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Screening of Salt Tolerance Capability of Wheat Genotypes under Salt Stress Condition

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Abstract To screen salt tolerance wheat genotypes, germination and seedling growth characters were used as screening criteria. 33 wheat genotypes were tested under 5 different salt concentrations (0, 5, 10, 15 and 20 dSm^{-1}) at central laboratory, Sher-e-bangla Agricultural University, Dhaka-1207, during February to March, 2016. The experiment was conducted with a complete randomize design (CRD) with 5 replications. The results of the experiment revealed that, various germination and seedling growth parameters of the wheat genotypes varied significantly under salt stress. A marked reduction of germination rate, shoot and root length, shoot and root dry weight, relative water content, water retention capacity and vigor index was observed with the increasing of salt concentration for most of the wheat genotypes except ESWYT-5, ESWYT-6 and BARI GOM 28. ESWYT-5, ESWYT-6 and BARI GOM 28 showed consistently better performance against salt stress and there were slow linear reduction was observed with the increasing of salt concentration from 0 to 20 dSm^{-1}. So considering the above fact, ESWYT-5, ESWYT-6 and BARI GOM 28 could be promising salt stress genotype against moderate saline condition.

Keywords Salinity Stress, Wheat Genotypes, Tolerant Genotype, Sensitive Genotypes

1. Introduction

By 2050 the world population will be about 9.10 billion, which will be 34% higher from today and we need to feed another 2.30 billion people with limited resources. Food production must need to be increased about 70% and to meet this huge demand cereal production will need to increase about 3 billion metric tons from 2.10 billion metric tons today. But in a dilemma, the world agriculture in 21st century faces versatile challenges. Soil salinity is one of the major abiotic stresses which directly affect plant physiology which causes drastic reduction of crop production. World's 25% cultivable lands are salinity affected among 400 million ha of total land and the salt intrusion scenario is alarmingly increasing. Bangladesh is also not beyond this threat. In Bangladesh the salinity affected area was 83.3 million ha in 1973, 102 million ha in 2000 and in 2009 it has reached up to 105.5 million ha and the area is being expanded with times being Soil Resource and Development Institute [45]. The dramatic increasing of saline area is caused by rise of the sea levels, global warming.

Wheat is a temperate cultivable cereal crop ranked second after rice mainly cultivated in the north and north-west region of Bangladesh. A huge amount of cultivable lands in the coastal belt remain fallow and the sole cropping pattern is fallow-Aman-fallow. Inclusion of wheat in this traditional saline belt cropping pattern could be an effective means for optimizing land utilization to supplement the food production and nutritional deficit of the ever growing population of Bangladesh. Reclamation of saline soil is very much expensive where salt tolerance wheat genotype selection could be a feasible and cost effective mean for the saline belt.

The soil salinity may responsible for many detrimental effects on plant growth and development at physiological and biochemical level Munns [32]. In saline soils, seeds with lower osmotic potential fail to absorb water; increase the accumulation of toxic ions (Na^+ and Cl^-) and finally there is a delay, decrease and disruption of seed germination Ashraf and Foolad [8]. Metabolism, physiological act and morphological feature of plant changed by soil salinity in and drastically reduce the growth and yield Ashraf and Harris [5]. Ramaden *et al.* [35] reported that higher salinity level in the germination media build up a high osmotic pressure in the solution which restricted the uptake of soil water required for proper germination of seed. Seed embryo badly affected by higher salt concentration which result there is a delay and reduction of germination percentage of seed. Percentage of germination, length of coleoptiles, length of root and seedling growth reduced by detrimental effect of salinity Lallu and Dixit [26]; Ganndha *et al*. [19]; Bera *et al*. [10] and Agnihotri *et al*. [2]. Cha-um *et al*. [12] mentioned that plant that was exposed to salinity stress, water potential was reduced then water use efficiency was also reduced. But the salt tolerance species exert a high capacity to resist salt stress through biosynthesis and accumulation of compatible solute. These solutes increase the overall osmotic pressure within the cell there by empowering plant cell to affirm both turgor and driving gradient for water absorption Hasegawa *et al*. [20]. According to Kumar *et al.* [25] numerous plants have improved mechanism either to restrict salt uptake to their cell or to tolerate within the cell. Zhu [47] also reported that plant faces salt stress condition; affirm a high K^+ concentration and low Na^+ concentration in the cytosol. They do this by regulation of expression and activity of K^+ and Na^+ transporters and H^+ pumps that creates the driving force for transport. Regulation of K^+ uptake and prevention of Na^+ influx, promotion of Na^+ efflux from the cell and use of Na^+ for K^+ adjustment are the strategies generally use by plant to maintain expected K^+/ Na^+ ration in cytosol. So, a high K^+/Na^+ ratio in cytosol is always expected for normal functioning of the plant cell Zhu [47]. Only physiological markers for example Na^+, K^+ content, K^+: Na^+ ratio and accumulation pattern of proline are less suitable, even in the point of view of some researchers are not promising enough for screening the salt tolerance genotypes Shannon [40].

The varietal variation in salinity tolerance that exists among crop plant can be used through screening program by exposing target traits for salt tolerance Kingsbury *et al*. [24]. Physiological tolerance along with some agronomic traits and their relationship with salt tolerance indices could be a feasible means are considered strong enough to be a selection tool in breeding of salt tolerance cultivars Allakhverdiev *et al*. [4].

Therefore, with a view to expand the cultivation and to sustain the yield of wheat in the coastal belt, the present piece of work was implemented to evaluate some agronomic and physiological traits of wheat as screening criteria against salinity condition.

2. Materials and Methods

The experiment was implemented at the central laboratory of Sher-e-Bangla Agricultural University, Dhaka-1207 from February to March, 2016. The experiment was conducted in single factor Completely Randomize Design (CRD) with five replications.

The performance of 33 wheat genotypes including 5 wheat varieties and 28 advanced lines were collected form Wheat Research Centre, Nashipur, Dinajpur and Bangladesh Agricultural Research Institute, respectively (Table 1) and tested under five different salinity levels (0, 5, 10, 15 and 20 dSm^{-1}) for present research.

Table 1. List of wheat genotypes used for present research

Sl. No.	Genotypes	Remarks
01	SATYN-22	Advanced line
02	SATYN-15	Advanced line
03	SATYN-21	Advanced line
04	SAYYN-17	Advanced line
05	SATYN-23	Advanced line
06	ESWYT-5	Advanced line
07	SATYN-24	Advanced line
08	ESWYT-6	Advanced line
09	SATYN-3	Advanced line
10	SATYN-27	Advanced line
11	SATYN-12	Advanced line
12	SATYN-6	Advanced line
13	SATYN-19	Advanced line
14	SATYN-16	Advanced line
15	SATYN-25	Advanced line
16	WICYT-7	Advanced line
17	WICYT-9	Advanced line
18	WICYT-28	Advanced line
19	WICYT-35	Advanced line
20	WICYT-41	Advanced line
21	WICYT-15	Advanced line
22	WICYT-20	Advanced line
23	WICYT-25	Advanced line
24	WICYT-26	Advanced line
25	SATYN-2	Advanced line
26	SATYN-10	Advanced line
27	SATYN-14	Advanced line
28	SATYN-20	Advanced line
29	BARI GOM 25	Variety
30	BARI GOM 26	Variety
31	BARI GOM 27	Variety
32	BARI GOM 28	Variety
33	BARI GOM 29	Variety

2.1. Seed Placement for Germination

33 wheat genotypes were collected from Wheat Research Centre, Nashipur, Dinajpur and Bangladesh Agricultural Research Institute and dried for 3 hrs under sunlight. Filter paper were cut according to the petri dish size and place into the bottom of the dish. 30 seeds of each wheat genotypes were placed into the petri dish. 0, 1.4625, 2.925, 4.3875 and 5.85 g NaCl were dissolved in 500 ml distill water separately to get 0, 5, 10, 15 and 20 dSm^{-1} NaCl solution, respectively. The salt solutions were sprayed as per treatment on petri dish until the saturated condition and spraying continued with 6 hrs interval.

