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SALINITY TOLERANCE OF FORAGE COWPEA [*VIGNA UNGUICULATA* (L.) WALP.] DURING GERMINATION AND EARLY SEEDLING GROWTH

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SUMMARY

In the present investigation, four cowpea varieties *viz*., Kohinoor, BL-1, BL-2 and EC-4216 were tested for their relative salt tolerance to increasing levels of salinity in the combinations of salts which nearly exist in the natural salt affected soils in India. Seeds were germinated in petri dishes and were exposed to four salinity [4, 8, 12 and 16 EC (dS m^{-1})] levels. The germination percentage, shoot length, root length, fresh weight and dry weight of seedling were recorded. The main effects of salinity on varieties and the interaction effects among varieties were significant ($p \leq 0.05$). At the highest salinity (16 dS/m) level, reduction in GP over control ranged from 14% for BL-2 to 74% for BL-1, SSL 77% for Kohinoor to 96% for BL-1, for SRL 59% for BL-1 to 83% for BL-2. GP showed significant correlation with SL, FW, DW, moderately significant correlation with SVI-I, II, III and highly significant correlation in SVI-IV. It was inferred that salinity stress significantly decrease germination and growth parameters of seedlings of four forage cowpea varieties; however variety BL-2 was found relatively tolerant to salinity than Kohinoor, EC-4216 and BL-1.

Key words : Salinity, cowpea, germination percentage, shoot length and seed vigour indices

Salinity is a wide spread environmental stress for crop plants in arid and coastal regions. The salinity of the soil and irrigated water is a problem that restricts yield on almost 40 million hectares of irrigated land, which is approximately one third of the irrigated land on earth (Norlyn and Epstein., 1984, Pons *et al.* 2011). In India, about 5.95 million ha areas have been affected by salinity. The loss of productivity due to salinity has been reported 6.2 million tons. Five states *viz*. Haryana, Punjab, Rajasthan, Gujarat and Andhra Pradesh accounts for 48% of the total salt affected soils of the country (Singh *et al.,* 2020, Mandal *et al*., 2010). Due to increasing salt salinity large areas of arable land are being removed from crop production every year (Chapman, 1975, Epstein *et al*., 1980, Sairam and Tyagi 2004). High levels of soil salinity can significantly inhibit seed germination and seedling growth, due to the combined effects of high osmotic potential and specific ion toxicity (Grieve and Suarez, 1997). Intolerance to salinity may result in physiological and biochemical disorders which prevent or delay germination or cause abnormal seedlings (Rehman *et al.,* 1996; Ungar, 1996). To fulfill the food, feed, fodder and industrial raw material demands of growing population, development of salt tolerant and high yielding crop varieties/ genotypes/lines is necessary. Establishment of seedlings at early growth stages of crop plants is one of the most important determinants of high green fodder yield in severely affected soil salinity areas (Akhtar and Hussain.. 2008). Increasing salinity levels are reported to reduce germination percentage, shoot and root length, shoot and root fresh and dry weights and seed salinity indices of some of forage legumes (Dheeravathu *et al*., 2017, Dheeravathu *et al*., 2021a). Hence, introduction of salt tolerant plants is one of the ways to utilize the waste saline water and lands (Baccio *et al*., 2004). Forage legumes have high demand as forage for producing high-quality meat and milk (Boelt *et al*., 2015).

