

SCREENING OF BIG ONION VARIETIES FOR SODICITY TOLERANCE

Abstract

Sodicity is a major factor affects crop growth and productivity at global level. Out of 1.5 billion ha of cultivable land at global level, 23% are affected due to salinity and 37% by sodicity. Fourteen Big onion varieties were screened by employing germination test in an osmotic solution of Na_2CO_3 (Sodium bicarbonate). Simultaneously, all the varieties were allowed to germinate in distilled water (control). Three Replications of 20 seeds of each variety were counted and distributed over two layers of paper towel (21x21 cm) previously moistened with water equivalent to three times the dry weight of the paper and tied both ends with rubber band and kept in a plastic tray with different concentrations (0, 25mM, 50mM, 75mM, 100 M) of Na_2CO_3 . At the end of the 21st day, final germination percent, root length, shoot length, root dry weight, shoot weight, Relative water content and membrane stability index, were recorded in Na_2CO_3 solution as against the distilled water was calculated. The experiment was designed as a completely randomized design with two factors. As a result a decline in all onion growth paramers, with increasing sodicity stress has been recorded . Significant differences were observed between the varieties and different Na_2CO_3 concentrations. Irrespective of Na_2CO_3 concentrations, Bhima Safed recorded significantly maximum stress tolerant index compared to other varieties and minimum stress tolerant index value recorded bhima red variety. Hence result is Bhima safed variety tolerant variety to sodicity and Bhima red variety sensitive sodicity.

Keywords: Sodicity, Na_2CO_3 (Sodium bicarbonate), paper towel, relative water content.

Introduction

Sodicity is a major factor affects crop growth and productivity at global level. According to the estimates, about one third of the irrigated land on the earth is affected by salt stress. Out of 1.5 billion ha of cultivable land at global level, 23% are affected due to salinity and 37% by sodicity. Salinity is caused due to high accumulation of Ca, Mg as well as sodium and then anions such as SO_4 , NO_3 , CO_3 and HCO_3 , Cl, etc. and sodicity is due to high accumulation of sodium in the soil. The pH of sodic soil more than eight, ESP is more than 15 and EC is less than 4.

In Tamil Nadu 4.69 lakh ha area has been affected by different levels of salinity and sodicity. Tiruchirappalli is important district of Tamil Nadu have 11,165 ha of land affected by salinity and sodicity. In Tiruchirappalli district, Manikandam block are affected severely due to sodicity with an area of around 5000 acres.

Onion is one of the most important commercially grown vegetable crops in India. Two types of onion, *Allium cepa* var. *cepa* and *Allium cepa* var. *aggregatum* are under cultivation in india. *Allium cepa* var. *cepa* commonly referred as big onion or common onion. India is the second largest producer of onion after china with an annual production of 55 lakh tonnes in 5.3 lakh hectares. In Tamilnadu onion is cultivated in 28,000 hectares with a total production value of 3 lakh tonnes. Onion is an ancient crop that is believed to be originated in Central Asia, and has been under cultivation for over 5000 years. In addition onion is added as an important spice ingredient in foods, soups, salads and stews. It is rich in vitamin E and has a myriad of therapeutic properties including the prevention of age- dependent changes in the blood vessels, loss of appetite, treatment of bacterial infections such as dysentery, management of ulcers, wounds, scars, asthma and also as an adjuvant therapy for diabetes (WHO, 1999). Selenium level in onion was found to be $0.024 \mu\text{g g}^{-1}$, which plays important role in the health and immune system. Antioxidants in onion lowers oxidative stress suppress inflammation and enhance immunity. Sodium toxicity can be seen as necrosis of leaf tips and plant yellowing in onions .Sodicity cause onion tip burning symptom and affect the onion bulb formation.

Materials and Methods

The study was conducted at Horticultural College and Research Institute for Women (HC& RI (W)), Trichy during 2021. The method suggested by Arunkumar *et al.*, (2021) was followed to screen the big onion varieties against sodicity stress environment under laboratory conditions. Fourteen Big onion varieties were screened by employing germination test in an osmotic solution of Na_2CO_3 (Sodium bicarbonate). Simultaneously, all the varieties were allowed to germinate in distilled water (control). Three Replications of 20 seeds of each