2.2. Data Recorded on Germination Traits

Germination was recorded at 24 hrs interval and continued up to 11th day. More than 2 mm long plumule and radicle seed was considered as germinated seed.

The germination rate was calculated using following formula:

$$\text{Rate of germination (\%)} = \frac{Total Number of germinated seeds}{Total seed placed for germination} \times 100$$

Co-efficient of germination (CG) was calculated using the following formula Copeland [14]:

$$\text{Coefficient of germination (\%)} = \frac{A1+A2+\cdots+Ax}{A1T1+A2T2+\cdots AxTx} \times 100$$

Where,

A= Number of seeds germinated

T= Time corresponding to A

x= Number of days to final count

Vigour index was calculated using following formula Abdul-Baki and Anderson [1]:

$$\text{Vigour index} = \frac{Total germination \times Seedling length\ (mm)}{100}$$

2.3. Data Recorded on Shoot and Root

At 11th day after seed placement, five seedlings of each petri dish were randomly sampled. Shoot and root length of single seedling were recorded with meter scale. Then the shoot and root of the seedling were dried for 48 hrs then dry weight of shoot and root were recorded using electric balance.

After recording the fresh weight leaf of each seedling place into petri dish for 24 hrs then leaf soaking with distilled water, then turgid weight was recorded, after 48 hrs drying ~~for~~ the dry weight was measured.

Relative water content was measured using following formula Baque *et al*. [9]:

$$\text{Relative water content (WRC) (\%)} = \frac{Fresh weight - Dry weight}{Tugid weight - Dry weight} \times 100$$

Water saturation deficit was recorded using following formula Baque *et al*. [9]:

Water saturation deficit (WSD) = 100- Relative water content

Water retention capacity was measured following formula Baque *et al.* [9]:

$$\text{Water retention capacity (WTC)} = \frac{Turgid weight}{Dry weight}$$

2.4. Statistical Analysis

The collected data were analyzed statistically following CRD design by MSTAT-C computer package program and the treatments were compared by Least Significance Differences (LSD) test.

3. Result and Discussion

3.1. Germination Percentage

Germination percentage significantly varied among wheat genotypes under different level of saline concentration (Table 2). The rate of germination decreased with the increasing of salt concentration. ESWYT-5, ESWYT-6 and BARI GOM 28 showed consistency against different levels of saline concentration and gave the highest germination rate (98.89, 94.44, 92.11, 91.57 and 88.00% in ESWYT-5; 97.78, 94.44, 90.19, 90.23 and 87.10% in ESWYT-6 and 97.46, 92.72, 89.89, 89.31 and 86.67% in BARI GOM 28 at 0, 5, 10, 15 and 20 dSm^{-1}, respectively). On the other hand the lowest germination rate was counted for BARI GOM 29 and SATYN-20 (32.22 and 33.33% at 0 dSm^{-1}, respectively). The reduction trend of germination percentages rapidly increase with the increasing of NaCl concentration for BARI GOM 29 (85.00, 87.78, 88.89 and 90.00 at 5, 10, 15 and 20 dSm^{-1}, respectively). So, in the context of germination percentage to salinity tolerance/sensitivity, it may be concluded that among 33 wheat genotypes ESWYT-5, ESWYT-6 and BARI GOM 28 might be referred as salt tolerance cultivars and BARI GOM 29 as most salinity sensitive cultivar. The germination of wheat genotype could be affected in two ways under salinity condition. First of all, in the germination media excess salt might be reduced the osmotic potential of tested seed to such extent that seeds that were placed for germination unable to absorb enough water necessary for transportation of mineral nutrients which were crucial for germination and the second one was ~~is~~ the embryo of the tested seed adversely affected by the toxicity of salt salutes Mujeeb-ur-Rahman *et al.* [31]. In the physiological point of view, the absorption of more K^+/Na^+ is essential for seed germination. The rise of salinity level decreases the K^+/Na^+ ratio Carmer *et al.* [15] which injures the embryo of the germinal seed. Khan *et al.* [22] also reported that, up taking of salt in sensitive plant competes with the up taking of compatible nutrients ions, especially K^+, which causes K^+ deficiency. In salinity stress condition, sensitive wheat genotypes absorb more Na^+ than K^+ Ashraf and Oleary [7] and Sairam*et al.* [37] as a result germination decreases. Amount of Na^+ uptake by cereals was reported as salt tolerant indices Ashraf and Khanum [6]. In some halophytes like wheat, the exclusion of Na^+ and inclusion of K^+, salt tolerance mechanism might absence referred as sensitive cultivar Poustini and Siosemardeh [33]. On the other hand increasing the absorption of osmotically active constituents like sugar organic acid, proline, glycine, K^+ and Cl^- which trigger the nutrient release selectivity and osmotic adjustment to salinity referred as salt tolerance genotypes. Similar result also found by different scientists in different crops like: Khatkar and Kuhad [23] in wheat; Shirazi [42], Lallu and Dixit [26] in mustard; Bera *et al.* [10] in chickpea.

Table 2. Effect of salinity level on germination rate of different wheat genotypes at different salt concentrations

Genotypes	Germination rate (%) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	77.33 i	75.55 f-h	51.11 n	41.10 kl	33.34 kl
SATYN-15	88.89 e-g	80.00 de	73.44 f-h	67.05 e	53.31 ef
SATYN-21	88.89 e-g	87.78 c	82.40 bc	66.66 ef	63.60 d
SAYYN-17	77.66 i	52.22 l	48.05 n	43.14 k	31.11 lm
SATYN-23	87.78 f-h	74.44 g-i	66.66 jk	67.77 e	55.55 e
ESWYT-5	98.89 a	94.44 a	92.11 a	91.57 a	88.00 a
SATYN-24	84.44 h	82.11 d	74.44 e-g	75.55 c	67.77 c
ESWYT-6	97.78 ab	94.44 a	90.19 a	90.23 a	87.10 a
SATYN-3	62.22 k	50.00 l	31.11 o	30.22 m	25.55 n
SATYN-27	76.66 i	65.55 k	47.75 n	38.47 l	35.98 jk
SATYN-12	70.00 j	68.92 jk	62.22 lm	50.00 j	37.77 j
SATYN-6	93.33 cd	88.89 bc	84.49 b	76.66 c	71.44 b
SATYN-19	88.89 e-g	78.89 d-f	74.44 e-g	66.66 ef	45.55 i
SATYN-16	86.66 gh	78.89 d-f	64.44 kl	63.33 f-h	49.96 gh
SATYN-25	91.11 d-f	82.22 d	78.88 cd	73.86 cd	68.89 bc
WICYT-7	93.33 cd	70.00 j	61.11 lm	59.51 i	55.55 e
WICYT-9	88.88 e-g	82.22 d	68.89 ij	62.89 g-i	52.17 fg
WICYT-28	93.33 cd	75.55 f-h	70.51 h-j	66.43 e-g	54.98 ef
WICYT-35	91.11 d-f	82.22 d	75.55 def	67.77 e	62.03 d
WICYT-41	94.42 b-d	77.77 e-g	74.44 efg	71.63 d	68.62 bc
WICYT-15	80.00 i	71.11 ij	60.00 m	61.11 hi	61.82 d
WICYT-20	94.44 b-d	65.55 k	63.33 k-m	60.15 hi	56.22 e
WICYT-25	48.88 l	34.39 m	31.24 o	15.55 o	10.37 p
WICYT-26	92.22 c-e	77.77 e-g	76.66 d-f	67.77 e	48.89 h
SATYN-2	95.55 a-c	87.77 c	85.55 b	84.44 b	67.77 c
SATYN-10	95.55 a-c	88.88 bc	77.77 de	75.55 c	66.66 c
SATYN-14	78.89 i	72.22 h-j	70.59 g-i	51.11 j	49.64 gh
SATYN-20	33.33 n	28.88 n	17.77 q	14.74 op	9.988 p
BARI GOM 25	37.77 m	34.83 m	24.44 p	19.94 n	19.98 o
BARI GOM 26	92.22 c-e	77.77 e-g	63.33 k-m	61.11 hi	53.42 ef
BARI GOM 27	84.44 h	53.33 l	31.11 o	27.77 m	28.89 m
BARI GOM 28	97.46 ab	92.72 ab	89.89 a	89.31 a	86.67 a
BARI GOM 29	32.22 n	15.00 o	12.22 r	11.11 p	10.00 p
LSD $_{(0.05)}$	3.66	4.12	3.91	3.67	3.03
CV (%)	3.58	4.64	4.97	5.06	4.77