Cowpea [*Vigna unguiculata* (L.) Walp.] is an annual herbaceous *kharif* and summer (C_3) legume crop. Cowpea is grown throughout the lowland tropics of Africa, India, south eastern Asia, Australia and coastal areas of South and Central America. In India, cowpea is grown throughout India including considerable areas in Rajasthan, Gujarat, Maharashtra, Karnataka and Tamil Nadu. It has a great potential for sustainable agriculture in marginal lands and semi-arid regions of the country (Nguyen *et al*., 2017; Panchta *et al*., 2021). It is estimated that about 6.5 lakh hectare is under different forms of cowpea and the share of fodder cowpea is 3.0 lakh ha (Pandey and Roy., 2011). Average green fodder yield is 40-45 t /ha and average dry fodder yield 5.0-6.0 t/ha. The nutritive value of fresh biomass of cowpea on organic matter (O/M) basis is almost 125%, digestible crude protein (DCP 62.0%) and digestible energy 2.2 M cal /kg metabolizable energy. Singh *et al*. (2003) reported that cowpea hay is a nutritious balanced fodder for animals. It can provide income, food, and climate solutions for small holders' farmers. Like other legumes, it also has unique ability to fix atmospheric nitrogen into nitrate, thus improve fertility status of soils (Nguyen *et al*., 2019; Arya *et al*. 2021). Legumes are considered a relatively salt sensitive family (Mass and Hoffman, 1977) within which limited variability for salinity tolerance has been detected (Johansen *et al*., 1990). Increasing salinity levels affected germination percentage, germination rate, seedling shoot and root length, seed vigour index-I, II and III in legumes and forage legumes *viz*., soybean, chickpea, faba bean, black gram, centro, clitoria, siratro and berseem (Dheeravathu *et al*., 2017, and 2021; Bimurzayev *et al*., 2021; Awasthi *et al.,* 2016; Jyotsna *et al*., (2020); Priyadharshini *et al*., 2019 and Pavli *et al*., 2021).

Cowpea like other plants in the legume family, is placed among the most sensitive plants, because its tolerance threshold was estimated to be close to 2.5 dS m^{-1} (West & Francois, 1982). Considering the adverse effects of salt stress on seed germination, establishment of seedlings at early growth, crop growth and productivity, the development of salt-tolerant varieties/ genotypes/ lines and more particularly salt-tolerant forage cowpea could play a major role in sustaining livestock production in the salt-affected lands and would also be helpful in future breeding programs. Diminutive or very limited information are available on forage cowpea on salinity stress. Therefore, the present investigation was carried out to study performance of four cowpea cultivars on seed germination; seedling shoot length, root length and different seed vigour indices were tested for their relative salt tolerance to increasing levels of salinity in those combinations of salts which nearly exist in the natural salt affected soils.

MATERIALS AND METHODS

This study was conducted at Crop Improvement Division of ICAR- Indian Grassland and Fodder Research Institute, Jhansi (25°45'N, 78°58'E, 233m above msl), during 2018. Experiment consisted of four forage cowpea varieties *viz.,* Kohinoor, BL-1, BL-2 and EC-4216 varieties, with different salinity levels *i.e.* 0 as control (distilled water), 4, 8, 12 and 16 EC (dSm^{-1}) as prepared by mixing the different salts according to Richards *et al.,* (1954) and Dheeravathu *et al.,* (2018), which were evaluated in a factorial Completely Randomized Design in petri plates and replicated thrice. The seeds were surface sterilized with 0.01% mercuric chloride (w/v) for 10 min to avoid fungal invasion, followed by washing with distilled water. These treated seeds were used for the experiment. For each variety 50 seeds for each of the four salt treatments were used. Seeds were allowed to germinate in laboratory condition on filter paper (Whatman No. 2) in sterilized 15 cm (diameter) petri dishes soaked in a solution of the respective salt concentration. Small amount (10 g) of artificial sand was added to each petri dish, after the germination for support and early growth of seedling in petri plates, respective salt concentration was maintained up to 10 days. The number of germinated seeds was counted every day up to 10 days and the seeds were considered germinated when the radicle emerged. At the 10^{th} day (starting of germination), five seedlings were randomly selected and seedling and root length with their fresh weight and dry weight were measured, the fresh weight and dry weight of seedling were obtained after the length assessment. For dry weight recording, the seedlings were wrapped in brown paper bags and placed in oven at 80°C for 24 h. The dry weight of the seedlings was recorded.