variety were counted and distributed over two layers of paper towel (21x21 cm) previously moistened with sodic solution equivalent to three times the dry weight of the paper and tied both ends with rubber band and kept in a plastic bucket with different concentrations (0, 25mM, 50mM, mM, 100 M) of Na₂CO₃ (Sodium bicarbonate) and covered with polythene bag and placed at 25±1°C in an illuminated germinator.. Germination percentage was recorded 7 days after. At the end of the 21st day, final germination per cent, root length, shoot length, vigour index, stress tolerant index were recorded in Na₂CO₃ solution as against the distilled water was calculated. The experiment was designed as a completely randomized design with two factors. The first factor was the varieties and the second one is external sodicity stress. A seed was considered to be germinated when the emerging radicle elongated to 1 mm. Radicle length, hypocotyl length, seedling fresh weight and dry weight were calculated as described by Uniyale *et al.*, (1998). Observations were recorded on germination percentage, root length (cm), shoot length (cm), root dry weight (mg) and shoot dry weight (mg). Analysis of variance was carried out as described by Steel *et al.*, (1997). Statistical significance of means was tested by Randomised Block Design.

Table 1. Effect of different concentrations of Na₂CO₃ on germination percentage of big onion varieties.

Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
A. Krithiman	80.00	72.00	68.00	54.00	48.33	41.33	60.61

Bhimasafed	85.33	78.66	84.00	65.66	58.33	47.33	69.78
Bhimashweta	85.66	77.33	76.00	64.00	53.33	43.33	65.78
A. Kalyan	70.66	62.66	61.33	55.00	47.33	42.00	56.49
Bhimashakti	74.66	61.33	60.00	52.33	37.33	28.00	52.27
AFDR	76.00	65.33	61.33	51.33	36.00	32.66	53.77
Bhima Light red	69.33	64.00	60.00	50.66	36.00	32.66	52.10
Bhima Dark red	57.33	54.67	53.33	46.66	37.33	22.00	45.21
B. Kiran	73.33	64.00	62.00	50.00	39.00	32.00	53.39
A.Yojith	77.33	69.33	65.33	51.33	38.66	28.33	55.04
Bhima Super	68.00	65.33	61.33	51.33	37.66	25.33	51.50
Bhima Shubra	62.00	60.00	58.66	49.33	36.4	24.00	48.40
Bhima raj	60.00	58.00	55.00	43.33	35.33	23.00	45.77
Bhima Red	51.33	44.67	43.33	40.66	32.33	18.00	38.8
Mean	70.42	64.09	62.11	51.78	40.95	31.42	53.46

	SEd	CD(0.05)
Variety	0.43	0.85
Sodicity	0.28	0.55
Variety X Sodicity	1.05	2.08

Table 2. Effect of different concentrations of Na₂CO₃ on root length of big onion varieties

Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
A. Krithiman	5.70	5.47	5.00	4.80	3.97	1.13	4.35

Bhima safed	6.57	5.93	5.83	5.50	4.67	1.20	4.95
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Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
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Bhimashweta	5.80	5.73	5.63	4.87	3.10	1.17	4.38
A. Kalyan	5.10	5.03	4.67	4.00	3.70	0.77	3.88
Bhima shakti	4.33	4.03	3.90	3.67	3.30	0.88	3.35
AFDR	5.00	5.07	3.90	3.77	2.50	0.83	3.51
Bhima Light red	5.97	5.67	5.60	4.70	4.03	0.83	4.47
Bhima Dark red	4.07	3.33	2.80	2.57	1.50	0.60	2.48
B. Kiran	5.43	5.10	4.93	4.07	3.43	0.80	3.96
A.Yojith	4.97	5.20	4.73	4.57	4.20	0.73	4.07
Bhima Super	4.80	4.90	4.40	3.87	3.63	0.76	3.73
Bhima Shubra	4.34	3.54	3.00	2.54	1.86	0.70	3.06
Bhima raj	4.30	3.44	2.90	2.44	1.66	0.65	2.95
Bhima Red	4.00	3.11	2.60	2.37	1.30	0.50	2.31
Mean	4.00	3.11	2.60	2.37	1.30	0.50	3.62

