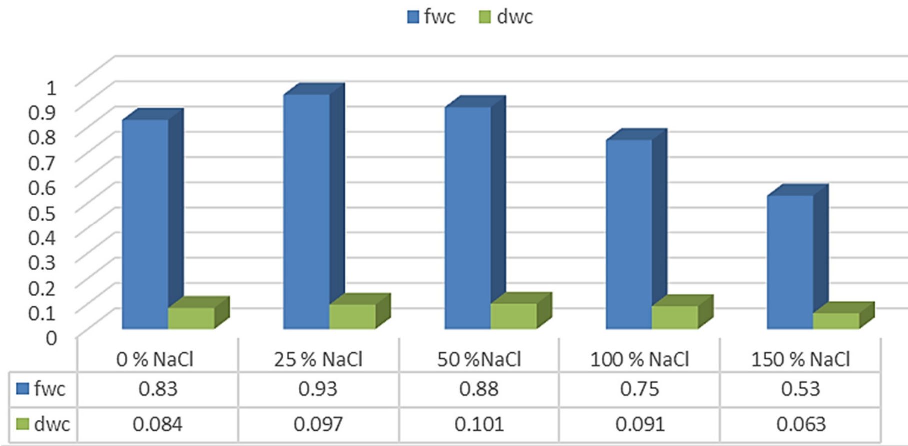

Figure 6. Effect of salt stress on fresh weight coleoptile (FWC) and dry weight coleoptile (DWC)

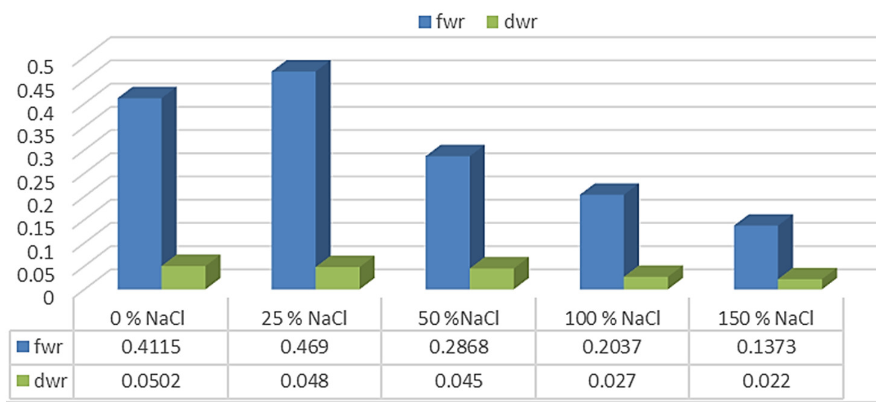

Figure 7. Effect of salt stress on fresh weight radicle (FWR) and dry weight radicle (DWR)

Table 2. Variation table on average o number of seed germinated (number), germination rate (%), average germination time, fresh and dry weight of coleoptile (g), fresh and dry weight of the radicle (g) between each other and salinity concentrations (NaCl)

		NGS		GR		AGT		SW			
SOV	DF	KO	F	KO	F	KO	F	KO	F		
Variety	7	0,808	0,561 ns	20,208	0,561 ns	1,751386	105,8826**	0,123009	24,6484**		
NaCl	4	2,346	1,627 ns	58,646	1,627 ns	2,958983	178,8896**	0,007745	1,5520 ns		
NaCl* Variety	28	1,412	0,980 ns	35,31	0,980 ns	0,084929	5,1345**	0,008469	1,6970*		
Error		1,442		36,042		0,016541		0,004991			
CV		0.0615		0.0615		0.0489		0.1416			
		FWC		DWC		FWR		DWR			
Variety	7	0,092	4,641**	0,001	10,736**	0,087352	6,4256**	0,000458	6,2707**		
NaCl	4	0,603	30,448**	0,005	59,606**	0,461621	33,9567**	0,004016	54,9408**		
NaCl* variety	28	0,057	2,906**	0,001	12,823**	0,054695	4,0233**	0,000322	4,4028**		
Error		0,020		9,3.10-05		0,063462		7,31.10-05			
CV		0.1793		1.1049		0.3865		0.2230			
		FW		DW		TS		RL		CL	
Variety	7	3,722	4,866**	0,029	45,999**	0,042665	35,7238**	148,9701	0,5812 ns	828,6604	5,2962**
NaCl	4	12,798	16,732**	0,062	96,392**	0,108327	90,7038**	12480,42	48,6977**	771,8715	4,9332*
NaCl* Variety	28	2,260	2,955**	0,001	2,144*	0,00643	5,3836**	390,0093	1,5218 ns	284,7421	1,8199*
Error		0,765		0,001		0,001194		256,2836		156,4636	
CV		0.2858		0.0679		0.0884		0.02933		0.3305	