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.2. Shoot Length

Salinity level significantly affected the shoot length of wheat genotypes (Table 3). The magnitude of reduction of shoot length was lower in ESWYT-5, ESWYT-6 and BARI GOM 28 under different levels of salt concentration. The shoot length ranged from 180.2 mm in ESWYT-5 to 122.00 in BARI GOM 29 at control solution (0 dSm^{-1}); 161.70 mm in ESWYT-5 to 39.60 mm in SATYN-20 at 5 dSm^{-1} NaCl solution; 147.20 mm in ESWYT-5 to 28.27 mm in SATYN-14 at 10 dSm^{-1} NaCl solution; 120.50 mm in ESWYT-5 to 10.47 mm in WICYT-41 at 15 dSm^{-1} NaCl solution. Wheat genotype ESWYT-5 showed statistically similarity with ESWYT-6 at 5 dSm^{-1} NaCl solution; at 15 dSm^{-1} NaCl concentrations, WICYT- 41 showed statistically at par with WICYT-9 and WICYT-14 wheat genotypes. At 20 dSm^{-1} NaCl solution maximum shoot length was recorded for ESWYT-5 followed by ESWYT-6 and BARI GOM 28 but there was a dramatic change of shoot length in SATYN-22 and SATYN-25 and they did not survive at 20 dSm^{-1} NaCl solution. The lower shoot length for salt sensitive cultivars might be due to more accumulation of Na^{+} which retard the cell division and elongation process and ultimately reduce the shoot length of salt sensitive cultivars For a consequence it might be concluded that ESWYT-5, ESWYT-6 and BARI GOM 28 wheat cultivars may be tolerance to salt.

Table 3. Effect of salinity level on shoot length of different wheat genotypes at different salt concentrations

Genotypes	Shoot length (mm) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	147.3 c-e	140.0 c-e	40.35 o	33.35 p-r	0.00 r
SATYN-15	136.4 g-k	129.0 fg	59.13 m	41.79 n	29.03 k
SATYN-21	131.8 j-n	128.5 fg	103.5 d	91.13 c	39.53 hi
SAYYN-17	134.1 h-l	125.0 g-j	100.7 de	68.60 h	37.58 ij
SATYN-23	139.3 f-j	114.5 k-m	98.15 ef	81.36 f	29.31 k
ESWYT-5	180.2 a	161.7 a	147.2 a	120.5 a	116.2 a
SATYN-24	130.7 k-n	117.3 k-m	101.5 de	86.17 de	71.40 d
ESWYT-6	169.8 b	157.3 ab	138.7 b	106.6 b	99.72 b
SATYN-3	152.9 c	140.7 cd	83.96 ij	45.87 m	37.87 ij
SATYN-27	124.3 no	120.6 h-k	57.70 m	55.73 j	49.20 f
SATYN-12	140.1 e-i	133.9 ef	93.87 fg	89.26 cd	82.33 c
SATYN-6	140.7 e-h	105.5 o	87.27 h-j	84.71 ef	82.14 c
SATYN-19	127.9 l-o	111.3 m-o	86.90 h-j	53.07 jk	38.53 i
SATYN-16	136.3 g-k	112.4 l-n	77.20 k	70.58 gh	45.73 g
SATYN-25	132.9 h-m	133.6 ef	98.00 ef	73.92 g	0.00 r
WICYT-7	136.7 g-k	70.00 q	57.49 m	38.13 no	9.068 q
WICYT-9	139.1 f-j	50.60 r	31.00 rst	11.07 v	8.836 q
WICYT-28	129.7 k-o	50.83 r	38.87 op	30.42 q-s	13.07 n-p
WICYT-35	143.6 d-g	114.4 k-m	33.23 q-s	24.27 t	15.47 n
WICYT-41	142.2 d-g	126.7 gh	45.67 n	10.47 v	9.928 q
WICYT-15	143.3 d-g	70.51 q	65.73 l	51.27 kl	42.20 h
WICYT-20	132.7 i-m	48.87 r	35.67 pq	27.37 st	21.60 m
WICYT-25	132.8 i-m	126.7 gh	56.40 m	36.75 op	24.85 l
WICYT-26	153.2 c	142.5 cd	41.20 no	36.73 op	26.66 kl
SATYN-2	146.1 c-f	136.6 de	82.87 j	73.00 g	13.27 n-p
SATYN-10	127.1 l-o	85.80 p	35.03 p-r	34.07 pq	28.17 k
SATYN-14	124.3 no	107.7 no	28.27 t	12.53 v	13.80 no
SATYN-20	129.1 k-o	39.60 s	28.80 st	18.14 u	11.40 o-q
BARI GOM 25	149.9 cd	143.6 c	64.00 l	60.47 i	55.61 e
BARI GOM 26	125.6 m-o	118.8 j-l	87.63 hi	55.47 j	50.07 f
BARI GOM 27	129.2 k-o	126.1 g-i	89.47 gh	49.20 lm	35.00 j
BARI GOM 28	167.4 b	153.2 b	134.0 c	104.7 b	97.17 b
BARI GOM 29	122.0 o	119.8 i-k	33.70 qr	29.54 rs	10.47 pq
$LSD_{(0.05)}$	7.90	6.43	4.59	3.84	2.99
CV (%)	4.53	4.51	5.12	5.61	6.34

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.3. Root Length

The root length was varied significantly among wheat genotypes under different salt concentration (Table 4). Consistently ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes had shown a slower reduction against the increasing of salt concentration. At 0 dSm^{-1} salt concentration root length ranged from 164.20 mm in ESWYT-5 to 13.32 mm in SATYN-12; at 5, 10 and 15 dSm^{-1} salt concentrations root length ranges from 152.10 mm in ESWYT-5 to 5.13 mm in SATYN-19, 109.30 mm in ESWYT-5 to 3.96 mm in SATYN-19, 69.79 mm in ESWYT-5 to 3.03 mm in SATYN-19, respectively. Longest root length distinctly was found from ESWYT-5, ESWYT-6 and BARI GOM 28 at 20 dSm^{-1}, on the other hand seedlings of SATYN-22 and SATYN-25 did not survive at the same salt concentration. In conclusion, it may be said that ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes could be salt tolerance and SATYN-19, SATYN-12 sensitive to saline condition in respect of root length. SATYN-22 and SATYN-25 might be very much sensitive to salt at higher salt concentration in the context of root length. Shoot and root length severely affected by salt stress and as a consequence there was a drastic reduction observed for salt stress sensitive genotypes. It has been found that, under slat stress condition photosynthetic rate is reduced markedly, lost huge energy in salt removal mechanism, reduced transportation of compatible nutrient, arrested cell division and enlargement, decreased shoot length, for consequence there was a marked reduction of shoot and root length. Similar findings also reported by Moud and Maghsoudi [30], Datta *et al.* [17], Mujeeb *et al*. [31], Tarmatt and Munns [46] and Dager *et al*. [16].

