SCREENING OF AGGREGATUM ONION VARIETIES FOR SODICITY TOLERANCE

Abstract

Sodicity is a major factor affects crop growth and productivity at global level. In the global cultivable land at global level, 23% is affected by salinity and 37% land by sodicity. Two seed propagating aggregatum onion varieties (CO 5, CO 6) and two bulb propagating aggregatum onion varieties (Permbalur local, thuraiyur local) were screened by employing germination test in an osmatic solution of $NaHCO_3$ (Sodium bicorbanate). Two varieties (CO 5, CO 6) are seeds 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, 10mM, 20mM, 30 mM, 40 mM, 50 mM) of $NaHCO_3$ (sodium bicorbanate). Also another bulb propagated varieties, perambalur and thuraiyur local varieties bulb directly sown in beaker have 1.5 kg sand. Control beaker irrigated with water and another beaker irrigated with sodic solution. Germination percentage was recorded 7 days after. At the end of the 21 th day, in four aggregatum onion varieties where final germination per cent, germination rate, root length, shoot length, root dry weight, shoot weight, vigour index, stress tolerant index, Relative water content and membrane stability index, were recorded in NaHCO3 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 $NaHCO_3$ concentrations. Irrespective of $NaHCO_3$ concentrations two seed propagating aggregatum onion varieties, CO 6 recorded significantly maximum stress tolerant index compare with CO 5 and two bulb propagating aggregatum onion varieties, Thuraiyur local variety recorded significantly maximum vigour index compare with Perambalur local in all sodicity concentation. Based on stress tolerant index, CO 6 and thuraiyur local variety tolerant to sodicity stress and CO 5, perambalur local variety suceptible to sodicity stress.

Keywords: Sodicity, $NaHCO_3$ (sodium bicorbanate), perambalur local, thuraiyur local, relative water content.

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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" (Tomaz *et al*.,2020). 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. Aggregatum onion (*Allium cepa var. aggregatum*) also known as multiplier onions or small onion, most important commercial vegetable crops grown in Southern India and Tamil Nadu. Aggregatum onion is sensitive to sodicity stress during its earlier growth stages and its later growth stages. When aggregatum onion is to long term sodic stress, yield is drastically reduced due to premature senescence of leaves. Screening and identification of aggregatum onion varieties staring sodicity tolerance will decrease the economic loss caused by sodicity

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 µg 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

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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 Kumar, P.A *et al.*, (2021) was followed to screen the aggregatum onion varieties against sodicity stress environment under laboratory condition. Two seed propagating aggregatum onion varieties (CO 5, CO 6) and two bulb propagating aggregatum onion varieties (Permbalur local, thuraiyur local) were screened by employing germination test in an osmatic solution of $NaHCO_3$ (Sodium bicorbanate). Two varieties (CO 5, CO 6) are seeds 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, 10mM, 20mM, 30mM, 40mM, 50mM) of Na_2HCO_3 (Sodium bicorbanate). Also another bulb propagated varieties, perambalur and thuraiyur local varieties bulb directly sown in beaker have 1.5 kg sand. Control beaker irrigated with water and another beaker irrigated with different concentrations (0, 10mM, 20mM, 30mM, 40mM, 50mM) of sodic solution. Germination percentage was recorded 7 days after. At the end of the 21 th day, in four aggregatum onion varieties where final germination per cent, root length, shoot length, vigour index, stress tolerant index, Relative water content and membrane stability index, were recorded in $NaHCO_3$ solution as against the distilled water was calculated.

Vigour index

The vigour index of the seedlings are calculated using the following formula proposed by Abdul-Baki and Anderson (1973) and expressed as per cent

Vigour Index = (Shoot length + Root length) x Germination percentage

Stress tolerance index

Stress tolerance index was calculated using the following formula proposed by Dhopte and Livera (1989) and expressed as per cent.