Determination of germination percent was computed as per the following equations Germination percent = S/T×100

This formula S is the number of germinated seeds, T is the total number of seeds

Seed salinity vigour indices-I, II, III, IV and

V were computed as per the following equations:

Seed salinity vigour index-I = Final germination (%) × average seedling length [(shoot + root length (cm)].

Seed salinity vigour index-II = Final germination (%) × fresh weight of seedling [(shoot + root (mg)].

Seed salinity vigour index-III = Final germination (%) × dry weight of seedling [(shoot + root (mg)].

Seed salinity vigour index-IV = Final germination (%) × average shoot length (cm) Seed salinity vigour index-V = Final germination (%) × average root length (cm)

Seedling total water content (STWC) was calculated by following the method described by Dheeravathu *et al*., (2018, 2021a) using the formula: seedling fresh weight (mg)-seedling dry weight (mg)/ seedling fresh weight (mg).

Statistical analysis:

Whole data were subjected to ANOVA (factorial CRD with three replications) using the PROC GLIMMIX procedure in SAS (V 9.3 SAS Institute Inc, Cary, NC, USA) and Microsoft Excel. The correlation study was performed using Jamovi version 1.2.27 at a 5% level of significance. The treatment means were separated using Fisher's least significance difference (LSD) test (p = 0.05).

RESULTS AND DISCUSSION

The main effects of salinity on varieties and the interaction effects among varieties were significant in GP, SVI-III, SVI-IV and SVI-V parameters (Table 1). Highly significant interactions were found between variety and level of salinity in GP, SVI-III, SVI-IV and SVI-V (Table 1).

Effect of salt stress on seed germination percentage, seedling shoot length, root length and root to shoot length ratio

Seed germination percentage (GP), seedling shoot length (SSL), seedling root length (SRL) and root to shoot length ratio (RSR) reduced for all varieties as level of salinity increased (Table 2). While an EC level of 4 dS/m had very less or no significant effect GP, SSL, SRL and RSR and at the highest salinity (16 dS/m) level reduction in GP over control ranged from 14% for BL-2 to 74% for BL-1, for SSL 77% for Kohinoor to 96% for BL-1, for RSL 59% for BL-1 to 83% for BL-2. But increasing root to shoot ratio was observed at increasing salinity levels compared to control, as a result RSR declined from 0.7-1.0 for Controls to 1.3-9.1 ratio at the highest salinity level (Table 2) highest RSR (9.1%) was observed in variety BL-1 and lowest was recorded in variety BL-2 (1.3%) (Table 2 and Fig 2).

Effect of salt stress on cowpea seedling fresh, dry weight, root to shoot length ratio and seedling water content

The fresh weight of seedling of all four cowpea varieties was strongly affected by all salinity levels. Seedling fresh weight was reduced at high salinity level [16EC (dS m^{-1})], highest reduction was observed in Kohinoor and EC-4216 (22 mg), followed by BL-1 (26 mg) and lowest reduction was observed in BL-2 (28mg), while highest mean percentage of reduction was noted in BL-2 (40%) followed by BL-1 (36%), Kohinoor (32%) and least in EC-4216 (29%) Table 3. Dry weight were reduced at high salinity levels [8 and 16 EC (dS m^{-1})], whereas, fresh weight was reduced more as compared to dry weight of seedling

TABLE 1

ANOVA results of the effect of salt stress on germination percentage, seedling shoot length, seedling root length, seedling fresh weight and dry weight

Variable	df	GP	SSL	SRL	SVI-I	SVI-II	SVI-III	SVI-IV	SVI-V
Replications	2	24NS	0.02NS	0.23NS	0.11NS	6.56NS	0.02	0.19**	0.22NS
Variety	3	3575**	4.47NS	2.95NS	14.08NS	752.35 NS	38.85**	4.56**	4.140**
Salinity	4	3373**	9.03NS	3.57NS	26.78 NS	876.90 NS	61.79**	38.56**	16.586**
Variety × Salinity	12	593**	0.44NS	0.51NS	1.93 NS	12.24 NS	0.18**	2.10**	2.01**

**Significance level, p < .01. GP-Germination percentage, SSL-Seedling shoot length, SRL-Seedling root length, Seed vigour indices-I, II, III, IV and V.