Table 4. Effect of salinity level on root length of different wheat genotypes at different salt concentrations

Genotypes	Root length (mm) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	129.1 d	87.67 g-i	36.23 l	27.69 o	0.00 s
SATYN-15	120.5 ef	84.47 ij	42.41 ij	50.85 g	34.20 e
SATYN-21	119.6 f	90.40 f-h	65.87 e	58.71 e	27.33 g
SAYYN-17	113.1 gh	109.2 d	62.87 f	53.30 fg	41.84 d
SATYN-23	142.0 c	92.93 f	65.64 e	64.57 bc	28.96 f
ESWYT-5	164.2 a	152.1 a	109.3 a	69.79 a	64.80 a
SATYN-24	82.03 no	120.5 c	65.07 ef	63.37 bc	23.73 ijk
ESWYT-6	160.29 a	150.1 a	95.48 b	65.13 b	63.72 a
SATYN-3	115.7 fg	72.57 l	64.35 ef	28.09 no	29.42 f
SATYN-27	89.13 lm	82.89 j	24.83 o	31.60 lm	18.80 m
SATYN-12	13.32 p	7.83 rs	16.99 q	5.048 s	5.91 q
SATYN-6	114.8 fg	91.67 fg	44.07 i	51.00 g	43.67 c
SATYN-19	14.99 p	5.13 s	3.96 s	3.03 s	4.21 r
SATYN-16	120.4 ef	107.6 d	79.40 c	60.07 de	51.33 b
SATYN-25	121.1 gh	86.60 h-j	56.27 g	62.13 cd	0.00 s
WICYT-7	85.33 mn	25.07 o	13.27 r	32.80 kl	16.73 n
WICYT-9	130.8 d	14.33 p	21.27 p	30.20 mn	26.00 gh
WICYT-28	91.07 kl	9.83 qr	41.80 ijk	24.87 p	19.07 m
WICYT-35	95.00 jk	14.07 pq	29.67 n	43.30 i	25.07 hi
WICYT-41	105.5 i	32.27 n	23.27 op	33.73 kl	14.80 o
WICYT-15	116.4 fg	35.87 n	58.47 g	34.80 k	34.53 e
WICYT-20	112.5 gh	23.53 o	70.87 d	54.87 f	34.47 e
WICYT-25	113.3 gh	90.67 f-h	52.28 h	48.15 h	41.04 d
WICYT-26	107.7 hi	64.00 m	41.47 jk	18.10 q	9.096 p
SATYN-2	128.2 d	67.60 m	42.90 ij	19.65 q	22.93 jkl
SATYN-10	99.27 j	63.67 m	33.80 lm	40.60 j	24.20 ij
SATYN-14	126.7 d	74.00 kl	35.47 l	20.00 q	26.53 gh
SATYN-20	77.53 o	18.07 p	14.28 r	10.07 r	6.520 q
BARI GOM 25	91.13 kl	77.20 k	32.17 m	28.40 no	22.50 kl
BARI GOM 26	128.3 d	99.47 e	58.40 g	24.60 p	22.88 jkl
BARI GOM 27	125.3 de	82.40 j	39.53 k	26.07 op	22.08 l
BARI GOM 28	150.9 b	138.3 b	94.6 b	68.59 a	63.68 a
BARI GOM 29	138.3 c	94.56 f	25.15 o	20.33 q	6.420 q
$LSD_{(0.05)}$	5.66	4.45	2.50	2.46	1.54
CV (%)	4.18	4.96	4.27	5.27	4.81

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.4. Shoot Dry Weight

Salinity level had highly significant influence on shoot dry weight of different wheat genotypes (Table 5). ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes showed consistently slower reduction for shoot dry weight with the increasing of salinity levels. Maximum shoot dry weight was reported from ESWYT-5 genotypes followed by ESWYT-6 and BARI GOM 28 at all the NaCl concentrations whereas SATYN-22 and SATYN-12 wheat genotypes showed more sensitivity to salinity stress condition and produced lowest shoot dry weight. At 20 dSm^{-1} salt concentration, SATYN-22 and SATYN-12 wheat genotypes did not survive. Therefore, ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes showed promising performance against salinity stress condition in terms of shoot dry weight.

Table 5. Effect of salinity level on shoot dry weight of different wheat genotypes at different salt concentrations

Genotypes	Shoot dry weight (mg) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	6.42 p	5.44 q	3.65 t	2.54 o	0.00 w
SATYN-15	7.46 l-n	7.26 mn	6.49 o	3.76 m	3.11 rs
SATYN-21	7.89 k-m	7.42 lm	7.51 i-k	6.72 f	5.17 i-k
SAYYN-17	7.97 kl	7.55 lm	7.57 h-j	6.83 f	4.90 j-m
SATYN-23	7.55 lmn	6.64 op	4.92 rs	3.98 m	3.53 p-r
ESWYT-5	16.64 a	13.90 a	13.07 a	11.30 a	9.18 a
SATYN-24	6.60 op	5.31 qr	5.11 qr	6.78 f	6.50 de
ESWYT-6	15.73 b	13.25 b	12.46 b	10.46 b	8.53 b
SATYN-3	9.43 i	7.33 mn	5.28 qr	5.23 k	4.47 mn
SATYN-27	7.35 mn	6.74 o	6.53 o	5.56 ij	4.76 k-m
SATYN-12	6.03 p	3.12 t	3.62 t	2.62 o	2.28 uv
SATYN-6	7.70 lm	6.31 op	7.95 e-h	7.80 e	6.31 ef
SATYN-19	7.87 k-m	6.21 p	7.33 j-l	6.91 f	6.28 ef
SATYN-16	8.37 jk	8.13 jk	8.15 ef	6.71 f	4.81 j-m
SATYN-25	7.50 l-n	7.55 lm	6.78 m-o	5.71 hi	0.00 w
WICYT-7	13.47 ef	10.98 ef	8.30 e	8.12 d	6.93 cd
WICYT-9	11.85 gh	9.92 g	7.11 k-m	5.35 jk	2.62 tu
WICYT-28	11.46 h	3.81 s	3.43 t	3.15 n	3.37 q-s
WICYT-35	7.06 no	4.84 r	4.61 s	3.87 m	4.21 no
WICYT-41	9.03 i	7.93 kl	7.84 f-i	6.05 g	5.64 gh
WICYT-15	11.95 gh	9.21 h	6.67 no	6.92 f	5.25 h-j
WICYT-20	13.77 de	11.33 de	7.59 h-j	5.50 i-k	5.07 i-l
WICYT-25	14.96 c	12.23 c	7.08 l-n	5.94 gh	2.03 v
WICYT-26	12.92 f	11.61 d	7.37 j-l	6.75 f	5.89 fg
SATYN-2	15.09 c	8.82 hi	6.42 o	3.31 n	3.65 pq
SATYN-10	13.73 de	10.72 f	8.01 e-g	6.79 f	5.52 g-i
SATYN-14	14.25 d	11.52 d	8.79 d	6.71 f	5.14 i-k
SATYN-20	12.30 g	8.68 i	5.72 p	4.79 l	4.67 l-n
BARI GOM 25	13.62 e	8.93 hi	5.20 qr	3.11 n	2.97 st
BARI GOM 26	8.94 ij	6.83 no	5.13 qr	4.88 l	3.86 op
BARI GOM 27	11.48 h	8.56 ij	7.72 g-j	7.69 e	7.34 c
BARI GOM 28	15.48 bc	12.63 c	9.87 c	8.85 c	8.31 b
BARI GOM 29	12.31 g	9.76 g	5.49 pq	3.08 n	2.30 uv
$LSD_{(0.05)}$	0.61	0.52	0.41	0.31	0.46
CV (%)	4.53	4.86	4.72	4.24	7.89