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$$\text{Stress tolerance index} = \frac{\text{Vigour index of the treated seedling}}{\text{Vigour index of the control seedling}} \times 100$$

Membrane stability index

The Membrane stability index was estimated according to Sullivan (1960). This experiment was carried out to determine the extent of membrane damage in tissues subjected to sodicity stress. In membrane stability index, the total inorganic ions (mainly K+) leaked out, is measured in terms of electrical conductivity (EC) of the bathing medium before and after the treatment, using a conductivity bridge. Leaf discs (about 20) of the test sample where taken in a test tube 10 ml of deionised water. The test tubes are covered and subjected to two high temperature regimes (450C and 550 C) for 30 minutes, usually in a water bath. In practice, an initial EC, just before transfer to the high temperature treatment is taken. The EC determined is recorded (Eca). After 30 minutes, the EC is again measured (Ecb). After this the tubes are boiled at 1000 C for 10 minutes and the EC again recorded (Ecc)

$$\text{Percent leakage} = \frac{\text{Ecb} - \text{Eca}}{\text{Ecc}} \times 100$$

Relative Water Content

The relative Water Content (RWC) was estimated according to Barrs and Weatherly (1962) and calculated by using following formula and expressed as per cent.

RWC = [(Fresh weight – Dry weight) / (Turgid weight – Dry weight)] x 100

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 and hypocotyl length were calculated as described by Uniyal *et al*., (1998). Analysis of variance was carried out as described by Steel *et al*., (1997). Statistical significance of means was tested by Completely Randomised Design

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Result & Discussion

The analysis of variance showed significant differences among the genotypes and treatments. Significant differences were observed under different $NaHCO_3$ concentrations of 0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50mM.

Table 1.a. Effect of different concentrations of $NaHCO_3$ on germination percentage of aggregatum onion seedlings.

Variety	Control	10 mM	20 mM	30 mM	40 mM	50 mM	Mean
Co 5	94.0	86.6	78.00	71.6	59.6	49.3	**73.1**
C0 6	96.0	90.3*	88.2*	84.3*	77.0*	65.6*	**83.2***
Mean	**95.0**	**88.4**	**83.1**	**77.9**	**68.3**	**57.4**	**78.2**

	SEd	CD(0.05)
V	0.72	1.48
S	1.24	2.57
VS	1.76	3.64

Table 1.b. Effect of different concentrations of $NaHCO_3$ on germination percentage of aggregatum onion bulb

Variety	Control	10 mM	20 mM	30 mM	40 mM	50 mM	Mean
Perambalur local	100	90.6	79.6	70.3	59.6	48.4	74.7
Thuraiyur local	100	94.6*	86.3*	78.3*	72.6*	58.4*	81.6*
Mean	100	92.6	82.9	74.3	66.1	53.4	78.2

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	SEd	CD(0.05)
V	0.82	1.69
S	1.42	2.93
VS	2.01	4.15

Germination percentage

The impact of sodicity stresses on germination percentage of four aggregatum onion varieties screened through laboratory experiment was assessed. A decline in seed germination percentage with increasing sodicity stress has been recorded (Table 1). Among two seed propagating aggregatum onion varieties, CO 6 recorded significantly maximum vigour index compared with CO 5 and two bulb propagating aggregatum onion varieties, thuraiyur local variety recorded significantly maximum vigour index compared with Perambalur local in all sodicity concentation (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) .At maximum sodicity concentration 50 mM ($NaHCO_3$), the varieties CO 6 and thuraiyur local variety exhibited maximum (65.6%, 58.4%) germination percentage and CO 5 and perambalur local variety exbited minimum (49.3%, 48.4%) germination percentage values. It was observed that germination percentage with decreasing water potential of the environment probably was triggered by the low hydraulic conductivity where, $NaHCO_3$ 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), Souguir *et al*., (2013), Ravi *et al*., (2011) and Alejandra *et al.*, (2010).

Table 2.a. Effect of different concentrations of $NaHCO_3$ on root length (cm) of aggregatum onion seedlings.