	SEd	CD (0.05)
Variety	0.03	0.06
sodicity	0.02	0.03
Variety X sodicity	0.07	0.14

A. Krithiman	7.50	6.10	5.83	5.73	5.30	1.53	5.33
Bhima safed	9.00	9.03	8.67	8.43	6.80	3.23	7.53
Bhima shweta	7.10	7.10	6.90	6.57	5.30	2.40	5.90
A. Kalyan	6.90	6.83	6.87	6.33	5.80	2.47	5.87
Bhima shakti	7.00	6.67	6.00	5.33	4.23	1.87	5.18
AFDR	7.30	5.90	5.83	5.67	5.13	1.80	5.27
Bhima Light red	7.33	6.90	6.57	5.80	5.40	1.67	5.61
Bhima Dark red	5.80	5.77	5.43	4.93	4.00	2.30	4.71
B. Kiran	6.70	6.30	5.67	5.07	4.60	2.03	5.06
A.Yojith	7.30	5.93	5.83	5.67	5.03	0.40	5.03
Bhima Super	6.47	6.10	5.32	4.67	4.57	1.63	4.81
Bhima Shubra	7.50	5.70	5.83	5.73	5.30	1.53	4.63
Bhima raj	7.30	5.93	5.67	5.43	5.10	3.23	4.53
Bhima Red	7.10	5.37	5.10	4.37	4.10	2.40	4.30
Mean	7.21	6.72	6.45	6.07	5.25	2.04	5.62

	SEd	CD(0.05)
Variety	0.04	0.09
sodicity	0.03	0.06
Variety X sodicity	0.11	0.23

Table 3. Effect of different concentrations of Na₂CO₃ shoot length of big onion varieties

Table 4. Effect of different concentrations of Na₂CO₃ vigour index of big onion varieties

Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
A. Krithiman	1056	833	736	569	448	110	625
Bhima safed	1329	1177	1218	915	669	210	920
Bhima shweta	1041	992	952	732	448	155	720
A. Kalyan	848	743	708	568	450	136	576
Bhima shakti	846	656	594	471	281	77	488
AFDR	935	717	597	485	275	86	516
Bhima Light red	922	804	730	532	339	82	568
Bhima Dark red	566	497	439	350	205	64	354
B. Kiran	889	730	657	457	313	91	523
A. Yojith	949	772	690	526	357	32	554
Bhima Super	766	719	593	438	309	61	481
Bhima Shubra	734	554	518	408	261	54	422
Bhima raj	696	543	471	341	239	89	397
Bhima Red	570	379	334	274	175	52	297
Mean	868	723	660	505	341	93	531

	SEd	CD(0.05)
Variety	18.0	35.65
sodicity	11.82	23.34
Variety X Sodicity	44.23	87.33

Table 5. Effect of different concentrations of Na₂CO₃ stress tolerance index of big onion varieties

	SEd	CD(0.05)
Variety	0.46	0.92
sodicity	0.30	0.60
Variety X sodicity	1.15	2.27

Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
A. Krithiman	85.0	76.4	72.1	70.7	69.1	66.9	73.37
Bhima safed	86.5	79.4	75.5	72.4	70.5	68.0	75.38
Bhima shweta	84.3	78.3	73.1	70.0	69.8	65.2	73.45
A. Kalyan	83.4	76.4	71.7	66.5	62.6	61.0	70.27
Bhima shakti	81.8	75.5	70.9	66.5	65.4	59.6	69.95
AFDR	82.11	77.5	72.1	69.3	68.4	60.3	71.62
Bhima Light red	83.3	70.3	66.4	65.5	59.3	59.4	67.37
Bhima Dark red	83.5	75.7	61.5	58.2	56.3	54.6	64.97
B. Kiran	83.3	78.9	73.4	70.2	69.1	60.9	72.63
A. Yojith	84.8	76.7	63.8	60.9	58.3	56.0	66.75
Bhima Super	82.0	76.5	71.9	67.5	66.4	59.8	70.68
Bhima Shubra	83.0	78.3	63.1	60.9	60.1	59.0	67.40
Bhima raj	84.0	76.7	63.5	60.2	57.3	55.6	66.22
Bhima Red	84.5	74.3	60.3	56.4	55.4	52.7	63.93
Mean	83.68	76.49	68.52	65.37	63.43	59.93	69.57

Table 6. Effect of different concentrations of Na₂CO₃ Relative water content of big

Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
A. Krithiman	85.0	76.4	72.1	70.7	69.1	66.9	73.37
Bhima safed	86.5	79.4	75.5	72.4	70.5	68.0	75.38

onion varieties (10 seedlings

Bhimashweta	84.3	78.3	73.1	70.0	69.8	65.2	73.45
A. Kalyan	81.8	76.4	71.7	66.5	62.6	61.0	70.27
Bhima shakti	81.8	75.5	70.9	66.5	65.4	59.6	69.95
AFDR	82.1	77.5	72.1	69.3	68.4	60.3	71.62
Bhima Light red	83.3	70.3	66.4	65.5	59.3	59.4	67.37
Bhima Dark red	83.5	75.7	61.5	58.2	56.3	54.6	64.97
B. Kiran	83.3	78.9	73.4	70.2	69.1	60.9	72.63
A.Yojith	84.8	76.7	63.8	60.9	58.3	56.0	66.75
Bhima Super	82.0	76.5	71.9	67.5	66.4	59.8	70.68
Bhima Shubra	83.0	78.3	63.1	60.9	60.1	59.0	67.40
Bhima raj	84.0	76.7	63.5	60.2	57.3	55.6	66.93
Bhima Red	84.5	74.3	60.3	56.4	55.4	52.7	63.93
Mean	83.68	76.49	68.52	65.37	63.43	59.93	69.57