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

Table 6. Effect of salinity level on root dry weight of different wheat genotypes at different salt concentrations

Genotypes	Root dry weight (mg) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	6.39 l	6.44 g	1.61 q	2.80 o	0.00 w
SATYN-15	4.30 r	5.62 j	3.49 m	4.61 g	5.63 f
SATYN-21	4.81 pq	4.95 lm	4.69 j	2.36 p	1.83 tu
SAYYN-17	5.16 op	6.75 f	4.88 ij	4.17 hi	2.77 n
SATYN-23	5.18 op	5.05 k-m	4.21 kl	4.37 h	2.55 op
ESWYT-5	16.16 a	13.65 a	11.71 a	10.45 a	8.59 a
SATYN-24	4.81 pq	5.67 j	5.35 gh	4.02 ij	4.13 i
ESWYT-6	15.37 b	13.70 a	11.60 a	10.09 b	8.48 a
SATYN-3	6.05 lm	4.43 o	3.99 l	4.11 ij	2.37 pq
SATYN-27	5.69 mn	5.77 ij	2.16 p	3.96 i-k	2.11 rs
SATYN-12	3.83 s	3.44 pq	3.10 no	3.57 l-n	5.88 de
SATYN-6	4.67 qr	3.74 p	4.86 ij	3.38 n	3.72 j
SATYN-19	2.64 t	1.58 s	1.55 q	1.16 t	1.15 v
SATYN-16	5.31 no	5.29 k	4.30 k	3.49 mn	3.36 lm
SATYN-25	4.67 qr	5.64 j	5.37 g	3.94 jk	3.52 kl
WICYT-7	3.53 s	2.02 r	5.84 f	2.07 q	0.00 w
WICYT-9	7.45 ij	4.19 o	3.59 m	5.14 f	6.05 cd
WICYT-28	8.79 g	4.49 no	5.97 f	5.71 e	6.07 c
WICYT-35	7.67 ij	5.25 kl	4.41 k	6.95 d	4.09 i
WICYT-41	11.07 e	8.82 b	6.79 d	7.95 c	6.27 b
WICYT-15	8.88 g	6.87 d-f	5.16 gh	5.63 e	5.29 g
WICYT-20	7.78 i	4.75 mn	5.07 hi	4.35 h	1.99 st
WICYT-25	11.85 d	6.85 ef	3.32 mn	2.34 p	1.99 st
WICYT-26	13.05 c	7.16 cd	7.33 c	3.77 kl	3.19 m
SATYN-2	9.68 f	6.10 h	6.35 e	3.62 lm	3.64 jk
SATYN-10	6.85 k	7.28 c	4.74 j	5.24 f	2.65 no
SATYN-14	8.31 h	7.09 c-e	3.03 o	3.02 o	2.51 op
SATYN-20	5.21 o	3.52 pq	2.11 p	1.82 r	1.20 v
BARI GOM 25	5.09 op	6.06 hi	4.20 kl	3.95 i-k	2.28 qr
BARI GOM 26	7.67 ij	6.59 fg	6.57 de	3.52 mn	4.88 h
BARI GOM 27	6.80 k	6.58 fg	3.59 m	1.32 st	1.77 u
BARI GOM 28	15.08 b	12.15 b	10.67 b	10.30 a	8.41 a
BARI GOM 29	7.37 j	3.43 q	1.92 p	1.46 s	1.17 v
LSD $_{(0.05)}$	0.39	0.30	0.28	0.22	0.19
CV (%)	4.2	4.35	4.64	4.17	4.31

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.5. Root Dry Weight

Root dry weight of wheat genotypes severely affected by different salt concentrations (Table 6) with some exceptions of ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes. Root dry weight ranged from 16.16, 13.65, 11.71 and 10.45 mg in ESWYT-5 to 2.64, 1.58, 1.55 and 1.16 mg in SATYN-19 wheat genotypes at 0, 5, 10 and 15 dSm^{-1} salinity levels, respectively were found. At 20 dSm^{-1} salt concentrations ESWYT-5, ESWYT-6 and BARI GOM 28 produced the maximum root dry weight (8.59, 8.49 and 8.41 mg, respectively) and 0.00 mg root dry weight was found for both SATYN-22 and SATYN-12 wheat genotypes. In criteria for screening salt tolerance wheat genotype ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes exhibited better tolerance against salt affected conditions irrespective of root dry weight. Dry weight is the consequence of plant physiological and biological activity. Under salt stress condition marked reduction was observed of this parameter Akbarimoghaddam *et al*. [3], Bhatti *et al*. [11] and Rumena [36]. It has been found that under stress condition photosynthetic rate is reduced markedly, spent huge energy in salt removal mechanism, reduced transportation of compatible nutrient, arrested cell division and enlargement, decreased shoot length, leaf number and ultimately reduction of plant growth and accumulation of dry matter is occurred Meiri and Poljakoff-Mayber [28], Long and Baker [27] and Seeman and Sharkey [39]. Cherian and

Reddy [13] found that salt level 7.50 dSm^{-1} quit detrimental for seedling, which results about 60% reduction of dry weight in *Suaeda nudiflora*. Decreasing of plant dry matter indicates the increasing of salinity level Sharma [41]. In this present piece of work, dry weight of seedling also adversely affected by salinity condition. The negative impact was varied among wheat genotypes which indicate different sensitivity of wheat genotypes to salt stress. Singh *et al.* [44]) and Moud and Maghsoudi [30] also found varied sensitivity of wheat genotypes on the basis of seedling growth in their research. Karim *et al.* [21] emphasizes that, seedling growth is one of the most important character for screening of salt tolerance at the early growth stage.

Table 7. Effect of salinity level on relative water content of different wheat genotypes at different salt concentrations