Variety	Control	10 mM	20 mM	30 mM	40 mM	50 mM	Mean
Co 5	5.00	4.89*	4.52	3.85	3.32	3.12	4.08
C0 6	5.11*	4.90*	4.83*	4.44*	4.03*	3.53*	4.46*
Mean	**5.06**	**4.89**	**4.68**	**4.14**	**3.67**	**3.32**	**4.27**

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	SEd	CD(0.05)
V	0.03	0.07
S	0.06	0.13
VS	0.09	0.19

Table 2.b. Effect of different concentrations of $NaHCO_3$ on root length (cm) of aggregatum onion bulb.

Variety	Control	10mM	20mM	30mM	40mM	50 mM	
Perambalur local	8.30	7.80	5.15	2.95	1.50	0.40	**4.35**
Thuraiyur local	10.00*	9.00*	8.60*	4.03*	2.60*	0.93*	**5.86***
Mean	**9.15**	**8.40**	**6.87**	**3.49**	**2.05**	**0.65**	**5.10**

	SEd	CD(0.05)
V	0.04	0.09
S	0.08	0.016
VS	0.11	0.23

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). Who 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 climatize the drought stress. Therefore, the growth of radical and hypocotyls should reflect the adapt ability 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 $NaHCO_3$ concentrations. Among two seed propagating aggregatum onion varieties, CO 6 recorded significantly maximum membrane stability index compared with CO 5 and

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two bulb propagating aggregatum onion varieties , Thuraiyur local recorded significantly maximum membrane stability index compared with Perambalur local in all sodicity concentation (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM). At maximum sodicity concentration 50 mM ($NaHCO_3$), the varieties CO 6 and Thuraiyur local variety exhibited maximum (3.53 cm, 0.93 cm) root length and CO 5 and perambalur local variety exbited minimum (3.12 cm, 0.40 cm) root length values.

Table 3.a. Effect of different concentrations of NaHCO3 on shoot length (cm) of aggregatum onion seedlings

Variety	**Control**	**10 mM**	**20 mM**	**30 mM**	**40 mM**	**50 mM**	**Mean**
Co 5	6.8	6.5	6.3	5.9	5.5	5.0	**5.9**
C0 6	7.0*	6.8*	6.6*	6.4*	6.1*	5.9*	**6.4***
Mean	**6.8**	**6.6**	**6.4**	**6.1**	**5.7**	**5.4**	**6.2**

	SEd	**CD(0.05)**
V	0.04	0.09
S	0.07	0.15
VS	0.10	0.22

Table 3.b. Effect of different concentrations of $NaHCO_3$ on shoot length (cm) of aggregatum onion bulb.

Variety	Control	10mM	20mM	30mM	40mM	50 mM	**Mean**
Perambalur local	21.7	19.6	16.4	12.9	7.1	2.3	**13.3**
Thuraiyur local	24.2*	22.0*	19.1*	14.6*	9.2*	4.2*	**15.5**
Mean	**22.9**	**20.8**	**17.7**	**13.7**	**8.1**	**3.2**	**14.4**

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	SED	CD(0.05)
V	0.11	0.24
S	0.20	0.42
VS	**0.28**	**0.59**

Shoot length

The revealed significant difference in shoot length between the aggregatum onion varieties and different $NaHCO_3$ concentrations (Table 3). At different sodicity concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM of $NaHCO_3$), CO 6 and thuraiyur local variety recorded significantly maximum shoot length value and CO 5 and Perambalur local variety recorded minimum shoot length value. At maximum sodicity concentration 50 mM ($NaHCO_3$), the varieties CO 6 and thuraiyur local variety exhibited maximum (5.9 cm, 4.2 cm) shoot length and CO 5 and perambalur local variety exbited minimum (5.0 cm, 2.3 cm) shoot length values.

Table 4.a. Effect of different concentrations of $NaHCO_3$ on Vigour Index of aggregatum onion bulb.

Variety	**Control**	**10mM**	**20mM**	**30mM**	**40mM**	**50 mM**	**Mean**
CO 5	1109	978	842	694	524	399	757.6
CO 6	1137	1056*	1005*	910*	777*	616*	916.8*
Mean	**1123**	**1016**	**923**	**802**	**650**	**507**	**837**

	SED	CD(0.05)
V	7.34	15.16
S	12.72	26.26
VS	17.9	37.14

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Table 4.b. Effect of different concentrations of $NaHCO_3$ on Vigour Index of aggregatum onion bulb.