TABLE 2

Effect of salt stress on seed germination percentage, seedling shoot length, seedling root length and root to shoot ratio and seedling fresh weight

Salinity/parameters	Kohinoor	BL1	BL2	EC4216
		Germination %		
Control	100.00+0.94a	94.00+1.89bcd	98.00+0.94abc	100.00+0.47a
4EC	94.00+0.47bcd	82.00+0.94fg	96.33+1.89ab	94.67+4.01abcd
	(6.00)	(12.77)	(1.70)	(5.33)
8EC	92.00+0.94cd	70.00+2.36h	96.00+1.19 abc	86.00+0.94 ef
	(8.00)	(25.53)	(2.04)	(14.00)
12EC	90.00+0.47de	30.00+2.36j	94.00+0.94bcd	74.00+1.41h
	(10.00)	(68.09)	(4.08)	(26.00)
16EC	80.00+0.94g	24.00+0.47k	84.33+1.19fg	36.00+2.83i
	(20.00)	(74.47)	(13.95)	(64.00)
		Shoot length (cm)		
Control	3.48+0.12abc	4.29+0.14 abc	7.22+0.08a	4.26+0.02 abc
4EC	3.38+0.12abc	1.81+0.05 abc	4.51+0.10 abc	4.12+0.10 abc
	(2.72)	(57.86)	(37.45)	(3.27)
8EC	1.57+0.07 abc	1.60+0.14bc	1.87+0.03 abc	1.80+0.05 abc
	(54.82)	(62.62)	(74.11)	(57.66)
12EC	1.40+0.14 abc	0.91+0.09 abc	1.03+0.02 abc	0.81+0.05 abc
	(59.74)	(78.79)	(85.68)	(81.07)
16EC	0.79+0.14 abc	0.18+0.01c	0.69+0.05bc	0.31+0.01bc
	(77.30)	(95.92)	(90.49)	(92.81)
		Root length (cm)		
Control	3.24+0.09ab	3.87+0.21ab	5.25+0.12ab	5.29+0.22a
4EC	2.11+0.12b	3.09+0.33ab	3.08+0.26ab	4.60+0.24ab
	(34.81)	(20.29)	(41.39)	(12.98)
8EC	2.10+0.05b	2.48+0.26ab	1.86+0.07b	3.89+0.05ab
	(35.23)	(35.95)	(64.61)	(26.42)
12EC	1.89+0.09ab	2.02+0.05ab	1.60+0.19ab	2.02+0.03ab
	(41.74)	(47.93)	(69.47)	(61.77)
16EC	1.10+0.05b	1.59+0.14b	0.90+0.09b	0.99+0.05b
	(65.98)	(58.82)	(82.85)	(81.21)
		Root to shoot ratio		
Control	0.9	0.9	0.7	1.0
4EC	0.6	1.7	0.7	1.1
8EC	1.3	1.5	1.0	2.2
12EC	1.3	2.2	1.6	2.5
16EC	1.4	9.1	1.3	3.2

Means followed by the same letter (s) in column (s) are not significantly different ($p<.05$), where letter "a" represents the least value, the data are the mean ± SE (n=3); % ROC-% Reduction Over the Control, A value in parenthesis depicts per cent reduction over control.

at increasing level of salinity, relatively (Table 3). These results corroborate other studies that indicate that seedlings subjected to increased salinity levels show decreased fresh and dry weight in berseem and sweet William (*Dianthus barbatus*) Azizi *et al.,* 2011; Dheeravathu *et al*., 2021a). Increasing salinity concentration levels, increasing dry weight to fresh weight ratio was observed in all varieties. This indicated that the higher seedling fresh weight at control as well as at lower level of salinity stress was mainly due to an increase in the seedling tissue water content (Table 3). In general, high soil salinity inhibits seed germination due to the low osmotic potential created around the seed, which prevents water uptake (Welbaum *et al.,* 1990). The reducing total seedling water content was observed in all the four varieties and highest reduction was recorded at 12 and 16 EC (dS m^{-1}) (Fig 1). It may be the reason our results showed that at high salinity level water content is less compared to control.