Genotypes	Relative water content (%) at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	85.30 c-f	87.86 ab	85.29 cd	65.48 h	0.00 s
SATYN-15	59.51 l	54.46 m	73.13 h-k	53.5 l	57.29 lm
SATYN-21	83.42 ef	75.40 gh	79.63 e-g	69.02 fg	69.17 fg
SAYYN-17	66.87 k	78.61 e-g	72.17 i-l	78.13 c-e	79.33 bc
SATYN-23	84.89 d-f	75.13 gh	69.66 k-n	53.90 l	64.11 h-j
ESWYT-5	89.80 a	90.60 a	92.54 a	83.48 a	87.39 a
SATYN-24	83.96 ef	80.00 d-f	71.16 j-m	76.52 de	62.22 i-k
ESWYT-6	89.55 ab	90.20 a	92.17 ab	82.21 ab	87.21 a
SATYN-3	72.14 ij	70.46 i	77.01 f-h	54.79 kl	53.92 m
SATYN-27	88.39 a-d	76.87 fg	55.09 r	61.12 i	60.75 j-l
SATYN-12	74.81 hj	81.69 de	73.36 h-k	67.69 f-h	68.92 fg
SATYN-6	78.91 gh	82.06 c-e	75.69 g-i	71.04 f	70.75 ef
SATYN-19	78.47 gh	76.89 fg	74.18 h-j	77.16 de	80.54 b
SATYN-16	76.22 hi	82.42 cd	80.03 ef	58.72 ij	65.53 g-i
SATYN-25	87.18 a-e	87.23 ab	85.88 cd	81.41 a-c	76.12 cd
WICYT-7	82.41 fg	65.16 j	40.03 u	60.08 ij	0.00 s
WICYT-9	86.59 a-f	61.48 k	63.57 op	61.56 i	61.92 i-k
WICYT-28	89.08 a-c	58.53 kl	38.21 u	29.28 o	43.62 p
WICYT-35	85.42 b-f	39.88 o	65.82 n-p	71.19 f	27.86 r
WICYT-41	85.31 c-f	24.96 p	61.70 pq	58.10 i-k	44.80 op
WICYT-15	71.91 j	60.01 k	46.53 st	74.96 e	66.38 gh
WICYT-20	72.23 ij	55.08 lm	87.99 bc	67.09 gh	78.56 bc
WICYT-25	78.73 gh	51.63 m	67.63 m-o	56.57 j-l	59.66 kl
WICYT-26	78.61 gh	58.61 kl	68.71 l-n	35.85 n	46.79 n-p
SATYN-2	72.31 ij	69.32 i	62.21 pq	37.06 n	47.46 no
SATYN-10	86.04 a-f	85.42 bc	50.09 s	54.96 kl	35.51 q
SATYN-14	86.34 a-f	71.05 i	58.75 qr	30.01 o	49.09 n
SATYN-20	42.44 m	44.18 n	44.81 t	46.99 m	35.45 q
BARI GOM 25	78.04 h	78.53 e-g	72.39 i-l	67.81 f-h	73.81 de
BARI GOM 26	78.78 gh	85.39 bc	82.93 de	81.57 ac	72.94 de
BARI GOM 27	76.32 hi	72.56 hi	71.56 i-m	78.91 b-d	74.59 d
BARI GOM 28	89.15 a-c	89.89 a	90.91 ab	81.96 ab	86.64 a
BARI GOM 29	72.94 ij	54.58 m	59.23 qr	67.77 f-h	66.37
LSD $_{(0.05)}$	4.18	3.64	4.24	3.51	3.69
CV (%)	4.22	4.14	4.88	4.42	5.08

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.6. Relative Water Content

Relative water content (RWC) could be the perfect most indicator of plant hydrologic condition as it denotes the physiological consequences of cellular water deficit. Water potential that possess the energy status of plant water which is effective for the transportation of water in the soil-plant-atmosphere chain. A wide range of statistical difference was observed for relative water content of wheat genotypes under different salt concentrations (Table 7). The relative water content ranged from 89.80, 90.60, 92.54 and 83.48% in ESWYT-5 to 42.44% in SATYN-20; 24.96% in WICYT-41; 38.21 and 29.28% in WICYT-28 were recorded at 0, 5, 10 and 15 dSm^{-1}, respectively. ESWYT-6 and BARI GOM 28 showed similar trend with ESWYT-5 in most of the salinity levels. At maximum salinity level (20 dSm^{-1}) relative water content ranged from 87.39% in ESWYT-5 to 0 % in SATYN-22 and WICYT-7, respectively were found. ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes exhibited much better performance against different salt concentrations for relative water content. Under salt stress condition tolerance plant can grow vigorously, minimize the salt uptake and maximize potential salt load per unit area by their compartmentalization technique and provide better water use efficiency thus plant growth not hampered Flower *et al.* [18]. Salt tolerance cultivar may be defined as the plant which has the capacity to grow under low water potential. In this point of view, high relative water content is one of tolerance technique to stress condition Sinclair and Ludlow [43]. Similar finding was reported by Sairam *et al.* [37] who reported that under salt stress condition, relative water content higher in salt tolerant cultivar than the sensitive one.

Table 8. Effect of salinity level on water saturation deficit of different wheat genotypes at different salt concentrations

Treatment	Water saturation deficit at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	14.70 kl	12.14 q	14.71 r	34.52 k	0.00 s
SATYN-15	40.49 b	45.54 e	26.87 lm	57.30 c	20.67 q
SATYN-21	16.58 hi	24.60 lm	20.37 p	30.98 lm	30.83 n
SAYYN-17	10.20 q	21.39 n	27.83 kl	21.87 o	42.71 g
SATYN-23	15.11 jk	24.87 l	30.34 ij	46.10 e	35.89 kl
ESWYT-5	10.20 q	9.40 r	7.46 t	16.52 q	12.61 r
SATYN-24	16.04 ij	20.00 n	28.84 jk	23.48 no	37.78 i-k
ESWYT-6	10.45 pq	9.80 r	7.83 t	17.79 q	12.79 r
SATYN-3	27.86 d	29.54 ij	22.99 o	45.21 ef	46.06 f
SATYN-27	11.61 op	23.13 m	44.91 d	53.01 d	39.25 hi
SATYN-12	10.45 pq	18.31 o	26.64 lm	32.31 kl	31.08 n
SATYN-6	21.09 g	17.94 o	24.31 no	28.96 m	29.25 n
SATYN-19	21.53 g	23.11 m	25.82 mn	22.84 no	19.46 q
SATYN-16	23.78 f	17.58 o	19.97 p	41.28 g-i	34.47 lm
SATYN-25	12.82 no	12.77 q	14.12 r	18.59 pq	23.88 p
WICYT-7	17.59 h	34.84 h	59.97 a	39.92 h-j	0.00 s
WICYT-9	13.41 mn	38.52 g	36.43 f	38.44 j	38.08 ij
WICYT-28	10.92 pq	56.32 c	61.72 a	70.72 a	56.38 c
WICYT-35	14.58 k-m	60.52 b	55.19 b	28.81 m	72.14 a
WICYT-41	14.69 kl	75.04 a	38.30 f	41.90 gh	55.20 cd
WICYT-15	28.09 d	39.99 fg	53.47 b	25.04 n	33.62 m
WICYT-20	33.13 c	44.92 e	12.01 s	32.91 kl	21.44 q
WICYT-25	25.19 e	55.82 c	32.37 gh	43.43 fg	40.34 h
WICYT-26	21.39 g	41.40 f	31.29 hi	64.15 b	53.21 de
SATYN-2	27.69 d	30.68 i	37.79 f	62.94 b	52.54 e
SATYN-10	13.96 k-n	14.58 p	49.91 c	45.04 ef	64.49 b
SATYN-14	13.66 l-n	28.95 jk	41.25 e	69.99 a	51.91 e
SATYN-20	57.56 a	48.37 d	34.19 g	38.88 ij	36.15 j-l
BARI GOM 25	21.96 g	21.47 n	27.61 k-m	32.19 kl	26.19 o
BARI GOM 26	21.22 g	9.804 r	17.07 q	18.43 q	27.06 o
BARI GOM 27	23.68 f	27.43 k	28.44 j-l	21.09 op	25.41 op
BARI GOM 28	10.85 pq	10.11 r	9.09 t	18.04 q	13.36 r
BARI GOM 29	27.06 d	45.42 e	40.77 e	32.23 kl	33.363 m
LSD $_{(0.05)}$	1.26	1.61	1.95	2.53	2.10
CV (%)	4.83	4.26	5.1	5.49	5.11

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.7. Water Saturation Deficit

The amount of water vapor needs to be increased in the air to attain a saturation point without disturbing the environmental condition (temperature and pressure) is called water saturation deficit. It is opposite to relative water content. Salinity level had highly significant influence on water saturation deficit among different wheat genotypes (Table 8). The result revealed that, water saturation deficit ranged from 57.56 in SATYN-20, 75.04 in WICYT-41, 61.72 and 70.72 in WICYT-28 to 10.20, 9.40, 7.46 and 16.52 in ESWYT-5 at 0, 5, 10 and 15 dSm^{-1}, respectively were observed. At 20 dSm^{-1} the maximum water saturation deficit 72.14 was observed in WICYT-35. SATYN-22 and WICYT-7 showed very much sensitivity to higher salt concentration (20 dSm^{-1}) and those were not survived. Therefore, ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes exerted better tolerance against salinity condition in case of water saturation deficit. Due to lack of compartmentalization technique, the salinity sensitive cultivars failed to uptake enough water necessary for running the physiological process smoothly under salt stress condition, thus there was a huge water deficit occurred in sensitive cultivars than the tolerance cultivars. Similar result was reported by Baque *et al*. [9].