Variety	Control	10mM	20mM	30mM	40mM	50 mM	Control
Perambalur local	3000	2482	1715	1114	512	130	1492
Thuraiyur local	3420*	2932*	2390*	1464*	856*	299*	1839*
Mean	**3210**	**2706**	**2052**	**1289**	**684**	**214.5**	**1692**

	SED	CD(0.05)
V	19.1	39.5
S	33.1	68.4
VS	46.9	96.8

Vigour index

The impact of sodicity stresses on vigour index of four aggregatum onion varieties screened through laboratory experiment was assessed. In terms of vigour index of four aggregatum onion varieties exhibited significant variations in response to different sodicity levels (Table 5). Among two seed propagating aggregatum onion varieties, CO 6 recorded significantly maximum vigour index compared with CO 5 and two bulb propagating aggregatum onion varieties, Thuraiyur local variety recorded significantly maximum vigour index compared with perambalur local in all sodicity concentation (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) . At maximum sodicity concentration 50 mM ($NaHCO_3$), the varieties CO 6 and Thuraiyur local variety exhibited maximum (616, 299) vigour index and CO 5 and perambalur local variety exbited minimum (399, 130) vigour index values.

Table 5.a. Effect of different concentrations of $NaHCO_3$ on stress tolerant index of aggregatum onion bulb.

Variety	Control	10mM	20mM	30mM	40mM	50 mM	Control
CO 5	100	88.1	75.9	62.5	47.0	35.9	68.2
CO 6	100	92.8*	88.3*	80.0*	68.3*	54.1*	80.5*
Mean	**100**	**90.4**	**82.0**	**71.2**	**57.6**	**44.9**	**74.4**

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	SED	CD(0.05)
V	0.49	1.01
S	0.85	1.75
VS	1.20	2.48

Table 5.b. Effect of different concentrations of $NaHCO_3$ on stress tolerant index of aggregatum onion bulb.

Variety	Control	10mM	20mM	30mM	40mM	50 mM	Meanl
Perambalur local	100	82.7	57.1	37.1	17.0	4.3	49.7
Thuraiyur local	100	85.7*	69.8*	42.8*	25.0*	8.7*	55.3*
Mean	100	84.2	63.4	39.9	20.9	6.5	52.5

	SED	CD(0.05)
V	0.47	0.97
S	0.81	1.68
VS	1.15	2.37

Stress tolerant index

Different levels of sodicity also cause adverse effects at intensities of vigour index of four small onion varieties. sThe revealed significant difference between the aggregatum onion varieties and different different $NaHCO_3$ concentrations (Table 5). At different sodicity concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM of $NaHCO_3$), CO 6 and Thuraiyur local variety recorded significantly maximum stress tolerant index and CO 5 and perambalur local variety recorded minimum stress tolerant index. At maximum sodicity concentration 50 mM ($NaHCO_3$), the varieties CO 6 and thuraiyur local variety exhibited maximum (54.1%, 8.7%) stress tolerant index and CO 5 and perambalur local variety exbited minimum (35.9%, 4.3%) stress tolerant index values.

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Table 6.a Effect of different concentrations of $NaHCO_3$ Relative water content (%) of aggregatum onion seedlings

Variety	Control	10 mM	20 mM	30 mM	40 mM	50 mM	Mean
Co 5	81.0	79.0	66.0	63.0	58.0	55.0	**66.9**
C0 6	84.0	80.0	77.0	71.0	60.0	58.0*	**71.6***
Mean	**82.5**	**79.5**	**71.5***	**67.0***	**59.0**	**56.5**	**69.33**

	SEd	**CD(0.05)**
V	0.50	1.04
S	0.88	1.81
VS	1.24	2.56

Table 6.b. Effect of different concentrations of $NaHCO_3$ on Relative water content (%) of aggregatum onion bulb.