Our results are in conformity with Dheeravathu *et al*., (2021a), who reported that at increasing salinity concentration levels, there is

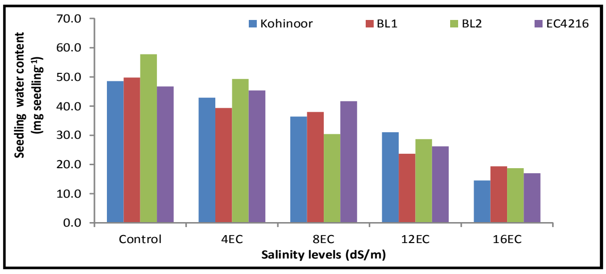

Fig. 1. Effect of salinity stress on seedling water content.

increasing dry weight to fresh weight ratio in berseem. Similar results of higher dry matter content in the leaves of cotton varieties was also reported by Leidi and Saiz (1997) as salt tolerant than susceptible types. The reducing total seedling water content was observed in all the four varieties and highest reduction was recorded at 12 and 16 EC (dS m^{-1}) (Fig 1).

Effect of salinity stress on different seed vigour indices

The main aim of this study was to identify and characterize the seedling shoot length, seedling root length, seedling fresh weight, seedling dry weight and seed salinity vigour indices for salt tolerant screening of forage cowpea during germination and early seedling growth stages to determine their potential for salt tolerance. Three seed salinity vigour indices *viz*., I, II and III were calculated and recorded as per Dheeravathu *et al*., (2021a) methodology. Formulae for seed salinity vigour indices- IV and V were standardized for forage cowpea. Average mean stress-seedling vigour index-I was observed more in EC-4216 (395), followed by Kohinoor (380), BL-2 (372) and least was observed in BL-1 (207), while seedling vigour indices-II and III variety-wise values are BL-2 (3911, 822); Kohinoor, (3626, 739); EC-4216, (3083, 501) and BL-1 (2174, 509) respectively. The values for seedling vigour index- IV were BL-2 (192) followed by Kohinoor (163), EC-4216 (154) and least was

Fig. 2. Effect of salt stress on (a) germination, (b) seedling shoot length and root length.

TABLE 3
Effect of salt stress on seedling fresh and dry weight and dry weight to fresh weight ratio

Salinity/ parameters	Seedling fresh weight (mg/seedling)				Dry weight (mg/seedling)				Dry weight to fresh weight ratio			
	Kohinoor	BL1	BL2	EC4216	Kohinoor	BL1	BL2	EC4216	Kohinoor	BL1	BL2	EC4216
Control	59±0.9	59±1.8	70±0.6	55±0.5	10.7±0.13	9.5±0.16	11.8±0.17	8.2±0.12	0.18	0.16	0.17	0.15
4EC	53±0.6 (11)	48±0.9 (19)	60±0.7 (13)	53±0.9 (3)	10.1±0.22 (5.6)	8.9±0.25 (6.6)	11.2±0.23 (5.7)	7.7±0.24 (6.3)	0.19	0.18	0.18	0.14
8EC	45±0.6 (23)	46±0.3 (23)	41±1.2 (42)	48±0.9 (12)	9.1±0.16 (15.0)	7.7±0.14 (18.8)	10.1±0.13 (14.3)	6.6±0.15 (19.1)	0.20	0.17	0.25	0.14
12EC	39±1.5 (33)	31±0.0 (48)	38±1.5 (45)	32±0.9 (41)	8.4±0.11 (20.9)	7.1±0.13 (25.4)	9.5±0.12 (19.7)	6.0±0.29 (26.9)	0.21	0.23	0.25	0.19
16EC	22±0.9 (62.2)	26±0.9 (56.3)	28±1.0 (60.2)	22±0.1 (60.2)	7.9±0.36 (25.9)	6.5±1.16 (31.3)	9.0±0.18 (24.3)	4.8±0.21 (40.9)	0.35	0.25	0.32	0.22
Mean % ROC	32	36	40	29	16.9	20.5	16.0	23.3				

The data are the mean ± SE (n=3); % ROC-% Reduction Over the Control, A value in parenthesis depicts per cent reduction over control.