Table 9. Effect of salinity level on water retention capacity of different wheat genotypes at different salt concentrations

Genotypes	Water retention capacity at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	8.62 p	8.772 q	12.35 bc	8.53 i-k	0.00 t
SATYN-15	12.19 ij	12.45 fg	11.28 de	9.69 f	6.85 pq
SATYN-21	9.70 no	13.13 de	10.73 e-g	7.94 kl	10.24 e-g
SAYYN-17	12.21 ij	11.68 hi	11.84 cd	8.99 g-i	7.81 no
SATYN-23	9.178 op	11.25 ij	9.634 jk	9.05 g-i	7.87 m-o
ESWYT-5	16.40 a	24.60 a	13.93 a	12.06 a	19.34 a
SATYN-24	10.59 m	12.54 e-g	10.61 f-h	8.02 kl	8.43 k-m
ESWYT-6	15.95 a	24.14 a	12.61 b	11.91 a	10.18 e-g
SATYN-3	10.88 lm	13.26 d	8.95 lm	10.34 e	9.06 ij
SATYN-27	10.16 mn	9.982 l-n	9.41 kl	9.25 f-h	6.46 q
SATYN-12	12.92 f-i	9.700 m-o	6.70 p	10.57 de	10.44 d-f
SATYN-6	10.69 lm	11.20 ij	9.58 jk	10.54 de	10.63 de
SATYN-19	10.54 m	10.26 k-m	10.65 f-h	10.78 c-e	7.82 no
SATYN-16	11.38 kl	11.16 ij	10.37 g-i	10.53 de	10.71 de
SATYN-25	12.61 g-i	13.06 d-f	10.09 h-j	8.21 j-l	9.55 hi
WICYT-7	13.09 d-g	9.04 o-q	6.45 pq	9.71 f	0.00 t
WICYT-9	12.25 h-j	17.73 c	5.04 s	7.72 l	8.16 l-n
WICYT-28	13.55 c-f	9.46 n-p	5.78 r	5.23 n	11.33 c
WICYT-35	9.444 no	11.01 ij	5.80 r	6.81 m	5.46 r
WICYT-41	13.76 cd	5.82 t	6.94 op	5.07 n	4.79 s
WICYT-15	13.43 c-f	7.022 r	8.26 n	6.83 m	7.36 op
WICYT-20	10.87 lm	6.338 st	8.54 mn	9.19 f-h	6.36 q
WICYT-25	10.84 lm	8.792 pq	5.96 qr	8.74 h-j	8.84 jk
WICYT-26	11.80 jk	12.26 gh	6.62 p	6.32 m	9.03 ij
SATYN-2	11.82 jk	11.22 ij	7.42 o	5.60 n	9.69 gh
SATYN-10	9.28 op	17.18 c	9.66 jk	6.862 m	8.73 j-l
SATYN-14	11.75 jk	6.80 rs	6.47 pq	8.76 h-j	8.27 k-n
SATYN-20	9.538 no	7.22 r	4.92 s	10.8 c-e	9.55 hi
BARI GOM 25	12.97 e-h	13.22 d	11.94 c	11.28 bc	9.68 gh
BARI GOM 26	14.15 bc	10.58 j-l	10.96 ef	9.58 fg	10.04 f-h
BARI GOM 27	12.66 g-i	12.11 gh	9.17 kl	10.99 b-d	10.82 cd
BARI GOM 28	14.87 b	21.23 b	12.11 bc	11.50 ab	15.78 b
BARI GOM 29	13.68 c-e	10.85 jk	10.03 ij	9.65 f	8.14 mn
$LSD_{(0.05)}$	0.75	0.68	0.58	0.60	0.58
CV (%)	5.07	4.69	5.05	5.36	5.47

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.8. Water Retention Capacity

The amount of water useful for crop hold by the crop plant is the water retention capacity. Different salt concentrations significantly influenced water retention capacity of wheat genotypes (Table 9). Highest water retention capacity ranged from 16.40, 24.60, 13.93, 12.06 19.34 in ESWYT-5 to 8.62 in SATYN-22, 5.82 in WICYT-41, 4.92 in SATYN-20, 5.07 in WICYT-41 and 0 in both SATYN-22 and WICYT-7 at 0, 5, 10, 15 and 20 dSm^{-1}, respectively were observed. The tolerance cultivars have the capacity to uptake water under salt stress condition than the sensitive ones and gained the maximum turgid weight, in consequence they gained the maximum water retention capacity. The result also coincides with the result of Sangakkara *et al.* [38].

Table 10. Effect of salinity level on coefficient of germination of different wheat genotypes at different salt concentrations

Genotypes	Coefficient of germination at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	15.89 a-h	14.33 jk	13.61 j	14.73 e-i	13.81 h-k
SATYN-15	15.76 a-i	14.84 g-jk	14.14 g-j	15.01 e-i	12.97 k
SATYN-21	16.04 a-f	15.43 d-i	14.58 d-j	15.57 b-e	13.45 i-k
SAYYN-17	15.35 d-k	15.02 f-j	14.06 h-j	14.43 g-j	14.14 f-i
SATYN-23	15.43 c-k	15.43 d-i	14.13 g-j	14.91 e-i	13.89 g-k
ESWYT-5	16.56 a	16.68 a	16.48 a	16.78 a	17.33 a
SATYN-24	15.26 f-k	15.00 f-k	15.09 c-g	14.76 e-i	14.27 e-i
ESWYT-6	16.53 a	16.63 ab	16.47 a	16.59 a	16.69 ab
SATYN-3	15.64 a-j	14.89 g-k	14.68 d-i	14.17 ij	13.88 g-k
SATYN-27	15.30 e-k	13.98 k	14.13 g-j	14.14 ij	14.59 e-h
SATYN-12	15.77 a-i	14.67 i-k	13.71 ij	14.82 e-i	14.46 e-h
SATYN-6	16.20 a-e	15.52 c-i	14.50 e-j	15.25 c-g	14.92 d-f
SATYN-19	16.07 a-f	14.88 g-k	14.39 f-j	14.37 g-j	14.63 e-h
SATYN-16	15.84 a-h	14.67 i-k	14.70 d-h	14.16 ij	14.18 f-i
SATYN-25	16.01 a-g	15.26 e-j	14.56 e-j	14.21 h-j	14.06 f-j
WICYT-7	16.11 a-f	16.26 a-e	14.74 d-h	14.63 f-i	14.02 f-j
WICYT-9	16.26 a-d	15.61 b-i	16.24 ab	14.63 f-i	16.51 ab
WICYT-28	16.06 a-f	14.90 g-k	16.29 ab	15.09 d-h	16.39 ab
WICYT-35	15.84 a-h	15.79 a-g	14.35 f-j	13.67 j	16.40 ab
WICYT-41	15.07 h-k	16.23 a-e	15.17 c-f	15.98 a-d	14.81 d-g
WICYT-15	16.14 a-f	16.43 a-d	16.22 ab	16.51 a	16.50 ab
WICYT-20	16.21 a-e	16.01 a-f	16.26 ab	16.58 a	16.08 bc
WICYT-25	15.31 e-k	15.00 f-k	15.95 a-c	16.37 ab	16.29 b
WICYT-26	15.47 b-j	15.70 a-h	15.92 a-c	15.99 a-d	15.24 c-e
SATYN-2	16.36 a-c	16.45 a-d	16.46 a	16.22 ab	16.13 bc
SATYN-10	15.85 a-h	16.00 a-f	16.17 ab	16.04 a-c	15.78 b-d
SATYN-14	15.58 b-j	15.40 e-i	15.55 a-d	15.51 b-f	16.09 bc
SATYN-20	15.59 b-j	15.26 e-j	15.43 b-e	16.02 a-c	14.27 e-i
BARI GOM 25	14.89 i-k	14.74 h-k	13.98 h-j	13.68 j	13.15 jk
BARI GOM 26	15.11 g-k	14.92 g-k	14.28 f-j	14.78 e-i	14.72 e-h
BARI GOM 27	14.77 jk	14.62 i-k	14.87 d-h	14.42 g-j	14.36 e-i
BARI GOM 28	16.40 ab	16.50 a-c	16.44 a	16.63 a	16.67 ab
BARI GOM 29	14.52 k	14.84 g-k	14.27 f-j	14.34 h-j	14.49 e-h
LSD $_{(0.05)}$	0.93	1.02	0.97	0.90	0.99
CV (%)	4.72	5.31	5.15	4.7	5.28