Significant level *P<0.05 **P< 0.01

SOV: Source Variation, NGS: Number of germinated seeds, GR: Germinated rate, AGT: Average germination time, SW: Seed weight, FWC: Fresh weight of coleoptile, DWC: Dry weight of coleoptile, FWR: Fresh weight of radicle, DWR: Dry weight of radicle, FW: Fresh weight, DW: Dry weight, TS: Total seed weight, RL: Radicle length, CL: Coleoptile length.

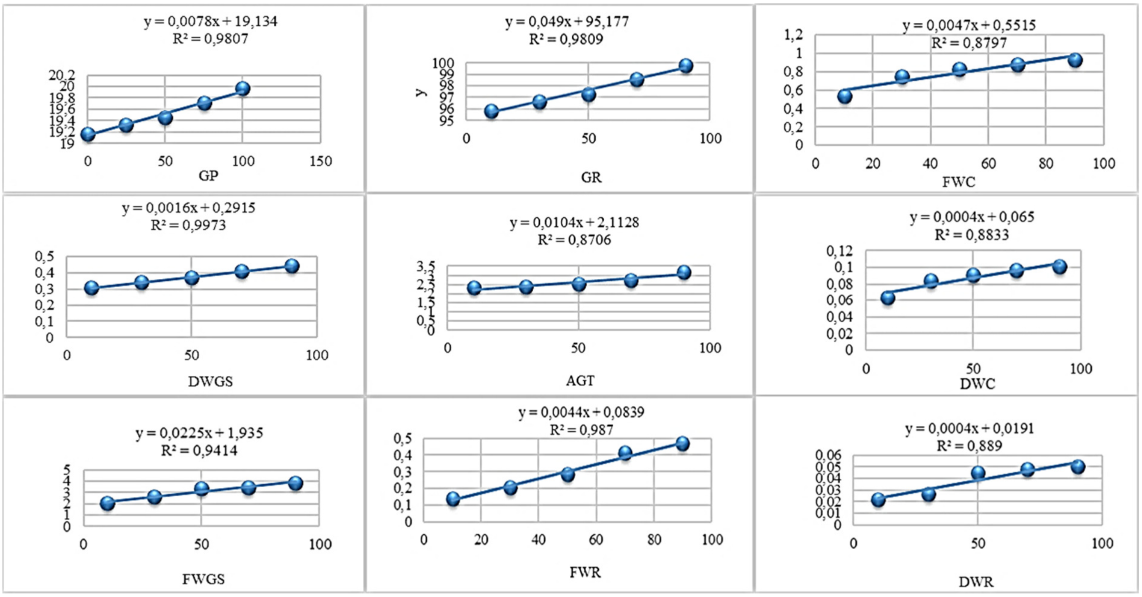

Figure 8. Regression analysis table on averages of number of seeds germinated (number), germination rate (%), average germination time, fresh and dry weight of germinated seeds (g), fresh and dry weight of the coleoptile (g), fresh and dry weight of the radicle (g), the length of the coleoptile and radicle (mm) between each other and salinity concentrations (NaCl), effect of different salt stress percentage of fresh weight radicle (FWR) and dry weight radicle (DWR)

Conclusions

According the results obtained in the present investigation, we can conclude that overall showed better tolerance to salt stress with effect of NaCl on germination and biomass production at seedling stage. It is important to determine the yield and yield items of the varieties and to study for sustainability in saline areas especially where rice is grown. For this reason, like these researches should be increased in that's area.

Authors' Contributions

Both authors read and approved the final manuscript.

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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