TABLE 4
Correlations among different parameters in forage cowpea subjected to salinity stress

PM	GP	SL	RL	FW	DW	SVI-I	SVI-II	SVI-III	SVI-IV	SVI-V
GP	1									
SL	0.271*	1								
RL	0.129	0.825***	1							
FW	0.268*	0.837***	0.813***	1						
DW	0.294*	0.582***	0.518***	0.697***	1					
SVI-I	0.322**	0.958***	0.874***	0.869***	0.633***	1				
SV-II	0.371**	0.888***	0.752***	0.891***	0.641***	0.913***	1			
SVI-III	0.318**	0.750***	0.678***	0.865***	0.931***	0.786***	0.812***	1		
SVI-IV	0.589***	0.309**	0.284*	0.284*	0.282*	0.302*	0.299*	0.298*	1	
SVI-V	0.445**	0.184	0.368*	0.237	0.215	0.232	0.120	0.198	0.815***	1

Significant at * p < .05 (Significant), ** p < .01 (Moderately significant), *** p < .001 (Highly significant) levels; PM: Parameters; GP: Germination percentage; SL: Shoot length: RL: Root length; FW-Fresh weight, DW-Dry weight, SVI-I:Seedling vigour index-I; SVI-II: Seedling vigour index-II, SVI-III: Seedling vigour index-III, SVI-IV -Seedling vigour index-IV, SVI-V -Seedling vigour index-V.

observed in BL-1 (73). In case of seedling vigour index-V, EC-4216 (239) recorded higher followed by BL-2 (175), Kohinoor (163), and least was observed in BL-1(131). Based on the results, seed salinity vigour index- III was found to be more effective than seed salinity vigour indices-I, II, IV and V for screening salinity stress tolerance in cowpea (Table 5).

The results showed that with an increasing level of salt stress, GP, SL, RL, FW, and DW parameters of cowpea varieties decreased compared to control. However, these parameters varied among the assessed forage cowpea varieties. Salts are common and necessary components of soil and many salts (e.g. sodium nitrate, potassium carbonate, bicarbonate and potassium chloride) are essential plant nutrients at low concentrations (Dheeravathu *et al.*, 2021b). Results at 4 dS/m had very less or no significant effect GP, SSL, SRL and RSR. The reduction of germination percentage was observed in all the four varieties at 4-16EC and highest reduction were noted at highest salinity 16 dS/m (Table-2). The reason for germination loss can be attributed to presence of higher amount of cations and anions in the salt water. This results in reduced water potential for which seed could not absorb water leading to water deficiency (Jamil *at el.*, 2006).

At increasing salinity levels 4-12 dS/m, percentage of reduction in root length is less than shoot length but highest reduction was observed at 16 dS/m. These results were also in line with the results of Kandil *et al.,* (2017) obtained for forage cowpea. Dheeravathu *et al.*, (2021a) also reported that on the basis of GP and SL, RL and FW and seed salinity vigour indices- I, II and III in four berseem cultivars. The results revealed that germination percentage, seedling shoot and root length, seedling fresh weight and seed salinity vigour indices-I, II, III, IV and V of cowpea varieties *viz.,* Kohinoor, BL-1, BL-2 and EC-4216 were strongly affected ($p < 0.05$) by all salt treatments (Table 2 and Table 5). GP showed significant correlation with SL, FW, DW, while moderately with SVI-I, II, III and highly significant correlation SVI-IV (Table-4). Seedling shoot length (SSL), seedling root length (SRL) and fresh weight reduced, Shoot length reduction (% ROC) was recorded more compared to root length, while root to shoot length ratio (RSR) and dry weight to fresh weight ratio (DFR) increased for all varieties as level of salinity increased. Our results agreed with Dheeravathu *et al.*, (2021a). Seed salinity vigour index-III is very difficult to assess in very small or very bold seeded forage legumes and grasses (10 days after germination), however the use of artificial sand in petri plates provided support for proper seedling growth. As this is a very simple and easy technique it will be useful for *in- vitro* screening for salinity stress tolerance. This is our first report on seed salinity vigour index-IV and V in forage cowpea.