	SEd	CD(0.05)
Variety	0.26	0.51
sodicity	0.22	0.49
Variety X sodicity	0.72	1.32

Table7. Effect of different concentrations of Na₂CO₃ Membrane stability index of big onion varieties (10 seedlings)

Varieties	0mM	10 mM	20mM	30 mM	40mM	50mM	Mean
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UNDER PEER REVIEW

A. Krithiman	71.1	68.8	65.0	64.1	61.9	56.4	64.55
Bhima safed	74.2	70.5	67.2	65.0	63.0	58.2	66.35
Bhimashweta	73.5	68.3	65.9	64.8	60.2	55.0	64.62
A. Kalyan	71.7	66.2	61.4	57.6	56.4	50.4	60.62
Bhima shakti	70.7	65.9	61.2	60.4	54.8	48.3	60.22
AFDR	72.3	67.8	64.1	63.4	55.3	49.1	62.00
Bhima Light red	65.3	61.1	60.9	54.0	54.4	48.9	57.43
Bhima Dark red	70.9	56.9	53.5	52.0	49.6	45.2	54.68
B. Kiran	73.8	68.2	65.8	65.8	56.7	51.2	63.58
A.Yojith	71.1	58.9	55.3	53.3	51.0	45.3	55.82
Bhima Super	71.4	66.4	62.8	61.4	55.3	50.6	61.32
Bhima Shubra	73.5	58.2	55.7	55.5	54.0	48.6	57.58
Bhima raj	71.8	58.6	55.2	52.3	50.6	44.5	55.50
Bhima Red	69.4	55.2	51.8	51.4	47.7	41.3	52.80
Mean	71.48	63.64	60.41	58.64	55.06	49.50	59.9

	SEd	CD (0.05)
Variety	0.21	0.46
sodicity	0.27	0.37
Variety X sodicity	0.76	1.20

Result & Discussion

The analysis of variance showed significant differences among the genotypes and treatments (Table 1). Significant differences were observed under different Na_2CO_3 concentrations of 0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50mM.

Germination Percentage

A decline in seed germination percentage with increasing stress has been recorded (Table 1). Significant differences were observed for germination percentage between the varieties and different Na_2CO_3 concentrations. Irrespective of Na_2CO_3 concentrations, Bhima Safed recorded significantly maximum germination percentage (85.33%) compared to other varieties. Germination percentage was lowest in Bhima Red variety (18%). At all concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) of Na_2CO_3 , Bhima Safed variety recorded significantly maximum germination percentage compared to other varieties and the same trend maintained in all concentrations of Na_2CO_3 , Bhima red exhibited minimum germination percentage compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhimasafed variety exhibited maximum (47.33%) and Bhima Red variety exhibited minimum (18%) values.

It was observed that germination percentage with decreasing water potential of the environment probably was triggered by the low hydraulic conductivity where, Na_2CO_3 makes water unavailable to seeds, affecting the imbibition process of the seed which is fundamental for germination. Results of the current study were in agreement with findings of El-Saifi *et al.*, (2010), Souguiret *et al.*, (2013), Ravi *et al.*, (2011) and Alejandra *et al.*, (2010).

Root length

Root length is an important trait against Sodicity stress in plant varieties, with longer root growth has resistant ability for salt. Sodicity stress cause drought stress, while that condition Early and rapid elongation of roots is an important indication of tolerance. Ability of continued elongation of root under water stress and longer root length at deeper layer are useful in extracting water in upland conditions (Kim *et al.*, 2001, Narayan, 1991). The high Na^+ as a result, water deficiency occurs around the root system of plants (Qadir *et al.*, 2007). The plant embryo grows at germination and progresses radicles that become the primary roots and penetrate down into the soil. After radicle emergence, hypocotyl emerges and lifts the growing tip above the ground. Under drought stress condition, the root develops faster

than the hypocotyls to acclimatize the drought stress. Therefore, the growth of radical and hypocotyls should reflect the adaptability of plant to drought stress (Zhu *et al.*, 2006).