Variety	**Control**	**10mM**	**20mM**	**30mM**	**40mM**	**50 mM**	**Mean**
Perambalur local	84.0	73.0	70.0	69.0	67.0	63.0	**71.0**
Thuraiyur local	88.0*	75.0	72.0	70.0	69.0	67.0*	**73.5***
Mean	**86.3**	**74.0**	**71.0**	**69.5**	**68.0**	**65.0**	**72.3**

	SED	**CD(0.05)**
V	0.58	1.20
S	1.00	2.08
VS	1.42	2.94

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Relative water content

The revealed significant difference in Relative water content between the aggregatum onion varieties and different different NaHCO3 concentrations (Table 6). At different sodicity concentrations (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM of NaHCO3), CO 6 and thuraiyur local variety recorded significantly maximum relative water content and CO 5 and perambalur local variety recorded minimum relative water content. At maximum sodicity concentration 50 mM (NaHCO3), the varieties CO 6 and thuraiyur local variety exhibited maximum (58.0%, 67.0%) relative water content and CO 5 and perambalure local variety exbited minimum (55.0%, 63.0%) relative water content values. 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 ofdraught stress (desiccation period) around the roots as well in leaf tissues" (Delatorre et al., 2010).

Table7.a. Effect of different concentrations of $NaHCO_3$ Membrane stability index of aggregatum onion seedlings.

Variety	**Control**	**10 mM**	**20 mM**	**30 mM**	**40 mM**	**50 mM**	**Mean**
Co 5	73.0	72.1	68.1	64.8	57.8	51.4	**64.5**
C0 6	74.2	71.5	69.2	66.6	62.3*	58.2*	**67***
Mean	**73.6**	**71.8**	**68.6**	**65.6**	**60.0**	**54.7**	**65.7**

	SEd	CD(0.05)
V	0.67	1.38
S	1.16	2.40
VS	1.64	3.40

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Table 7.b .Effect of different concentrations of $NaHCO_3$ on Membrane stability index of aggregatum onion bulb.

Variety	Control	10mM	20 mM	30mM	40mM	50 mM	Mean
Perambalur local	79.58	76.1	71.5	68.8	57.8	51.0	**67.4**
Thuraiyur local	82.24	79.5*	76.2*	72.6*	64.3*	58.4*	**72.1***
Mean	**80.9**	**77.7**	**73.8**	**70.7**	**61.05**	**54.7**	**69.8**

	SEd	CD(0.05)
V	0.65	1.35
S	1.13	2.34
VS	1.60	3.31

Membrane stability index

The impact of sodicity stresses on seedling dry weight of four aggregatum onion varieties screened through laboratory experiment was assessed. In terms of membrane stability index of four aggregatum onion varieties exhibited significant variations in response to different sodicity levels (Table 7). Among two seed propagating aggregatum onion varieties, CO 6 recorded significantly maximum membrane stability index compared with CO 5 and two bulb propagating aggregatum onion varieties , thuraiyur local recorded significantly maximum membrane stability index compared with perambalur local in all sodicity concentation (0 mM, 10 mM, 20 mM, 30 mM, 40 mM, 50 mM) . At maximum sodicity concentration 50 mM ($NaHCO_3$), the varieties CO 6 and Thuraiyur local variety exhibited maximum (58.2%, 58.4%) membrane stability index and CO 5 and perambalur local variety exbited minimum (51.4%, 51.0%) membrane stability index values.

Conclusion

The impact of sodicity stresses on four aggregatum onion varieties screened through laboratory experiment was assessed. As a result a decline in all onion growth paramers, germination per cent, root length, shoot length, vigour index, stress tolerant index, relative water content and membrane stability index with increasing sodicity stress has been recorded. Significant differences were observed between the varieties and different $NaHCO_3$ concentrations. Irrespective of $NaHCO_3$ concentrations, CO 6 and thuraiyur local variety

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recorded maximum value in all growth parameters compared to other varieties CO 5 and perambalur local. Based on stress tolerant index result concluded, CO 6 and thuraiyur local variety tolerant to sodicity stress and CO 5, perambalur Local variety suceptible to sodicity stress.

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