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.9. Coefficient of Germination

Salinity levels significantly influenced the coefficient of germination of wheat genotypes (Table 10). Maximum coefficient of germination ranged from 16.56, 16.68, 16.48 16.78 and 17.33 in ESWYT-5 to 14.52 in BARI GOM 29, 13.98 in SATYN-27, 13.61 in SATYN-22, 13.67 in WICYT-35 and 12.97 in SATYN-15 at 0, 5, 10, 15 and 20 dSm^{-1}, respectively were recorded. The reduction of germination rate with the increasing of salt concentration occurred for salt sensitive cultivars which caused reduction of coefficient of germination under salt stress condition. Similar results were reported by Akbarimoghaddam *et al.* [3], Datta *et al*. [17], Mujeeb-ur-Rahman *et al.* [31], Rahman *et al*. [34], Singh *et al*. [44] and Mirza and Mahmood [29].

Table 11. Effect of salinity level on vigor index of different wheat genotypes at different salt concentrations

Genotypes	Vigour index at different salt concentrations				
	0 dS m^{-1}	5 dS m^{-1}	10 dS m^{-1}	15 dS m^{-1}	20 dS m^{-1}
SATYN-22	213.7 ij	152.7 gh	39.11 rs	60.41 j	0.00 q
SATYN-15	251.0 b-d	170.7 e	73.32 jk	119.6 c	42.59 i
SATYN-21	223.2 g-i	195.7 d	141.3 d	103.4 e	46.09 h
SAYYN-17	191.8 m	137.1 i	81.85 i	61.02 j	24.69 o
SATYN-23	246.9 c-e	173.5 e	109.2 f	98.76 ef	32.39 kl
ESWYT-5	270.5 a	287.7 a	210.5 a	155.78 a	164.8 a
SATYN-24	179.7 n	195.0 d	124.1 e	113.1 d	82.13 d
ESWYT-6	270.7 a	252.6 b	205.57 a	152.7 a	162.89 a
SATYN-3	167.1 o	103.8 k	46.18 pq	28.62 pq	26.15 no
SATYN-27	163.6 o	133.5 i	39.40 rs	33.58 p	16.61 p
SATYN-12	107.5 q	85.51 lm	68.96 kl	47.17 no	33.35 jkl
SATYN-6	238.6 ef	175.1 e	97.68 gh	93.83 fg	28.37 mn
SATYN-19	127.1 p	115.6 j	77.83 ij	43.04 o	62.47 f
SATYN-16	222.4 hi	196.8 d	137.5 d	92.55 gh	71.54 e
SATYN-25	202.3 k-m	207.9 c	99.30 g	88.15 hi	0.00 q
WICYT-7	207.4 j-l	66.51 o	12.70 u	55.18 kl	14.33 p
WICYT-9	239.9 d-f	53.43 p	36.08 s	59.54 jk	46.87 h
WICYT-28	213.5 i-k	42.32 q	71.71 jk	50.39 l-n	27.87 no
WICYT-35	216.1 ij	23.40 st	47.49 op	86.35 i	36.47 j
WICYT-41	234.0 fg	91.82 l	58.93 mn	100.9 e	31.34 lm
WICYT-15	207.6 j-l	75.67 no	74.44 jk	52.59 lm	48.05 h
WICYT-20	231.5 f-h	47.51 pq	147.9 c	98.35 ef	53.62 g
WICYT-25	120.4 p	32.60 r	43.47 p-r	13.22 s	16.00 p
WICYT-26	240.6 d-f	147.1 h	63.33 lm	45.97 no	96.80 c
SATYN-2	248.8 c-e	161.1 fg	71.60 jk	22.76 r	24.51 o
SATYN-10	216.3 ij	169.2 ef	53.58 no	63.01 j	34.92 jk
SATYN-14	197.9 lm	131.2 i	48.19 op	16.64 s	27.77 no
SATYN-20	68.94 s	16.64 t	7.654 u	6.268 t	1.790 q
BARI GOM 25	91.00 r	81.09 mn	23.52 t	23.74 qr	15.60 p
BARI GOM 26	234.1 fg	189.6 d	92.54 h	48.75 mn	52.66 g
BARI GOM 27	258.0 bc	130.2 i	40.07 qrs	13.74 s	16.49 p
BARI GOM 28	262.0 ab	244.6 b	163.3 b	134.6 b	105.3 b
BARI GOM 29	95.81 r	32.16 rs	7.186 u	5.544 t	1.688 q
LSD $_{(0.05)}$	11.38	9.17	6.40	5.1	3.34
CV (%)	4.51	5.6	6.66	6.58	6.88

Values having same letter(s) do not differed significantly by least significant difference (LSD) at 5% level

3.10. Vigour Index

Salinity levels significantly affected vigour index among different wheat genotypes (table 11). The magnitude of reduction of vigour index was slow in case of ESWYT-5 followed by ESWYT-6 and BARI GOM 28*ie.*they hold a consistently decreasing trend but most of wheat genotypes exerted rapid reduction of vigour index with the increasing of salinity level. ESWYT-5 scored the maximum vigour index (287.70, 210.5, 155.78 and 164.80 at 5, 10, 15 and 20 dSm^{-1}, respectively) but at control ESWYT-6 scored the maximum vigour index (270.70) which showed similarity with ESWYT-5 and BARI GOM 28 at control. On the other hand the minimum vigour index were recorded from SATYN-20 (68.94, 16.64 at 0, 5 dSm^{-1}, respectively). BARI GOM 29 scored 7.19 and 5.54 vigour index at 10 and 15 dSm^{-1}, respectively. At 20 dSm^{-1} SATYN-22 and SATYN-25 wheat genotypes did not survive. Irrespective of vigour index, WICYT-7, SATYN-20 also showed sensitivity to salt stress condition. The higher vigour index attributed to higher germination rate and seedling length for salt tolerance cultivars. On the other hand the sensitive ones had the lower germination rate and seedling length, ultimately had a lower vigour index. Similar results were reported by Moud and Maghsoudi [30], Singh *et al*. [44] and Karim *et al*. [21].

4. Conclusions

Considering the above results obtaining from the present piece of work it may be concluded that among 33 wheat genotypes ESWYT-5, ESWYT-6 and BARI GOM 28 wheat genotypes were salt tolerance which were attributed to higher germination rate, shoot length, root length, shoot dry weight, root dry weight, relative water content, water retention capacity, coefficient of velocity and vigor index and rest of the wheat genotypes found to be moderately to strongly sensitive to salt stress.

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