CONCLUSION

The current study indicated that increasing

TABLE 5
Effect of salt stress on different seed salinity vigour indices in cowpea varieties

Salinity/parameters	SVI-I			
	Kohinoor	BL1	BL2	EC4216
Control	707+17abc	770+9 abc	1219+50a	937+5ab
4EC	511+21 abc	409+26 abc	738+7 abc	841+7 abc
8EC	395+9 abc	288+14 abc	364+9 abc	490+5 abc
12EC	380+17 abc	90+9 abc	252+10ab	205+7 abc
16EC	233+24 abc	40+12c	134+14 abc	46+12 abc
Mean stress*	380	207	372	395
% ROC	46	73	69	58
			SVI-II	
Control	5924+92ab	5569+177 abc	6823+64a	5486+47ab
4EC	4979+59 abc	3953+90 abc	5824+73 abc	5017+92 abc
8EC	4180+60 abc	3199+33 abc	3891+116 abc	4150+90 abc
12EC	3554+147 abc	922+3 abc	3591+151ab	2380+92 abc
16EC	1792+94 abc	621+90c	2337+104 abc	785+9 abc
Mean stress*	3626	2174	3911	3083
% ROC	39	61	43	44
			SVI-III	
Control	1069+26b	895+34d	1158+21a	819+16e
4EC	948+33c	743+41f	1068+40b	750+4f
8EC	800+21e	554+31i	887+32d	568+33i
12EC	704+43g	411+19k	741+33f	419+34k
16EC	506+85j	325+182l	593+49h	267+12m
Mean stress*	739	509	822	501
% ROC	31	43	29	39
			SVI-IV	
Control	348+12d	403+14bc	707+8a	426+2bc
4EC	318+12d	148+5ef	435+10b	390+10c
8EC	145+7fg	112+14efg	179+3e	155+5ef
12EC	126+14g	27+9hi	97+2h	60+5hi
16EC	63+4hi	4+1j	58+5i	11+1j
Mean stress*	163	73	192	154
% ROC	53	82	73	64
			SVI-V	
	324+9fgh	364+21c	515+12a	529+22a
4EC	199+12d	253+33d	297+26d	435+24b
8EC	193+5ef	174+26e	178+7fhg	335+5c
12EC	170+9efg	60+5efgh	151+19ghi	150+3efgh
16EC	88+5ij	3+14hi	76+9j	36+5j
Mean stress*	163	131	175	239
% ROC	50	64	66	55

Means followed by the same letter (s) in column (s) are not significantly different ($p<.05$), where letter "a" represents the least value, the data are the mean ± SE (n=3), Mean stress*:4,8,12 and 16ECmean values, % ROC-% Reduction over the Control.

salinity levels affected germination percentage, seedling shoot and root length, seedling fresh weight and seed salinity vigour index-I, II, IV and V of the four cowpea varieties *viz*., Kohinoor, BL-1, BL-2 and EC-4216. It was concluded that the BL-2 variety showed better salt tolerance than other tested varieties compared to control. We identified that seed salinity vigour index-III is the best screening seed salinity vigour index technique for salinity stress tolerance than seed salinity vigour index-I, II, IV and V. However, confirmations of these results have to be made in the pot/ hydroponic/ field affected by salinity.

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