A decline in seedling root length with increasing sodicity stress has been recorded (Table 2). Significant differences were observed for root length between the varieties and different Na_2CO_3 concentrations. Irrespective of Na_2CO_3 concentrations, Bhima Safed recorded significantly maximum root length (6.57cm) compared to other varieties. Root length was lowest in Bhima Red variety (0.5cm). At all concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) of Na_2CO_3 , Bhima Safed variety recorded significantly maximum root length compared to other varieties and the same trend maintained in all concentrations of Na_2CO_3 , Bhima red exhibited minimum root length compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhimasafed variety exhibited maximum (1.2 cm) and Bhima Red variety exhibited minimum (0.5 cm) root length values.

Shoot length

The impact of sodicity stresses on Shoot length of 14 big onion varieties screened through laboratory experiment was assessed. In terms of Shoot length of 14 big onion varieties exhibited significant variations in response to different sodicity levels (Table 3). Among 14 big onion varieties Bhima Safed variety recorded significantly maximum Plant height compared to other varieties in different concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) of Na_2CO_3 and the same trend maintained in all concentrations of Na_2CO_3 . Bhima red variety exhibited minimum Shoot length compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhima safed variety exhibited maximum (1.23 cm) and Bhima Red variety exhibited minimum (0.5 cm) shoot length value.

Vigour Index

Different levels of sodicity also caused adverse effects at various intensities on vigour index of big onion seedlings (Table 4). Among 14 big onion varieties Bhima Safed variety recorded significantly maximum vigour index compared to other varieties in different concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) of Na_2CO_3 and the same trend maintained in all concentrations of Na_2CO_3 , Bhima red variety exhibited minimum vigour index compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhima safed variety exhibited maximum (210) and Bhima Red variety exhibited minimum (52) vigour index value.

Stress tolerant index

Different levels of sodicity also caused adverse effects at various intensities on vigour index of big onion seedlings (Table 5). Among 14 big onion varieties Bhima Safed variety recorded significantly maximum stress tolerant index compared to other varieties in different concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) of Na_2CO_3 and the same trend maintained in all concentrations of Na_2CO_3 , Bhima red variety exhibited minimum vigour index compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhima safed variety exhibited maximum (68 %) and Bhima Red variety exhibited minimum (52.7 %) stress tolerant index value.

Relative water content

The revealed significant difference in Relative water content between the big onion varieties and different different Na_2CO_3 concentrations (Table 6). Irrespective of Na_2CO_3 concentrations, Bhima Safed recorded significantly maximum Relative water content (86.5%) compared to other varieties. Relative water content was lowest in Bhima Red variety (52.7 %). At different sodicity concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM of Na_2CO_3), Bhima Safed variety recorded significantly maximum Relative water content compared to other varieties and the same trend maintained in all concentrations of Na_2CO_3 . Bhima red exhibited minimum relative water content compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhima safed variety exhibited maximum (68%) and Bhima Red variety exhibited minimum (52.7 %) Relative water content value. The high Na^+ as a result, water deficiency occurs around the root system of plants (Qadir et al., 2007).

Under such forced water deficiency environment, leaf relative water content reduced. (Marschner, 1995) and allow to retain the excess amount of water to regulate the desired rate of metabolism during the spell of draught stress (desiccation period) around the roots as well in leaf tissues (Delatorre et al., 2010).

Membrane stability index

The impact of sodicity stresses on seedling dry weight of 14 big onion varieties screened through laboratory experiment was assessed. In terms of membrane stability index of 14 big onion varieties exhibited significant variations in response to different sodicity levels (Table 7). Among 14 big onion varieties Bhima Safed variety recorded significantly

maximum membrane stability index compared to other varieties in different concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) of Na_2CO_3 and the same trend maintained in all concentrations of Na_2CO_3 . Bhima red variety exhibited minimum membrane stability index compared to other varieties. At maximum sodicity concentration 50 mM Na_2CO_3 the variety Bhimasafed variety exhibited maximum (58.2) and Bhima Red variety exhibited minimum (52.3) seedling dry weight value.

Conclusion.

The impact of sodicity stresses on 14 big onion varieties screened through laboratory experiment was assessed. As a result a decline in all onion growth parameters, germination per cent, root length, shoot length, root dry weight, shoot weight, Relative water content and membrane stability index with increasing sodicity stress has been recorded. Significant differences were observed between the varieties and different Na_2CO_3 concentrations. Irrespective of Na_2CO_3 concentrations, Bhima Safed recorded significantly maximum value in all growth parameters compared to other varieties and minimum value recorded bhima red variety. Hence result is Bhima safed variety tolerant variety to sodicity and Bhima red variety sensitive sodicity.

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